Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume X. Receptors — Fish, Littoral, Benthos

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

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Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

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VOLUME X

RECEPTORS - FISH

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* indicates final report

FINAL REPORT

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PHYTOPLANKTON AND PRIMARY PRODUCTIVITY IN THE NORTHEAST GULF OF ALASKA AND LOWER COOK INLET

Prepared by:
Jerry D. Larrance, David A. Tennant,
Alexander J. Chester, and Patricia A. Ruffio

Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
3711 15th Avenue N.E.
Seattle, Washington 98105

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I. INTRODUCTION

The phytoplankton and primary productivity studies in the northeastern Gulf of Alaska and lower Cook Inlet conducted for OCSEAP were designed to provide a baseline of phytoplankton standing stocks and rates of primary production in those areas. Although initial guidelines placed emphasis on broad areal distributions of these parameters in the Gulf, a shift was made to concentrate the investigations in selected nearshore areas, principally lower Cook Inlet. This concentration of effort focused the studies in areas of high probable impact caused by oil and gas development activity, i.e., the potential lease area in lower Cook Inlet. It also permitted more thorough descriptions to be made of seasonal sequences of phytoplankton and related parameters.

The general intent of the study was to document the species composition and standing stock of the phytoplankton, primary productivity, and the environmental factors controlling production. These parameters were measured in lower Cook Inlet with sufficient frequency during spring and summer 1976, to develop a picture of the seasonal succession of events involving productivity and species composition.

Measurements were made within the upper 50 m of water of chlorophyll *a*, primary production, inorganic nutrient concentrations, temperature, salinity, and incident and underwater ambient irradiance. The several dominant phytoplankton species and their population densities were determined. The data have been examined for relationships to productivity and standing stocks in order to gain insights into the major forces which drive primary production.

The information obtained during this study provides a baseline against which future data can be compared in an attempt to ascertain effects of possible contamination. The data help define areas and seasons of particularly high biological production and can further be applied to develop models for estimating timing and size of phytoplankton blooms. The models, in turn, may be applied to help understand the dynamics of primary production in lower Cook Inlet and, in conjunction with monitored variables, to facilitate detection of future changes in the ecosystem should they occur.

Although phytoplankton are likely to repopulate an area shortly following an oil spill, the species composition may be very different after prolonged contamination. The new dominant species may be inadequate to nourish grazers, and thus significant changes may occur in the food web. In addition to large spills, continuous or intermittent low-level contamination is almost certain to exist in the area around and downstream of an oil field. The resultant chronic effects on phytoplankton production is virtually unknown. Unless predevelopment conditions are determined, these chronic effects cannot be detected.

II. FIELD ACTIVITIES

Six oceanographic cruises were completed from October 1975 through August 1976 (Table 1). The first cruise in October-November 1975 was a broad scale survey of the northeastern Gulf of Alaska (Figure 1). The five subsequent cruises were conducted in lower Cook Inlet from April-August 1975 (Figure 2) in order to determine seasonal patterns of primary productivity, standing stocks, and related variables in that region. During cruise GOA-1 studies of zooplankton, low-molecular weight hydrocarbons and suspended particulate matter distributions were conducted concurrently. Only the zooplankton studies accompanied our efforts in Cook Inlet.

Time-series observations were made for 24-hour periods at selected stations to determine variability. On cruise GOA-1, 24-hour stations were occupied at stations 6, 46, and 62. During the Cook Inlet cruises, 24-hour stations were taken at stations 6, 11, and 13 as time permitted.

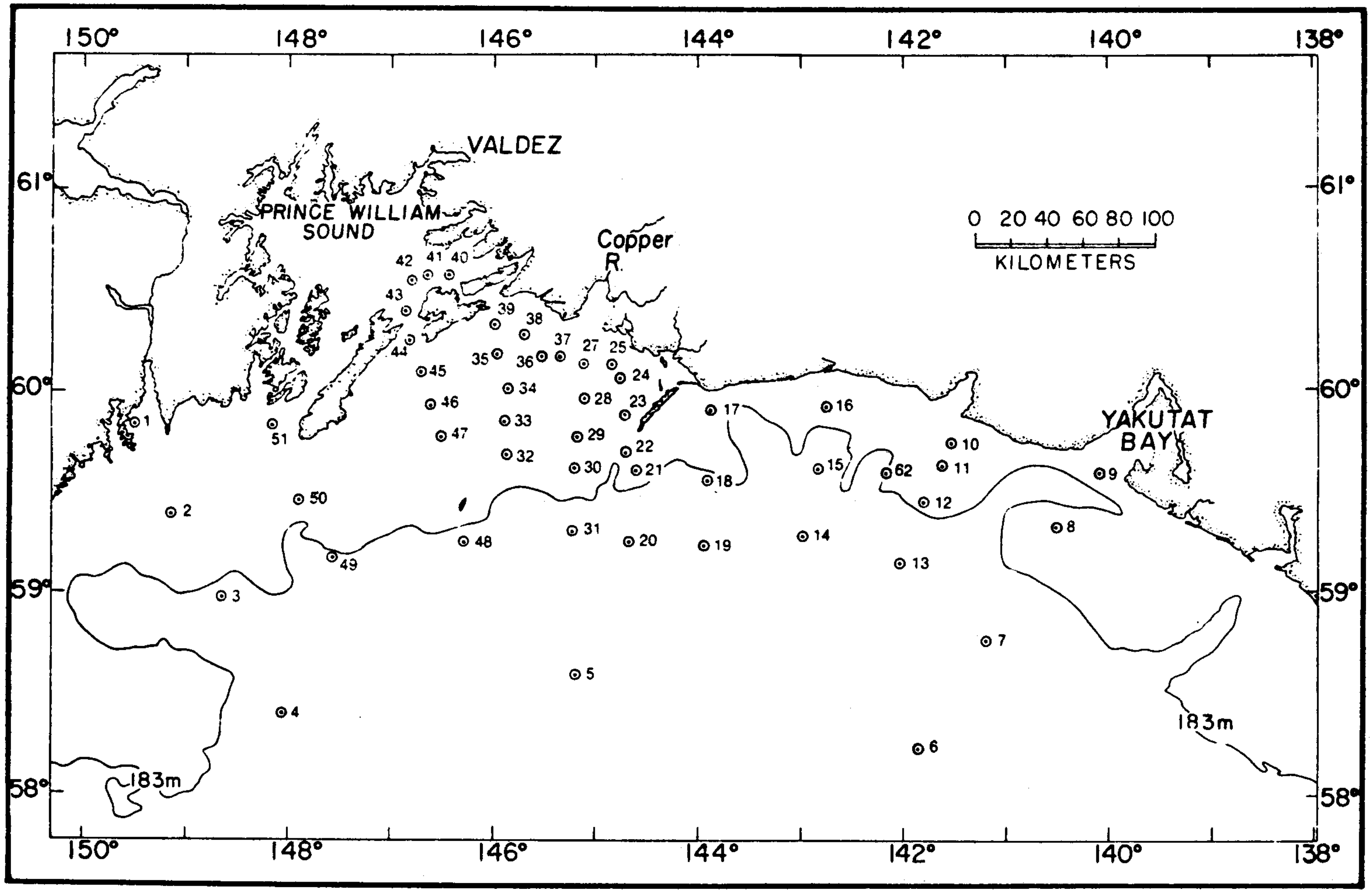

Figure 1. Station locations in the Gulf of Alaska, October-November 1975.

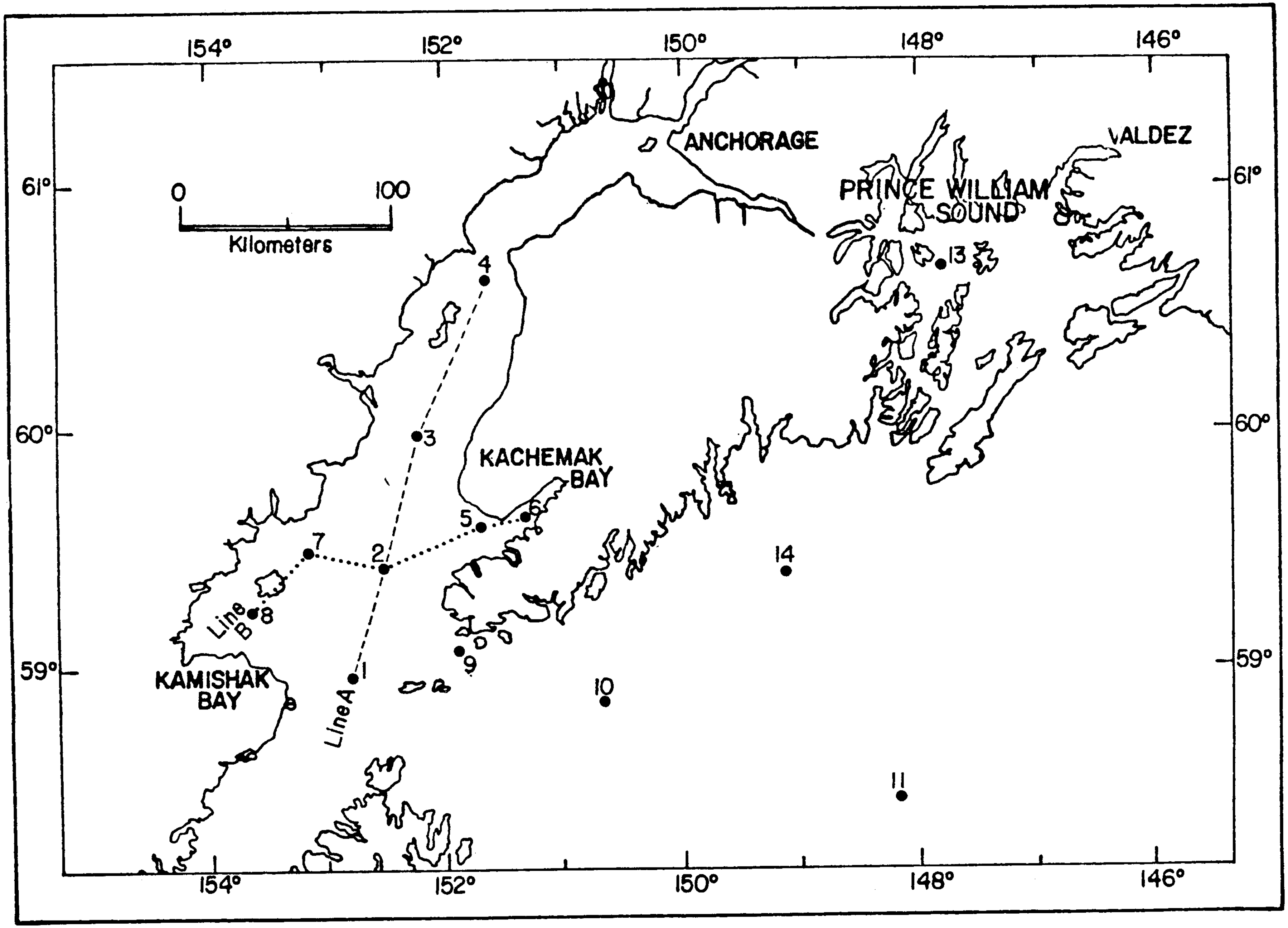

Figure 2. Station locations in lower Cook Inlet, April-August 1976.

Table 1. Plankton sampling schedule for Gulf of Alaska and lower Cook Inlet, 1975-1976.

Cruise Designations				
PMEL	OCSEAP	Vessel	Dates	Stations Sampled
GOA-1	RP4-DI-75C, Leg I	OSS DISCOVERER	10/21-11/10/75	1-51, 62
GOA-2	RP4-DI-76A, Leg III	"	4/6 - 4/13/76	1-13
GOA-3	RP4-DI-76A, Leg V	"	5/5 - 5/9	1-11
GOA-4	RP4-DI-76A, Leg VII	"	5/24- 5/30	1-8, 10-14
GOA-5	RP4-AC-76, Leg II	R/V ACONA	7/8 - 7/15	1-11
GOA-6	RP4-SU-76B, Leg II	OSS SURVEYOR	8/24- 8/31	1-14

III. METHODS

Water samples were collected by Niskin bottles and CTD (Conductivity-Temperature-Depth) profiles were simultaneously recorded. Usually, 8 to 10 samples were taken from the upper 50 m. Portions of the sample were taken for phytoplankton, nutrient, and chlorophyll a and phaeopigment analyses and for primary productivity experiments. The sampling during GOA-1 was closely coordinated with the suspended matter and hydrocarbon programs.

The phytoplankton samples were preserved in 1 percent formalin buffered with sodium acetate and returned to Seattle for analysis using the Utermöhl (1931) inverted microscope technique. Cells were identified to the lowest practicable taxon and counted. Sufficient numbers of cells of the dominant species were counted to bring the random counting error within acceptable limits (Lund et al., 1958).

Chlorophyll a and phaeopigment concentrations were determined by fluorometric techniques described by Strickland and Parsons (1968) and Yentsch and Menzel (1963). Modifications to the basic techniques were applied so that smaller sample volumes could be used and more complete extraction of pigments could be obtained using sonification. Seawater samples of 253 ml were filtered through glass-fiber filters with a few mg $MgCO_3$ on top. The filter was immersed in 10 ml of 90 percent distilled acetone and sonicated for 1 min using a sonic disintegrator. The samples were then centrifuged or refiltered and the fluorescence of the supernatant determined according to standard techniques. All pigment analyses were conducted immediately after sampling.

Primary productivity was measured by standard carbon-14 techniques (Strickland and Parsons, 1968). Two bottle casts were taken each day--predawn and prenoon. Half-day photosynthesis experiments were conducted using simulated *in situ* incubations. Incubation periods were dawn to LAN (local apparent noon) and LAN to dark. Five to eight depths were sampled at each station according to a fixed set of light transmission ratings. During GOA-1 these light depths were 95, 75, 50, 30, 18, 5.5, and 2 percent of the incident surface light. The depths were 92, 61, 46, 24, 11, 5.5, 1.5, and 1 percent for the remainder of the cruises. At noon stations, sampling depths were determined from underwater quantum sensor and secchi disk readings. The quantum sensor measures light quanta in the photosynthetically active region (approx. 400-680 nm). Sampling depths for the morning stations were selected based on data from previous stations.

Two light and one dark bottles from each depth were incubated. The resulting filters were immersed in scintillation-fluor solution and returned to Seattle and analyzed by liquid-scintillation techniques.

Incident solar radiation between wave lengths of 3 and 0.3 nm were measured at the ship's deck by an Eppley Model 8-48 pyranometer and by a quantum sensor identical to the underwater instrument. Continuous recordings were made by a strip chart recorder equipped with an integrator to give total energy over a given time period, e.g., each day or each incubation period.

Seawater samples for determination of dissolved inorganic nutrient concentrations were frozen and returned to the University of Washington, Department of Oceanography, for analysis. Dissolved nitrate, nitrite, ammonia, silicate, and phosphate were determined using Auto Analyzer techniques.

A. Statistical Reliability

Hobson (1964) studied the error inherent in enumeration of phytoplankton samples. Three possible error sources were listed:

1. Distribution in the field (e.g., patchiness),
2. Subsampling from the water bottle,
3. Errors associated with counting technique.

He concluded that for less numerous cells (species) errors 1 and 3 are about the same. Error 2 was found to be small. For microflagellates error 2 becomes the largest component of variability. There seems to be no explanation other than that swarming may occur in the water bottle.

Lund, Kipling, and LaCren (1958) looked at errors in the counting procedure. Their results for 95 percent confidence levels about a count are shown in Figure 3. In this study we tried to attain counts of at least 100 individuals each for the three or four most abundant species. This results in a counting accuracy of ± 20 percent. The sources of error for chlorophyll concentration are similar to those for phytoplankton enumeration, except that the analytical error is of a different nature and is generally smaller than for cell counts. Replicate analyses performed during this study indicate that the analytical error was usually less than 6 percent for chlorophyll values exceeding 0.5 mg/m^3.

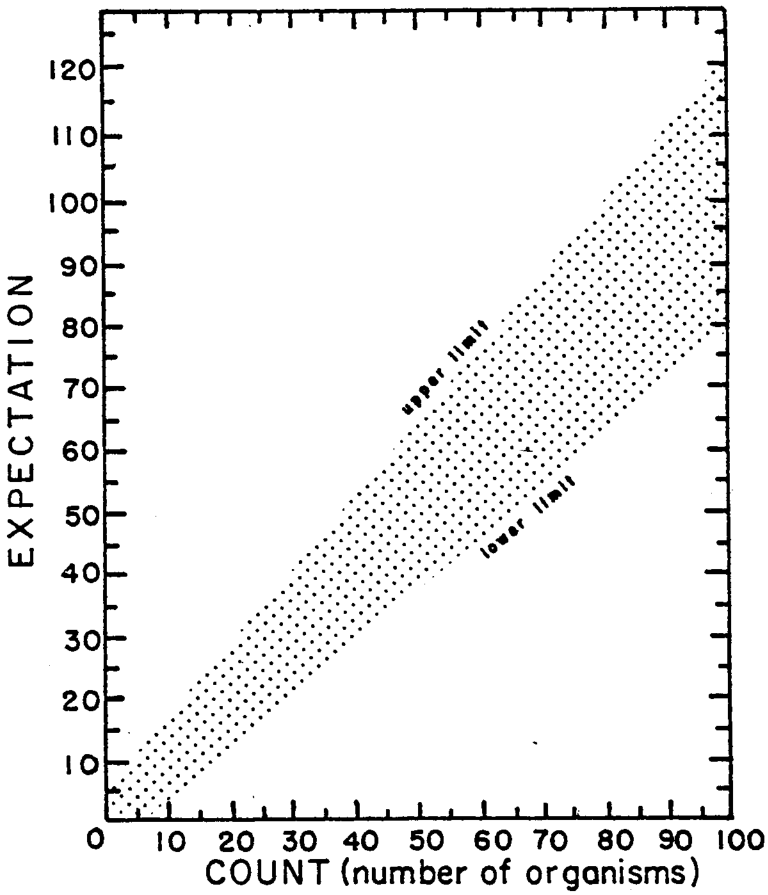

Figure 3. 95% of confidence intervals about phytoplankton counts. For the confidence limits of a single count find the count on the horizontal axis and draw a vertical line through it. The limits are read off from the vertical axis at the points where this line cuts the upper and lower boundaries of the shaded zone.

The chlorophyll variability measured over 24-hour periods in Kachemak Bay was calculated from data collected on several cruises. As with typical count data from heterogeneously distributed populations, the variance of chlorophyll values is proportional to the mean. Thus, a log transformation of the data was employed to reduce this dependency. Variances were calculated for each depth and used to determine confidence limits. The overall 95 percent confidence intervals for a single chlorophyll observation can be calculated by multiplying or dividing the value by 1.6. This factor ranged from 1.1 when chlorophyll was uniformly distributed with depth (early spring) to 2.7 during the chlorophyll maximum in late May when vertical patchiness was accentuated.

IV. CURRENT STATE OF KNOWLEDGE

A. Gulf of Alaska

The information available in the literature on phytoplankton standing stocks in the Gulf of Alaska is limited mainly to open waters of the southern portion of the Gulf. Several Japanese workers have reported diatom species from the southern Gulf of Alaska sampled by fine mesh nets. Karohji (1972) summarized Alaskan Gyre populations as dominated by *Nitzschia seriata, Phaeoceros,* and *Rhizosolenia hebatata f. spinifera.* Ohwada and Kon (1963) concentrated algae from water samples by centrifugation. Their results from open water agree in general with Karohji's (1972) and they found 3 x 10^6 cells L^{-1} near Juneau of which 88 percent were *Skeletonema costatum.*

Phytoplankton of the Pacific Subarctic Region appear to be primarily nanoplankton (cell diameters < 20 nm). McAllister et al. (1960) reported the dominant group at Ocean Station "P" (lat. 50^{o}N, long. 145^{o}W) were coccolithophores (nanoplankton size). Parsons (1972) measured particle sizes during a transpacific crossing and found the dominant sizes were 8-16 nm. The average size of half the diatom species reported from the subarctic region was < 20 nm (Semina and Tarkova, 1972).

Koblents-Mishke, O.I. (1961) attempted to show the phytogeographical regionalization of the northeastern Pacific. She characterized a boreal group of phytoplankton including *Thalassiothrix longissima, Denticula marina, Chaetoceros decipiens,* and *Ceratium pentagonum.*

Larrance (1971) reported primary productivity, nutrients, and chlorophyll a data south of Adak Island. During and before the 1960's, Canadian scientists of the Pacific Oceanographic Group at Nanaimo, B.C. conducted studies of chlorophyll a, primary production, and zooplankton at Ocean Station "P." The data from these measurements can be found in several numbers of the Fisheries Research Board of Canada, Manuscript Report Series (Oceanographic and Limnological). From the Canadian data, McAllister (1969) estimated the mean annual primary production at Station "P" was 48 gCm^{-2} and Larrance (1971) estimated annual production between 80 and 200 gCm^{-2} at the $176^{o}W$ meridian. Koblents-Mishke (1965) estimated annual production at 102 gCm^{-2} in the Gulf of Alaska.

Spring blooms of phytoplankton in the Gulf of Alaska typically commence in April in nearshore areas and offshore in May and June (Anderson and Munson, 1972; Parsons et al., 1966). The onset of the blooms requires shallower stabilization of the upper waters than in winter and an increase in incident sunlight (Sverdrup, 1953; Parsons et al., 1966; Taniguchi, 1969; Larrance, 1971; and Semina and Tarkova, 1972). At Station "P" (McAllister, 1969) and south of the Aleutian Islands (Larrance, 1971) phytoplankton standing stocks do not reach high levels in spring and summer even though photosynthesis is stimulated by higher light energy. As a consequence, nutrient depletion in the euphotic zone does not occur in summer as in many temperate waters.

Although the referenced information given here is incomplete, three pertinent points are apparent: (1) The existing information describes primarily the southern offshore portion of the Gulf of Alaska and limited data are available along the northern Gulf of Alaska continental shelf. (2) No previous sampling program has produced phytoplankton and primary production data applicable to the OCSEAP objectives in terms of spatial and temporal continuity and frequency in the study region. (3) A coherent picture of phytoplankton species distribution cannot be presented from information in previous reports.

B. Cook Inlet and Other Inshore Areas

Information on Cook Inlet was synthesized by Evans et al. (1972). The net circulation pattern in lower Cook Inlet is consistent with many observed water properties. Inflow from the Gulf of Alaska is on the eastern side of the Inlet between the Barren Islands and Kenai Peninsula. Outflow is past Cape Douglas on the west side. The highly saline oceanic water flows north along the eastern side and water freshened by runoff and heavily laden with particulate matter flows south along the west side of the Inlet. Intense shear zones are reported between these two opposing currents.

During the spring, large amounts of nitrate and silicate are supplied by runoff from upper Cook Inlet. In the lower Inlet spring and summer phytoplankton blooms reduce these nutrients. Nutrients are also supplied by cold ocean water entering the Inlet at depth and rising as the bottom shoals to the north.

Kinney et al. (1970) presented hydrographic and nutrient data taken in late May 1968, the same season as GOA-4 in the present study. There was evidence of a decrease in nitrate and silicate concentrations in the lower Inlet. Surface water flowing out of the Inlet (one station) was totally depleted of nitrate. Nitrate in Kachemak Bay declined to very low values at the surface between April and July 1969, and was substantially replenished by October (Knull and Williamson, 1969a,b,c).

Knull and Williamson also reported *Thalassiosira* and *Chaetoceros* blooms in Kachemak Bay in spring and summer. Other studies conducted inshore include

Iverson et al. (1974), who reported successive summer blooms of the *Thalassiosira aestivalis* and *Skeletonema costatum* in Auke Bay, Alaska; and Horner et al. (1973), who found a major diatom bloom in March-April in the Valdez area followed by a summer population composed principally of small flagellates and dinoflagellates in the fall. The major peaks of chlorophyll and primary production in Prince William Sound coincided with the spring diatom bloom (Goering et al., 1973). They estimated net annual primary production at 185 gCm^{-2}.

V. RESULTS

The detailed data have been submitted to the Environmental Data Service according to procedures by the OCSEAP Project Office.

A. Gulf of Alaska

1. Phytoplankton Distribution

The results presented here are based on analyses of phytoplankton samples taken from 10 m depth. The areal distributions of phytoplankton species are probably more important than the depth distributions for these baseline studies.

Unidentified microflagellates of various species ranging in diameter from 5-25 μm were ubiquitous in the study area. They were the most numerous group at 27 stations and were within the three most numerous groups at all but a few stations (Table 2). Two areas of high abundance of microflagellates occurred off the continental shelf in the central and eastern portions of the study area and nearshore southeast of Prince William Sound, but they were not abundant in the Sound (Figure 4). Their concentrations were as high as $1 \cdot 10^5$ cells/ℓ at station 15 and averaged $5 \cdot 10^3$ cells/ℓ for all stations.

The distributions of substantial quantities of two species, *Dictyocha fibula* (a silicoflagellate) and *Fragillariopsis* sp. (a diatom), were nearly mutually exclusive (Figures 5 and 6). These distributions are based on

Table 2. Rank order of cell concentrations of most frequently recurring phytoplankton groups in northeastern Gulf of Alaska, October-November 1975[1]

Station	Microflagellates	*Thallassionema nitzschioides*	*Dictyocha fibula*	Coccolithophorids	*Skeletonema costatum*	*Fragilariopsis* spp.	*Thalassiosira* spp.	*Chaetoceros* spp.	Dinoflagellates
16,17,19,21,28 31,32,33,45,47	1								
8,14,27,30	1			2					
23,24,29	1	2							
2	1	2	3						
3	1	2	3				4		
5	1		3			2	4		5
6	1					2	3		4
12	1			3		2			
13	1			2		3			
15	1					2			3
18	1	3		2					
20	1					2			
46	1	2	4						3
38	2	1							
39	2	1		4				3	
43	2	1	4				5	3	
44		1	5				4	3	2
48	2	1	3						
50	3	1	2						
51A		1	2						

Table 2. (contd.)

Station	Microflagellates	*Thallassionema nitzschioides*	*Dictyocha fibula*	Coccolithophorids	*Skeletonema costatum*	*Fragilariopsis* spp.	*Thalassiosira* spp.	*Chaetoceros* spp.	Dinoflagellates
1			1						
4	3	2	1				4		
51	3	2	1						
7	3					2			
40		2			1				
41	2				1				
42					1				

[1]Includes only the groups in which concentrations were $>10^3$ cells/ℓ. No groups at stations 9, 10, 22, 34, and 49 were $>10^3$ cells/ℓ

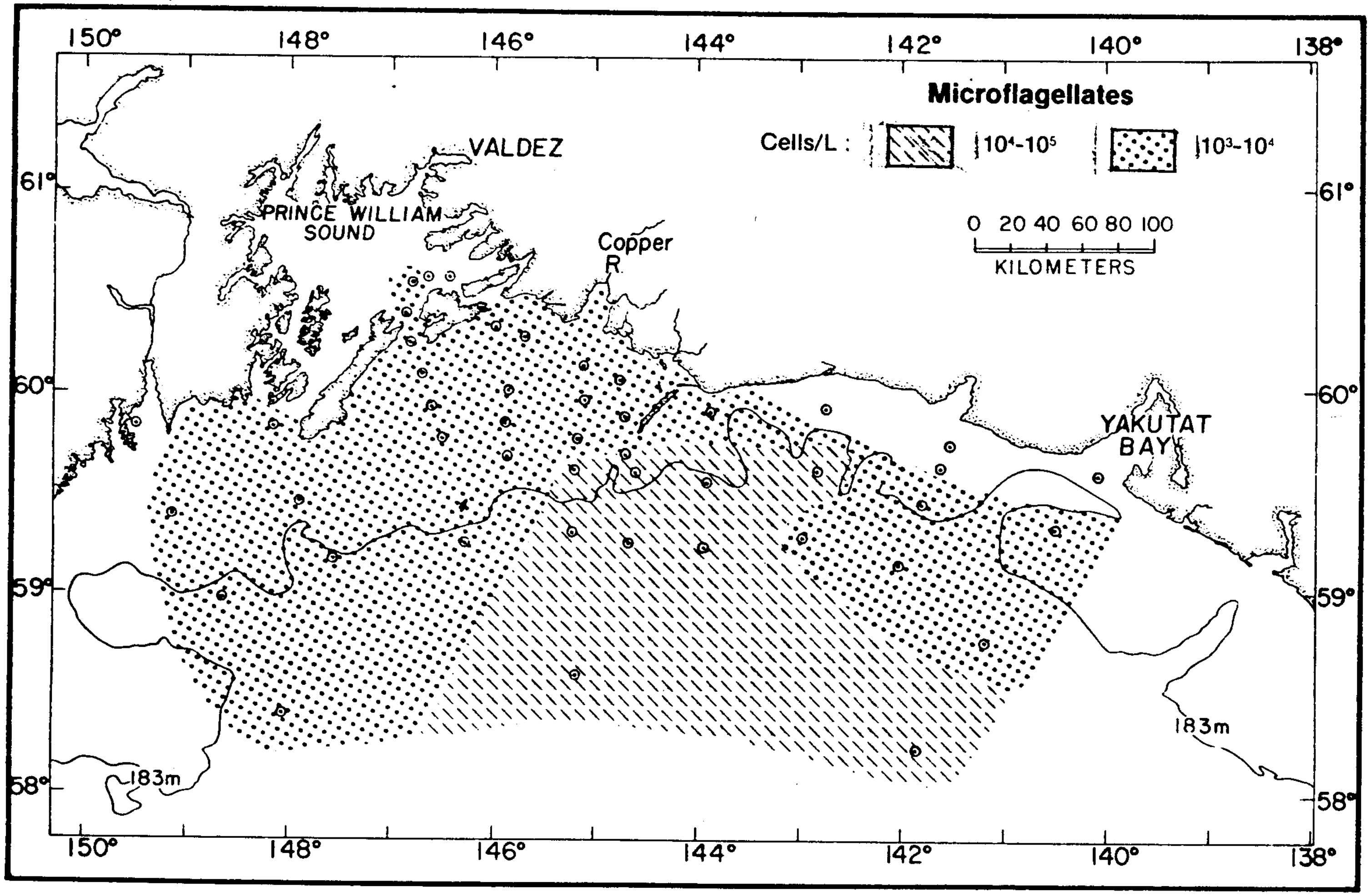

Figure 4. Distribution of Microflagellates at 10 m, October-November 1975.

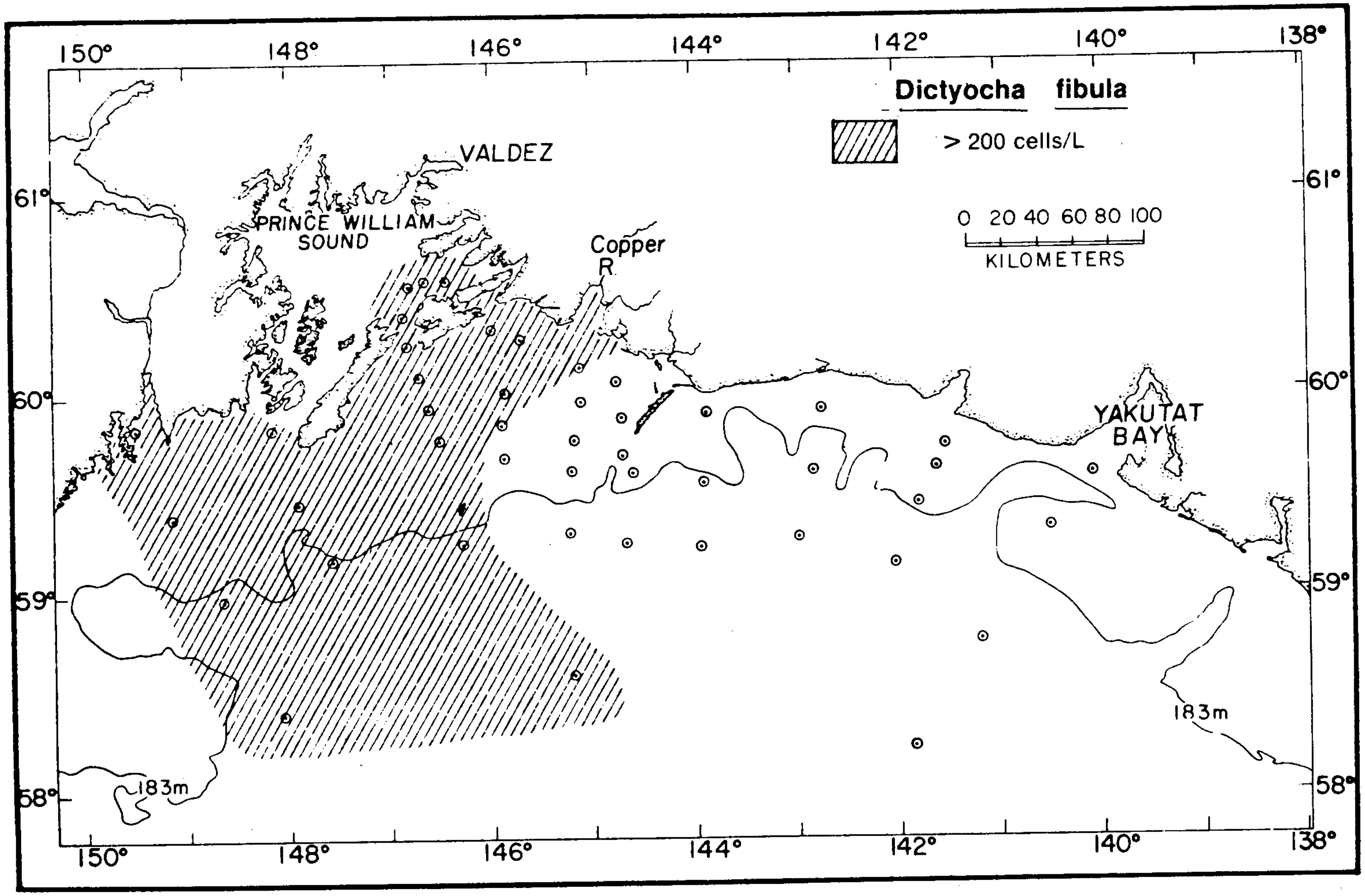

Figure 5. Distribution of *Dictyocha fibula* at 10 m, October-November 1975.

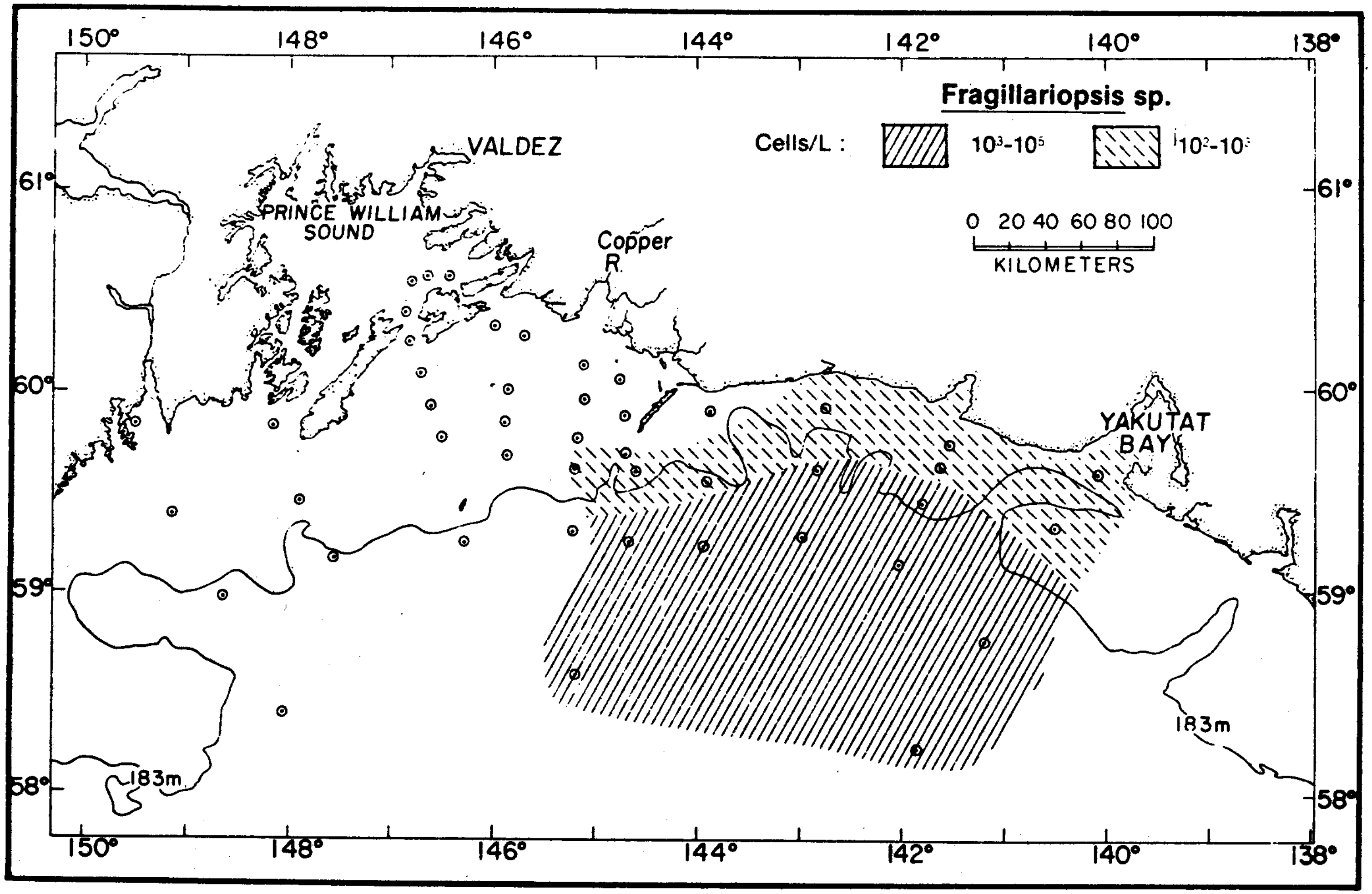

Figure 6. Distribution of *Fragillariopsis* spp. at 10 m, October-November 1975.

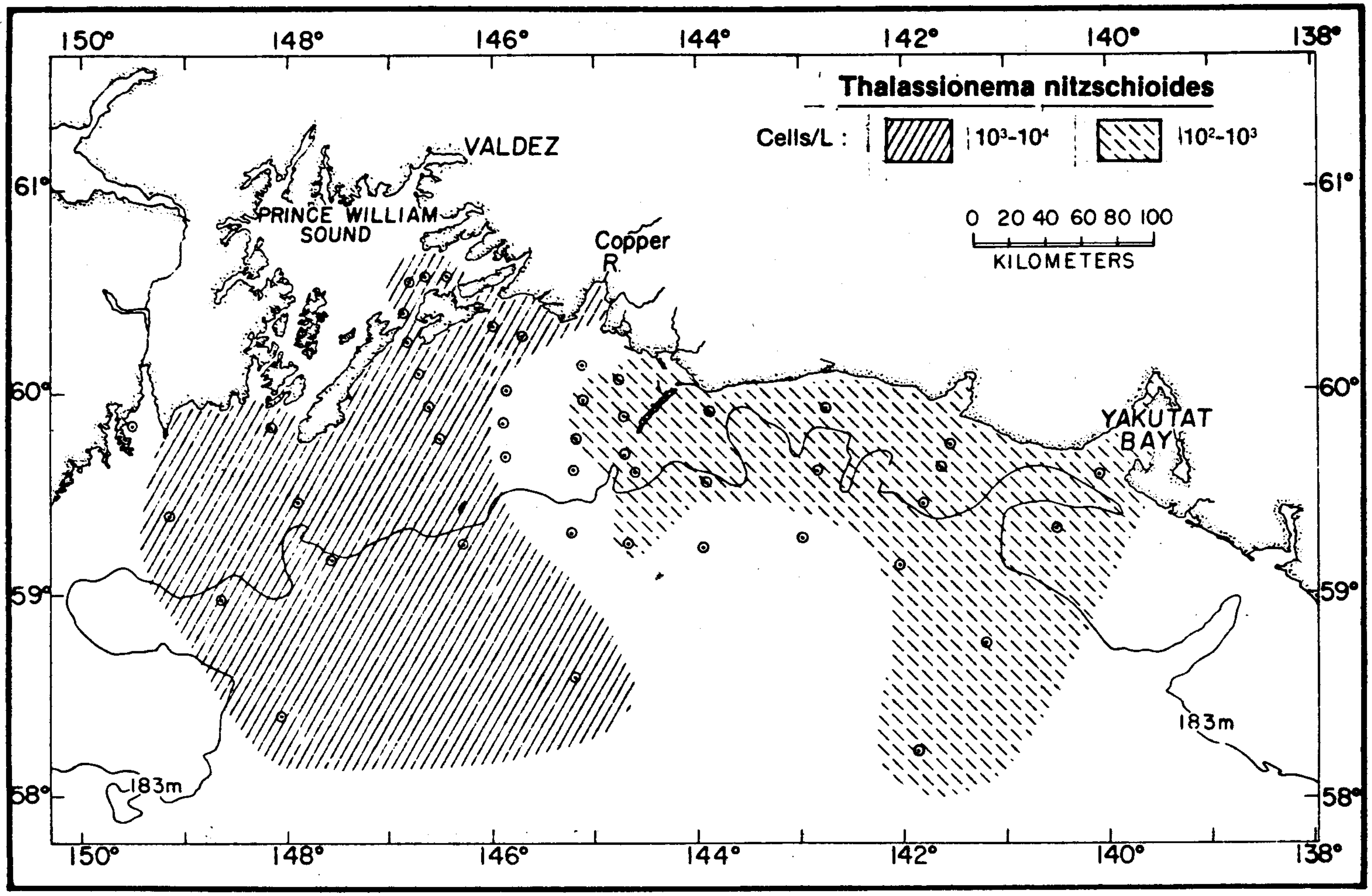

Figure 7. Distribution of *Thalassionema nitzschioides* at 10 m, October-November 1975.

population densities greater than 200 cells/ℓ; lower concentrations were not considered. *Dictyocha fibula* averaged 1300 cells/ℓ among those samples in which it was found and reached a maximum of 5000 cells/ℓ. The mean concentration of *Fragillariopsis* was 1700 cells/ℓ and ranged up to $43 \cdot 10^3$ cells/ℓ. Neither species was found in significant abundance nearshore west from Yakutat Bay nearly to the Copper River.

In addition, the pennate diatom *Thalassionema nitzschioides* was nearly ubiquitous, but its highest abundances occurred in the western area almost identical to that of Dictyocha (Figure 7). The diatom *Skeletonema costatum* was found only in Prince William Sound where it was responsible for the large bloom at station 40. The concentration at 5 m was $1.7 \cdot 10^6$ cells/ℓ. The populations in Prince William Sound were almost all diatoms as contrasted to the other areas where flagellates were always a large proportion of the community.

Data from cruise GOA-1 describes phytoplankton populations only in the fall season. Because phytoplankton communities normally display short-term changes in composition of species and in levels of production, conditions at other seasons can be expected to be very different. To obtain an "adequate" baseline of phytoplankton in an area, observations must be made at intervals frequent enough to determine the seasonal succession of dominant species. The most abundant species are listed in Table 3.

2. Chlorophyll, Primary Productivity, Light, and Nutrients

Station locations, incident solar radiation, and integrated water column values of chlorophyll a and carbon assimilation are given in Table 4. Chlorophyll in the upper 50 m is generally more abundant offshore of the continental shelf than on the shelf (Figure 8). The mean chlorophyll value on the shelf (omitting stations in Prince William Sound) was 18 mg chlorophyll a m^{-2} while the mean in deeper water was 33 mg m^{-2}. The distribution appeared somewhat

Table 3. Most abundant phytoplankton species and groups occuring at 10 m in northeastern Gulf of Alaska, October-November 1975

CHRYSOPHYTES

Dictyocha fibula
Coccolithus pelagicus
Pontosphaera huxleyi
Pterosperma sp.
miscellaneous coccolithophorids

DIATOMS

Asteromphalus heptactis
Bateriastrum delicatulum
Chaetoceros debilis
Chaetoceros (hyalochaete) spp.
Coscinodiscus excentricus
Coscinodiscus lineatus
Coscinodiscus radiatus
Coscinodiscus stellaris
Coscinodiscus spp.
Denticula semina
Fragilariopsis spp.
Navicula spp
Nitzschia delicatissima
Nitzschia longissima
Rhizosolenia setigera
Skeletonema costatum
Thalassionema nitzschioides
Thalassiosira decipiens
Thalassiosira nordenskioldii
Thallassiosira spp.

DINOFLAGELLATES

Ceratium lineatum
Ceratium pentagonum
Ceratium tripos
Dinophysis spp.
Exuviella spp.
Gymnodinium lohmanni
Gymnodinium splendens
Gymnodinium spp.
Peridinium minisculum
Peridinium spp.
Peridiniales

OTHER

microflagellates

Table 4. Chlorophyll in the upper 50 m, primary productivity in the euphotic zone, and daily light intensities at the surface, northeast Gulf of Alaska in October-November 1975

Station	Latitude (N)	Longitude (W)	Chlorophyll a (mg/m^2)	Carbon Assimilation (mgC/m^2 day)	Incident Solar Radiation (ly/day)
01A	59°51'	149°30'	13.6	451	101
002	59°24'	149°09'	17.7	736	101
003	59°00'	148°40'	39.3		
004	58°24'	148°04'	28.8	673	114
049	59°10'	147°37'	7.0		
050	59°20'	147°56'	17.0		
051	59°50'	148°11'	7.8		
51A	59°25'	147°01'	15.1	451	146
048	59°16'	146°16'	20.3	193	146
047	59°48'	146°34'	13.3		
46A	59°56'	146°39'	21.2		
46B	59°56'	146°39'	7.9	409	132
46C	59°55'	146°37'	14.5		
46D	59°55'	146°39'	14.6		
46E	59°55'	146°39'	16.3	373	132
46F	59°54'	146°39'	13.7		
46G	59°54'	146°39'	14.7		
46H	59°54'	146°39'	11.1		
46I	59°54'	146°38'	17.1	384	123
46J	59°55'	146°38'	14.8	434	123
045	60°02'	146°42'	16.5		
044	60°14'	146°47'	22.5		
043	60°23'	146°54'	24.3		
042	60°31'	146°47'	15.8		
041	60°33'	146°37'	14.5	471	63
40A	60°33'	146°27'	78.4		
40B	60°33'	146°27'	82.7	2918	63
039	60°15'	145°56'	15.1		
038	60°16	145°43	25.8		

Table 4. (contd.)

Station	Latitude (N)	Longitude (W)	Chlorophyll a (mg/m^2)	Carbon Assimilation (mgC/m^2 day)	Incident Solar Radiation (ly/day)
037	60°09'	145°22'	19.5		
027	60°08'	145°06'	10.2	132	65
025	60°08'	144°50'	21.6	210	65
024	60°03'	144°47'	21.1		
028	59°59'	145°08'	10.5		
036	60°08'	145°30'	24.2		
035	60°11'	145°58'	10.6	39	40
034	60°01'	145°53'	24.1		
033	59°51'	145°55'	30.2		
032	59°41'	145°53'	15.6		
005	58°38'	145°15'	29.7		
05A	58°53'	145°15'	31.4		
031	59°19'	145°16'	35.2	529	71
030	59°37'	145°14'	25.5		
029	59°46'	145°12'	17.5		
023	59°52'	144°43'	10.8		
022	59°40'	144°39'	14.6	86	61
021	59°37'	144°39'	8.5		
020	59°15'	144°40'	42.9	728	73
22A	59°44'	144°37'	24.3	322	73
019	59°14'	143°56'	40.9		
018	59°33'	143°56'	22.5		
017	59°54'	143°53'	22.8	183	35
014	59°17'	142°59'	28.3	552	54
016	59°55'	142°45'	24.7		
015	59°36'	142°50'	29.5		
62A	59°34'	142°10'	38.2		
62B	59°34'	142°10'	45.1	546	56
62C	59°34'	142°10'	45.3	565	56
62D	59°34'	142°10'	39.0		

Table 4. (contd.)

Station	Latitude (N)	Longitude (W)	Chlorophyll *a* (mg/m^2)	Assimilation (mgC/m^2 day)	Radiation (ly/day)
62E	59°34'	142°10'	34.8		
62F	59°34'	142°10'	12.7		
62G	59°34'	142°10'	26.5		
62H	59°34'	142°10'	38.4	464	57
62I	59°34'	142°10'	32.4	724	57
013	59°09'	142°03'	45.5		
012	59°27'	141°48'	13.2		
011	59°37'	141°38'	13.5		
010	59°44'	141°32'	18.8	75	30
009	59°34'	140°06'	7.7	84	30
009	59°19'	140°31'	33.2		
007	58°46'	141°12'	30.7		
06A	58°13'	141°55'	40.0	360	69
06B	58°13'	141°55'	45.4	541	69
06C	58°13'	141°55'	37.1		

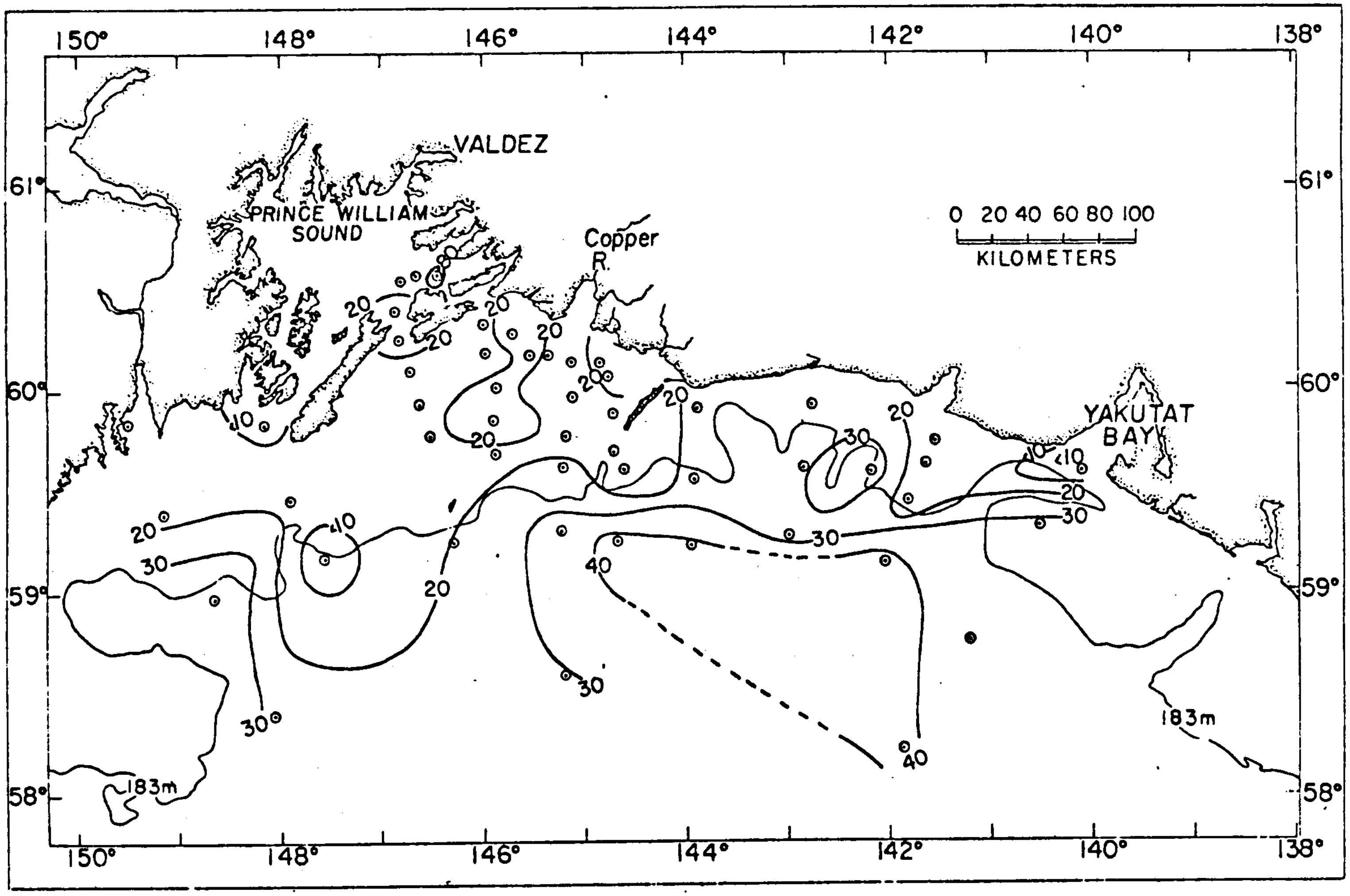

Figure 8. Chlorophyll a (mg/m^2) in the upper 50 m, October - November 1975.

patchy to the west and south of Kayak Island, which may be related to the plumes of the Copper River and other drainages east of Kayak Island.

At station 40 in Prince William Sound there was about twice as much chlorophyll a (80.6 mg/m^2) as the next highest value measured (45.5 mg/m^2 at station 13 which is offshore). A bloom of *Skeletonema costatum* was in progress at station 40 and Prince William Sound was the only place this species was found in the phytoplankton samples. Clearly, population size and composition at station 40 were anomalous for autumn conditions in the Gulf, but similar local blooms may be common in the inshore waters.

Daily primary productivity integrated from the surface down to the 1 percent light depth ranged between 39 and 736 mgC/m^2, except for station 40 where daily production was 2.9 gC/m^2. The areal distribution of productivity (Figure 9) was somewhat similar to chlorophyll in that the values were higher offshore. However, on the continental shelf west of $146^{\circ}30'$W, the productivity inside the 100 fathom (183 m) isobath east of Prince William Sound averaged 141 mgC/m^2 with a range of 39-204 mgC/m^2, and in the remainder of the area the mean was 522 with a range of 193-736 mgC/m^2.

Nitrate at the surface ranged between 2.7 and 12 µg-at/ℓ. The surface nitrate was less than 5 µg-at/ℓ at all the Prince William Sound stations and only one other (nearshore). Values greater than 10 were found offshore and near Yakutat Bay. Although nitrate concentrations less than 5 µg-at/ℓ are in the normal range to limit primary production, that did not appear to be the case here. The assimilation numbers (mg carbon assimilated/hour x mg chlorophyll a) were moderate to high (greater than 6) in Prince William Sound. Low assimilation numbers could indicate possible nutrient limitation.

Surface silicate concentrations ranged between 15 and 20 μg-at/ℓ except in Prince William Sound where values were 8.7-14.6, and in the vicinity of Icy Bay and Yakutat Bay where silicates were as high as 23.1 μg-at/ℓ. These higher values could be associated with runoff from glaciers in the region.

It does not appear that any of the measured nutrients (nitrate, ammonia, nitrite, phosphate, and silicate) limited phytoplankton production.

The significant difference between primary productivity in the nearshore area east of Prince William Sound and the remainder of the area (Figure 9) may be explained by suspended particulate matter distributions. Values are given in Table 5 for mean 1 percent light depths (determined from Secchi disk readings) and corresponding suspended matter and productivity. The suspended matter data were kindly provided by Dr. Richard Feely of our Laboratory, whose field studies were conducted concurrently with ours. The high total suspended particulate matter at the surface correlated with low productivity and with a shallow euphotic zone (Table 5).

The data in Table 5 suggest that the nearshore waters east of Prince William Sound contained large amounts of suspended matter draining from nearby glaciers in the Icy Bay and Copper River drainages which caused high attenuation of light in the water, and thus lowered primary productivity.

A comparison of the suspended matter and chlorophyll distributions indicates that a smaller proportion of the high suspended matter concentrations in the nearshore area was attributable to phytoplankton than in the offshore area. An inverse correlation existed between the two, similar to that between primary

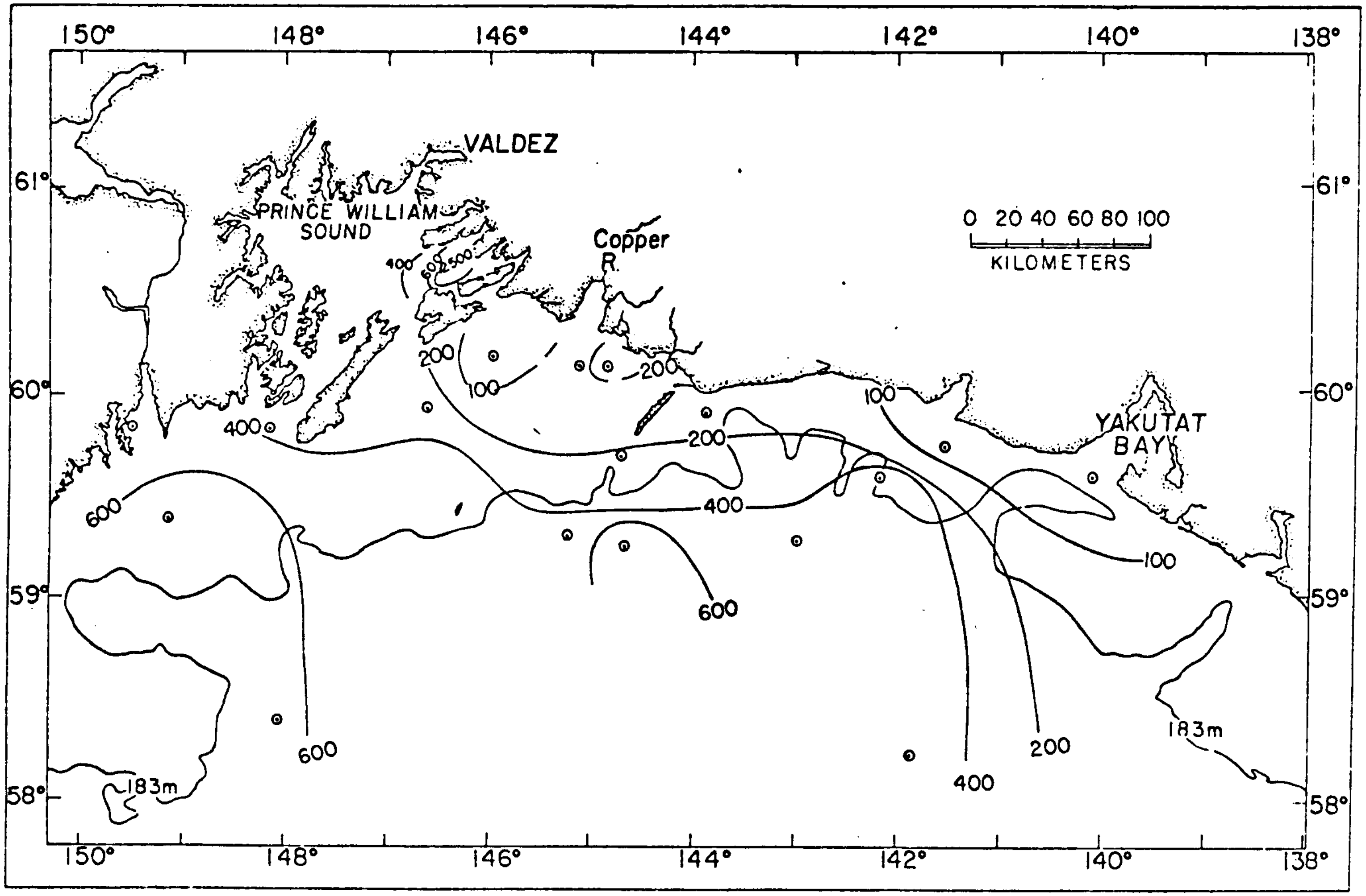

Figure 9. Primary production (mgC/m^2-day) in the euphotic zone, October - November 1975.

Table 5. Mean values of 1% light depths, total suspended matter (TSM) in the upper 20 m, and daily primary production at three nearshore and five offshore stations

	1% Light Depth (m)	TSM (mg/ℓ)	Productivity (mgC/m^2 day)
Nearshore	16	1.12	163
Offshore	34	0.31	538

production and suspended matter. The mean chlorophyll a concentration was 16 mg/ℓ in the upper 50 m at those stations where suspended matter was greater than 1.0 mg/ℓ and in the remainder of the area (except Prince William Sound) the chlorophyll averaged 24 mg/ℓ.

3. Conclusions

The conclusions summarized here must be regarded as tentative for reasons discussed in the previous section.

a. Several unidentified species of microflagellates were dominant in the phytoplankton populations of the Gulf. A silicoflagellate, *Dictyocha fibula*, and a diatom, *Fragillariopsis* sp., appeared to have nearly mutually exclusive distributions. *Thalassionema nitzschioides* was nearly ubiquitous in the study area. Diatoms dominated the Prince William Sound populations with *Skeletonema costatum* principally responsible for a local bloom.

b. Primary productivity in the northern Gulf of Alaska during mid-autumn was on the order of 400 mgC/m^2 day.

c. Primary productivity was inhibited in nearshore areas influenced by runoff where suspended matter loads were high. The suspended matter increased light attenuation which decreased the euphotic zone and, hence, primary productivity.

d. Nutrient concentrations were sufficient to sustain high rates of primary production.

B. Lower Cook Inlet

1. Phytoplankton Distribution

The distributions of major phytoplankton groups were somewhat coherent seasonally and by area in the study region (Figures 10-14; Tables 6 and 7). The spring and summer populations were dominated by diatoms and microflagellates with chrysophytes, dinoflagellates, and green algae appearing less frequently and in much lower abundance.

In April, production was uniformly low throughout the area without the appearance of a pronounced spring bloom except in Prince William Sound. Microflagellates dominated the populations offshore, at the southernmost stations in Cook Inlet, and in Prince William Sound (station 13). At the latter station microflagellate cell concentrations were $7 \cdot 10^5$ cells/ℓ, while elsewhere concentrations were $< 10^4$ cells/ℓ. Several species of *Thalassiosira* dominated the Kachemak Bay area, especially station 5 where *Thalassiosira decipiens, T. gravida,* and *T. rotula* were all prominent. The northern stations (3 and 4) were dominated by *Melosira sulcata* which was always dominant at station 4, just south of the Forelands.

In early May station 13 was not occupied. Microflagellates dominated offshore where their concentrations were $> 10^5$ cells/ℓ at stations 10 and 11. Similar abundances persisted through August at station 11. *Thalassiosira* increased

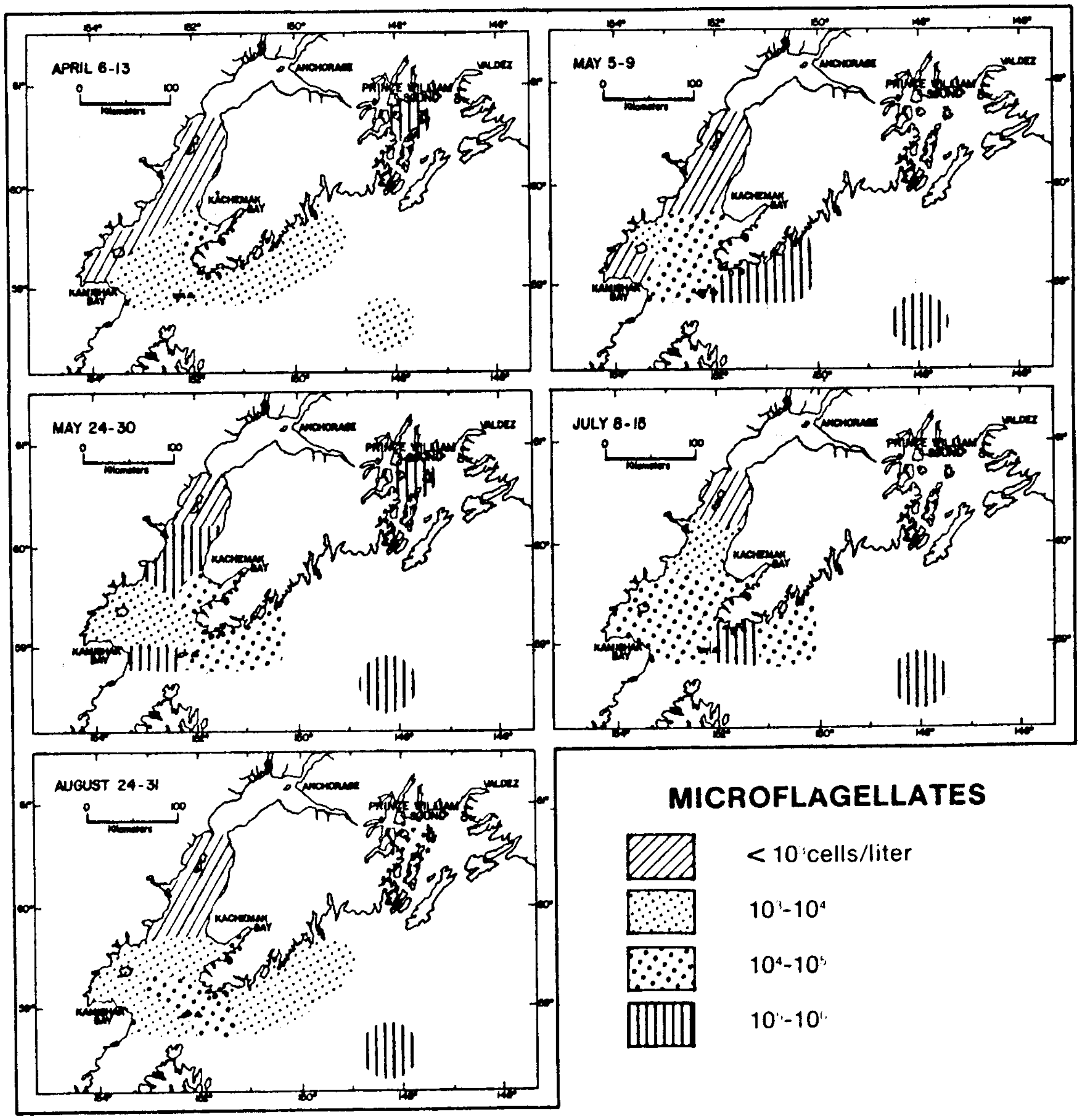

Figure 10. Distribution of Microflagellates at 10 m, April-August 1976.

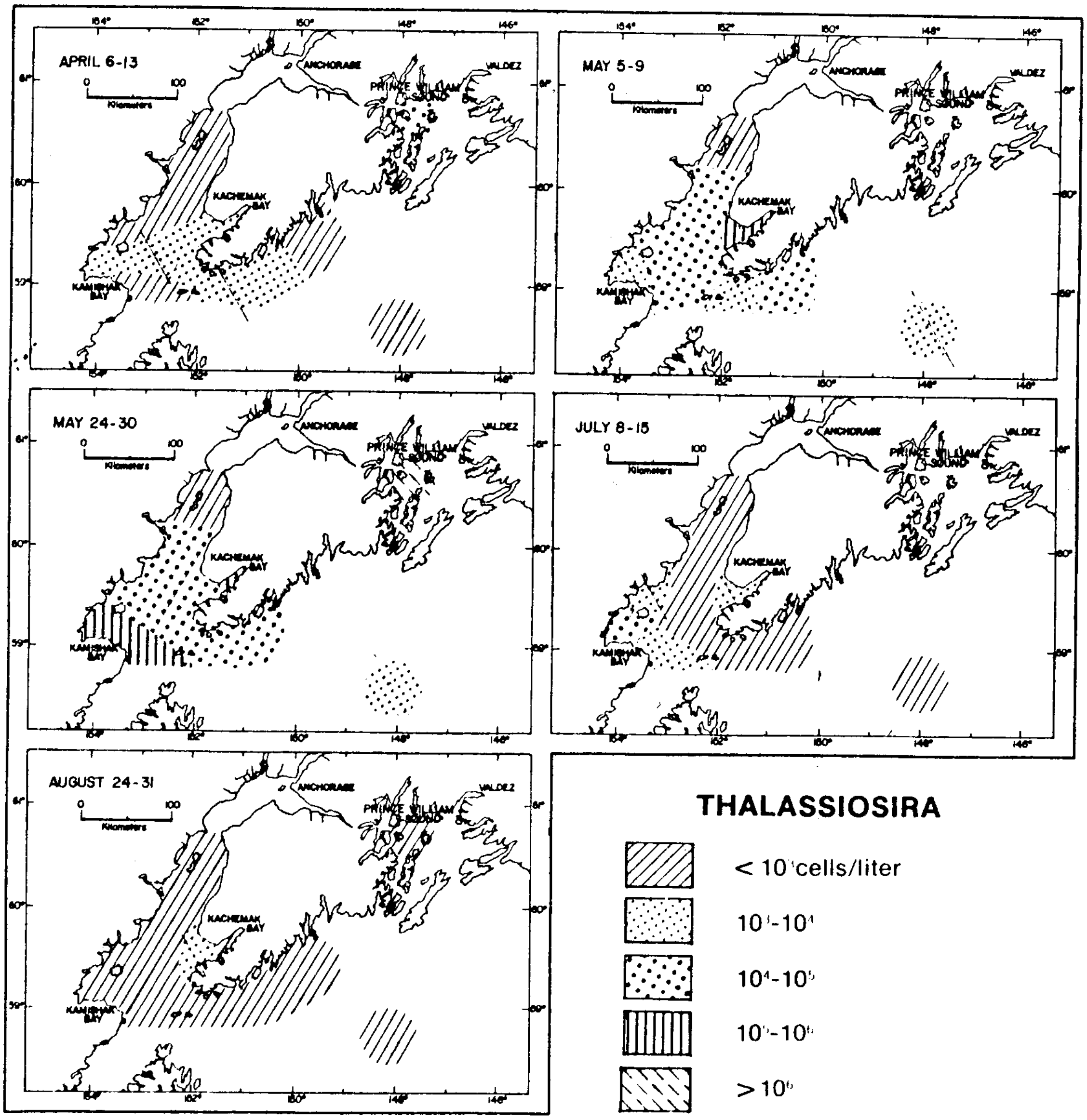

Figure 11. Distribution of *Thalassiosira* spp. at 10 m, April-August 1976.

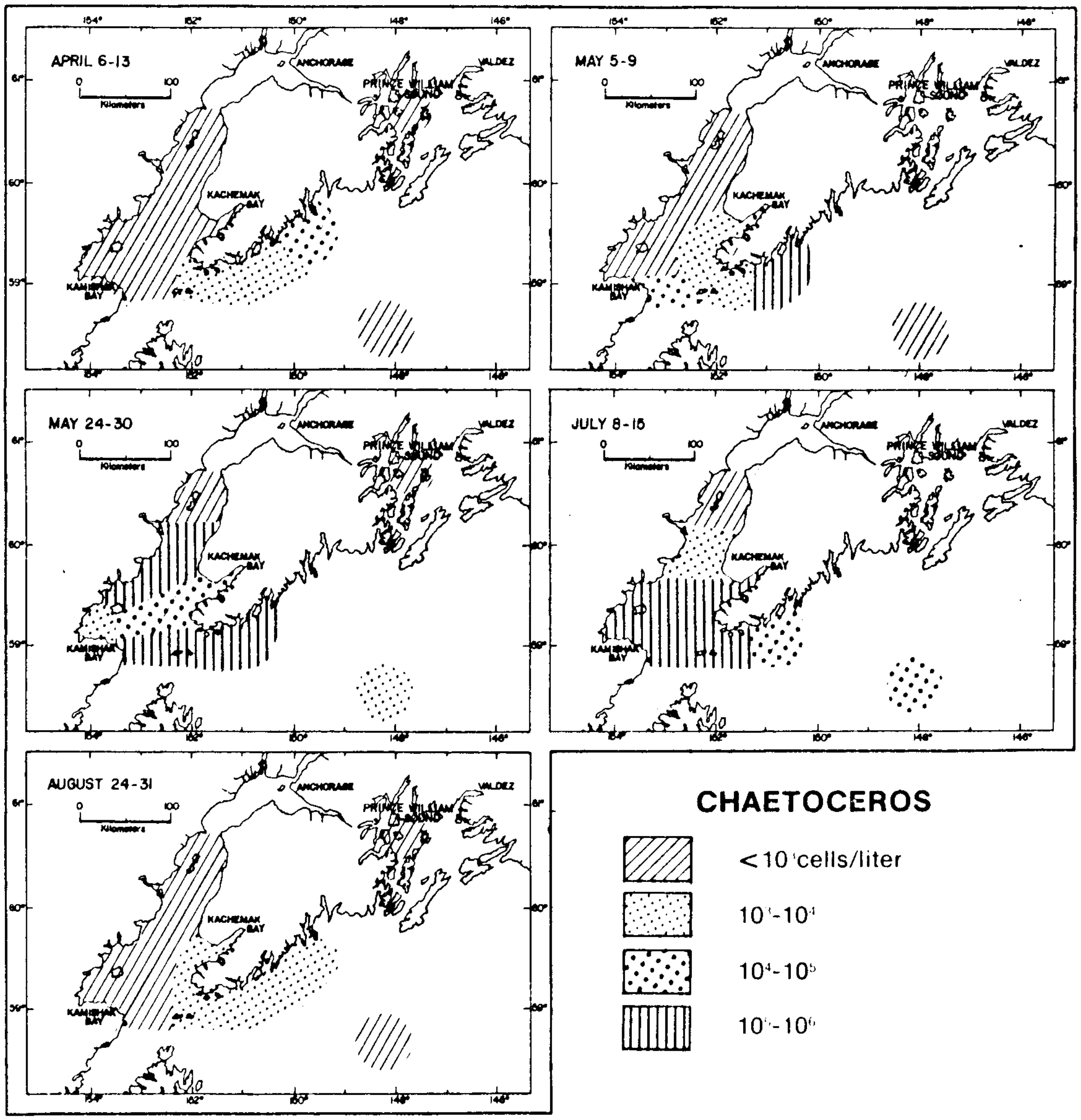

Figure 12. Distribution of *Chaetoceros* spp. at 10 m, April-August 1976.

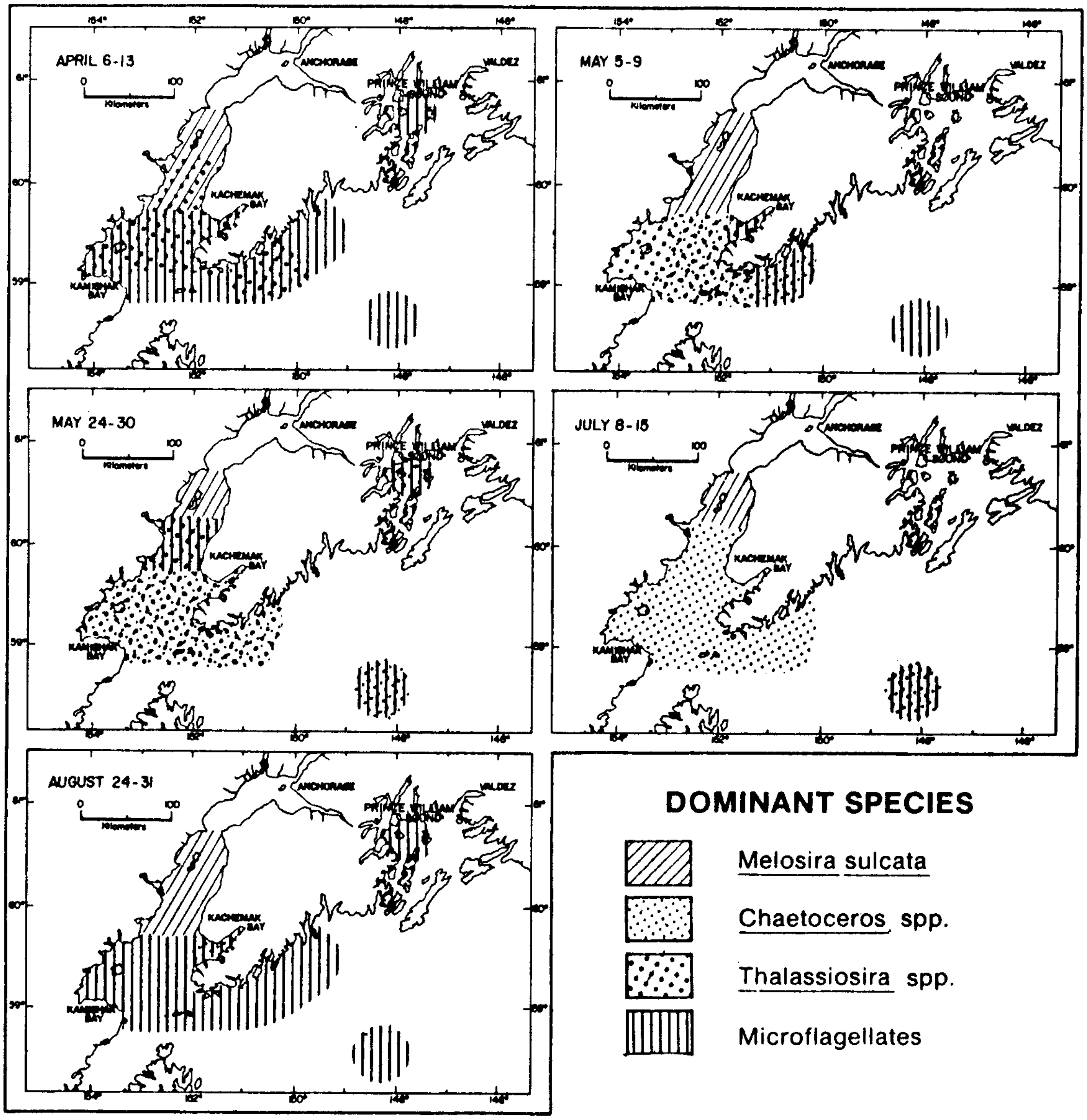

Figure 13. Distribution of dominant phytoplankton groups, April-August 1976.

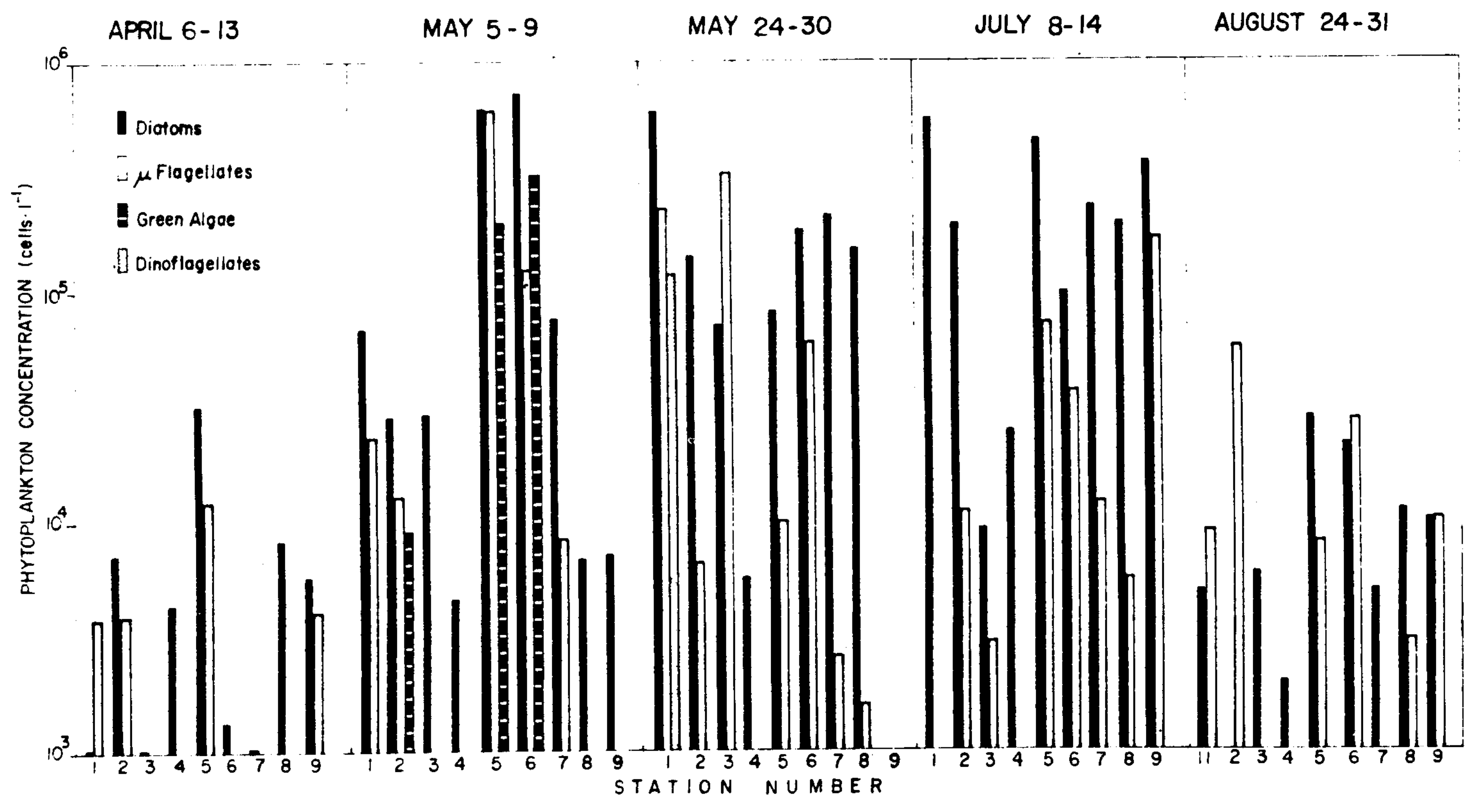

Figure 14. Phytoplankton abundance by major groups, lower Cook Inlet, 1976.

Table 6. Phytoplankton species present in abundances > 1000 cells/ℓ in lower Cook Inlet, April-August 1976

	April 7-12	May 6-9	May 25-28	July 10-15	August 25-31
CHRYSOPHYTES					
Dictyocha fibula				x	
Ebria tripartita				x	
DIATOMS					
Actinoptychus undulatus				x	
Bacteriastrum delicatulum					x
Ceratulina bergonii				x	x
Chaetoceros affinis			x	x	
Chaetoceros compressus				x	x
Chaetoceros concavicornis	x	x	x	x	
Chaetoceros constrictus				x	x
Chaetoceros convolutus				x	
Chaetoceros debilis		x	x	x	x
Chaetoceros decipiens		x	x	x	
Chaetoceros didymus				x	
Chaetoceros radicans			x	x	
Chaetoceros secundus				x	
Chaetoceros socialis		x	x		x
Chaetoceros spp.			x	x	x
Corethron hystrix			x	x	
Cylindrotheca closterium	x		x		
Denticula semina			x	x	
Fragilariopsis spp.	x	x	x	x	
Leptocylindricus danicus				x	
Melosira sulcata	x	x	x	x	x
Navicula distans					x
Navicula spp.				x	x
Nitzschia delicatissima	x	x	x	x	x
Nitzschia longissima	x	x	x	x	x
Nitzschia spp.				x	x

Table 6 contd.

	April 7-12	May 6-9	May 25-28	July 10-15	August 25-31
DIATOMS contd.					
Rhizosolenia delicatula				x	
Rhizosolenia fragillissima				x	
Rhizosolenia stolterfothii				x	
Schroederella delicatula		x		x	
Skeletonema costatum			x		
Stephenopyxis nipponica				x	
Thallassionema nitzschioides	x	x	x	x	x
Thalassiosira aestivalis	x	x	x	x	x
Thalassiosira decipiens	x	x	x		
Thalassiosira gravida	x		x		
Thalassiosira nordenskioldii	x	x	x		
Thalassiosira pacifica	x		x	x	
Thalassiosira polychorda		x	x		
Thalassiosira rotula	x	x	x		
Thalassiosira spp.	x	x	x	x	
Tropidoneis antarctica				x	
DINOFLAGELLATES					
Exuviella spp.	x	x	x		
Gymnodinium lohmanni	x				
Oxytoxum spp.			x	x	
Peridinium minisculum			x		
Peridinium spp.		x	x	x	
MISCELLANEOUS					
green algae		x	x	x	x
microflagellates	x	x	x	x	x

Table 7. Rank order of most frequently occurring phytoplankton groups in lower Cook Inlet. April-August 1976.

Station \ Taxon	µ flagellates	*Thalassiosira* spp.	*Chaetoceros* spp.	*Melosira sulcata*	*Thalassionema nitzschioides*	*Nitzschia* spp.	Dinoflagellates
GOA 2							
1	1	3	5				4
2	1	2	4				
3		1		2	5		4
4	2			1			
5	2	1				4	
6	2	1					
7	2	1			3	4	
8		2	1		3		
9	1	2			4	3	
10	2	1	5		3	4	
11	1	5	2			3	
13	1	5					2
14	1		3			5	2
GOA 3							
1	2	3	1			4	5
2	1	2	4			5	
3		1		2	3		
4				1			
5	2	1	4		5		

Table 7. contd.

Station \ Taxon	µ flagellates	*Thalassiosira* spp.	*Chaetoceros* spp.	*Melosira sulcata*	*Thalassionema nitzschioides*	*Nitzschia* spp.	Dinoflagellates
GOA 3							
6	4	1	2				
7	2	1			4	3	
8	3	1			2		4
9		2	1				
10	1	3	2			5	4
11	1	2				3	
GOA 4							
1	2	3	1			5	4
2	3	2	1		5		
3	1	2	4	3	5		
4				1	4		
5	2	1	3		4		5
6	3	1	2				4
7	4	2	1		3	5	
8	4	1	3		2		
10	3	2	1			4	
11	1	5	3			4	
13	2	1					4
GOA 5							
1		3	1				
2	2		1				

Table 7. contd.

Station \ Taxon	μ flagellates	*Thalassiosira* spp.	*Chaetoceros* spp.	*Melosira sulcata*	*Thalassionema nitzschioides*	*Nitzschia* spp.	Dinoflagellates
GOA 5							
3	2	5	1		3		
4		5		1			
5	2	3	1				
6	2	3	1			4	
7	2	4	1		3		
8	4	3	1		2		
9	2		1			5	
10	2		1				
11	1		2		3		
GOA 6							
1	1		5		3	2	4
2	1	4			5	3	2
3	4			3	1	2	
4				2			
5	2	5	1		4	3	
6	1	5	3		2		4
7				2	3		
8	2	5					4
9	1		3		2	4	5

Table 7. contd.

Taxon / Station	µ flagellates	*Thalassiosira* spp.	*Chaetoceros* spp.	*Melosira sulcata*	*Thalassionema nitzschioides*	*Nitzschia* spp.	Dinoflagellates
GOA 6							
10	1		2		3		4
11	1	4	3		2		
13	1				4		3
14	1		4		2	3	

throughout the area and was dominant in the lower Inlet except at station 4. In Kachemak Bay, numbers of *Thalassiosira aestivalis* were as high as 10^6 cells/ℓ. A distinct cross Inlet gradient in *Thalassiosira* abundances occurred with low concentrations on the west side in Kamishak Bay, 10^4-10^5 cells/ℓ in midchannel, and the Kachemak Bay bloom to the east. Concentrations of several *Chaetoceros* species reached 10^4-10^5 cells/ℓ southeast of the Kenai Peninsula (station 10) where they were codominant with microflagellates. They were secondarily dominant to *Thalassiosira* in midchannel of the lower Inlet.

By late May, *Thalassiosira aestivalis* still dominated inner Kachemak Bay (> 10^5 cells/ℓ) and shared dominance with *T. decipiens* and *T. nordenskioldii* at concentrations of 10^5-10^6 cells/ℓ in Kamishak Bay and between Cape Douglas and the Barren Islands (station 1). The concentration of *T. aestivalis* at station 13 in Prince William Sound was $3 \cdot 10^6$ cells/ℓ, the largest observed during the entire study. *Chaetoceros* numbers had increased significantly in the Inlet since early May and were between 10^4 and 10^6 cells/ℓ, except in Kamishak Bay where the *Thalassiosira* bloom was occurring. Microflagellates were present in moderate to high concentrations except in Kamishak Bay and at station 4. Especially high concentrations were observed in Prince William Sound and offshore at station 11 (10^5-10^6 cells/ℓ).

The large *Thalassiosira* blooms in May had subsided to low levels by July with concentrations generally < 10^4 cells/ℓ. *Chaetoceros* was the dominant genus at that time represented by concentrations of 10^5-10^6 cells/ℓ in the lower Inlet including Kamishak and Kachemak Bays and lesser amounts (10^3-10^4 cells/ℓ) north of Kachemak. Offshore at station 11 and southeast of Kenai Peninsula concentrations were moderately high (10^4-10^5 cells/ℓ). Microflagellates were in moderate to high abundance both in the southern Inlet and offshore.

By late August, the diatom populations had subsided and microflagellates were dominant in the lower Inlet, offshore, and in Prince William Sound. Cell concentrations were low for all species except microflagellates offshore where they persisted in high numbers. Moderate concentrations of flagellates occurred in Kennedy Entrance and in Prince William Sound.

In addition to the diatoms and microflagellates discussed above, several other forms were prominent but seasonal or areal distributional patterns in their occurrence or abundance are not readily discernible. The pennate diatom *Thalassionema nitzschioides* was ubiquitous in the study region from May through August, often in concentrations of 10^3-10^4 cells/ℓ. In late May, substantial numbers ($8 \cdot 10^4$ cells/ℓ) of *T. nitzschioides* occurred in Prince William Sound. Another diatom, *Denticula semina*, occurred in moderately high quantities in late May and July (10^4-10^5 cells/ℓ) offshore, but was not found elsewhere at any time. Several species of *Fragilariopsis* appeared occasionally in low numbers during the study, but were high only in Prince William Sound in April and May. *Nitzschia delicatissima, N. longissima,* and other *Nitzschia* species occurred at all sampling times, but usually in low numbers. Dinoflagellates were never present in large quantities, but seemed to be most prevalent in July and August. *Ceratium* and *Peridinium* were the genera most often represented.

The composition of phytoplankton populations in lower Cook Inlet exhibits a species succession through the season as well as distinct features in different areas. The northern portion of the study area was always dominated by *Melosira sulcata* and populations were never abundant. In the middle and southern areas of the Inlet, the "initial" population in April was low and dominated by microflagellates with some *Thalassiosira* occurring in Kachemak and Kamishak Bays as well as the middle portion of the Inlet and off the southeastern coast of the Kenai Peninsula. The *Thalassiosira* present at that time (chiefly *T. aestivalis*) could mark the initiation of the bloom which followed in early May in Kachemak Bay and subsequently seemed to spread westward throughout the middle and southern Inlet by late May.

The *Thalassiosira* bloom had subsided by July, but the *Chaetoceros* bloom followed the *Thalassiosira* bloom by about one to two months. *Chaetoceros* had begun to increase in the Inlet in early May simultaneously with the peak of the *Thalassiosira* bloom in Kachemak Bay and the subsequent pattern for *Chaetoceros* in space and time was similar to that for *Thalassiosira* reaching peak abundances in July. By August *Thalassiosira* and *Chaetoceros* were both present in very low numbers throughout the lower Inlet and microflagellates once again prevailed, although in low numbers. (The primary *Chaetoceros* bloom species was *C. debilis*.)

A bloom of *Thalassiosira aestivalis* occurred concurrently in Prince William Sound and lower Cook Inlet. It was $3 \cdot 10^6$ cells/ℓ in late May, but barely present in August. Only trace quantities of *Chaetoceros* were found in Prince William Sound, however. *Thalassiosira* has been recorded as an early spring bloom genus also in Puget Sound and Prince William Sound.

The offshore station (11) was included in the study to compare open Gulf of Alaska populations and seasonal sequences to those inshore. Microflagellates dominated that station throughout spring and summer in moderately high numbers (10^5-10^6 cells/ℓ). Moderate increases of *Thalassiosira* and *Chaetoceros* occurred at station 11 and in the lower Inlet simultaneously. Although several species of *Thalassiosira* were represented, the major species was *T. aestivalis*. Unlike the inshore blooms of *Chaetoceros debilis*, however, the major species offshore was *C. concavicornis*, a much larger and robust form.

2. Distributions of Chlorophyll, Primary Productivity, and Nutrients

A summary of chlorophyll, primary productivity, and nitrate values in the upper layers is listed in Table 8 along with incident solar radiation for general

Table 8. Lower Cook Inlet data summary. April-August 1976. Chlorophyll and nitrate values are integrated to 25 m. Primary production is integrated to the 1% light depth.

Cruise/ Station	Chlorophyll a (mg/m^2)	Primary Production (mgC/m^2-dy)	Nitrate (mg-at/m^2)	Solar Radiation (ly/dy)	1% Light Depth (m)
GOA2/1	13				
2A	8		534		
2B	13		356		
3	8	43	473	111	8
4	11		430		1
5A	13	911	435	186	13(1)
5B	21	883	342	145	22
6A	10		390		14
6B	12	246	326	186	18
6C	12		319		18
6D	13		310		18
6E	12		426		
6F	9	217	358	145	18(1)
6G	9		408		
7	9	44	298	237	3(1)
8	9		332		5
9	12		330		
10	16	751	307	237	30
11A	14		304		
11B	14		307		
11C	12	389	342	140	30(1)

Table 8. contd.

Cruise/ Station	Chlorophyll a (mg/m²)	Primary Production (mgC/m²-dy)	Nitrate (mg-at/m²)	Solar Radiation (ly/dy)	1% Light Depth (m)
GOA2/13A	80		239		12
13B	60		291		
13C	64		280		
13D	104	836	272	66	12(1)
13E	78		278		
13F	93	1188	275	66	12(1)
14	12		434		
GOA3/ 1	26	1128	414	298	27(1)
2	24		419		
3	16	224	368	298	4
4	5		406		1
5A	125		234		
5B	173		195		15
6A	267		186		
6B	220		226		8
6C	240	7699	128	582	8
7	26		372		11
8	23		383		
9	15	528	424	312	16(1)
10	43		370		
11A	16		434		19
GOA4/ 1	78		288		
2	142	7522	296	502	17

Table 8. contd.

Cruise/ Station	Chlorophyll a (mg/m^2)	Primary Production (mgC/m^2-dy)	Nitrate (mg-at/m^2)	Solar Radiation (ly/dy)	1% Light Depth (m)
GOA4/ 3	43		268		7
4	13		406		1
5	123		2		10
6A	90		66		
6B	201	4813[2]	66	625	10[1]
6C	187		51		
6D	249		49	625	11
6E	161		63		
6F	135		38		
7	60	2321	216	508	6[1]
8	92		240		9
10	77		294		
11A	14		281		35
11B	44		238		
13A	194		98		
13B	101	1885		320	16
13C	164		112		14
13D	222		109		15
13E	123		109		
13F	149	3978	117	644	15[1]
14			296		14
GOA5/ 1	159		128		16
2	75	4307	138	353	16[1]

Table 8. contd.

Cruise/ Station	Chlorophyll a (mg/m^2)	Primary Production (mgC/m^2-dy)	Nitrate (mg-at/m^2)	Solar Radiation (ly/dy)	1% Light Depth (m)
GOA5/ 3	16	548	175	587	14(1)
4	36		245		3
5	203		68		16
6A	49		90		8
6B	52		90		
6C	67	2906(3)	92	358	8(1)
6D	64		80		10
6E	75		70	358	12
6F	77		98		8
6G	117				8
7A	62		56		16
7B	69		38		16
8A	61		52		18
8B	91	3581	33	353	17
9	130		79		16
10	39	1565	44	351	16(1)
11A	38		109		36
11B	26		122		22
11C	24	2402	144	348	36(1)
11D	31		111		36
GOA6/ 1	15		87		41
2	23	738	115	82	41(1)
3A	20		135		14

Table 8. contd.

Cruise/ Station	Chlorophyll a (mg/m²)	Primary Production (mgC/m²-dy)	Nitrate (mg-at/m²)	Solar Radiation (ly/dy)	1% Light Depth (m)
GOA6/ 3B	23	374	292	228	10
4	34		238		3
5	39	710	125	122	16[1]
6A	42		59		14
6B	38	920	67	122	8
6C	32		81		
6D	54		61		10
6E	30		88		
6F	22	596		228	10[1]
7	22	725	286	183	14[1]
8	41		309		14
9	26	1016	158	183	31
10	20		114		
11A	20	1901[4]	131	377	41[1]
11B	37		135	377	24
13	25	1350	3	480	38
14	33		71		35

(1) For morning incubations the 1% light depth was chosen based on previous data.
(2) The daily production rate is calculated from ½ day incubations at 6B and 6D.
(3) The daily production rate is calculated from ½ day incubations at 6C and 6E.
(4) The daily production rate is calculated from ½ day incubations at 11A and 11B.

comparisons by season and area. The concentration of nitrate (Table 9) was selected for discussion because it is most often the critical plant nutrient when nutrient limitation of primary production occurs.

Table 9. Nitrate concentrations (mg at/m^2) integrated from surface to 25 m in lower Cook Inlet, 1976.

Station	Early April	Early May	Late May	Early July	Late August
1	554	414	288	128	87
2	445	419	296	138	115
3	473	368	268	175	214
4	430	406	406	245	238
5	389	214	2	68	125
6	362	180	56	87	71
7	298	372	216	47	286
8	332	383	240	43	309
9	330	424	-	79	158
10	307	370	294	44	114
11	318	434	245	122	133
13	272	-	109	-	2
14	434	-	296	-	71

a. Lower Cook Inlet

The changes in chlorophyll *a* and primary productivity from April through August were typical of spring and summer successions of phytoplankton quantities and production in northern temperate waters (Figures 15-17). Mean values of chlorophyll, nitrate, insolation, and productivity for stations 1-9 are shown in Figures 18 and 19. Chlorophyll *a* throughout lower Cook Inlet was low (< 25 mg/m^2) in early April, increased steadily through early July (25-240 mg/m^2), then decreased to less than 25 mg/m^2 again by late August. Primary productivity reached a peak of about 4.9 gC/m^2 day in late May and decreased to about 0.7 gC/m^2 day by late August. During early April there were sufficient amounts of nitrate for vigorous phytoplankton growth but sunlight values were low. As light energy increased with time there was a concomitant increase in chlorophyll *a* and primary productivity and decrease in nitrate concentration until early July. By late August chlorophyll *a* was less than one-third of what it was in July, nitrate increased slightly, and insolation decreased sharply.

b. Kachemak and Kamishak Bays

Kachemak Bay (stations 5 and 6) was the most productive area in lower Cook Inlet. Primary productivity and chlorophyll *a* concentrations were consistently greater than elsewhere in lower Cook Inlet by as much as two orders of magnitude (Figures 15-17). Productivity in Kachemak Bay increased about ten-fold between early April and early May to 7.7 gC/m^2 day, then steadily decreased to roughly its original levels by late August. Chlorophyll *a* concentrations increased at a similar rate and returned to nearly the April concentrations by late August.

Primary productivity in Kamishak Bay increased almost 100 times from April to July while chlorophyll *a* concentrations increased about ten-fold. Chlorophyll *a* concentrations were typically 0.1 as high as those in Kachemak Bay and primary productivity was about 0.1 to 0.5 as great in Kamishak as in Kachemak Bay.

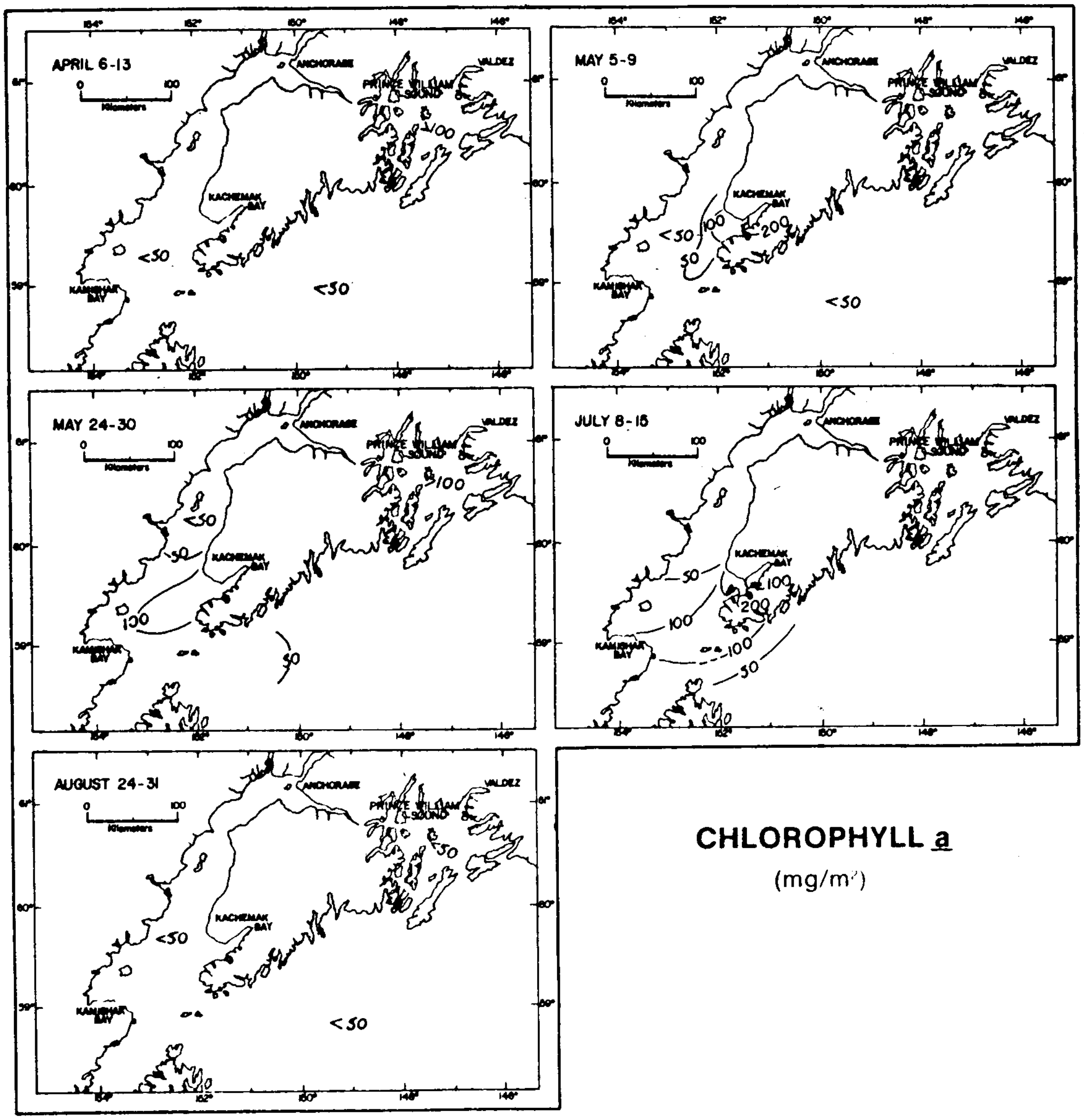

Figure 15. Distribution of Chlorophyll a (mg/m^2) integrated from 0-25 m, April-August 1976.

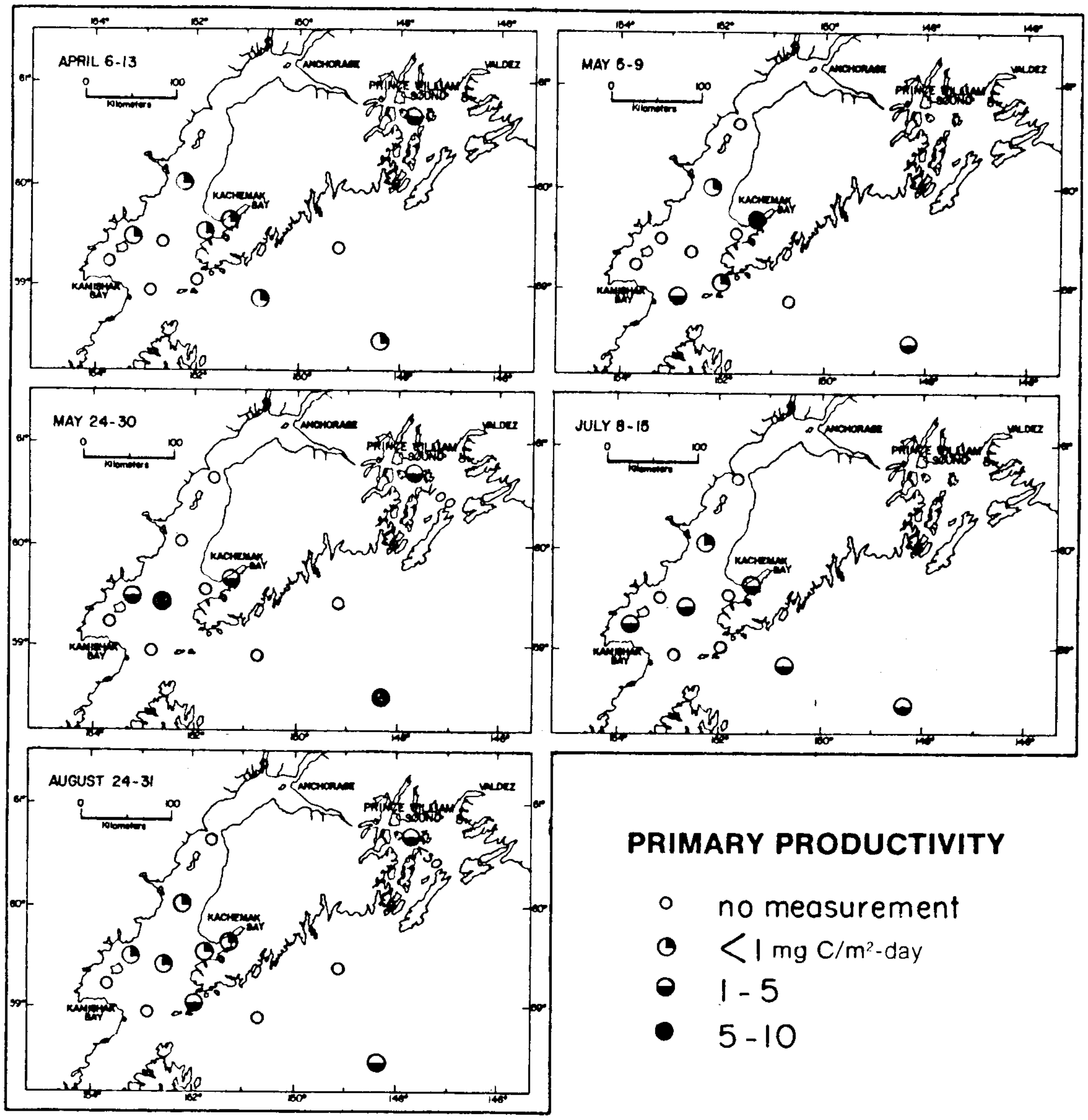

Figure 16. Distribution of primary productivity (mgC/m^2-day) integrated over the euphotic zone, April-August 1976.

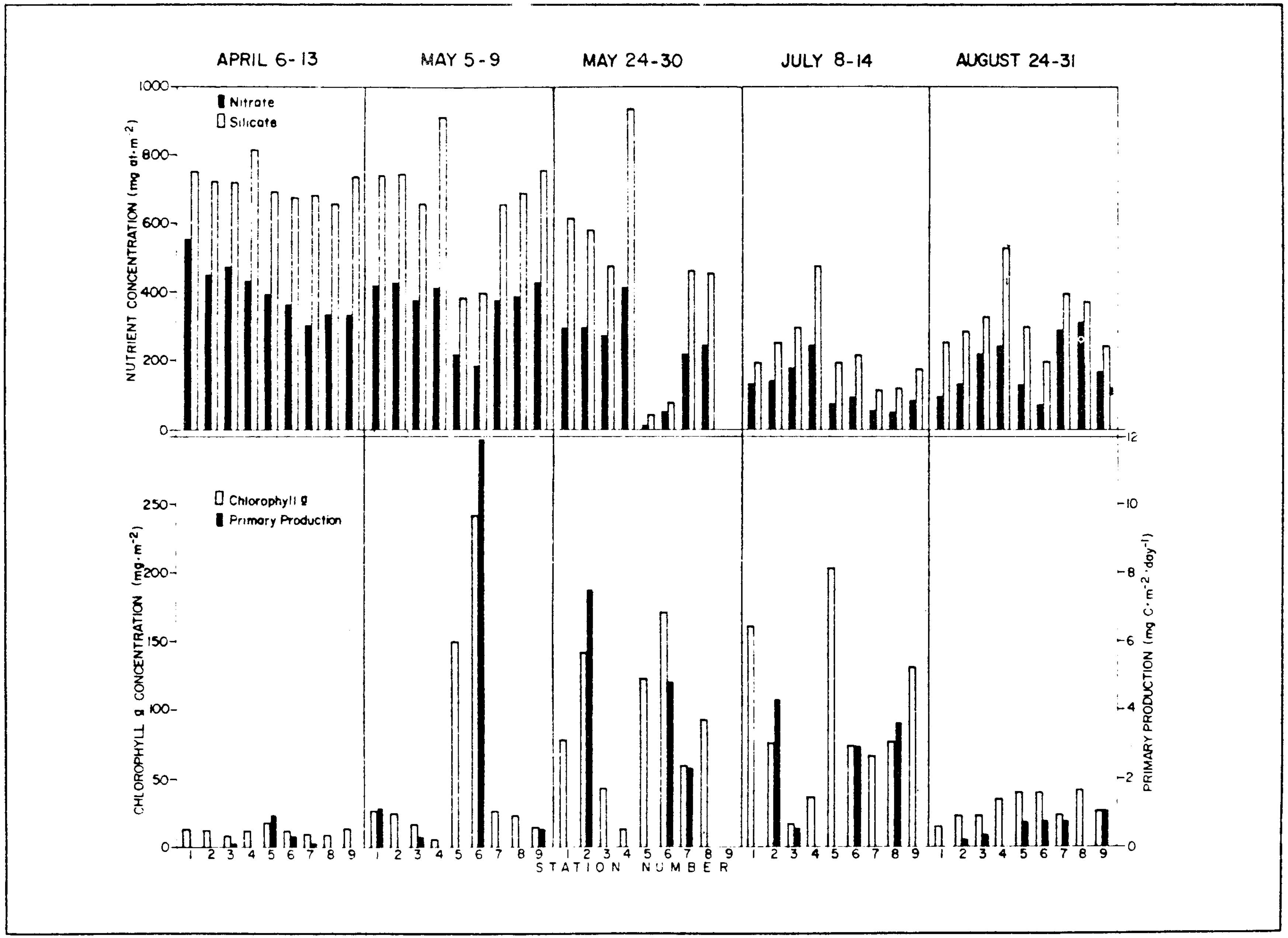

Figure 17. Nutrients, chlorophyll a and primary production, lower Cook Inlet, 1976. Chlorophyll a and nutrients are integrated from 0-25 m; production is integrated to the 1% light depth.

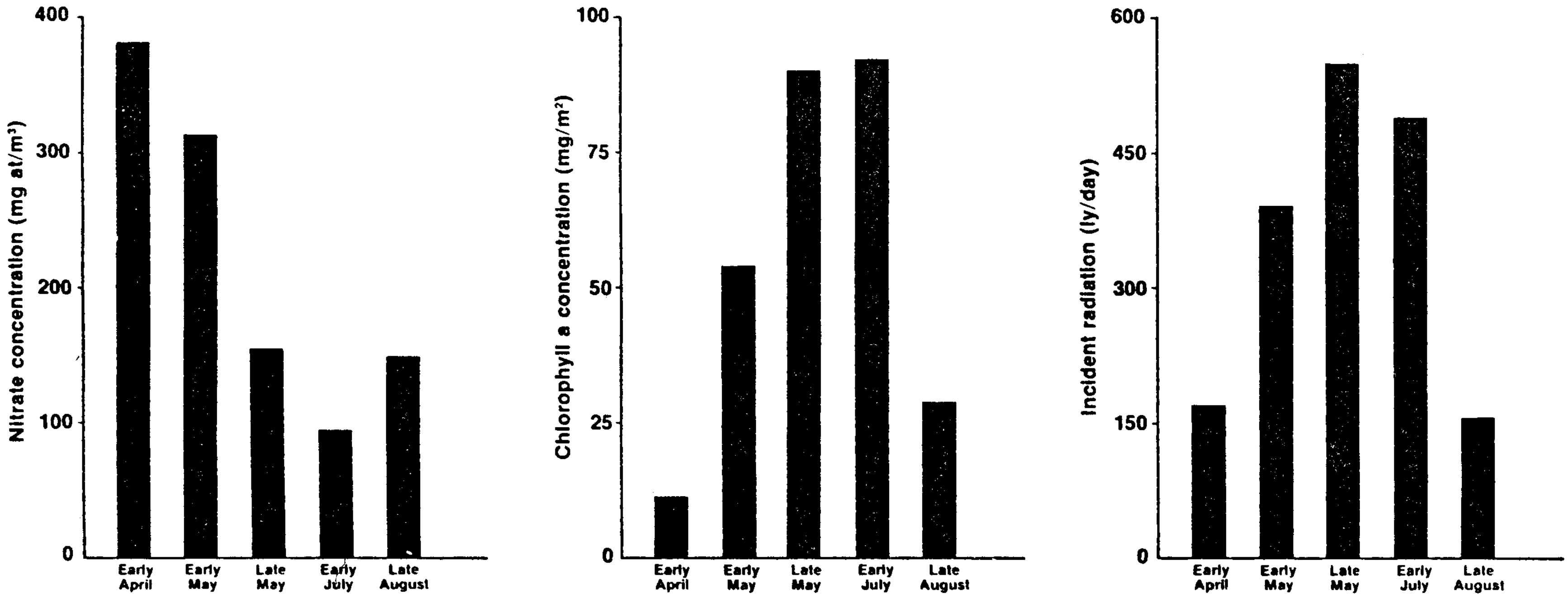

FIGURE 18. Nitrate, chlorophyll a and insolation values from Cook Inlet. Nitrates and chlorophyll a are averages from stations 1-9 and integrated from surface to 25m. Insolation values are averages from stations 1-9.

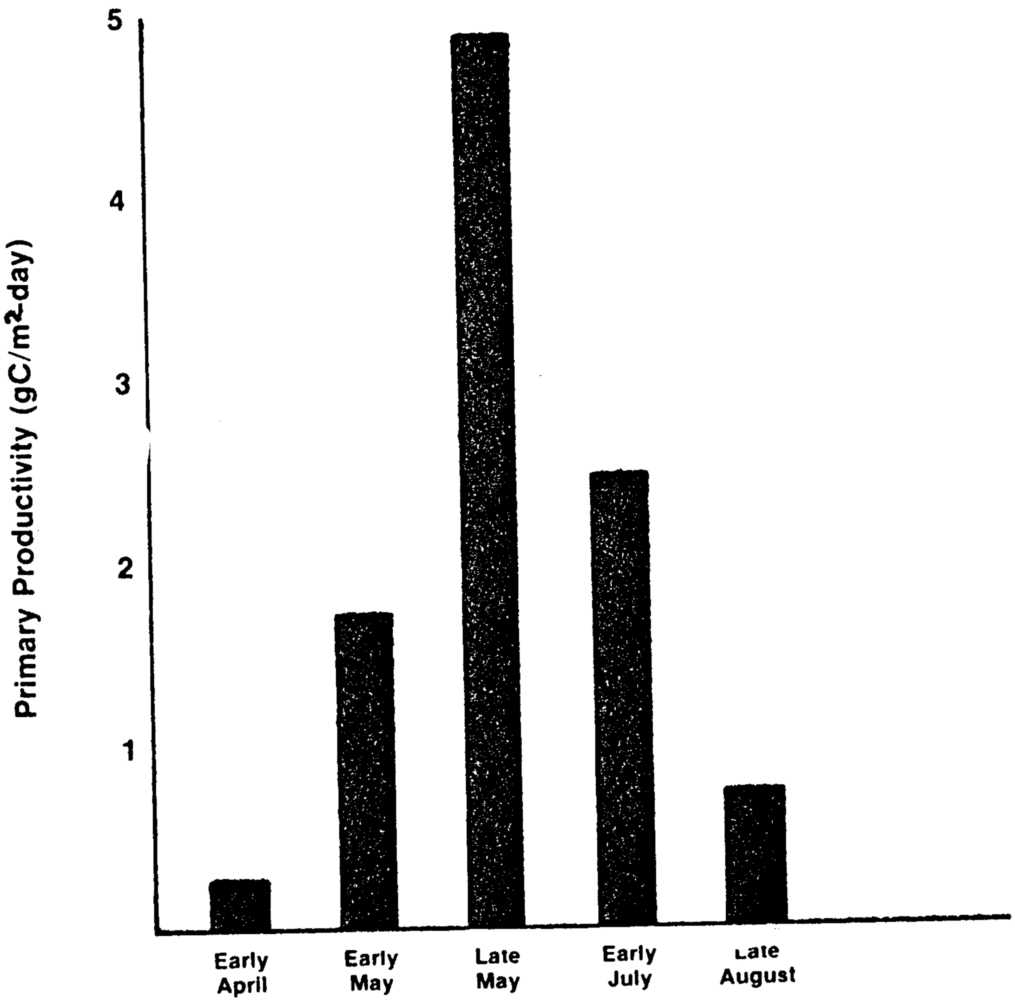

Figure 19. Average primary productivity, lower Cook Inlet, 1976.

Nitrate concentrations in Kachemak Bay decreased rapidly from early April to late May, then remained very low in the surface layer through late August. Nitrate concentrations decreased sharply in Kamishak Bay between late May and early July and increased rapidly by late August.

A pronounced pycnocline developed in Kachemak Bay by late May and persisted at least through early July (Figure 20). A well-developed pycnocline in Kamishak Bay, however, was never observed.

c. Stations 3 and 4

These stations were characterized by turbidity and low productivity. The euphotic zone at station 4 was extremely shallow, ranging from 1-3 m. Primary productivity was not measured at station 4 because of uncertainties in the results created by the shallow euphotic zone. The high turbidity was primarily due to terrigenous material. Maximum production at station 3 was about one-tenth that in Kachemak Bay and occurred during early July. Chlorophyll a values increased five-fold from early April to late May and early July; maximum values were about one-third of those in Kachemak Bay.

d. Prince William Sound

Station 13 was sampled only during early April, late May, and late August. A phytoplankton bloom was in progress during early April; chlorophyll a concentrations were about 100 mg/m^2 (0-50 m) and primary production was about 1 g/m^2 day. Nitrates were plentiful and the water column was well mixed. By late May the chlorophyll a concentration had roughly doubled, primary production was 2-4 times greater, the water had stratified considerably, and nitrates were about half the April concentrations. By late August the chlorophyll a concentration had decreased to 39 mg/m^2 (0-50 m) and nitrates were depleted in the surface layer. Primary productivity was about the same as in early April. Insolation increased five-fold between April and July. The

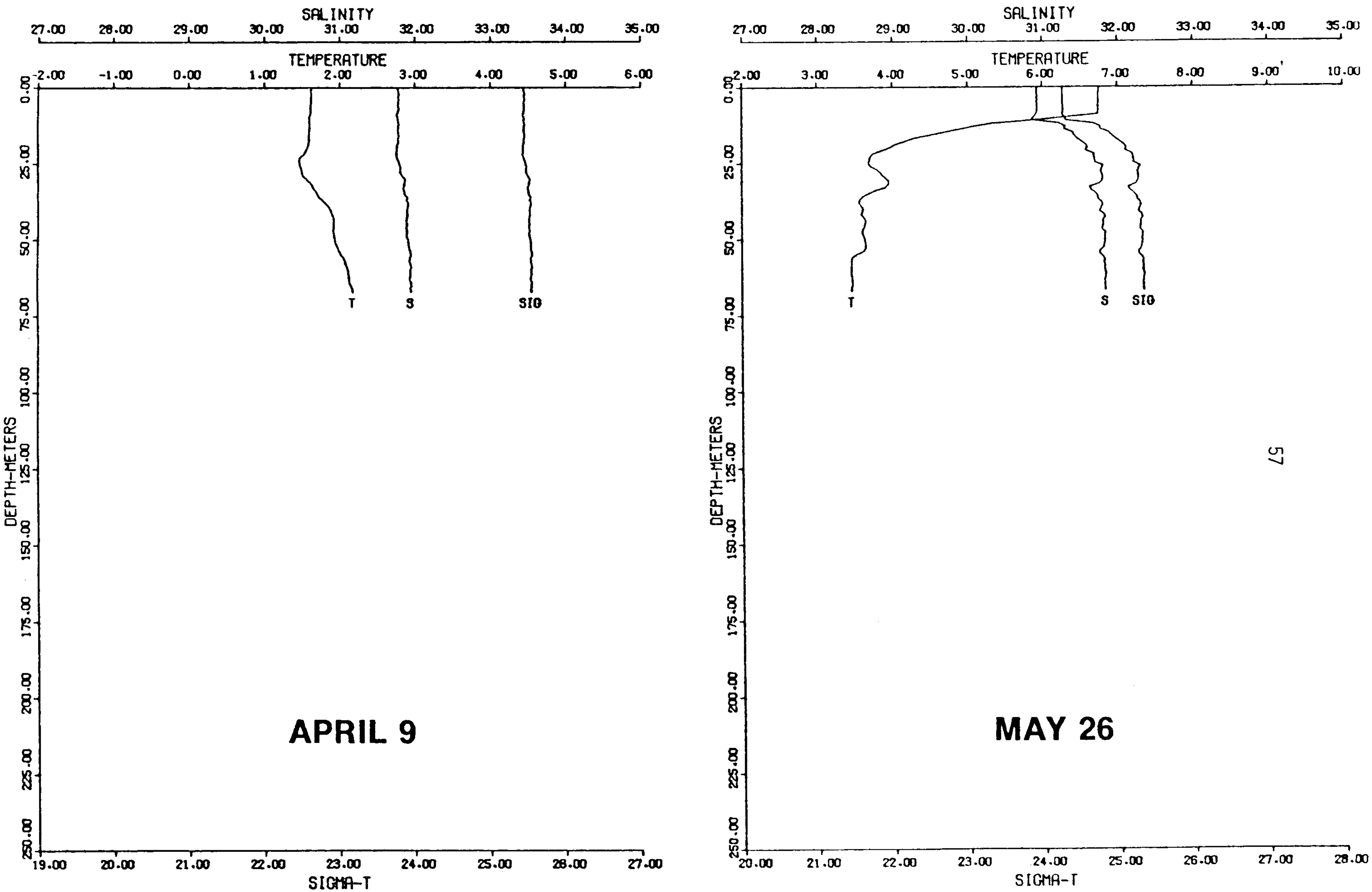

FIGURE 20. **Temperature, salinity and σ_T at station 6 during early April and late May, 1976.**

progression of events at station 13 was much the same as in Kachemak Bay but the bloom started earlier in Prince William Sound and the temporal changes in productivity were not as great.

e. Station 11

Station 11 appears to be of quasi-oceanic nature. Being about 200 miles offshore, the suspended load (not measured) is small compared to the inshore waters and the euphotic zone relatively deep (28-35 m). Chlorophyll a concentrations approximately doubled between early April and late May then decreased 20 percent by late August. Nitrate concentrations were depleted in the surface layers by early July, then increased slightly by late August.

The major features of the seasonal and spatial distributions discussed above are summarized below:

(1) Kachemak Bay (stations 5 and 6) and station 13 in Prince William Sound appear to be the most productive areas sampled and remain highly productive for the longest period of time.

(2) Primary productivity at stations 3 and especially 4 was relatively low presumbaly because the heavy suspended load restricted light penetration.

(3) At several stations, chlorophyll a concentrations and primary production increased about an order of magnitude between early April and late May, maintained a high level through early July, then decreased to near the early April levels by late August. Concomitantly, nitrate concentrations tended to be high in early April, diminish rapidly after early May, became depleted in surface layers by early July and were slightly replenished by late August. Daily insolation increased several-fold and the water column became stratified as the season progressed. Thus, the succession of events from early April through late August was rather typical of northern temperate waters. That is, a spring phytoplankton bloom is generated by greater daily insolation and seasonal density stratification of the upper waters which combine to provide more

light energy to the cells. Subsequently, nutrient depletion occurs in the upper mixed layer caused by intense photosynthesis and production, and standing stocks decrease in midsummer.

3. Water Properties and Primary Productivity

It has been well established that parts of lower Cook Inlet, especially Kachemak Bay, are biologically highly productive (Kinney et al., 1970; Knull and Williamson, 1969; and Evans et al., 1972). The descriptive data reported above emphasize the intense phytoplankton productivity, particularly in the spring. The general net circulation pattern in lower Cook Inlet was described by Evans et al., 1972. The hydrographic and chemical data presented by Knull and Williamson (1969) suggest the possibility of a gyre system present in outer Kachemak Bay. They also estimated a "half-life" residence time of water in Kachemak Bay of 13-14 days. From these results and those in the present study, an explanation of the causes of the observed production can be attempted.

The contrast in times of phytoplankton blooms and subsequent nitrate depletion among Kachemak Bay (stations 5 and 6), midchannel (station 2), and Kamishak Bay (stations 7 and 8) can be explained by a combination of differences in stratification, circulation, and turbidity. In the late winter and early spring, there was probably insufficient light energy in the water column to support a substantial increase of phytoplankton. This was because of low daily insolation and shading by ice. By early April, the sunlight intensity had increased, the area was ice free, and the nutrient concentrations were high. These conditions were all favorable for commencement of a bloom, but the water column was well mixed at all stations except 3 (see Appendix and Figure 2). Mixing was apparently too deep to allow development of a bloom at those locations. In addition, highly turbid water from northern Cook Inlet attenuated the penetration of light which reduced the euphotic zone to a relatively shallow layer in the northern and western portions of the study area. At station 6, however, a slight pycnocline was present below about 30 m. Productivity and chlorophyll were uniformly low at all stations.

By early May there was still no stratification at stations 1, 2, and 7-9 and no significant increase in chlorophyll. Density was uniform with depth at those stations, while a thermocline occurred at stations 5 and 6 in the upper 15 m (no machine plots of temperature and salinity are available for early May and July). At the latter two stations, large blooms were in progress. The loss of near-surface nitrates was about 12-14 mg at/m^3 reducing the concentrations to about 2-5 mg at/m^3. Similar nutrient losses did not occur at the other stations.

In late May, slight but distinct thermoclines at stations 1 and 2 were accompanied by surface nitrate decreases (about 5 mg at/m^3) and a three- to six-fold increase in chlorophyll. Thus a moderate bloom had begun with thermocline formation. Similar changes in chlorophyll and nitrate occurred in Kamishak Bay, although the water was well mixed but clearer than in April. At Kachemak Bay stations, on the other hand, nitrate was undetectable in the upper 15 m and sub-surface chlorophyll maxima were distinct.

From the above sequence of events, it seems probable that the key to initiation of a phytoplankton bloom in lower Cook Inlet is stratification of the water column (as is typical for temperate ocean waters). In addition, water transparency must be adequate to permit 1 percent of the light incident on the surface to penetrate deeper than about 10 m. (The water at station 4 was always too turbid for bloom development.)

Stratification in Cook Inlet is caused by either fresh water runoff from adjacent drainages or by surface heating. Salinity of the oceanic water entering through Kennedy Entrance (station 9) was about 32 $^{o}/oo$. Lower salinity water was found mainly in the northern and western areas indicating runoff from northern

Cook.Inlet. Similarly, local drainage into Kachemak Bay was often indicated by salinity < 32 $^{o}/_{oo}$, particularly at station 6. Early in the year the runoff water was as cold as -1°C, but by midsummer it was as warm as the inflowing oceanic water (> 10°C).

The observation that large blooms and depletion of nitrate occurred at stations 5 and 6 by late May at the same time that moderate to high nitrate concentrations were sustained in the entering oceanic water, supports the notion that residence time of water in Kachemak Bay is sufficiently long to permit these changes to occur locally. That is, the observed changes are nonadvective. In the midchannel area, although productivity was high in late May and July (7.5 and 4.3 gC/m^2 day, respectively), dramatic nitrate depletion did not occur as in Kachemak Bay (Tables 8 and 9). This suggests that the exchange of water in the midchannel area was greater than in Kachemak Bay.

In terms of effects of proposed oil development on the Cook Inlet environment, it would seem important to obtain information on the transport of water and exchange rates (or residence times) in these biologically distinct areas and to understand how such circulation influences the biological populations and their production in these areas.

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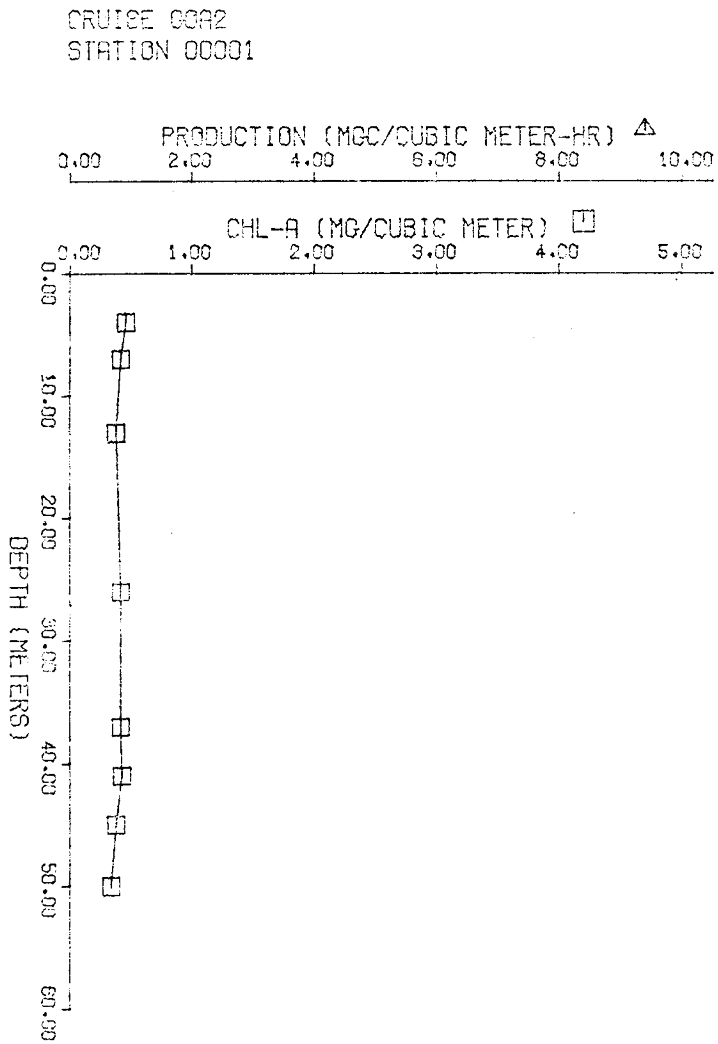
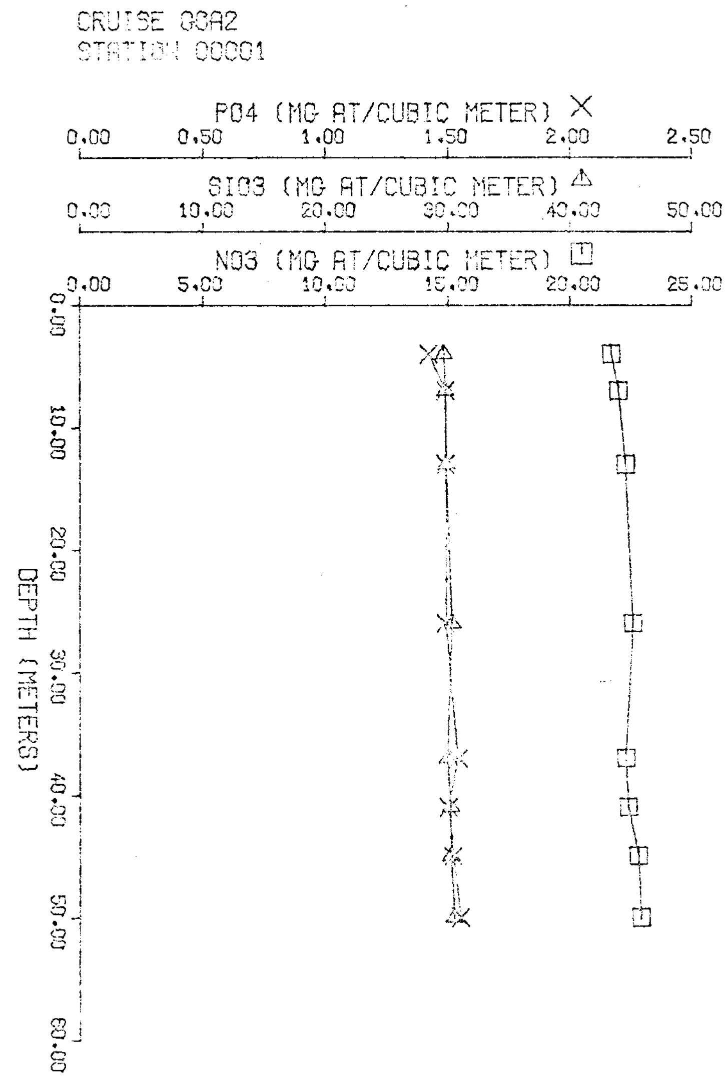
APPENDIX A

Vertical profiles of chlorophyll, primary productivity, and nutrients, lower Cook Inlet, April-August 1976.





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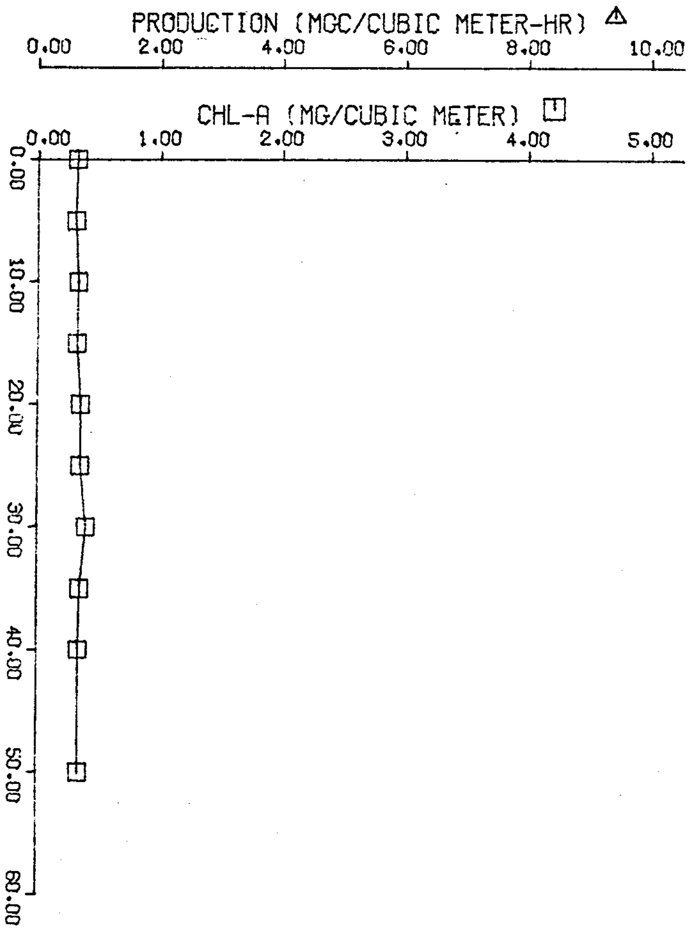

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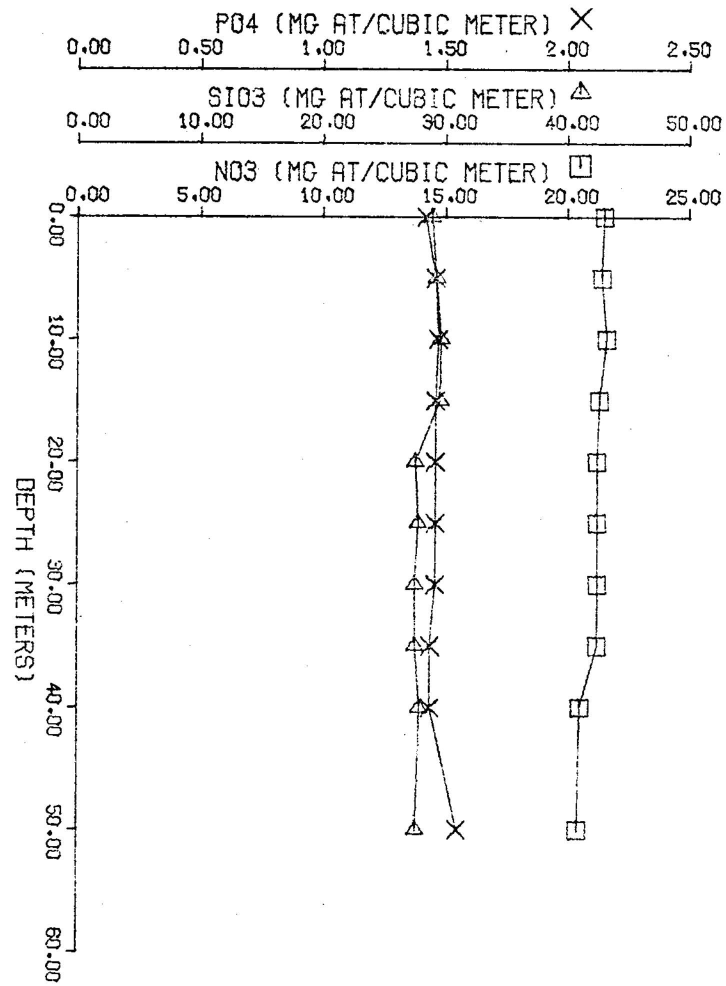

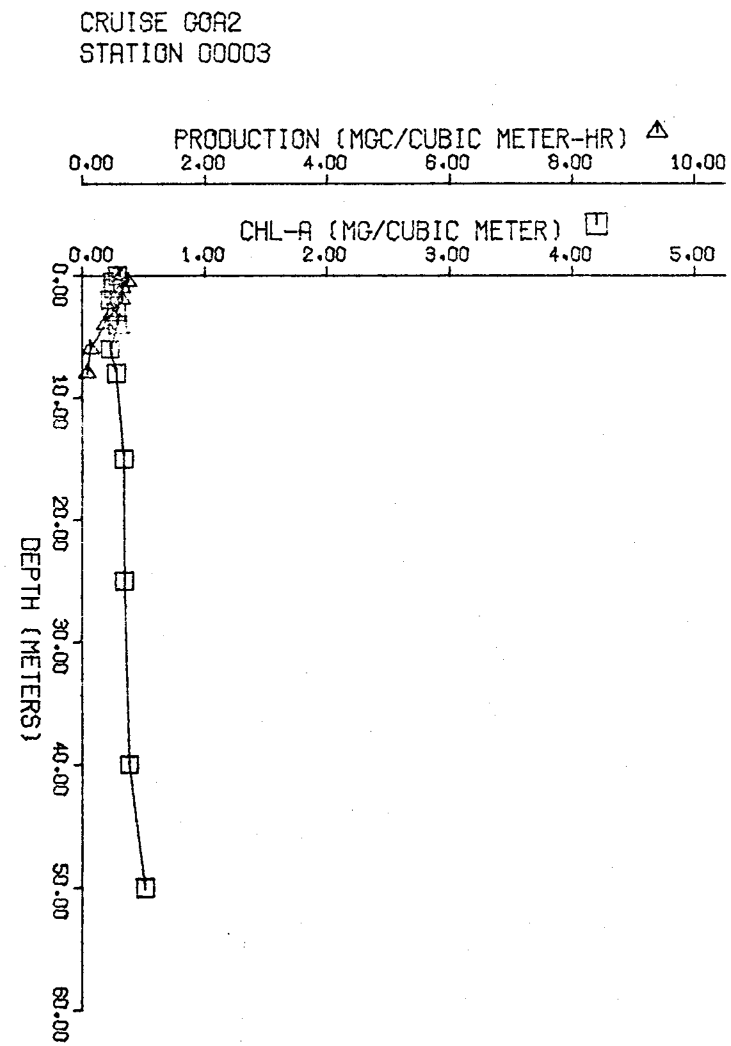
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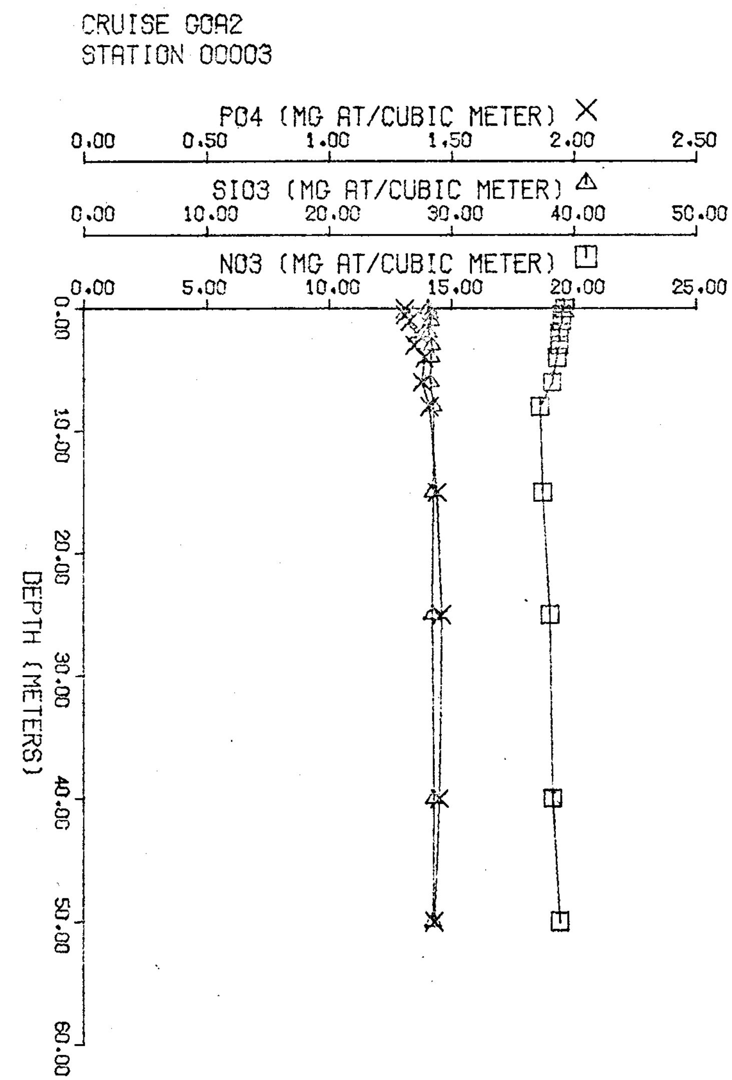
CHL-A (MG/CUBIC METER)
0.00 1.00 2.00 3.00 4.00 5.00
DEPTH (METERS)
0.00 10.00 20.00 30.00 40.00 50.00 60.00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SIO3 (MG AT/CUBIC METER)
0.00 10.00 20.00 30.00 40.00 50.00
NO3 (MG AT/CUBIC METER)
0.00 5.00 10.00 15.00 20.00 25.00
DEPTH (METERS)
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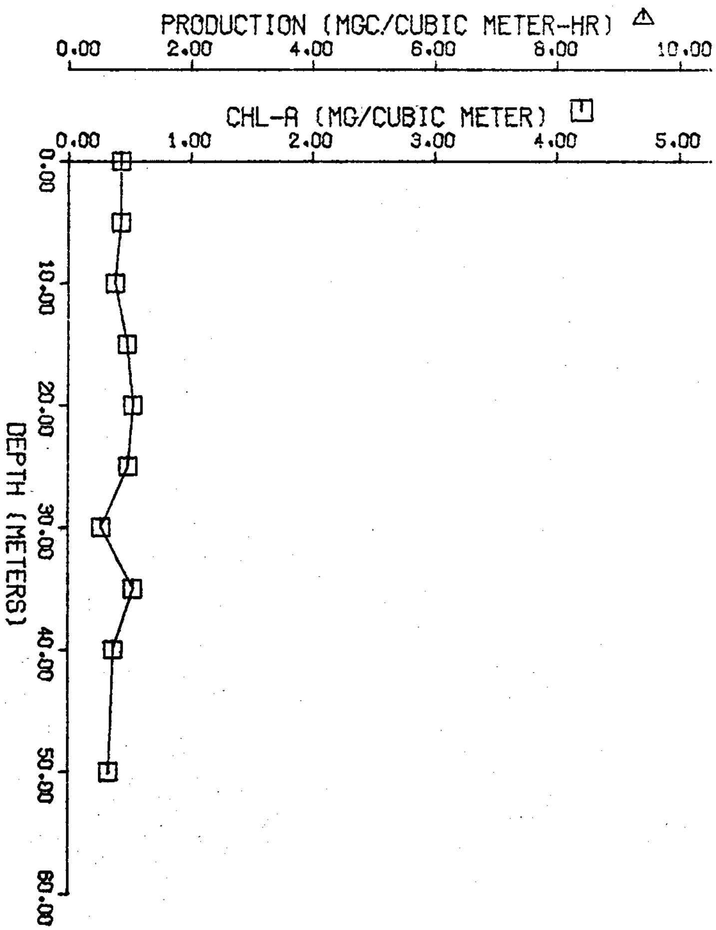

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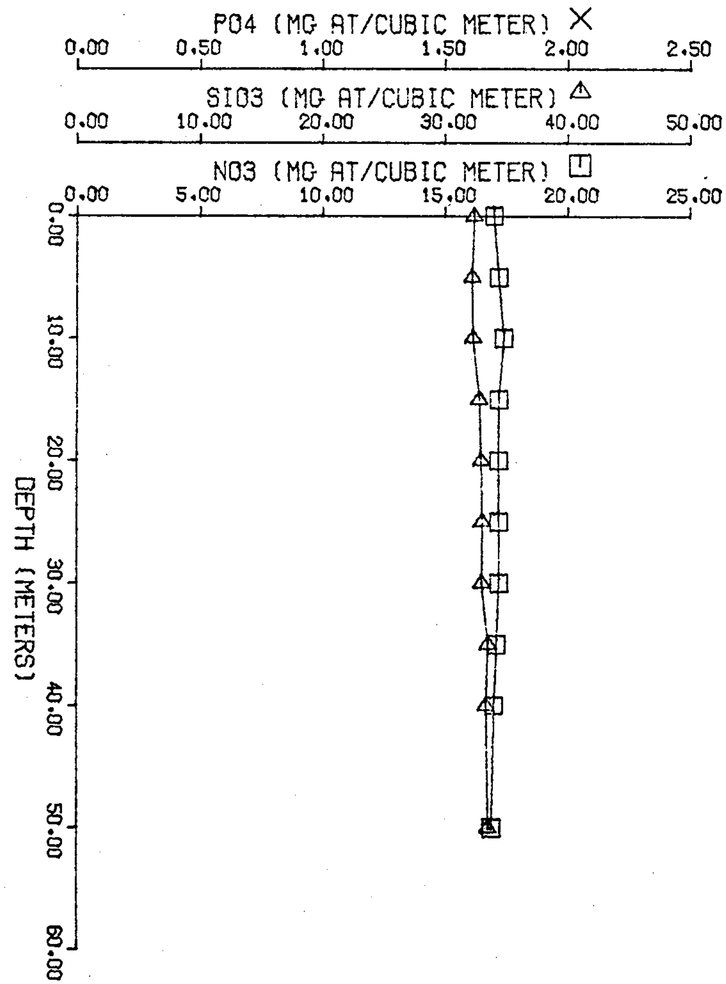

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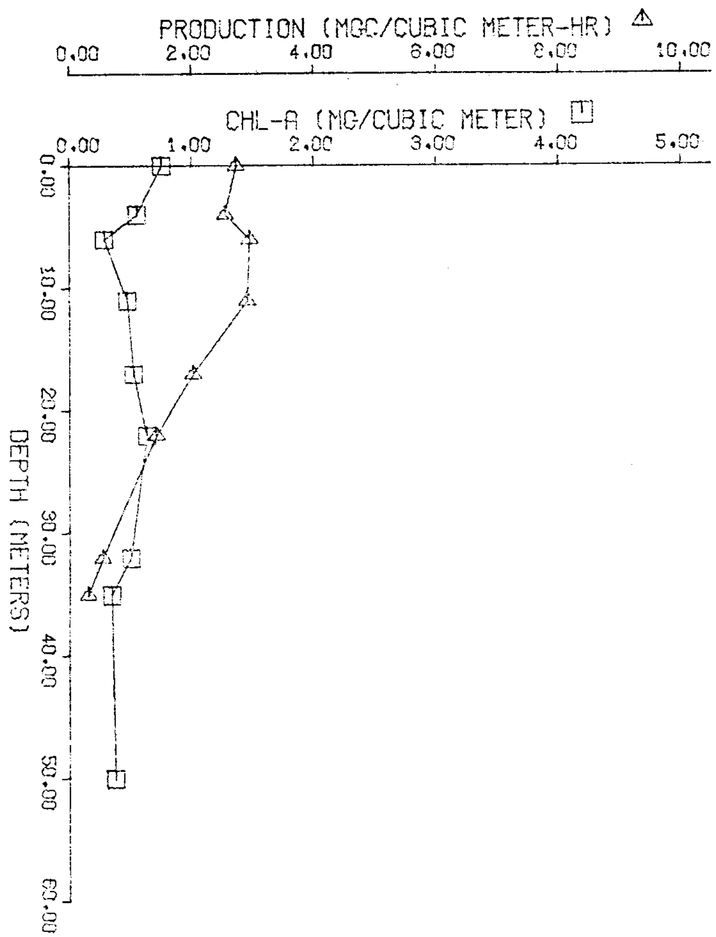

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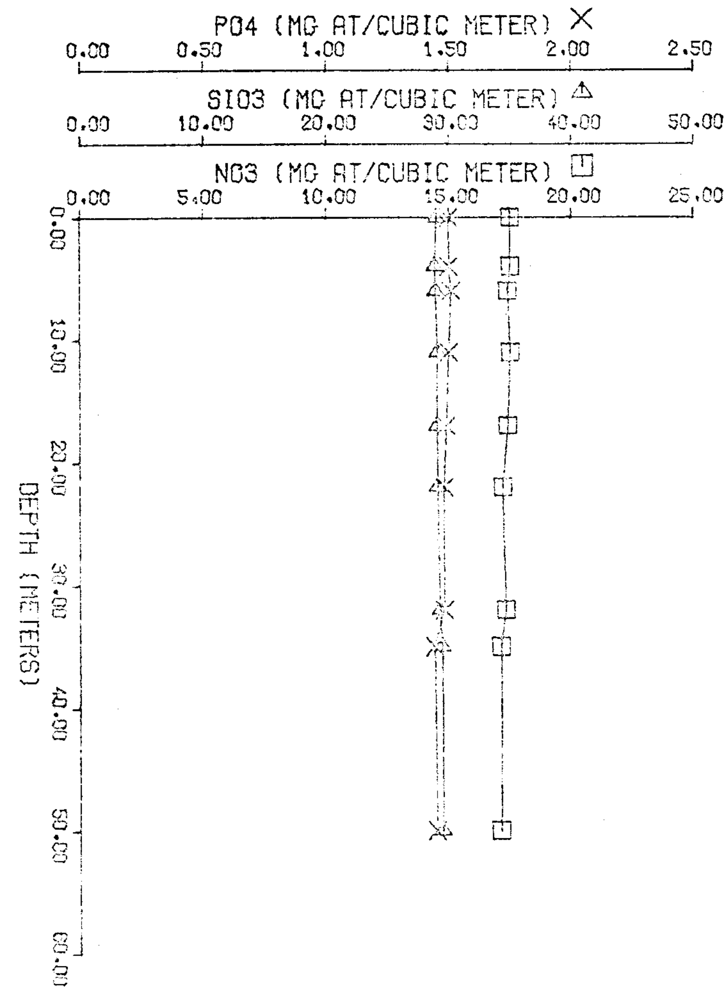

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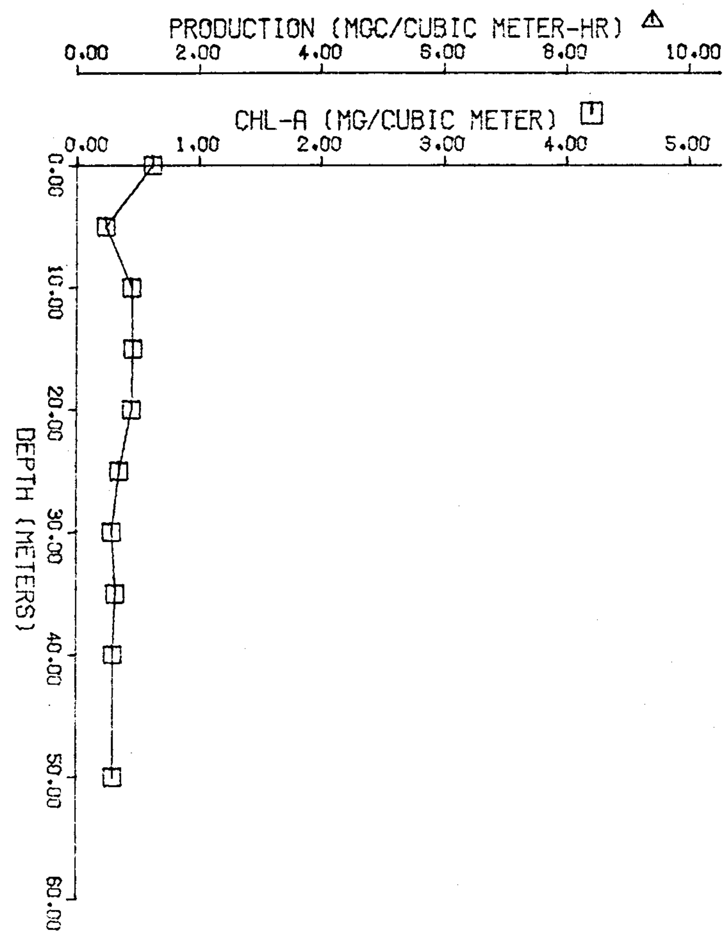

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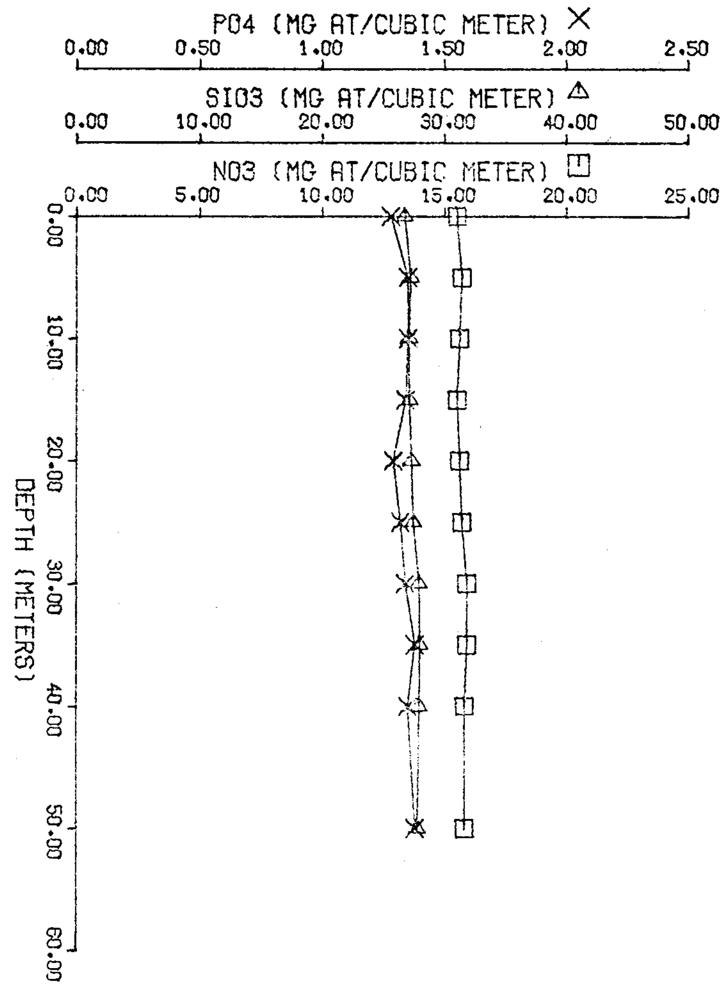

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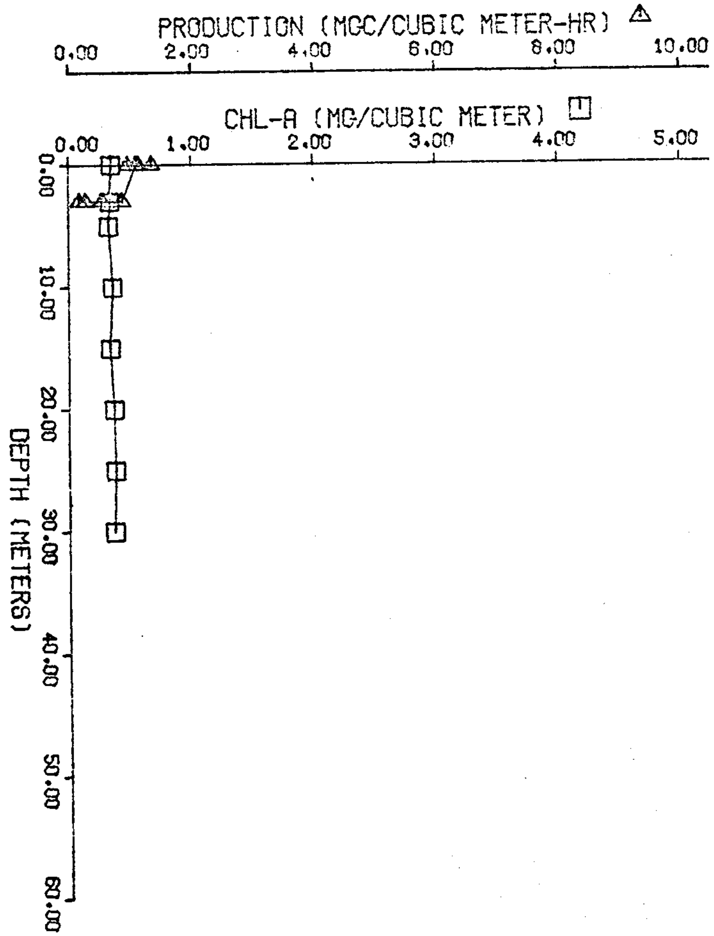

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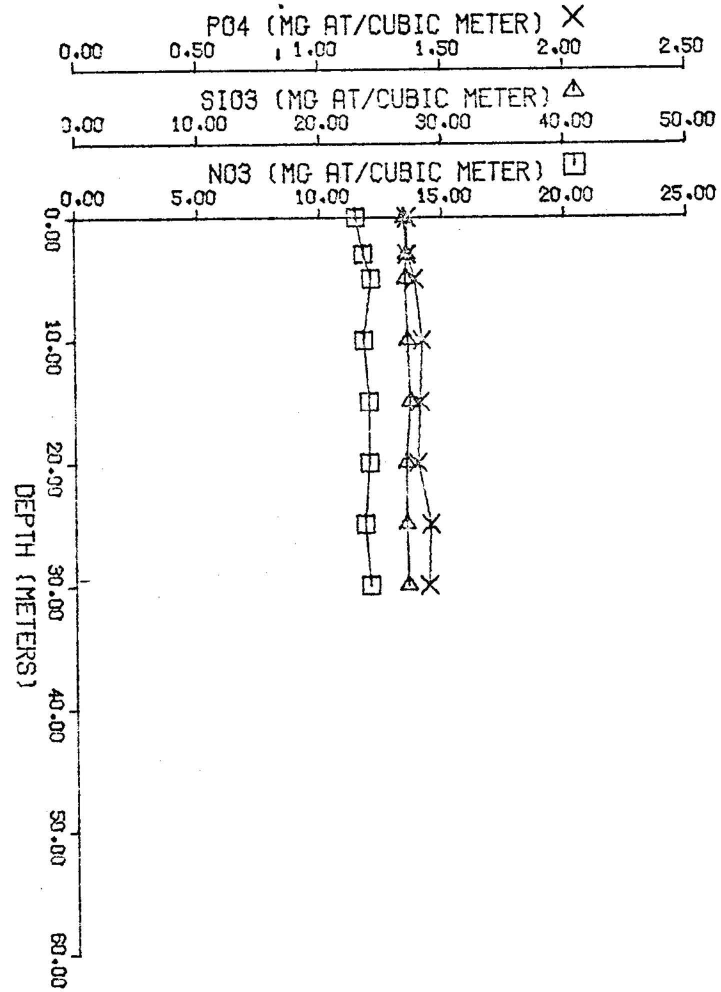

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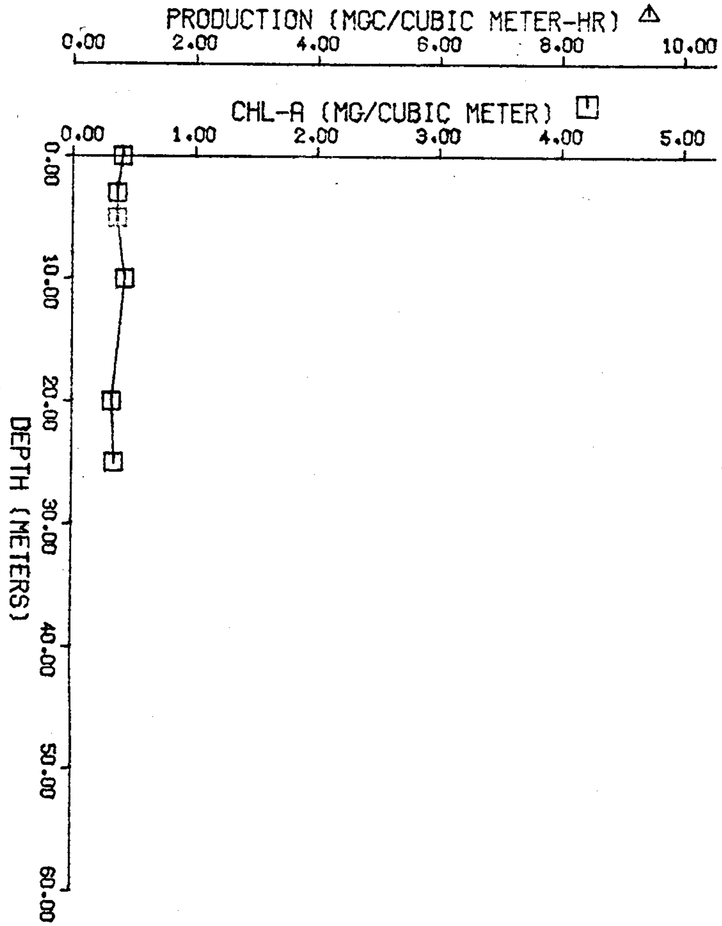

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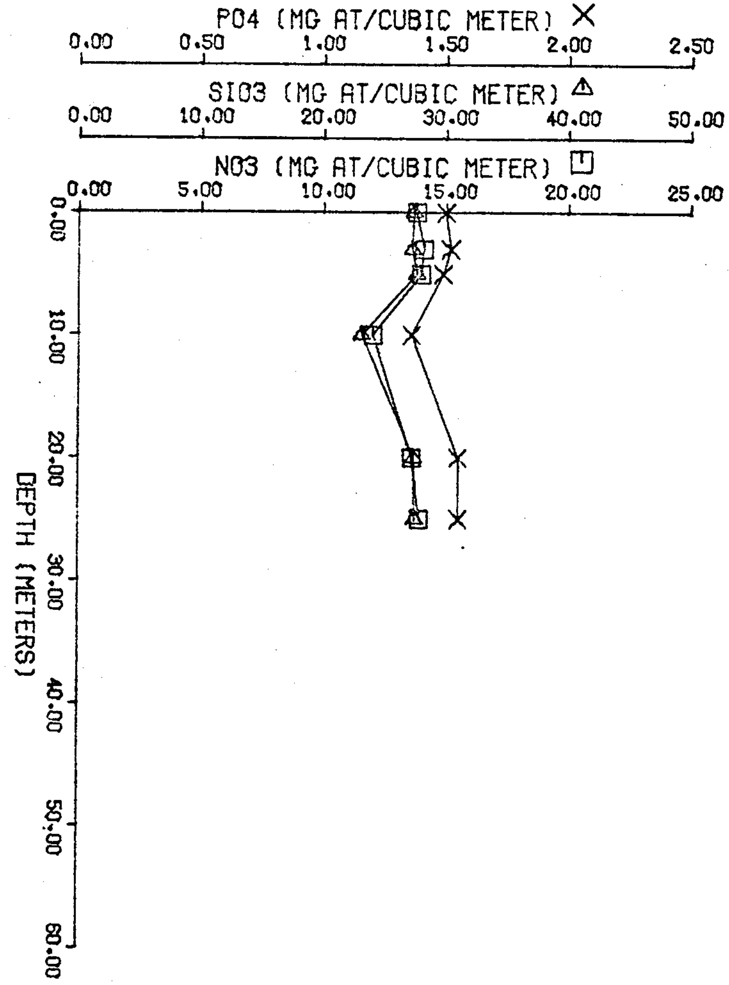

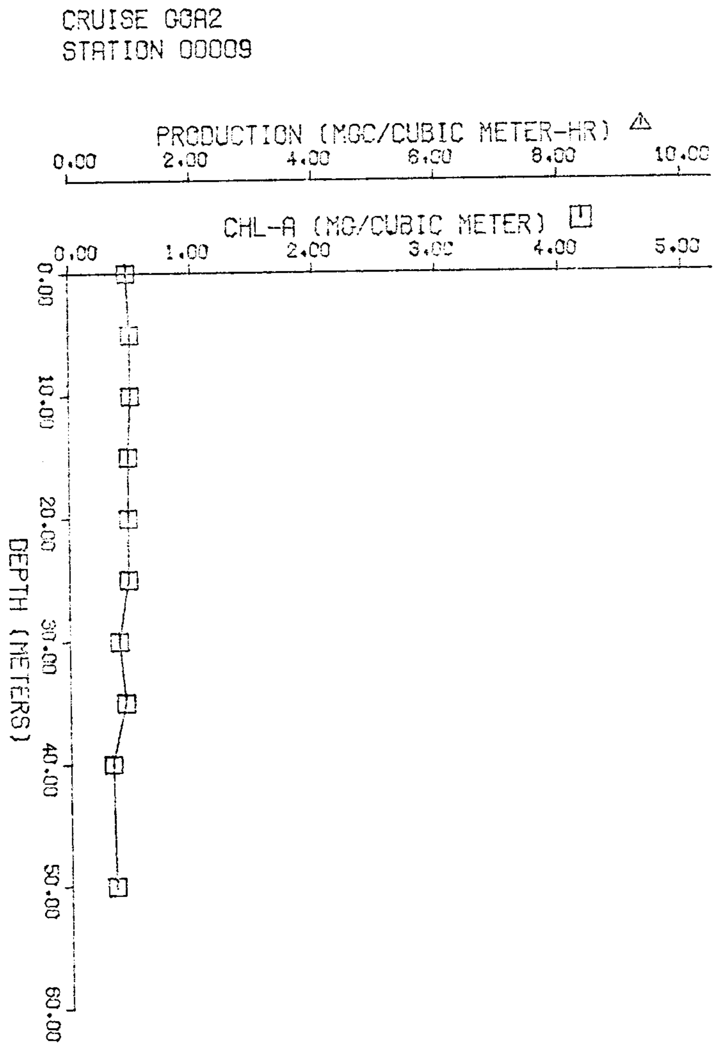

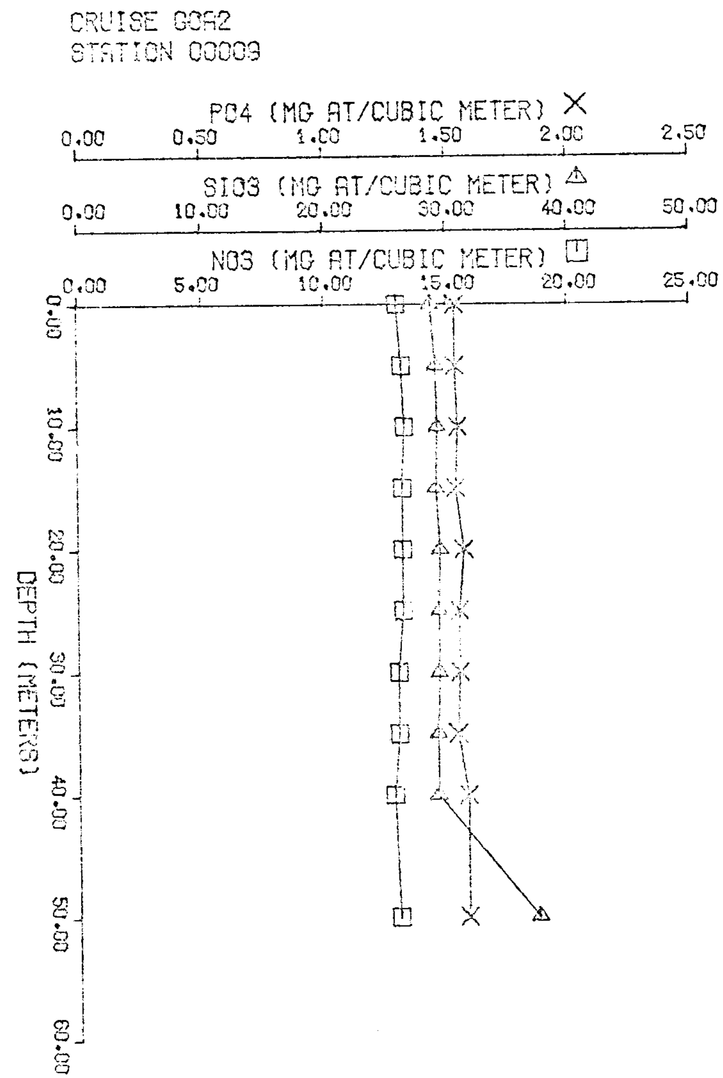

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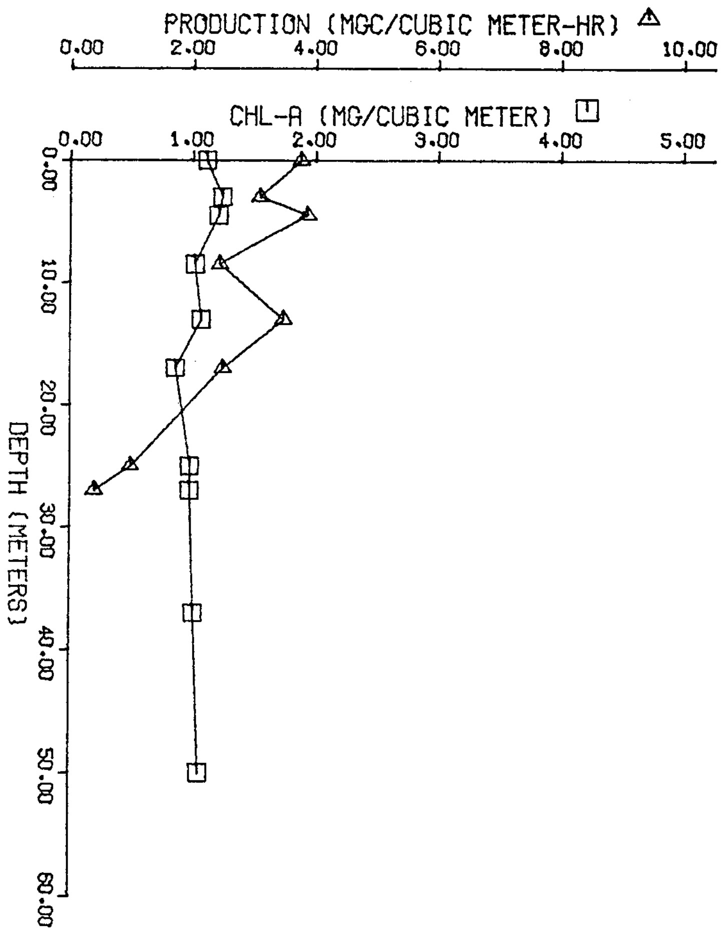

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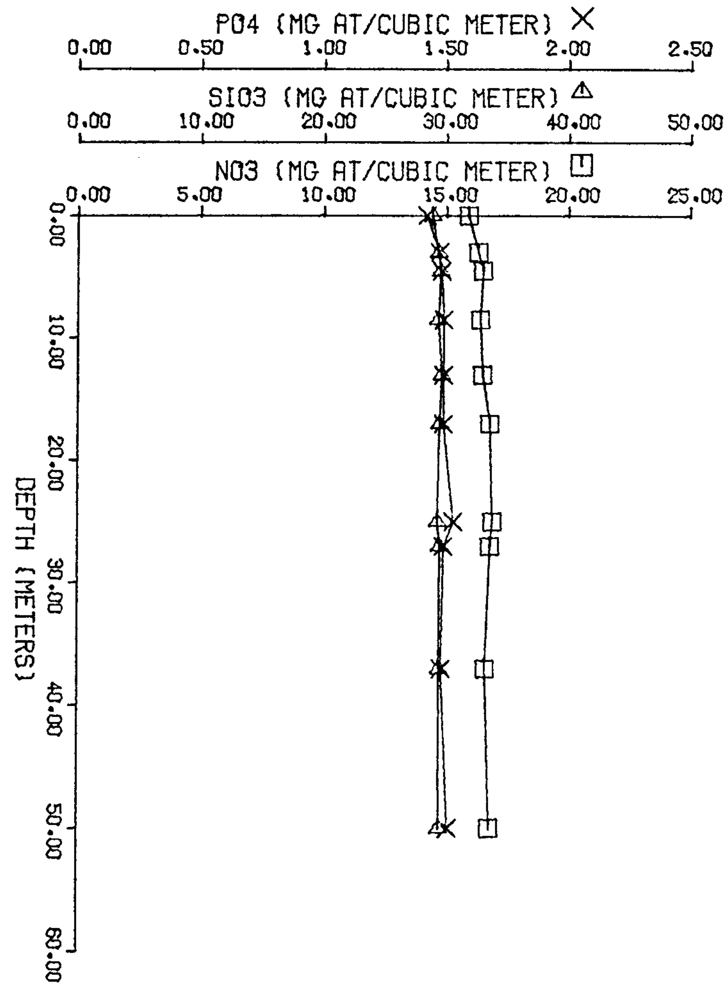

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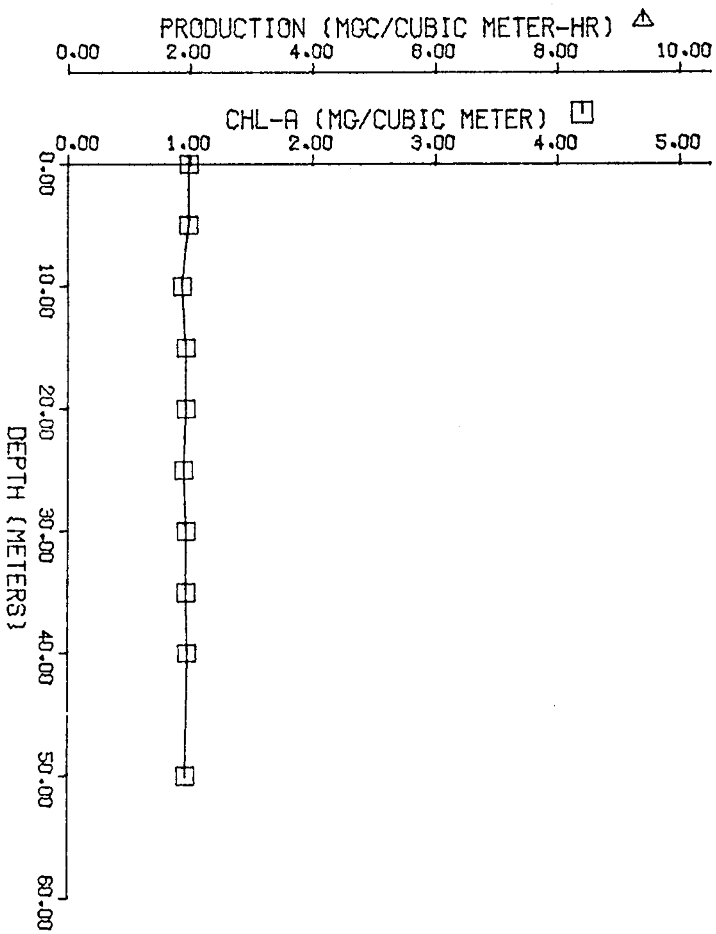

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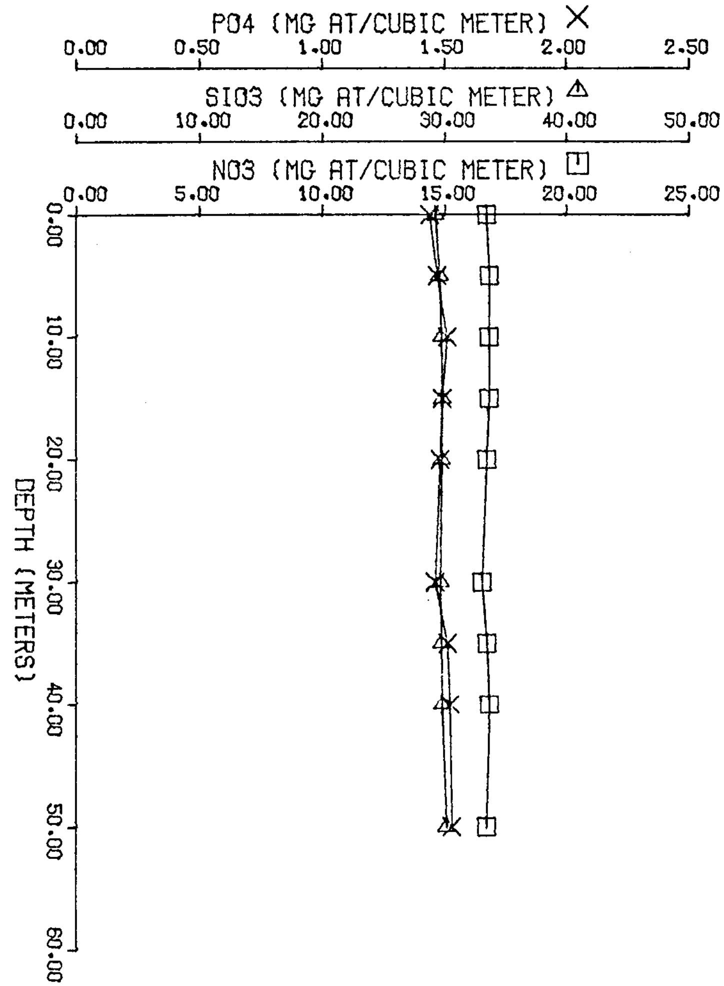

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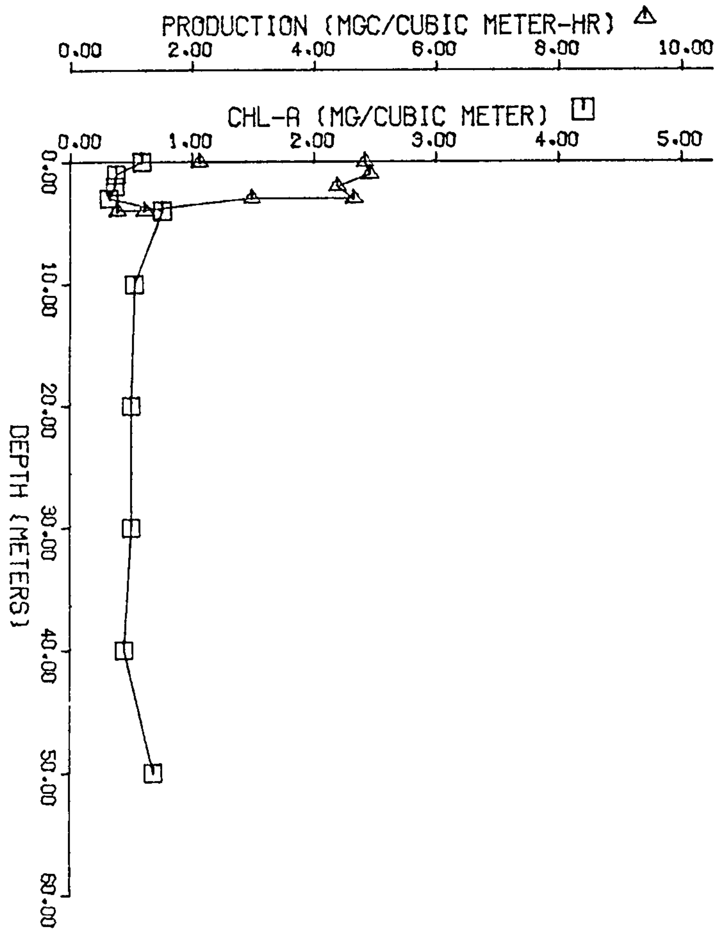

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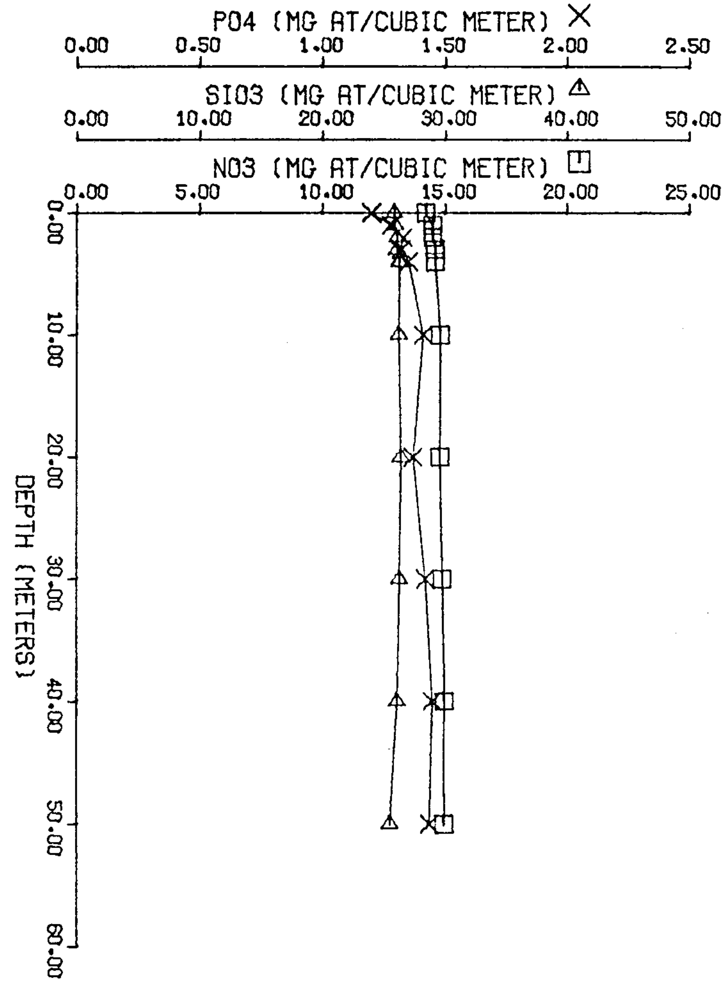

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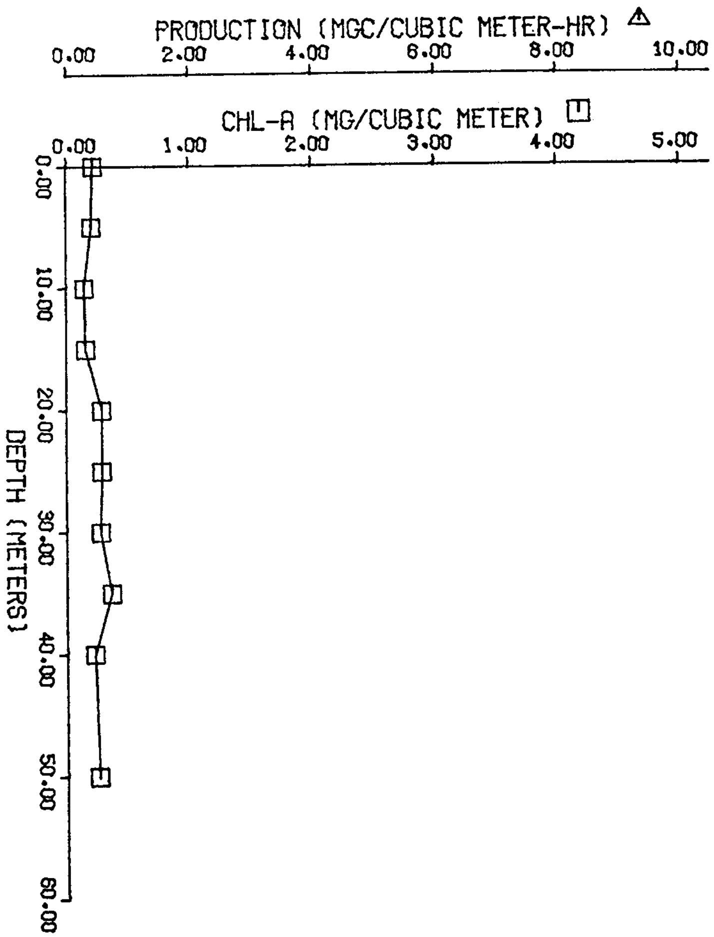

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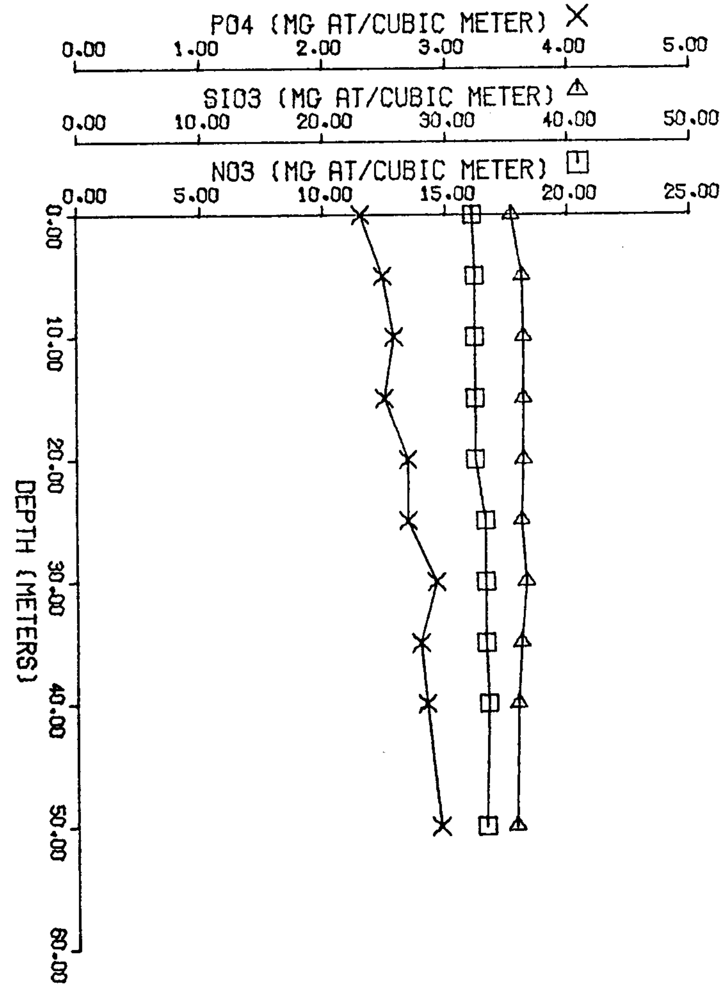
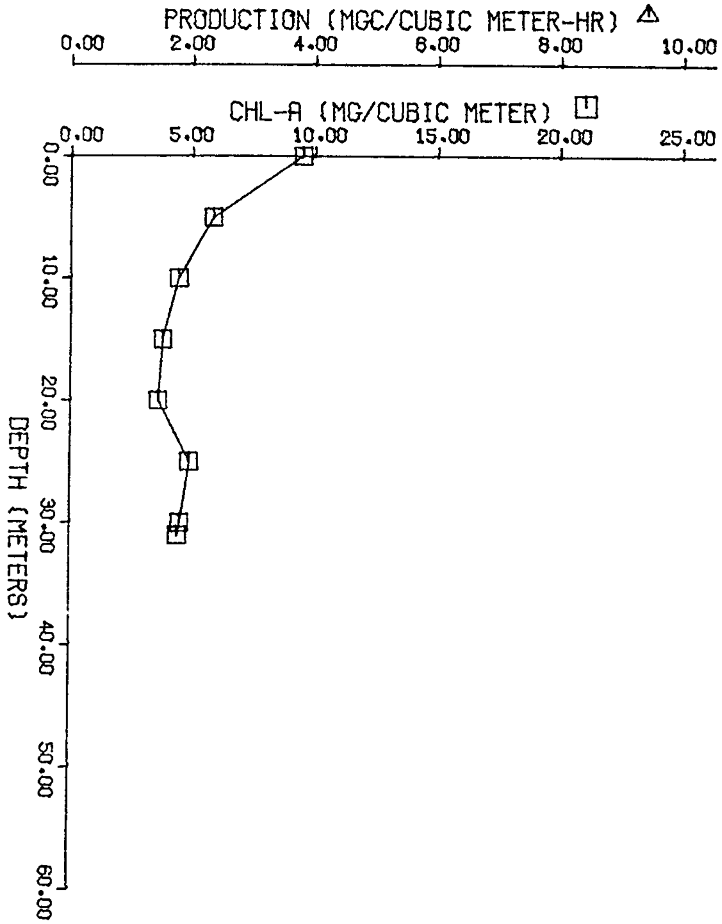
STATION 00004

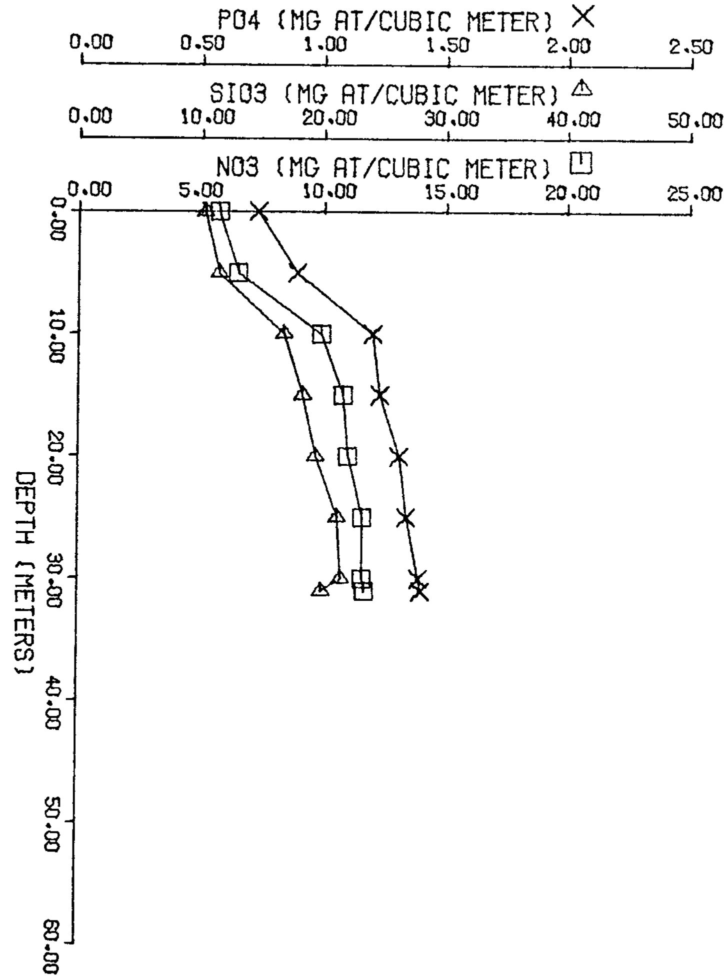


CRUISE GOA3
STATION 00005

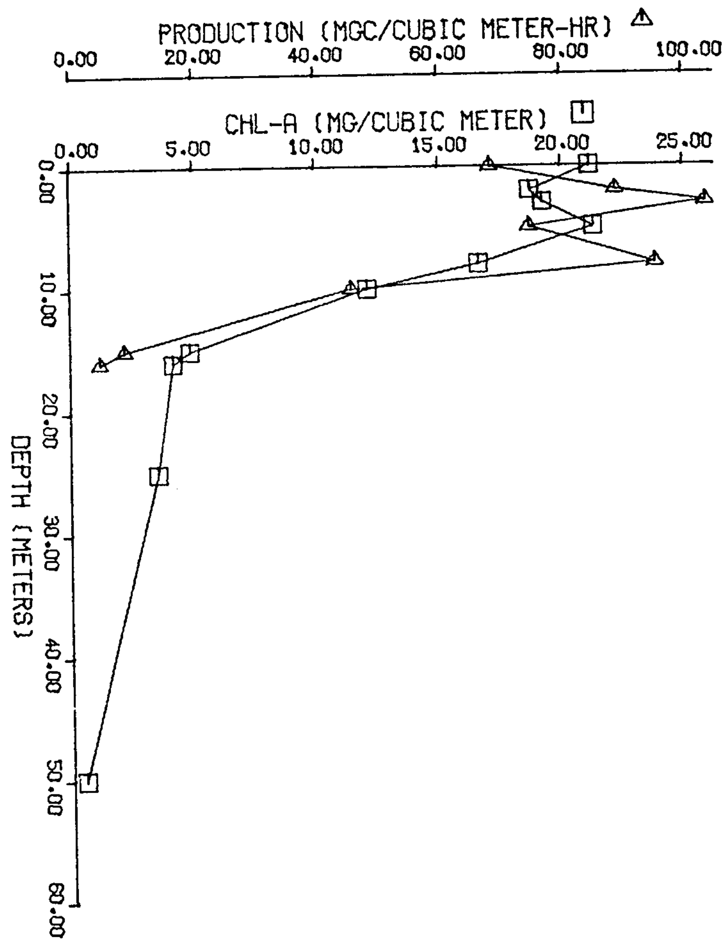


NO VALUES FOR VARIABLE WITH SYMBOL △

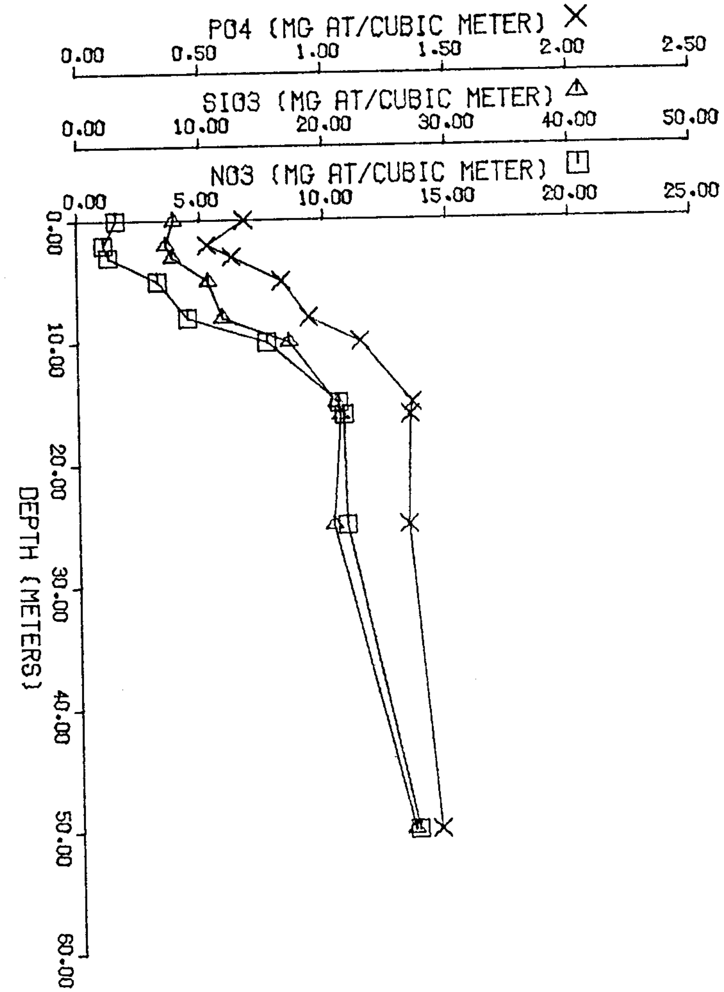
CRUISE GOA3
STATION 00005



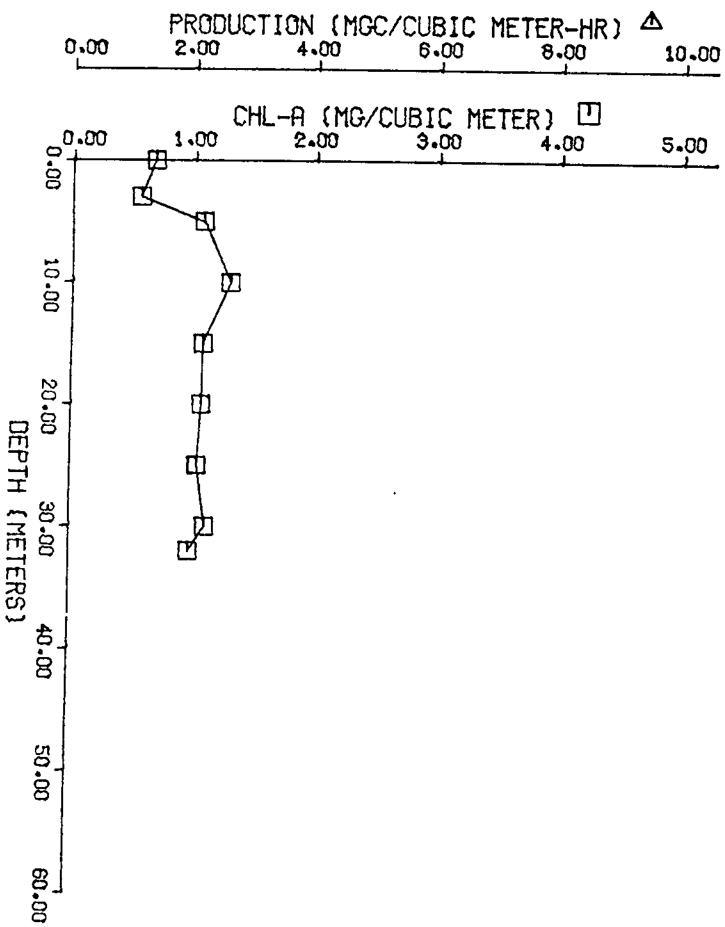
CRUISE GOA3
STATION 0006A



CRUISE GOA3
STATION 0006A

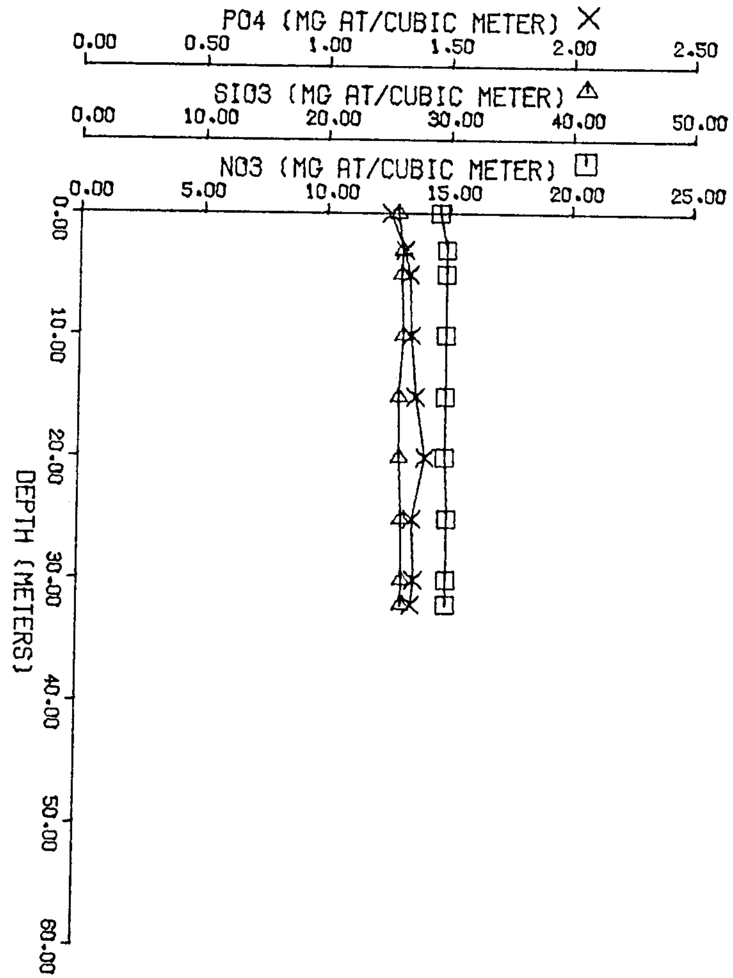


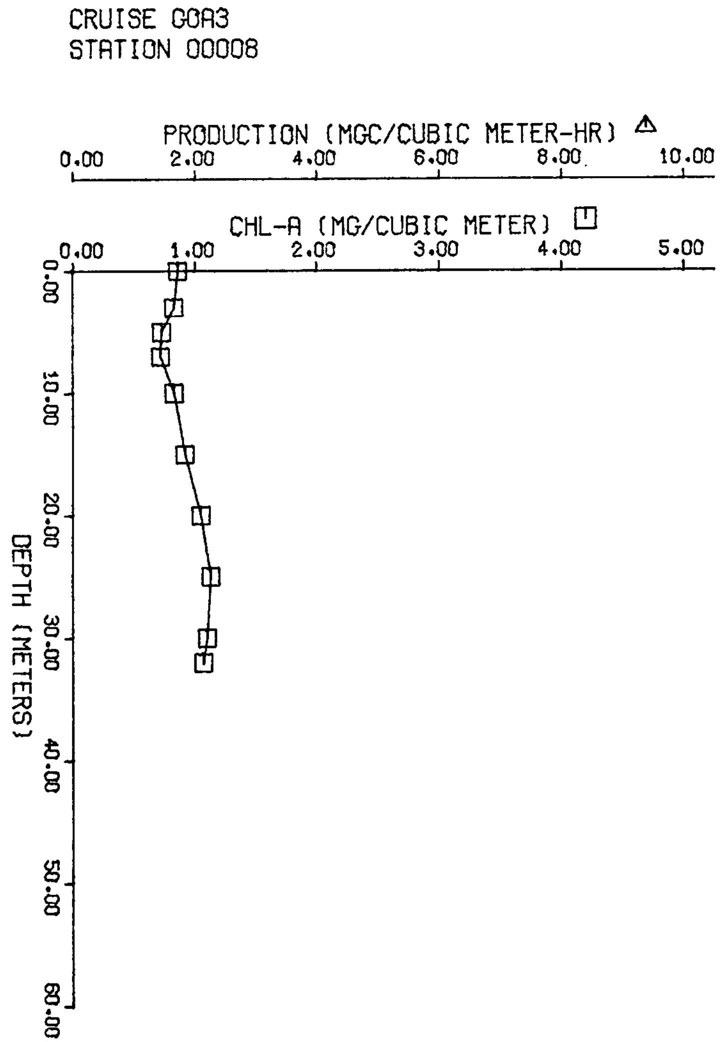
CRUISE GOA3
STATION 00007



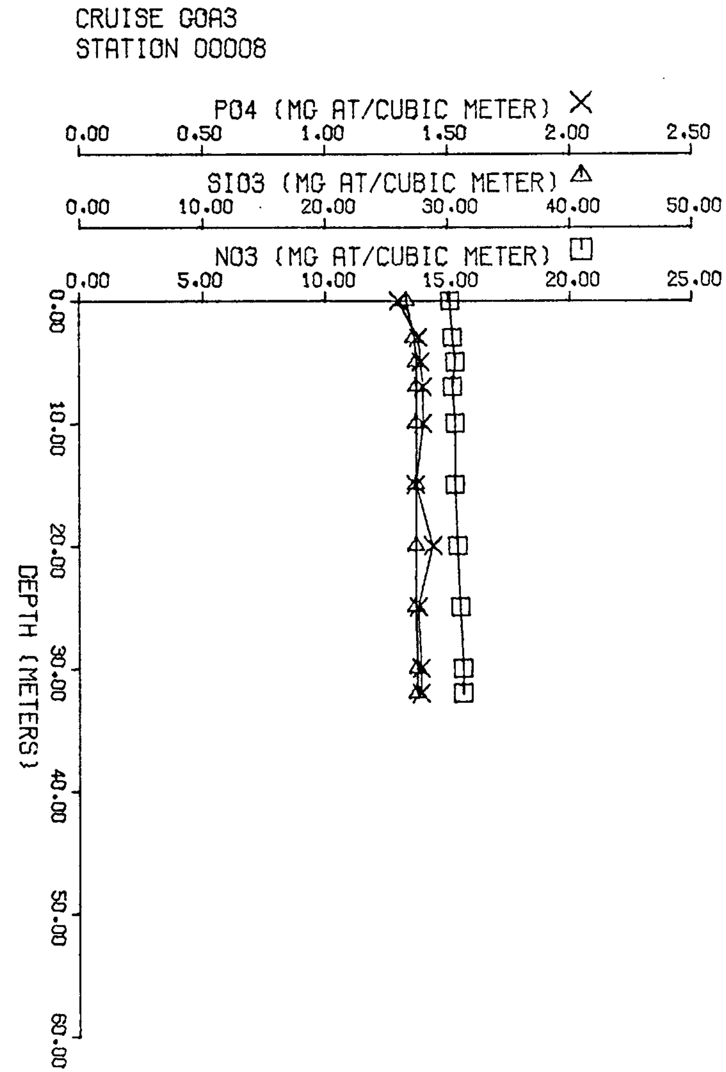
NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA3
STATION 00007





NO VALUES FOR VARIABLE WITH SYMBOL △



CRUISE GOA3
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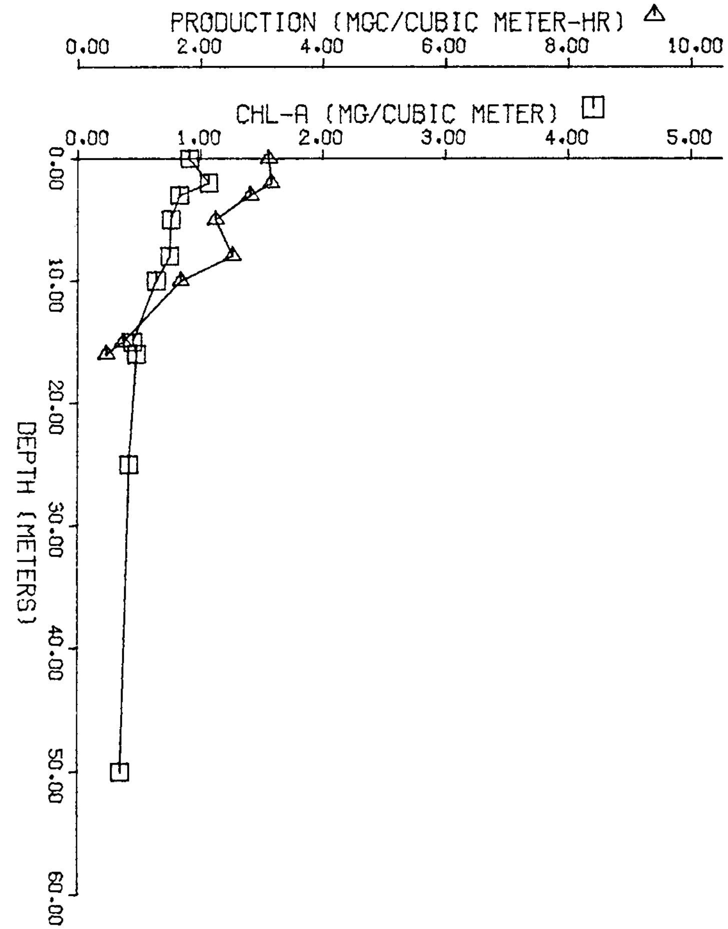
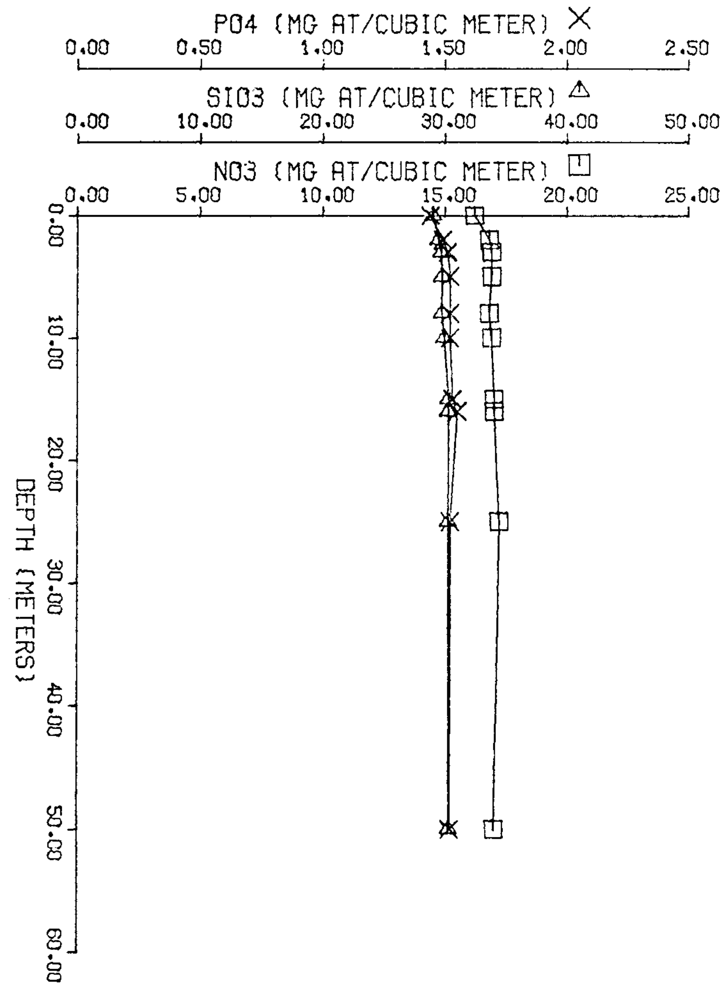
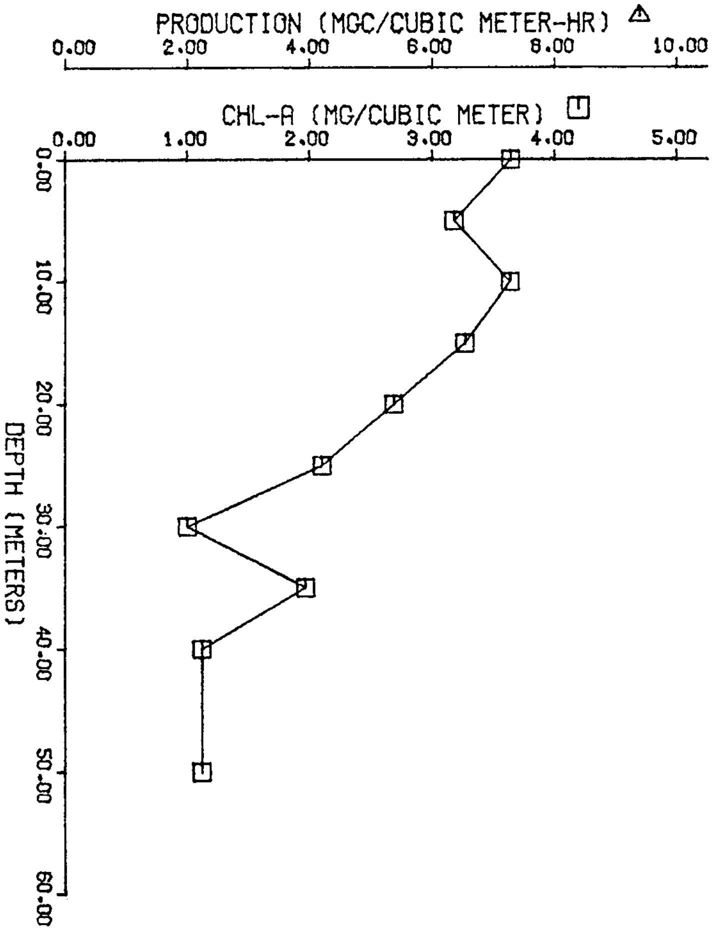


CRUISE GOA3
STATION 00009

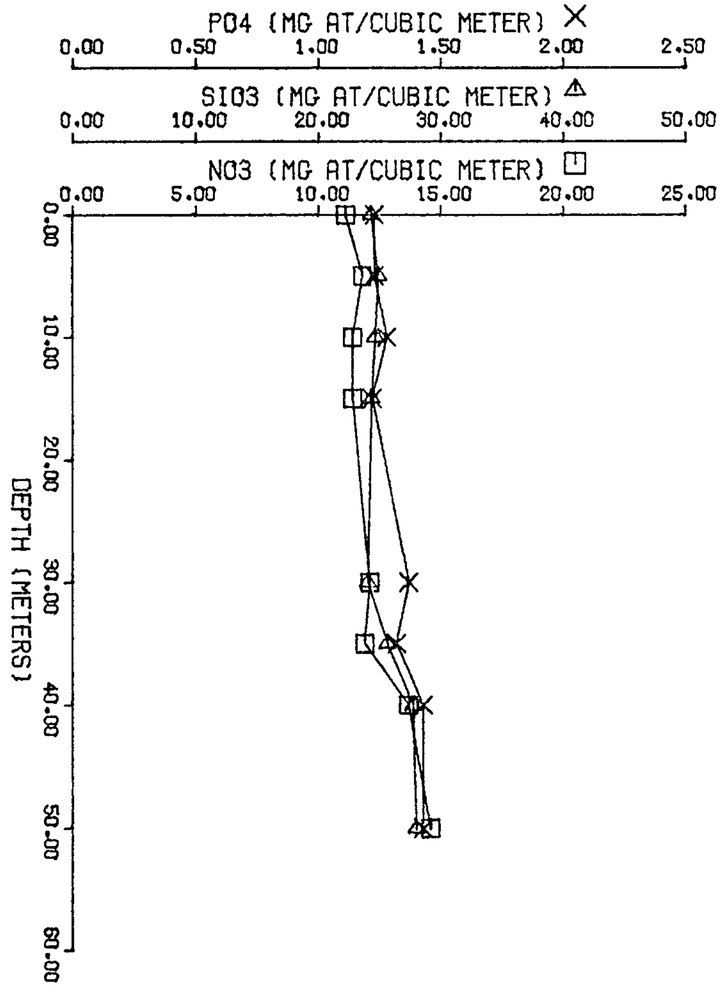


CRUISE GOA4
STATION 00001

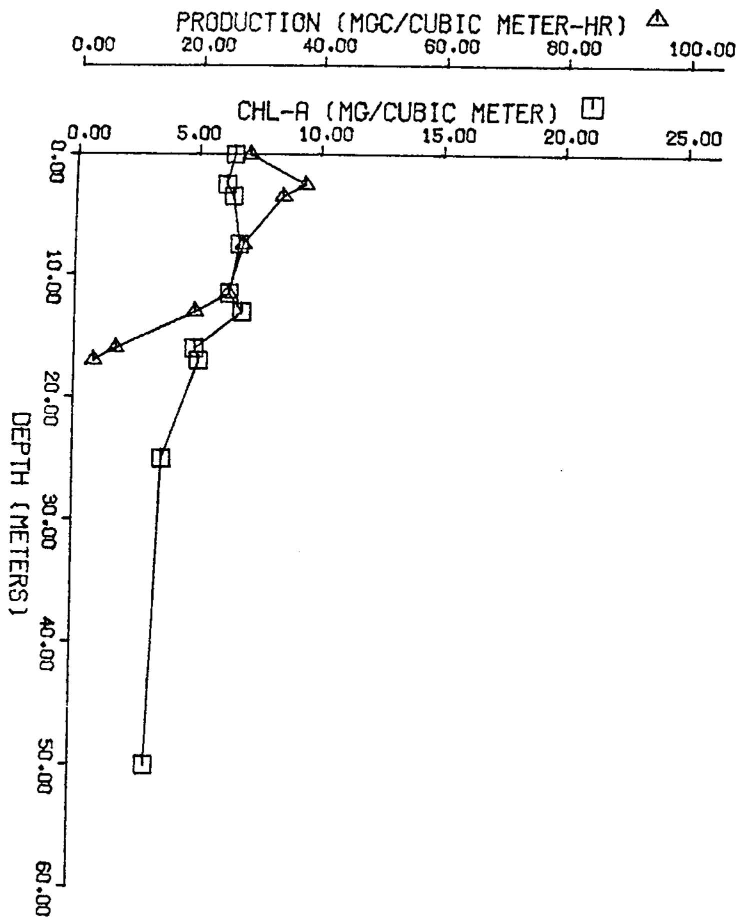


NO VALUES FOR VARIABLE WITH SYMBOL △

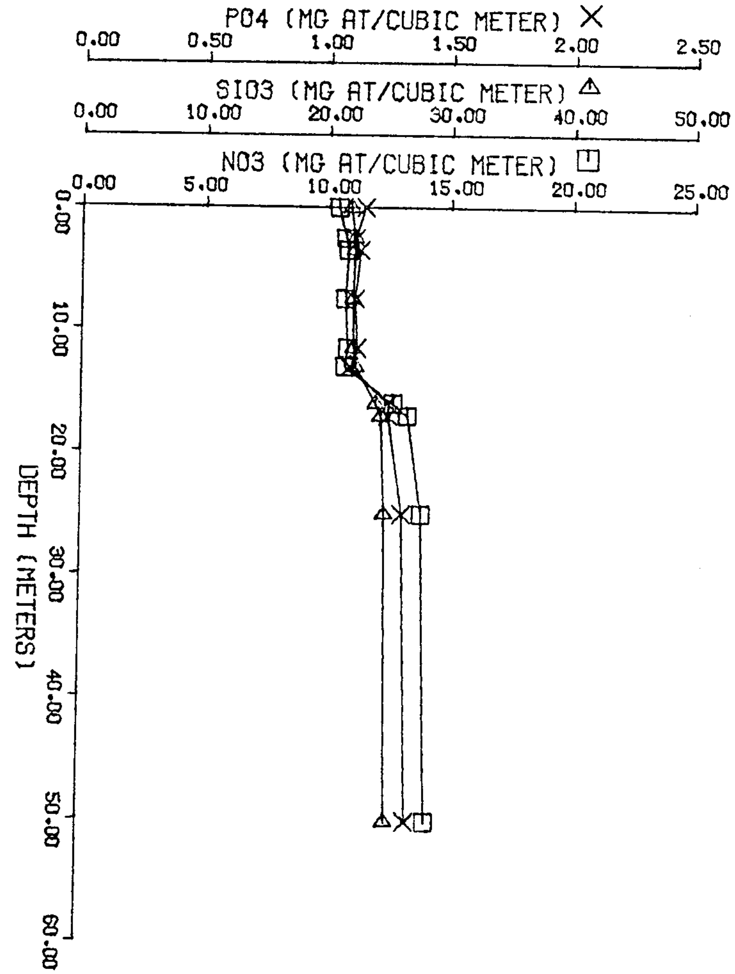
CRUISE GOA4
STATION 00001



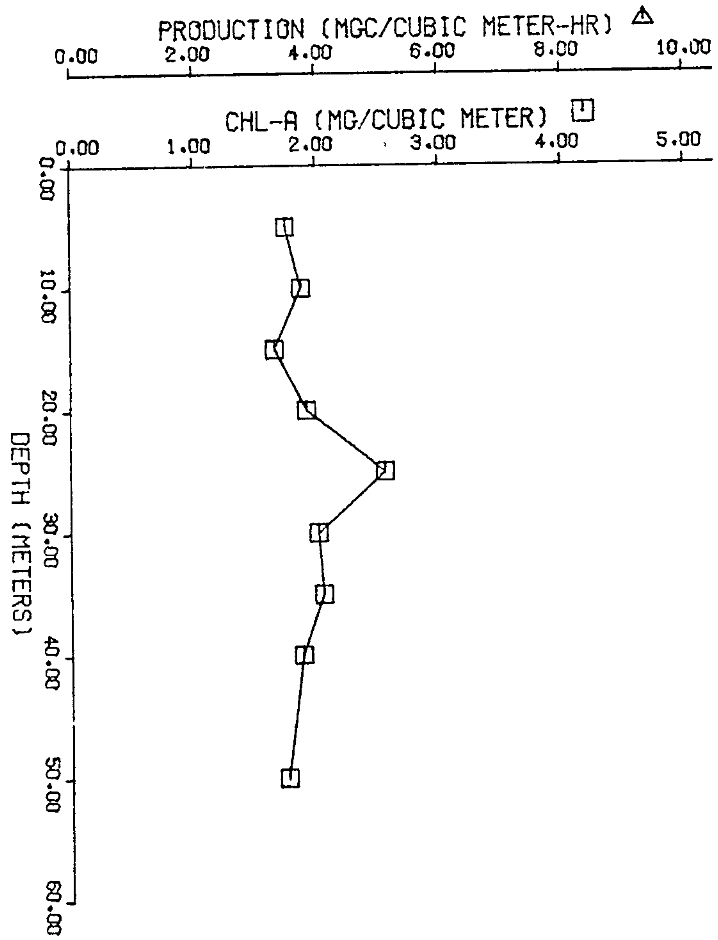
CRUISE GOA4
STATION 00002



CRUISE GOA4
STATION 00002

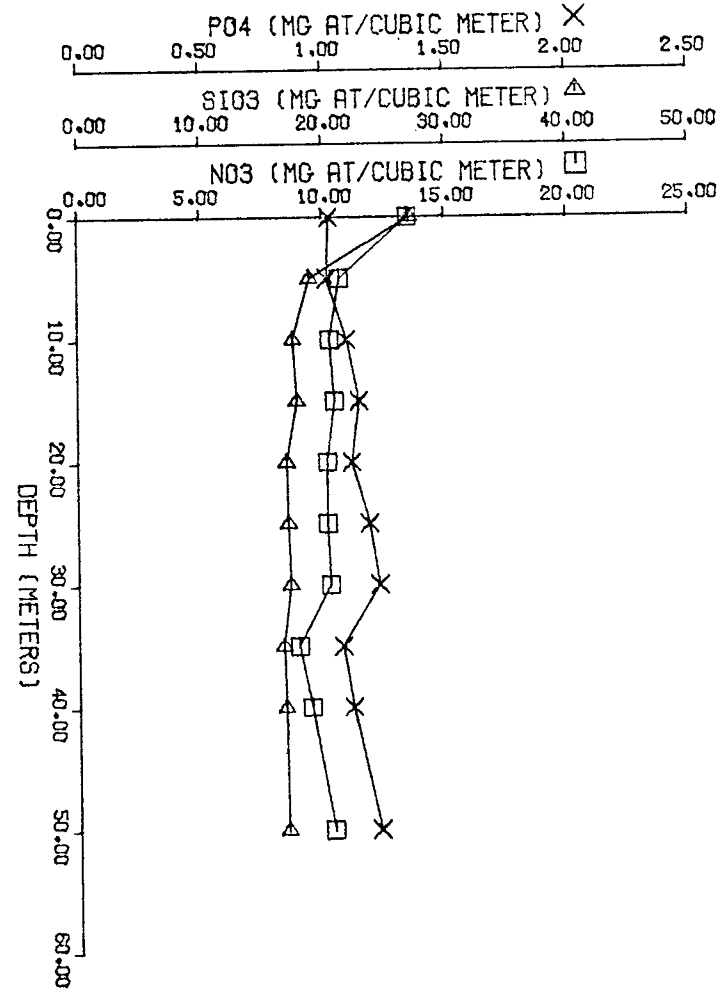


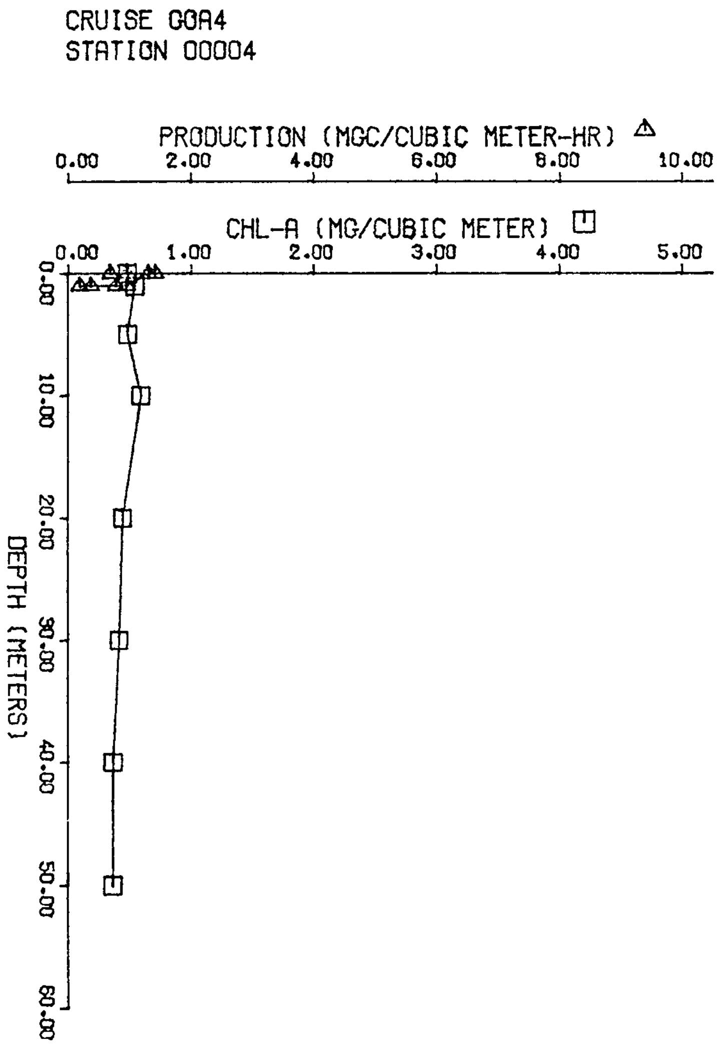
CRUISE GOA4
STATION 00003



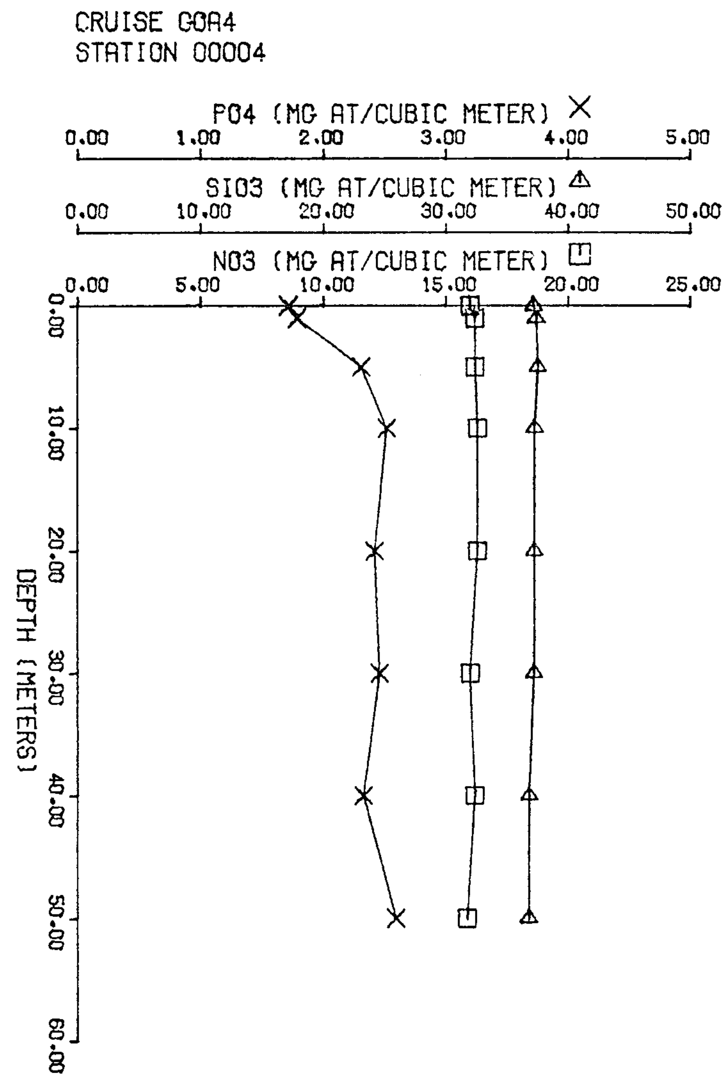
NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA4
STATION 00003

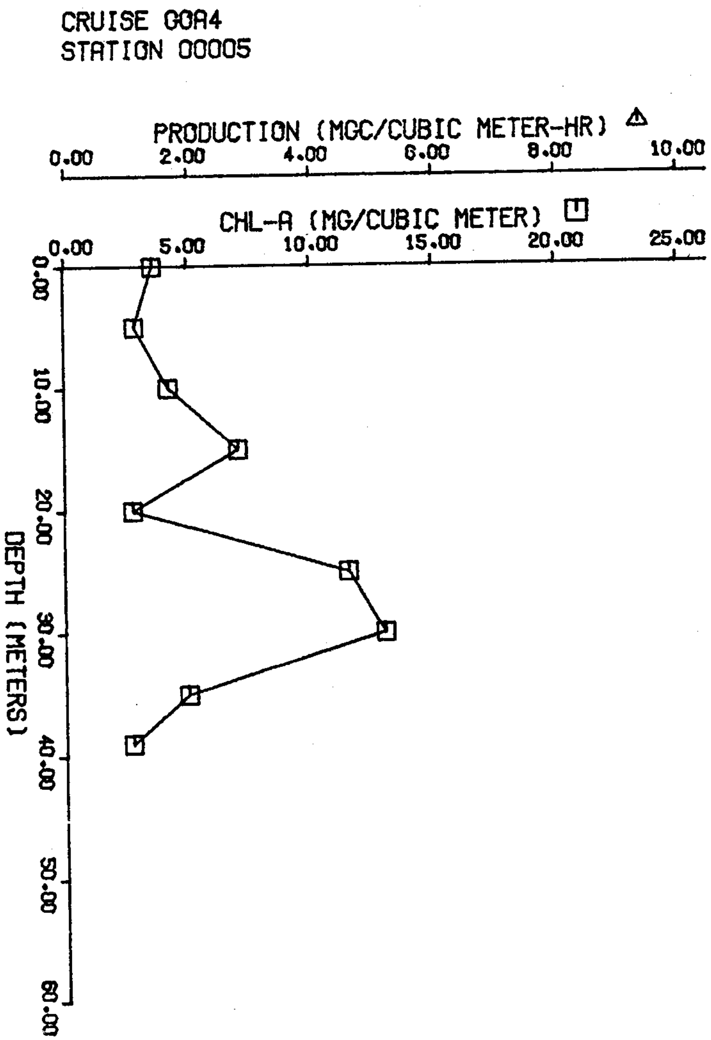




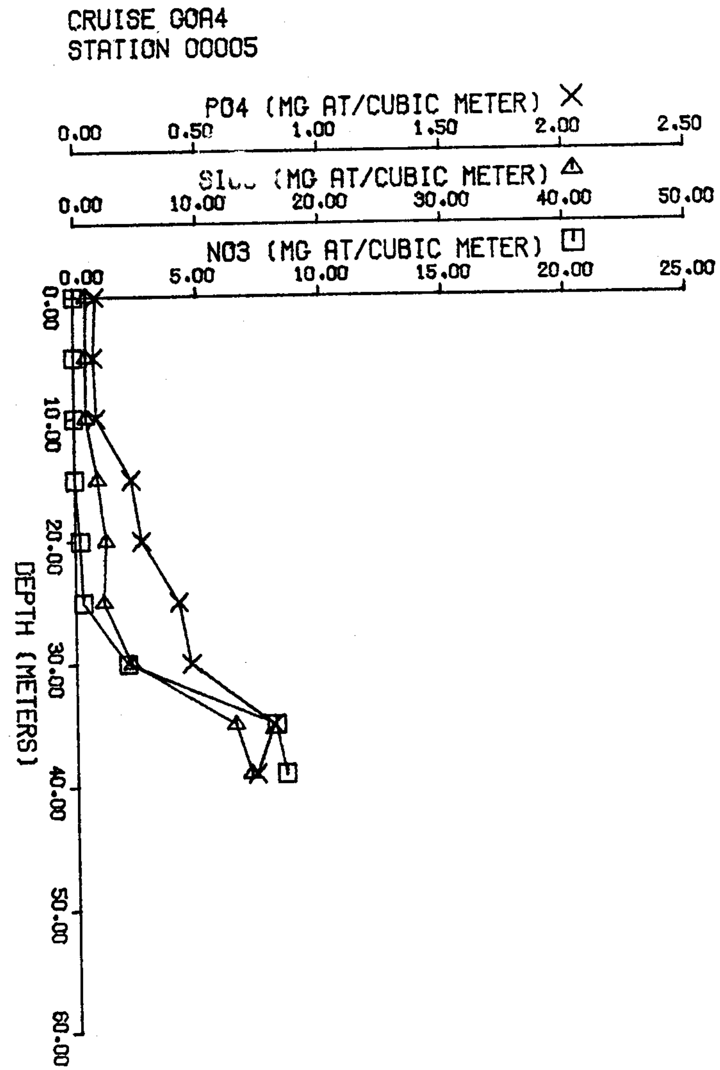
CRUISE GOA4
STATION 00004
PRODUCTION (MGC/CUBIC METER-HR)
0.00 2.00 4.00 6.00 8.00 10.00
CHL-A (MG/CUBIC METER)
0.00 1.00 2.00 3.00 4.00 5.00
DEPTH (METERS)
0.00 10.00 20.00 30.00 40.00 50.00 60.00

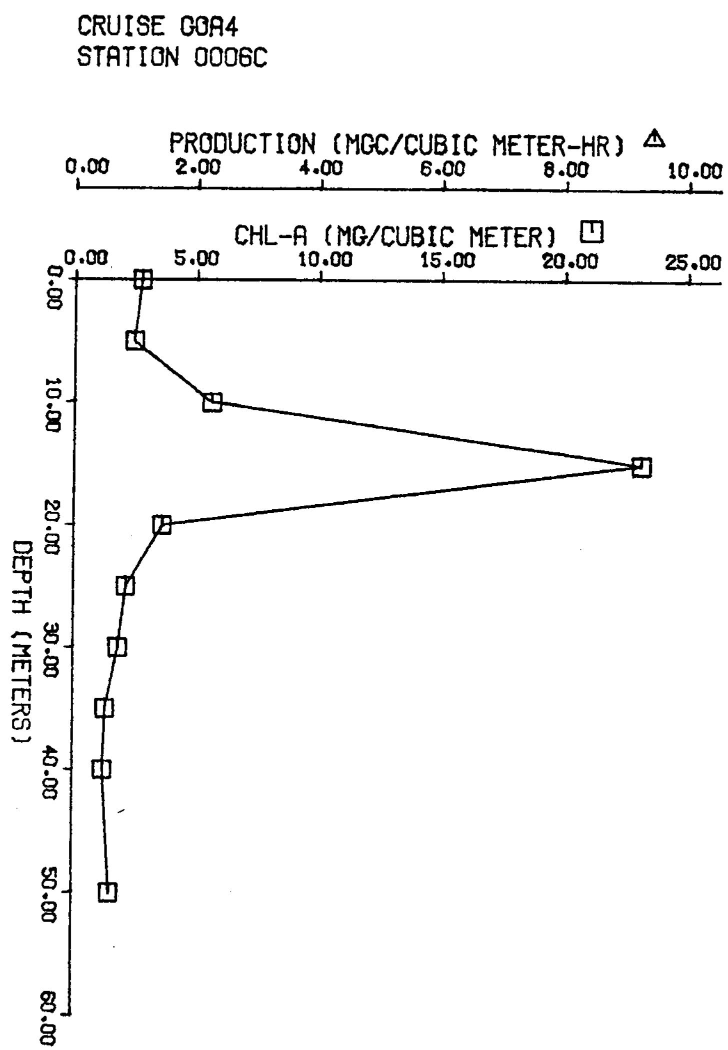


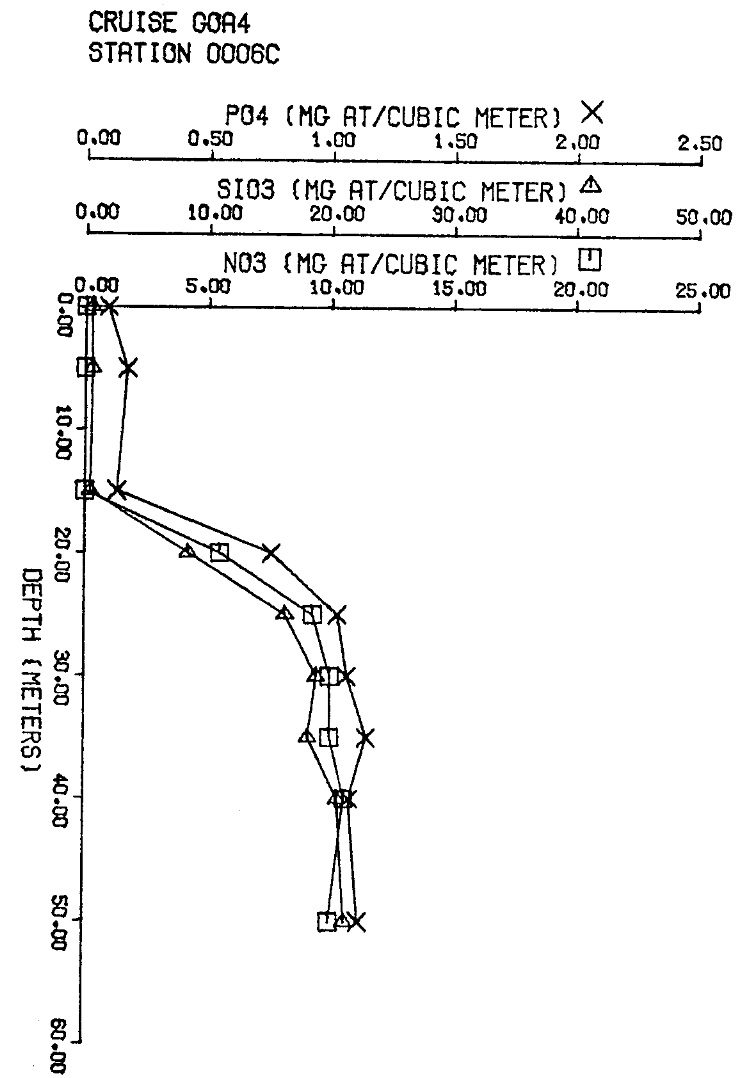
CRUISE GOA4
STATION 00004
PO4 (MG AT/CUBIC METER)
0.00 1.00 2.00 3.00 4.00 5.00
SIO3 (MG AT/CUBIC METER)
0.00 10.00 20.00 30.00 40.00 50.00
NO3 (MG AT/CUBIC METER)
0.00 5.00 10.00 15.00 20.00 25.00
DEPTH (METERS)
0.00 10.00 20.00 30.00 40.00 50.00 60.00



NO VALUES FOR VARIABLE WITH SYMBOL △







NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA4
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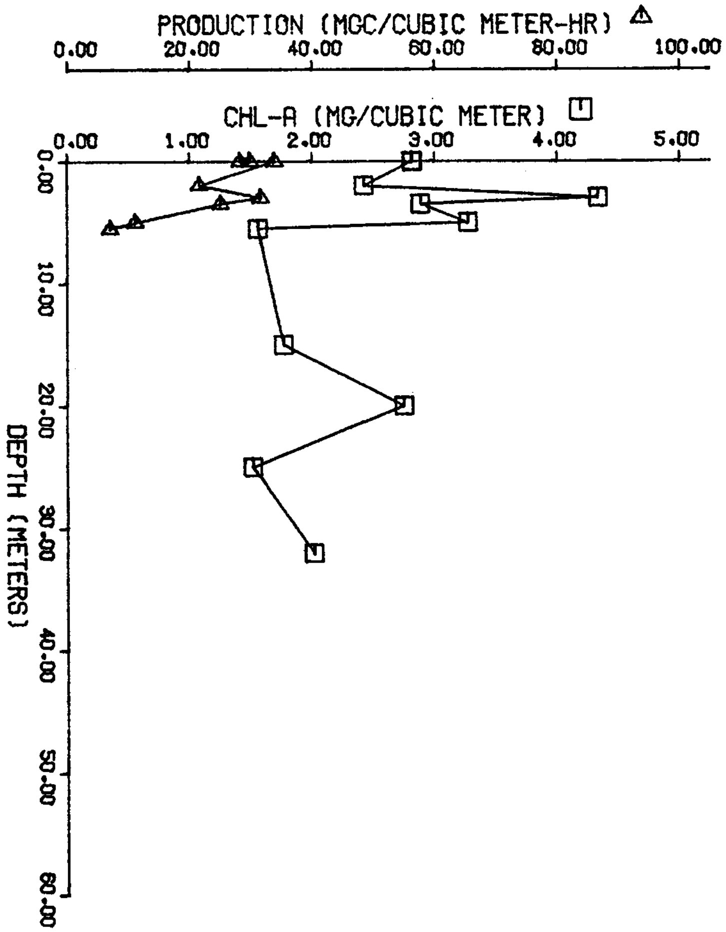
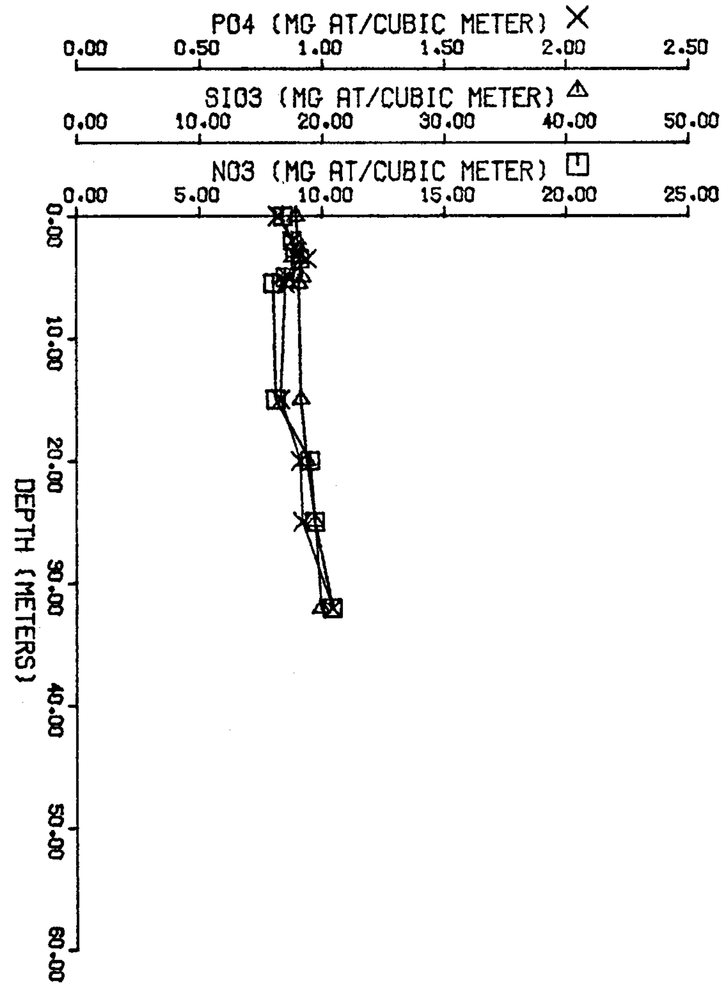
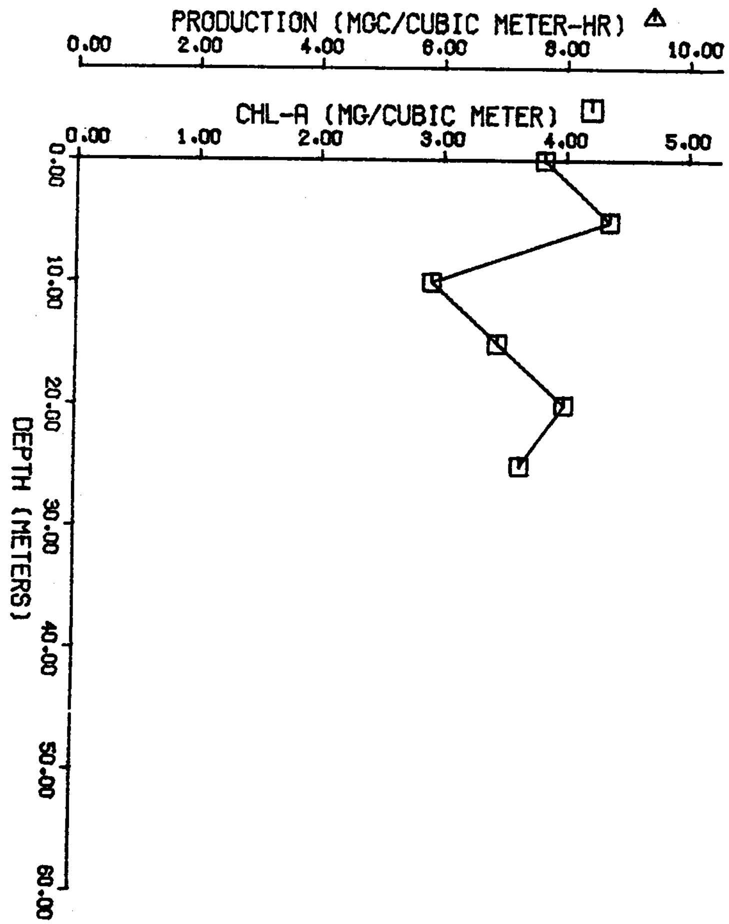


CRUISE GOA4
STATION 00007

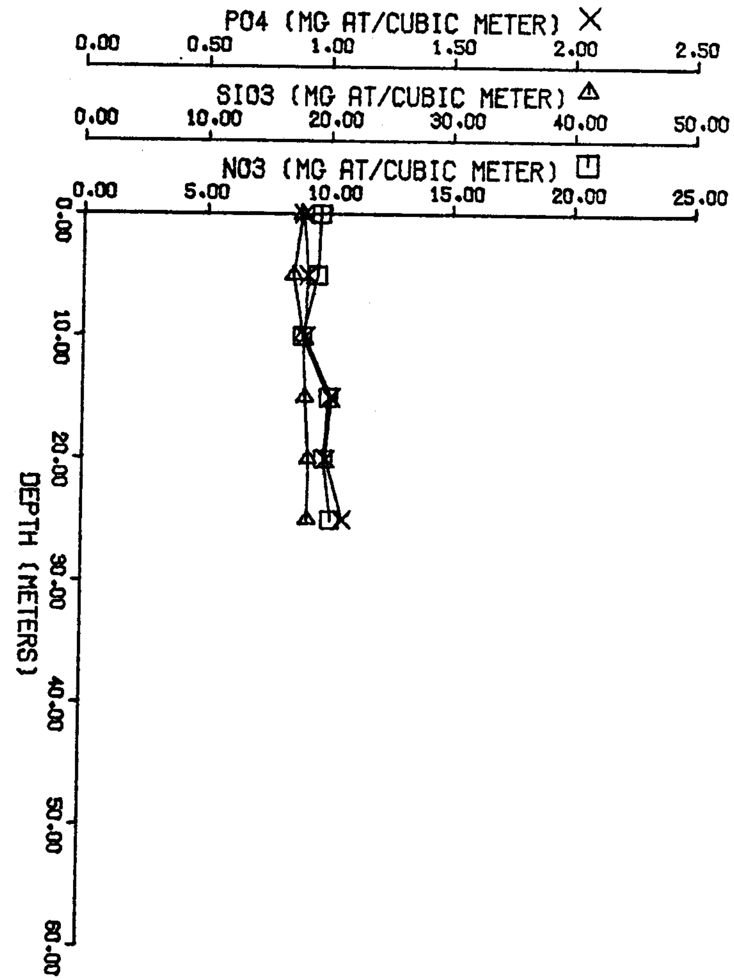


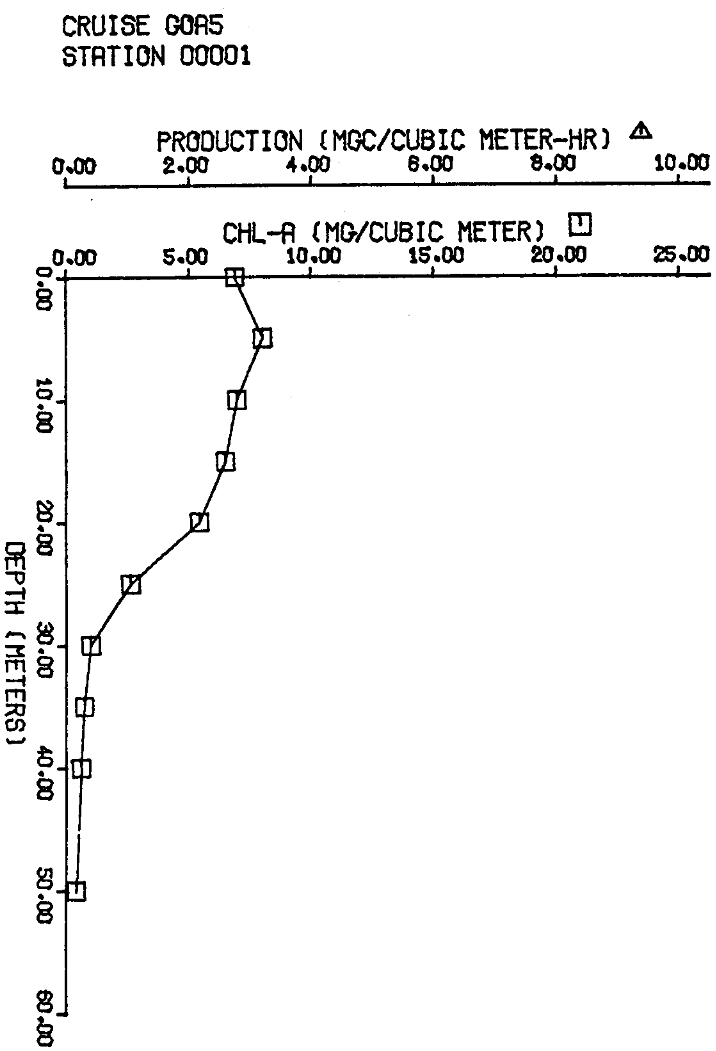
CRUISE GOA4
STATION 00008



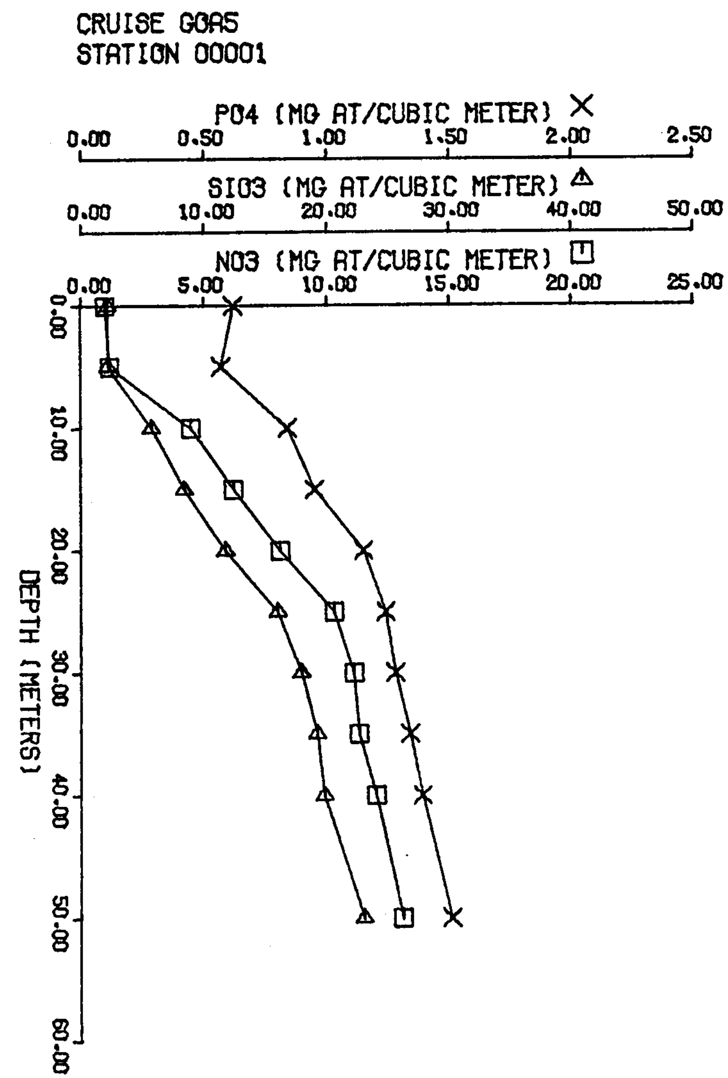
NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA4
STATION 00008

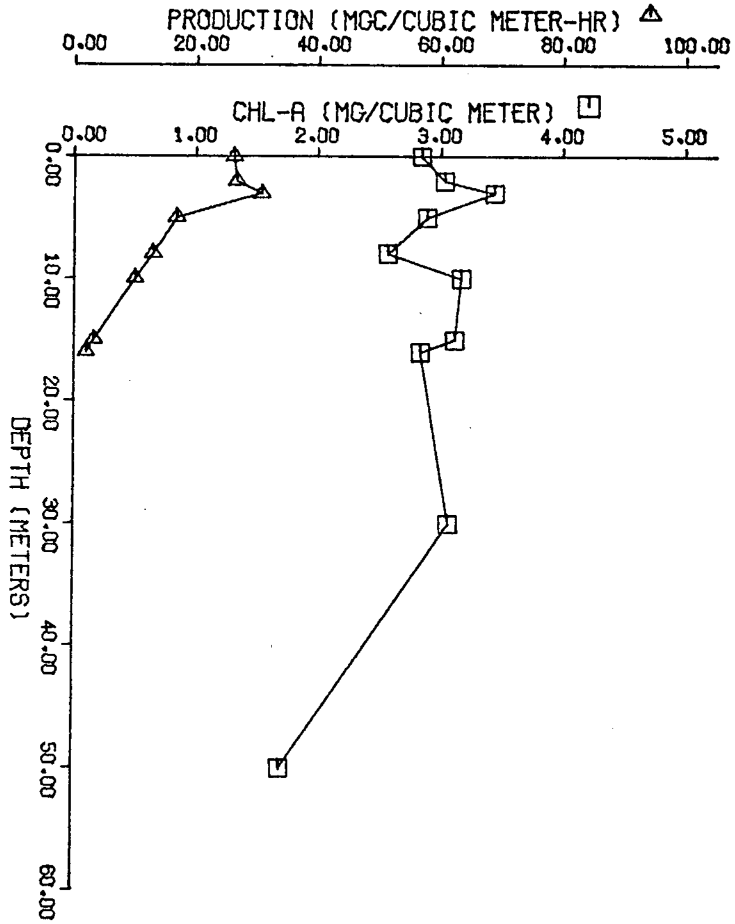




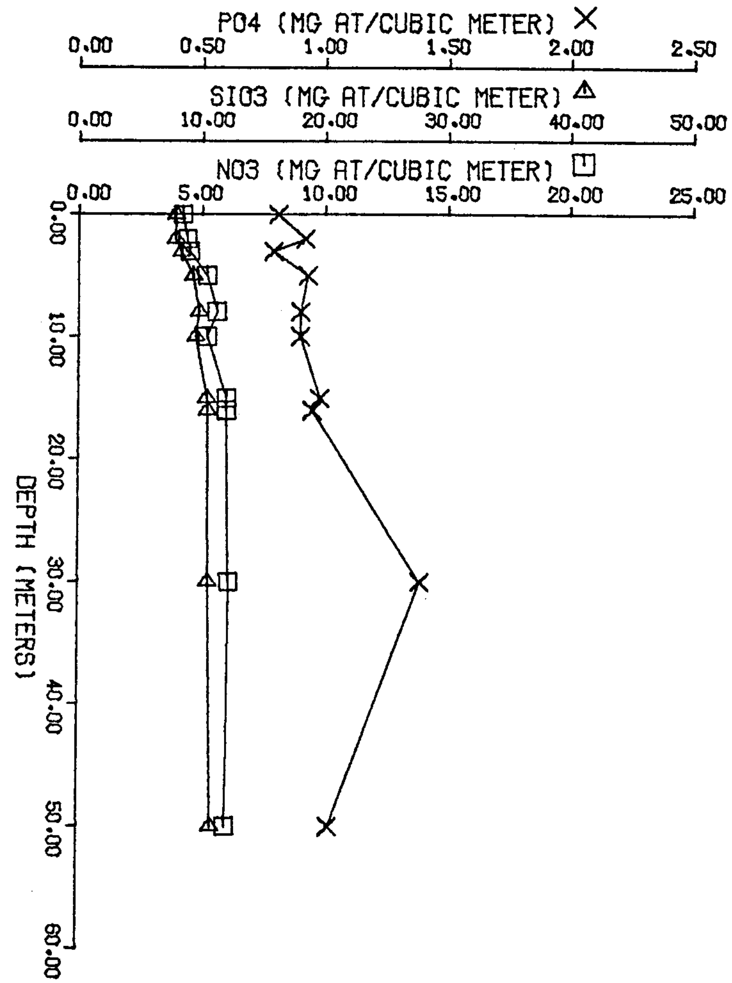
NO VALUES FOR VARIABLE WITH SYMBOL △

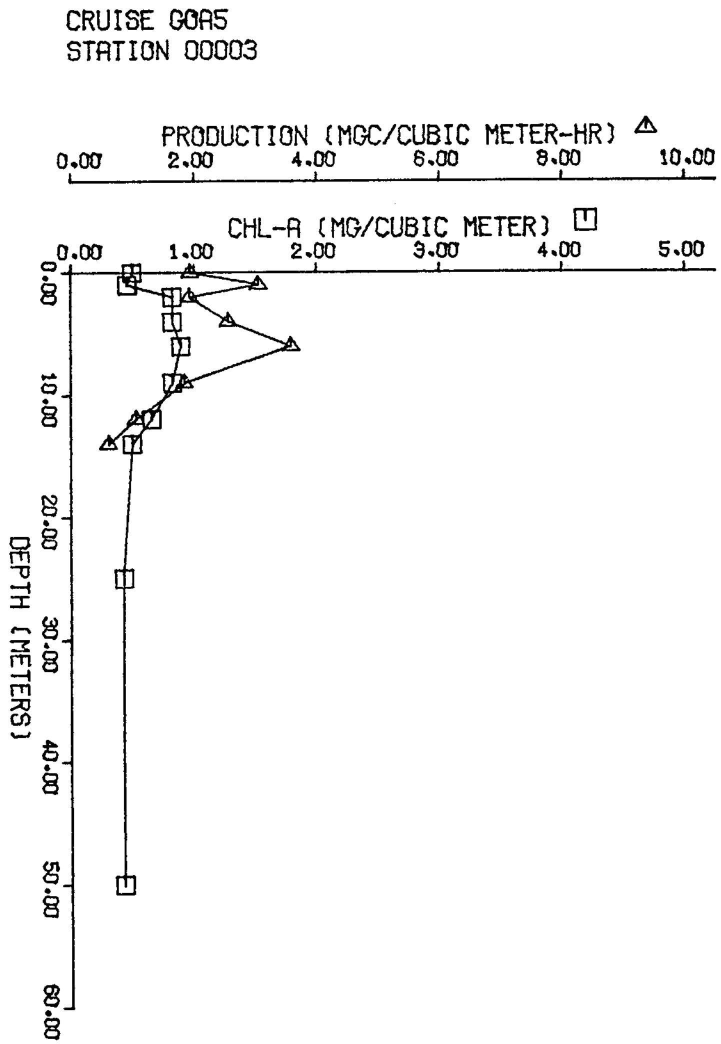


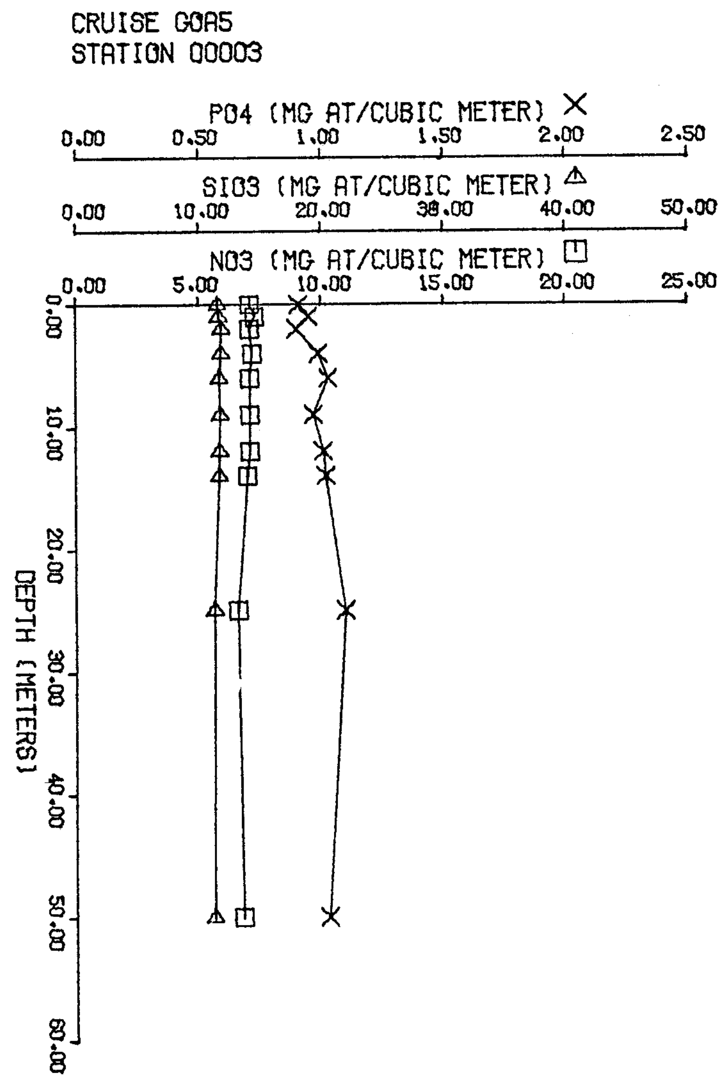
CRUISE GOA5
STATION 00002



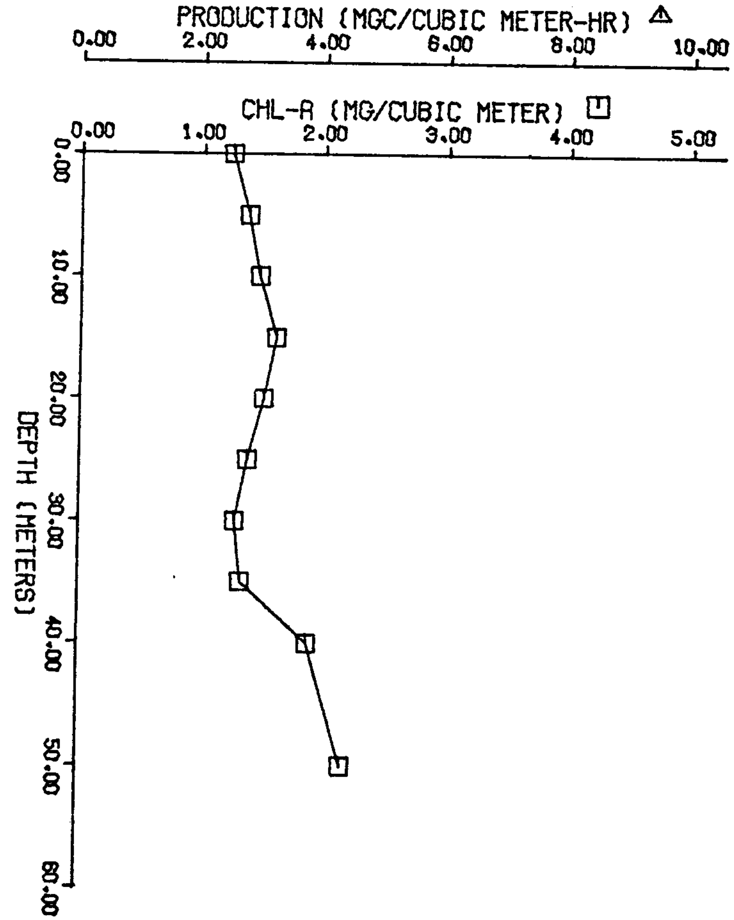
CRUISE GOA5
STATION 00002




CRUISE GOA5
STATION 00003
PRODUCTION (MGC/CUBIC METER-HR)
0.00
2.00
4.00
6.00
8.00
10.00
CHL-A (MG/CUBIC METER)
0.00
1.00
2.00
3.00
4.00
5.00
DEPTH (METERS)
0.00
10.00
20.00
30.00
40.00
50.00
60.00

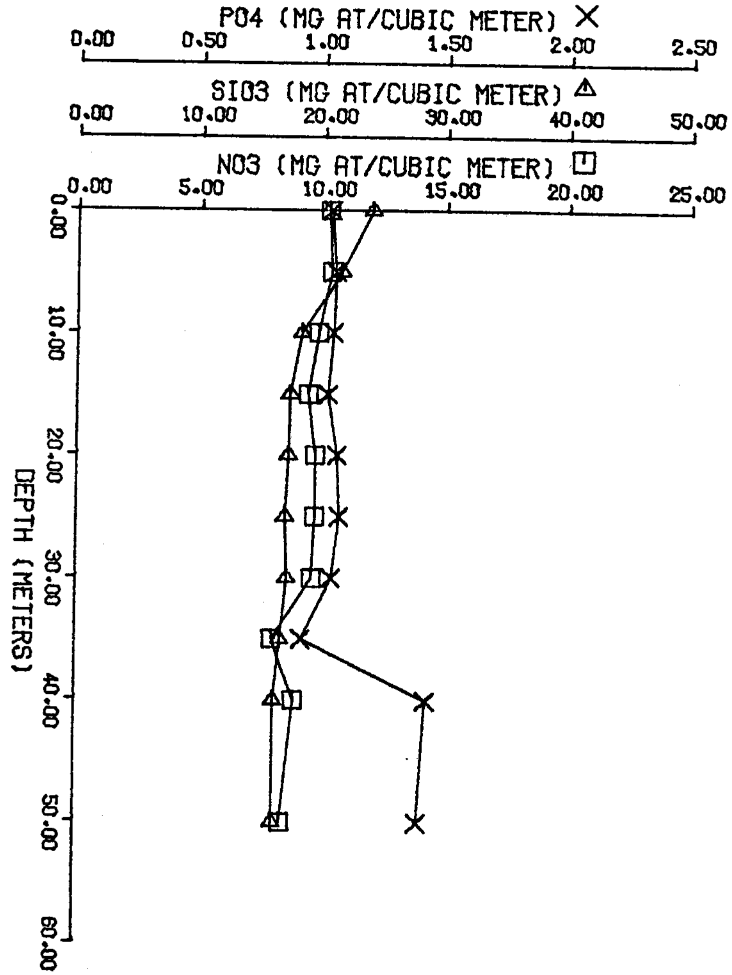

CRUISE GOA5
STATION 00003
PO4 (MG AT/CUBIC METER)
0.00
0.50
1.00
1.50
2.00
2.50
SIO3 (MG AT/CUBIC METER)
0.00
10.00
20.00
30.00
40.00
50.00
NO3 (MG AT/CUBIC METER)
0.00
5.00
10.00
15.00
20.00
25.00
DEPTH (METERS)
0.00
10.00
20.00
30.00
40.00
50.00
60.00

CRUISE GOA5
STATION 00004

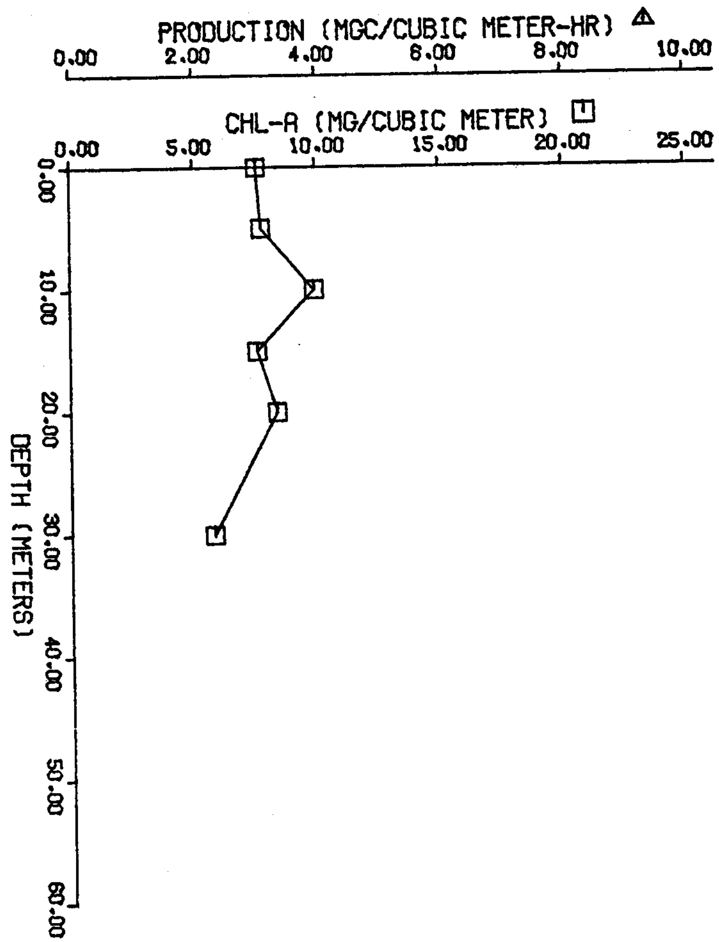


NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA5
STATION 00004

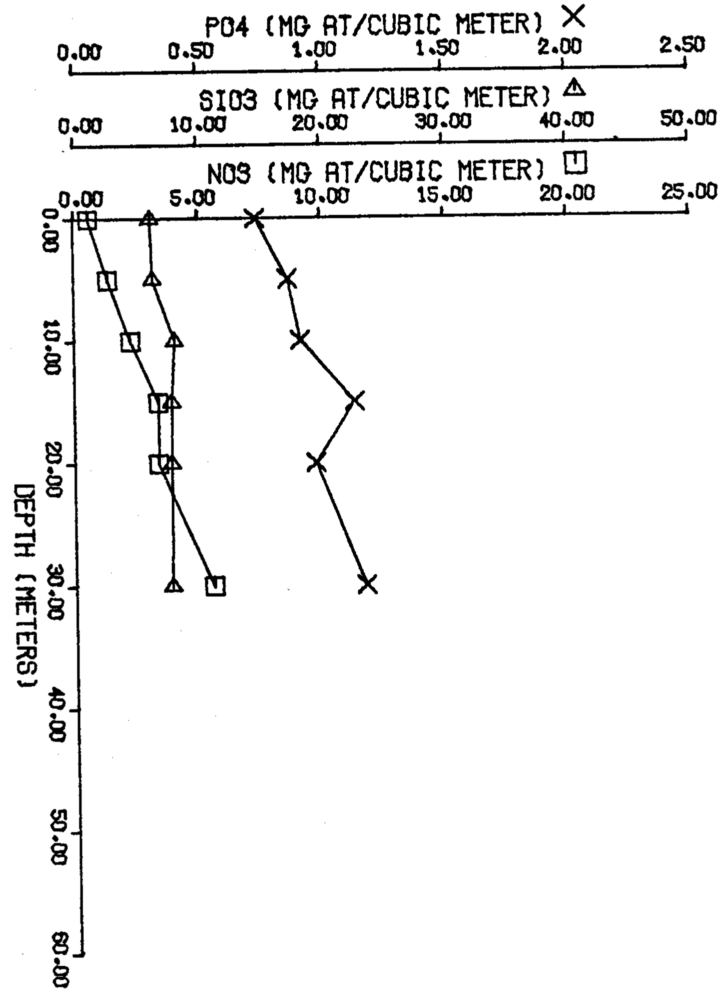


CRUISE GOA5
STATION 00005

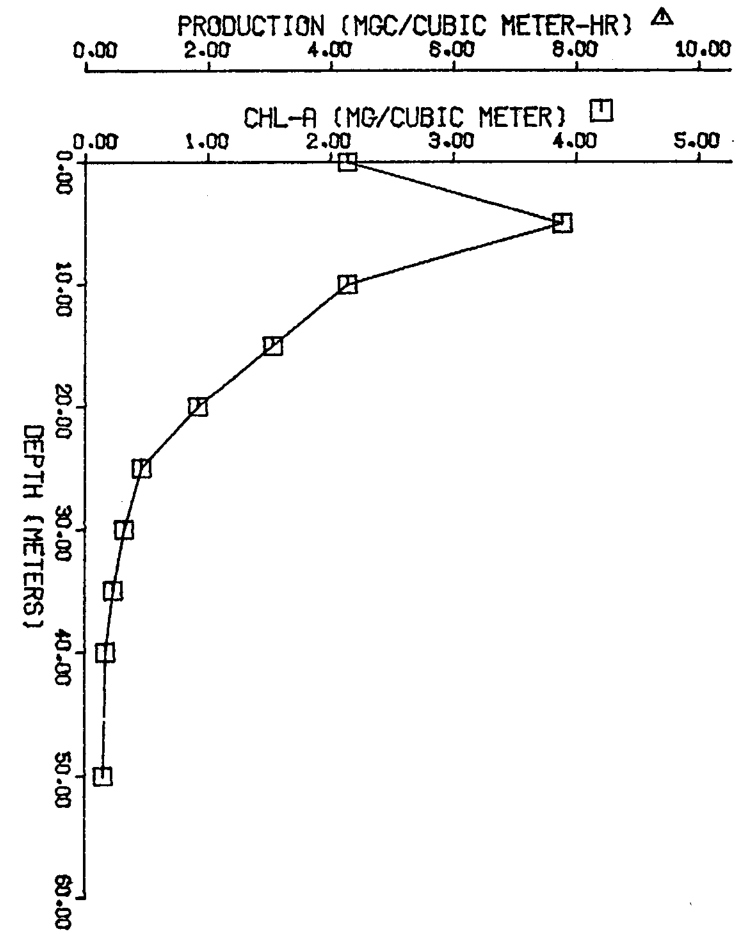


NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA5
STATION 00005

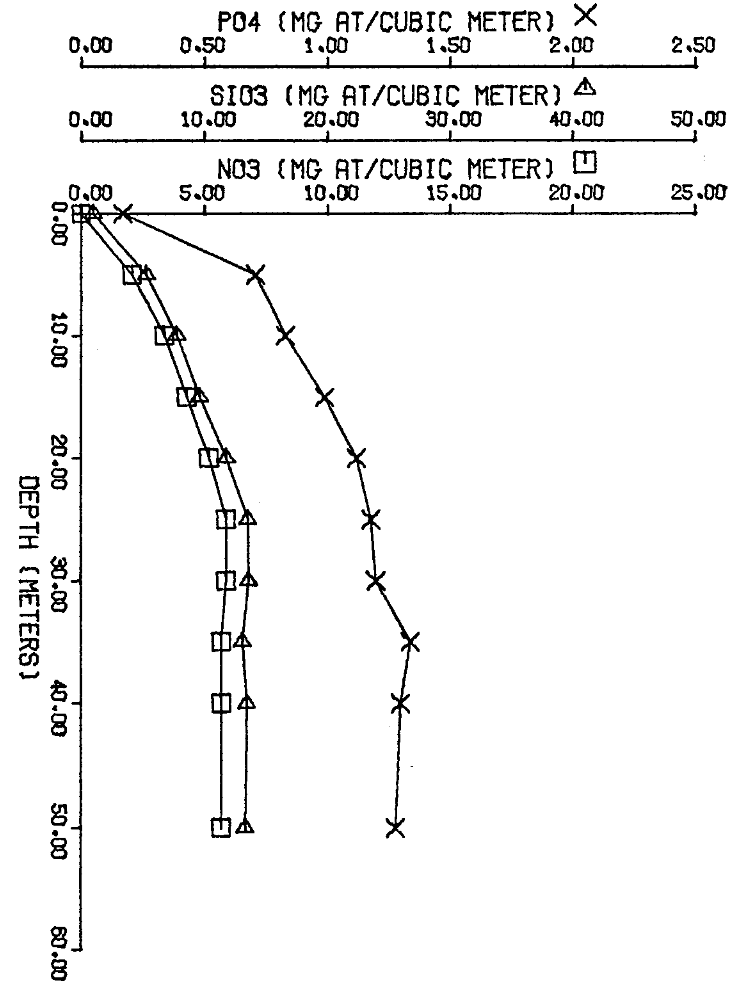


CRUISE GOA5
STATION 0006A

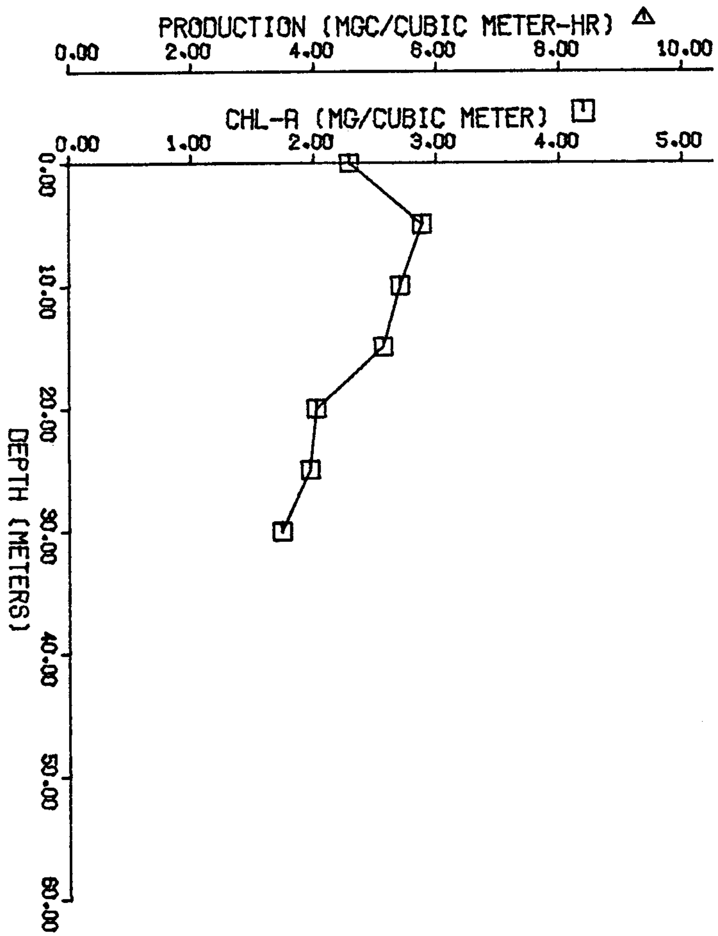


NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA5
STATION 0006A

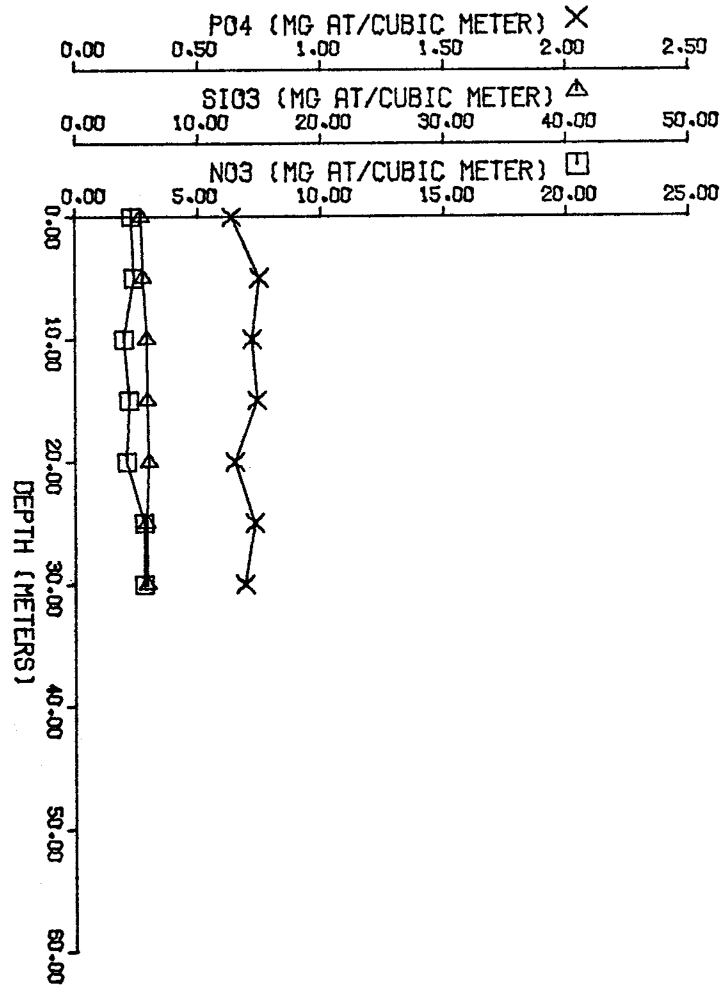


CRUISE GOA5
STATION 0007A



NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA5
STATION 0007A



CRUISE GOA5
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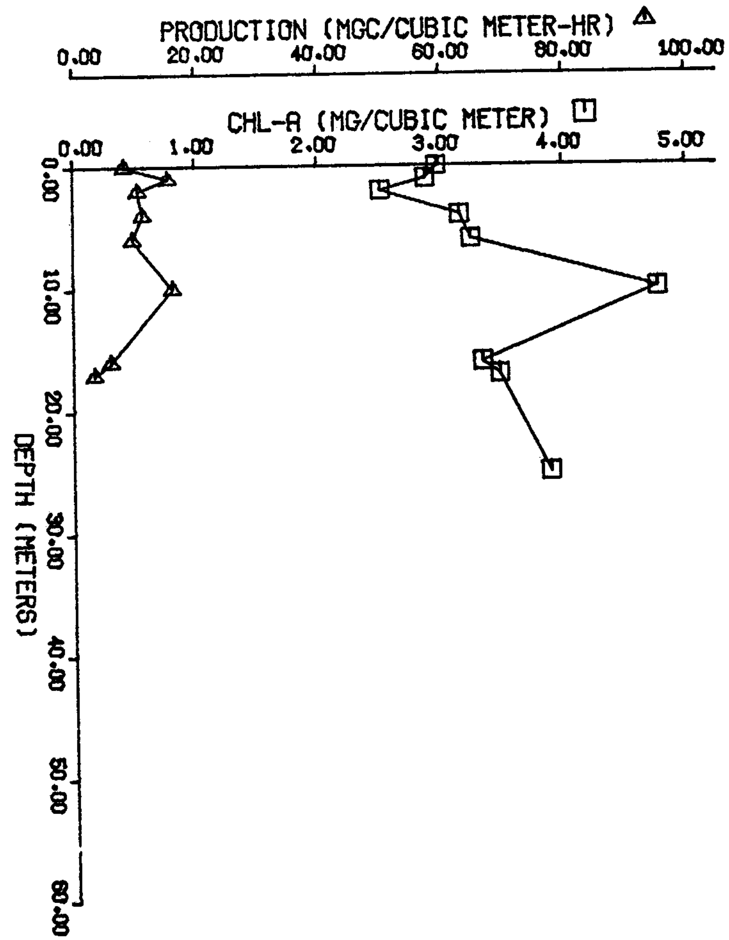
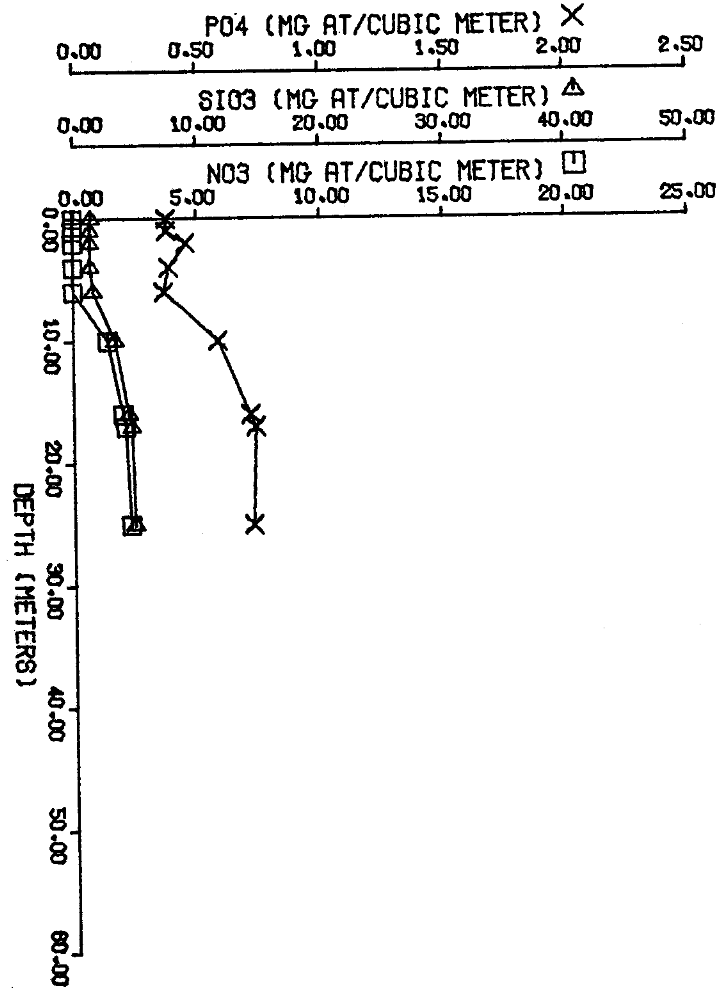
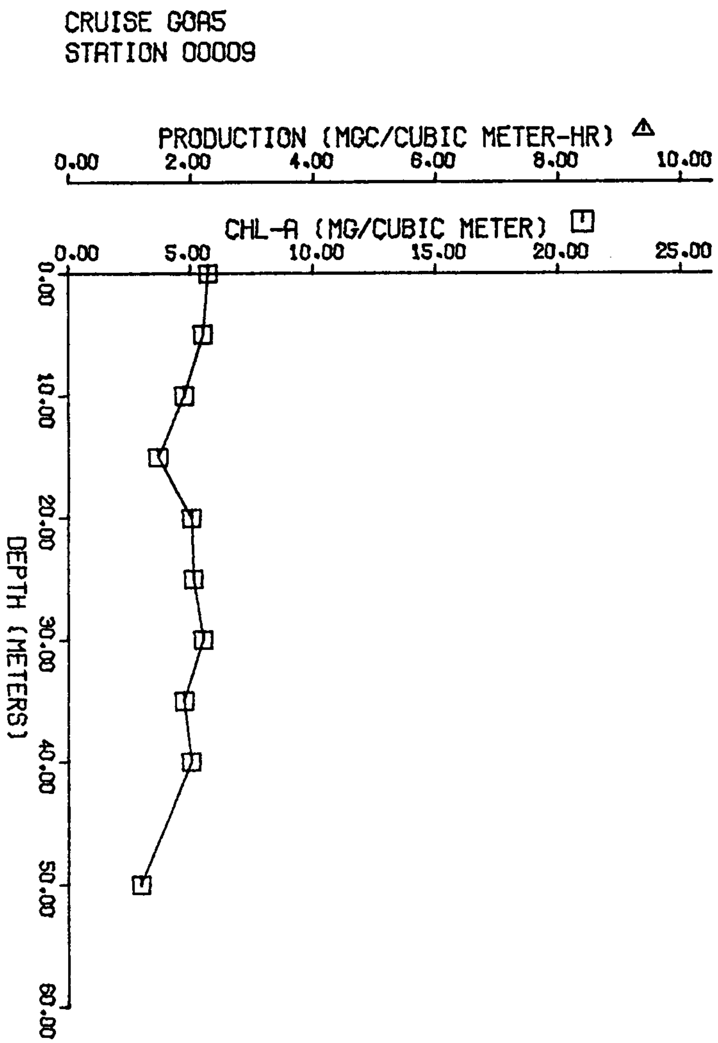
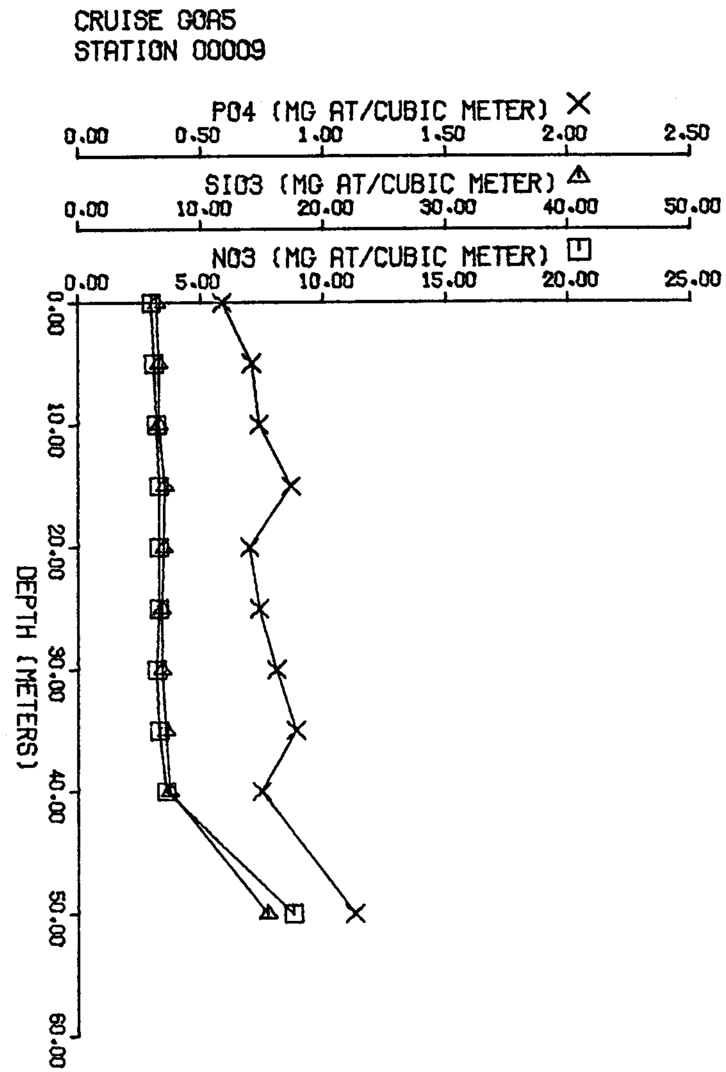


CRUISE GOA5
STATION 0008B

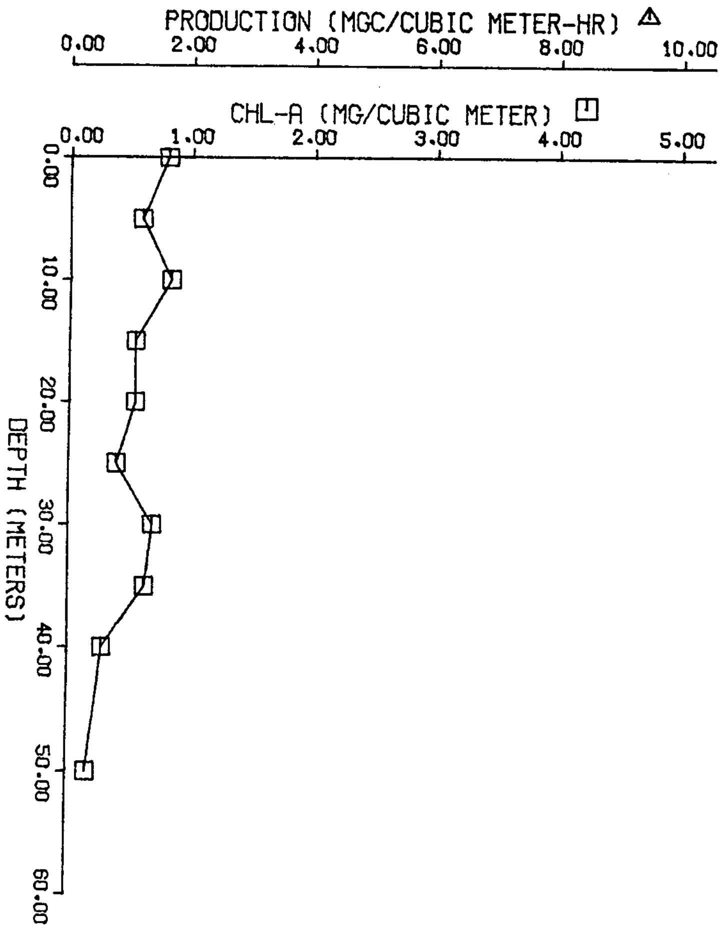




NO VALUES FOR VARIABLE WITH SYMBOL △

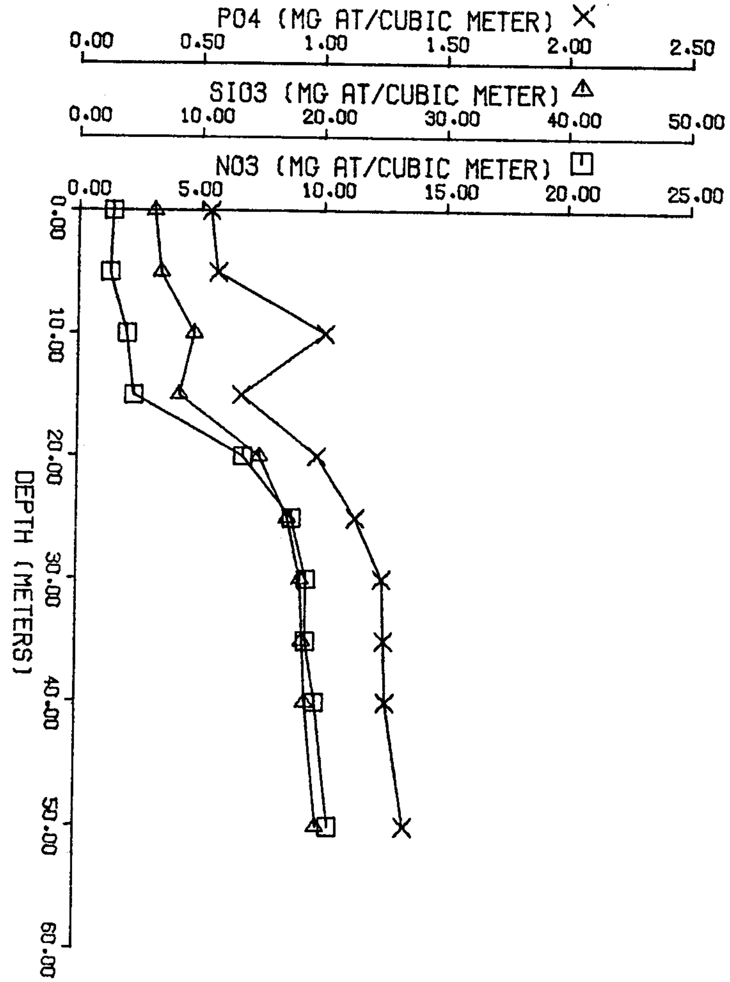


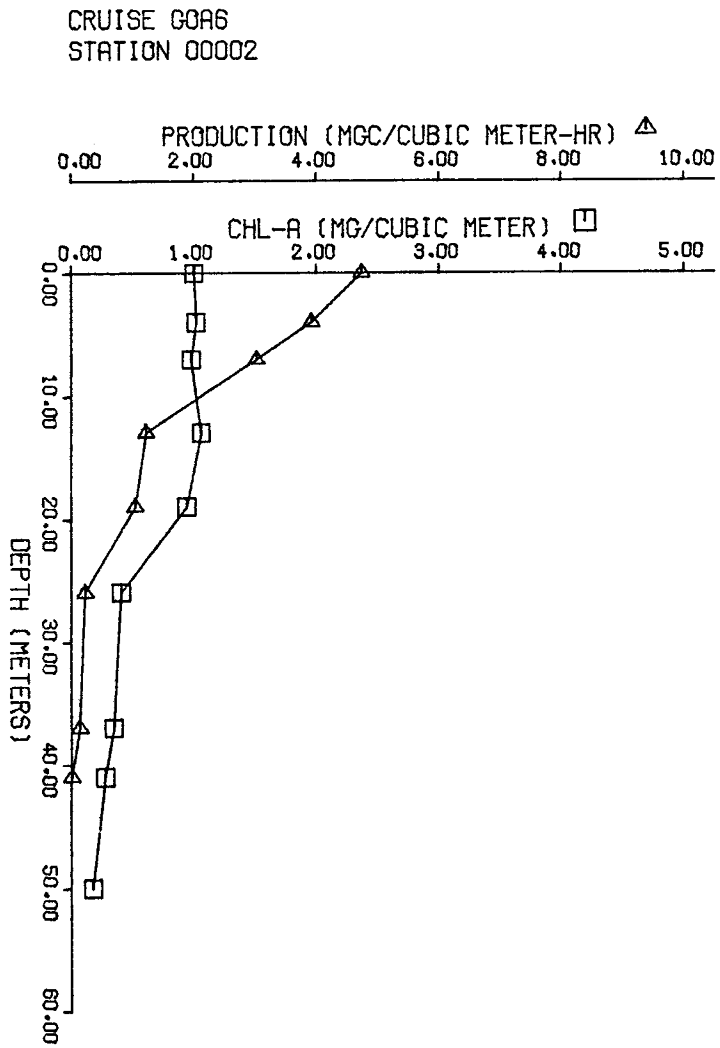
CRUISE GOA6
STATION 00001

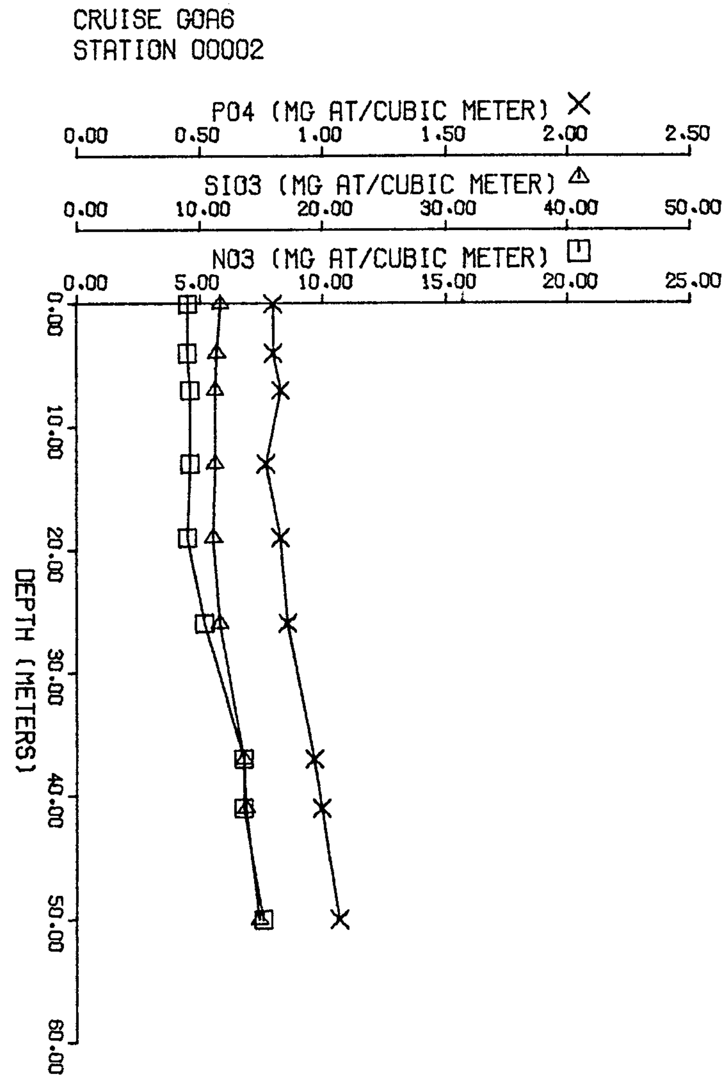


NO VALUES FOR VARIABLE WITH SYMBOL △

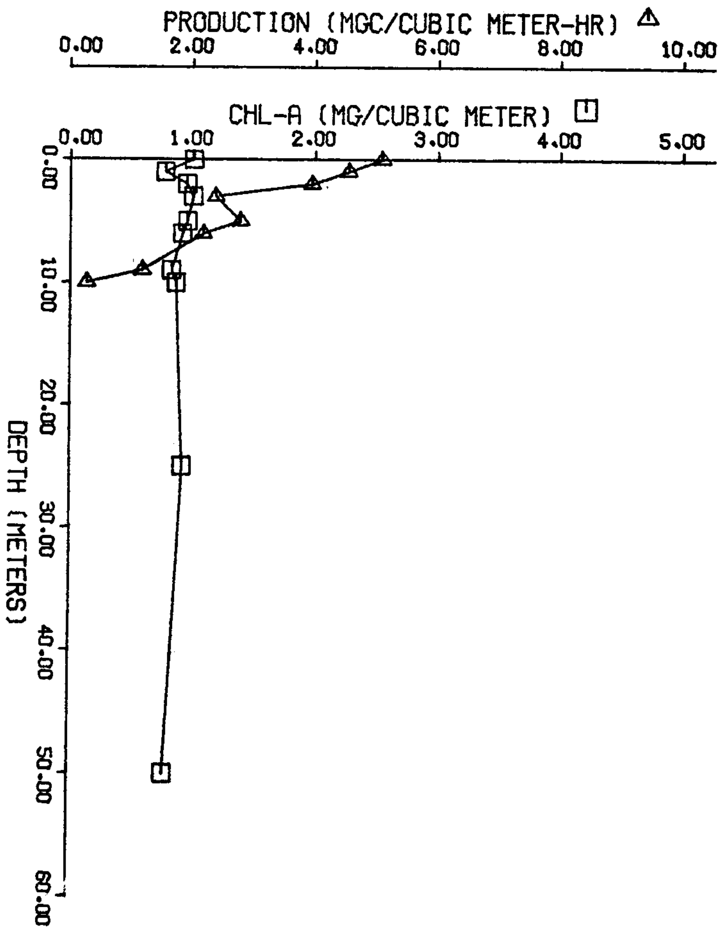
CRUISE GOA6
STATION 00001



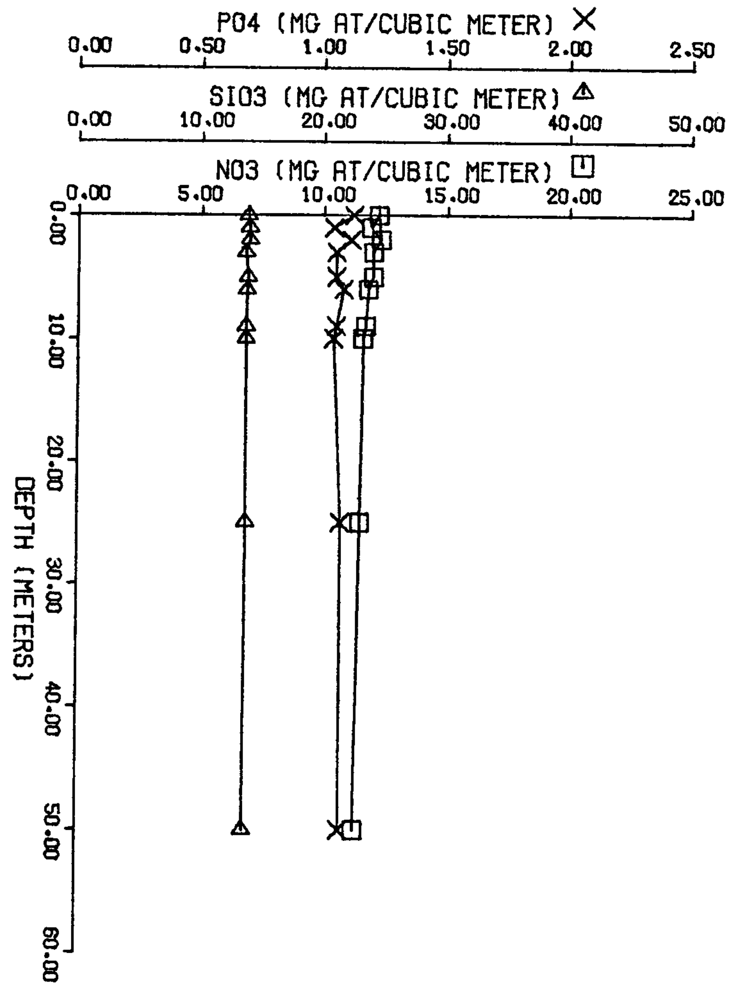

CRUISE GOA6
STATION 00002
PRODUCTION (MGC/CUBIC METER-HR)
0.00 2.00 4.00 6.00 8.00 10.00
CHL-A (MG/CUBIC METER)
0.00 1.00 2.00 3.00 4.00 5.00
DEPTH (METERS)
0.00 10.00 20.00 30.00 40.00 50.00 60.00


CRUISE GOA6
STATION 00002
PO4 (MG AT/CUBIC METER)
0.00 0.50 1.00 1.50 2.00 2.50
SIO3 (MG AT/CUBIC METER)
0.00 10.00 20.00 30.00 40.00 50.00
NO3 (MG AT/CUBIC METER)
0.00 5.00 10.00 15.00 20.00 25.00
DEPTH (METERS)
0.00 10.00 20.00 30.00 40.00 50.00 60.00

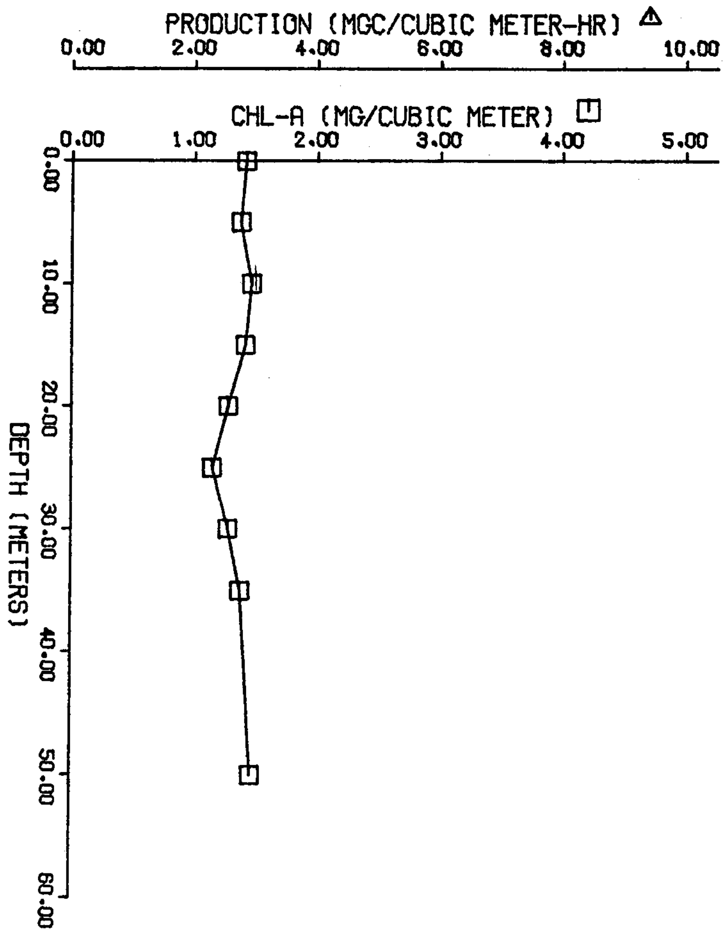
CRUISE GOA6
STATION 0003B



CRUISE GOA6
STATION 0003B

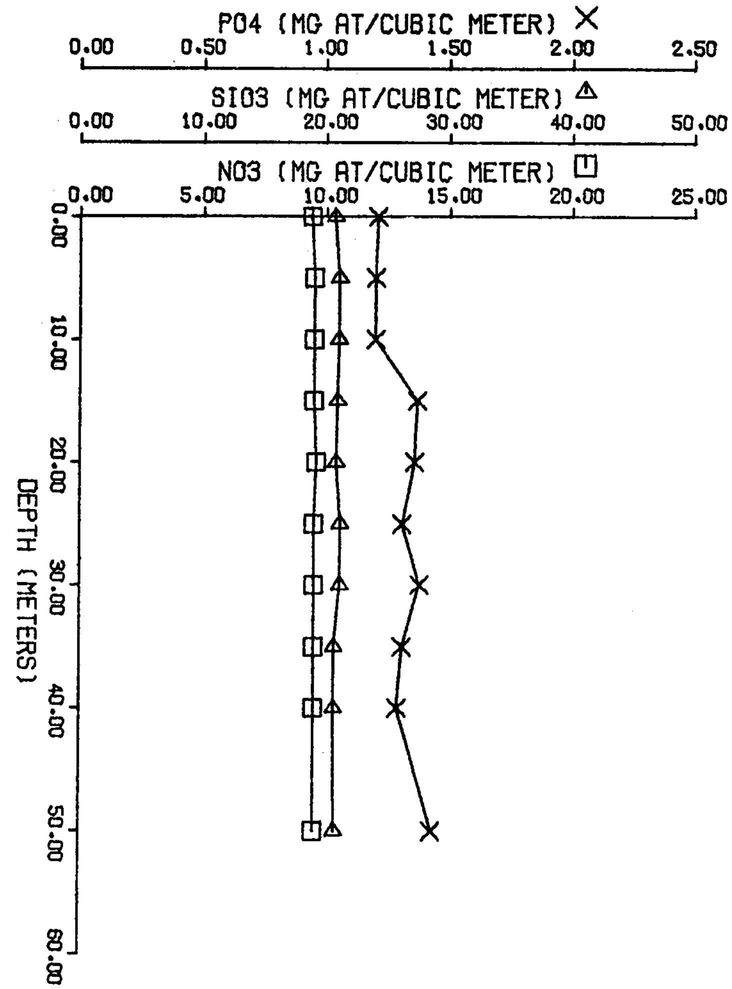


CRUISE GOA6
STATION 00004

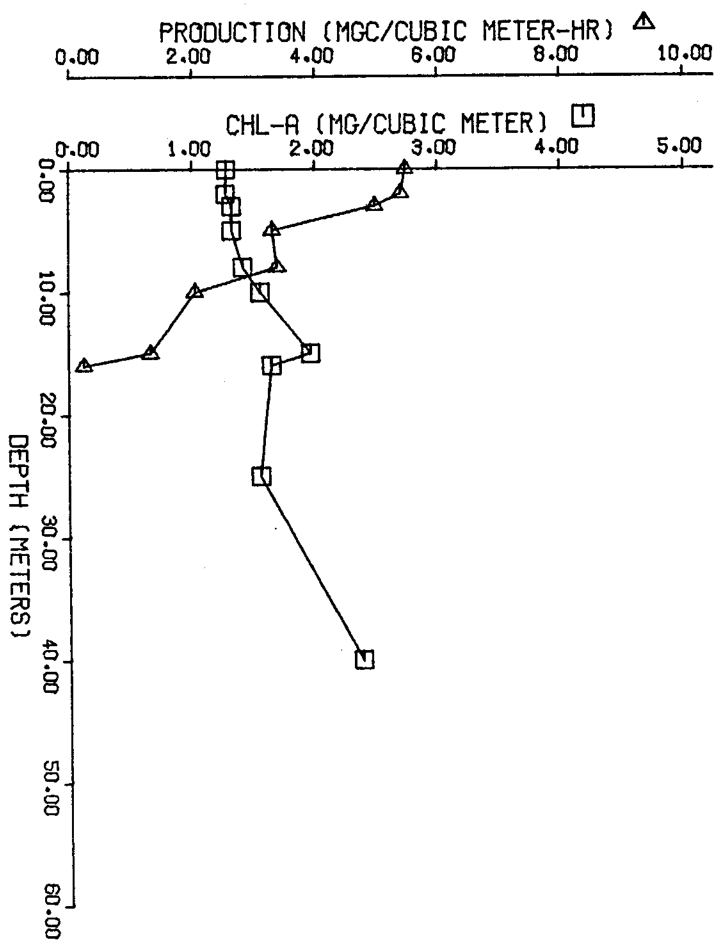


NO VALUES FOR VARIABLE WITH SYMBOL △

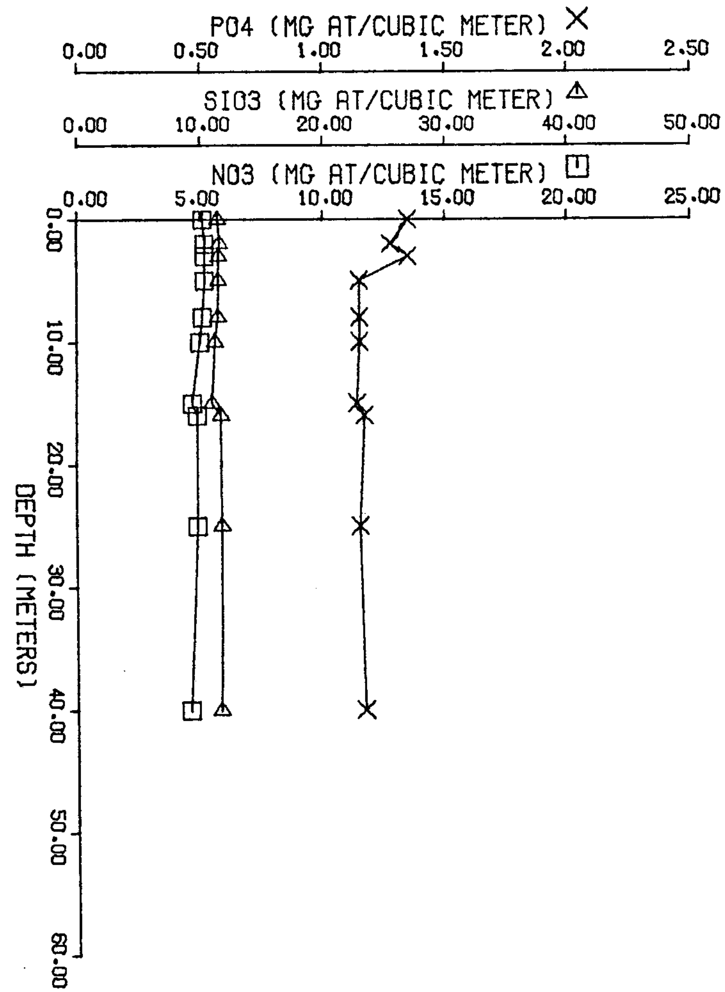
CRUISE GOA6
STATION 00004



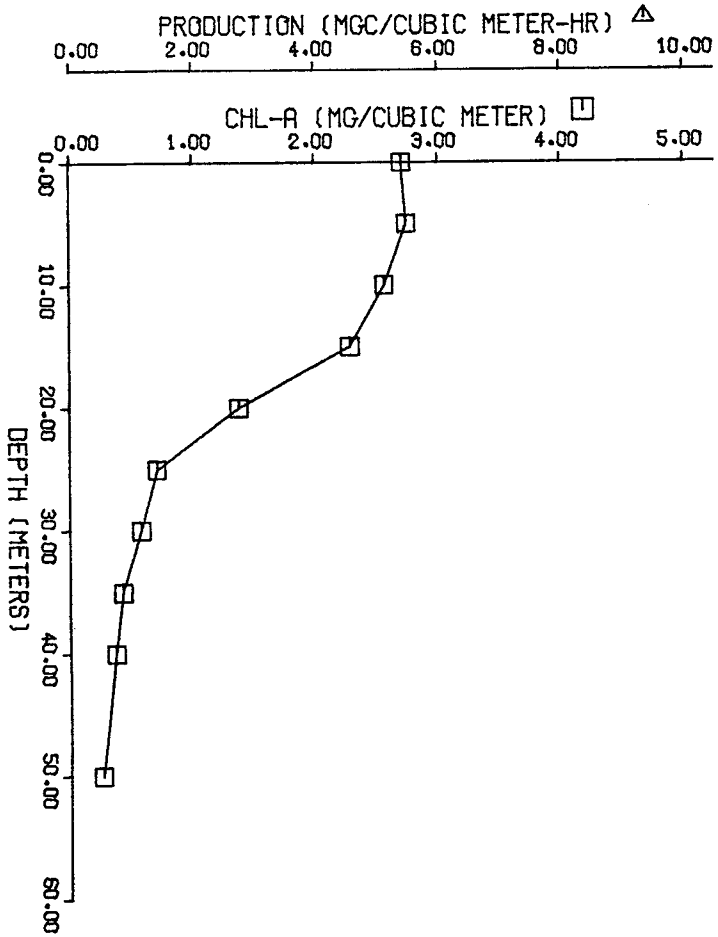
CRUISE GOA6
STATION 00005



CRUISE GOA6
STATION 00005

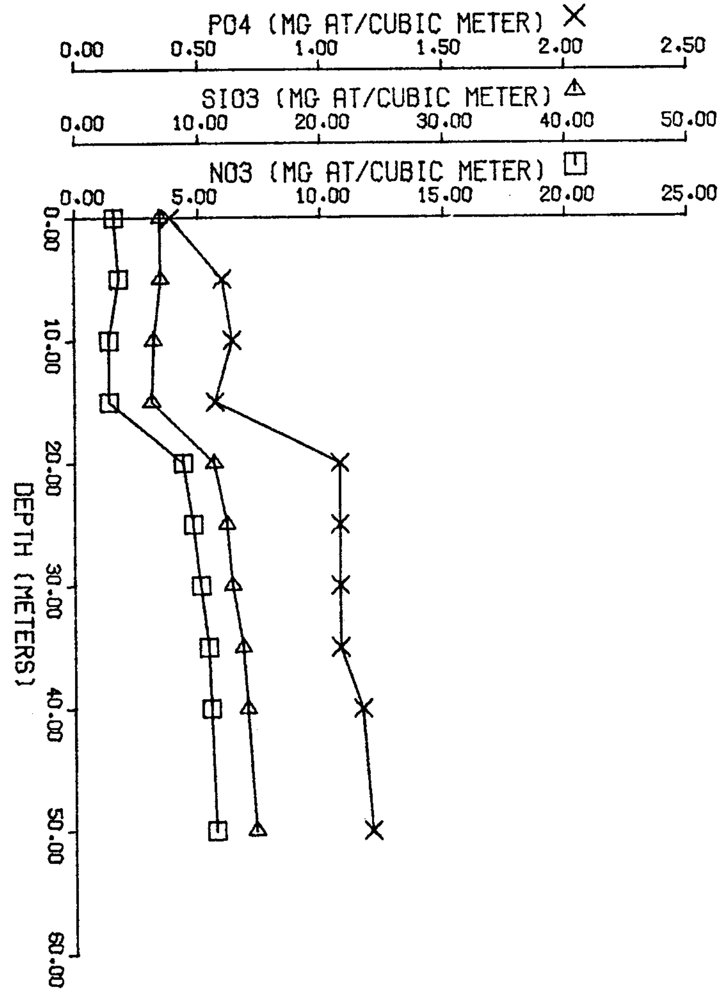


CRUISE GOA6
STATION 0006D

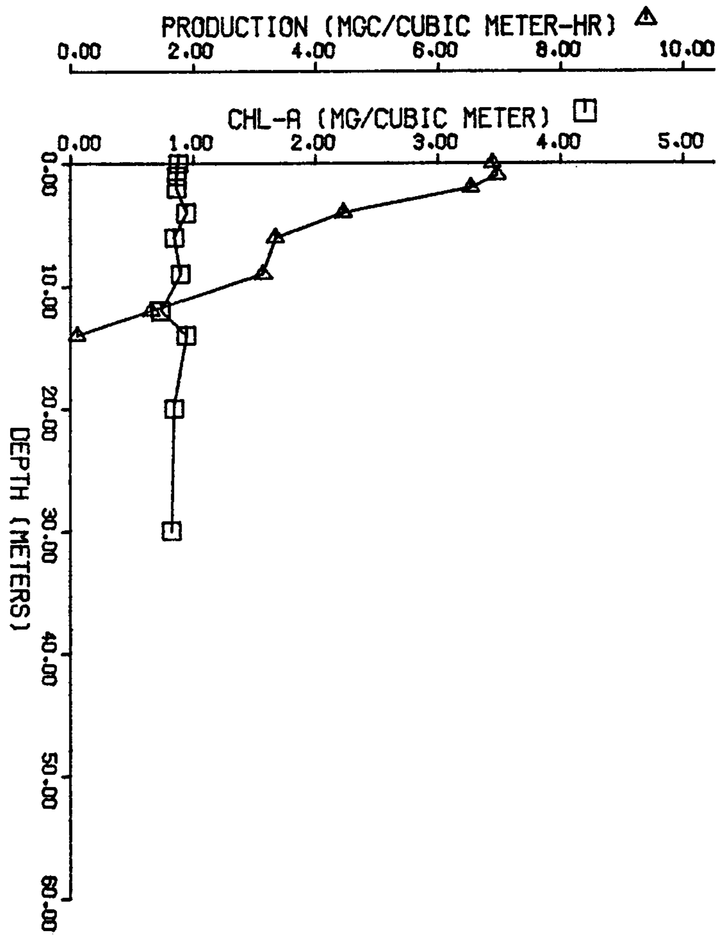


NO VALUES FOR VARIABLE WITH SYMBOL △

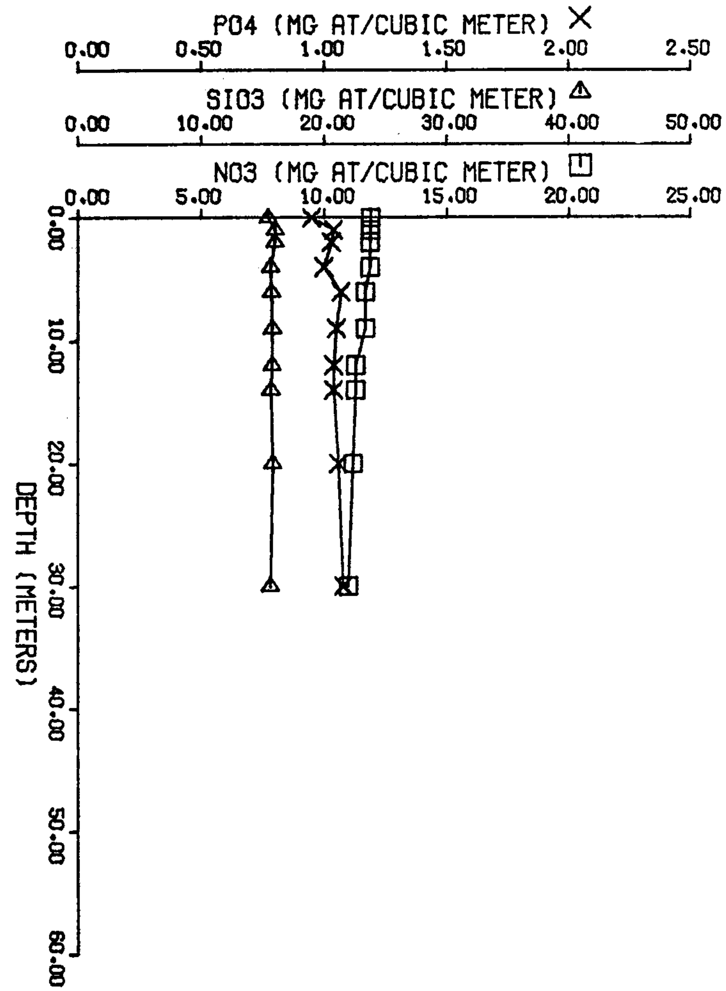
CRUISE GOA6
STATION 0006D

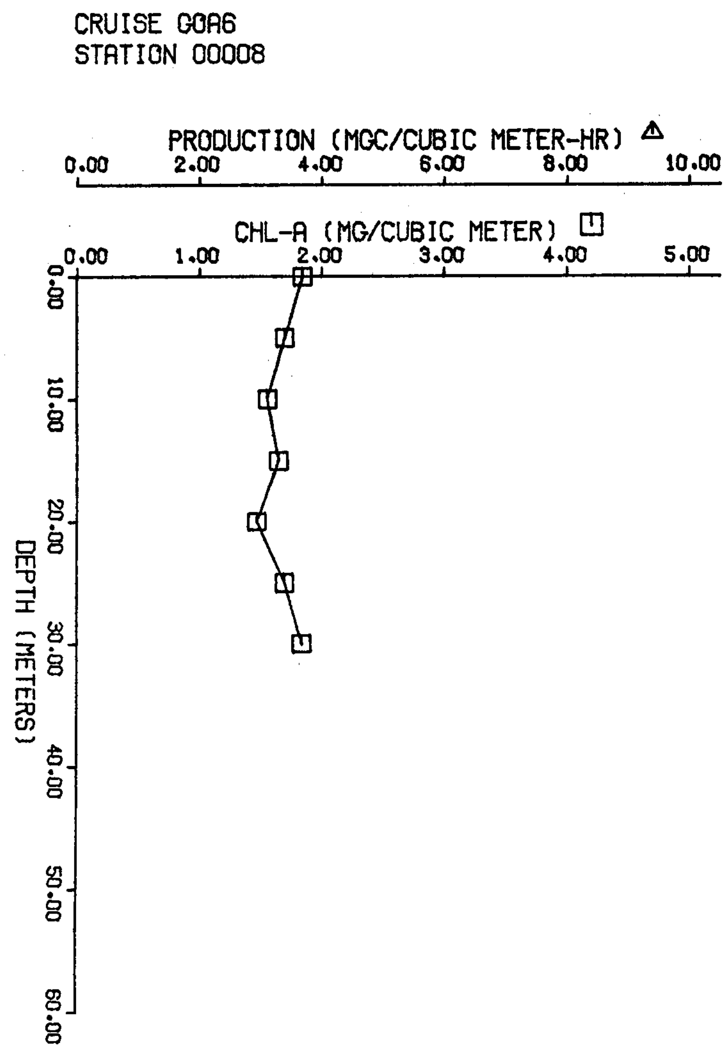


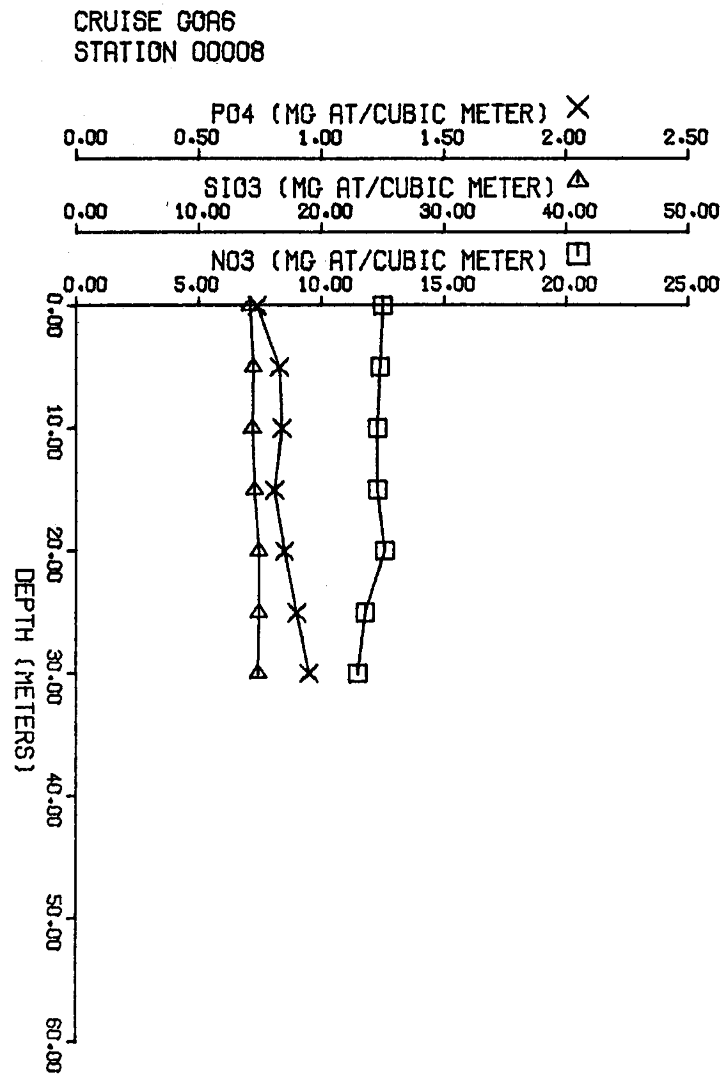
CRUISE GOA6
STATION 00007



CRUISE GOA6
STATION 00007







NO VALUES FOR VARIABLE WITH SYMBOL △

CRUISE GOA6
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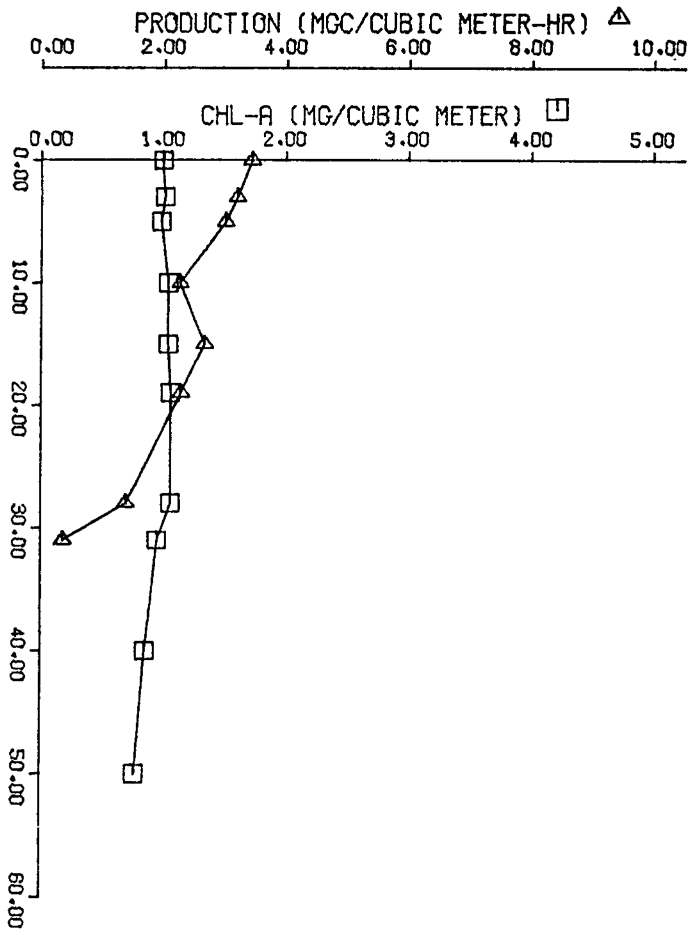

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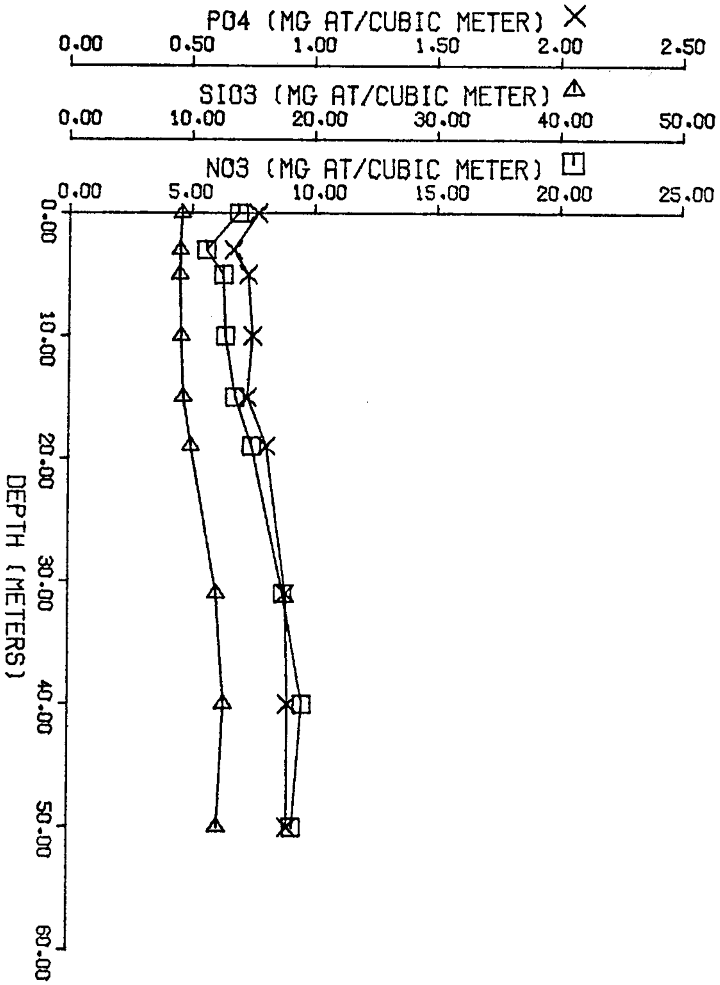
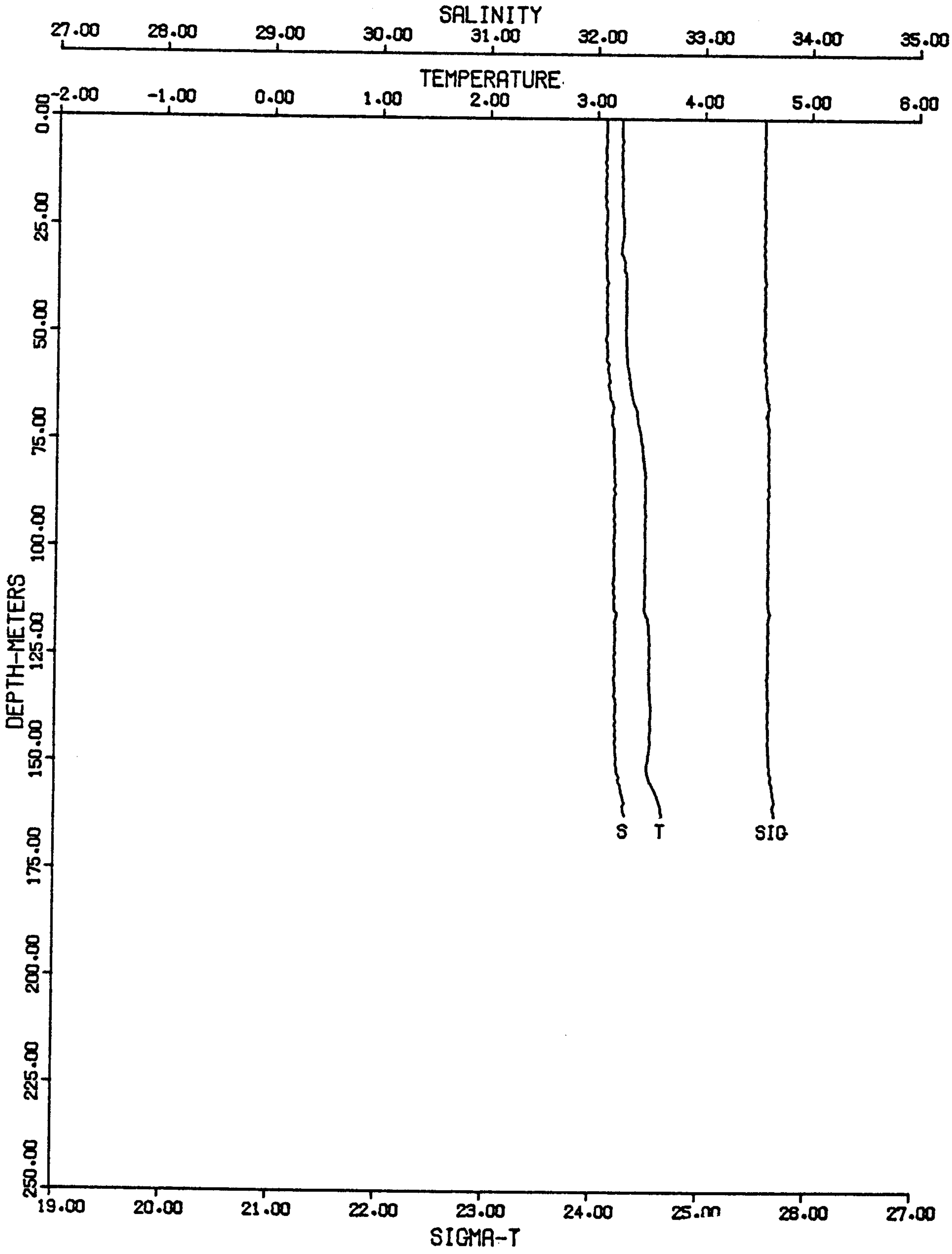


APPENDIX B

Vertical profiles of salinity, temperature and sigma-t, lower Cook Inlet, April-August 1976.



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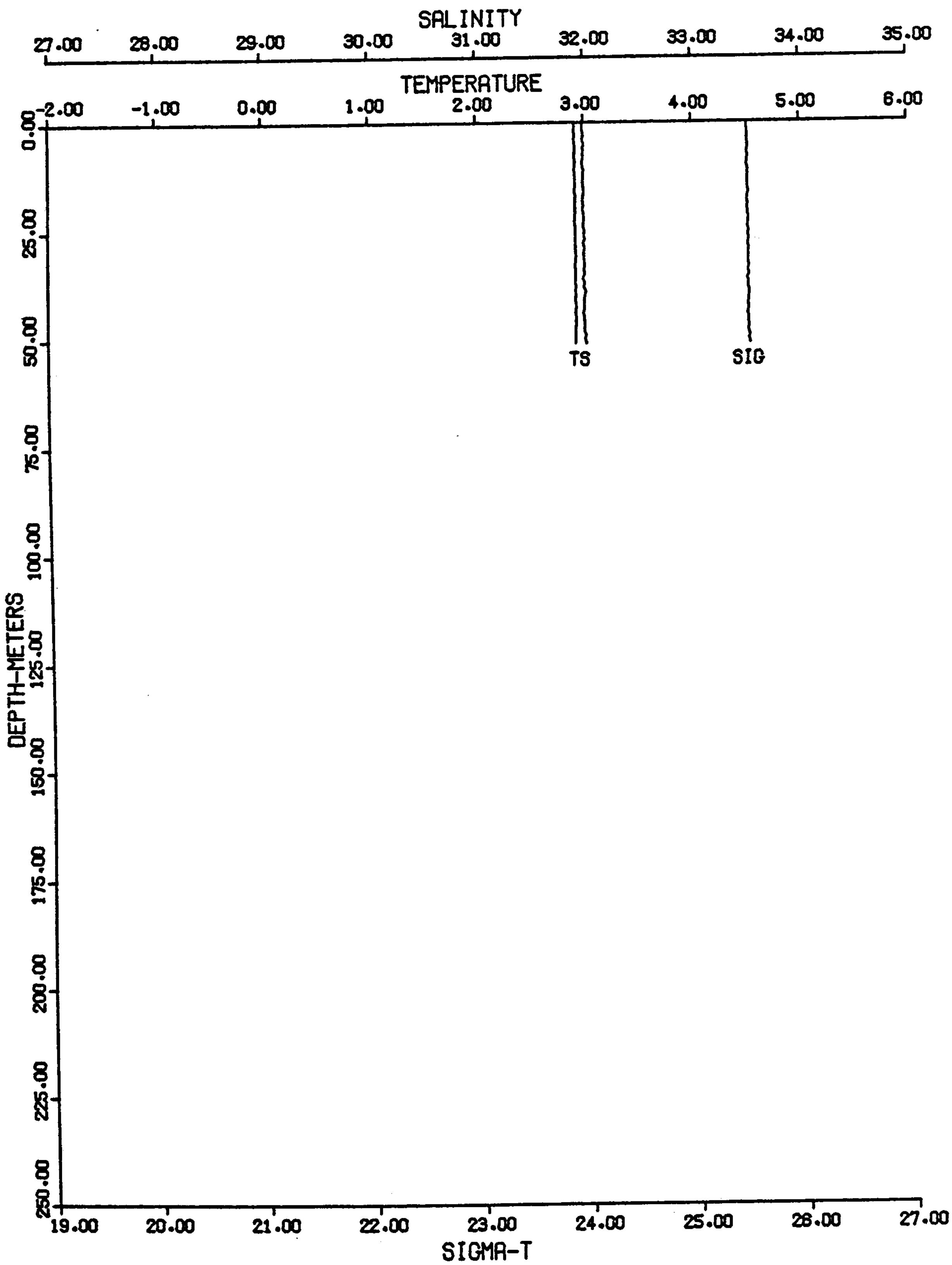

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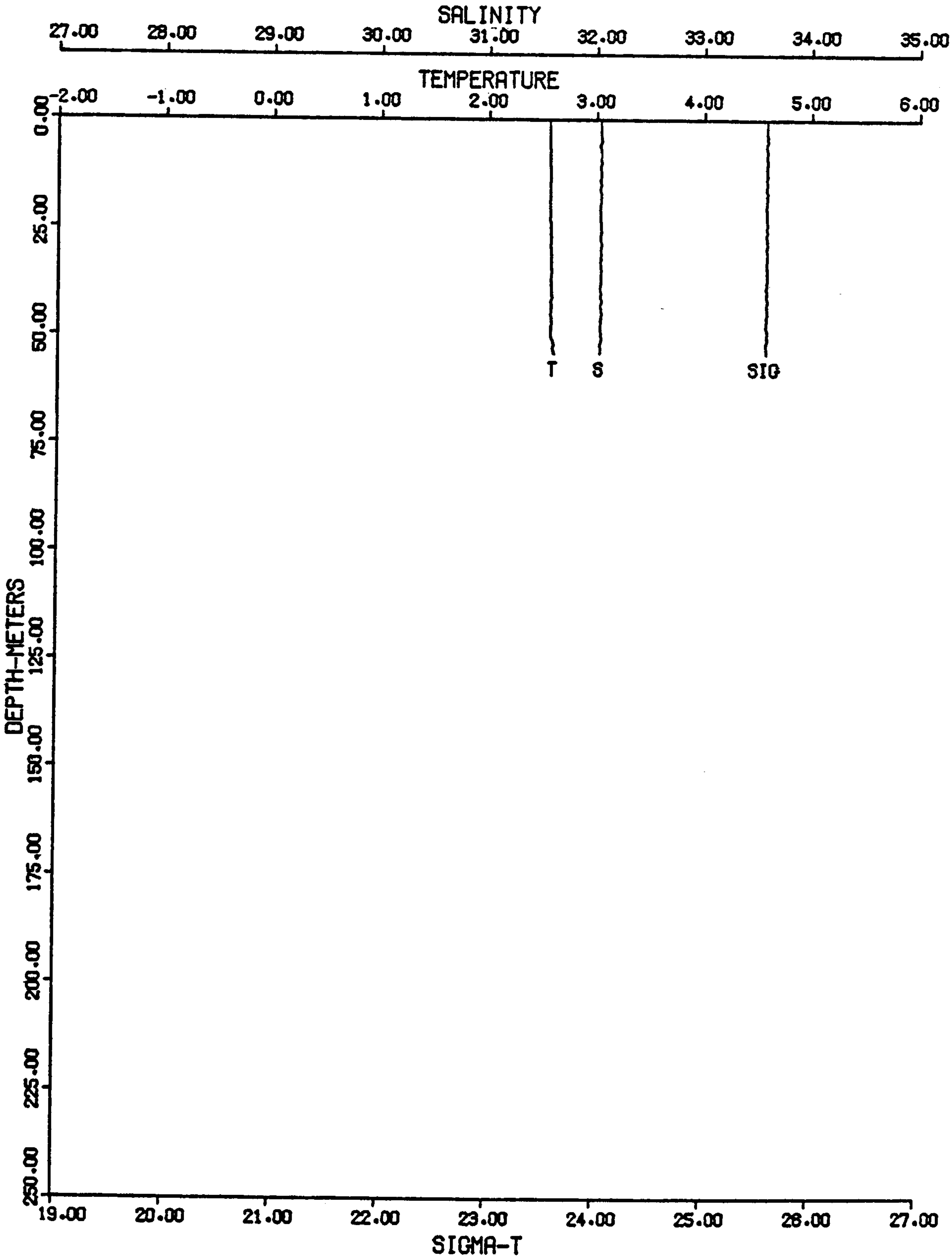

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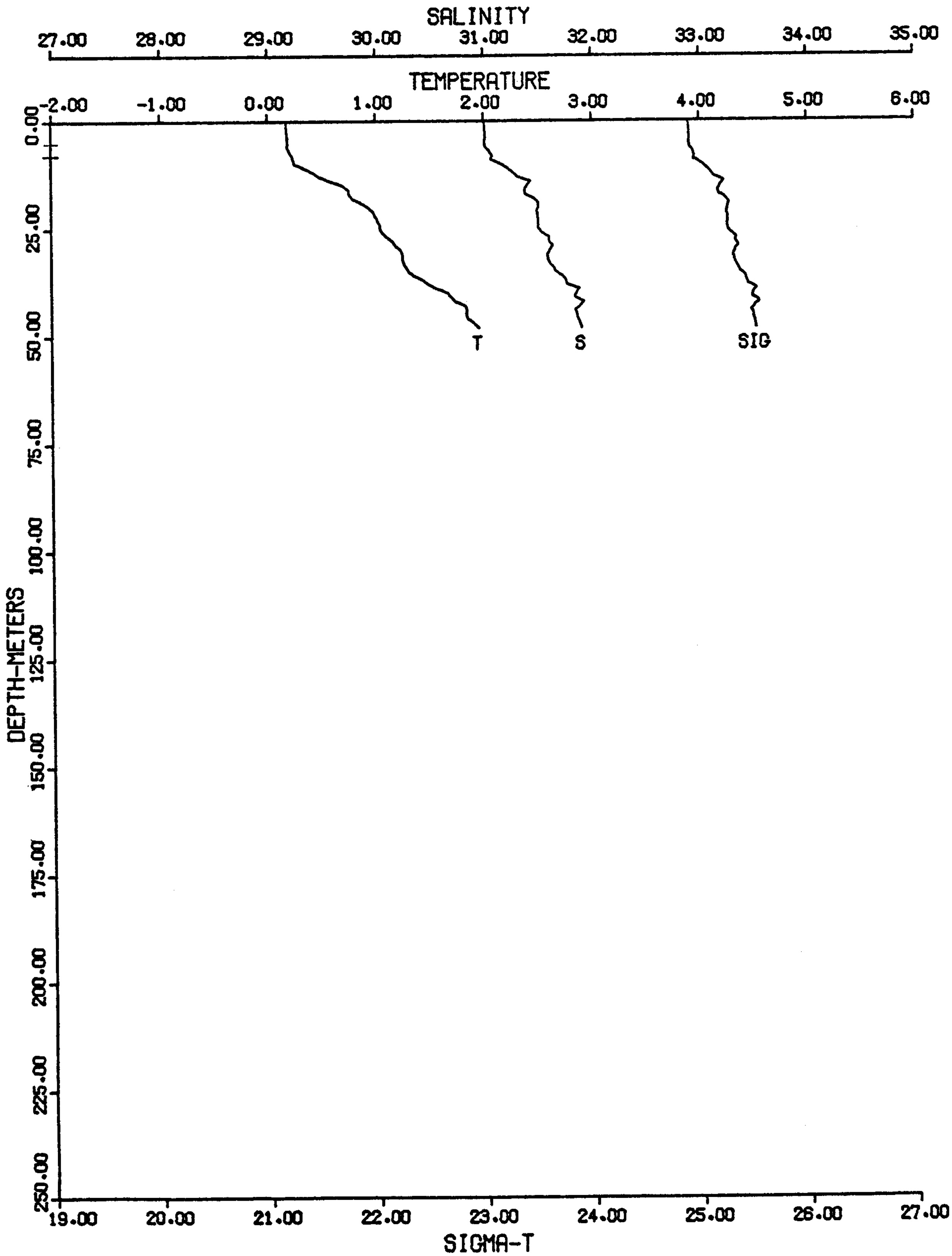

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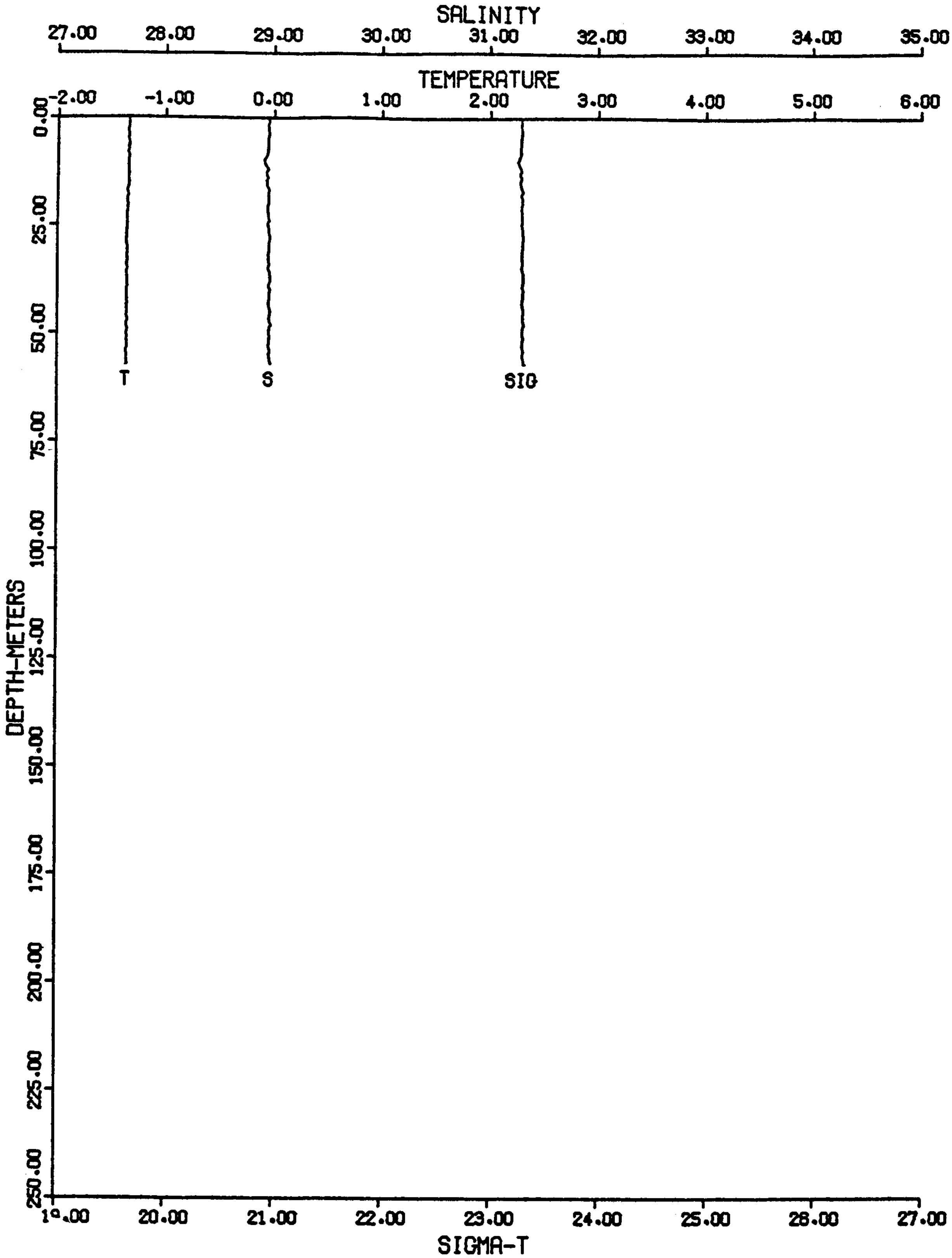

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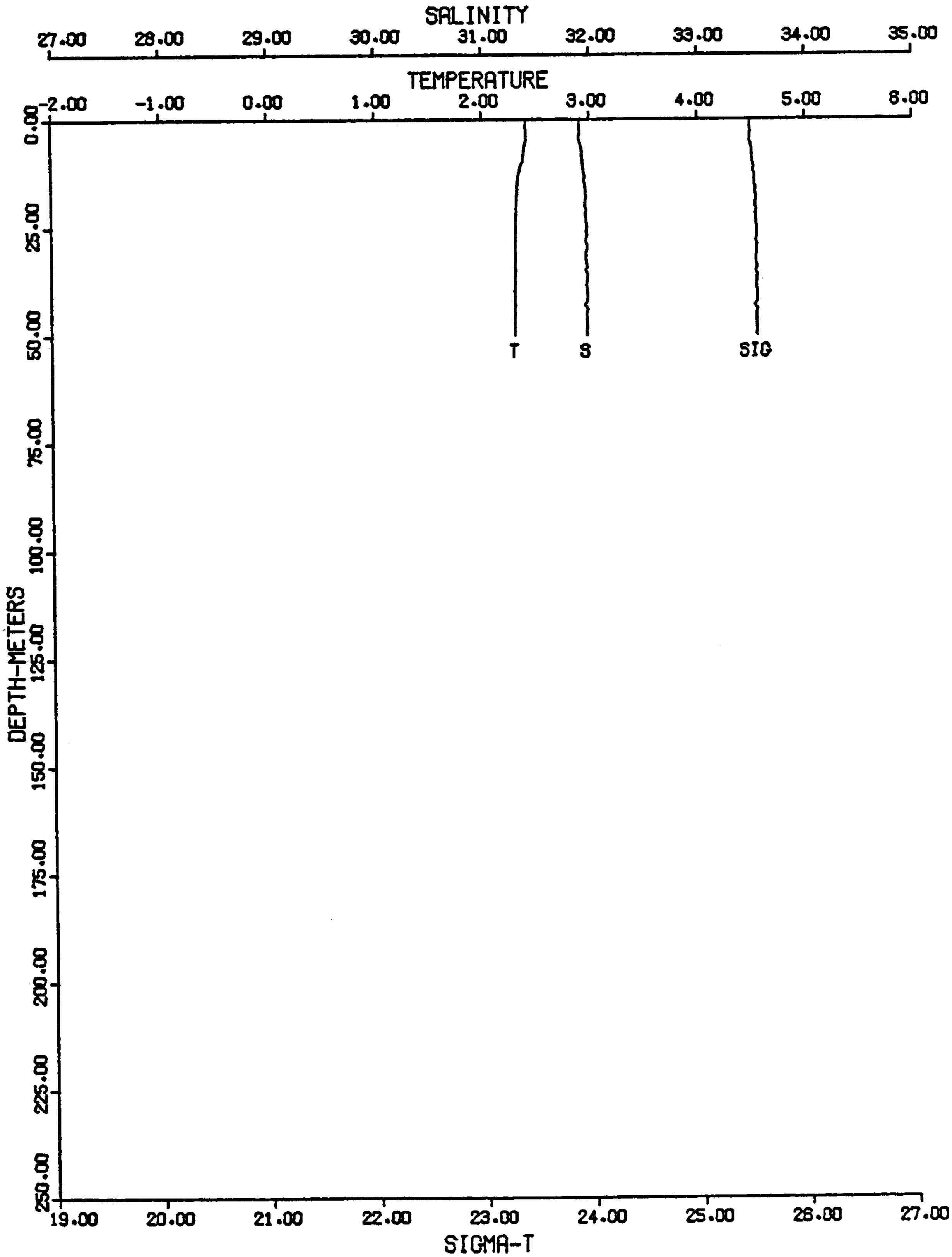

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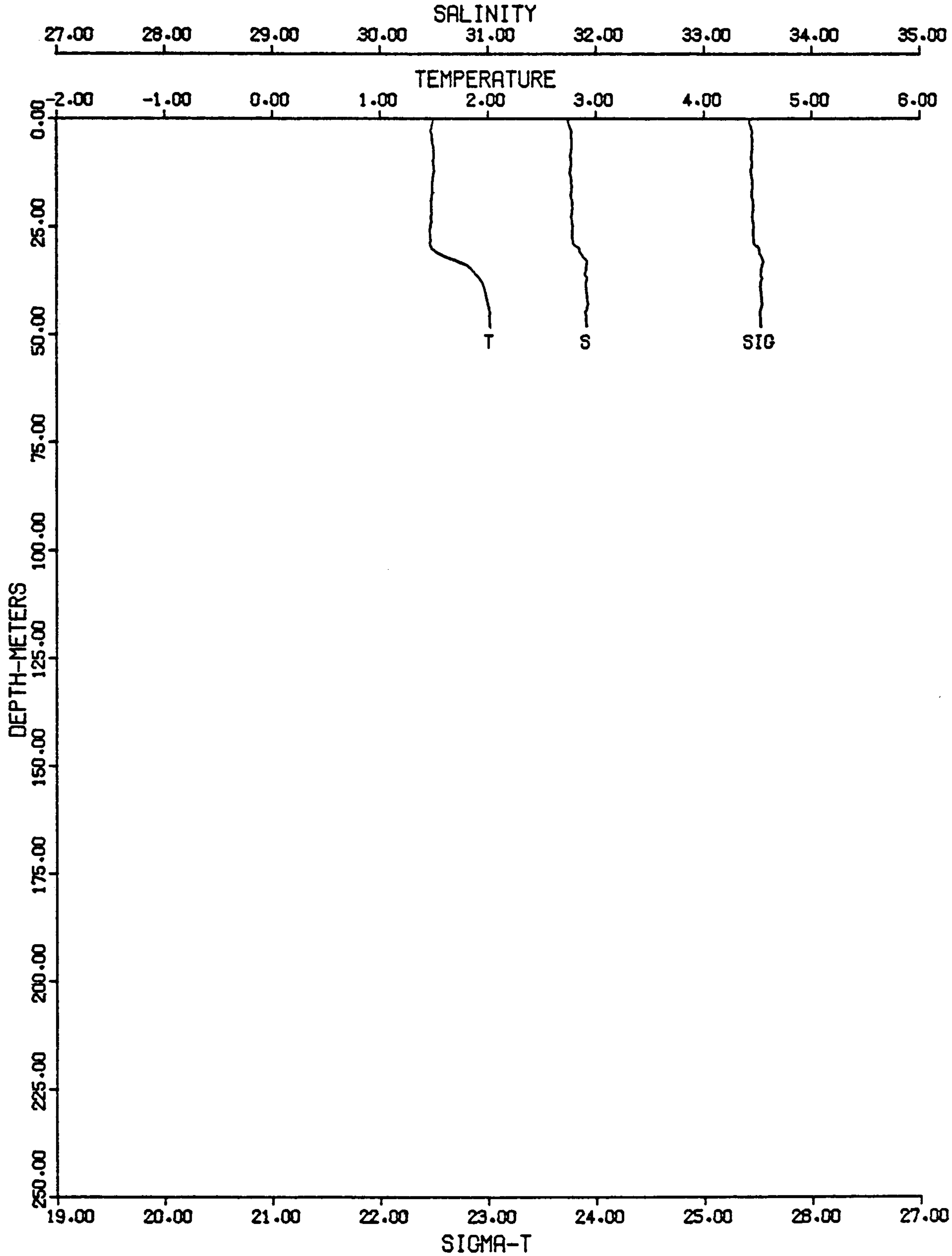

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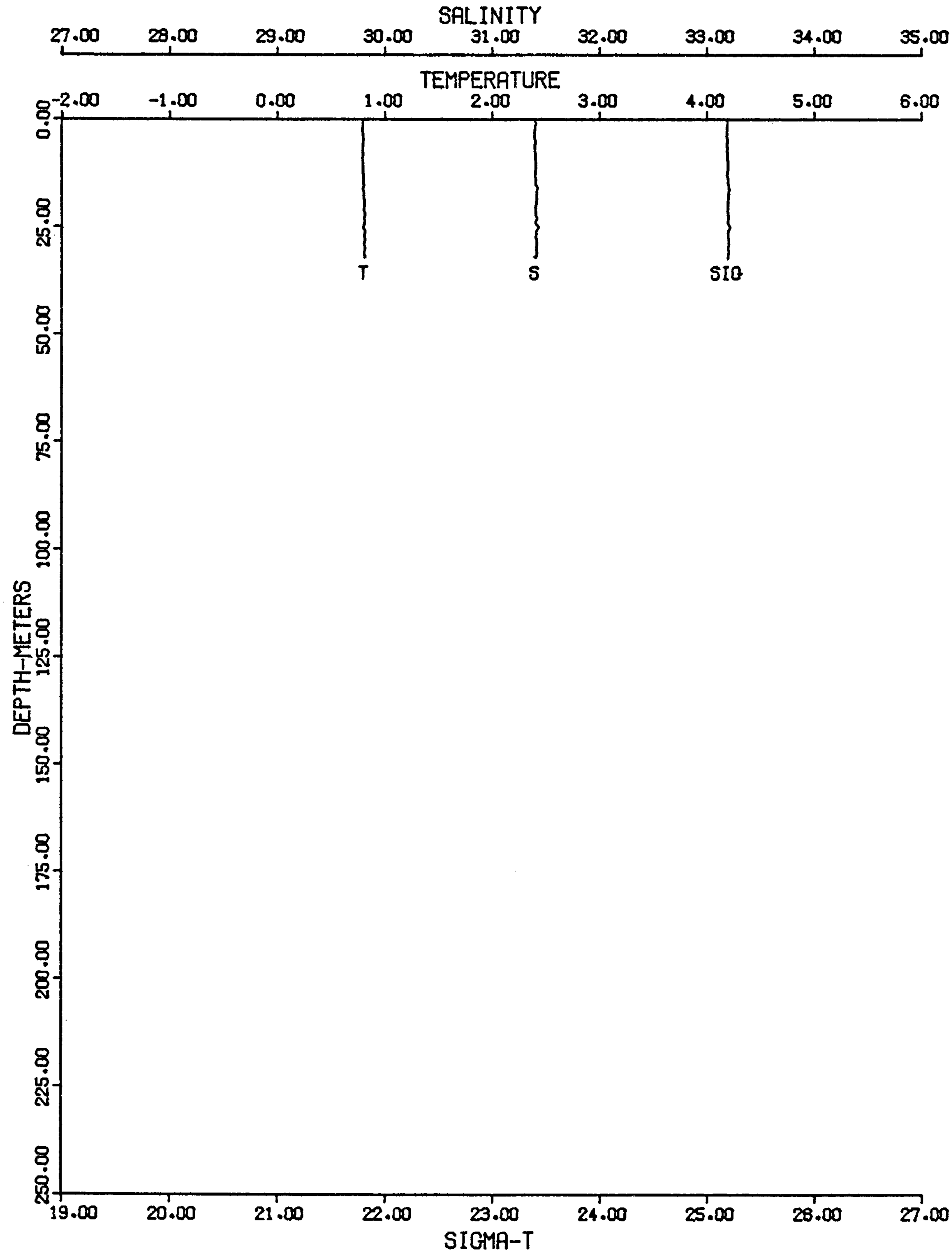

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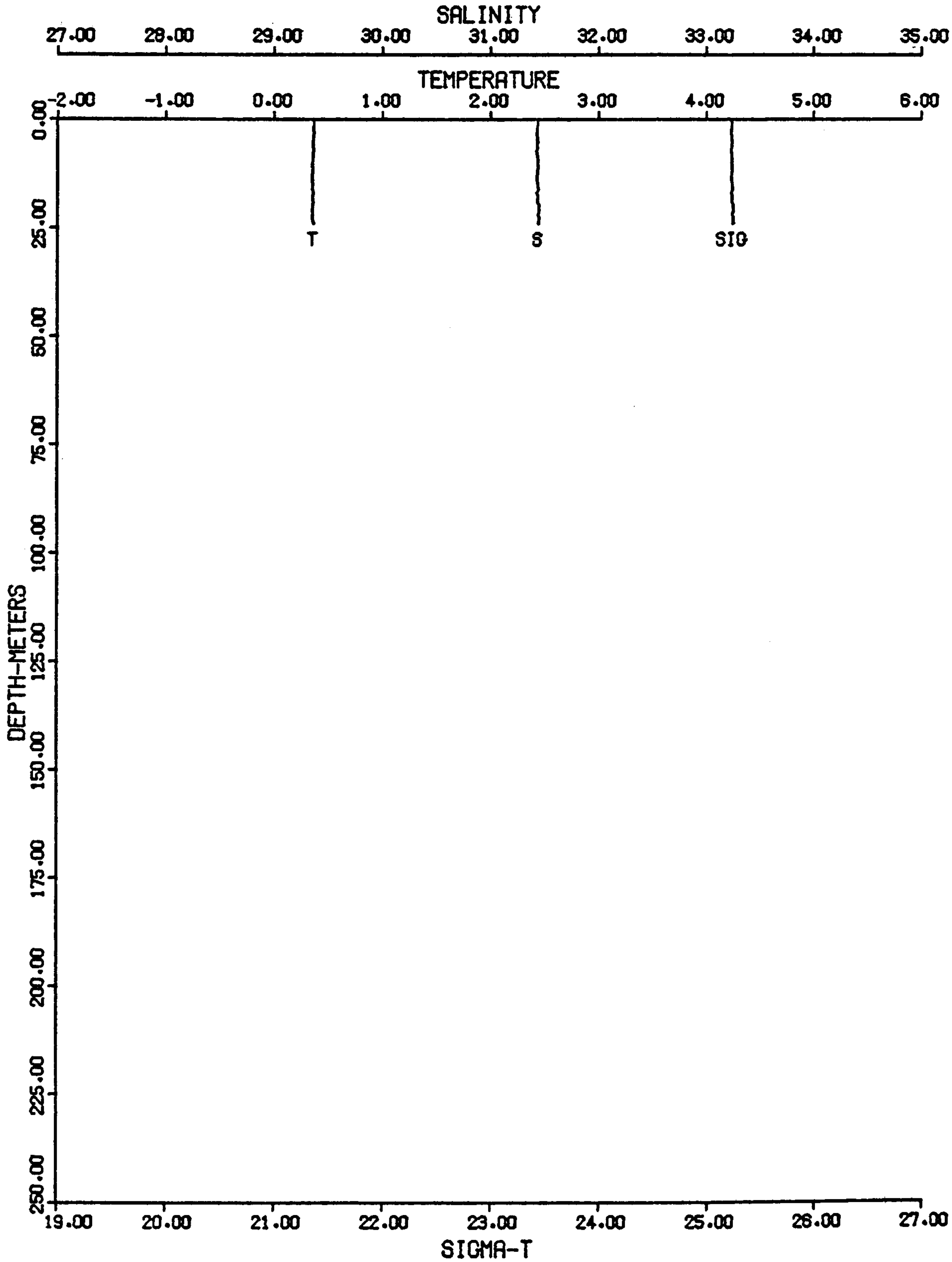

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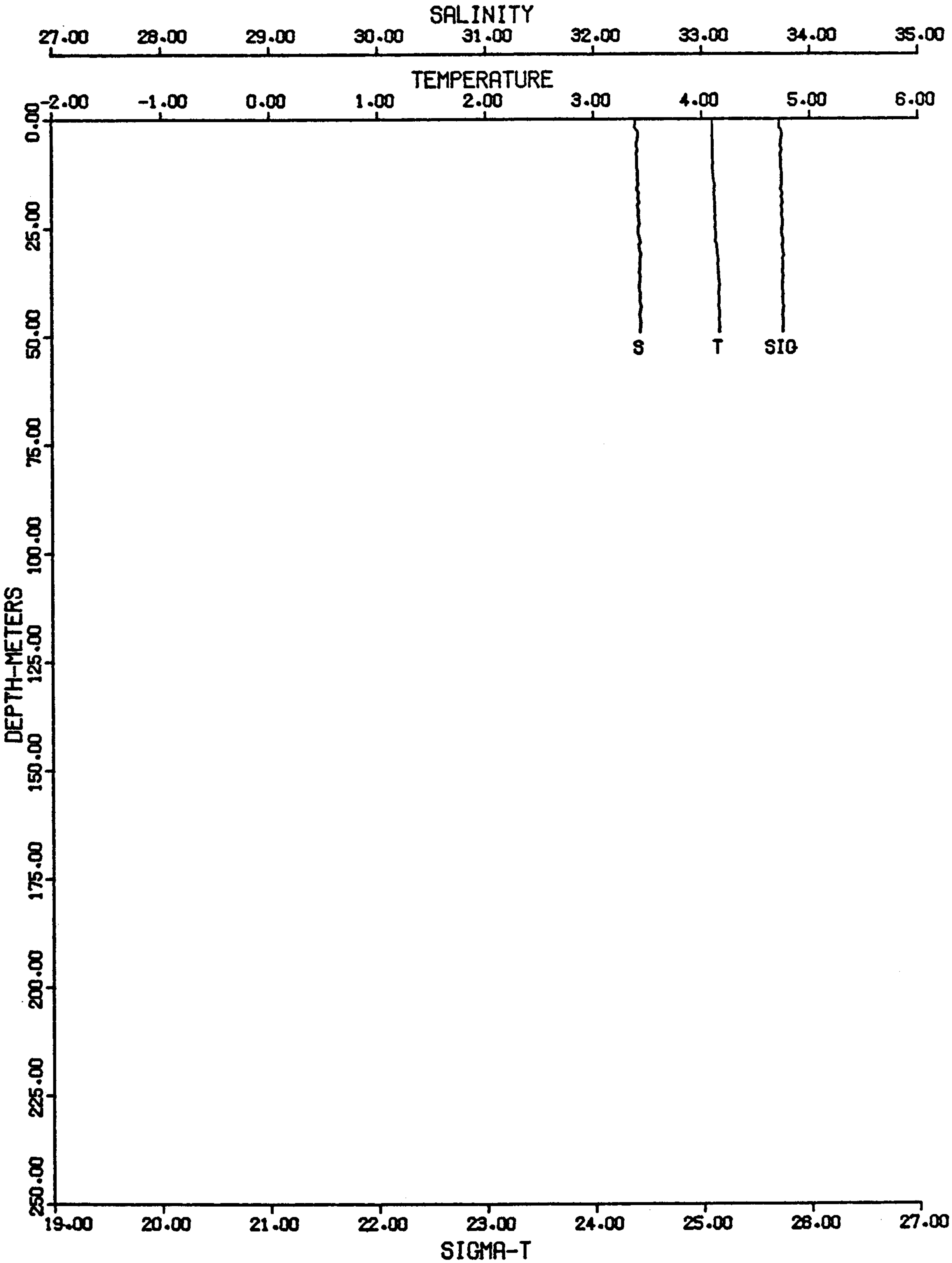

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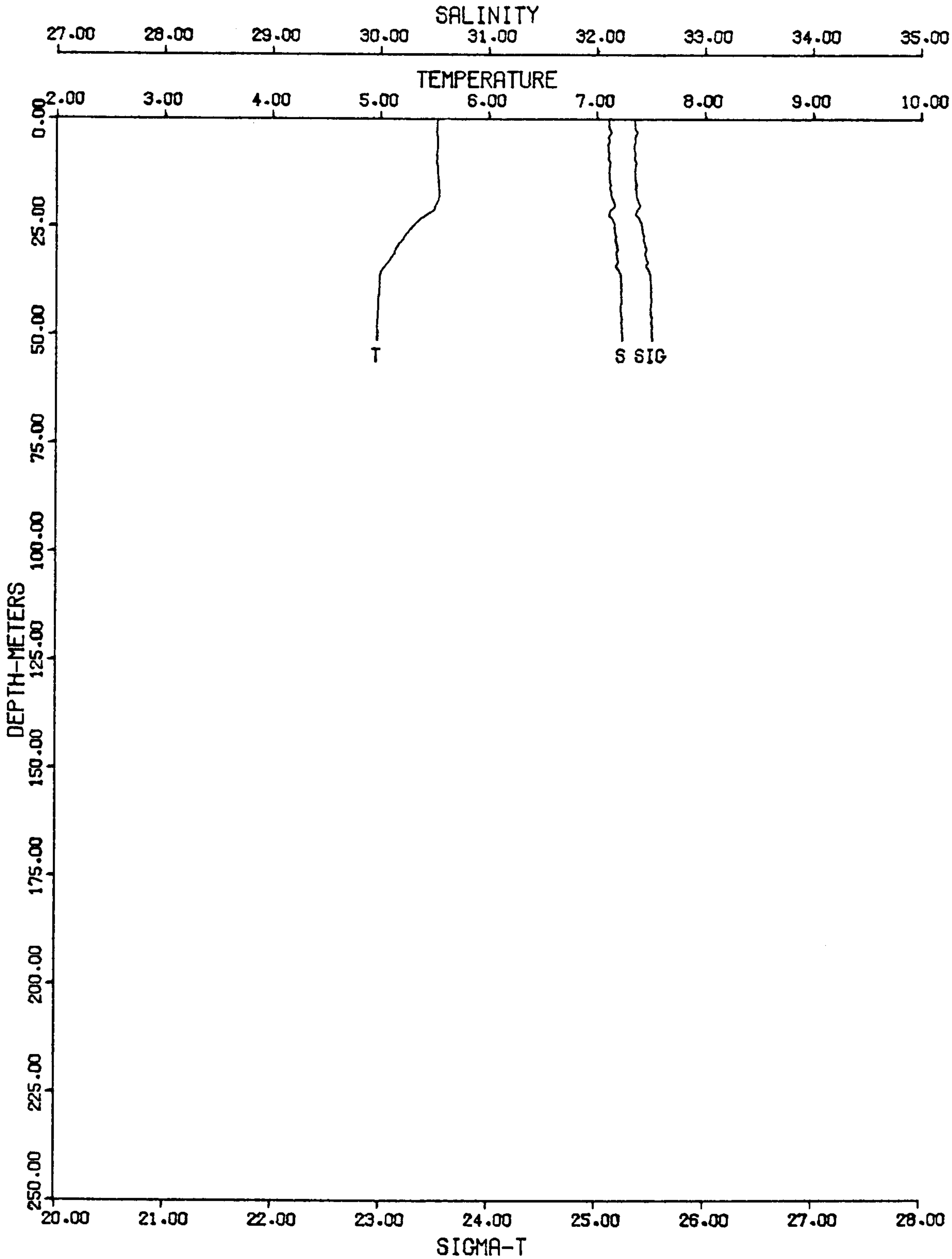

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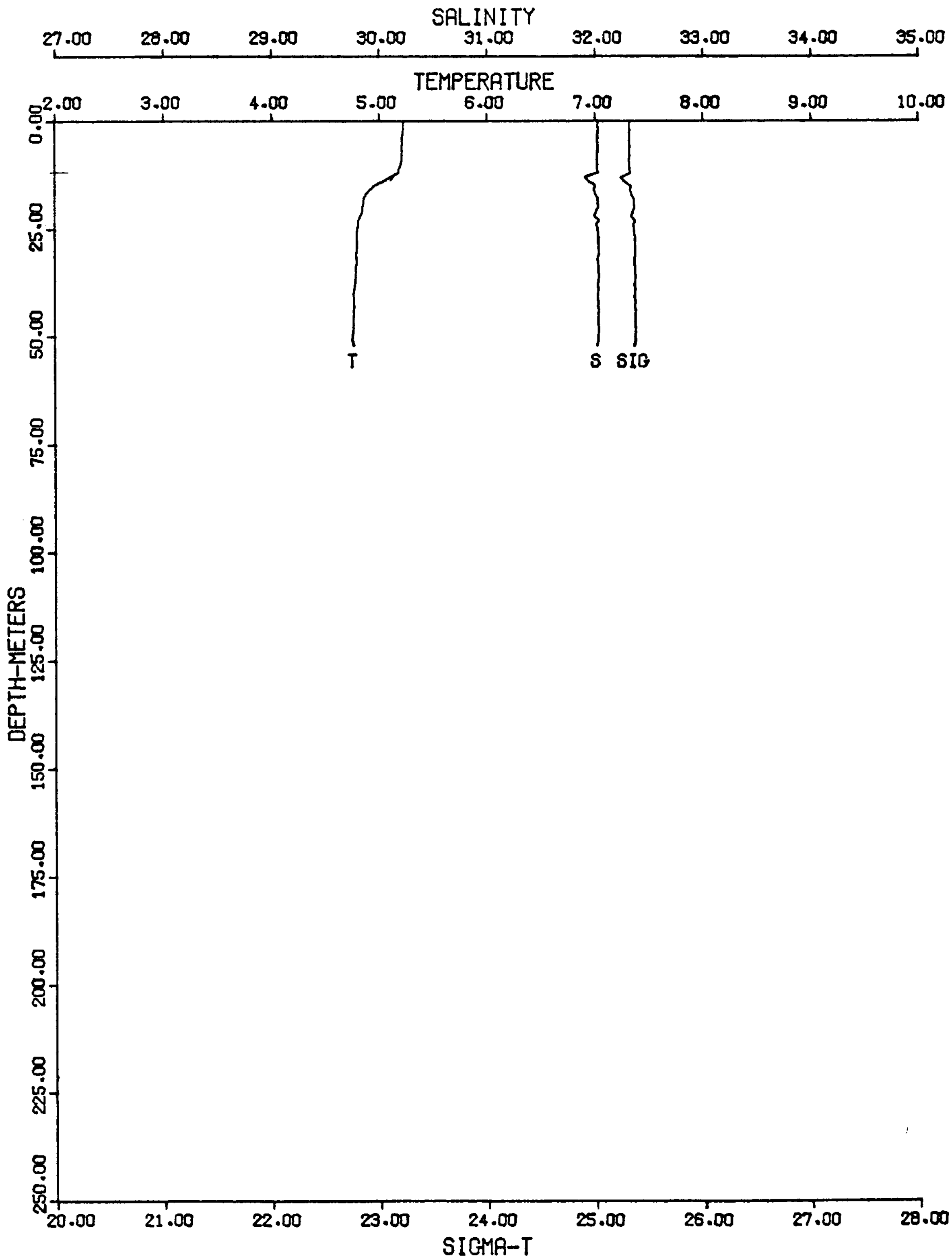

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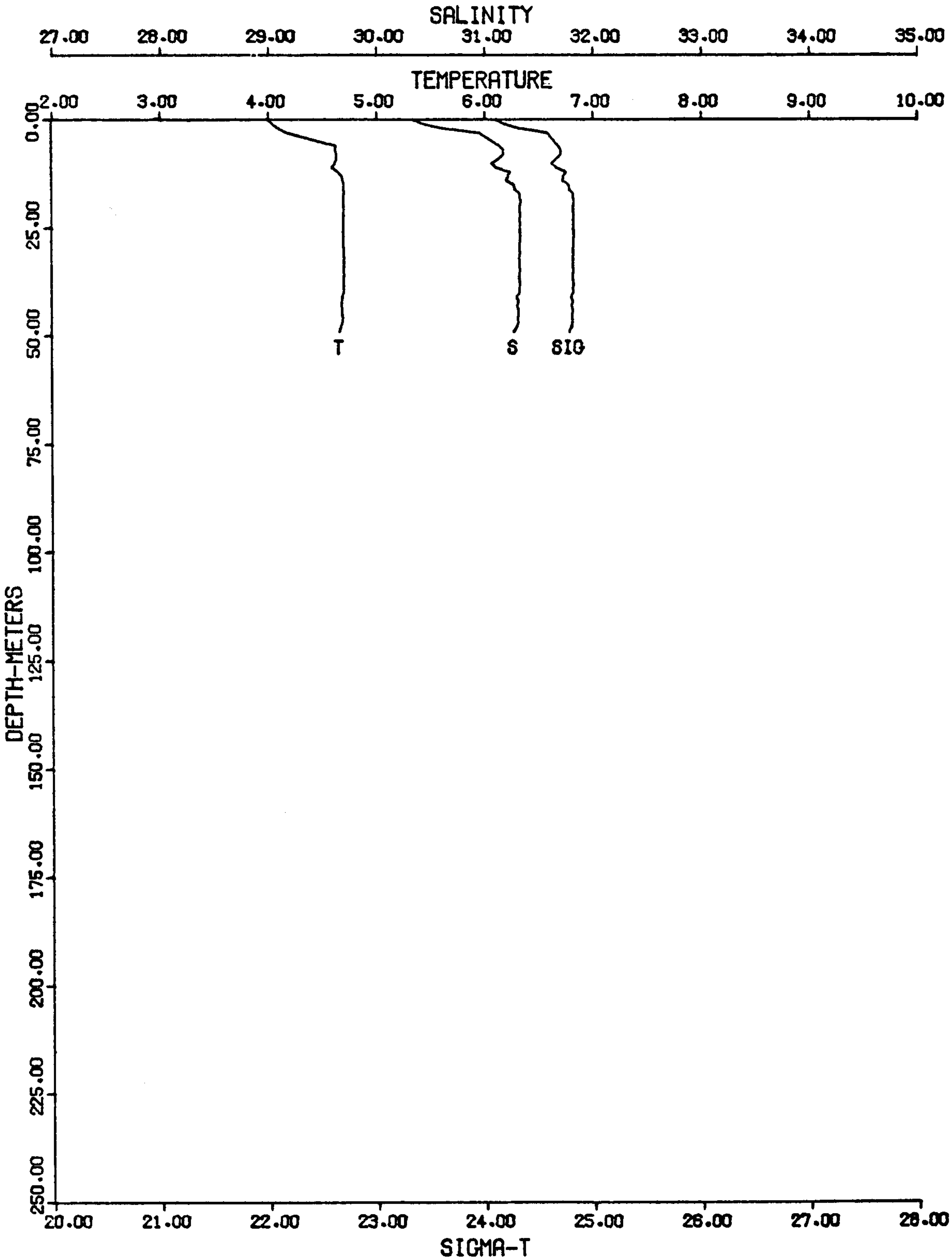

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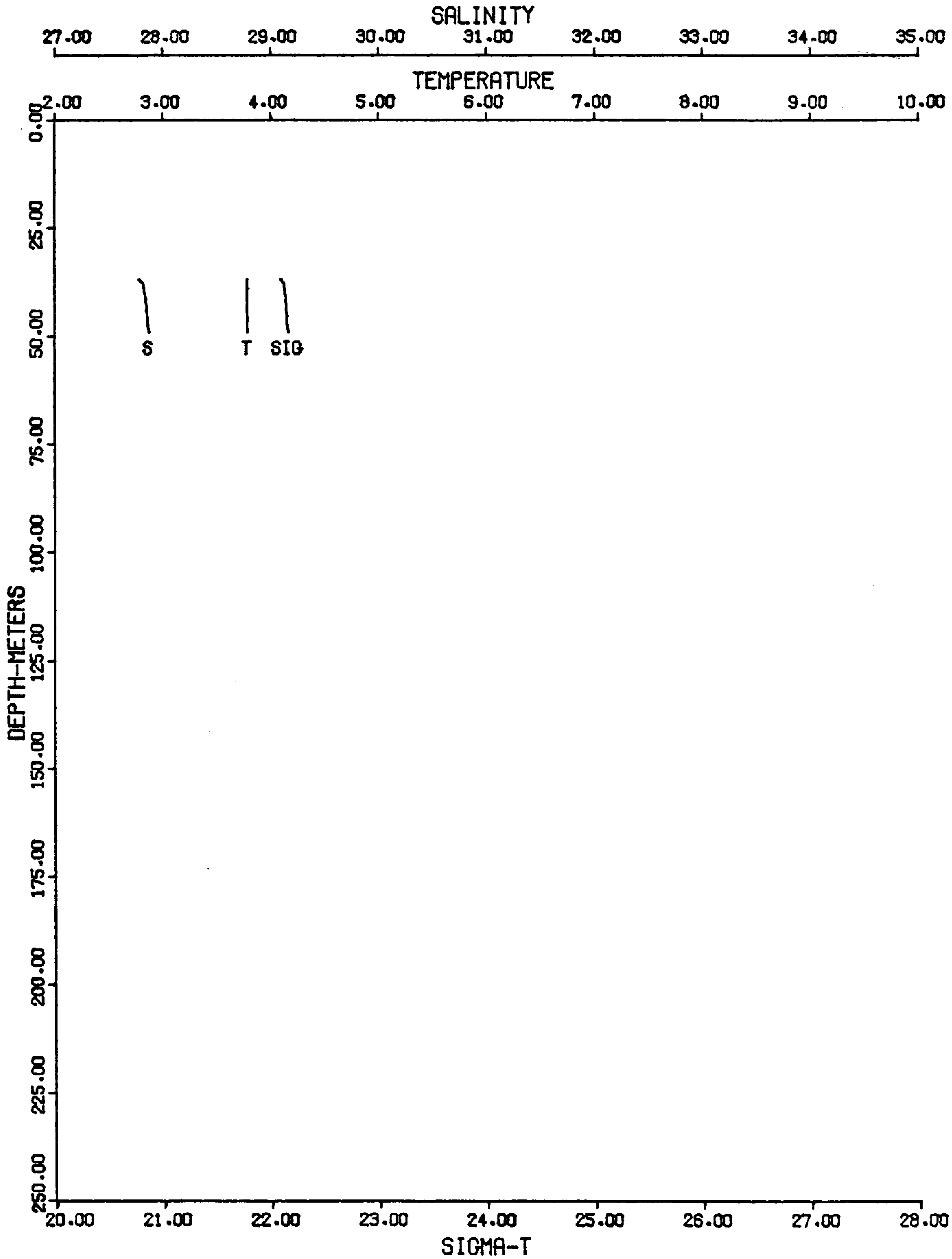

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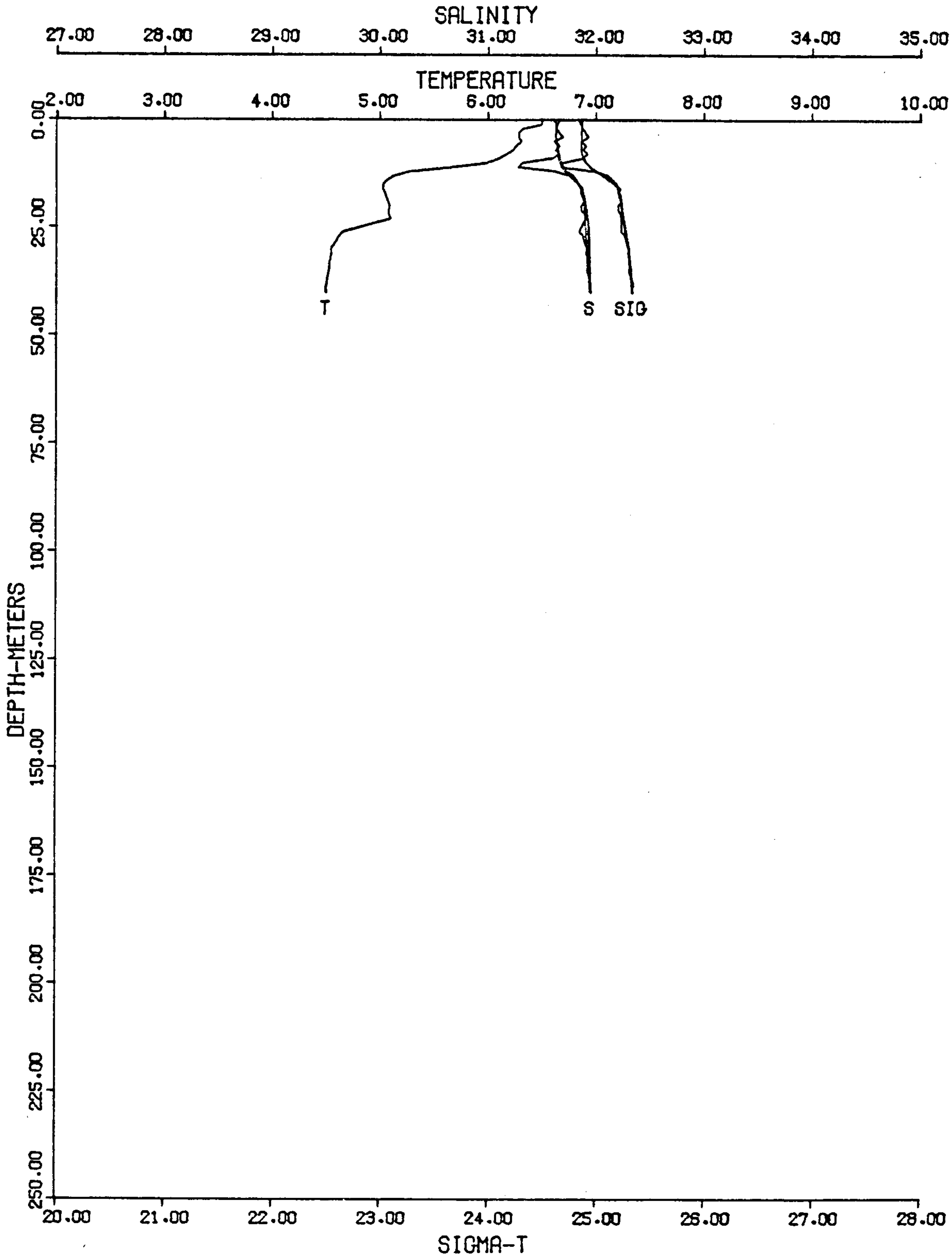

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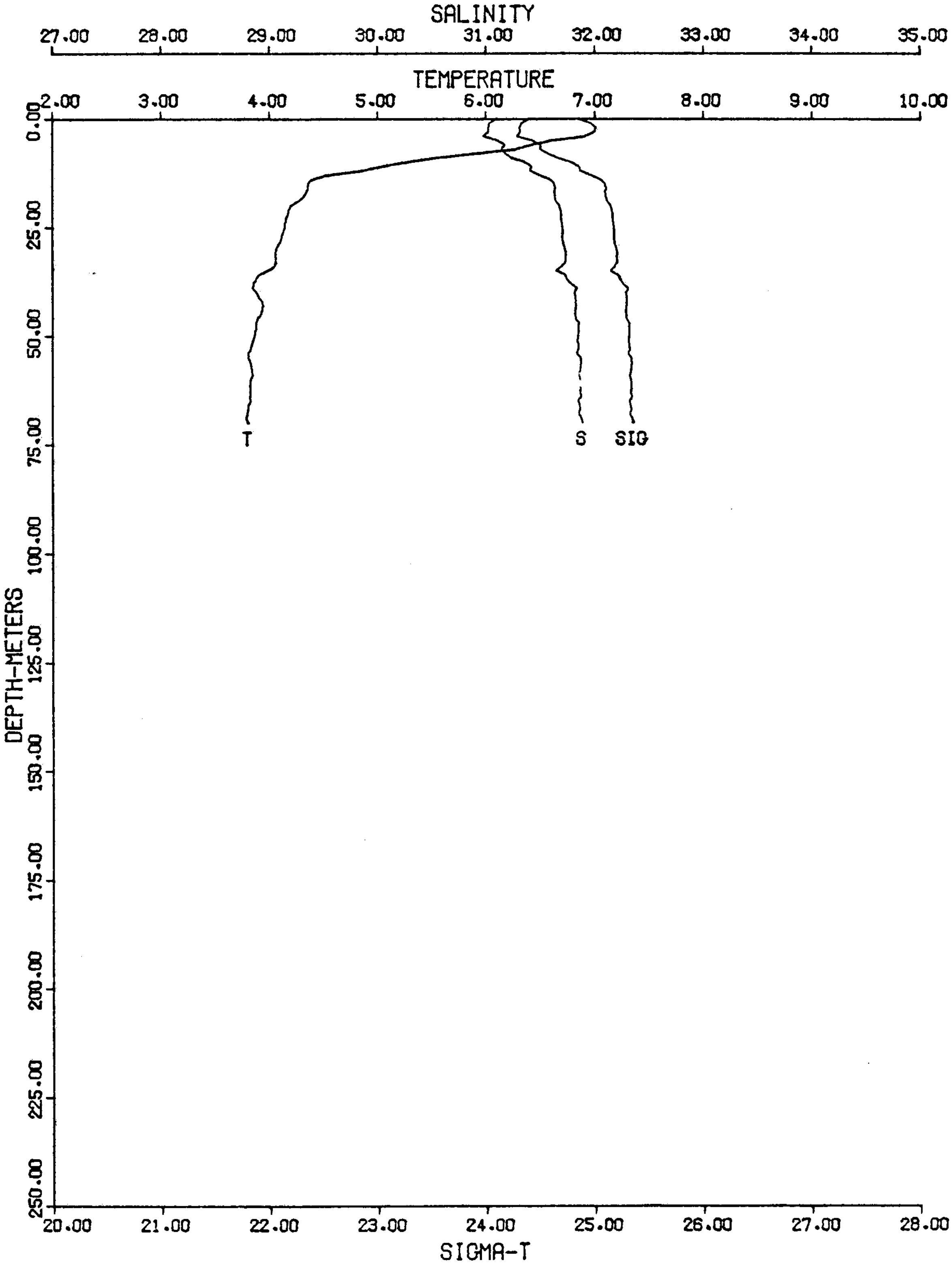

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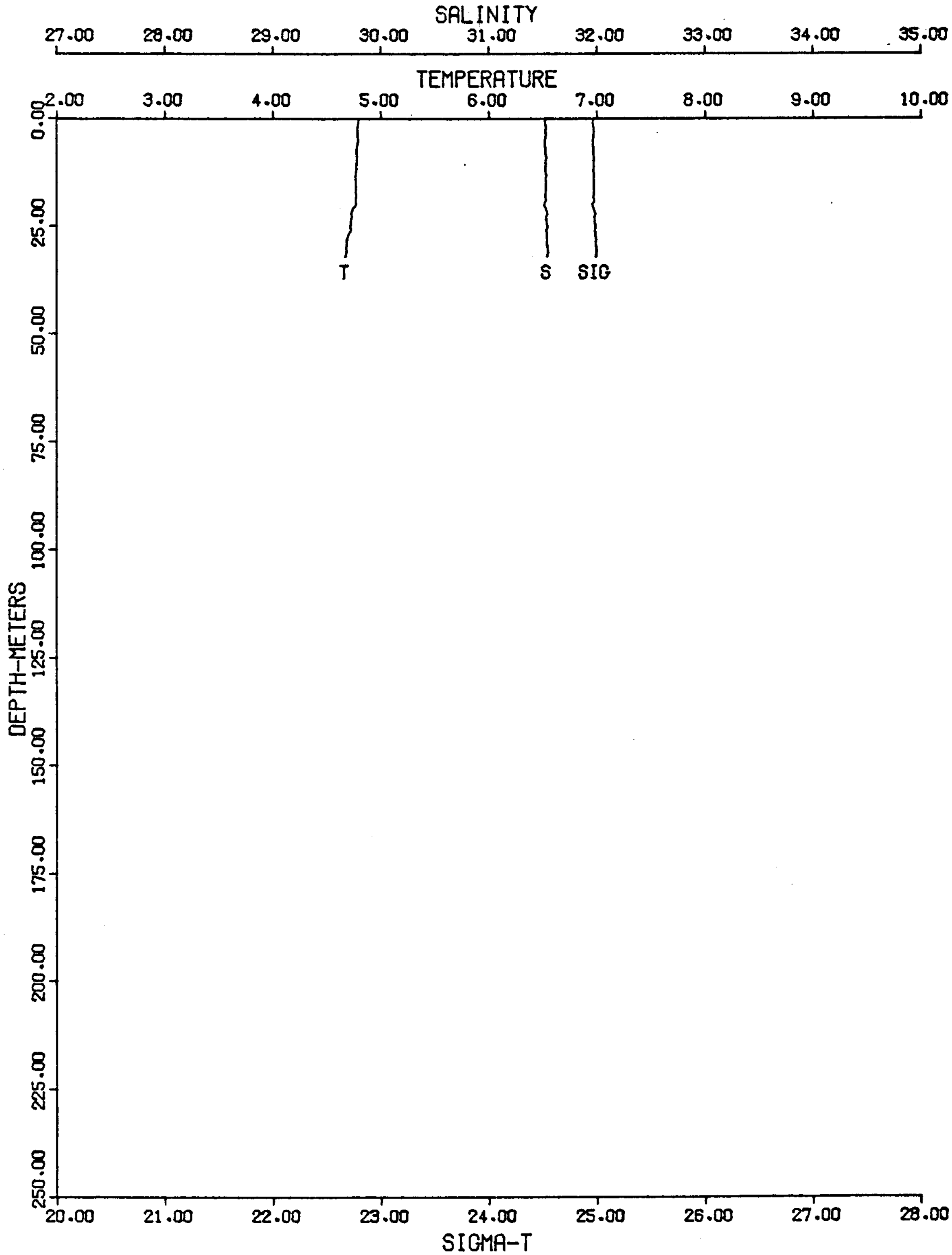

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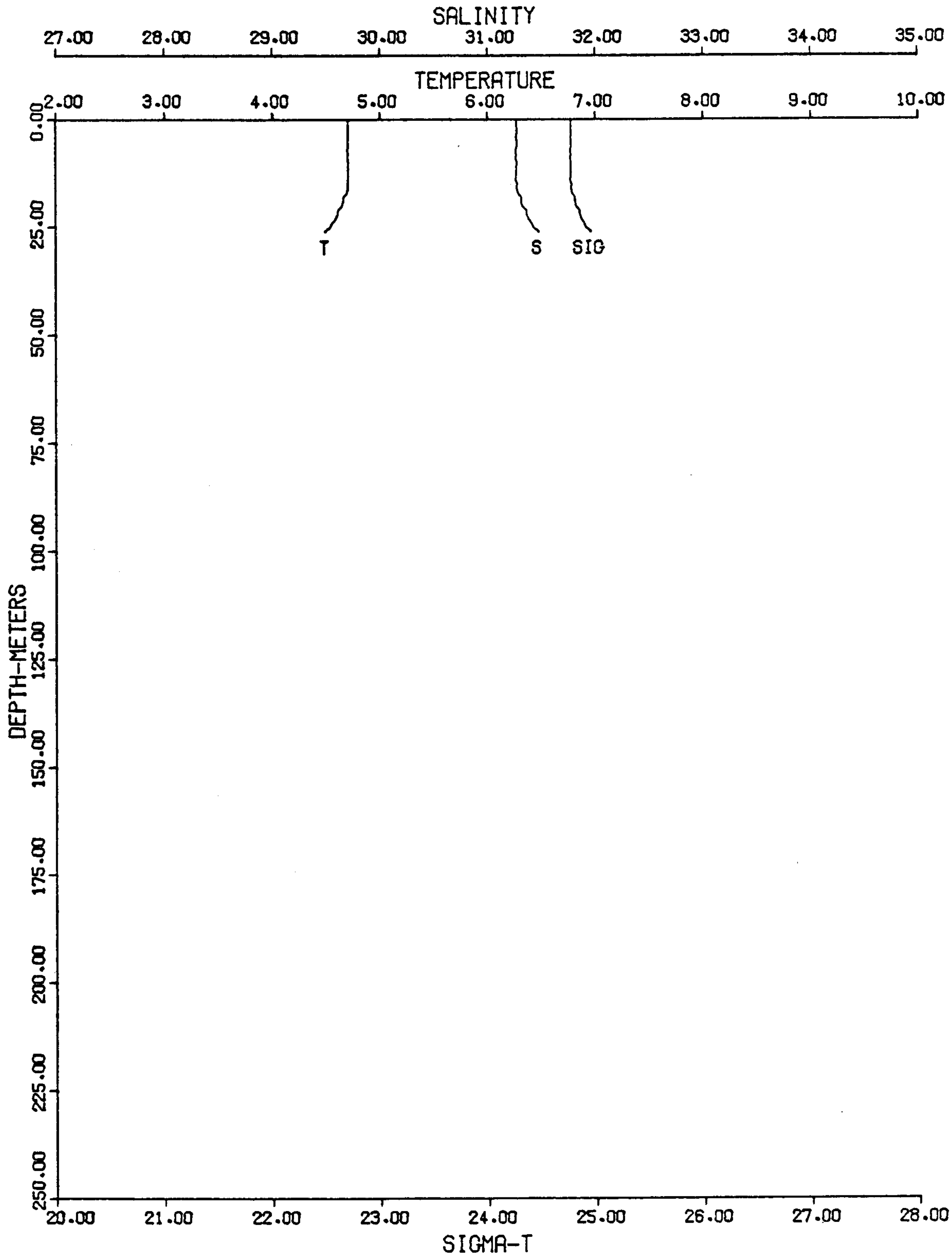

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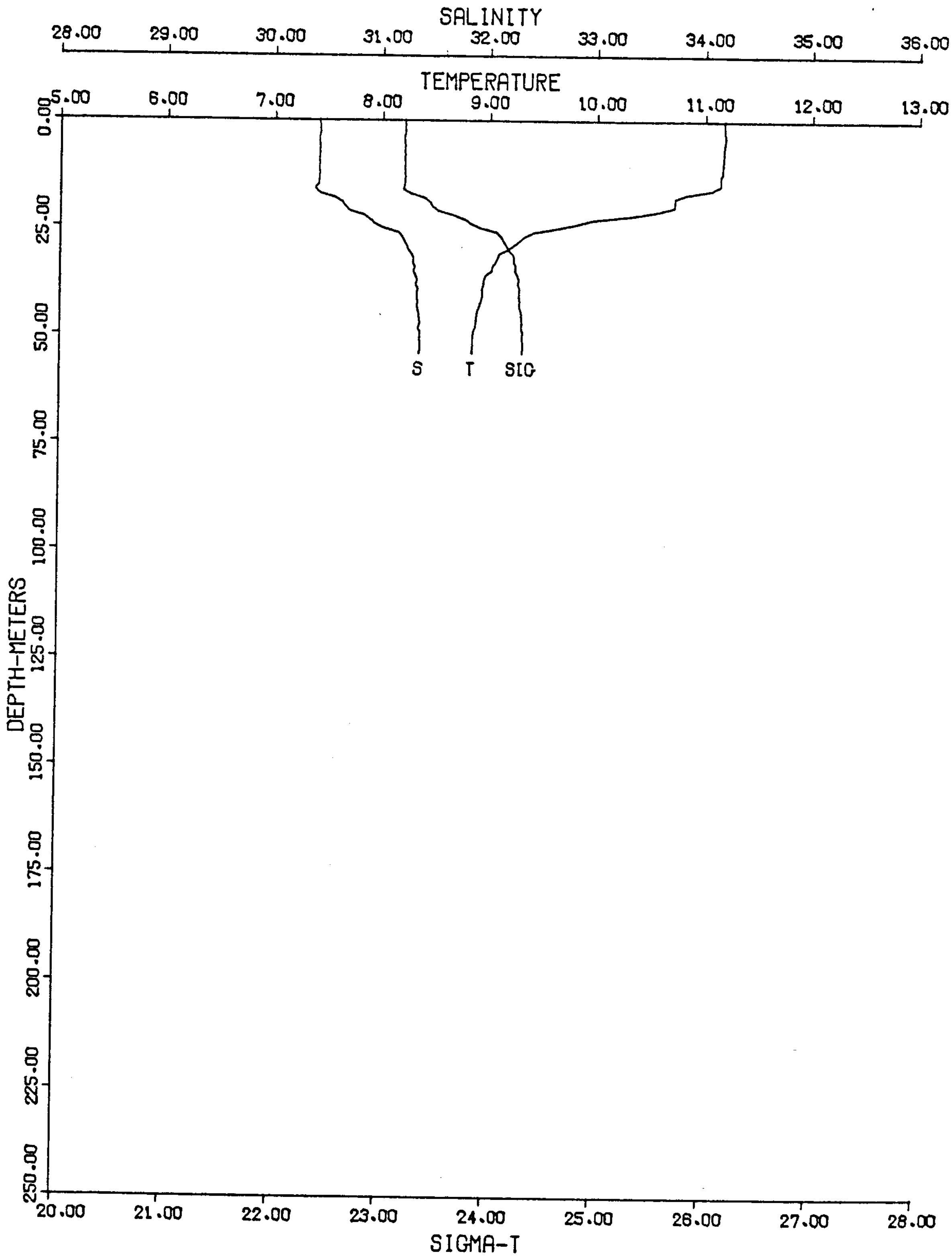

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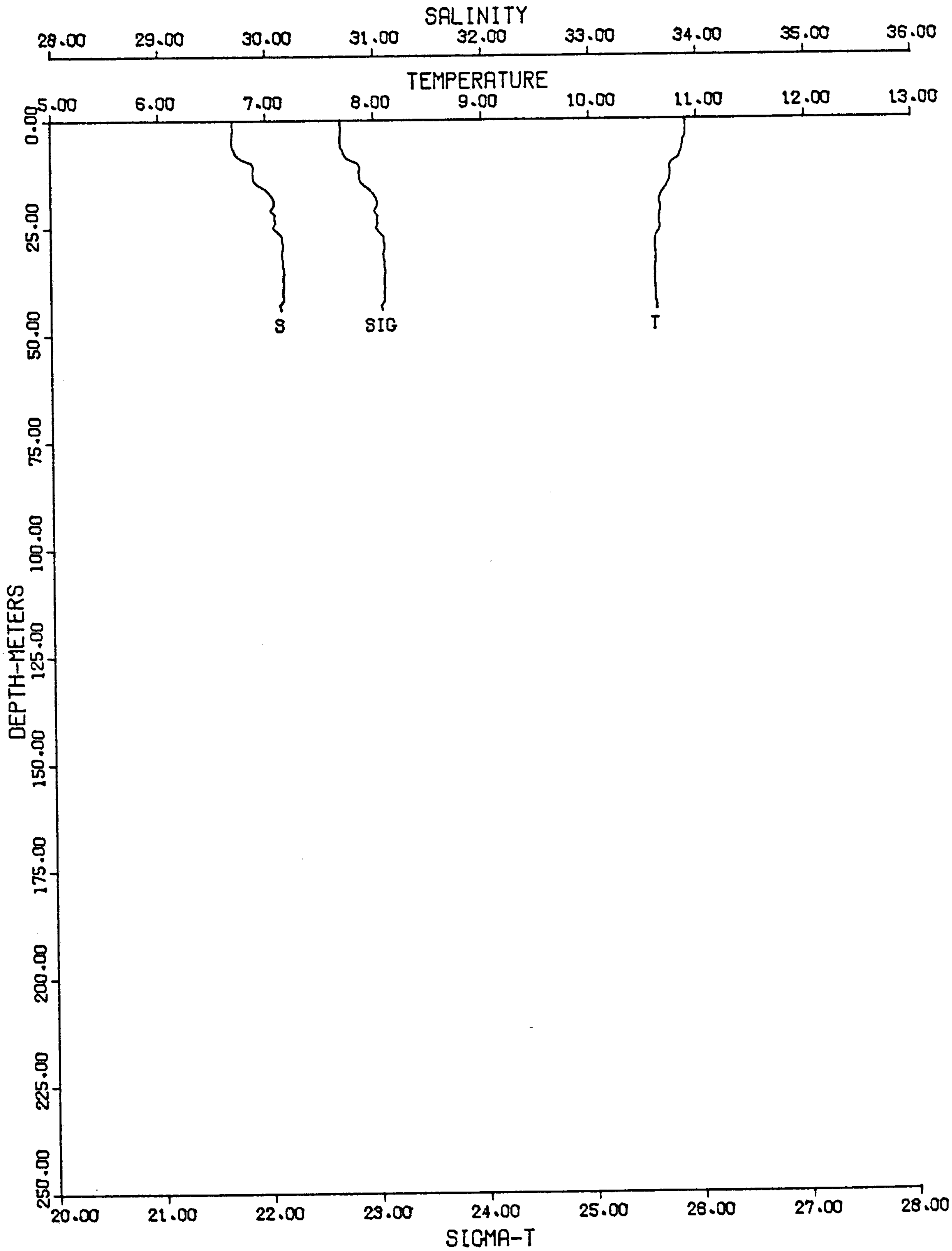

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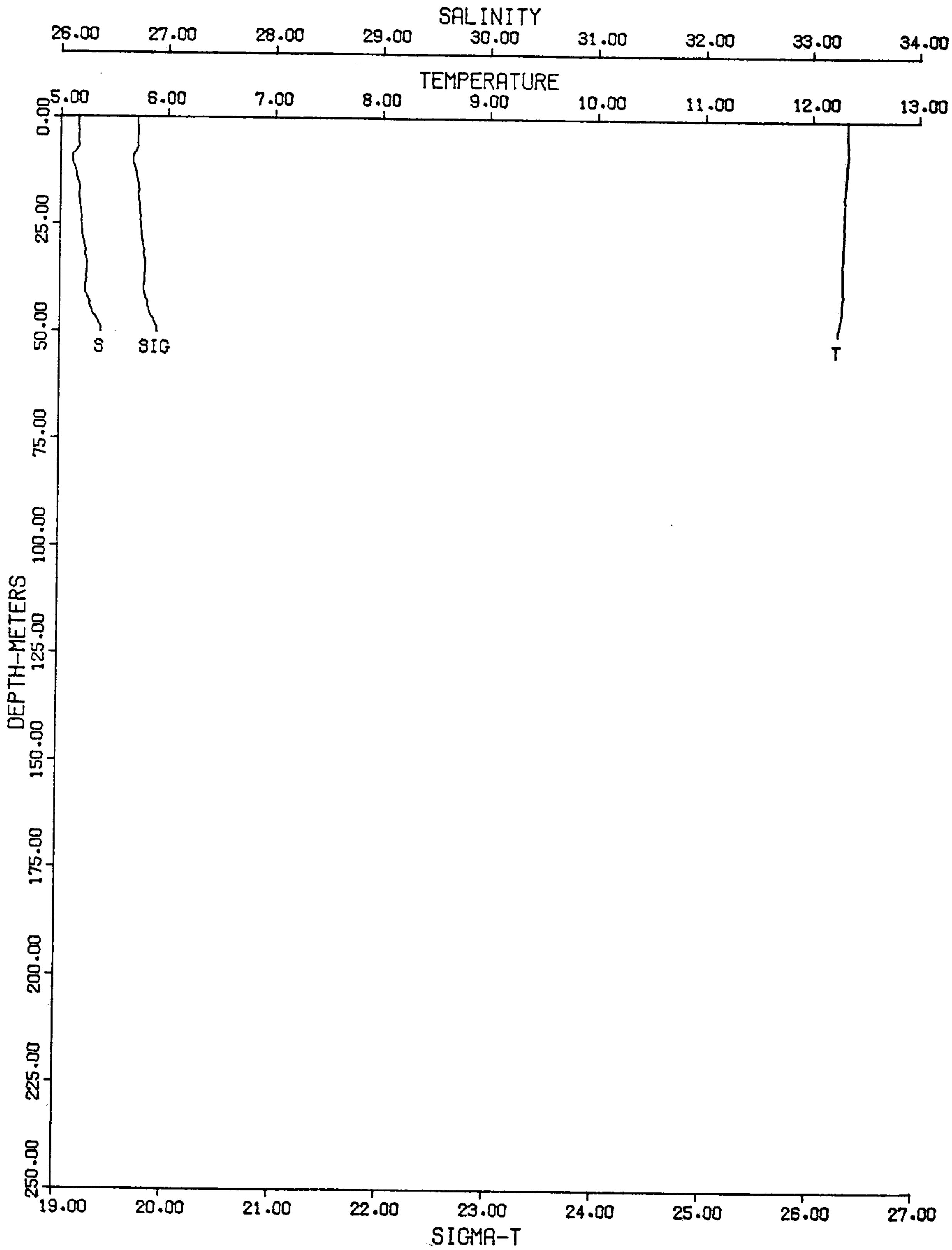

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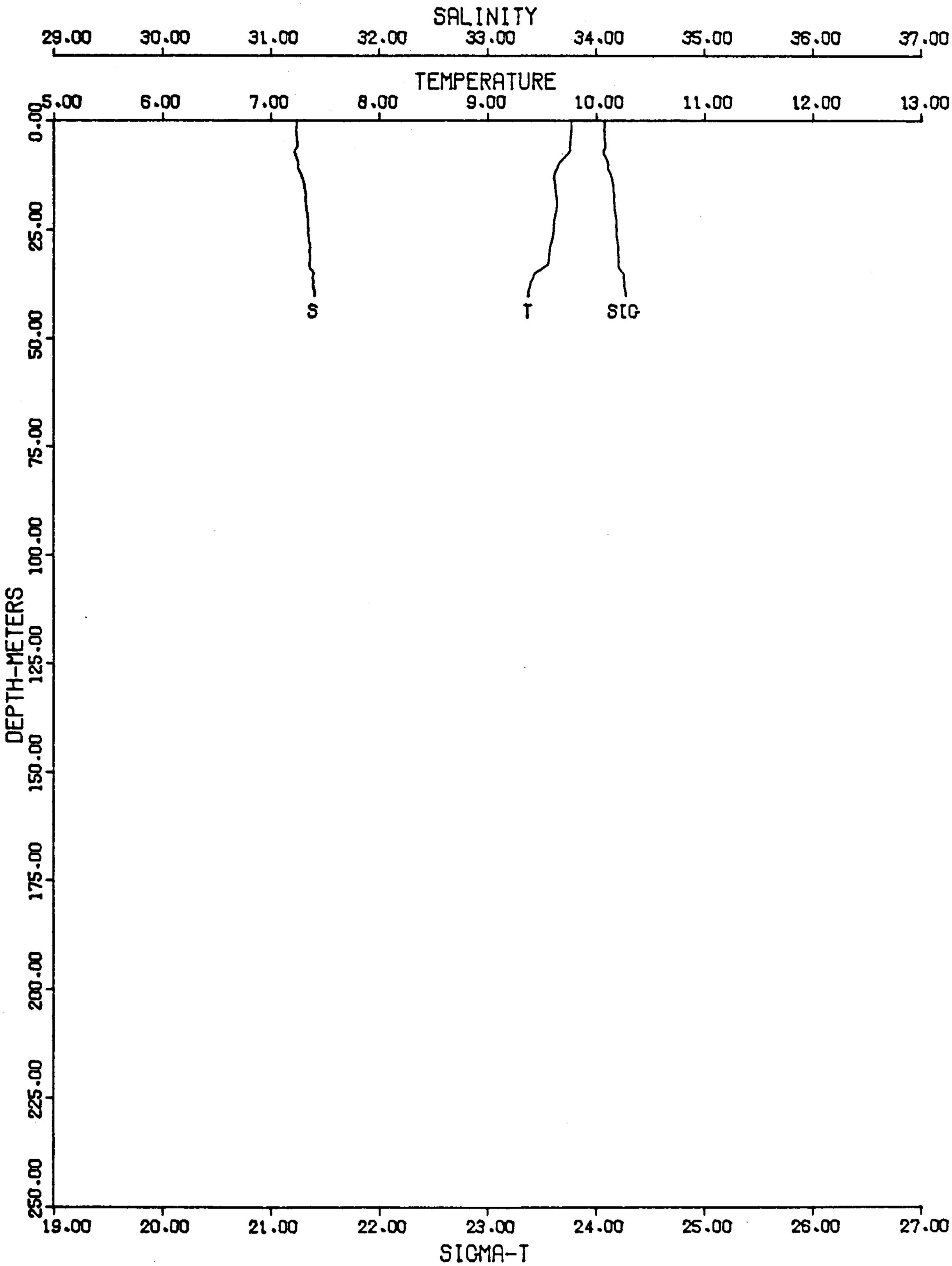

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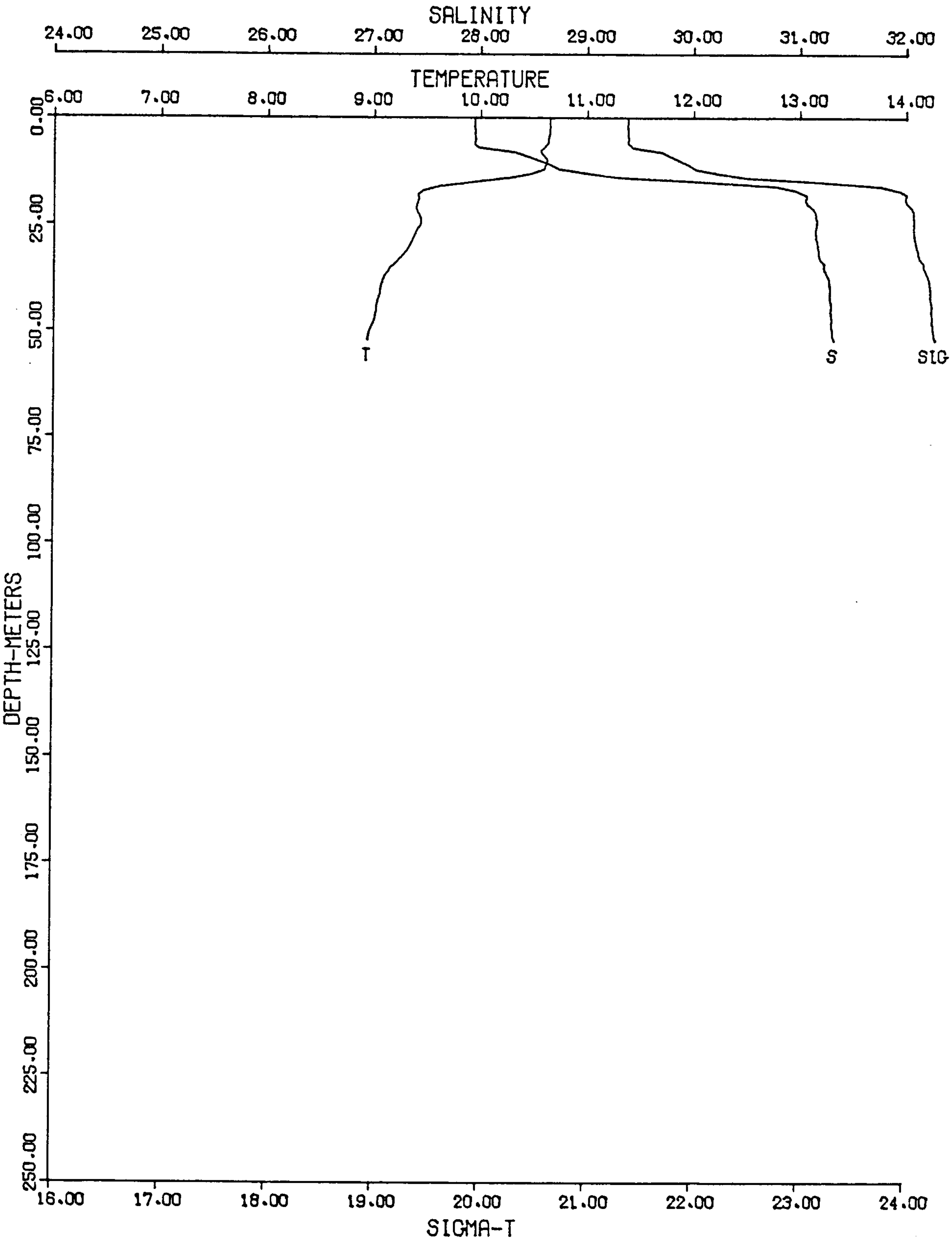

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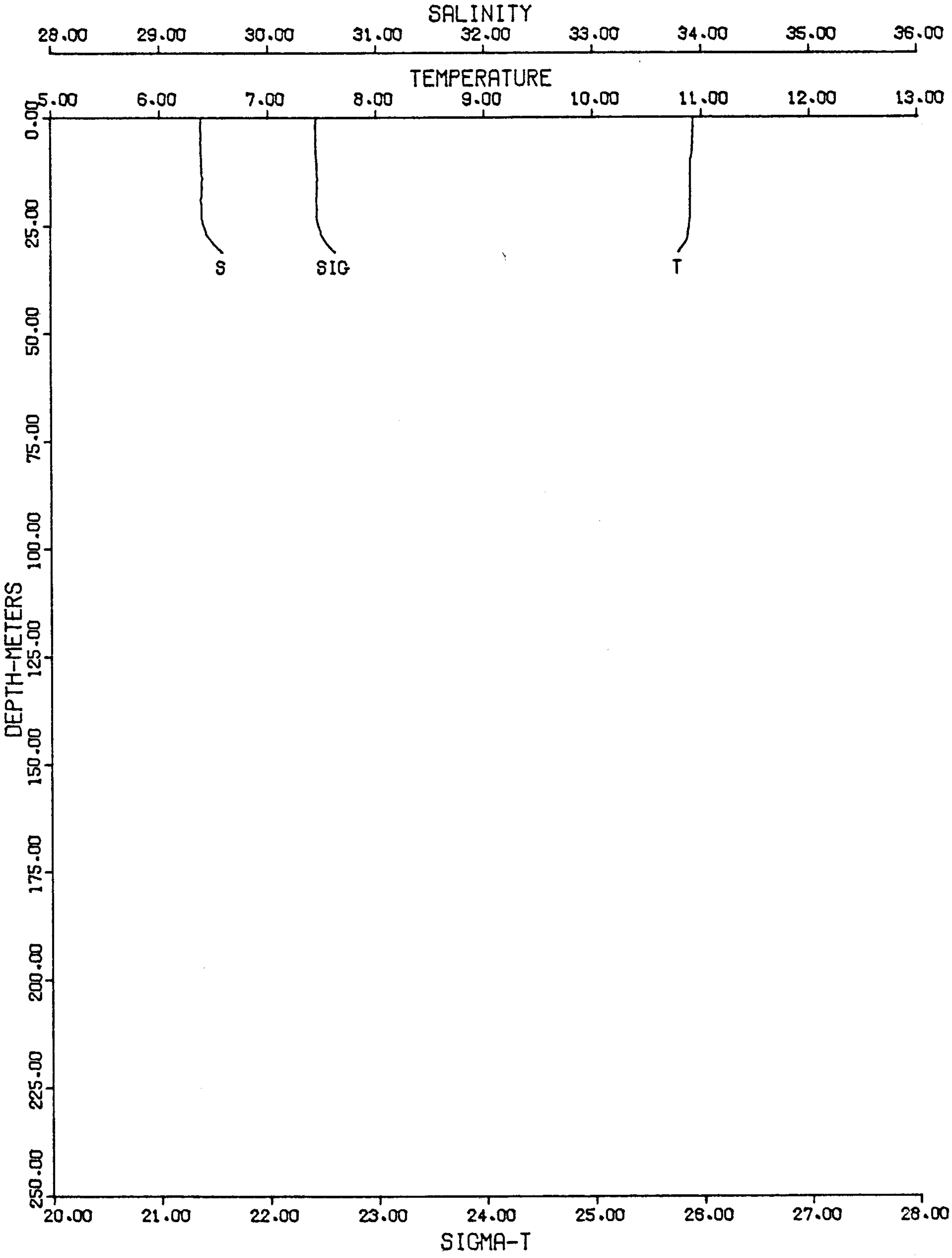

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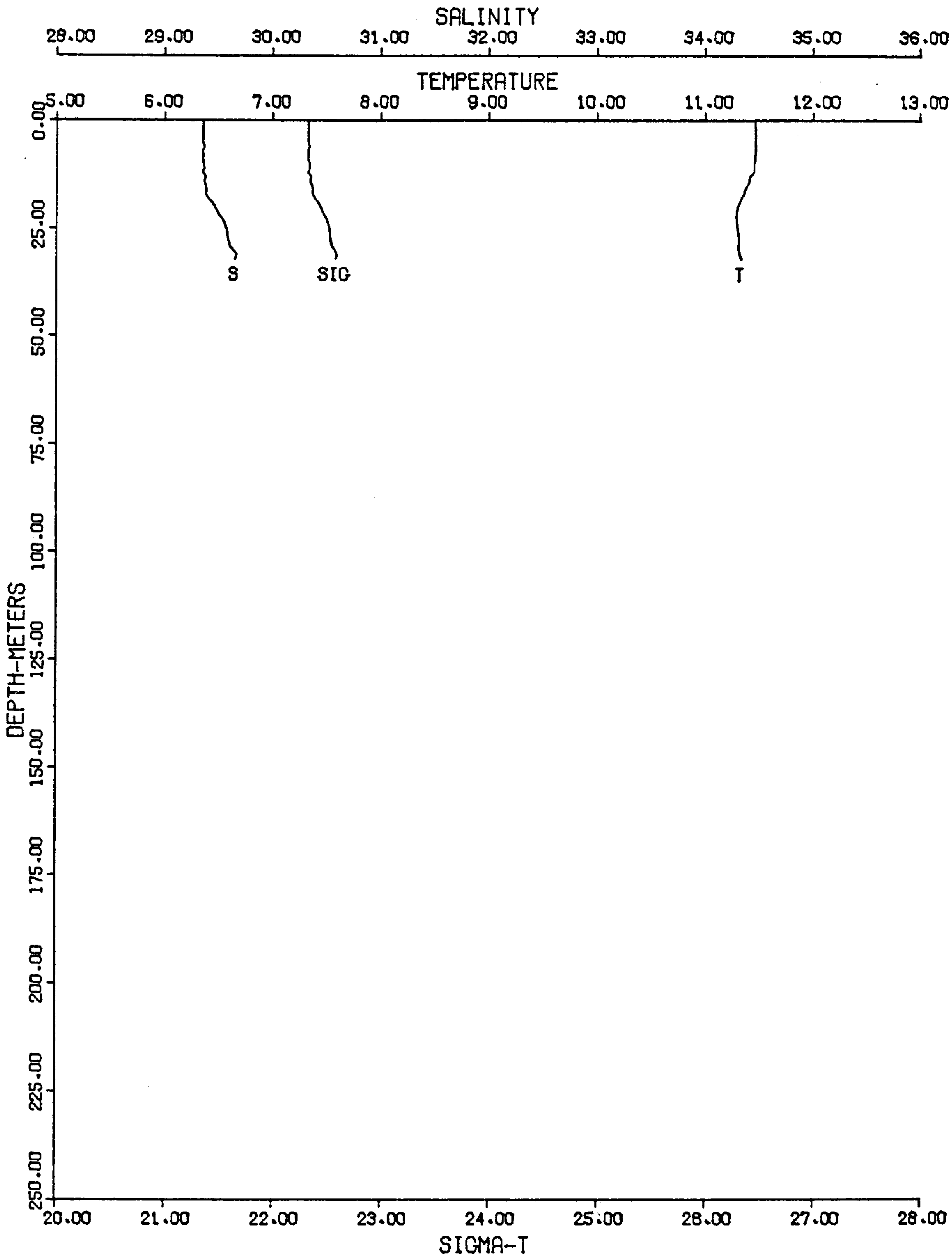

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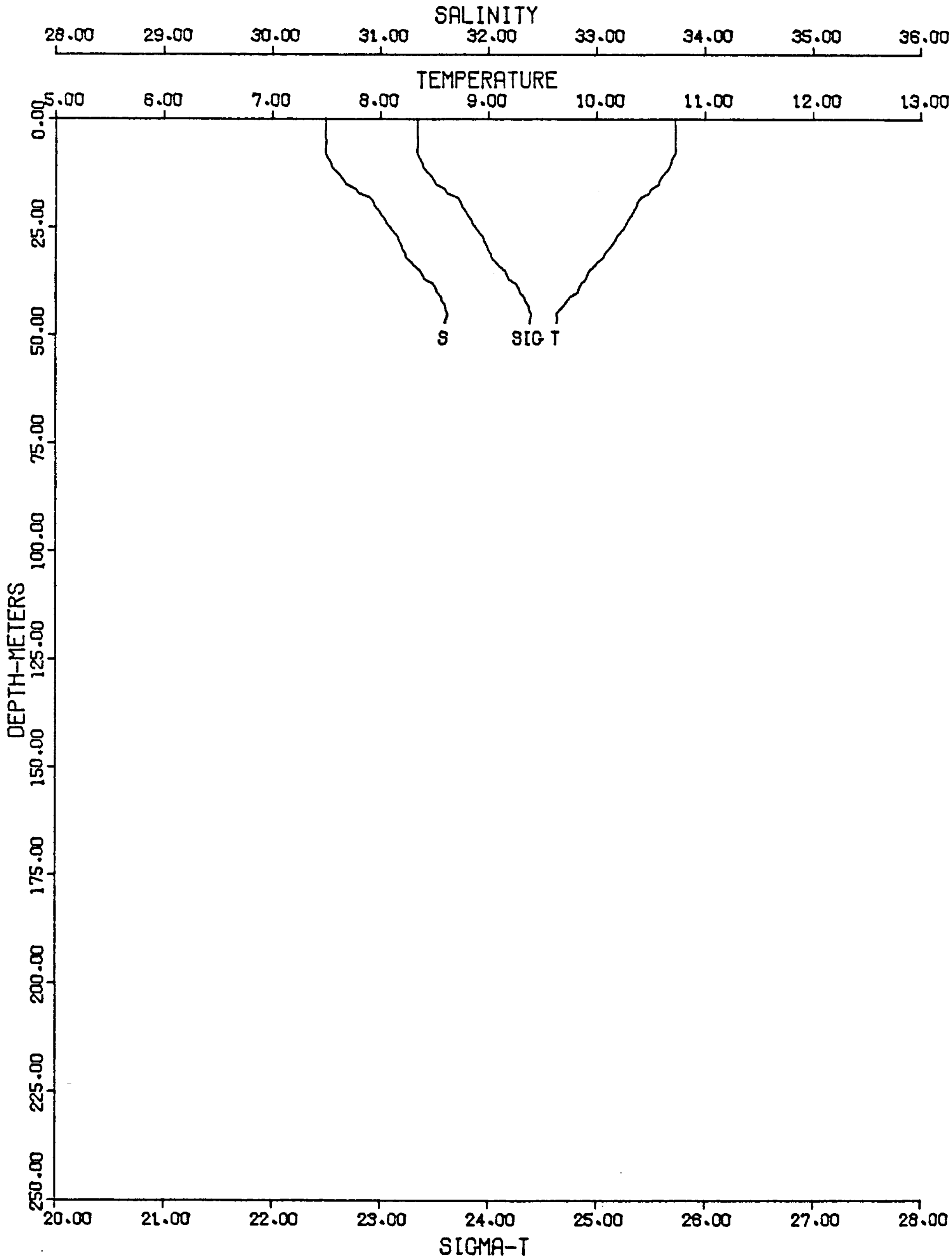

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CRUISE GOA 6

ANNUAL REPORT

Research Unit #425
Reporting Period:
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138 Pages

INITIAL ZOOPLANKTON INVESTIGATIONS IN PRINCE WILLIAM SOUND, GULF OF ALASKA AND LOWER COOK INLET

Dr. David M. Damkaer

Principal Investigator

Pacific Marine Environmental Laboratory

National Oceanic and Atmospheric Administration

3711 15th Avenue N.E.

Seattle, Washington 98105

(Report prepared by D. B. Dey and D. M. Damkaer)

31 March 1977

I. SUMMARY

Prince William Sound and Gulf of Alaska, 1975

Zooplankton was sampled during two cruises to the northern Gulf of Alaska: in Prince William Sound in October, and on the continental shelf in November 1975. The zooplankton studies are part of a comprehensive environmental assessment of the Alaskan shelf, in light of present and future offshore petroleum resource development.

The fauna of the subarctic Pacific region is not particularly diverse, when compared to warm-water plankton. Nevertheless, we are dealing, in the net-zooplankton, with a complex that undoubtedly comprises several hundred species. We have identified about 100 species from the fall and early winter. Relatively few species might be treated as principal components, because of their numbers and mass, or because of their critical roles in the transfer and conversion of matter and energy within the ecosystem.

During late 1975, the most common zooplankton species were found to have vertical distributions fitting into four basic patterns, including an important group of species that spend the day in deep water, and rise into the surface layer at night. Though the bulk of the zooplankton remained below 100 m, there appeared to be a sixfold increase in zooplankton volume above this level during the night. Such active movements must be considered if the daily and seasonal cycles of distribution and abundance of organisms are to be adequately assessed. The migrating organisms include animals which are major grazers and which in turn are major food items for higher trophic levels, particularly commercial fishes. If pollutants are introduced into the surface layers, the pollutants may not be contained, but could quickly be transferred to deeper water by these active migrators.

Lower Cook Inlet, Gulf of Alaska, Prince William Sound, 1976

The 0-25 m zooplankton volumes were uniformly low throughout Lower Cook Inlet during Cruise I (April, 1976). There was an increase in plankton volume in early May, with perhaps a maximum in Kachemak Bay. By late May, the plankton volumes were moderately high everywhere in Lower Cook Inlet. By early July, Kachemak Bay plankton volumes had decreased somewhat, but other Lower Cook Inlet stations had maximum plankton volumes for the period Cruises I-V. Zooplankton volumes in open Lower Cook Inlet were therefore roughly equivalent to and paralleled those from the open ocean just off the continental shelf (Station 11).

Except for larvae of benthic invertebrates, which are very important as recruits and as food sources, the most abundant plankton in Lower Cook Inlet are identical to those of the surface and near-surface open ocean (Station 11). There are many more species of holoplankton in the open ocean, but the shallower water of Cook Inlet excludes them.

II. INTRODUCTION

A. General scope of the study

Zooplankton are important components of the environment in terms of volume, in terms of their roles in the ecosystem, and in terms of probable sensitivity to the kinds of development anticipated on the Alaska OCS. Zooplankton are necessary for the maintenance of fish, shellfish, and other living resources. Zooplankton are also important in the movement and concentration of environmental contaminants. In the northeastern Pacific, particularly its estuaries and coastal seas, relatively little is known of the distribution and abundance, seasonal cycles, or vertical distributions and migrations of zooplankton. Assessments of these factors are necessary for the study of ecological processes relevant to environmental problems.

B. Specific objectives

The objectives of this project are to determine the seasonal distribution and abundance of zooplankton in selected areas of the Gulf of Alaska. Particular attention is being given to the distributions of copepods (the most abundant net-plankton and the key grazers), amphipods and euphausids (important food for fishes), chaetognaths (key carnivores), larval decapods, and some other groups. All major taxa are enumerated as such whether or not the individual species can be identified. This work will lead to development of a monitoring strategy. Also, it will ultimately contribute to an ecosystem model by defining pathways and amounts of energy or material flow and indicating the relative importance of the several populations.

C. Relevance to problems of petroleum development

There is no doubt that we would be indifferent to the marine environment were it not for the living systems it contains and supports. Except for possible esthetic effects, we would not be concerned about physical degradation of an environment without life. But our coastal waters do contain living things, in a great variety and abundance, many of which are utilized directly as valuable foods, and all of which, indirectly or directly, are part of a single closely-integrated environmental system. Exploration for and production and movement of oil on the continental shelf holds potential dangers for these sensitive organisms. Among these organisms, the zooplankton hold a major position. Many organisms are planktonic for their entire life cycle, and even organisms which are not usually thought of as plankton pass through critical early life stages in the plankton. For example, intertidal animals, which might be killed due to local disturbances, are dependent on distant breeding stocks for their recruitment, the new colonizers coming via the plankton. Most benthic and nektonic organisms have planktonic eggs and/or larval stages. These early stages are usually more sensitive than the adult forms.

We should be concerned about all levels of pollution and environmental perturbations. The environment need not be so drastically altered as to kill the plankton outright. The transfer of matter and energy through the various links of the living system is so subtle that very minor changes may easily upset the timing of these transfers or the pathways (species) on which they may occur. A seemingly small change in timing, or a seemingly insignificant shift in pathways, may drastically alter the occurrence and cycles of key members of the community.

The living systems are as much a part of the environment as are the more accessible physical features. An environmental assessment must therefore take into account the distribution and abundance of the living components. Subtle changes in water quality, through any man-caused perturbations, might initially be detected by the response of organisms. Probably these responses will first be noticed by shifts in the relative abundance of species, certain organisms being more responsive to change than others. Such changes are impossible to document solely after the fact.

Under normal circumstances the abundances of plankton organisms are extremely variable in time and space. Without a long series (several years) of closely-spaced observations it is not possible to delineate "typical" or "average" abundances. But with sufficient observations, the probable maxima and minima can be described, together with statistical statements as to variability, so that the likelihood of detecting given numerical changes can be predicted.

Only with such forehand knowledge of community composition and its variations in time and space could real changes in populations be noticed. Catastrophic changes are easy to monitor, and normally the environment is resilient and responsive enough to return relatively soon to a standard condition once the stress is removed. But a slow and steady degradation of the environment is the more serious alteration. And it is with such changes that we should be most concerned. These are the long-range subtle changes that ultimately would alter the environmental balance, possibly in a very undesirable and irreversible way.

III. CURRENT STATE OF KNOWLEDGE

North of about 45° N, the subarctic Pacific comprises a faunal as well as a hydrographic region. Most of the zooplankton of the upper layers are found throughout the subarctic but are not found in the central North Pacific (below 40° N), nor are many of the southernspecies common to the subarctic region. In the northeast Pacific, the Gulf of Alaska is dominated by the cyclonic Alaskan gyre, a tributary of the North Pacific's westwind drift. The center of this gyre is characterized by a slight upwelling, with higher salinities and nutrient concentrations than are found shoreward and to the south within the Gulf. As in the rest of the subarctic Pacific, there is a permanent halocline at about 100-150 m in the Gulf of Alaska, and a seasonal (summer) halocline at about 30-50 m. However, the permanent halocline is often absent over the shelf in winter, since the dominant winter winds result in coastal downwelling. There is a net dilution of the water mass as it passes counterclockwise around the Gulf, increasing in the summer at maximum runoff.

The seasonal thermocline varies in depth and extent during the summer, but is usually below 25 m though not below 100 m.

Plankton in the Gulf of Alaska has been studied for decades, but the efforts have been irregular and usually limited to near-surface waters in the summer. We have a fair idea of large-scale faunal distributions in the water masses of the whole North Pacific, but very little information on detailed distributions in specific areas within the Gulf of Alaska. Much is known about the <u>kinds</u> of plankton organisms in the Gulf and, except for larval stages and a few large and important groups like cyclopoid copepods, the general taxonomic problems are manageable. However, it is still necessary to be familiar with a diffuse literature when dealing with the taxonomy of Gulf of Alaska plankton, for there are no comprehensive "keys" for routine identifications.

Because of the irregular space/time investigations, there is not much information on the dynamics of plankton populations within the Gulf of Alaska, including seasonal cycles of single species, species successions, or recruitment. In addition, almost nothing is known about feeding patterns and rates, reproduction and growth, migrations, metabolic processes, and relative sensitivities. Limits of variability in time and space should be outlined in such a way that we can specify subsequent sampling efforts required to detect given changes. This is the fundamental problem and should be given high priority.

Most of the area's information is extrapolated from studies at Station "P" (50° N, 145° W), on the southern edge of the Gulf of Alaska. Studies at Station "P" have given us a reasonable idea of seasonal cycles of phytoplankton and zooplankton in general in this oceanic region, but the populations and their cycles are probably not equivalent in the waters of the Alaskan shelf.

Though it has not been well-substantiated, the "spring" increase in phytoplankton activity appears to begin in February or March around the perimeter of the Gulf of Alaska, and advances toward the center until April or May. This follows from the progression of water-column stability (Parsons, et al., 1966). In the oceanic region, in the deep water away from the shelf, there is no sudden increase in phytoplankton biomass as is typical for other temperate ocean areas (e.g., North Atlantic). This is due to the life histories of the main species of grazing copepods. In the North Pacific these species (Calanus cristatus and C. plumchrus) breed independently of the increase in phytoplankton biomass, in contrast to the related species in the North Atlantic whose breeding depends on and follows the spring increase in phytoplankton standing stock. Thus, in the central Gulf of Alaska, the main biomass increase of the spring period is expected in the zooplankton, not the phytoplankton. One might expect the typical "North Atlantic pattern" in the shallow shelf waters, since the critical effect of the large grazers is related to their sudden ascension from deep waters. The relationship between the phytoplankton and the zooplankton grazers of the shallow shelf waters, therefore, may include an important lag-time, enabling the phytoplankton standing stock to increase abruptly ("spring bloom"), although this has not yet been well-documented for the Gulf of Alaska.

At the southern edge of the Gulf of Alaska (LeBrasseur, 1965), the zooplankton biomass to about 150 m (the total depth is on the order of 4000 m, so that considerable zooplankton mass is not included) declines to a yearly minimum of approximately 10 g wet weight/1000 m^3. In March there is an increase in zooplankton standing stock, reaching a yearly maximum around late May of about 175 g wet weight/1000 m^3. Copepods by far dominate this biomass (greater than 90%), and the increase in the year's standing stock is in large part due to the seasonal ascent of overwintering populations. The second most abundant group, the chaetognaths, account for less than 5% of the biomass. Other major zooplankton groups are euphausids and amphipods. There is a year-to-year variation of roughly plus or minus 50% of the mean copepod biomass.

The vertical distributions of zooplankton are very important, for their occurrence at the surface is often related solely to their vertical movements. Their horizontal distributions are also determined to a great degree by the depth ranges occupied. The impact of zooplankton on the phytoplankton, growing only in the near-surface layer, is controlled by the vertical distribution of the principal grazers. And the active movement of zooplankton into deep water is a major biological mechanism of energy and matter transfer in the oceans. The study of vertical distributions of zooplankton in the Gulf of Alaska has barely begun. Most work is based only on surface samples or on integrated net tows (e.g., 150 m to the surface). Some data are available on the distributions of deep water forms, but the only data on the vertical distributions of near-surface plankton are from the southern edge of the Gulf of Alaska. Barraclough, *et al*. (1969), for example, have reported *Calanus cristatus* in a dense layer migrating between about 30 m (day) and the surface (night). Marlowe and Miller (1975) have recently investigated summer vertical distributions of the most common zooplankton of the upper 500 m at Station "P." The zooplankton fit into five basic patterns of vertical distributions. Less than 10% of the species exhibited daily vertical migration (at that time), but these were large and abundant enough to result in a significant daily change in surface biomass.

IV. STUDY AREA

Original program guidelines called for broad area coverage a few times a year. Consequently, the first zooplankton investigation (on NOAA *Discoverer*) was to be conducted in the northeast Gulf of Alaska in

October and November, between Resurrection Bay and Yakutat (fig. 2). Prior to that cruise, the Principal Investigator was asked to use the University of Alaska's Acona in Prince William Sound, although the cruise ultimately was undertaken on the NOAA Surveyor, in early October (fig. 1).

Thirty stations were occupied in the Prince William Sound region (fig. 1). The first nine stations were at a single very deep locality well within Prince William Sound, and were occupied every 4-6 hrs for 48 hrs. This series has given a good indication of the incidence and magnitude of zooplankton diel vertical migration. The next 20 stations were at various locations and times throughout the Sound and its major fjords. Station 30 was in the open Gulf at 59° N, 147° W, during the return to Kodiak. Fifty-two stations were occupied on the open shelf (fig. 2). Two localities were sampled for 36 consecutive hrs (fig. 3).

The project was first directed into Lower Cook Inlet in April of 1976 (fig. 4) and in subsequent months a total of five cruises were taken to Cook Inlet:

Cruise I	6 - 13 April 1976	NOAA DISCOVERER
Cruise II	5 - 9 May 1976	NOAA DISCOVERER
Cruise III	24 - 30 May 1976	NOAA DISCOVERER
Cruise IV	8 - 15 July 1976	U. of Alaska ACONA
Cruise V	24 - 31 Aug 1976	NOAA SURVEYOR

The cruises included transects across the open continental shelf, for comparative purposes. Cruises I, III, and V also included a transect into another inshore area (Prince William Sound). Cruise tracklines are shown in Figures 5 - 9.

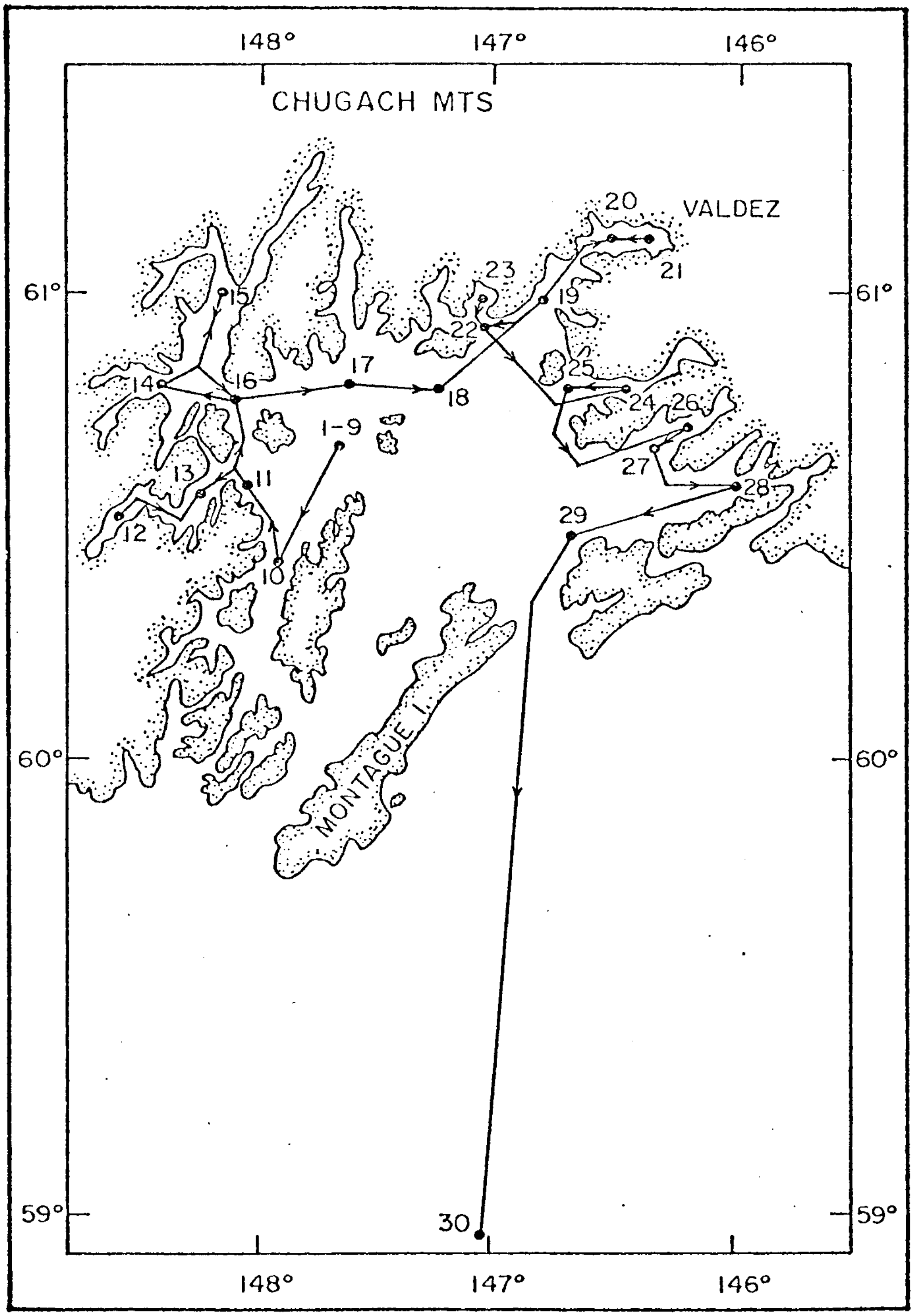

Figure 1. Stations and ship tracklines for Leg I, *Surveyor*, 30 Sep - 10 Oct 1975. The cruise track was approximately 700 km.

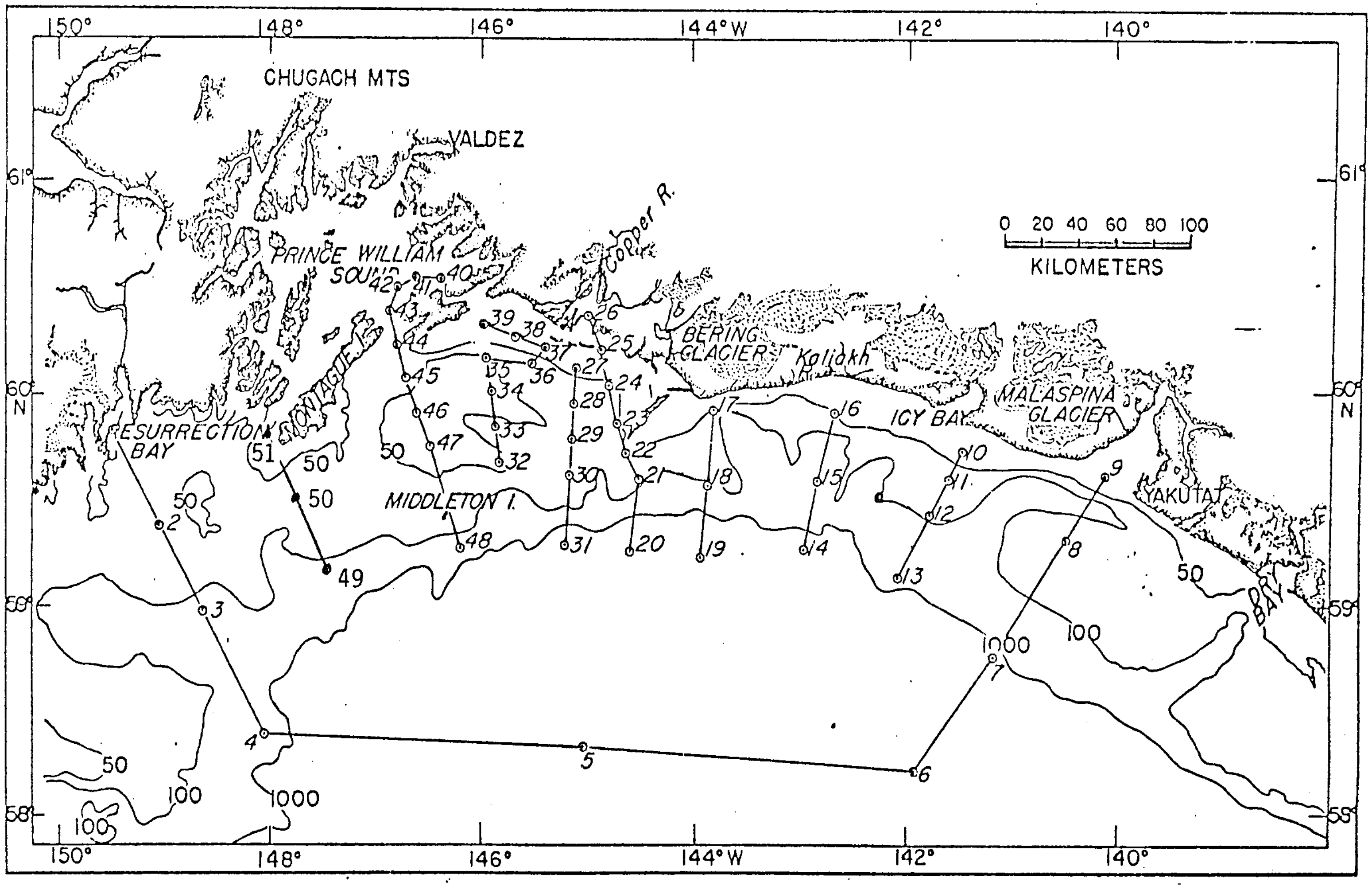

Figure 2. Sampling stations, Northeast Gulf of Alaska Cruise, 21 October-14 November, 1975, NOAA DISCOVERER.

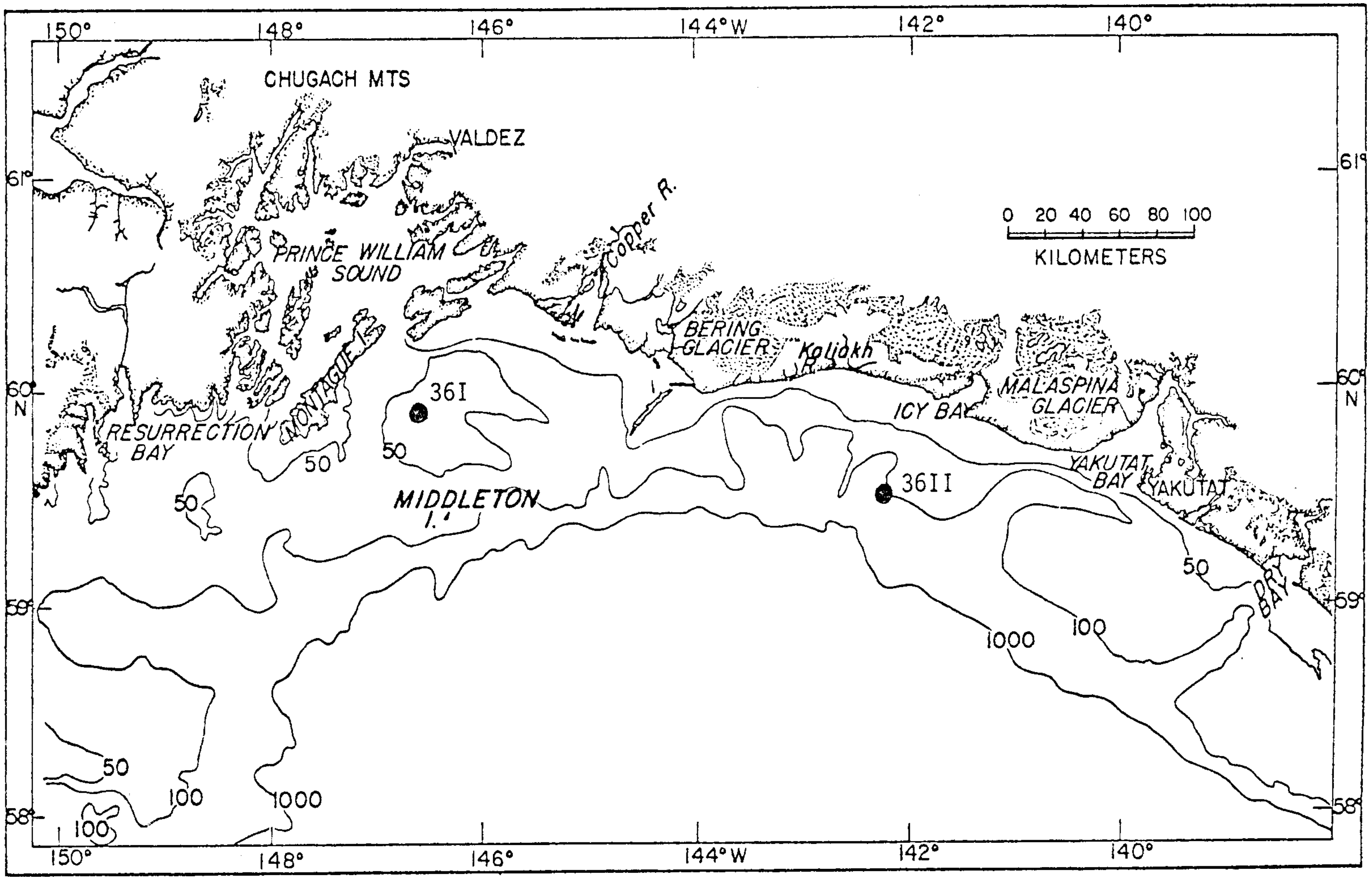

Figure 3. Zooplankton survey, northern Gulf of Alaska, two 36-hour stations, November 1975.

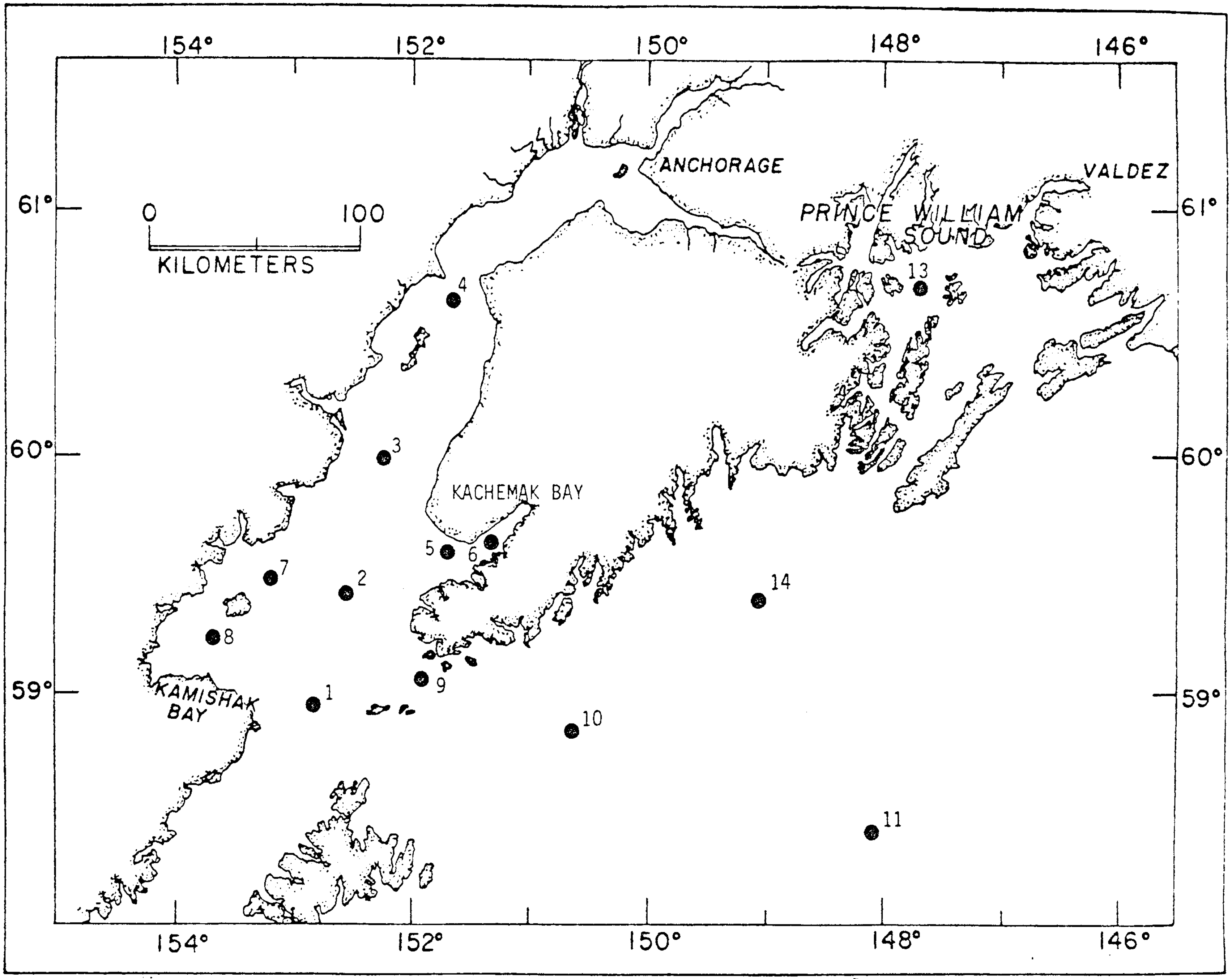

Figure 4. Station locations for Cook Inlet Cruises I-V, April - August, 1976.

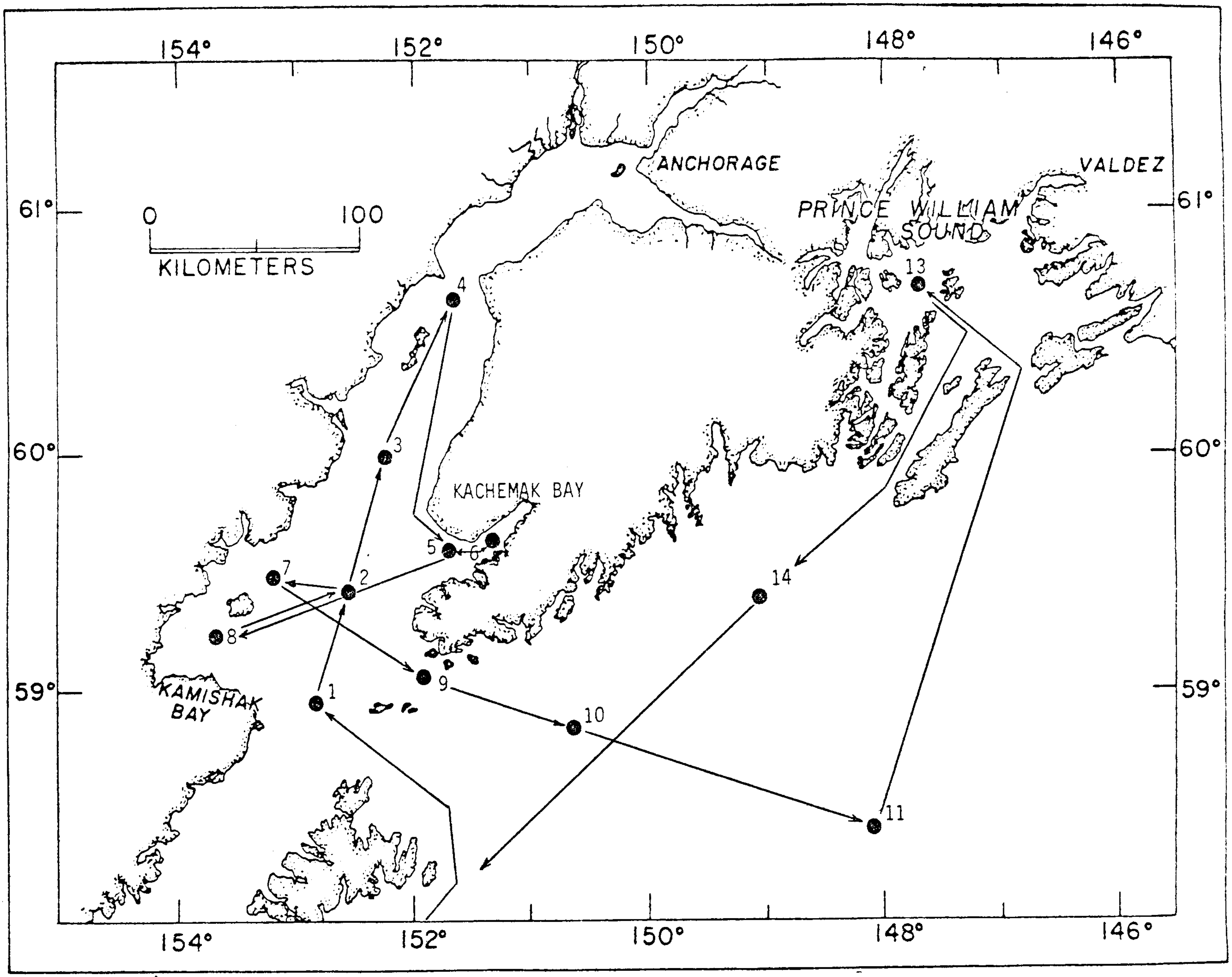

Figure 5. Cruise I (RP-4-DI-76A-LEG III), April 6 - April 13, 1976.

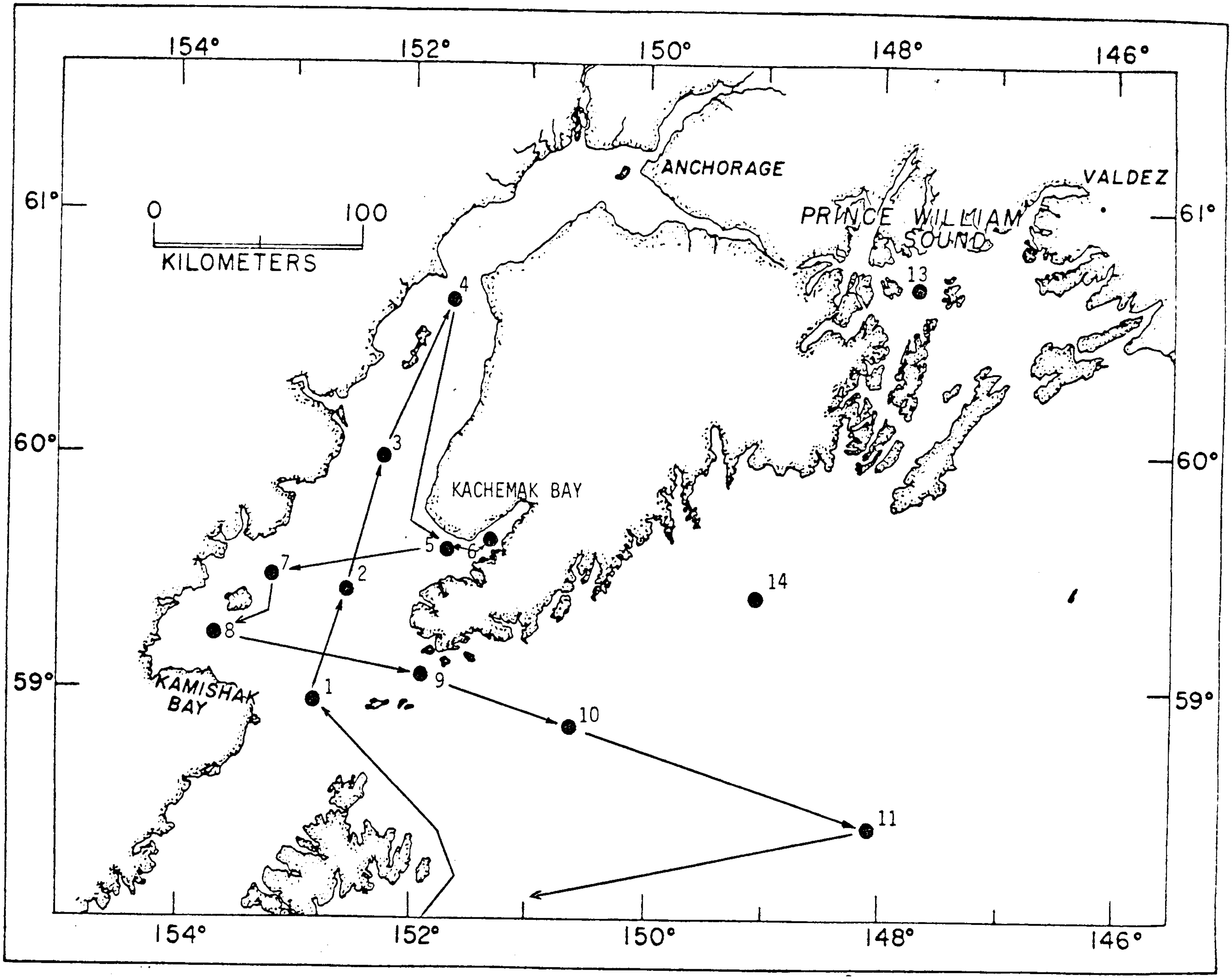

Figure 6. Cruise II (RP-4-76A-LEG V), May 5 - May 9, 1976.

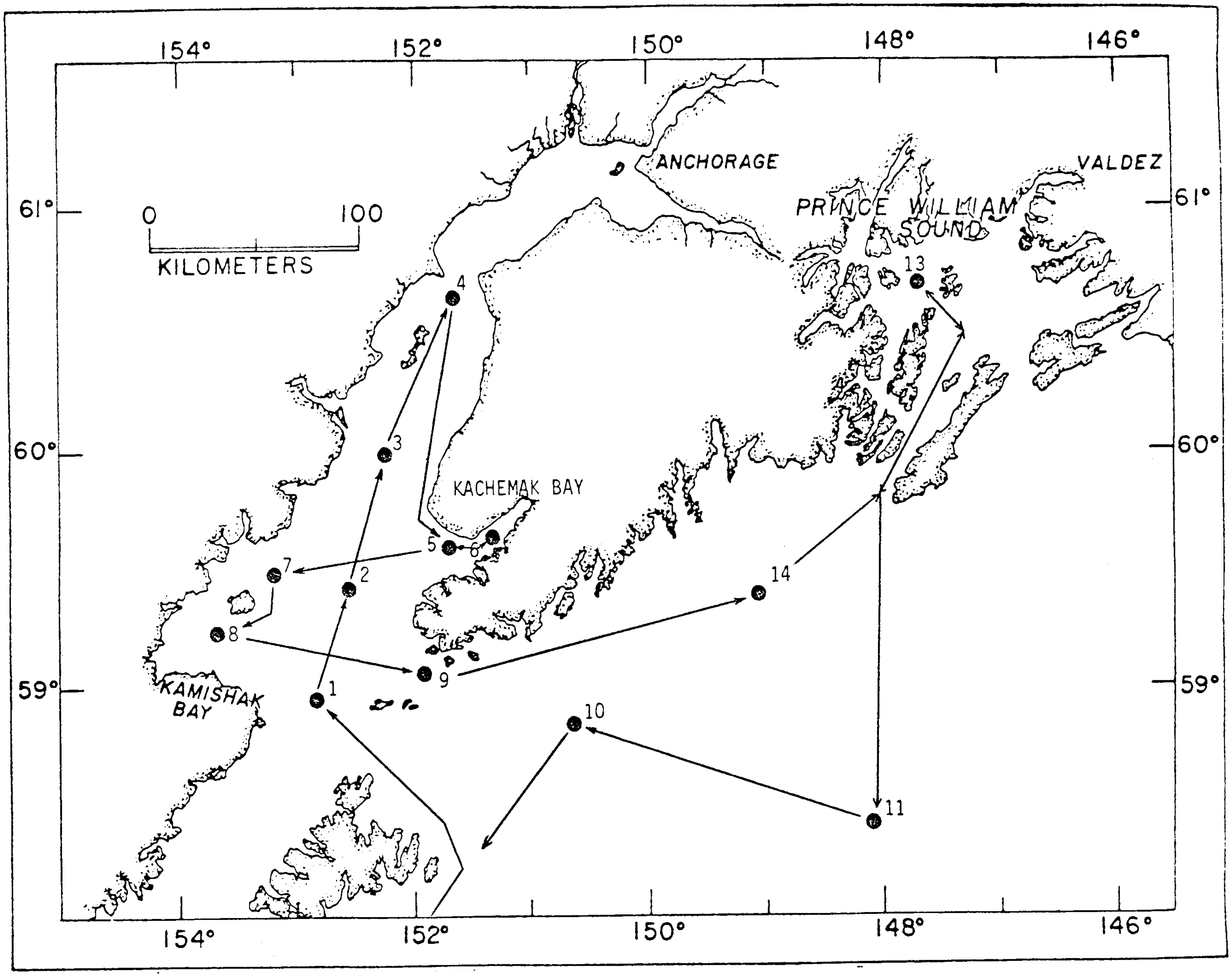

Figure 7. Cruise III (RP-4-DI-76A-LEG VII), May 24 - May 30, 1976.

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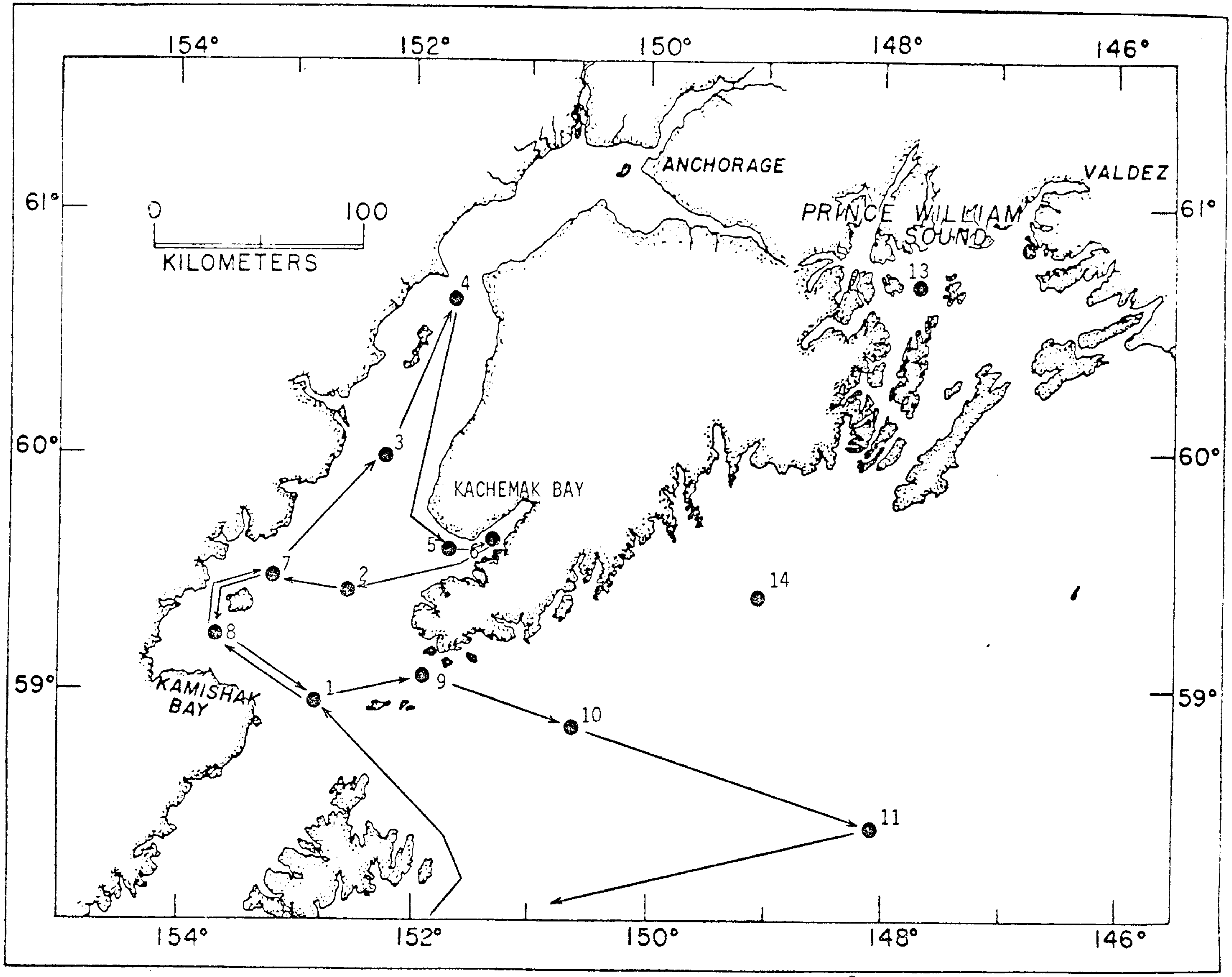

Figure 8. Cruise IV (R/V ACONA), July 8 - July 15, 1976.

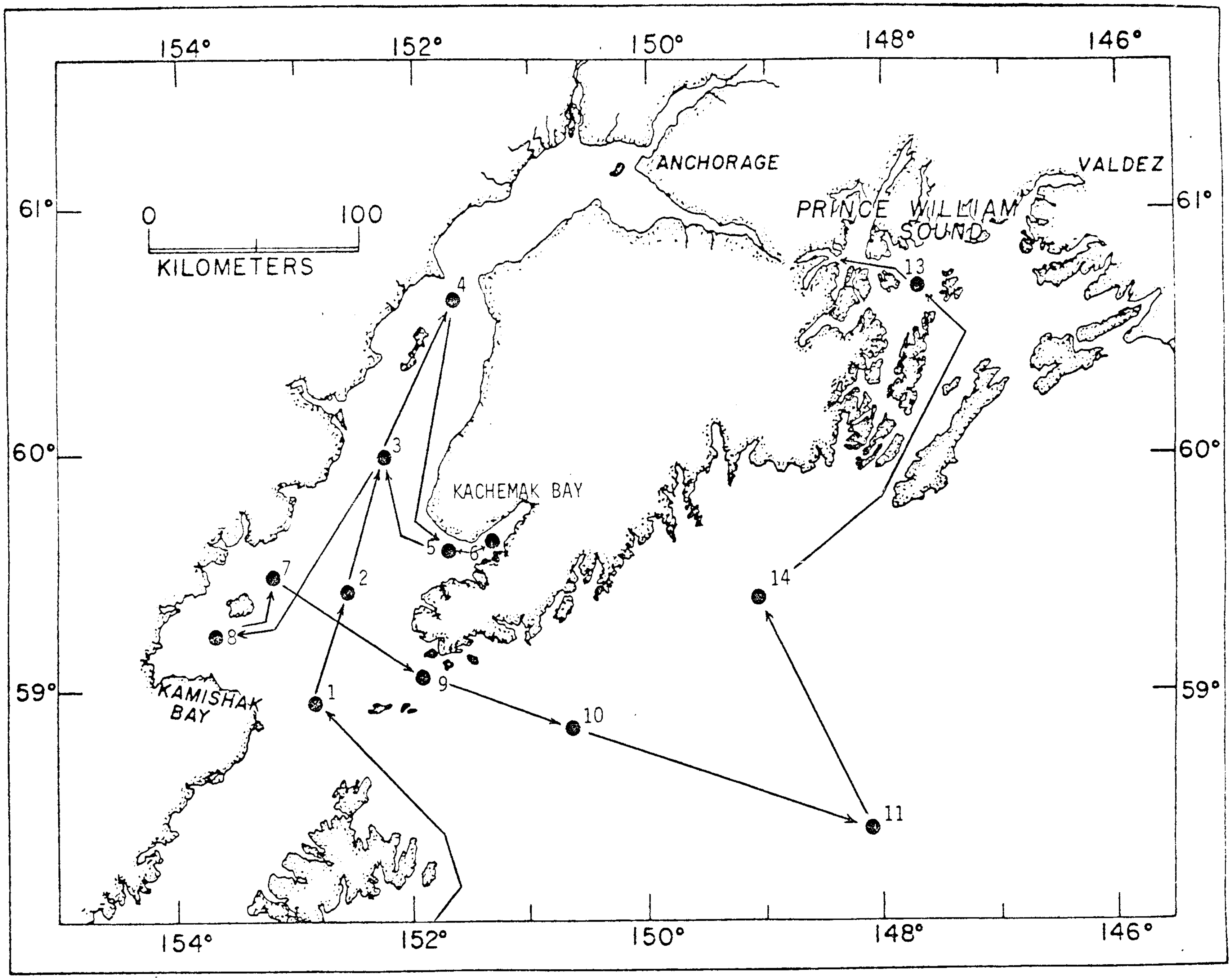

Figure 9. Cruise V (RP-4-76B-LEG II), August 24 - August 31, 1976.

V. SOURCES OF DATA

On all cruises zooplankton was sampled primarily with closing ring nets of 60 cm diameter and 211 μ mesh. These nets were hauled vertically through strata of varying thicknesses, obtaining discrete samples as follows (depth permitting): 25-0 m; 50-25 m; 100-50 m; 300-100 m; 500-300 m; the bottom-500 m. In addition, some samples were obtained with Tucker trawl, NIO net, and bongo net. In Prince William Sound (1975), 143 zooplankton samples were taken with the vertically-hauled net, nine with Tucker trawl (by A. Adams, University of Alaska), six with NIO net, and eight with bongo net (by Dr. English's staff). On the shelf, 125 zooplankton samples were collected with the vertically-hauled net and 101 with the bongo net in the fall of 1975.

On Cruises I-V to Lower Cook Inlet in 1976, zooplankton was sampled at noon and midnight with the closing ring nets and at each station samples were obtained with the bongo net, mesh sizes of 333 and 505 μ , towed obliquely between the surface and 200 m (or the bottom in shallow areas). The distribution of the samples between the cruises is as follows:

	Vertically Hauled Net	Bongo Net	
Cruise I (April)	51	26	
Cruise II (early May)	17	22	
Cruise III (late May)	43	28	
Cruise IV (July)	34	24	
Cruise V (August)	30	34	
	175	134	(Total 309)

Volume of water sampled was estimated as the product of wire length and the area of the net, assuming that filtration was 100%. There was little evidence of mesh clogging by phytoplankton, except in Kachemak Bay on Cruise II.

In the laboratory, each zooplankton sample is allowed to settle overnight in a graduated cylinder and the settled volume of the sample is recorded. The large or otherwise conspicuous organisms are then removed and enumerated. The smaller organisms are identified and enumerated from a subsample. Displacement plankton volumes were determined on board during Cruises IV and V in Lower Cook Inlet.

Data Processing: Data derived from laboratory analyses are recorded on easily read forms from which the key punching of data cards is done. The data are punched, the cards systematically verified and a duplicate copy is made of each deck of data cards to be submitted.

During the year, over 4,500 data cards covering seven cruises from October 1975 to August 1976 were processed and submitted (Table 1).

VI AND VII. RESULTS AND DISCUSSION

Prince William Sound and Gulf of Alaska, 1975

In Prince William Sound (Fig. 1) where the plankton were sampled in nine vertical series at one deep station during 48 consecutive hours, the estimated total zooplankton biomass (settled volume) varied between 0.1 and 7.4 ml/m^3. The average vertical distributions of zooplankton volume from the nine vertical series are shown in Figure 10. There was a definite and consistent nighttime increase in zooplankton volume in the upper 100 m, and especially in the surface layer (0-25 m), due principally to daily upward migrations of some relatively large forms (copepods, amphipods, euphausids and pteropods). The relative numerical increase in plankton was small, but the migrants were large enough to increase the

Cruise	File I.D. #	Area Covered	# Samples
Surveyor, 3 Oct-10 Oct 1975	SU7501	Prince William Sound	142
Discoverer, 20 Oct-10 Nov 1975	DI7501	Gulf of Alaska	24
Discoverer, 6 Apr-13 Apr 1976	CI7601	Lower Cook Inlet Gulf of Alaska Prince William Sound	24 (LCI)
Discoverer, 5 May-9 May 1976	CI7602	Lower Cook Inlet Gulf of Alaska	12 (LCI)
Discoverer, 24 May-30 May 1976	CI7603	Lower Cook Inlet Gulf of Alaska Prince William Sound	17 (LCI)
Acona, 8 July-15 July 1976	CI7604	Lower Cook Inlet Gulf of Alaska	9 (LCI)
Surveyor, 24 Aug-31 Aug 1976	CI7605	Lower Cook Inlet Gulf of Alaska Prince William Sound	6 (LCI)

Table 1. Summary of Data Submitted on Punched Cards.

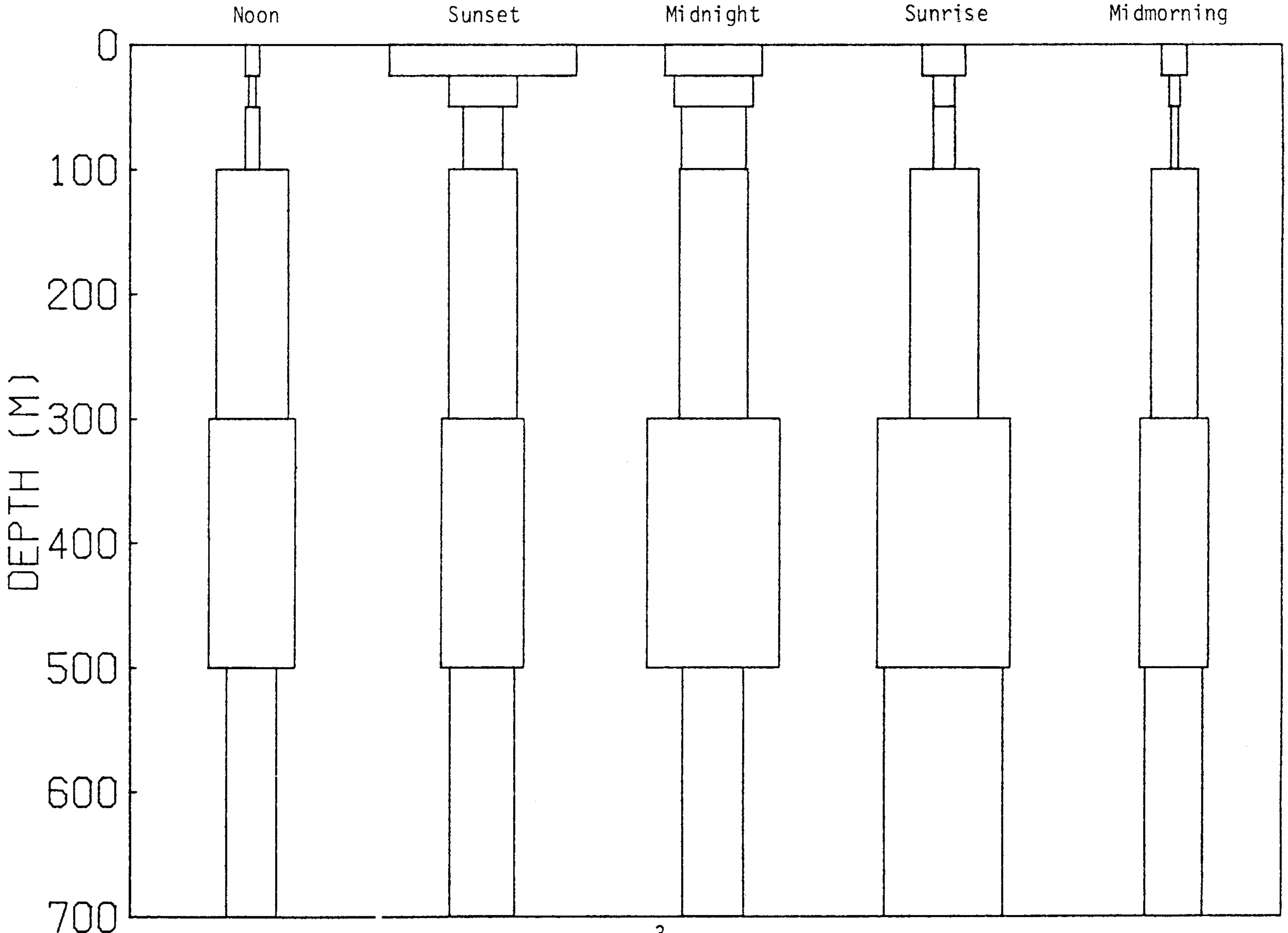

Figure 10. Zooplankton settled volumes (ml/m^3), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = 4 ml/m^3.

plankton volume significantly. The night volume in the 0-100 m layer was six times the day volume.

There was also an additional nighttime increase in the volume between 0 m and the greatest sampling depth (ca. 710 m), due to upward migration of organisms living in the unsampled layer above the bottom. There was probably also some avoidance of the net during daylight. The average daytime zooplankton volume down to 730 m at the deep station in Prince William Sound (stations 1-9, fig. 1) was ca. 1100 ml/m^2, while the average nighttime volume was ca. 1500 ml/m^2.

In the 0-25 m layer, the average daytime volume at stations 1-9 was 0.6 ml/m^3 (range: 0.4-0.7), compared to 3.0 ml/m^3 (range: 1.0-7.4) at night. The 0-25 m layer at that locality can be compared (table 2) with the 0-25 m layer in other localities within Prince William Sound (fig. 1). No geographic pattern can yet be discerned; stations 10 and 25 showed somewhat higher day plankton volumes than would be expected, while stations 16 and 22 showed somewhat less night volume than expected.

Table 2. Zooplankton, settled volume concentration (ml/m^3), 0-25 m, Prince William Sound, Alaska, October 1975.

Station	Day	Night	Station	Day	Night
1-9*	0.6	3.0	20	0.3	
10	1.4		21	0.3	
11		2.1	22		0.6
12	0.3		23	0.7	
13	1.0		24	1.0	
14		1.0	25	1.3	
15		1.0	26		4.9
16		0.4	27		1.4
17	0.4		28		2.0
18	1.1		29		1.4
19		1.4	30	1.0	

*Averages.

The average zooplankton volume concentration of all 14 day stations in the 0-25 m layer was 0.76 ml/m^3 (range: 0.3-1.4), while the comparable value for the 16 night stations was 2.14 ml/m^3 (range: 0.4-4.9).

In November on the open shelf (fig. 3), two 36 consecutive-hr stations were occupied, and zooplankton sampled with methods and depth intervals comparable to those used in Prince William Sound. The average zooplankton volume concentrations for the two day and two night sampling periods at each station did not indicate a marked nighttime increase in the upper layers. The average zooplankton volume concentration in the 0-25 m layer for the two shelf stations was about 1.2 ml/m^3, day and night. Neither station was as deep as most of the stations in Prince William Sound; station 36I was in only 55 m, although station 36II had 200 m depth. At station 36I the lesser depth may have precluded some deep migrants, but vertical migrations might not be significant on the shelf in November.

There was a substantial variety of plankton groups represented in these October-November samples. The most common groups were: Copepoda (by far the most numerous), Amphipoda, Euphausiacea, Ostracoda, Mysidacea, Decapoda, Chaetognatha, Tunicata, Medusae, Siphonophora, Ctenophora, Pteropoda, Polychaeta, and larval fishes.

The Copepoda of Prince William Sound were represented by about 30 species (table 3). The abundances and vertical distributions of some of the most significant species can be mentioned. These data are based on the 48 consecutive-hr station.

The most abundant copepods were small surface-living species, such as *Acartia longiremis*, *Oithona similis*, and adult *Pseudocalanus* spp. The significance of these small copepods comes from their key role in

Table 3. Zooplankton species and major groups, Prince William Sound, Alaska October 1975, April - August 1976

COPEPODA CALANOIDA

Calanidae

Calanus cristatus
C. marshallae
C. pacificus
C. plumchrus
C. tenuicornis

Eucalanidae

Eucalanus bungii bungii

Pseudocalanidae

Microcalanus spp.
Pseudocalanus spp.

Aetideidae

Aetideus pacificus
Chiridius gracilis
C. poppei
Gaetanus juveniles
Gaidius variabilis

Euchaetidae

Euchaeta elongata

Metridiidae

Metridia curticauda
M. lucens
M. okhotensis
Pleuromamma robusta

Centropagidae

Centropages abdominalis

Heterorhabdidae

Heterorhabdus tanneri

Candaciidae

Candacia columbiae

Acartiidae

Acartia longiremis

COPEPODA CYCLOPOIDA

Oithonidae

Oithona similis
O. spinirostris

Oncaeidae

Lubbockia wilsonae
Oncaea borealis
O. prolata

CHAETOGNATHA

Eukrohnia hamata
Sagitta elegans

POLYCHAETA

Typhloscolecidae

Typhloscolex mulleri

Tomopteridae

Tomopteris septentrionalis

MEDUSAE

SIPHONOPHORA

CTENOPHORA

GASTROPODA-Pteropoda

Limacinidae

Table 3 (continued).

Limacina helicina

Clionidae

Clione limacina

CEPHALOPODA

OSTRACODA

ISOPODA

AMPHIPODA

Gammaridae

Lysianassidae

Cyphocaris challengeri

Hyperiidae

Hyperia hystrix
Parathemisto pacifica
P. libellula

Phrosinidae

Primno sp.

Scinidae

Scina sp.

MYSIDACIA

EUPHAUSIACEA

Thysanopodidae

Euphausia pacifica
Thysanoessa inermis
T. longipes
T. raschii
T. spinifera

DECAPODA

SALPA

LARVACEA

Oikopleuridae

Oikopleura sp.

Larval fish and fish eggs

the conversion of plant materials into animal form, in their high concentrations (up to 2000/m^3), and in their high metabolic rates and material/energy turnover. Some other small, though abundant (up to 500/m^3), copepods are more evenly distributed through the water column, or with perhaps minima at mid-depths: *Microcalanus* spp., *Oncaea borealis*, and juvenile *Pseudocalanus* spp.

Several common species of copepods are only found in the deeper layers; this category includes the most important "key" grazers *Calanus cristatus*, *C. marshallae*, and *C. plumchrus*. The latter showed some tendency toward upward migration at night, but possibly this response in all of these species is slight by October. One might expect a more definite daily vertical migration of these species early in the year.

The most abundant dielly migrating copepods were *Metridia lucens* (both adults and stage V) and *M. okhotensis*. *Euchaeta elogata* were not particularly abundant, but their large size made them an important migrator, probably following their prey populations.

Euphausids were not nearly as abundant as copepods, but their large size and critical link between phytoplankton and large carnivores give them an important place in any environmental assessment. Five species, *Euphausia pacifica*, *Thysanoessa inermis*, *T. longipes*, *T. raschii*, and *T. spinifera*, were found. The most numerous (ca. 1-3/m^3) adult euphausids were *T. longipes*, with a day depth maximum between 100-300 and none above 100 m. Their night depth extended into the 0-25 m layer, although the highest concentration was between 25-50 m, with uniform concentration below.

Euphausid juveniles were also abundant (2-3/m^3), and remained mostly in the 0-25 m layer day and night, decreasing in concentration to ca. 100 m, with very few below.

Only two species of chaetognath were found, Eukrohnia hamata (ca. 2/m^3) and Sagitta elegans (5-10/m^3). The vertical distributions of these important carnivores were very consistent. Sagitta elegans showed a definite day and night surface preference, with a maximum between 0-25 m, decreasing evenly to 600 m. Eukrohnia hamata, on the other hand, had a maximum below 300 m, and was never found above 50 m.

Ostracods showed a movement into the upper 25 m at night, with uneven concentrations (20-50/m^3) to 700 m.

The pteropod Spiratella helicina had a day maximum (ca. 1/m^3) below 50 m, with none above. However, the maximum (1-4/m^3) was found in the upper 50 m during the night.

Several amphipods were collected, the most numerous (1-5/m^3) being Cyphocaris challengeri, Parathemisto japonica, and Primno sp. The latter two species were more or less uniformly distributed night and day between 0-300 m, with very few at greater depths. Cyphocaris challengeri was not in the upper 25 m during the day, with a maximum below 100 m. At night, however, the maximum was above 100 m, including high numbers in the 0-25 m layer.

Therefore, the most abundant species seemed to exhibit only a few patterns of vertical distribution (table 4 and figs. 11-23); (1) surface, day and night; (2) fairly uniform with depth; (3) only at depth (most species are in this category); and (4) daily migrators, with deep day maximum and shallow night maximum. Undoubtedly these patterns are a response to light, hydrographic features, and feeding relationships. At other times of the year, and with other species, these patterns would be expected to be modified.

Table 4. Zooplankton vertical distribution patterns, Prince William Sound, Alaska, October 1975.

I. Surface, day and night

Copepoda: *Acartia longiremis*, *Oithona similis*, *Pseudocalanus* spp. (adults)

Euphausid juveniles

Chaetognatha: *Sagitta elegans*

II. Fairly uniform with depth

Copepoda: *Microcalanus* spp., *Oncaea borealis*, *Pseudocalanus* spp. (juveniles)

Amphipoda: *Parathemisto japonica*, *Primno* sp.

III. Only at depth

Copepoda: *Calanus marshallae*, *C. plumchrus*

Chaetognatha: *Eukrohnia hamata*

IV. Diel migrators

Copepoda: *Euchaeta elongata*, *Metrida lucens*, *M. okhotensis*

Euphausiacea: *Thysanoessa longipes* (adults)

Amphipoda: *Cyphocaris challengeri*

Ostracoda

Pteropoda: *Spiratella helicina*

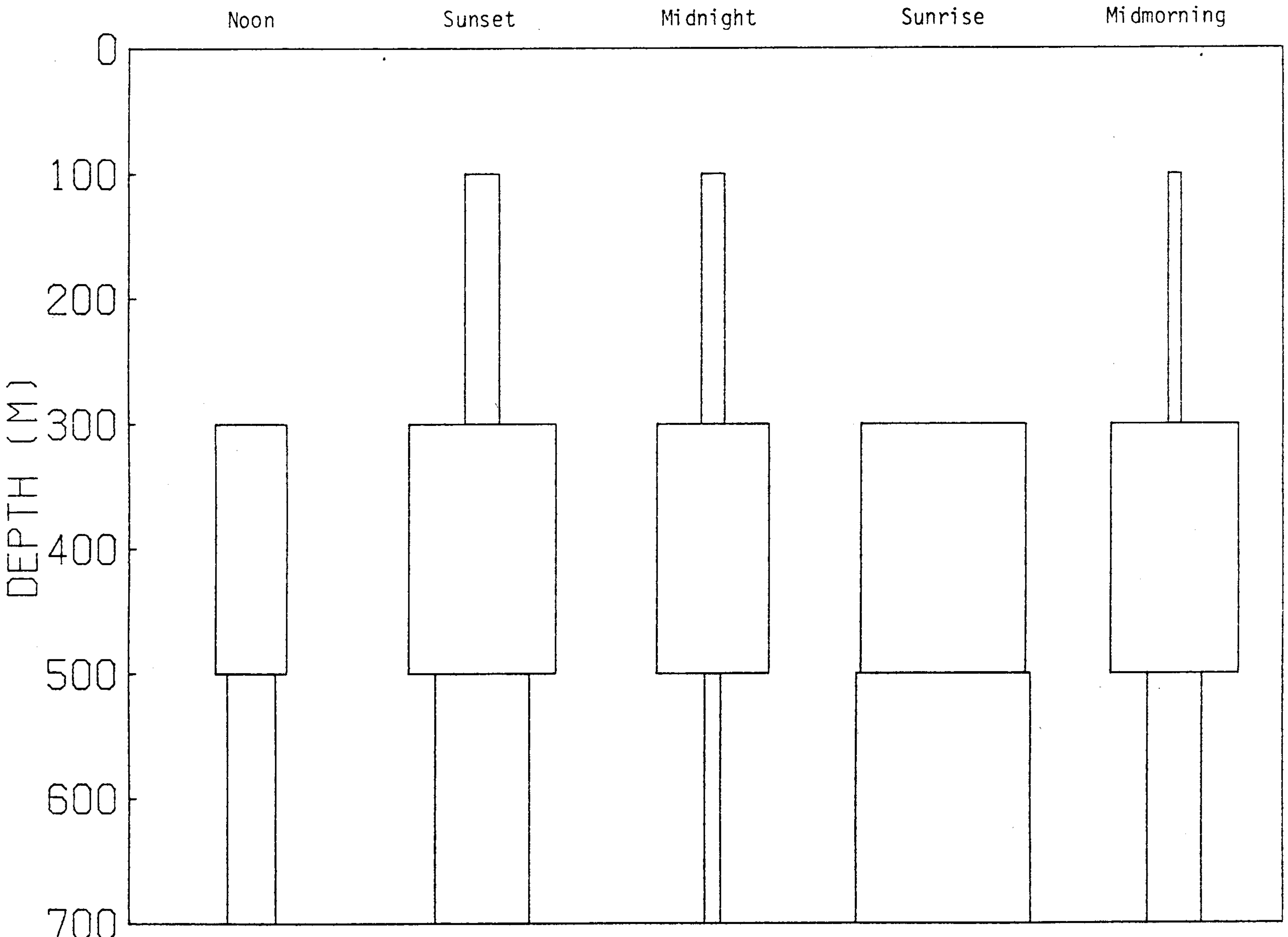

Figure 11. Calanus Plumchrus (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $20/m^3$.

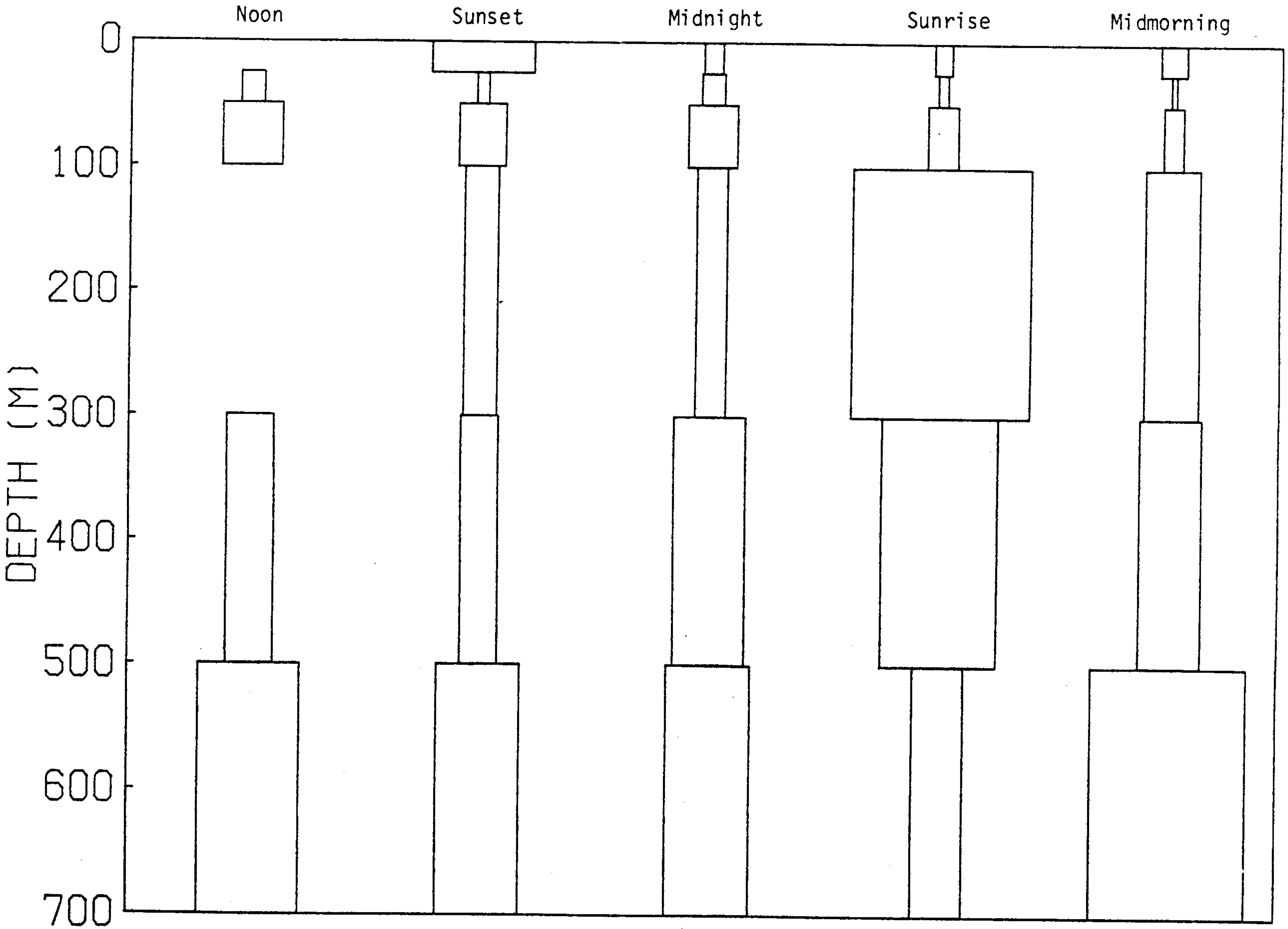

Figure 12. <u>Microcalanus</u> spp. (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $600/m^3$.

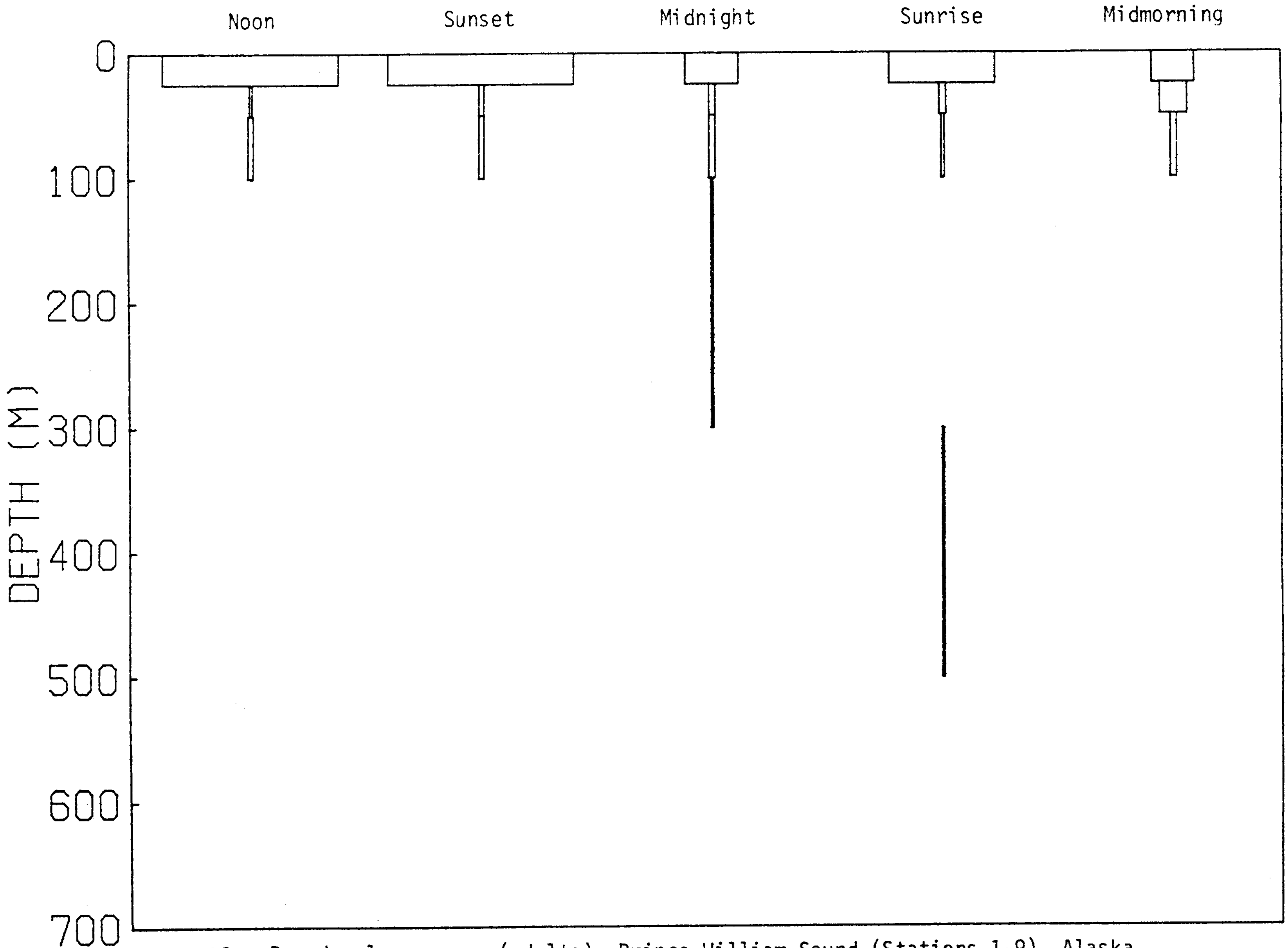

Figure 13. Pseudocalanus spp. (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = 245/m^3.

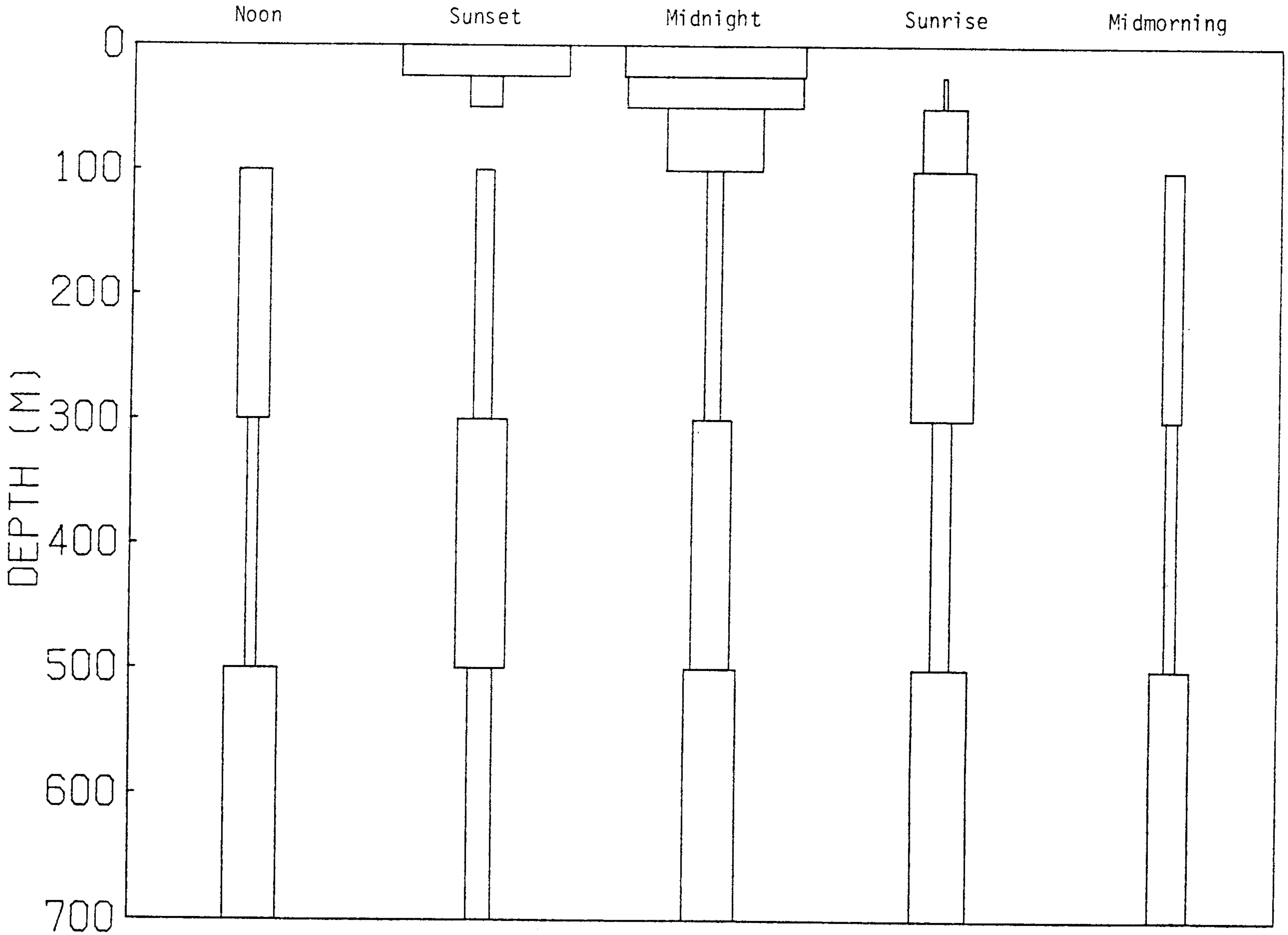

Figure 14. Metridia lucens (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = 85/m^3.

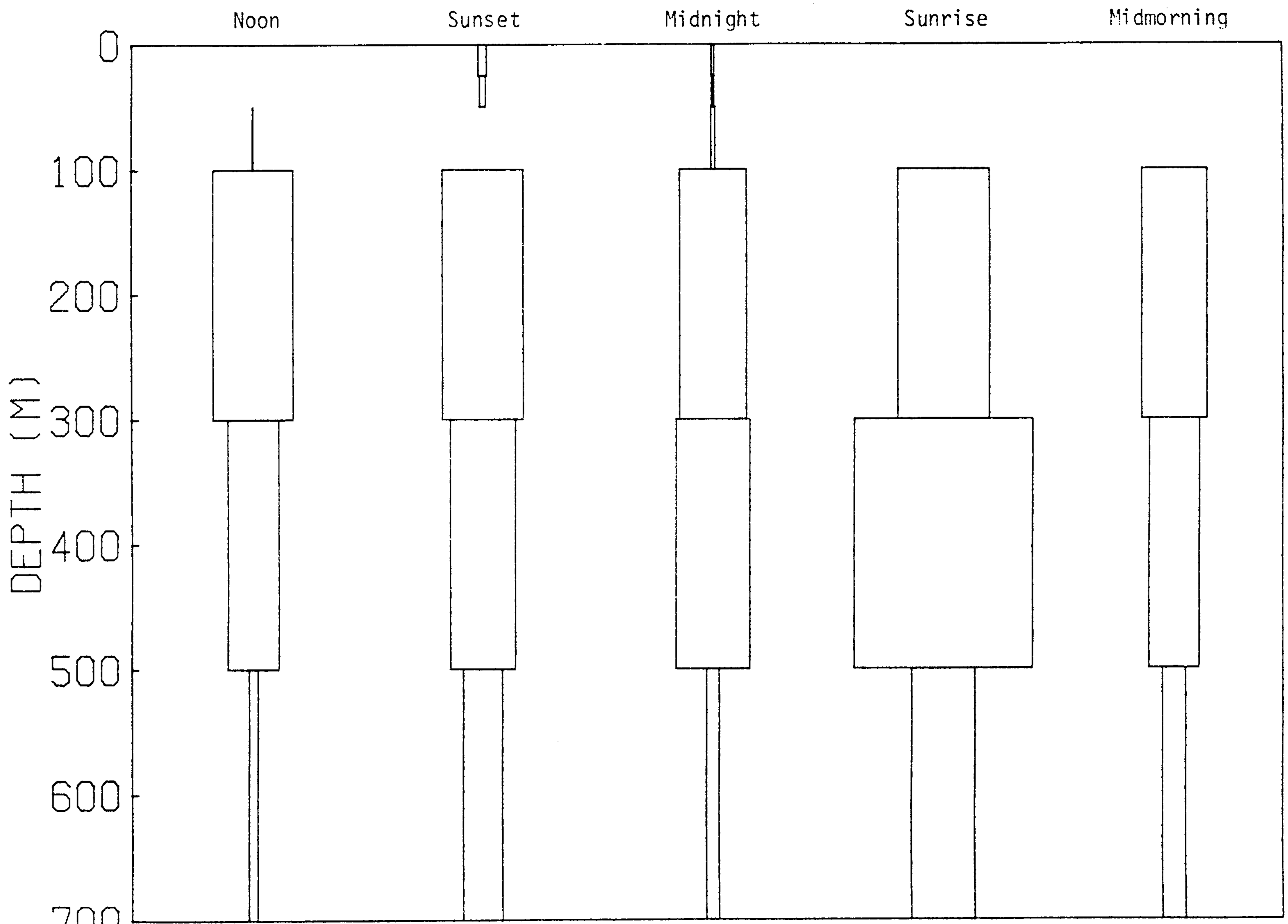

Figure 15. Metridia okhotensis (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $750/m^3$.

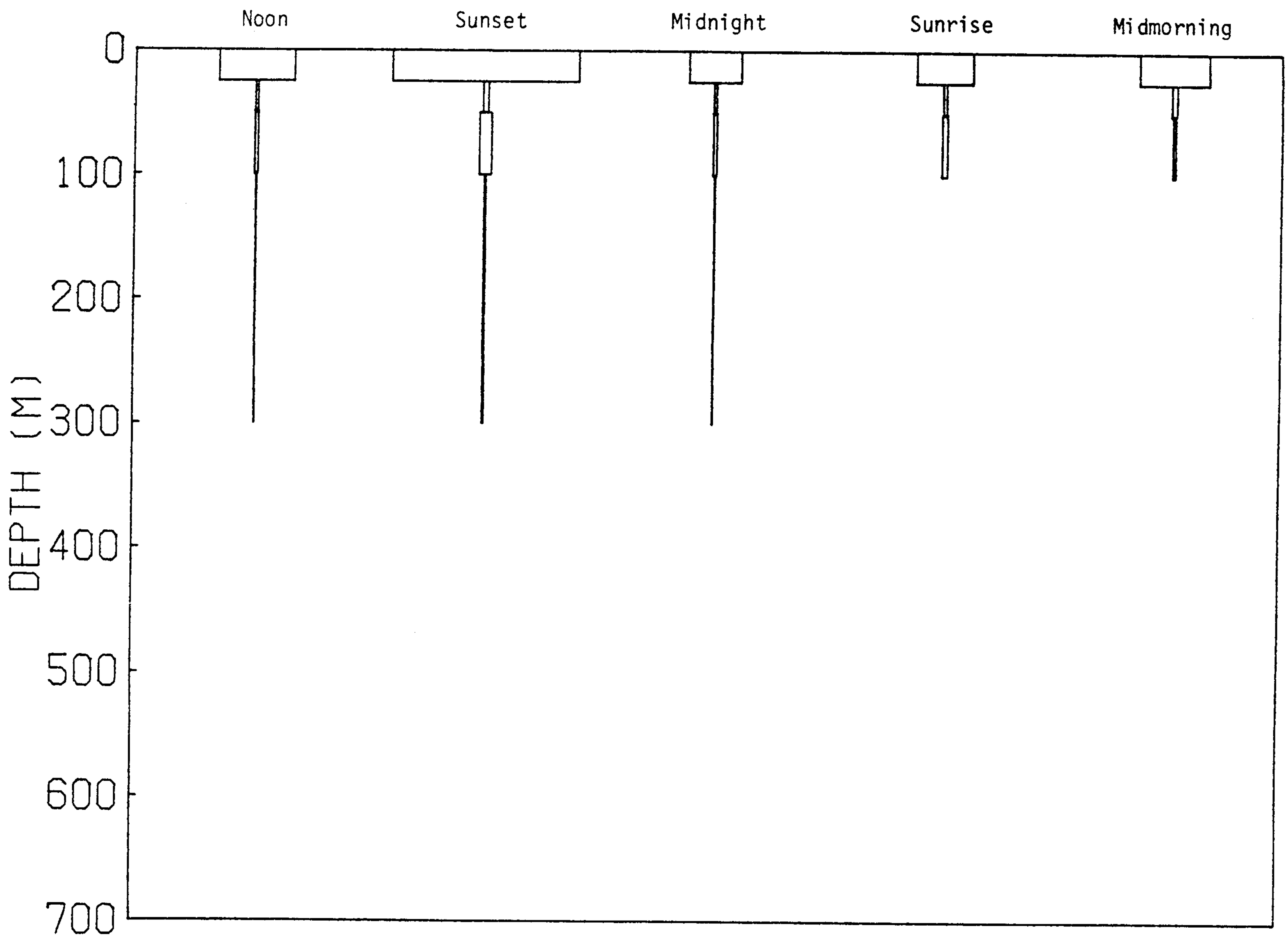

Figure 16. *Acartia longiremis* (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $1040/m^3$.

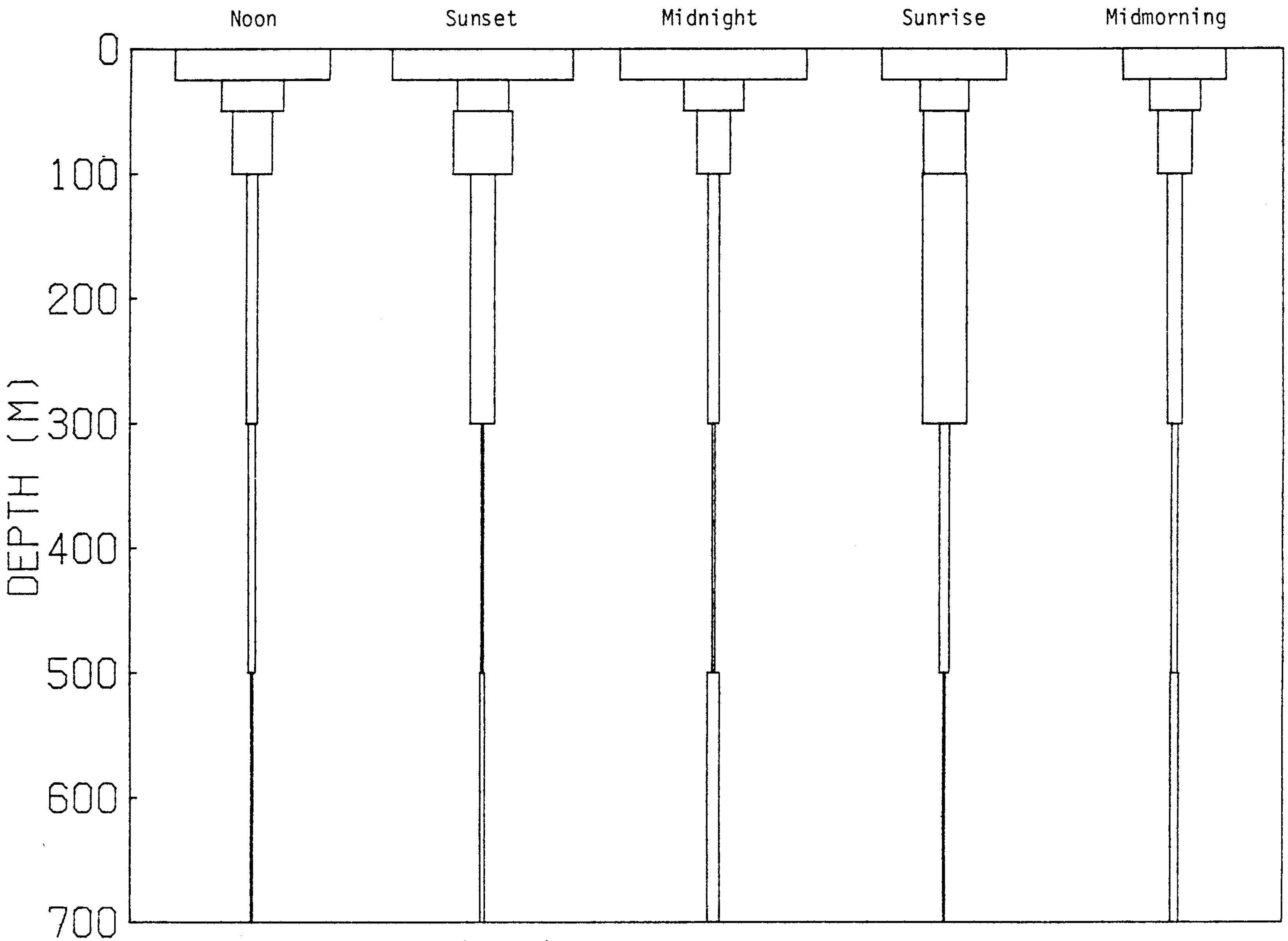

Figure 17. Oithona similis (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $640/m^3$.

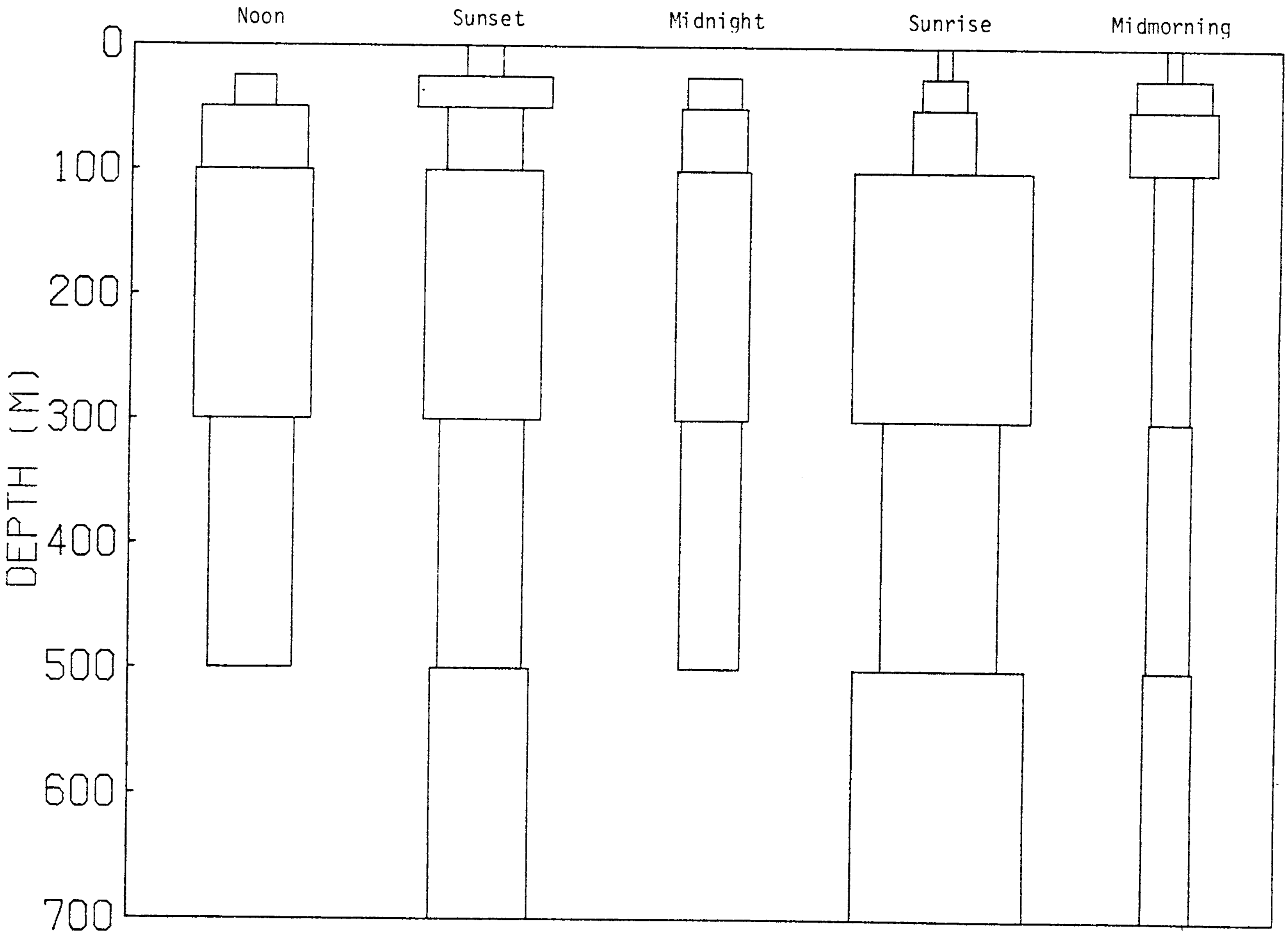

Figure 18. Oncaea borealis (adults), Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $170/m^3$.

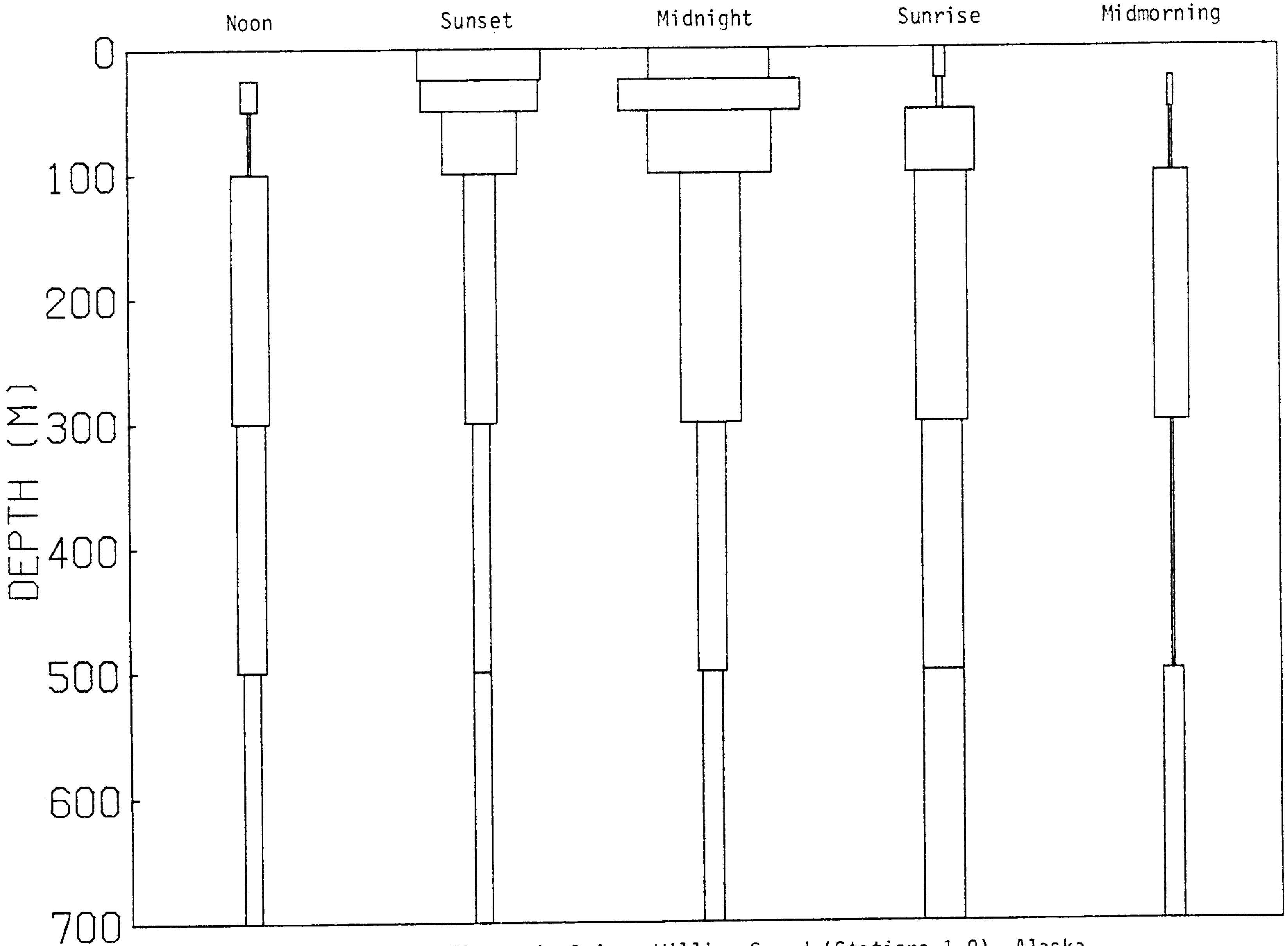

Figure 19. Cyphocaris challengeri, Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $5/m^3$.

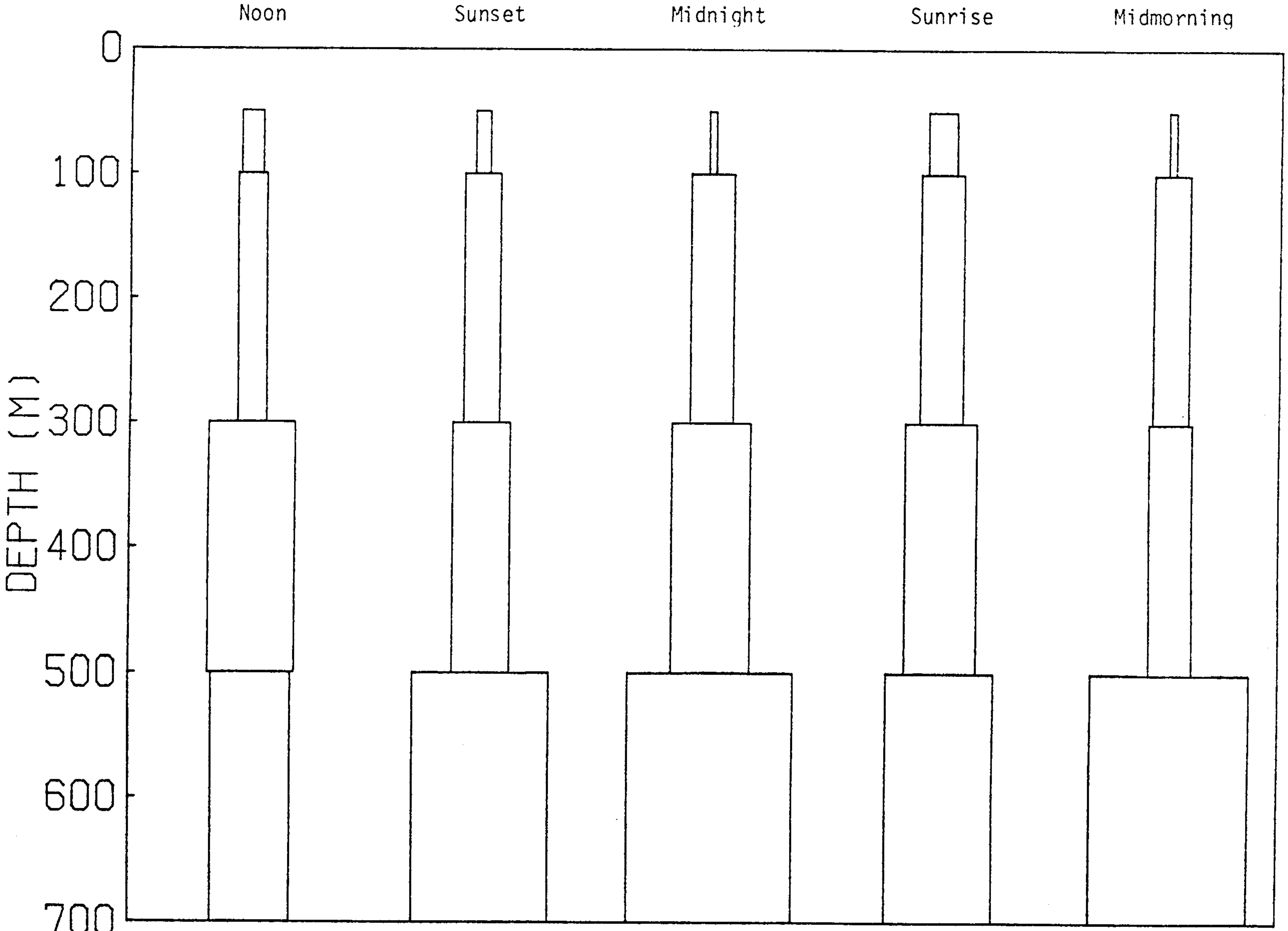

Figure 20. Eukrohnia hamata, Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $2/m^3$.

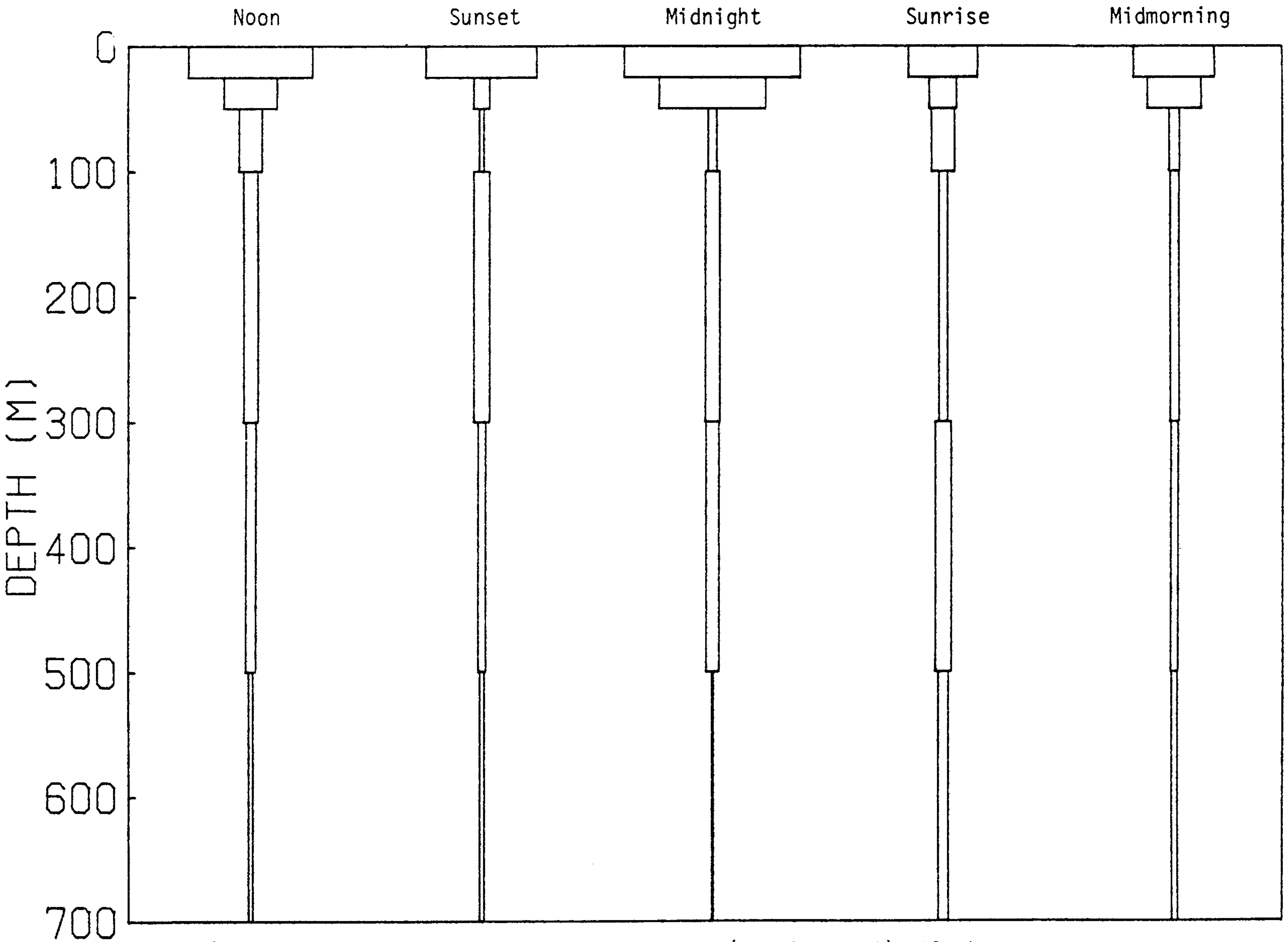

Figure 21. Sagitta elegans, Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $10/m^3$.

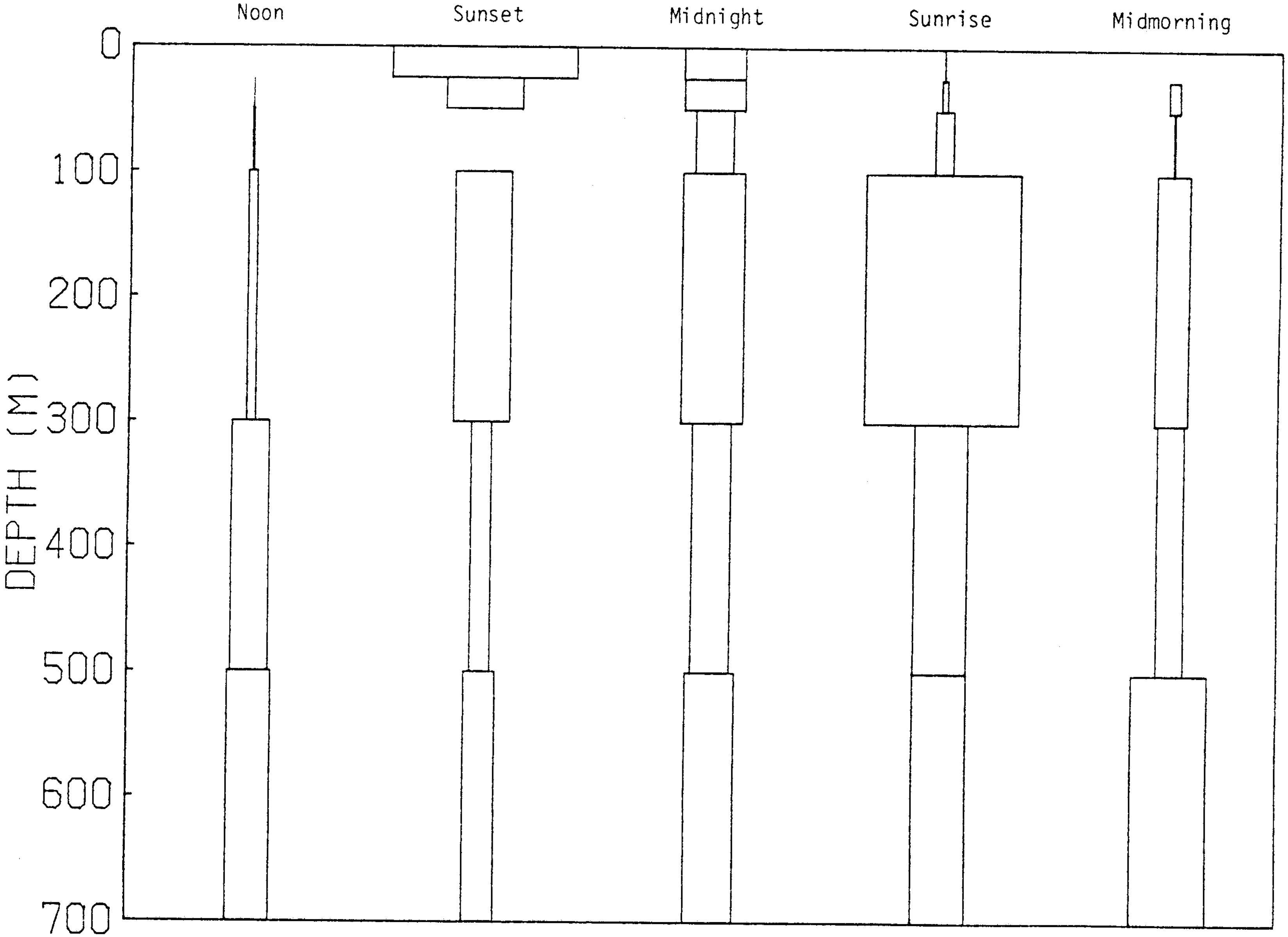

Figure 22. Ostracoda, Prince William Sound (Stations 1-9), Alaska
October 4-6, 1975; mean of all samples, 1 inch = 640/m^3.

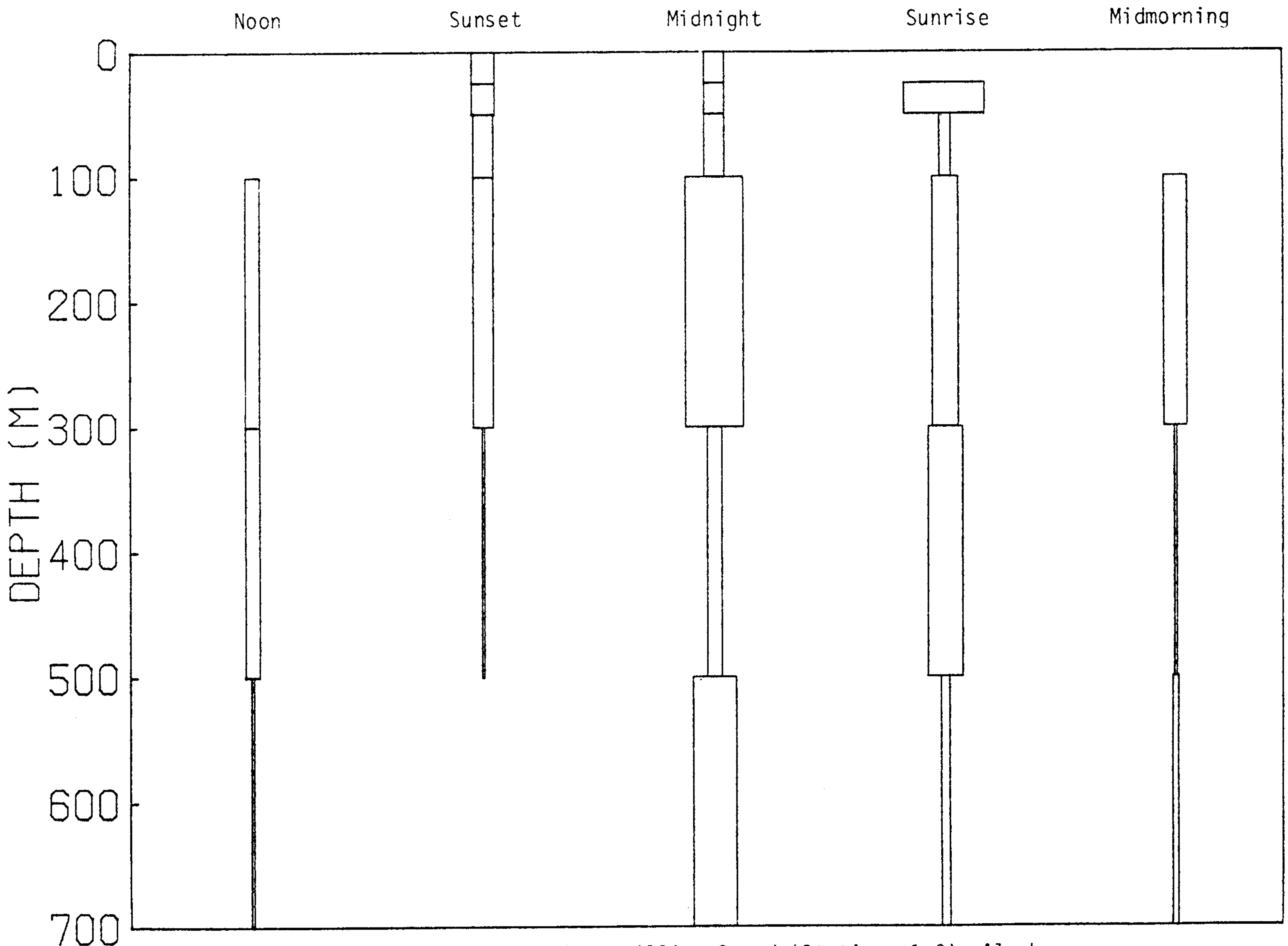

Figure 23. Thysanoessa longipes, Prince William Sound (Stations 1-9), Alaska October 4-6, 1975; mean of all samples, 1 inch = $0.5/m^3$.

Lower Cook Inlet, Gulf of Alaska and Prince William Sound, 1976

The plankton volumes for the entire water column at Kachemak Bay (Station 6), Lower Cook Inlet, as a measure of zooplankton biomass indicate that sometime after an apparent peak in spring a gradual decline occurred throughout the summer months (fig. 24 and table 5). The depth of Station 6 is 75 m and samples were collected there in three increments of 25 m each. No night samples were obtained during Cruise II.

Because of significant depth differences and the irregular occurrence of dense phytoplankton "blooms" it is perhaps most useful to compare plankton surface values (0-25 m) at Kachemak Bay with those of the more exposed stations of open Lower Cook Inlet (fig. 25 and tables 6,7). The general pattern of plankton standing stock with time at these stations contrasts noticeably with that of Kachemak Bay while comparing rather favorably with the Gulf of Alaska Station 11. No doubt the physical conditions found at the open Lower Cook Inlet stations more closely parallel what one finds at Station 11 and this situation clearly reflects the difficulties encountered in any attempt to generalize about the biology of an area as diverse and dynamic as Lower Cook Inlet.

The interpretations of zooplankton volumes, though obtained relatively quickly and simply, are complicated by the irregular occurrence of phytoplankton. Some phytoplankters form long intertwining chains and do not settle from the sample, but entangle zooplankton and other phytoplankton and give the appearance of a large plankton volume. For this reason. it is often easier and more revealing to compare the zooplankton of different times or areas by the kinds of plankton and their relative numerical abundance.

In Kachemak Bay, the largest numerical component of the zooplankton collected during these cruises was, throughout, the Copepoda. With this group the three

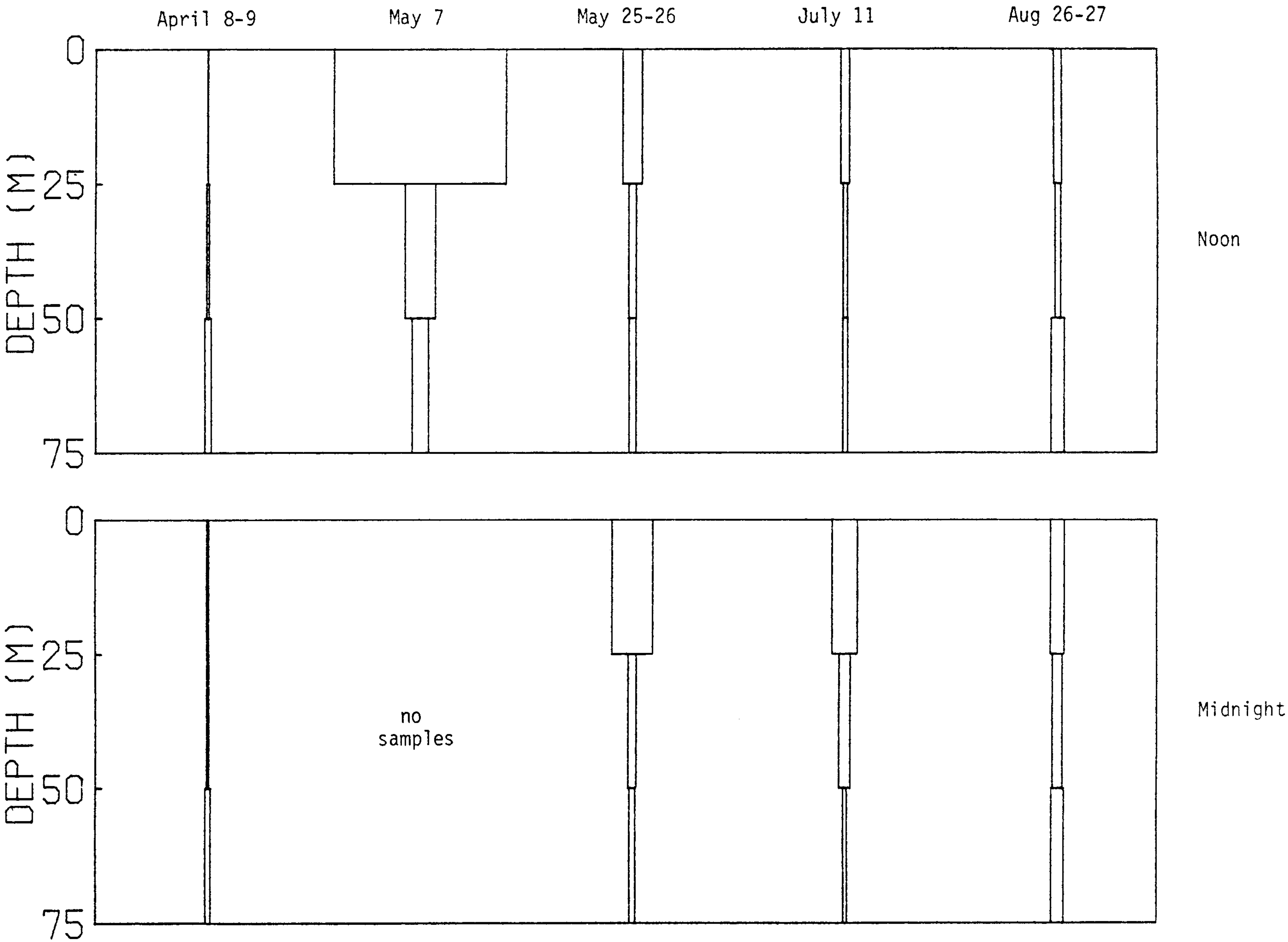

Figure 24. Zooplankton settled volumes (ml/m^3), Kachemak Bay, Alaska, 1976; 1 inch = 25 ml/m^3.

Table 5. Zooplankton settled volumes (ml/m^3), Kachemak Bay, Alaska

Vertical tows, 211 micron mesh.

	Date	Local Time	Depth Interval (m)	ml/m^3
Cruise I	8 Apr 76	1252	25-0	0.1
	"	1246	50-25	0.5
	"	1237	75-50	1.2
	9 Apr 76	0019	25-0	0.4
	"	0011	50-25	0.4
	"	0001	75-25	1.0
Cruise II	7 May 76	1257	25-0	27.9
	"	1251	25-0	37.1
	"	1242	50-25	5.0
	"	1225	50-25	6.3
	"	1212	75-50	3.3
	"	1201	75-50	2.9
Cruise III	26 May 76	0034	25-0	8.6
	"	0026	25-0	6.6
	"	0021	50-25	1.1
	"	0015	50-25	1.4
	"	0007	75-50	1.2
	25 May 76	2359	75-50	0.9
	26 May 76	1218	25-0	3.6
	"	1212	50-25	1.4
	"	1206	75-50	1.3
Cruise IV	11 July 76	0030	25-0	4.7
	"	0025	50-25	2.1
	"	0015	75-50	0.7
	"	1320	25-0	1.4
	"	1310	25-0	1.7
	"	1300	50-25	0.6
	"	1245	50-25	1.0
	"	1240	75-50	0.7
	"	1230	75-50	1.1
Cruise V	26 Aug 76	1355	25-0	1.3
	"	1345	50-0	1.1
	"	1325	75-0	2.5
	27 Aug 76	0150	25-0	2.6
	"	0145	50-0	1.9
	"	0130	75-0	2.4

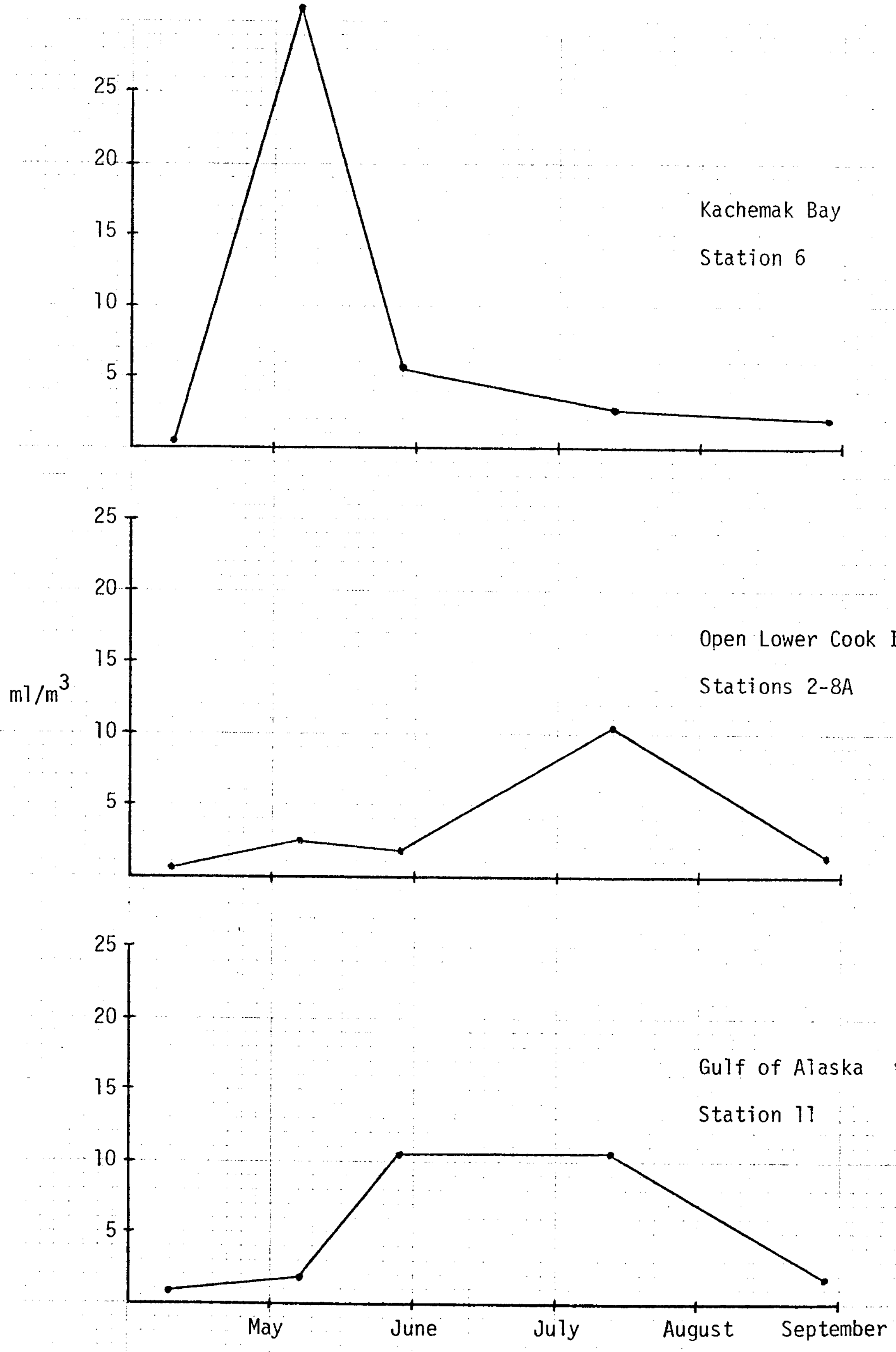

Figure 25. Zooplankton settled volumes, mean of all samples April - August 1976; Upper 25 m.

Table 6. Zooplankton settled volumes (ml/m^3), mean of day samples and mean of night samples; Kachemak Bay (Station 6) and other Lower Cook Inlet stations (Stations 2-8A); upper 25 m.

	Open Lower Cook Inlet	Kachemak Bay
Cruise I (early April)	Day 0.6	Day 0.1
	Night 0.4	Night 0.4
Cruise II (early May)	Day 0.3	Day 31.0
	Night 4.7	Night -
Cruise III (late May)	Day 0.6	Day 3.6
	Night 3.1	Night 7.6
Cruise IV (early July)	Day 5.5	Day 1.5
	Night 15.3	Night 3.6
Cruise V (late August)	Day 1.5	Day 1.3
	Night 1.1	Night 2.6

Table 7. Zooplankton settled volumes, mean of all samples; Kachemak Bay (Station 6) and Open Ocean (Station 11).

	I Early April	II Early May	III Late May	IV Early July	V Late August
Kachemak Bay (Station 6)					
(72 m)					
Upper 25 m, ml/m^3	0.3	31.0	5.6	2.6	2.0
Water column, ml/m^3	0.6	14.3	3.0	1.3	1.4
Water column, ml/m^2	43.2	1029.6	216.0	93.6	101.3
Open Ocean (Station 11)					
(1400 m)					
Upper 25 m, ml/m^3	0.9	1.9	10.4	10.5	1.9
Upper 500 m, ml/m^3	1.1	1.6	1.3	2.3	2.1
Water column, ml/m^3	0.5	-	0.6	0.9	-
Upper 500 m, ml/m^2	550.0	800.0	650.0	1150.0	1030.0
Water column, ml/m^2	750.0	-	840.0	1260.0	-

most abundant animals, Pseudocalanus spp., Acartia longiremis and Oithona similis, showed trends of increasing their numbers from spring through summer during what appears to be an overall decline in total plankton volumes (table 8). Also, analysis of samples from the last two cruises to Lower Cook Inlet has resulted in the addition to the species list of two important but previously undetected species of copepod, Centropages abdominalis and Tortanus discaudatus, as well as several other species usually associated with the benthos and of less significant concentrations (table 9). Additionally, the presence of Calanus glacialis was noted in samples from the two summer cruises, again confirming the extreme southern distribution of this Arctic species.

The abundance and vertical distributions of individual zooplankters in Kachemak Bay throughout the period of the five cruises in 1976 are shown in Figures 26 - 32. Among the more important animals, the chaetognaths were represented in Kachemak Bay by Sagitta elegans in July and August and after maintaining fairly constant concentrations from April to the end of May, sharp increases were recorded during these latter two cruises. The pattern for the group Euphausiacea somewhat paralleled that of Chaetognatha though the sharp summer increase was considerably less in magnitude and concentration values fell off again rather quickly by late August (table 8).

Cirripede (barnacle) nauplii, which undoubtedly form an important food source for plankton-feeding animals, were very abundant in Kachemak Bay in early April, were replaced by smaller numbers of the more advanced larval form (cyprid) by early May, and by late May there were no specimens of either form collected in the vertical tows. Six weeks later, however, another generation was apparently well on its way as again the barnacle nauplii were found to be quite abundant and the concentration of the cyprid form was several times greater than recorded in early May. By late August, the nauplii and cyprids in the

	I (6-13 Apr)	II (5-9 May)	III (24-30 May)	IV (8-15 July)	V (24-31 Aug)
COPEPODA					
Pseudocalanus spp.	55.2	61.1	113.3	435.3	386.2
Acartia longiremis	38.2	109.4	13.4	374.0	731.7
Oithona similis	27.4	48.1	54.3	194.9	508.1
CHAETOGNATHA					
Sagitta elegans	3.7	2.8	3.3	47.2	101.6
CIRRIPEDIA					
Nauplii	372.6	0	0	118.8	650.4
Cyprids	0	2.8	0	9.8	20.3
Crab Larvae (Zoeae)	0.1	2.6	3.3	2.4	0
AMPHIPODA	0	0.1	0.02	0.1	0
EUPHAUSIACEA	1.7	1.9	4.0	25.4	0.6
Larval Fish	0	0.5	0.04	0.02	0.8
Fish Eggs	0	0.7	0	0.03	0

Table 8. Abundant Zooplankton Species and Important Groups, $\#/m^3$ in Water Column; mean values. Kachemak Bay, Alaska, April - August 1976.

Table 9. Zooplankton species and major groups, Kachemak Bay, Alaska April - August 1976 .

COPEPODA CALANOIDA

Calanidae

Calanus cristatus
C. glacialis
C. marshallae

Eucalanidae

Eucalanus juveniles

Pseudocalanidae

Microcalanus spp.
Pseudocalanus spp.

Aetideidae

Aetideus sp.

Metridiidae

Metridia lucens

Centropagidae

Centropages abdominalis

Acartiidae

Acartia clausii
A. longiremis
A. tumida

Tortanidae

Tortanus discaudatus

COPEPODA CYCLOPOIDA

Oithonidae

Oithona similis

Cyclopinidae

Cyclopina sp.

Oncaeidae

Oncaea borealis

COPEPODA HARPACTICOIDA

Tegastidae

Tegastes sp.

Tisbidae

Tisbe gracilis

COPEPODA MONSTRILLOIDA

CHAETOGNATHA

Sagitta elegans

ECHINODERMATA

POLYCHAETA

MEDUSAE

GASTROPODA

CLADOCERA

Polyphemidae

Podon leuckarti

Table 9 (continued).

CIRRIPEDIA

ANOMURA

BRACHYURA

ISOPODA

AMPHIPODA

MYSIDACEA

CUMACEA

EUPHAUSIACEA

Thysanopodidae

Thysanoessa longipes

T. raschii

DECAPODA

LARVACEA

Oikopleuridae

Oikopleura sp.

Larval fish and fish eggs

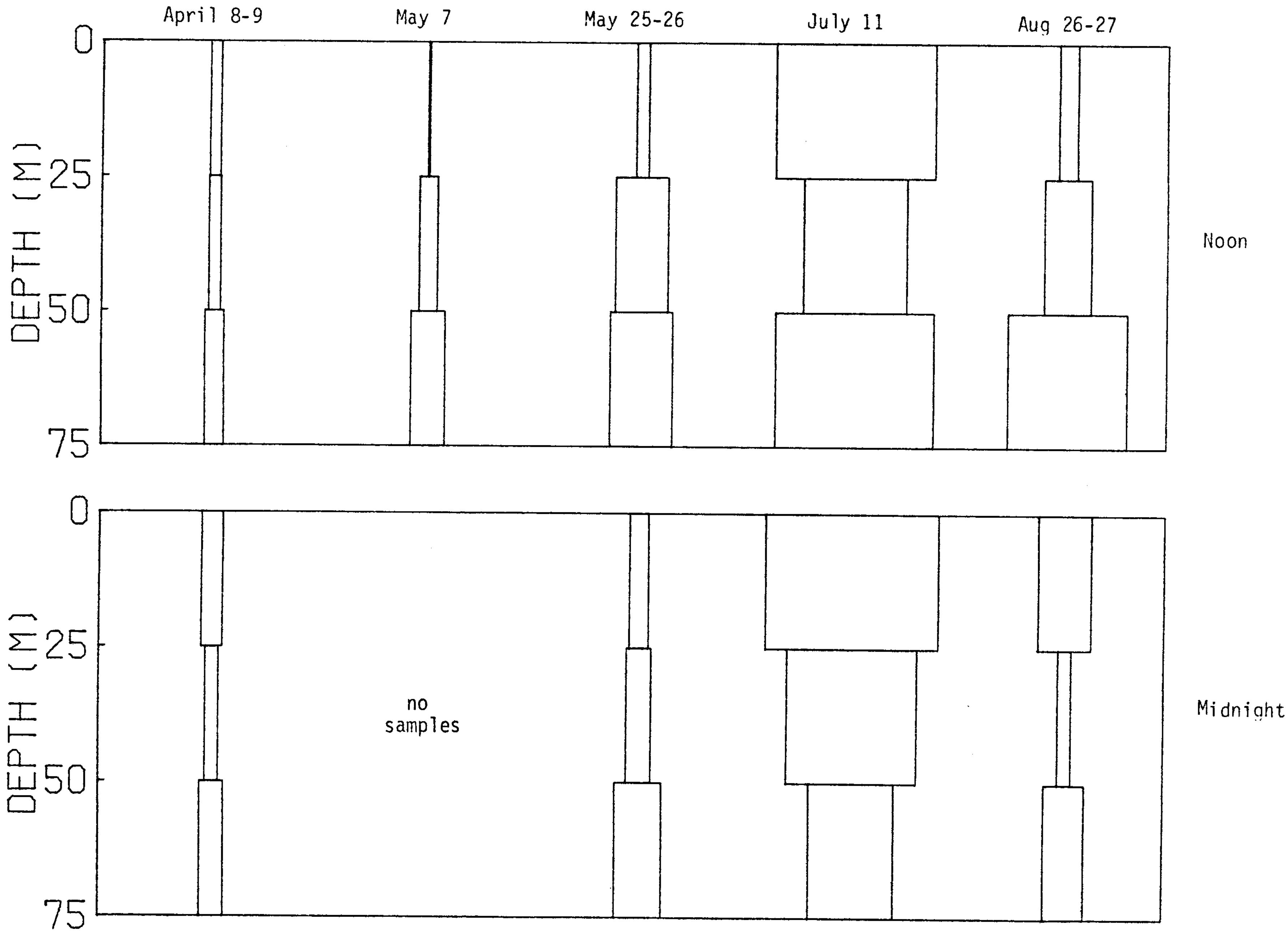

Figure 26. Pseudocalanus spp. (adults), Kachemak Bay, Alaska, 1976; 1 inch = 430/m^3.

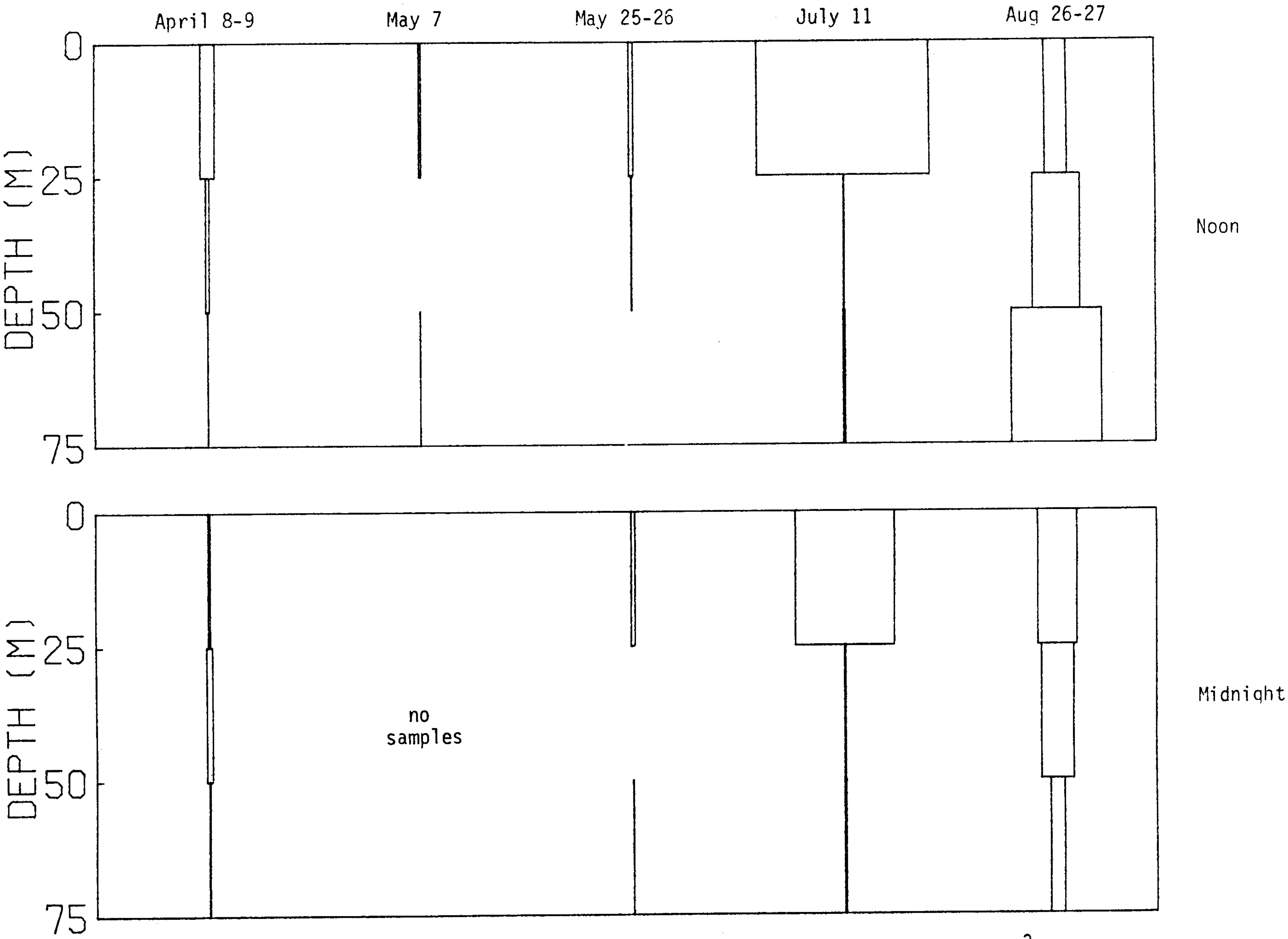

Figure 27. Acartia longiremis (adults), Kachemak Bay, Alaska, 1976; 1 inch = 1080/m^3.

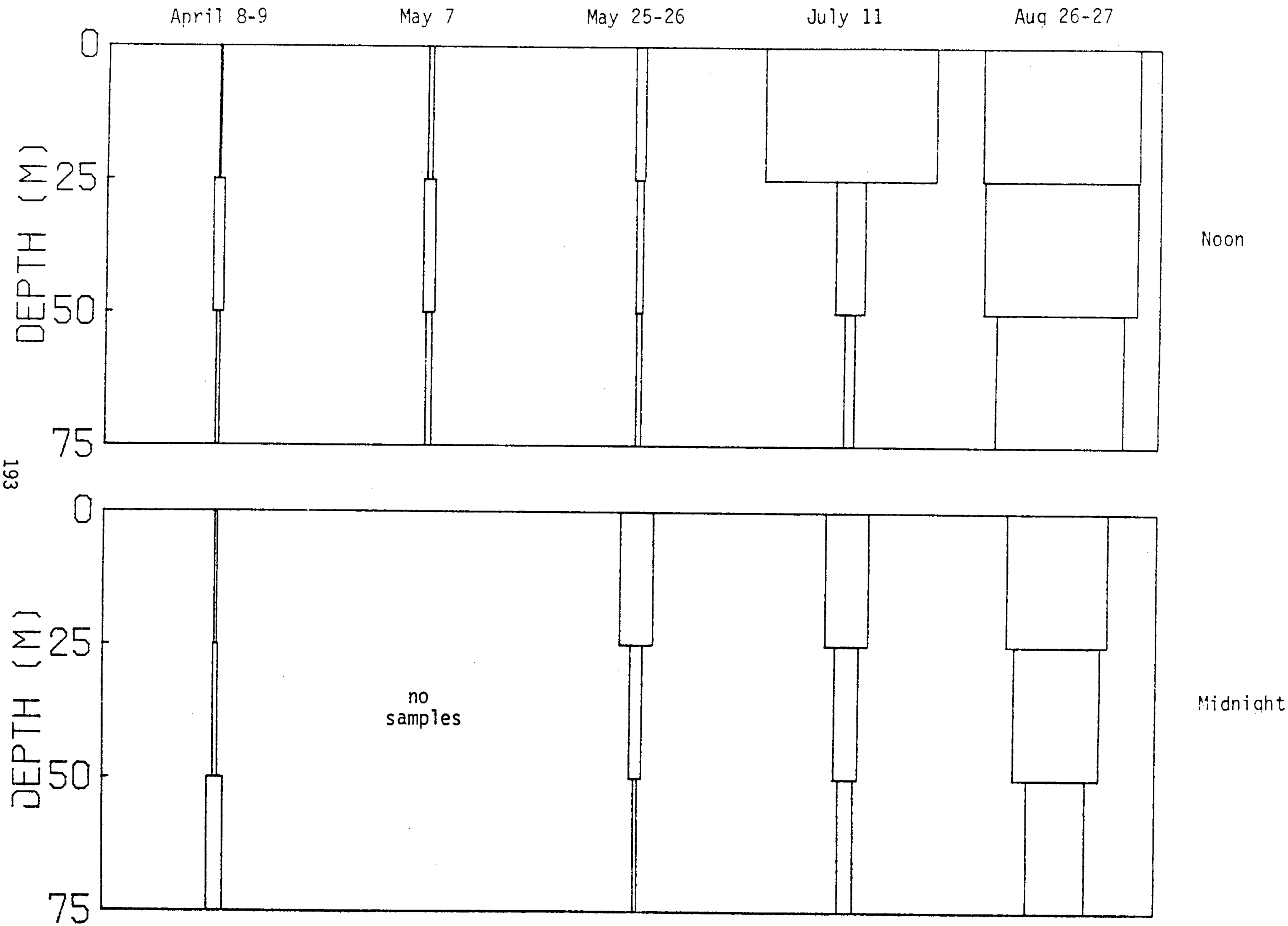

Figure 28. Oithona similis (adults), Kachemak Bay, Alaska, 1976; 1 inch = 530/m^3.

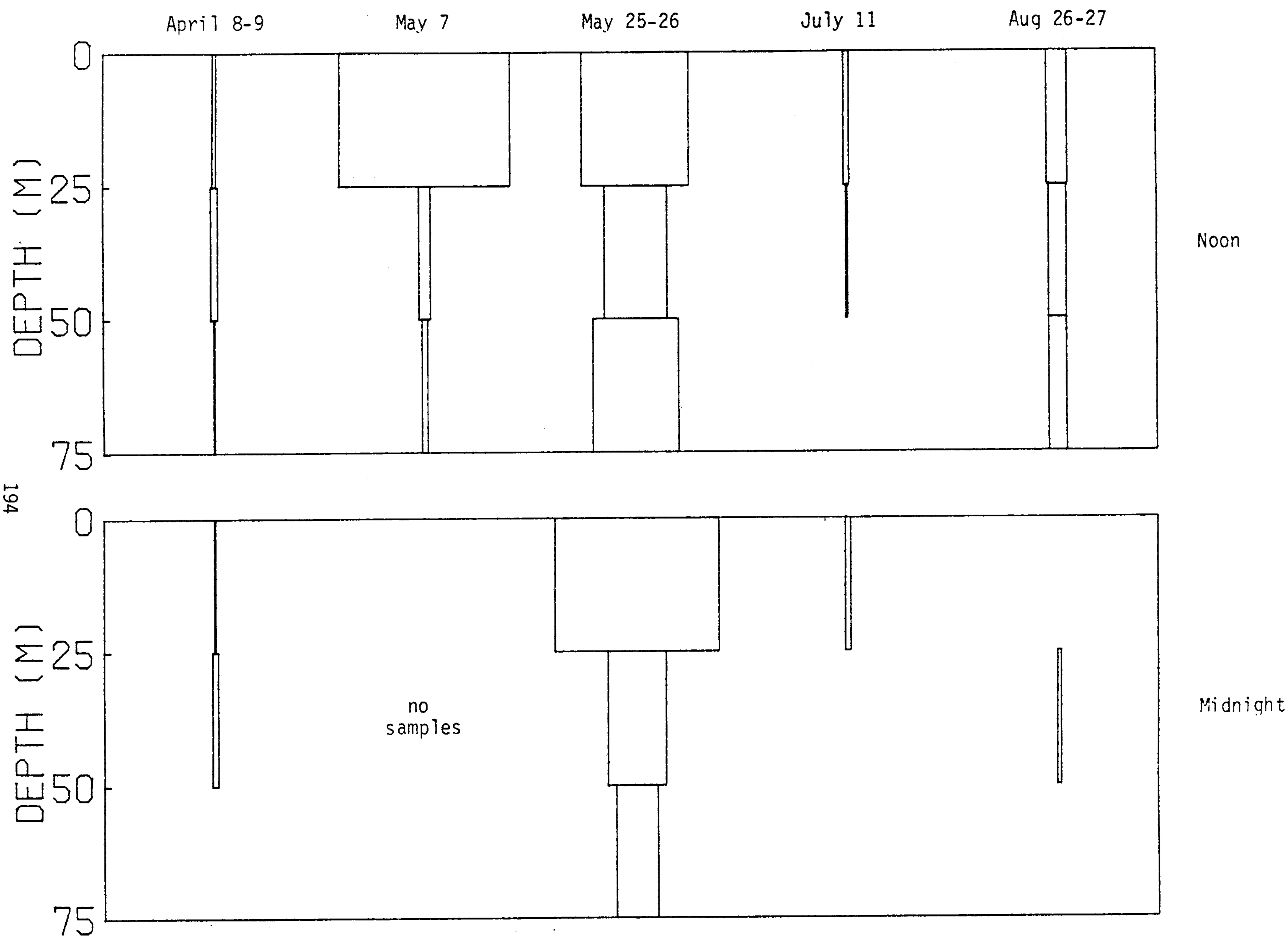

Figure 29. Copepoda nauplii, Kachemak Bay, Alaska, 1976; 1 inch = 760/m^3.

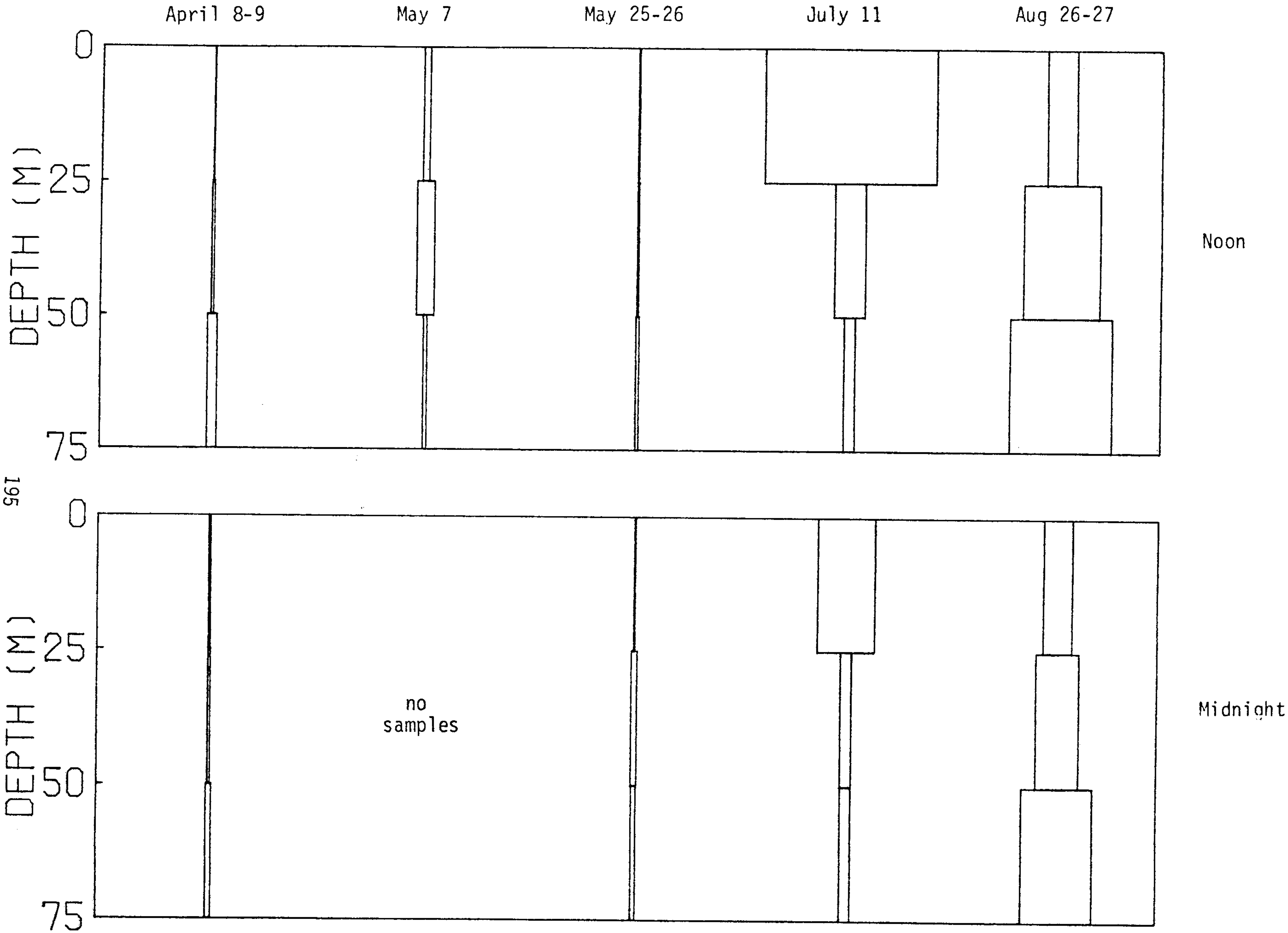

Figure 30. Sagitta elegans, Kachemak Bay, Alaska, 1976; 1 inch = 130/m^3.

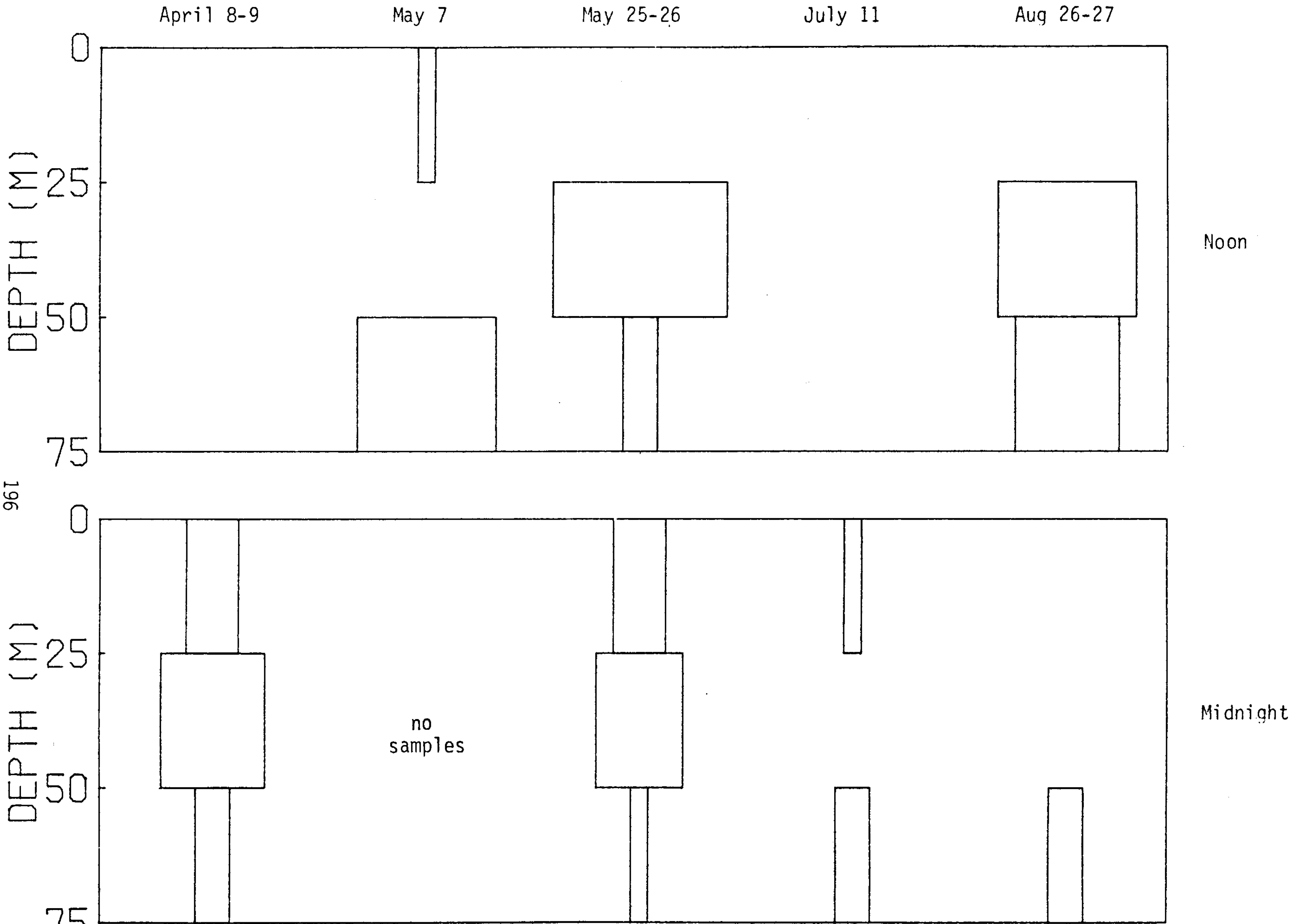

Figure 31. Euphausiacea, Kachemak Bay, Alaska, 1976; 1 inch = 8/m^3.

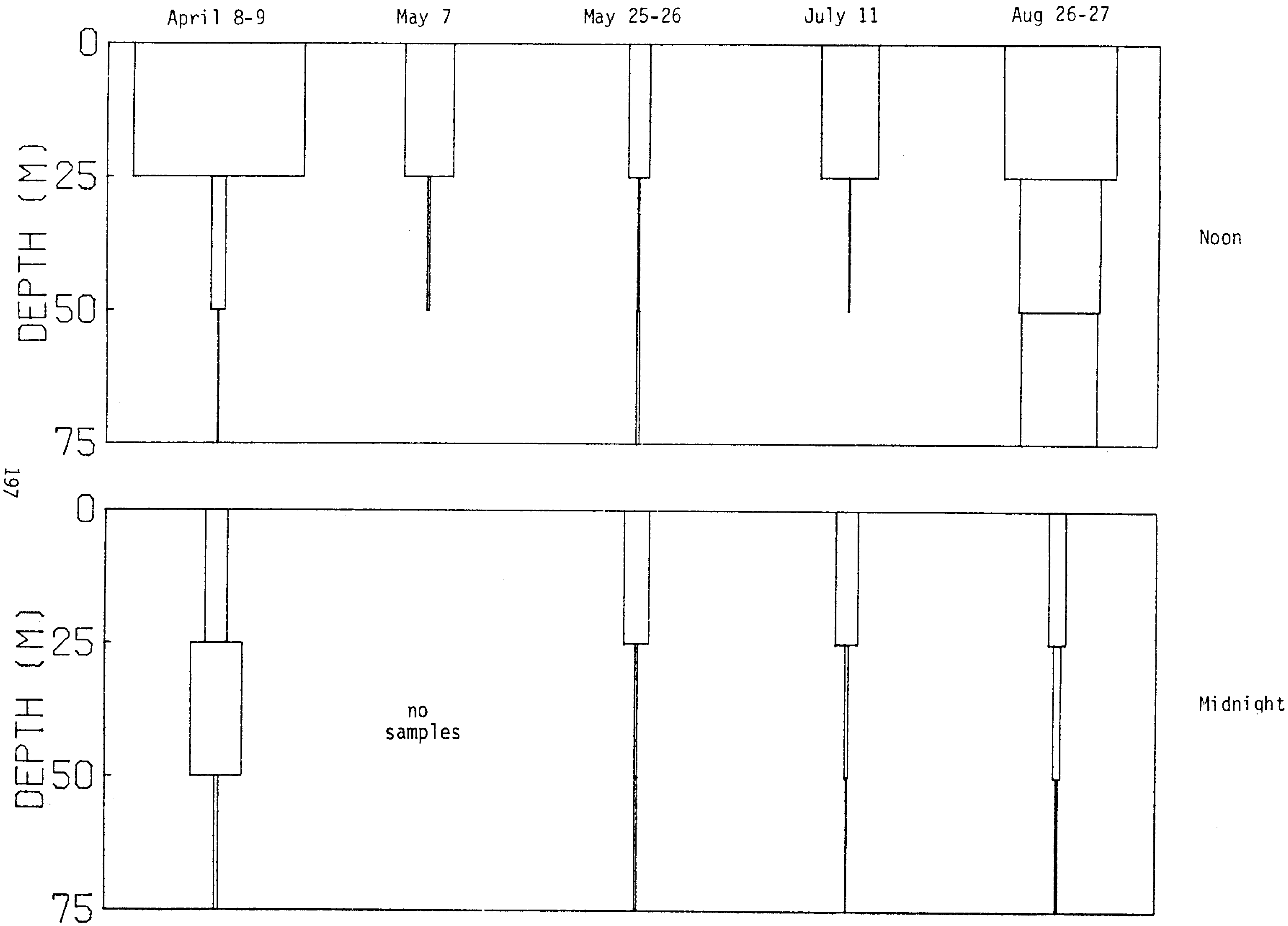

Figure 32. Cirripede nauplii, Kachemak Bay, Alaska, 1976; 1 inch = 1120/m^3.

water column had become extremely abundant and maxima for the five cruises were recorded (Table 8).

Crab larvae (zoeae), while not found in great numbers during Cruise I, reached moderate concentrations in the water column at Station 6 by Cruise II. These values fluctuated somewhat through Cruises III and IV (at stations in and near Kachemak Bay including Stations 2, 5, and 6) and by late August, no zoeae were found in the zooplankton samples (Table 8).

The Amphipoda of Kachemak Bay first showed their presence in the vertical hauls in early May, but in relatively low concentrations. The subsequent values found for this group remained less than $1/m^3$ in the water column in late May and early July. None was collected in the August samples (Table 8).

The highest ichthyoplankton concentrations were found in early May, during the apparent plankton biomass maximum in Kachemak Bay, and late August, with very low values found during the two cruises between these dates (Table 8).

The list of species and major groups for Kachemak Bay (table 9) shows only 18 species of copepods (only 4 or 5 are very abundant), while a comparable list from the open ocean (Station 11) (table 10) shows 35 species (again, however, only a few species would be very abundant). Of course, this is a function of the much greater depth (1400-1500 m) of Station 11. The numerous deep-water species are unable to enter or maintain themselves in Cook Inlet. All of the abundant copepods of Cook Inlet are also abundant on the open shelf and at Station 11. In addition to the benthos associated copepods, which have been found only in Cook Inlet, several major groups are usually found only in nearshore areas, and these have been caught in Cook Inlet but not at Station 11: cirripede (barnacle) larvae, cladocerans, and cumaceans.

Table 10. Zooplankton species and major groups, Open Ocean (Station 11) Gulf of Alaska, April 1976.

COPEPODA CALANOIDA

Calanidae

Calanus cristatus
C. marshallae
C. pacificus
C. plumchrus

Eucalanidae

Eucalanus bungii bungii

Pseudocalanidae

Microcalanus spp.
Pseudocalanus spp.

Spinocalanidae

Spinocalanus brevicaudatus

Aetideidae

Aetideus pacificus
Gaetanus simplex

Euchaetidae

Euchaeta elongata
E. sarsi

Scolecithricidae

Amallothrix inornata
Lophothrix frontalis
Racovitzanus antarcticus
Scolecithricella minor

Metridiidae

Metridia curticauda
M. lucens
M. okhotensis
M. princeps
Pleuromamma robusta

Lucicutiidae

Lucicutia ovalis

Heterorhabdidae

Disseta scopularis
Heterorhabdus tanneri
Heterostylites major

Augaptilidae

Haloptilus pseudooxycephalus

Candaciidae

Candacia columbiae

Acartiidae

Acartia longiremis

COPEPODA CYCLOPOIDA

Oithonidae

Oithona similis
O. spinirostris

Oncaeidae

Oncaea borealis
O. parila
O. prolata
O. sp.
Pseudolubbockia dilatata

COPEPODA HARPACTICOIDA

Tisbidae

Tisbe sp.

Table 10 (continued).

CHAETOGNATHA

Eukrohnia fowleri
E. hamata
Sagitta elegans

POLYCHAETA

Alciopidae

Lopadorrhynchidae

Pelagobia longicirrata

Tomopteridae

Tomopteris renata
T. septentrionalis

Typhloscolecidae

Typhloscolex mulleri

GASTROPODA - Pteropoda

Limacinidae

Limacina helicina

Clionidae

Clione limacina

EUPHAUSIACEA

Thysanopodidae

Thysanoessa inermis
T. longipes
T. raschii
T. spinifera

LARVACEA

Oikopleuridae

Oikopleura sp.

Table 11 presents the total zooplankton concentrations for all tows conducted at Station 11, Gulf of Alaska, 1976. A vertical distribution of zooplankton volumes collected in April is shown in Figure 33, and the specific, vertical distributions of several important species and taxonomic groups collected during this series, from 1500 m to the surface, are also included (figs. 34-42).

Three of the five cruises in 1976 included the station in Prince William Sound which had been sampled continuously for 48 hours the previous fall. The volumetric results for total zooplankton for these tows are presented in Table 12. Figure 43, depicting near-surface layer settled volumes for the three trips to Prince William Sound, when compared to Figure 25, shows considerably higher plankton concentrations than were found at Kachemak Bay, Open Lower Cook Inlet, or at Gulf of Alaska Station 11 on the respective cruises. Figure 44 presents the vertical distribution of zooplankton at Station 13 in Prince William Sound on these three cruises in 1976, while Table 13 further compares the temporal fluctuations of zooplankton present in the water column at Station 6 in Kachemak Bay, Station 11 in the Gulf of Alaska, and Station 13 in Prince William Sound.

Table 11. Zooplankton settled volumes (ml/m^3), Open Ocean (Station 11) Gulf of Alaska; Vertical tows, 211 micron mesh.

	Date	Local Time	Depth Interval (m)	ml/m^3
Cruise I	11 Apr 76	0157	25-0	0.9
	"	0151	50-25	3.7
	"	0139	100-50	1.4
	"	0120	300-100	1.2
	"	0058	500-300	0.7
	10 Apr 76	2355	Bottom-500	0.2
Cruise II	8 May 76	1605	25-0	1.9
	"	1559	50-25	2.0
	"	1550	100-50	2.7
	"	1533	300-100	1.9
	"	1502	500-300	0.8
Cruise III	29 May 76	1547	25-0	2.9
	"	1538	50-25	1.0
	"	1532	100-50	0.6
	"	1514	300-100	0.9
	"	1454	500-300	0.5
	"	1406	Bottom-500	0.1
	30 May 76	0123	25-0	17.1
	"	0115	50-25	8.9
	"	0105	100-50	2.8
	"	0045	300-100	1.2
	"	0018	500-300	0.9
Cruise IV	13 July 76	1630	25-0	13.5
	"	1620	50-25	10.5
	"	1610	100-50	5.3
	"	1545	300-100	1.8
	"	1515	500-300	1.0
	"	1400	Bottom-500	0.2
	14 July 76	0210	25-0	7.5
	"	0200	50-25	10.5
	"	0150	100-50	2.4
	"	0120	300-100	1.0
	"	0030	500-300	0.4
Cruise V	29 Aug 76	1320	25-0	9.3
	"	1330	50-25	7.4
	"	1255	100-50	2.8
	"	1240	300-100	1.6
	"	1215	500-300	1.4

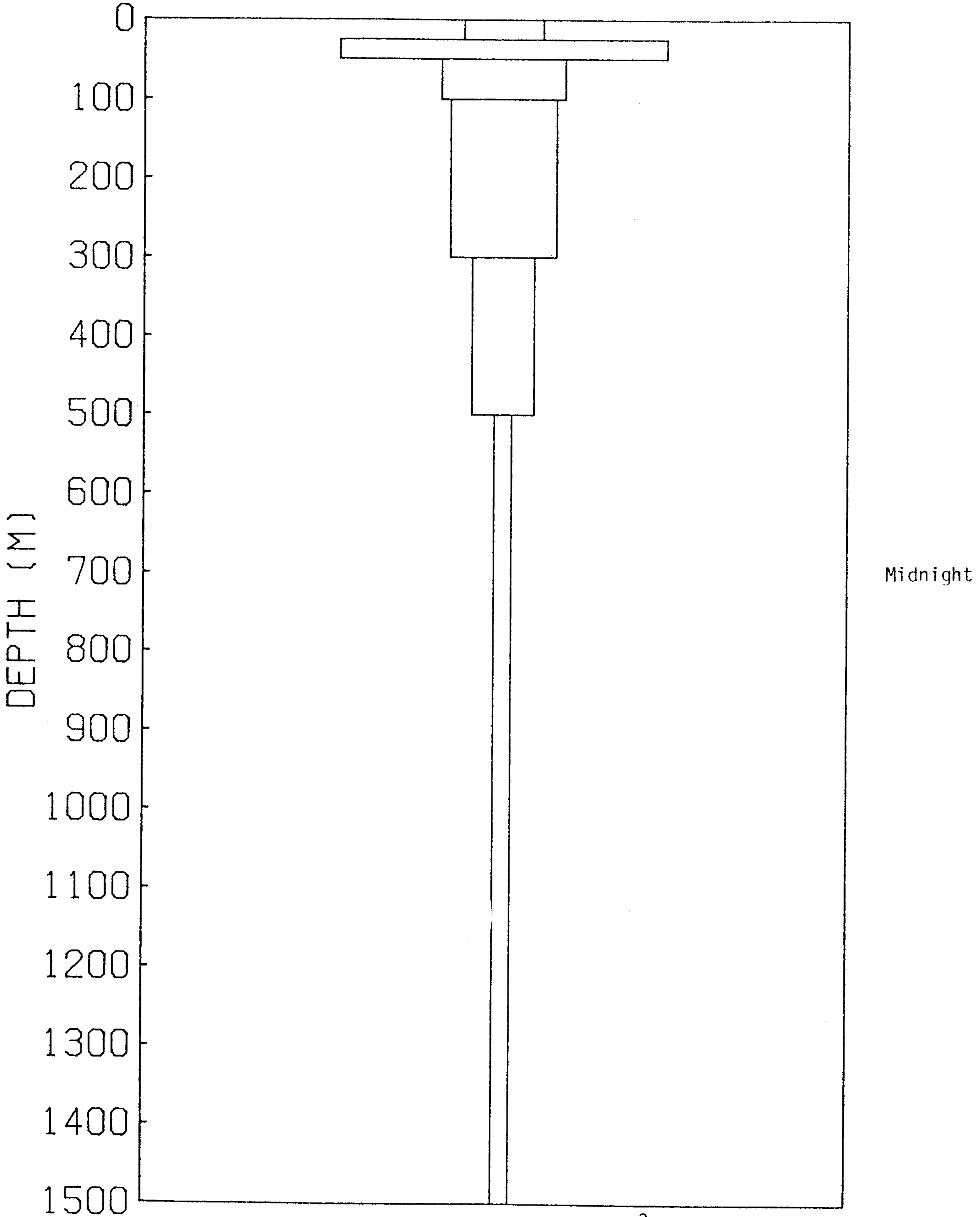

Figure 33. Zooplankton settled volumes (ml/m^3), Open Ocean (Station 11) Gulf of Alaska, 10-11 April 1976; 1 inch = 1.5 ml/m^3.

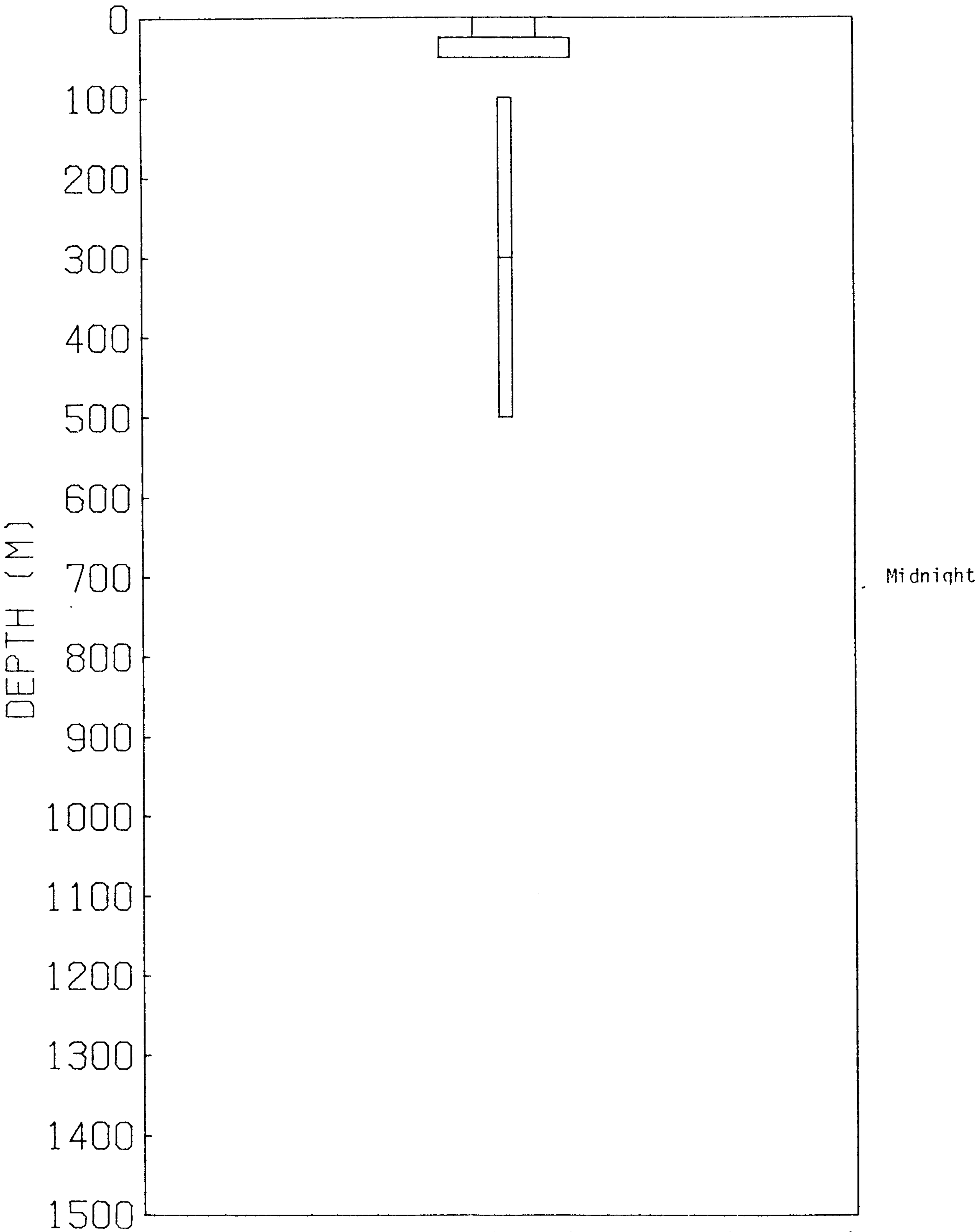

Figure 34. Calanus marshallae (adults), Open Ocean (Station 11) Gulf of Alaska, 10-11 April 1976; 1 inch = 0.6/m^3.

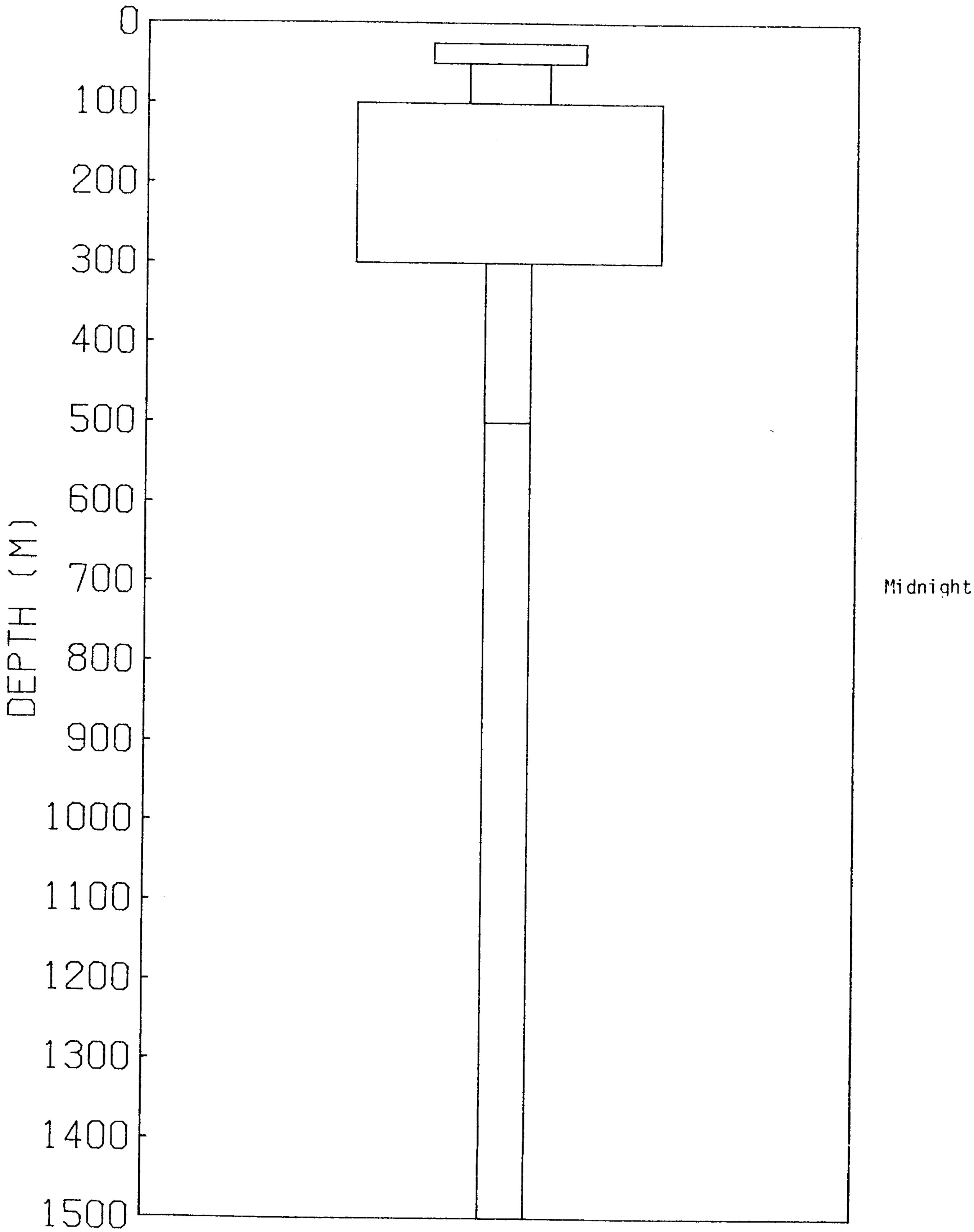

Figure 35. Microcalanus spp. (adults), Open Ocean (Station 11) Gulf of Alaska, 10-11 April 1976; 1 inch = 2.5/m^3.

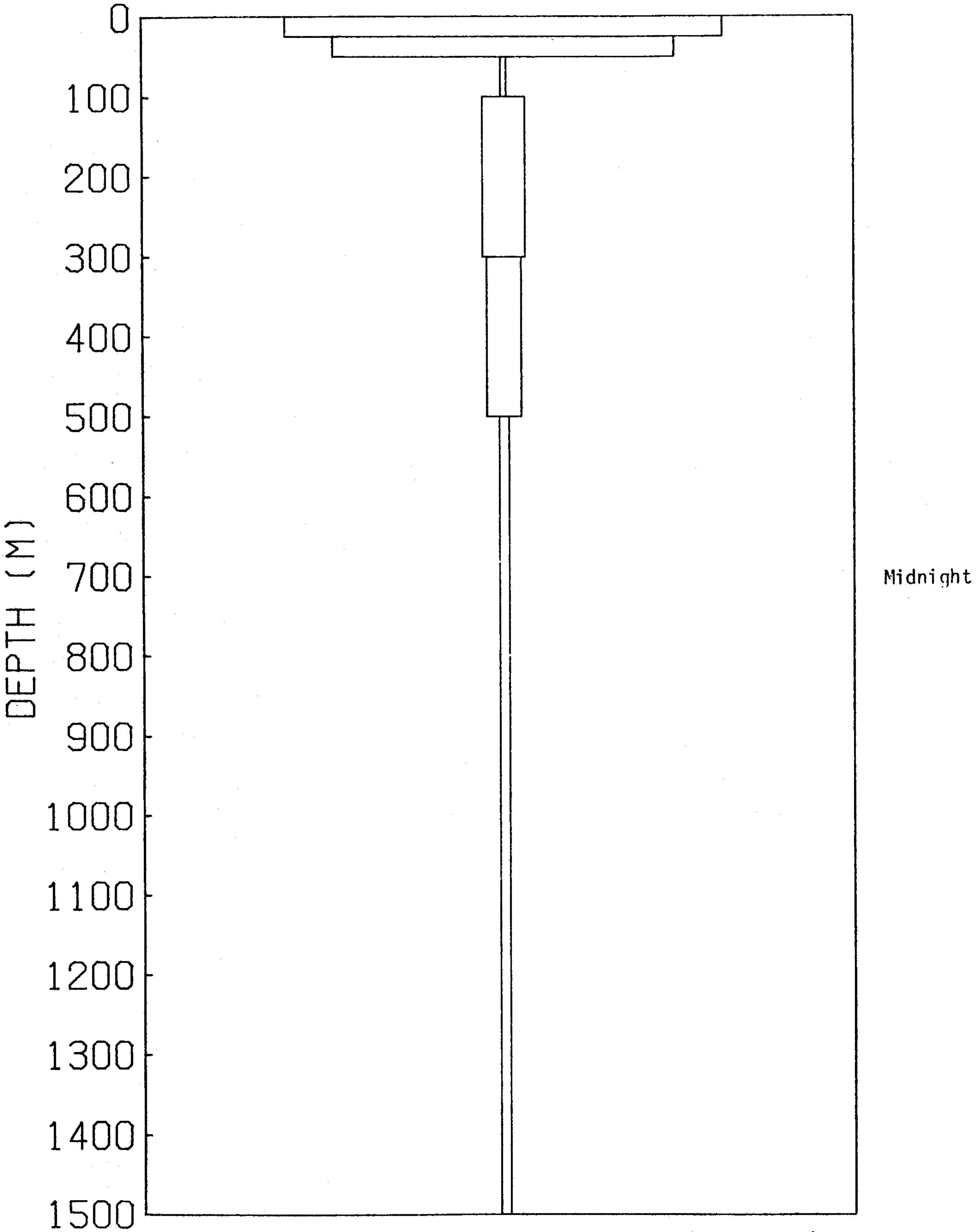

Figure 36. Metridia lucens (adults), Open Ocean (Station 11) Gulf of Alaska, 10-11 April 1976; 1 inch = $12/m^3$.

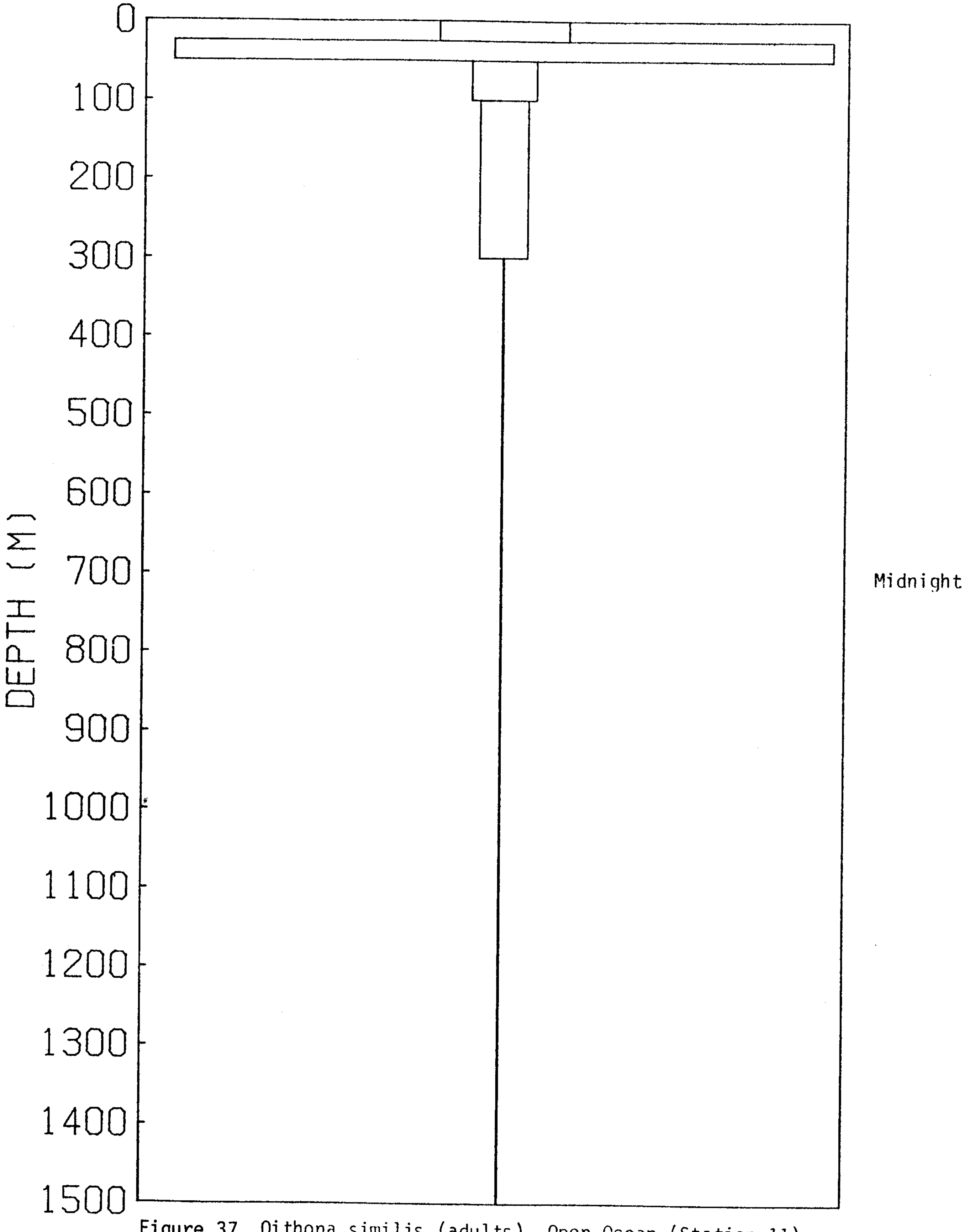

Figure 37. Oithona similis (adults), Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = $110/m^3$.

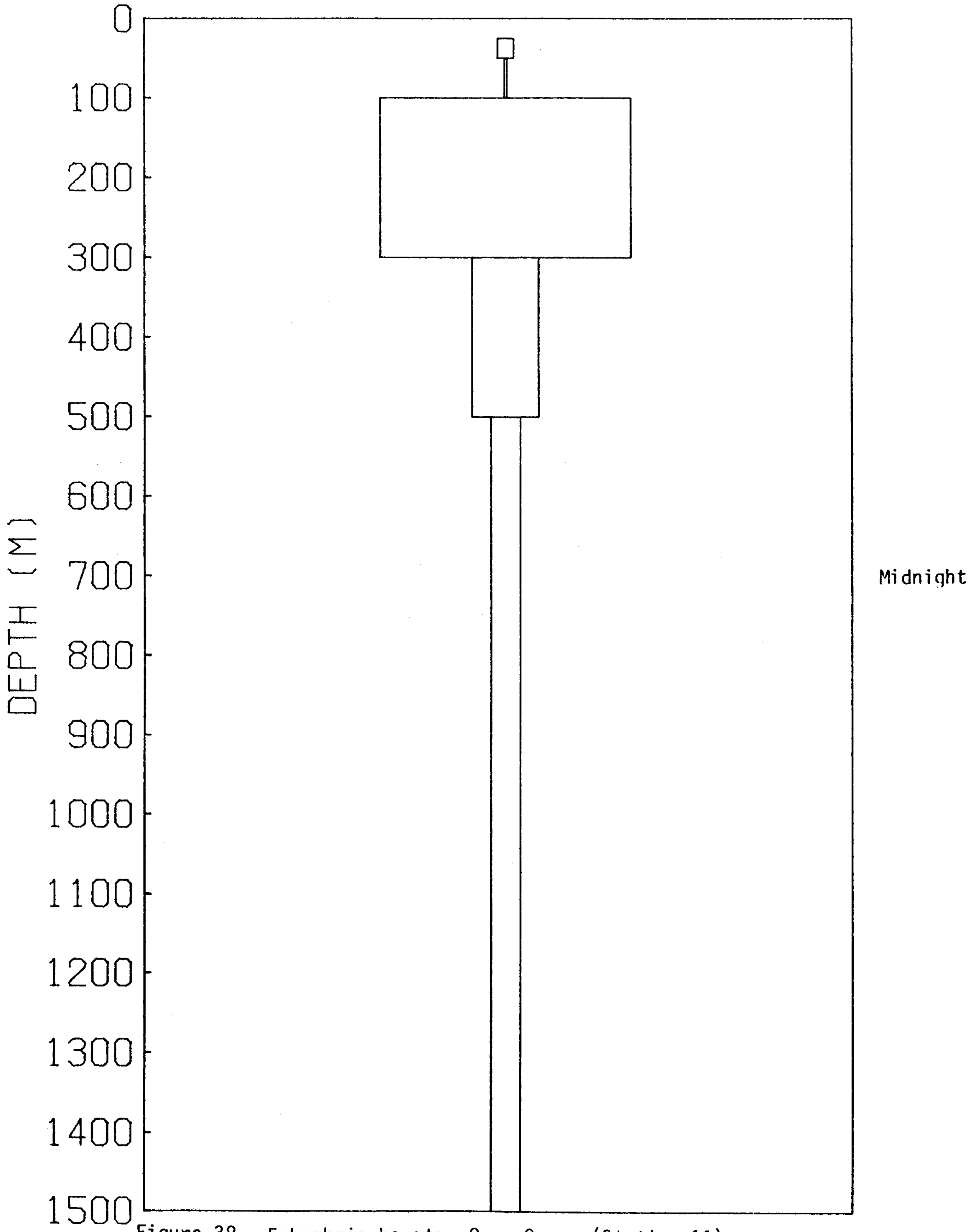

Figure 38. Eukrohnia hamata, Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = 5/m^3.

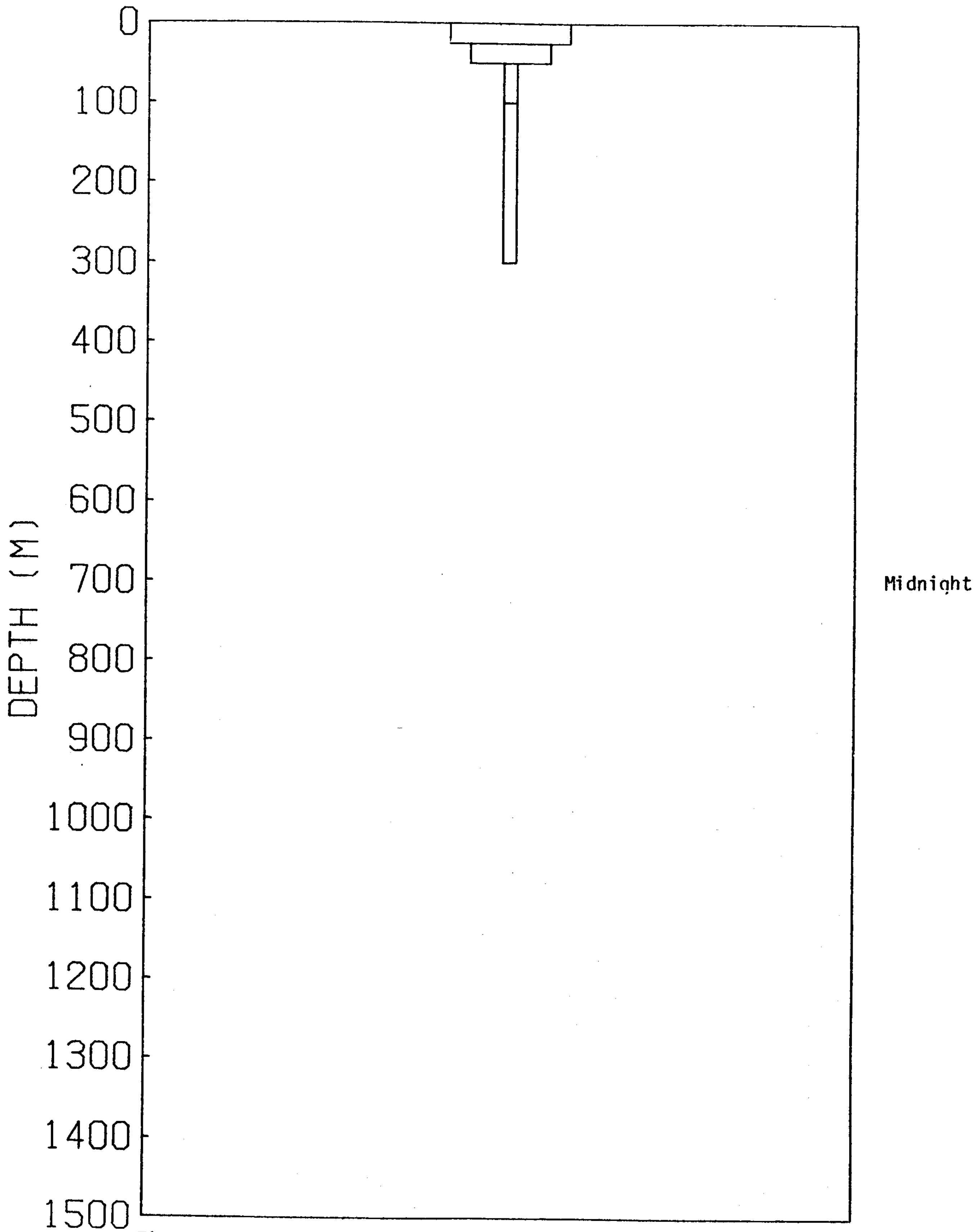

Figure 39. Sagitta elegans, Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = 1/m^3.

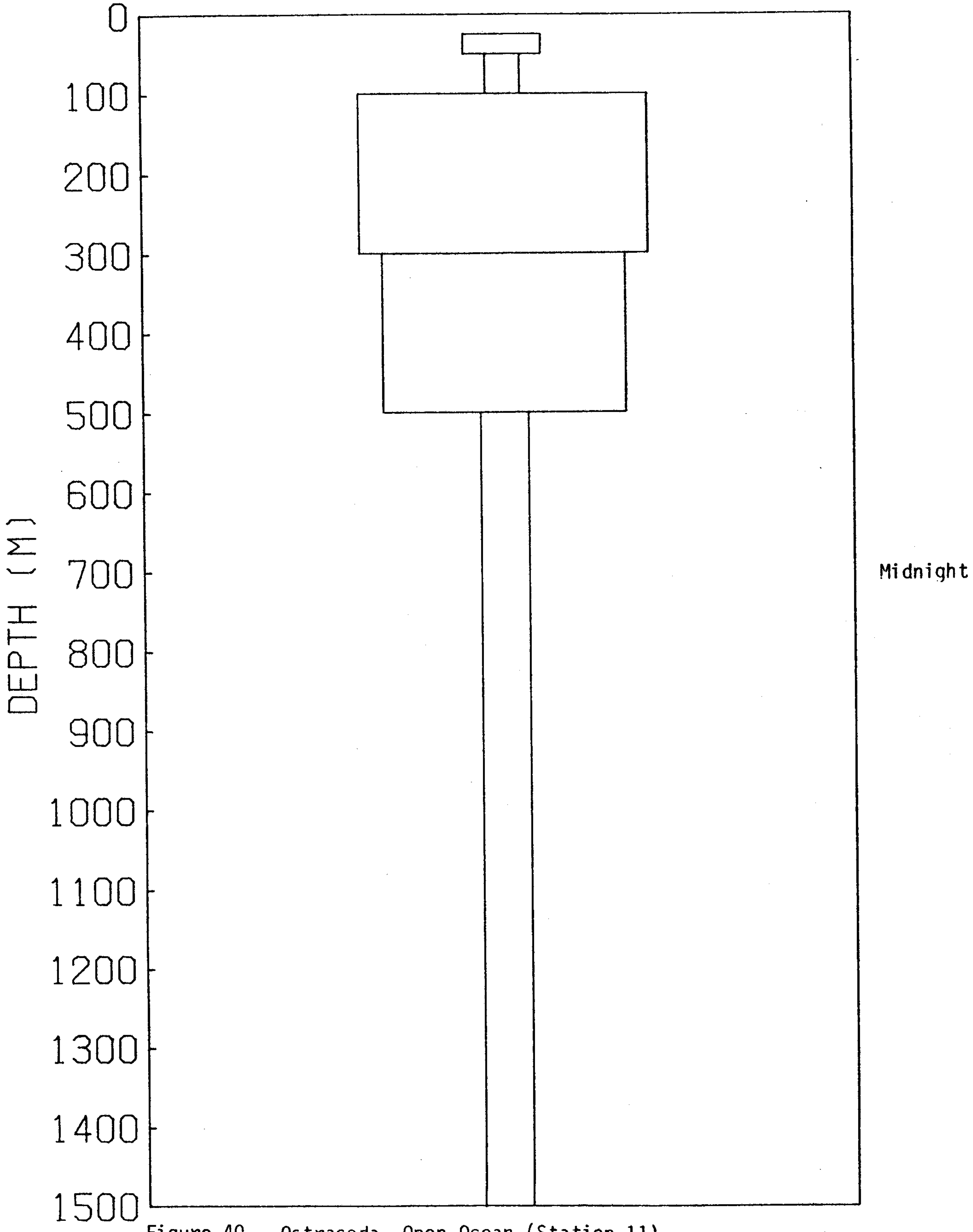

Figure 40. Ostracoda, Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = $2/m^3$.

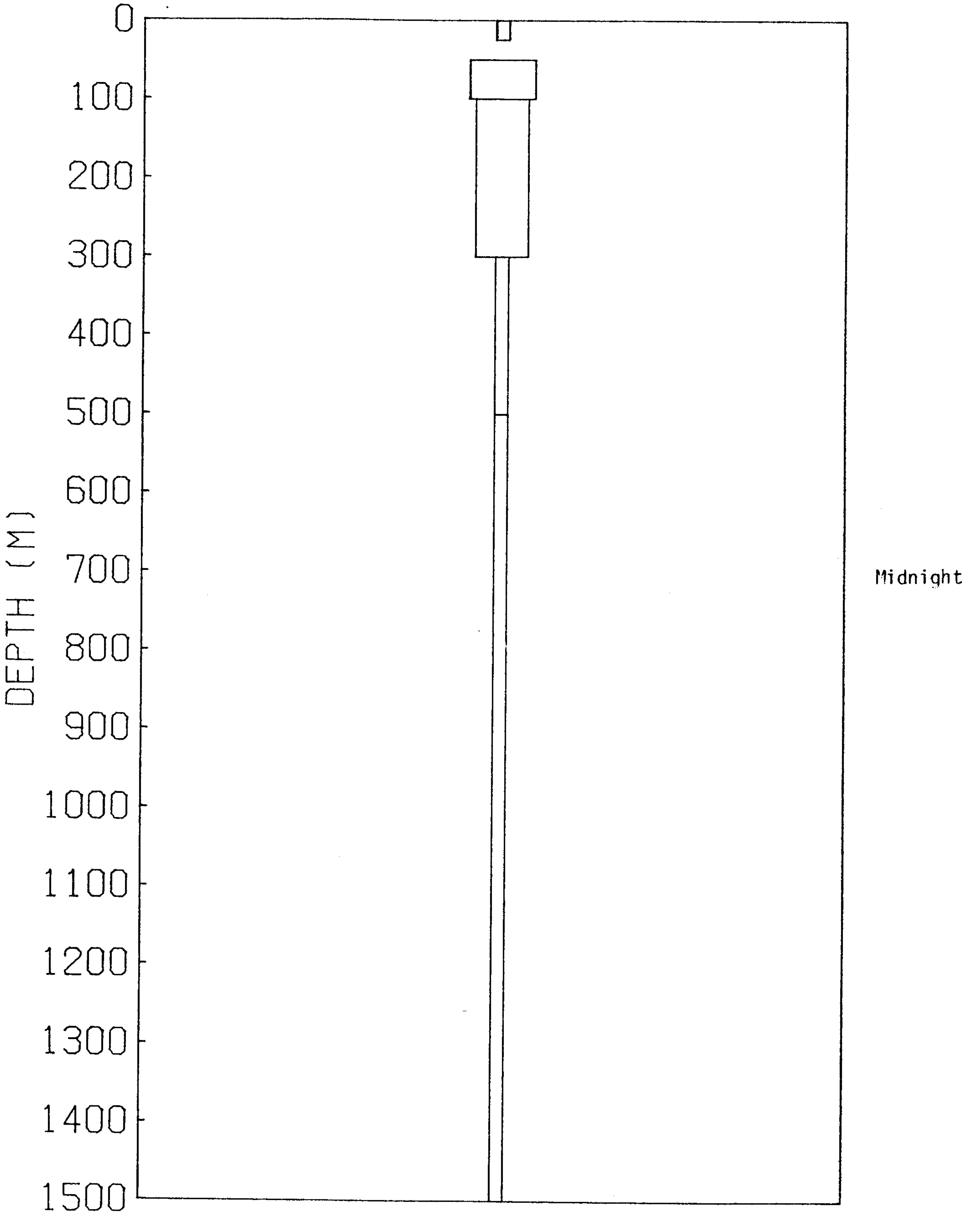

Figure 41. Amphipoda, Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = $1/m^3$.

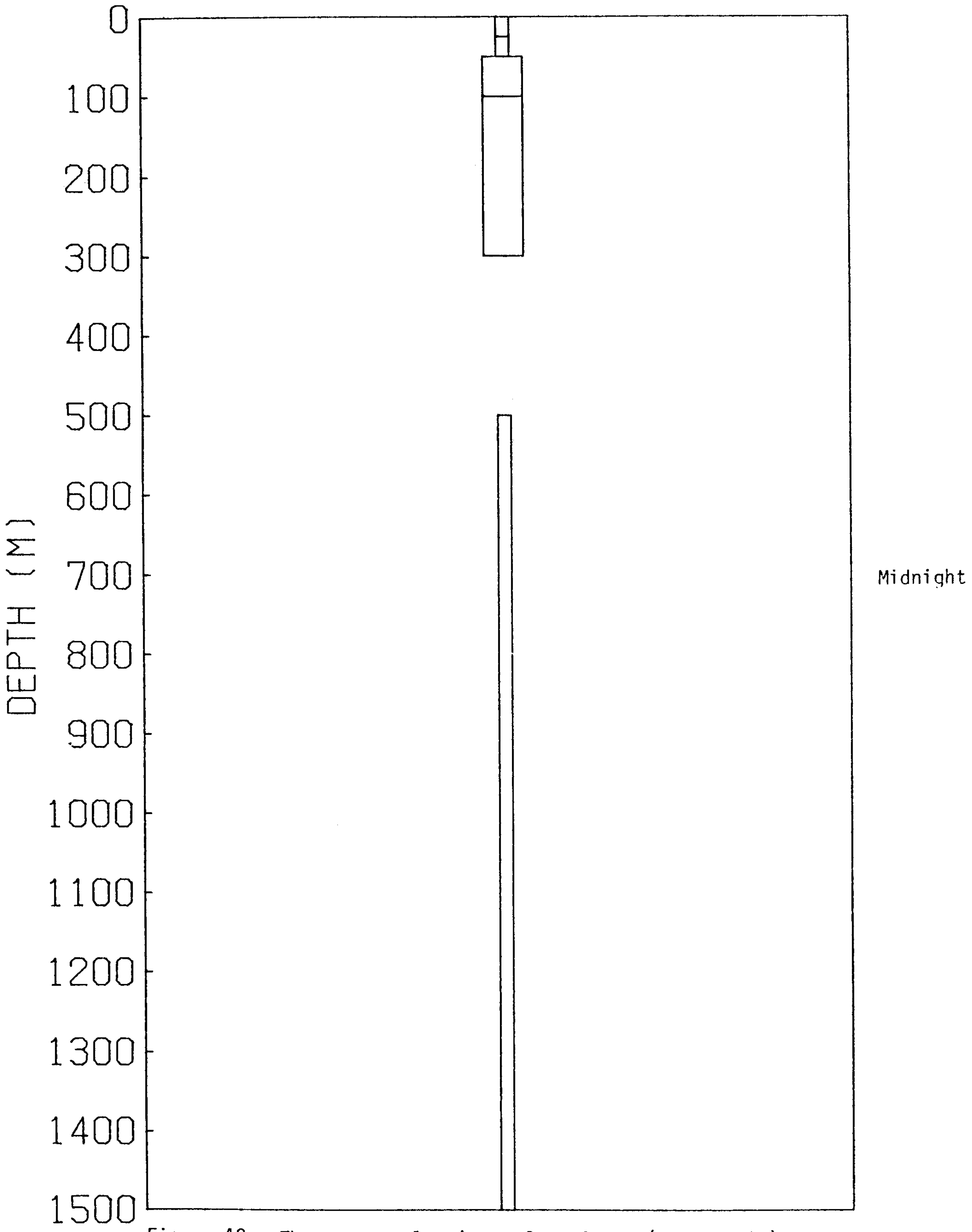

Figure 42. Thysanoessa longipes, Open Ocean (Station 11)

Gulf of Alaska, 10-11 April 1976; 1 inch = $1/m^3$.

Table 12. Zooplankton settled volumes (ml/m^3), Prince William Sound, Alaska Vertical tows, 211 micron mesh.

	Date	Local Time	Depth Interval (m)	ml/m^3
Cruise I	12 Apr 76	0140	25-0	18.6
	"	0133	50-25	15.6
	"	0125	100-50	3.6
	"	0106	300-100	0.7
	"	0044	500-300	0.6
	"	0012	700-500	0.4
	"	1201	25-0	23.6
	"	1156	50-25	44.6
	"	1150	100-50	0.4
	"	1139	300-100	1.8
	"	1119	500-300	1.0
	"	1047	700-500	0.6
Cruise III	28 May 76	1332	25-0	22.3
	"	1327	50-25	5.5
	"	1317	100-50	3.7
	"	1254	300-100	2.7
	"	1233	500-300	1.6
	"	1205	700-500	1.3
	"	0113	25-0	29.7
	"	0107	50-25	5.9
	"	0057	100-50	4.5
	"	0037	300-100	1.9
	"	0009	500-300	1.9
	29 May 76	2335	700-500	1.2
Cruise V	30 Aug 76	1438	25-0	5.6
	"	1425	50-25	3.7
	"	1410	100-50	1.9
	"	1350	300-100	2.8
	"	1325	500-300	4.2
	"	1250	700-500	2.8

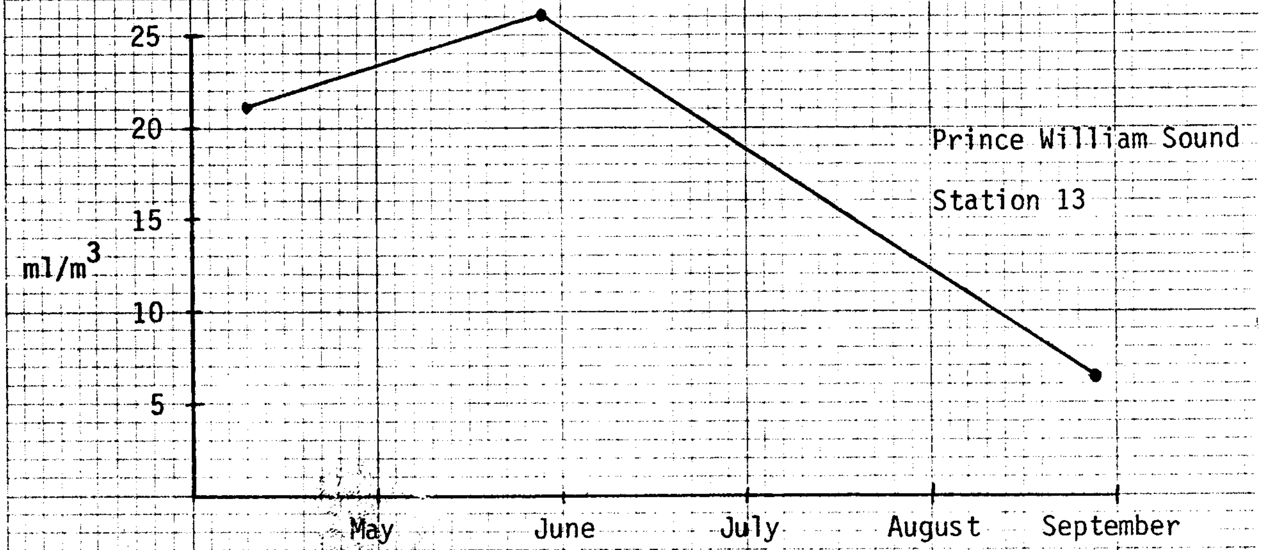

Figure 43. Zooplankton settled volumes, mean of all samples April - August 1976; Upper 25 m.

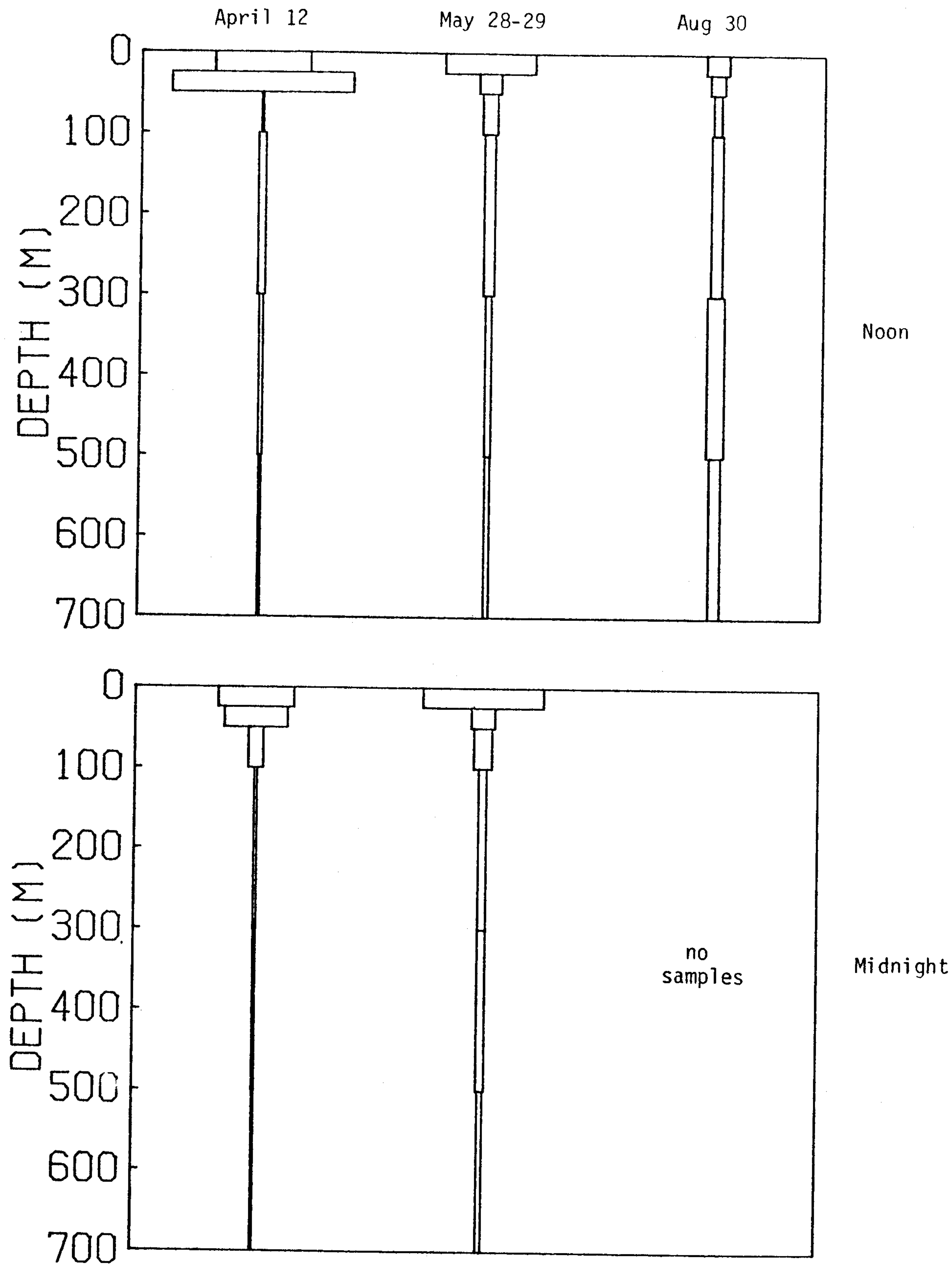

Figure 44. Zooplankton settled volumes (ml/m^3), Prince William Sound (Station 13), Alaska, 1976; 1 inch = $35/m^3$.

	I Early April	II Early May	III Late May	IV Early July	V Late August
Kachemak Bay (Station 6)					
z=75 m					
Water column, ml/m^2	43.2	1029.6	216.0	93.6	101.3
Open Ocean, GOA (Station 11)					
z=1500 m					
Water column, ml/m^2	750.0	-	840.0	1260.0	-
Upper 500 m, ml/m^2	550.0	800.0	650.0	1150.0	1030.0
Prince William Sound (Sta. 13)					
z=700 m					
Water column, ml/m^2	1890.0	-	2057.5	-	2287.5

Table 13. Zooplankton settled volumes (ml/m^2), Kachemak Bay, Alaska; Open Ocean (Station 11), Gulf of Alaska; Prince William Sound, Alaska. April - August 1976.

VIII. CONCLUSIONS

Prince William Sound and Gulf of Alaska, 1975

The determinations of zooplankton volumes and numbers of certain groups were consistent enough to give confidence in the estimates for Prince William Sound in October, 1975. The volumes of zooplankton were moderately high, about what one would expect in that area in October. These data demonstrate the necessity of accounting for time of day when sampling, particularly in the upper 100 m, and especially in the upper 25 m, where there is a sixfold or so increase in zooplankton biomass at night (October). One might expect even greater influences of diel vertical migrations in spring or summer. Obviously the appearance of large organisms in the surface each night will have an affect on the natural distributions of matter and energy, but will also be of great importance when deep-living organisms are exposed to pollutants in surface layers, when they incorporate such pollutants, and when they actively transport them to deep water.

In spite of the high numbers of species, even in an area of relatively low diversity like the subarctic Pacific, and the resultant potentially high number of vertical distribution patterns (one for each species), the most abundant species at this time could be grouped into one of four basic vertical distribution patterns (table 4).

No consistent geographic patterns of zooplankton volume concentration can yet be discerned within Prince William Sound. The same trend of night increases was noted throughout. Probably there will be species differences from place to place within the Sound, and these different species will result in different cycles of energy and matter transfer.

In November, the zooplankton volume on the shelf was similar to that in Prince William Sound in October, but there did not appear to be day-night changes in zooplankton volumes at these shallow shelf locations at that time.

Lower Cook Inlet and Gulf of Alaska, 1976

The plankton volumes for the entire water column at Kachemak Bay (Station 6), Lower Cook Inlet, as a measure of zooplankton biomass indicate that sometime after an apparent peak in spring a gradual decline occurs throughout the summer months.

The general pattern of plankton standing stock with time at the open Lower Cook Inlet stations (Stations 2-8) contrasts noticeably with that of Kachemak Bay and more closely parallels concentration fluctuations found at the Gulf of Alaska Station 11.

In Kachemak Bay, Lower Cook Inlet and at Station 11 in the Gulf of Alaska, the largest numerical component of the zooplankton is the Copepoda. While the diversity of species within this group is much greater at the Gulf of Alaska station, the several most abundant species are common to both locations.

From April through August at Station 6 in Kachemak Bay, there is a definite and consistent nighttime increase in total zooplankton volume in the surface layer (0-25 m). It is believed this is due to daily vertical migrations of zooplankton, particularly copepods. There was probably also some avoidance of the net during the daylight tows. The night volumes in the 0-25 m layer ranged from four times the day volumes in early April to approximately two times the day volumes in May, July and August.

IX. NEEDS FOR FURTHER STUDY

The initial objective of this study was to outline the amplitude and duration of the seasonal cycles of zooplankton in the northeast Gulf of Alaska. We believed this could best be done by time-intensive sampling within a rather limited but possibly representative area. This idea was rejected by the project management in favor of a broader areal coverage seasonally. Before the field work began in the open Gulf of Alaska and at the request of the Boulder project office, a preliminary survey of the zooplankton of Prince William Sound was undertaken.

Unfortunately, after the first field efforts in the northeast Gulf, the project direction became less certain, with interest shifting between the Kodiak area and Lower Cook Inlet. Ultimately, the field effort was focused on Lower Cook Inlet, although we attempted to retain some continuity with the initial surveys by obtaining a few samples in the northeast Gulf and Prince William Sound as time permitted.

Hydrographically, the northeast Gulf of Alaska, Prince William Sound, Lower Cook Inlet, and the Kodiak area are not equivalent. It should not be assumed that the zooplankton is identical, nor that the zooplankton of the different regions would have similar seasonal distributions and abundances. Therefore, since samples were not obtained for all seasons from any one region, it cannot be concluded that we now have attained the study's objective.

Even with a single year's survey, because of the expected great variability in zooplankton concentrations, doubt would remain as to the representativeness of the data. It would be essential to continue these assessments for a few years, to evaluate the year-to-year variability. In subsequent years, however, we would have a better estimate of the principal zooplankters and could limit the survey to a study of their cycles as a first approximation to modeling the zooplankton as a whole.

It is also likely that the principal zooplankton components (species) would change with season, one set of species dominating the system for a time, and succeeded by a different combination of species. With each change in species or life history stage, the potential pathways of matter transfer alter, and concurrently the environmental relationships of greatest concern.

It is likely that the gross patterns of matter and energy transfer within the net zooplankton are controlled by the daily and seasonal vertical movements of relatively few species. Therefore, comparisons of shallow and deep areas should be undertaken to test this assumption.

Since changes in zooplankton abundance can be very rapid at any one locality, it would be desirable to have frequent (perhaps biweekly) samples during parts of the year. These samples could be used for studies of certain basic zooplankton processes, such as growth rates, reproductive cycles, mortality rates, etc. Such studies are best conducted in limited areas where the most background information is available.

Eventually the question of potential impacts of selected pollutants will arise. There might be a tendency to rely on laboratory studies for this information, but the reactions of laboratory animals to laboratory stresses bears slight if any relationship to the reaction of natural populations in the field. Laboratory studies could possible suggest sensitivities and cause-effect relations, but the final assay is the response of the affected populations. And this response can only be judged in light of distributions and abundances of populations in time and space. Moreover, proper judgments can be made only if the "natural" levels and variabilities are understood. Then population deviations in quantity or quality might subsequently be related to environmental perturbations.

APPENDIX A

TABULATED ZOOPLANKTON DATA

PART I. PRINCE WILLIAM SOUND, STATIONS 1-9, OCTOBER 1975

PART II. KACHEMAK BAY, STATION 6, APRIL - AUGUST 1976

PART III. GULF OF ALASKA, STATION 11, APRIL 1976

PART I. PRINCE WILLIAM SOUND, STATIONS 1-9, OCTOBER 1975

CRUISE SU7501 LAT 60-40 N GMT DATE 10/04/75
STATION 00001 LONG 147 41 W GMT HOUR 1719
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(732- 518M) NUM/CU.M	(500- 286M) NUM/CU.M	(293- 97M) NUM/CU.M	(99- 50M) NUM/CU.M	(50- 22M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII						14.300
CALANUS MARSHALLAE A				5.400		
CALANUS MARSHALLAE J	252.100	13.300		26.800		
CALANUS PACIFICUS A					.100	.100
CALANUS PACIFICUS J					1.100	.700
CALANUS PLUMCHRUS A	6.000	10.000	1.800			
CALANUS PLUMCHRUS J	3.000	3.300				
EU. BUNGII BUNGII A		3.300				
EUCALANUS JUVENILES	3.000	3.300		1.800		
MICROCALANUS SPP.	60.000	26.700	25.500			
PSEUDOCALANUS SPP.					65.900	
PSEUDOCALANUS SPP. A				17.900		57.100
PSEUDOCALANUS SPP. J		603.300	314.500	17.900		42.900
GAETANUS JUVENILES		3.300	7.300			
GAIDIUS VARIABILIS A	3.000					
EUCHAETA JUVENILES			3.600	1.800		
METRID. CURTICAUDA A						.100
METRIDIA LUCENS A	24.000	10.000	5.500			
METRID. OKHOTENSIS A	18.000	26.700	32.700			
METRIDIA JUVENILES	24.000	153.300	140.000	17.900		
CENTR. ABDOMINALIS A						14.700
ACARTIA LONGIREMIS				26.800	38.300	
ACARTIA LONGIREMIS A						300.000
ACARTIA LONGIREMIS J						378.600
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	39.000	13.300	63.600	180.400	184.900	157.100
OITH. SPINIROSTRIS A					2.100	
LUBBOCKIA WILSONAE A				.100		
ONCAEA BORIALIS	6.000	6.700	9.100	19.600	10.600	
ONCAEA PROLATA	63.000					
ONCAEA SP. A	3.000					
CHAETOGNATHA						
CHAETOGNATHA	2.600	1.000	1.300	1.400		

(CONTINUED ON NEXT PAGE)

EUKROHNIA HAMATA	1.100	.600	.500	.200		
SAGITTA ELEGANS	.600	.400	.700	1.200	3.300	4.100
POLYCHAETA						
POLYCHAETA	.030	13.400	7.400	.300	.300	
CTENOPHORA						
CTENOPHORA						.400
HYDROZOA						
HYDROZOA	3.200	7.000	3.200	.100	.500	7.900
GASTROPODA						
GASTROPODA			2.200		4.300	14.300
OSTRACODA						
OSTRACODA	18.600	13.700	15.200	.200	.100	
AMPHIPODA						
AMPHIPODA	.600	.700	4.200	.200	.100	8.000
GAMMARIDAE		.100				
CYPHO. CHALLENGERI	.600	.600	1.100			
SCINIDAE			.020			
HYPEROCHE MEDUSARUM	.020					
PARATHEM. JAPONICA			.400	.100	.100	
PARATHEMISTO SPP.						1.600
PRIMNO SPP.			.800	.100		.700
MYSIDACEA						
MYSIDACEA	.100	.200	.100			
EUPHAUSIACEA						
EUPHAUSIACEA	.030		.200			.400
EUPHAUSID JUVENILES		.020	.040	.200		
EUPHAUSID NAUPLII				1.800	2.100	
EUPHAUSIA PACIFICA			.020			
THYSANOESSA INERMIS			.020			
THYSANOESSA LONGIPES	.030		.100			
THYSANOES. SPINIFERA			.020			

(CONTINUED ON NEXT PAGE)

DECAPODA			
DECAPODA		.020	.600
LARVACEA			
LARVACEA	.200	.020	

CRUISE SU7501 LAT 60-40 N GMT DATE 10/04/75
STATION 00002 LONG 147 41 W GMT HOUR 2055
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(699- 460M) NUM/CU.M	(500- 285M) NUM/CU.M	(300- 90M) NUM/CU.M	(100- 50M) NUM/CU.M	(48- 24M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII		3.300				7.100
CALANUS MARSHALLAE	2.300					
CALANUS MARSHALLAE A				.100	.300	
CALANUS MARSHALLAE J		16.700		.500	4.000	
CALANUS PACIFICUS A				.100	4.800	
CALANUS PACIFICUS J					4.800	
CALANUS PLUMCHRUS A	6.800	10.000				
MICROCALANUS SPP.	42.800	20.000		25.000	9.500	
PSEUDOCALANUS SPP. A					4.800	300.000
PSEUDOCALANUS SPP. J	263.700	616.700	454.200		16.700	1014.000
GAETANUS SIMPLEX J	2.300			.100		
GAETANUS JUVENILES		6.700	8.300			
GAIDIUS JUVENILES			2.800			
EUCHAETA ELONGATA A				.100		
EUCHAETA ELONGATA J				.100		
METRIDIA LUCENS		6.700				
METRIDIA LUCENS A	31.500		19.400			
METRIDIA OKHOTENSIS		26.700				
METRID. OKHOTENSIS A	4.500		41.500	.200		
METRIDIA JUVENILES	29.300	200.000	174.500		.100	
HETERORHA. TANNERI A		3.300				
CANDACIA COLUMBIAE A				.100		
ACARTIA LONGIREMIS			2.800	23.200	21.400	550.000
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	6.800	30.000	49.800	175.000	269.000	692.900
LUBBOCKIA WILSONAE A				.100		
ONCAEA BORIALIS		10.000	13.800	12.500	4.800	
ONCAEA PROLATA	40.600	6.700	2.800			
CHAETOGNATHA						
CHAETOGNATHA	1.400	1.000	1.400	1.900	3.600	8.600
EUKROHNIA HAMATA	1.100	1.300	.400	.300		
SAGITTA ELEGANS	.300	.700	1.000	1.600	3.600	8.600
POLYCHAETA						
POLYCHAETA		10.100	18.200	.500		.400

(CONTINUED ON NEXT PAGE)

POLYCHAETA LARVAE	.010					
CTENOPHORA						
CTENOPHORA	.010					.100
HYDROZOA						
HYDROZOA		.200	.800	.700	.700	1.000
GASTROPODA						
GASTROPODA		.020	11.500	5.400		
OSTRACODA						
OSTRACODA	18.300	17.100	34.200	.500	.100	
ISOPODA						
ISOPODA			.020			
AMPHIPODA						
AMPHIPODA	7.400	1.300	2.800	.800	1.000	1.700
LYSIANASSIDAE			.020			
CYPHO. CHALLENGERI	.600	1.100	1.300	.100		.600
SCINIDAE		.100				
PARATHEM. LIBELLULA	.100		.050			
PARATHEM. JAPONICA		.020	.600	.500	.600	1.100
PRIMNO MACROPA			.800			
PRIMNO SPP.		.100		.200	.400	
MYSIDACEA						
MYSIDACEA	.100	.100				
MYSIDACEA ADULTS			.100			
EUPHAUSIACEA						
EUPHAUSIACEA	.010		.300			
EUPHAUSID ADULTS		.100				
EUPHAUSID JUVENILES			.200	.800		.700
EUPHAUSIA PACIFICA			.020			
THYSANOESSA INERMIS			.030			
THYSANOESSA LONGIPES	.010		.050			
THYSANOE. LONGIPES A		.100				

(CONTINUED ON NEXT PAGE)

THYSANOES. SPINIFERA			.020			
DECAPODA						
DECAPODA ADULTS		.100	.030			
DECAPODA JUVENILES			.020			
PASIPHAEA PACIFICA A		.020				
LARVACEA						
LARVACEA	2.400		.020	.900	.300	15.0CC
TELEOSTEI						
FISH LARVAE			.020			

CRUISE SU7501 LAT 60-40 N GMT DATE 10/05/75
STATION 00003 LONG 147 40 W GMT HOUR 0354
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(618- 413M) NUM/CU.M	(485- 291M) NUM/CU.M	(300- 100M) NUM/CU.M	(100- 50M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII				1.800	2.400	
CALANUS MARSHALLAE J	8.700	7.400				
CALANUS PLUMCHRUS	26.100	25.900				
EUCALANUS JUVENILES	2.900	7.400				
MICROCALANUS SPP.	34.800	22.200	8.900	19.600	7.100	85.700
PSEUDOCALANUS SPP. A				17.900	14.300	57.100
PSEUDOCALANUS SPP. J	617.400	670.400	328.600	44.600	31.000	257.100
GAETANUS JUVENILES	5.800	11.100	1.800		2.400	
EUCHAETA ELONGATA					3.100	4.700
EUCHAETA JUVENILES			1.800			
EUCHAETA ELONGATA J				1.000		
METRIDIA LUCENS	14.500	29.600	1.800			78.600
METRIDIA LUCENS A					16.700	
METRIDIA OKHOTENSIS	20.300	25.900	17.900			
METRIDIA JUVENILES	63.800	148.100	105.400	5.400		
CENTROP. ABDOMINALIS						7.100
HETERORHAB. TANNERI	2.900					
CANDACIA COLUMBIAE					.700	.400
CANDACIA COLUMBIAE A				.100		
CANDACIA COLUMBIAE J						21.400
CANDACIA JUVENILES				7.100	9.500	
ACARTIA LONGIREMIS			14.300	89.300	45.200	1843.000
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	20.300	18.500	69.600	262.500	245.200	521.400
OITHONA SPINIROSTRIS				1.800		
ONCAEA BORIALIS	11.600	3.700	3.600	8.900	19.000	
ONCAEA PROLATA	20.300	7.400				
CHAETOGNATHA						
CHAETOGNATHA	1.800	1.600	1.300	.500	1.700	13.900
EUKROHNIA HAMATA	1.600	4.700	.600	.200		
SAGITTA ELEGANS	.300	.500	.700	.300	1.700	6.700
POLYCHAETA						
POLYCHAETA	.200	26.200	16.300	1.200	.700	1.400

(CONTINUED ON NEXT PAGE)

HYDROZOA						
HYDROZOA	.100	4.500	3.600	1.700	30.900	3.900
GASTROPODA						
GASTROPODA			.100	.200	12.300	22.400
CEPHALOPODA						
CEPHALOPODA	.010					
OSTRACODA						
OSTRACODA	12.000	1.500	18.700		23.800	89.600
AMPHIPODA						
AMPHIPODA	.600	.600	1.300	4.100	16.000	12.600
GAMMARIDAE		.020				
CYPHO. CHALLENGERI	.600	.400	.700	2.600	6.400	4.900
SCINIDAE	.010	.100	.100			
PARATHEM. LIBELLULA	.010	.020	.020	.100	.100	
PARATHEM. JAPONICA			.100			
PARATHEMISTO SPP.				.300	2.000	.600
PRIMNO SPP.			.400	1.200	.400	
MYSIDACEA						
MYSIDACEA	.100	.100	.100	.200		.100
EUPHAUSIACEA						
EUPHAUSIACEA		.020	.100	.200		
EUPHAUSID JUVENILES				.100	.100	2.700
THYSANOESSA LONGIPES		.020	.100			
THYSANOE. LONGIPES A				.100		
DECAPODA						
DECAPODA	.030	.020		.100		
LARVACEA						
LARVACEA	.100	.040		1.600	6.000	42.900
TELEOSTEI						
TELEOSTEI						.100

(CONTINUED ON NEXT PAGE)

FISH EGGS			2.000
FISH LARVAE	.010	.020	.100

CRUISE SU7501 LAT 60-40 N GMT DATE 10/05/75
STATION 00004 LONG 147 41 W GMT HOUR 0626
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(730- 487M) NUM/CU.M	(492- 298M) NUM/CU.M	(300- 100M) NUM/CU.M	(100- 48M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII	8.800					
CALANUS MARSHALLAE J	13.200	11.100				
CALANUS PLUMCHRUS	2.200	18.500				
CALANUS PLUMCHRUS A			1.800			
MICROCALANUS SPP.	35.300	40.700	14.300	20.000	9.500	7.100
PSEUDOCALANUS SPP. A				20.000	11.900	42.900
PSEUDOCALANUS SPP. J	355.100	563.000	364.300	1.700	28.600	107.100
GAETANUS JUVENILES	8.800	11.100				
GAIDIUS VARIABILIS	2.200	7.400				
GAIDIUS VARIABILIS A			1.800			
GAIDIUS VARIABILIS J			1.800			
EUCHAETA ELONGATA				2.100	2.600	3.900
EUCHAETA JUVENILES			1.800			
EUCHAETA ELONGATA J		7.400				
METRID. CURTICAUDA A				1.700		
METRIDIA LUCENS	30.900	25.900		65.000		185.700
METRIDIA LUCENS J					171.400	
METRIDIA OKHOTENSIS	6.600	22.200	30.400			
METRIDIA JUVENILES	35.300	192.600	133.900			
HETERORHA. TANNERI A			1.800			
CANDACIA COLUMBIAE						.300
CANDACIA COLUMBIAE J					2.400	
ACARTIA LONGIREMIS				33.300		385.700
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	52.900	25.900	89.300	210.000	231.000	1043.000
OITHONA SPINIROSTRIS					4.800	
ONCAEA BORIALIS		7.400	8.900	6.700	2.400	
ONCAEA PROLATA	59.600	3.700				
ONCAEA SP.	4.400					
CHAETOGNATHA						
CHAETOGNATHA	2.500	1.700	.800	.200	1.000	14.600
EUKROHNIA HAMATA	2.100	1.000	.200	.100		
EUKROHNIA SP.	2.300	1.000				

(CONTINUED ON NEXT PAGE)

SAGITTA ELEGANS	.100	.700	.600	.100	1.000	1.400
POLYCHAETA						
POLYCHAETA	4.800	11.200	14.400	.500	1.100	9.300
CTENOPHORA						
CTENOPHORA	.010					
HYDROZOA						
HYDROZOA	12.100	4.400	2.700	.300	.300	.290
GASTROPODA						
GASTROPODA				1.800	1.600	51.100
CEPHALOPODA						
CEPHALOPODA	.010					
OSTRACODA						
OSTRACODA	22.100	7.400	10.700	11.600	21.400	37.300
AMPHIPODA						
AMPHIPODA	.800	.900	.900	3.000	5.100	.360
CYPHO. CHALLENGERI	.800	.600	.400	2.000	2.600	.310
SCINIDAE		.100	.020	.100		
HYPERIIDAE	.010					
PARATHEM. LIBELLULA	.010		.020	.200		
PARATHEM. JAPONICA					2.000	.000
PARATHEMISTO SPP.		.020	.100	.500		
PRIMNO SPP.		.100	.400	.500	.600	
MYSIDACEA						
MYSIDACEA	.040	.100	.020	.100		
EUPHAUSIACEA						
EUPHAUSIACEA	.010	.100	.100	.100		
EUPHAUSID JUVENILES					.600	2.400
THYSANOESSA LONGIPES	.010	.100	.100	.100		
DECAPODA						
DECAPODA		.020		.100		.030

(CONTINUED ON NEXT PAGE)

PASIPHAEA PACIFICA				.100		
LARVACEA						
LARVACEA	.400	4.100	1.800		.700	57.600
TELEOSTEI						
FISH LARVAE				.100		

CRUISE SU7501 LAT 60-40 N GMT DATE 10/05/75
STATION 00005 LONG 147 41 W GMT HOUR 1221
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(602- 388M) NUM/CU.M	(409- 247M) NUM/CU.M	(295- 94M) NUM/CU.M	(91- 45M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII					2.400	
CALANUS MARSHALLAE	19.700					
CALANUS MARSHALLAE A					.100	.100
CALANUS MARSHALLAE J		10.900			.100	.400
CALANUS PLUMCHRUS		38.200				
CALANUS PLUMCHRUS A	24.700					
CALANUS PLUMCHRUS J	9.900					
EUCALANUS JUVENILES	9.900		5.300			
MICROCALANUS SPP.	24.700	49.100	73.700	12.500	7.100	7.100
PSEUDOCALANUS SPP.			784.200			
PSEUDOCALANUS SPP. A				10.700	9.500	164.300
PSEUDOCALANUS SPP. J	655.900	987.300		23.200	14.200	246.400
CHIRIDIUS GRACILIS A			5.300			
GAETANUS JUVENILES	4.900	16.400	5.300			
GAIDIUS JUVENILES		5.500				
EUCHAETA ELONGATA				1.600	.100	
EUCHAETA ELONGATA J			5.300			
METRIDIA LUCENS	54.200					
METRIDIA LUCENS A		16.400	36.800	28.600	4.800	
METRIDIA OKHOTENSIS	4.900					
METRID. OKHOTENSIS A		76.400	47.400			
METRIDIA JUVENILES	152.900		394.700			
CENTR. ABDOMINALIS A						7.100
CANDACIA COLUMBIAE J			5.300			
ACARTIA LONGIREMIS				32.100	26.200	507.100
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	9.900	38.200	194.700	173.200	247.600	432.100
OITHONA SPINIROSTRIS				1.800		
ONCAEA BORIALIS	4.900		21.100	10.700	2.480	3.600
ONCAEA PROLATA	24.700		5.300			
ONCAEA SP.		5.500				
CHAETOGNATHA						
CHAETOGNATHA	2.100	1.700	1.200	1.100	1.700	3.400

(CONTINUED ON NEXT PAGE)

EUKROHNIA HAMATA	1.500	1.000	.600	.300		
EUKROHNIA SP.	1.500					
SAGITTA ELEGANS	.500	.700	.600	.800	1.700	3.400
POLYCHAETA						
POLYCHAETA	.010	.400	5.600	2.100		.600
CTENOPHORA						
CTENOPHORA	.010					.100
HYDROZOA						
HYDROZOA		.700	7.000	1.100	1.100	5.300
GASTROPODA						
GASTROPODA		.100	.300	15.800	.100	
OSTRACODA						
OSTRACODA	29.600	27.300	68.400	8.900	2.400	
AMPHIPODA						
AMPHIPODA	.900	6.800	2.900	3.900	.700	.600
GAMMARIDAE		.020	.020			
CYPHO. CHALLENGERI	.800	1.000	1.800	1.900		.300
SCINIDAE		.100	.100			
PARATHEM. LIBELLULA	.010	.020	.100			
PARATHEM. JAPONICA		.040	.100	1.200		.300
PRIMNO MACROPA		.100				
PRIMNO SPP.	.010		.800	.800		
MYSIDACEA						
MYSIDACEA	.100	.200	.100			
EUPHAUSIACEA						
EUPHAUSIACEA	.030	.020	.100	.100	.900	
EUPHAUSID JUVENILES	.010					.300
EUPHAUSIA PACIFICA					.400	
THYSANOESSA INERMIS			.020	.100	.100	
THYSANOESSA LONGIPES		.020	.100	.100	.300	
THYSANOE. LONGIPES A	.010					

(CONTINUED ON NEXT PAGE)

DECAPODA					
DECAPODA	.100	.040			
LARVACEA					
LARVACEA	.100	5.300		.300	39.3CC
TELEOSTEI					
FISH LARVAE		.020	.100		

CRUISE SU7501 LAT 60-40 N GMT DATE 10/05/75
STATION 00006 LONG 147 41 W GMT HOUR 1801
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(732- 488M) NUM/CU.M	(500- 302M) NUM/CU.M	(300- 101M) NUM/CU.M	(108- 50M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII	2.900				8.600	3.600
CALANUS CRISTATUS J			2.500			
CALANUS MARSHALLAE A				.060		
CALANUS MARSHALLAE J	26.500	14.500		.200	.600	.400
CALANUS PACIFICUS A				.060	.100	.100
CALANUS PLUMCHRUS	11.800	25.500				
CALANUS PLUMCHRUS J				.060		
CAL. TENUICORNIS A					2.900	
EU. BUNGII BUNGII J					.100	
EUCALANUS JUVENILES	5.900					
MICROCALANUS SPP.	70.600	25.500	26.000	16.300	4.300	21.400
PSEUDOCALANUS SPP. A				2.500	17.100	85.700
PSEUDOCALANUS SPP. J	388.200	658.200	315.000	8.800	40.000	121.400
GAETANUS JUVENILES		3.600				
GAIDIUS JUVENILES	2.900					
METRIDIA LUCENS A	26.500	3.600	17.500			
METRID. OKHOTENSIS A	5.900	25.500	35.000			
METRIDIA JUVENILES	29.400	109.100	135.000			
ACARTIA LONGIREMIS				17.500	37.100	325.000
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	32.400	43.600	70.000	120.000	267.100	739.300
OITHONA SPINIROSTRIS				2.500	2.900	
ONCAEA BORIALIS	5.900	3.600		1.300	7.100	3.600
ONCAEA PROLATA	108.800	7.300				
CHAETOGNATHA						
CHAETOGNATHA	3.500	1.100	.900	.200	4.000	7.300
EUKROHNIA HAMATA	3.300	.600	.400			
SAGITTA ELEGANS	.300	.600	.500	.200	4.000	6.900
POLYCHAETA						
POLYCHAETA	9.000	11.100	15.400		.100	.100
CTENOPHORA						
CTENOPHORA		.020	.040			

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HYDROZOA						
HYDROZOA	29.700	15.900	7.500	.060	.400	9.700
GASTROPODA						
GASTROPODA	.040	.020	.400		18.600	10.700
CLADOCERA						
CLADOCERA		3.600				
OSTRACODA						
OSTRACODA	50.000	10.900	15.600	.060	8.600	
AMPHIPODA						
AMPHIPODA	.800	.900	5.700	.100	.400	1.900
CYPHO. CHALLENGERI	.700	.800	1.300	.060	.300	
SCINIDAE	.060	.100				
PARATHEM. LIBELLULA	.030					
PARATHEM. JAPONICA		.020	1.100			1.600
PRIMNO SPP.			.800	.060	.100	.300
MYSIDACEA						
MYSIDACEA	.070	.070	.100			
EUPHAUSIACEA						
EUPHAUSIACEA		.040	.040			
EUPHAUSID JUVENILES		.020		.200	.100	4.300
EUPHAUSID NAUPLII						3.600
THYSANOESSA LONGIPES		.020	.040			
DECAPODA						
DECAPODA	.010	.040				
LARVACEA						
LARVACEA	3.300	3.800		.200	7.300	50.000

CRUISE SU7501 LAT 60-40 N GMT DATE 10/06/75
STATION 00007 LONG 147 41 W GMT HOUR 0131
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(422- 269M) NUM/CU.M	(321- 188M) NUM/CU.M	(243- 81M) NUM/CU.M	(50- 23M) NUM/CU.M	(41- 20M) NUM/CU.M	(14- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII					1.400	
CALANUS MARSHALLAE	13.000					
CALANUS MARSHALLAE J		14.500				
CALANUS PACIFICUS A						8.600
CALANUS PLUMCHRUS	16.200	4.800				
EUCALANUS JUVENILES	3.200					
MICROCALANUS SPP.	9.700	4.800	28.600	.200	2.900	
PSEUDOCALANUS SPP. A					4.300	574.300
PSEUDOCALANUS SPP. J	389.200	709.700	296.400	7.400	14.300	934.300
CHIRIDIUS GRACILIS A		4.800				
GAETANUS JUVENILES	3.200		3.600		5.700	
GAIDIUS JUVENILES		4.800				
EUCHAETA JUVENILES						34.300
EUCHAETA ELONGATA J			3.600		8.600	
METRIDIA LUCENS					21.400	
METRIDIA LUCENS A		9.700	21.400			120.000
METRIDIA OKHOTENSIS					5.700	
METRID. OKHOTENSIS A	42.200	72.400	35.700			8.600
METRIDIA JUVENILES	191.400	188.300	246.400	1.500	165.700	745.700
HETERORHAB. TANNERI	3.200					
ACARTIA LONGIREMIS			10.700	.500	27.100	857.100
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS			142.900	1.300	210.000	1089.000
OITHONA SPINIROSTRIS					1.400	
ONCAEA BORIALIS	16.200	24.100	28.600	.100	12.900	8.600
CHAETOGNATHA						
CHAETOGNATHA	1.200	1.700	1.500	.100	.400	8.600
EUKROHNIA HAMATA	.800	.400	.400			
EUKROHNIA SP.	.030					
SAGITTA ELEGANS	.400	1.300	1.200		.400	8.600
POLYCHAETA						
POLYCHAETA	6.700	14.500	21.500	.100	.300	2.400

(CONTINUED ON NEXT PAGE)

HYDROZOA						
HYDROZOA	3.200	.030	.200		.700	4.300
GASTROPODA						
GASTROPODA			7.200		23.300	57.100
OSTRACODA						
OSTRACODA	16.800	43.400	14.300	.500	44.300	92.100
ISOPODA						
ISOPODA	3.200		.020	.200	1.400	
AMPHIPODA						
AMPHIPODA	1.100	1.700	7.200	.700	10.000	5.700
GAMMARIDAE		.020				
CYPHO. CHALLENGERI	.800	1.400	2.300	.100	1.700	3.600
SCINIDAE	.200	.020				
PARATHEM. LIBELLULA	.030	.020	.100		.100	
PARATHEM. JAPONICA			.300	.100	1.400	1.900
PRIMNO SPP.	.030	.200	.900	.200	1.000	.300
MYSIDACEA						
MYSIDACEA	.100	.100	.100			
EUPHAUSIACEA						
EUPHAUSIACEA		.050	.100		.600	9.100
EUPHAUSID JUVENILES					.300	8.000
THYSANOESSA INERMIS					.100	.700
THYSANOESSA LONGIPES		.050	.100		.100	.100
THYSANOESSA RASCHII						.300
THYSANOES. SPINIFERA			.020			
DECAPODA						
DECAPODA	.050	.020	.100			
LARVACEA						
LARVACEA	.010			.100	1.400	17.300
TELEOSTEI						
FISH LARVAE		.030	.100			.100

(CONTINUED ON NEXT PAGE)

CRUISE SU7501 LAT 60-40 N GMT DATE 10/06/75
STATION AC007 LONG 147 41 W GMT HOUR 0011
DEPTH 00740 M ZONE +10

VERTICAL HAULS

	(637- 0M) NUM/CU.M
COPEPODA CALANOIDA	
CALANUS PLUMCHRUS	7.800
MICROCALANUS SPP.	58.300
PSEUDOCALANUS SPP. J	675.700
GAETANUS JUVENILES	7.600
GAIDIUS JUVENILES	3.900
METRID. OKHOTENSIS A	38.600
METRIDIA JUVENILES	209.700
HETERORHAB. TANNERI	3.900
ACARTIA LONGIREMIS	93.200
COPEPODA CYCLOPOIDA	
OITHONA SIMILIS	209.700
ONCAEA BORIALIS	3.900
ONCAEA PROLATA	3.900
ONCAEA SP.	3.900
CHAETOGNATHA	
CHAETOGNATHA	2.200
EUKROHNIA HAMATA	.900
SAGITTA ELEGANS	1.300
POLYCHAETA	
POLYCHAETA	7.900
HYDROZOA	
HYDROZOA	.200
GASTROPODA	
GASTROPODA	.100
CEPHALOPODA	
CEPHALOPODA	.005
OSTRACODA	
OSTRACODA	27.700
ISOPODA	
ISOPODA	3.900
AMPHIPODA	
AMPHIPODA	2.600
GAMMARIDAE	.005
CYPHO. CHALLENGERI	1.800
SCINIDAE	.060
PARATHEM. LIBELLULA	.020

(CONTINUED ON NEXT PAGE)

PARATHEM. JAPONICA	.400
PRIMNO SPP.	.400
MYSIDACEA	
MYSIDACEA	.100
EUPHAUSIACEA	
EUPHAUSIACEA	4.200
EUPHAUSID JUVENILES	4.100
THYSANOESSA INERMIS	.010
THYSANOESSA LONGIPES	.030
THYSANOESSA RASCHII	.005
DECAPODA	
DECAPODA	.040
LARVACEA	
LARVACEA	3.900

CRUISE SU7501 — STATION 00008

LAT 60-40 N — LONG 147 41 W — DEPTH 00740 M

GMT DATE 10/06/75 — GMT HOUR 0613 — ZONE +10

VERTICAL HAULS

	(422- 278M) NUM/CU.M	(216- 134M) NUM/CU.M	(212- 70M) NUM/CU.M	(82- 41M) NUM/CU.M	(45- 22M) NUM/CU.M	(23- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII						5.700
CALANUS CRISTATUS A	6.900					
CALANUS MARSHALLAE J	6.900					
CALANUS PLUMCHRUS	13.700					
CALANUS PLUMCHRUS A		4.400				
EUCALANUS JUVENILES		4.400				
MICROCALANUS SPP.	20.600	4.400	19.300			8.600
PSEUDOCALANUS SPP. A			8.600		10.700	137.100
PSEUDOCALANUS SPP. J	939.400	742.200	207.900	40.700	27.900	371.400
CHIRIDIUS JUVENILES			6.400			
GAETANUS JUVENILES	13.700	8.900		15.000	4.300	
GAIDIUS VARIABILIS A	6.900					
EUCHAETA ELONGATA A	6.900					
EUCHAETA JUVENILES		4.400			2.100	
EUCHAETA ELONGATA J			2.100	4.300		20.000
METRID. CURTICAUDA A				2.100		
METRIDIA LUCENS A	20.600	8.900	19.300	47.100	38.600	25.700
METRID. OKHOTENSIS A	54.900	44.400	30.000	4.300		2.900
METRID. OKHOTENSIS J					2.100	
METRIDIA JUVENILES	219.400	235.600	160.700	216.400	203.600	97.100
HETERORHA. TANNERI A			2.100			
CANDACIA COLUMBIAE A			2.100			
CANDACIA JUVENILES				2.100		2.900
ACARTIA LONGIREMIS			8.600	19.300	40.700	362.900
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS		13.300		81.400	317.100	597.100
OITHONA SPINIROSTRIS				4.300	4.300	
LUBBOCKIA WILSONAE J			2.100			
ONCAEA BORIALIS	6.900	8.900	8.600	8.600	10.700	
CHAETOGNATHA						
CHAETOGNATHA	2.300	2.300	1.700	1.100	4.900	12.400
EUKROHNIA HAMATA	1.200	.900	.700			
SAGITTA ELEGANS	1.102	1.400	1.000	1.100	4.900	9.600

(CONTINUED ON NEXT PAGE)

POLYCHAETA						
POLYCHAETA	13.700	4.500	4.500	.100	2.700	3.900
CTENOPHORA						
CTENOPHORA	.030					
HYDROZOA						
HYDROZOA		.040	.500	.400	3.700	1.000
GASTROPODA						
GASTROPODA			4.500	11.400	19.100	15.600
OSTRACODA						
OSTRACODA	27.400	44.400	27.900	23.600	34.300	25.700
ISOPODA						
ISOPODA			.020	.100		2.800
AMPHIPODA						
AMPHIPODA	1.500	4.900	4.500	7.700	15.000	6.300
GAMMARIDAE		.020				
CYPHO. CHALLENGERI	1.400	2.800	3.000	6.500	10.400	5.300
SCINIDAE	.100	.020				
PARATHEM. LIBELLULA	.010	.040	.100	.100	.100	
PARATHEM. JAPONICA	.010	.800	.400	.600	1.700	1.000
PRIMNO SPP.		1.300	.900	.400	.100	
MYSIDACEA						
MYSIDACEA	.100	.700	.100			
EUPHAUSIACEA						
EUPHAUSIACEA	.030	.300	.300	.600	1.600	3.400
EUPHAUSID JUVENILES			.040	.200	1.100	3.100
EUPHAUSID NAUPLII						2.900
EUPHAUSIA PACIFICA					.100	.100
THYSANOESSA INERMIS				.400	.100	
THYSANOESSA LONGIPES	.030	.300	.200	.100	.100	.100
DECAPODA						
DECAPODA	.100		.100		.100	.100

(CONTINUED ON NEXT PAGE)

LARVACEA		
LARVACEA		18.6CC
TELEOSTEI		
FISH LARVAE	.010	

CRUISE SU7501 — LAT 60-40 N — GMT DATE 10/06/75
STATION 00009 — LONG 147 41 W — GMT HOUR 1227
DEPTH 00740 M — ZONE +10

VERTICAL HAULS

	(640- 392M) NUM/CU.M	(410- 240M) NUM/CU.M	(260- 0M) NUM/CU.M	(100- 50M) NUM/CU.M	(44- 21M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII					1.700	
CALANUS MARSHALLAE	18.000					
CALANUS MARSHALLAE J		20.700	2.400	2.100	1.700	
CALANUS PACIFICUS	6.000					
CALANUS PLUMCHRUS	24.000		2.400			
CALANUS PLUMCHRUS A		6.900				
MICROCALANUS SPP.	18.000	48.300	7.100	12.900	.900	
PSEUDOCALANUS SPP. A		6.900	42.900		15.400	196.000
PSEUDOCALANUS SPP. J	1134.000	944.800	209.500	23.600	12.000	92.000
AETIDEUS JUVENILES			2.400			
GAETANUS SIMPLEX J	12.000					
GAETANUS JUVENILES			4.800	4.300		
GAIDIUS JUVENILES	6.000	6.900	2.400			
EUCHAETA ELONGATA A	6.000					
EUCHAETA ELONGATA J	6.000			4.300		
METRIDIA LUCENS A	12.000	6.900	28.600	23.600		
METRID. OKHOTENSIS A	66.000	110.300	35.700			
METRIDIA JUVENILES	324.000	310.300	145.200	40.700	.900	
HETERORHA. TANNERI A			2.400			
ACARTIA LONGIREMIS			128.600	38.600	21.400	304.000
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	6.000	48.300	133.300	201.400	196.300	680.000
ONCAEA BORIALIS	36.000	27.600	9.500	4.300	8.600	
CHAETOGNATHA						
CHAETOGNATHA	2.200	2.500	11.600	2.700	2.100	10.100
EUKROHNIA HAMATA	1.400	.900	.200	.400		
SAGITTA ELEGANS	.800	1.500	1.800	2.400	2.100	6.100
POLYCHAETA						
POLYCHAETA	.040	20.800	4.800	.600	1.700	.100
HYDROZOA						
HYDROZOA		.200	.200	2.300		.400

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GASTROPODA						
GASTROPODA		.100	12.000	.500	6.900	20.0CC
OSTRACODA						
OSTRACODA	12.0C0	21.900	5.200	6.400	2.600	.1CC
ISOPODA						
ISOPODA		6.900		2.100		
AMPHIPODA						
AMPHIPODA	8.200	9.400	5.400	6.100	1.300	4.9CC
GAMMARIDAE	.030					
CYPHO. CHALLENGERI	1.900	1.700	1.600	2.900	.300	.4CC
SCINIDAE	.100	.100	.010			
PARATHEM. LIBELLULA	.040	.020	.100			
PARATHEM. JAPONICA	.100	.100	.700	.700	.600	.30C
PRIMNO SPP.	.080	.600	.600	.400	.400	.1CC
MYSIDACEA						
MYSIDACEA	.100	.200	.050			
EUPHAUSIACEA						
EUPHAUSIACEA	.050	.200	2.400	.300	2.300	.6CC
EUPHAUSID JUVENILES			2.100	.100	2.000	.600
EUPHAUSIA PACIFICA			.040			
THYSANOESSA INERMIS				.100		
THYSANOESSA LONGIPES	.050	.200	.200		.300	
THYSANOES. SPINIFERA			.050			
DECAPODA						
DECAPODA	.030	.100	.010			
PASIPHAEA PACIFICA			.010			
LARVACEA						
LARVACEA						4C.CCC
TELEOSTEI						
FISH LARVAE	.030	.020	.010	.100		.1CC

PART II. KACHEMAK BAY, STATION 6, APRIL - AUGUST 1976

CRUISE CI7601 LAT 59-36 N GMT DATE 04/08/76
STATION A0006 LONG 151 19 W GMT HOUR 2237
DEPTH 00077 M ZONE +10

VERTICAL HAULS

	(72- 49M) NUM/CU.M	(50- 24M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII	6.700	39.100	20.000
CALANUS GLACIALIS A	3.100		
CALANUS MARSHALLAE A		.100	.600
EUCALANUS JUVENILES		12.400	2.900
MICROCALANUS SPP. A	6.000		
MICROCALANUS SPP. J	14.100	1.400	
PSEUDOCALANUS SPP. A	61.000	37.100	34.300
PSEUDOCALANUS SPP. J	8.900	17.100	11.400
METRIDIA LUCENS A	1.500		
ACARTIA LONGIREMIS	2.200	31.600	117.100
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	14.900	43.300	5.700
CHAETOGNATHA			
SAGITTA ELEGANS	9.400	2.700	.400
POLYCHAETA			
POLYCHAETA	.300		.300
HYDROZOA			
HYDROZOA		.100	
OSTRACODA			
OSTRACODA	.100		
THORACICA			
CIRRIPEDE NAUPLII	6.700	120.200	1454.000
ISOPODA			
ISOPODA	.900		
DECAPODA			
DECAPODA	.100		
LARVACEA			
LARVACEA		.100	

CRUISE C17601 LAT 59-36 N GMT DATE 04/09/76
STATION B0006 LONG 151 19 W GMT HOUR 1001
DEPTH 00077 M ZONE +10

VERTICAL HAULS

		(72- 51M) NUM/CU.M	(50- 26M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA				
COPEPODA NAUPLII			32.700	7.100
CALANUS GLACIALIS	A	1.200	.300	.300
CALANUS MARSHALLAE	A	.200		.100
CALANUS MARSHALLAE	J	.200		
MICROCALANUS SPP.	A	8.500		
MICROCALANUS SPP.	J	20.400	4.500	
PSEUDOCALANUS SPP.	A	76.500	43.200	68.600
PSEUDOCALANUS SPP.	J	13.600	8.900	17.100
METRIDIA LUCENS			.100	
METRIDIA LUCENS	A	.200		
ACARTIA LONGIREMIS		6.800	46.100	15.700
COPEPODA CYCLOPOIDA				
OITHONA SIMILIS		62.900	19.300	11.400
CYCLOPINA SP.		6.800		
CHAETOGNATHA				
SAGITTA ELEGANS		5.100	2.400	2.100
HYDROZOA				
HYDROZOA		.200	.100	
GASTROPODA				
GASTROPODA				5.700
THORACICA				
THORACICA				188.600
CIRRIPEDE NAUPLII		34.000	431.500	
EUPHAUSIACEA				
THYSANOESSA LONGIPES		.200	.600	
THYSANOESSA RASCHII				.300
DECAPODA				
DECAPODA				.100

CRUISE C1[illegible]02 LAT 59-36 N GMT DATE 05/07/76
STATION [illegible]0006 LONG 151 18 W GMT HOUR 2101
DEPTH 00080 M ZONE +10

VERTICAL HAULS

	(75- 50M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPOD NAUPLII	30.000	80.000	502.900
CALANUS GLACIALIS A	.100		
CALANUS MARSHALLAE A		3.[illegible]	
EUCALANUS JUVENILES	2.[illegible]0	8.600	[illegible]
MICROCALANUS SPP. A	17.100	[illegible]	
MICROCALANUS SPP. J	20.000	2.900	
PSEUDOCALANUS SPP. A	67.100	60.000	
PSEUDOCALANUS SPP. J	42.900	91.400	22.900
ACARTIA [illegible]	2.900		14.200
ACARTIA [illegible]			225.700
COPEPODA CYCLOPOIDA			
OI[illegible]	12.900	37.100	40.000
CYC[illegible]	1.400		
ONCAEA [illegible]S	12.900	5.700	2.900
ECHINOIDEA			
ECHINODERM LARVAE		234.300	117.100
CHAETOGNATHA			
CHAETOGNATHA	2.400	30.000	[illegible]
POLYCHAETA			
POLYCHAETA	.100	17.100	[illegible]
POLYCHAETA LARVAE			[illegible]
HYDROZOA			
HYDROZOA		11.400	74.[illegible]
GASTROPODA			
GASTROPODA		5.700	8.[illegible]
OSTRACODA			
OSTRACODA			.100
THORACICA			
CIRRIPEDE CYPRIDS	11.400		
CIRRIPEDE NAUPLII		17.100	[illegible]
ISOPODA			
ISOPODA	.700		
AMPHIPODA			
PARATHEMISTO SPP.			[illegible]
EUPHAUSIACEA			
EUPHAUSIACEA	1.000		

(CONTINUED ON NEXT PAGE)

EUPHAUSID ADULTS		.100
EUPHAUSID JUVENILES		1.700
DECAPODA		
DECAPODA	.400	1.700
DECAPODA ZOEAE	.700	6.000
TELEOSTEI		
FISH EGGS	.100	1.200
FISH LARVAE	.100	1.000

CRUISE C17602	LAT 59-36 N	GMT DATE 05/07/76
STATION B0006	LONG 151 18 W	GMT HOUR 2112
	DEPTH 00080 M	ZONE +10

VERTICAL HAULS

	(75- 49M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII	37.100	51.400	1469.000
CALANUS GLACIALIS	.300		
CALANUS GLACIALIS A		.100	
EUCALANUS JUVENILES	5.700	5.700	11.400
MICROCALANUS SPP. A	17.100		
MICROCALANUS SPP. J	22.900	2.900	
PSEUDOCALANUS SPP. A	151.100	57.100	11.400
PSEUDOCALANUS SPP. J	54.300	117.100	74.300
ACARTIA LONGIREMIS A			17.100
ACARTIA JUVENILES			382.900
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	33.000	54.300	
ONCAEA BORIALIS	33.000	9.600	
ECHINOIDEA			
ECHINODERM LARVAE		140.000	171.400
CHAETOGNATHA			
CHAETOGNATHA	5.300	4.900	12.000
POLYCHAETA			
POLYCHAETA		.100	166.300
POLYCHAETA LARVAE			137.100
HYDROZOA			
HYDROZOA		35.700	302.900
GASTROPODA			
GASTROPODA		5.700	17.100
THORACICA			
CIRRIPEDE CYPRIDS	5.700		
CIRRIPEDE NAUPLII		28.600	531.400
ISOPODA			
ISOPODA	.300		
AMPHIPODA			
PARATHEMISTO SPP.			.300
MYSIDACEA			
MYSIDACEA	.100		
EUPHAUSIACEA			
EUPHAUSIACEA	.600		

(CONTINUED ON NEXT PAGE)

EUPHAUSID JUVENILES			7.600
DECAPODA			
DECAPODA	.100		
DECAPODA ZOEAE		2.900	5.300
TELEOSTEI			
FISH EGGS	.000	1.000	1.300
FISH LARVAE			1.700

CRUISE C17603 LAT 59-36 N GMT DATE 05/27/76
STATION A0006 LONG 151 19 W GMT HOUR 0859
DEPTH 00078 M ZONE +10

VERTICAL HAULS

	(73- 49M) NUM/CU.M	(50- 24M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII	202.900	214.300	860.600
CALANUS GLACIALIS A	1.900		
CALANUS JUVENILES	28.600	20.000	42.400
EUCALANUS JUVENILES	2.900		
MICROCALANUS SPP. A	11.400		
MICROCALANUS SPP. J	14.300		
PSEUDOCALANUS SPP. A	120.000	62.900	62.900
PSEUDOCALANUS SPP. J	125.700	188.600	248.500
AETIDEUS JUVENILES			12.100
METRIDIA LUCENS J		2.900	
ACARTIA LONGIREMIS A			30.300
ACARTIA TUMIDA J		2.900	
ACARTIA JUVENILES			66.700
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	11.400	42.900	131.400
CYCLOPINA SP.	14.300		
ONCAEA BORIALIS	45.700	5.700	
ECHINOIDEA			
ECHINODERM LARVAE	8.600	17.100	224.200
CHAETOGNATHA			
CHAETOGNATHA	5.000	7.300	.900
POLYCHAETA			
POLYCHAETA	154.300		
POLYCHAETA JUVENILES		92.900	715.000
POLYCHAETA LARVAE	162.900	125.700	2194.000
HYDROZOA			
HYDROZOA		11.400	127.400
MOLLUSCA			
MOLLUSCA LARVAE			84.800
CLADOCERA			
PODON LEUCKARTI			6.100
THORACICA			
CIRRIPEDE CYPRIDS	8.600	11.400	12.100
CIRRIPEDE NAUPLII	20.000	17.100	187.900
ISOPODA			
ISOPODA	8.600		

(CONTINUED ON NEXT PAGE)

AMPHIPODA			
AMPHIPODA	.100		
EUPHAUSIACEA			
EUPHAUSIACEA		.600	
EUPHAUSID ADULTS			.200
EUPHAUSID JUVENILES			13.300
DECAPODA			
DECAPODA	.100		
DECAPODA LARVAE			3.600
LARVACEA			
LARVACEA	11.400	22.900	48.500

CRUISE CI7603 LAT 59-36 N GMT DATE 05/26/76
STATION 80006 LONG 151 19 W GMT HOUR 0907
DEPTH 00078 M ZONE +10

VERTICAL HAULS

		(73- 49M) NUM/CU.M	(50- 24M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA				
COPEPODA NAUPLII		277.100	454.800	1029.000
CALANUS GLACIALIS	A	1.400		
CALANUS JUVENILES		14.300	32.900	42.900
EU. BUNGII BUNGII	J	14.300		
MICROCALANUS SPP.	A	8.600		
MICROCALANUS SPP.	J	8.600		
PSEUDOCALANUS SPP.	A	182.900	95.900	57.100
PSEUDOCALANUS SPP.	J	125.700	194.500	371.400
METRIDIA LUCENS	A	8.600		
METRIDIA LUCENS	J		2.700	
ACARTIA LONGIREMIS		2.900		
ACARTIA LONGIREMIS	A			28.600
ACARTIA TUMIDA	J	5.700		
ACARTIA JUVENILES				171.400
COPEPODA CYCLOPOIDA				
OITHONA SIMILIS		17.900	52.100	128.600
CYCLOPINA SP.		25.700		
ONCAEA BORIALIS		40.000		
COPEP. HARPACTICOIDA				
TEGASTES SP.		6.000		
ECHINOIDEA				
ECHINODERM LARVAE		5.700	43.800	314.300
CHAETOGNATHA				
CHAETOGNATHA		4.700	3.900	1.400
POLYCHAETA				
POLYCHAETA JUVENILES		180.000	134.200	700.000
POLYCHAETA LARVAE		388.600	197.300	2414.000
HYDROZOA				
HYDROZOA			27.400	171.400
MOLLUSCA				
MOLLUSCA LARVAE				142.900
GASTROPODA				
GASTROPODA			2.700	42.900
THORACICA				
CIRRIPEDE CYPRIDS		2.900	5.500	14.300
CIRRIPEDE NAUPLII		25.700	24.700	228.600

(CONTINUED ON NEXT PAGE)

ISOPODA			
ISOPODA	11.400	2.700	
AMPHIPODA			
AMPHIPODA	.100		
EUPHAUSIACEA			
EUPHAUSIACEA		.300	.300
EUPHAUSID ADULTS	.100		
EUPHAUSID JUVENILES	.100		1.400
DECAPODA			
DECAPODA LARVAE			5.000
LARVACEA			
LARVACEA		32.900	128.600
TELEOSTEI			
FISH LARVAE			.400

CRUISE C17603 LAT 59-36 N GMT DATE 05/26/76
STATION C0006 LONG 151 19 W GMT HOUR 2106
DEPTH 00075 M ZONE +10

VERTICAL HAULS

	(70- 50M) NUM/CU.M	(50- 24M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII	492.900	361.600	617.100
CALANUS CRISTATUS J		.100	
CALANUS GLACIALIS J		5.500	5.700
CALANUS JUVENILES	50.000	21.900	22.900
MICROCALANUS SPP. J	7.100	11.000	
PSEUDOCALANUS SPP. A	200.000	169.900	40.000
PSEUDOCALANUS SPP. J		279.500	222.900
AETIDEUS JUVENILES			5.700
ACARTIA LONGIREMIS		5.500	
ACARTIA LONGIREMIS A			34.300
ACARTIA JUVENILES			97.100
TORTA. DISCAUDATUS A			5.700
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	21.400	27.400	40.000
CYCLOPINA SP.	7.100		
ONCAEA BORIALIS	35.700	54.800	5.700
COPEP. MONSTRILLOIDA			
MONSTRILLIDAE			.100
CHAETOGNATHA			
CHAETOGNATHA	3.400	1.800	.900
POLYCHAETA			
POLYCHAETA JUVENILES	100.000	126.000	268.600
POLYCHAETA LARVAE	78.600	60.300	588.600
HYDROZOA			
HYDROZOA	.200		
GASTROPODA			
GASTROPODA		5.500	11.400
OSTRACODA			
OSTRACODA	.200		
THORACICA			
CIRRIPEDE CYPRIDS	7.100		5.700
CIRRIPEDE NAUPLII	28.600	16.400	177.100
CUMACEA			
CUMACEA	.200		
EUPHAUSIACEA			
EUPHAUSIACEA	.200	1.000	

(CONTINUED ON NEXT PAGE)

EUPHAUSID JUVENILES			18.400
DECAPODA			
DECAPODA ZOEAE			1.400
LARVACEA			
LARVACEA	7.100	5.500	28.600

CRUISE C17604 LAT 59-36 N GMT DATE 07/11/76
STATION AC006 LONG 151 19 W GMT HOUR C915
DEPTH CC071 M ZONE +1C

VERTICAL HAULS

		(66- 50M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA				
COPEPODA NAUPLII				28.600
CALANUS GLACIALIS	J	4.400	2.900	100.000
CALANUS MARSHALLAE	A			14.300
CALANUS MARSHALLAE	J	4.400	5.700	228.600
MICROCALANUS SPP.	A	8.900	2.900	
MICROCALANUS SPP.	J	13.300		
PSEUDOCALANUS SPP.	A	275.600	420.000	557.000
PSEUDOCALANUS SPP.	J	222.200	334.300	1343.000
CENTR. ABDOMINALIS	A			14.300
CENTR. ABDOMINALIS	J			14.300
ACARTIA LONGIREMIS	A	13.300	8.600	800.000
ACARTIA LONGIREMIS	J	97.800	105.700	1500.000
ACARTIA LONGIREMIS	F			271.400
ACARTIA LONGIREMIS	M			528.600
COPEPODA CYCLOPOIDA				
OITHONA SIMILIS		62.200	94.300	171.400
ONCAEA BOREALIS		8.900	14.300	
COPEP. HARPACTICOIDA				
TEGASTES SP.			11.400	
ECHINOIDEA				
ECHINODERM LARVAE				42.900
CHAETOGNATHA				
CHAETOGNATHA		10.400	11.000	57.100
POLYCHAETA				
POLYCHAETA		9.300	.300	
POLYCHAETA LARVAE		4.400		
HYDROZOA				
HYDROZOA			.100	57.600
MOLLUSCA				
MOLLUSCA LARVAE				300.000
GASTROPODA				
GASTROPODA			2.900	
CLADOCERA				
PODON LEUCKARTI		17.800		128.600
THORACICA				
CIRRIPEDE CYPRIDS		4.400	11.400	14.300

(CONTINUED ON NEXT PAGE)

CIRRIPEDE NAUPLII	4.400	28.600	185.700
ISOPODA			
ISOPODA	.400	3.100	
AMPHIPODA			
AMPHIPODA	.200	.400	
EUPHAUSIACEA			
EUPHAUSID ADULTS	.200		.100
EUPHAUSID JUVENILES	.900	.100	65.700
DECAPODA			
DECAPODA		.600	.300
DECAPODA ZOEAE	4.400	3.300	
TELEOSTEI			
FISH EGGS	.200		

CRUISE C17604 LAT 59-36 N GMT DATE C7/11/76
STATION 60006 LONG 151 19 W GMT HOUR 2130
DEPTH CCC71 M ZONE +1C

VERTICAL HAULS

	(66- 50M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII		8.600	28.600
CALANUS GLACIALIS J		34.300	
CALANUS MARSHALLAE A	.200		
CALANUS MARSHALLAE J	22.200	77.100	28.600
CALANUS MARSHALLAE F	.200		
MICROCALANUS SPP. A	8.900	12.900	
MICROCALANUS SPP. J	13.300	8.600	
PSEUDOCALANUS SPP. A	511.100	334.300	514.000
PSEUDOCALANUS SPP. J	262.200	381.400	3171.000
METRIDIA LUCENS	8.900	4.300	
CENTROP. ABDOMINALIS			57.100
CENTR. ABDOMINALIS J			171.400
ACARTIA LONGIREMIS A	17.800		1400.000
ACARTIA LONGIREMIS J	133.300	156.600	1000.000
ACARTIA LONGIREMIS F	8.900	4.300	429.000
ACARTIA LONGIREMIS M	8.900		971.000
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	40.000	115.700	685.700
ONCAEA BORIALIS	26.700	25.700	28.600
COPEP. HARPACTICOIDA			
TISBE SP.	4.400		
ECHINOIDEA			
ECHINODERM LARVAE		8.600	85.700
CHAETOGNATHA			
CHAETOGNATHA	11.300	30.600	171.400
POLYCHAETA			
POLYCHAETA	17.800		
POLYCHAETA LARVAE	8.900	8.600	28.600
HYDROZOA			
HYDROZOA	.200		28.900
MOLLUSCA			
MOLLUSCA LARVAE			542.900
GASTROPODA			
GASTROPODA			28.600
CLADOCERA			
PODON LEUCKARTI			885.700

(CONTINUED ON NEXT PAGE)

THORACICA			
CIRRIPEDE CYPRIDS			28.600
CIRRIPEDE NAUPLII		8.600	485.700
ISOPODA			
ISOPODA	.400	.100	
EUPHAUSIACEA			
EUPHAUSID JUVENILES	2.900	55.700	7.400
DECAPODA			
DECAPODA		.600	
DECAPODA ZOEAE	.900	4.300	1.700
LARVACEA			
LARVACEA			.300
TELEOSTEI			
FISH LARVAE			.100

CRUISE C17605 LAT 59-36 N GMT DATE 08/26/76
STATION A0006 LONG 151 19 W GMT HOUR 2225
DEPTH 00073 M ZONE +10

VERTICAL HAULS

	(68- 0M) NUM/CU.M	(50- 0M) NUM/CU.M	(26- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII	101.600	102.000	118.800
PSEUDOCALANUS SPP. A	386.200	153.100	
PSEUDOCALANUS SPP. J	670.700	306.100	445.500
PSEUDOCALANUS SPP. F	325.200	127.600	59.400
PSEUDOCALANUS SPP. M	61.000	25.500	
CENTR. ABDOMINALIS A	81.300	76.500	118.800
CENTR. ABDOMINALIS J	772.400		
ACARTIA CLAUSII A	731.700	102.000	237.600
ACARTIA LONGIREMIS A	731.700	382.700	178.200
ACARTIA LONGIREMIS F	406.500	178.600	148.500
ACARTIA LONGIREMIS M	325.200	204.100	29.700
ACARTIA JUVENILES	2134.000	1276.000	1396.000
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	508.100	612.200	623.800
ECHINOIDEA			
ECHINOIDEA		178.600	
ECHINODERM LARVAE	365.900		89.100
CHAETOGNATHA			
CHAETOGNATHA	101.600	76.500	29.700
POLYCHAETA			
POLYCHAETA LARVAE	20.300	178.600	
HYDROZOA			
HYDROZOA	20.300		
MOLLUSCA			
MOLLUSCA LARVAE	61.000	127.600	59.400
GASTROPODA			
GASTROPODA	304.900		
CLADOCERA			
PODON LEUCKARTI			59.400
THORACICA			
CIRRIPEDE CYPRIDS	20.300		
CIRRIPEDE NAUPLII	650.400	688.800	950.500
EUPHAUSIACEA			
EUPHAUSID ADULTS	.600	.800	
EUPHAUSID JUVENILES	20.300	.400	

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DECAPODA			
DECAPODA ZOEAE			1.500
LARVACEA			
LARVACEA	589.400	484.700	623.800
TELEOSTEI			
FISH LARVAE	.800	.600	.600

CRUISE CI7605 LAT 59-36 N GMT DATE 08/27/76
STATION B0006 LONG 151 19 W GMT HOUR 1030
DEPTH 00075 M ZONE +10

VERTICAL HAULS

	(70- 0M) NUM/CU.M	(50- 0M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA			
COPEPODA NAUPLII		21.400	
CALANUS GLACIALIS J	20.400	21.400	14.300
CALANUS MARSHALLAE J	20.400	21.400	
PSEUDOCALANUS SPP. J	459.200	428.600	571.400
PSEUDOCALANUS SPP. F	132.700	42.900	171.400
CENTR. ABDOMINALIS A	10.200	64.300	28.600
CENTR. ABDOMINALIS J	81.600	128.600	257.100
ACARTIA CLAUSII A	163.300	450.000	342.900
ACARTIA LONGIREMIS A	112.200	257.100	314.300
ACARTIA LONGIREMIS F	40.800	128.600	57.100
ACARTIA LONGIREMIS M	71.400	128.600	257.100
ACARTIA JUVENILES	734.700	792.900	1371.000
TORTA. DISCAUDATUS A		21.400	
TORTA. DISCAUDATUS J			28.600
COPEPODA CYCLOPOIDA			
OITHONA SIMILIS	234.700	342.900	400.000
ECHINOIDEA			
ECHINODERM LARVAE	102.000	385.700	
CHAETOGNATHA			
CHAETOGNATHA	71.400	42.900	28.600
POLYCHAETA			
POLYCHAETA LARVAE		.400	
HYDROZOA			
HYDROZOA	10.200	.500	
MOLLUSCA			
MOLLUSCA LARVAE	40.800	42.900	28.600
GASTROPODA			
GASTROPODA	102.000	64.300	
THORACICA			
CIRRIPEDE NAUPLII	20.400	64.300	142.900
MYSIDACEA			
MYSIDACEA	.300		.400
EUPHAUSIACEA			
EUPHAUSID ADULTS	.200		
EUPHAUSID JUVENILES	.800	.500	2.000

(CONTINUED ON NEXT PAGE)

DECAPODA			
DECAPODA			.100
DECAPODA ZOEAE	.500	1.900	2.900
LARVACEA			
LARVACEA	275.500	342.900	142.900
TELEOSTEI			
FISH LARVAE	1.400	1.800	2.400

PART III. GULF OF ALASKA, STATION 11, APRIL 1976

CRUISE CI7601 | STATION 00011

LAT 56-23 N | LONG 146 05 W | DEPTH 01520 M

GMT DATE 04/11/76 | GMT HOUR 0955 | ZONE +10

VERTICAL HAULS

	(1500- 470M) NUM/CU.M	(500- 315M) NUM/CU.M	(300- 100M) NUM/CU.M	(100- 48M) NUM/CU.M	(50- 25M) NUM/CU.M	(25- 0M) NUM/CU.M
COPEPODA CALANOIDA						
COPEPODA NAUPLII	1.900	.600			26.600	14.300
CALANUS CRISTATUS A	.010					
CALANUS CRISTATUS J	.100	.200	.020			
CALANUS MARSHALLAE A			.300			
CALANUS MARSHALLAE J			.300			
CALANUS MARSHALLAE F		.300			2.900	1.400
CALANUS PACIFICUS J	.700		.600			
CALANUS PLUMCHRUS J			1.100			
CALANUS PLUMCHRUS F		.300				
EUCAL. BUNGII BUNGII	.800	5.500				
EU. BUNGII BUNGII A			.900			
EUCALANUS JUVENILES			2.300	4.300	34.300	25.700
MICROCALANUS SPP. A	1.700	1.700	11.400	3.000	5.700	
MICROCALANUS SPP. J	.900	18.800	12.000	6.700	11.400	
PSEUDOCALANUS SPP. A						7.100
PSEUDOCALANUS SPP. J			.900			15.700
PSEUDOCALANUS SPP. M			.300			
SPI. BREVICAUDATUS A		.600				
AETIDEUS JUVENILES			1.400			
GAETANUS SIMPLEX A			.300	5.300		
GAETANUS SIMPLEX J				1.000		
GAETANUS JUVENILES			.300			
EUCHAETA SARSI A		.020				
EUCHAETA SARSI J	.300					
EUCHAETA ELONGATA	.090					
EUCHAETA ELONGATA A				.070	.400	
EUCHAETA ELONGATA J			.300	.070		
AMALLOTH. INORNATA A	.090					
LOPHOTH. FRONTALIS A		.020	.020			
LOPHOTH. FRONTALIS J		.040				
RACOV. ANTARCTICUS A			.900			
SCOLECITHRI. MINOR A				1.000		
SCOLECITHRI. MINOR J				.300		
METRID. CURTICAUDA A	.090					
METRIDIA LUCENS	1.300	4.600	5.700		45.700	58.600

(CONTINUED ON NEXT PAGE)

METRIDIA LUCENS A				.700		
METRIDIA LUCENS J				.300		
METRIDIA OKHOTENSIS		.300				
METRIDIA PRINCEPS A		.020				
PLEUROMAMMA ROBUSTA				2.000		
PLEUROMAM. ROBUSTA A			.200			
LUCICUTIA OVALIS A	.300					
DISSETA SCOPULARIS A	.090					
HETERORHA. TANNERI A	.090		.300			
HETERORHA. TANNERI J	.090					
HETEROSTYLI. MAJOR A			.020			
HPSEUDOOXYCEPHALUS A	.090					
CANDACIA COLUMBIAE A	.090			.070		
ACARTIA LONGIREMIS						1.400
COPEPODA CYCLOPOIDA						
OITHONA SIMILIS	.700	.900	40.300	54.300	551.400	106.600
OITHONA SPINIROSTRIS	.300	.900				
ONCAEA BOREALIS	.200	1.700	2.000	.700		
ONCAEA PROLATA	7.100	9.500		.300		
ONCAEA SP.	.800	.300				
ONCAEA SPP. MALES	5.000	3.800	.900			
ONCAEA PARILA	1.200	.600				
PSEUDOLUB. DILATATA	.200					
CHAETOGNATHA						
CHAETOGNATHA	1.600	3.700	11.800	.100	1.100	
EUKROHNIA HAMATA	1.100	2.500	9.400	.070	.600	
EUKROHNIA FOWLERI	.070					
SAGITTA ELEGANS			.100	.070	.600	.900
POLYCHAETA						
POLYCHAETA	.300	.040				
PELAGO. LONGICIRRATA	.030	.020				
TYPHLOSCOLEX MULLERI	.007		.020			
TOMOPTERIS RENATA			.020			
TOM. SEPTENTRIONALIS				.070	.300	
CTENOPHORA						
CTENOPHORA			.300		.400	

(CONTINUED ON NEXT PAGE)

HYDROZOA						
HYDROZOA	.100	1.600	.500	.100	.300	
GASTROPODA						
GASTROPODA			.400			
LIMACINA HELICINA					.400	
CLIONE LIMACINA	.003		.090			.100
CEPHALOPODA						
CEPHALOPODA	.003					
OSTRACODA						
OSTRACODA	1.800	9.100	10.800	1.300	2.900	
ISOPODA						
ISOPODA	.003					
AMPHIPODA						
AMPHIPODA	.030	.040	.400	.500		.100
MYSIDACEA						
MYSIDACEA	.003					
EUPHAUSIACEA						
EUPHAUSIACEA	.050	.040				1.900
EUPHAUSID NAUPLII	.090	.600				
THYSANOESSA INERMIS	.003					.600
THYSANOESSA LONGIPES	.045		.300	.300	.100	.100
THYSANOESSA RASCHII						.300
THYSANOES. SPINIFERA						.900
DECAPODA						
DECAPODA	.020	.020				
LARVACEA						
OIKOPLEURA SP.		.040			3.300	.700
TELEOSTEI						
TELEOSTEI	.003					

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FISH EGGS		.020
FISH LARVAE	.020	

ANNUAL REPORT

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

Dr. R. Ted Cooney - Principal Investigator

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

31 March 1977

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I. SUMMARY

Zooplankton and micronekton populations are being studied in a wide variety of habitats in the Bering and southeastern Chukchi seas. The general results of investigations conducted at the edge of the seasonal ice pack and in the coastal region between the Yukon River and Point Hope are presented.

In the southeast Bering Sea an oceanic assemblage is present along the shelf break during most seasons and extends over the shelf as the ice edge moves northward in the spring. The influence of the ice is seemingly related to the underlying cold, relatively low salinity water mass which excludes all but a few euryhaline and eurythermal species.

During the summer the coastal zone from Bristol Bay to Point Hope is characterized by a neritic community of relatively low diversity but continuous species composition. High standing stocks of two cladocerans and a neritic copepod were commonly observed.

Development of a simulation model to handle these data would be most useful. This formulation (a hypothesis) would provide a way of testing component relationships and objectively ordering numerous variables in terms of their ecological significance.

II. INTRODUCTION

This report details some of the initial results of studies on the unobtrusive pelagic fauna occurring in the Bering and Chukchi Seas. These organisms are recognized as important components of pelagic food webs, supporting unusually high standing stocks of upper level consumers, many of which are commercially valuable on the world market.

The problem of evaluating the potential effects of offshore petroleum development on this portion of the marine system is related to a scarcity of documented information about the responses of the zooplankton and micronekton communities to stresses likely to be imposed by industry. Even in the worst disasters, such as the Santa Barbara blowout of 1969, immediate reconnaissance studies in the field have usually failed to show changes in the distribution or abundance of micro-consumer assemblages (Smith and Lasker, 1969).

This should not be taken as evidence that massive accidental or chronic low level introductions to the system are not detrimental, but rather that our ability to detect short term changes and predict long term effects is inadequate. Laboratory experiments have demonstrated the bio-toxicity of many petroleum components. The burden of relevancy regarding the application of these findings to natural systems seemingly rests with hypotheses (models) which describe in detail the dependence among organisms and the sequence of external events which define seasonal limitations on interrelated biological processes. As a basis for constructing such a hypothesis (a model), the following specific objectives have been pursued during the past year:

1. Determine seasonal density distributions and environmental requirements of principal species of zooplankton, micronekton, and ichthyoplankton.

2. Determine the relationships of zooplankton and micronekton populations 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.

To accomplish these objectives a field research program was developed to study the distribution and abundance of unobtrusive pelagic fauna over the shelf of the southeast Bering Sea, in the nearshore zones of Norton Sound and Kotzebue Sound, offshore at specific locations in the Chukchi and north Bering Seas, and adjacent to the edge of the seasonal ice pack in these regions.

The significance of the zooplankton and micronekton community cannot be ignored. It includes annual representatives (early life history stages) of many of the animal populations in the Bering and Chukchi Seas. Species at higher trophic levels, particularly commercial fin-fishes, are dependent on the plankton community for their food supply following hatching of their pelagic eggs. Survival rates during the critical period when larvae begin to feed largely determine the relative success of year-classes and future recruitments into the commercial fisheries. Thus, the lower levels of the pelagic marine community represent a particularly crucial component of the Alaskan shelf ecosystem.

III. CURRENT STATE OF KNOWLEDGE

A cursory review of the understanding of the zooplankton and micronekton populations of the Bering Sea was presented as part of the 1976 annual report (see Appendix I). This review stressed general distributional patterns of several common species for which late spring, summer, and early fall data were available for a number of years.

Some aspects of the vertical distribution of pelagic copepods are reported for species in the northern North Pacific Ocean and Bering Sea by Minoda (1971) as part of several long-term studies conducted by Hokkaido University and the Fisheries Agency of Japan since the summer of 1953. Because copepods dominate the zooplankton community in these regions, an understanding of their ecological role in the system is probably very important. Of particular interest are the distribution patterns and behavior of species which: (1) may be restricted to the surface waters, (2) may migrate dielly from deep to shallow water, or (3) may be only temporary residents of the near surface community in the early spring and summer, after which they migrate to depth for overwintering. Representatives of these three major types occur in the Bering Sea.

Wing (1974) describes the kinds and abundance of zooplankton collected in the eastern Chukchi Sea in the fall of 1970. This information is expected to complement similar data collected from the NOAA vessel *Discoverer* this past summer in the area surveyed between the mouth of the Yukon River and Point Hope.

The present OCS effort in the Bering Sea has now reached a stage where interactions between those studying various trophic levels or components would be fruitful. Our field research this year at the edge of the seasonal ice pack will emphasize on site analyses of food dependencies for sea birds, marine mammals, and fishes which utilize zooplankton and micronekton. Bedard (1968) has already demonstrated the importance of the unobtrusive fauna in the diet of sea birds feeding in the northern Bering Sea. Three species of auklets were shown to depend heavily on macrozooplankton prior to, during, and following chick rearing on St. Lawrence Island. Thus the breeding season of these pelagic feeders appears to be closely correlated with the appearance of appropriate food items in the animal plankton and micronekton communities offshore.

IV. STUDY AREA

Zooplankton and micronekton communities are being studied seasonally in the southeast Bering Sea including Bristol Bay north to Nunivak Island, and west to the open ocean adjacent to the Pribilof Islands. Norton Sound and the nearshore southeastern Chukchi Sea from Bering Strait through Kotzebue Sound to Point Hope have also been sampled, but on a less regular schedule. The edge of the seasonal icepack in the Bering and Chukchi Seas is a major study regime.

V. SOURCES, MATERIALS, AND METHODS

Field collections have been acquired from a variety of NOAA survey vessels using a prescribed set of procedures and gear types. Zooplankton is routinely sampled over the shelf by fishing a 1-m net (0.333 mm Nitex) vertically through the water column from a few meters above the bottom to the surface. The net is retrieved at a rate of about 1 m/sec, then rinsed, and the sample preserved in 10% buffered formalin for processing at the University of Alaska Sorting Center. The vertical tow was adopted because the procedure is simple and can be used with equipment presently aboard most survey vessels. In addition, as most zooplankton communities are highly stratified, this methodology tends to reduce sampling variability associated with vertical patchiness. The method is not particularly well suited for sampling the more active members of the zooplankton assemblages or those which may occur in low abundance (i.e., larval fishes). Since our work was directed at the zooplankton community as a whole rather than specific components (i.e., ichthyoplankton), this approach was considered a reasonable compromise between detail and the availability of samples. At stations seaward of the shelf break, some vertical tows were taken from depths of 500 m to the surface to obtain samples of the deeper water fauna.

Organisms ranging from 10 to 100 mm total length (micronekton) were collected at specific locations using a 2-m Tucker midwater trawl (Tucker, 1951). This net presents a 4 m^2 mouth opening while being towed either horizontally or in a double oblique manner. Animals retained by 1/8-inch knotless nylon netting were removed and preserved (see above) for later identification and enumeration. The depth of most tows was monitored using a mechanical time-depth recorder, and the amount of water filtered determined using a flowmeter mounted in the mouth of the net. Most tows were made at night in the upper 100 m to take advantage of diel migration patterns which tend to concentrate organisms near the surface at this time. This small midwater trawl was towed at 2 to 3 m/sec at most locations.

Occasionally, a 60-cm standard MARMAP bongo net was fished to sample the rarer animal plankters. Nets of mesh size 0.303 mm and 0.505 mm were used, and a flowmeter was attached to measure volumes filtered. Tows were generally fished in a double oblique manner to a depth of 100 m at a speed of 1 to 2 m/sec. These procedures permitted sample acquisition at most times and locations without restrictions from weather or ship capabilities.

A unique sampling design was developed for each of the three major components of the study: (1) distribution and abundance measured over the shelf in the southeast Bering Sea, (2) distribution and abundance related to the edge of the seasonal ice pack, and (3) distribution and abundance in the nearshore areas between the Yukon River and Point Hope in the eastern Chukchi Sea.

As previously reported (1976 annual report) the southeast shelf was initially divided into eight statistical sub-regimes. A first order evaluation of data from the field now indicates that four major regimes (a pooling of sub-regimes) will be considered in the final statistical analyses (ANOVA and numerical clustering). These sub-units are: an open ocean regime (depths greater than 2000 m); a slope regime (depths between 2000 and 200 m); an outer shelf regime (depths between 200 and 50 m); and an inner shelf or coastal region (depths less than 50 m). These areas have been visited during several distinct seasons of the year to measure changes in standing stocks and species composition which accompany the formation and subsequent breakup of sea ice. The sampling design provides estimates of variance associated with sampling a station, sampling a sub-area, and sampling sub-areas within seasons.

The strategy employed in the ice-edge zone was similar. However, instead of considering discrete spatial provinces, questions were directed toward descriptions of the zooplankton and micronekton community as it might change along the east-west extent of the pack ice, and also along transects normal to the ice. In the latter case, collections were made as the vessel moved into the ice from open water. Vertical plankton tows, midwater trawls and some surface tows with a small neuston net were routinely taken. A sufficient number of replicate samples was taken to estimate sampling error and the variability associated with occupying a station for 24 hours.

The study of the nearshore zooplankton and micronekton communities from Norton Sound north to Point Hope was conducted in two ways: (1) a small boat (skiff) operation based at Unalakleet in cooperation with the Alaska Department of Fish and Game, and (2) a nearshore cruise aboard the NOAA vessel *Discoverer* (3-17 August 1976). The small boat oceanography included collections of zooplankton and micronekton taken with a 0.5-m net (0.333 mm Nitex) fished in a horizontal or double oblique manner at locations no more than 1 mile off the beach. Samples were taken in the area between Tolstoi Point and Cape Denbigh from June 23 to September 10, 1976. In addition to plankton, samples were taken for temperature, salinity, chlorophyll *a*, and nutrients (see Appendix II). Again, there was sufficient replication to describe variance in the data. Aboard the *Discoverer*, the collecting strategies were the same as described for the ice edge and shelf studies. It was necessary at some of the shallow stations to combine two or more vertical tows to obtain a sample of sufficient size.

Zooplankton and micronekton collections are processed quantitatively and qualitatively at the University of Alaska Marine Sorting Center. Most individual catches contain many more organisms than can be analysed directly, so the whole sample is initially screened for the large and rarer animals, and then specimens are sorted from smaller subsamples and enumerated. A fraction (usually one-fourth) of the original sample is archived for future reference. This technique provides estimates of the numbers of animals per sample for the numerically dominant taxa, and direct counts of the larger rarer organisms. A sufficient number of replicate subsamples is available to describe the variability associated with the standardized procedure.

A high-frequency (100 kHz) recording echo sounder is being evaluated for remote censusing of certain larger zooplankton and micronekton organisms. The system is sensitive to particles in the size range 5 mm and larger, and has been used experimentally to locate and census euphausiids in the upper 100 m (Cooney, 1971). The quantitative acoustic equipment was used at specific locations in the ice edge zone in conjunction with direct sampling by nets and trawls.

Organic matter pathway information and the rates at which phytoplankton is utilized by pelagic microconsumers have been examined at sea using common grazing species cultured for specific periods of time. Plant cells taken in water bottle samples were grazed by various zooplankters in experimental containers cooled by surface water. A Coulter counter was employed to monitor changes with time in the size composition of plant cells being removed by the grazers (see Dr. Alexander's annual report for a preliminary evaluation of this grazing rate study).

As part of a developing ecosystem study of the ice edge zone, the major components of a computer simulation model have been specified for the Bering Sea and some initial analyses conducted to identify the more sensitive components at the primary producer level. This work is being supervised by Dr. K. Green and Dr. Charles Geist.

VI. RESULTS

Field efforts this past year (1976-1977) have been directed toward completing a reconnaissance survey of zooplankton and micronekton over the shelf of the southeast Bering Sea and examining this same assemblage as it occurs in the nearshore and coastal areas from Bristol Bay to Point Hope. In addition, a more complex study of the unobtrusive fauna found adjacent to and in the edge zone of the seasonal icepack was initiated. This latter investigation represents the first step, beginning with first and second order pelagic consumers, in a developing coordinated ecosystem study of seasonal ice-related biological phenomena.

The overall results of the reconnaissance survey of the southeast Bering Sea and nearshore areas to the north will be submitted as an end-of-contract final report, 30 September 1977. However, some of the general descriptive information can now be reported.

In August 1976 the NOAA vessel *Discoverer* occupied 116 stations between the Yukon River and Point Hope (Fig. 1). A comparison of the species composition at seven selected sites, ranging from nearshore to midshelf, reveals a somewhat impoverished community with considerable continuity of dominant species (Table I). The most diverse assemblage occurred at Station 51 in the Bering Strait (also the deepest location). Using this grouping as a basis for comparison, the percentage of species in common with this relatively deep location ranged from a low of 61 in the far eastern portion of Norton Sound to 88 over the shelf directly south of the strait. The nearshore brackish water community (Stations 25 and 82) was characterized by high numbers of cladocerans, *Evadne* and *Podon*, and the neritic copepod, *Acartia clausi*. Five species (or composite taxa) were common to all areas:

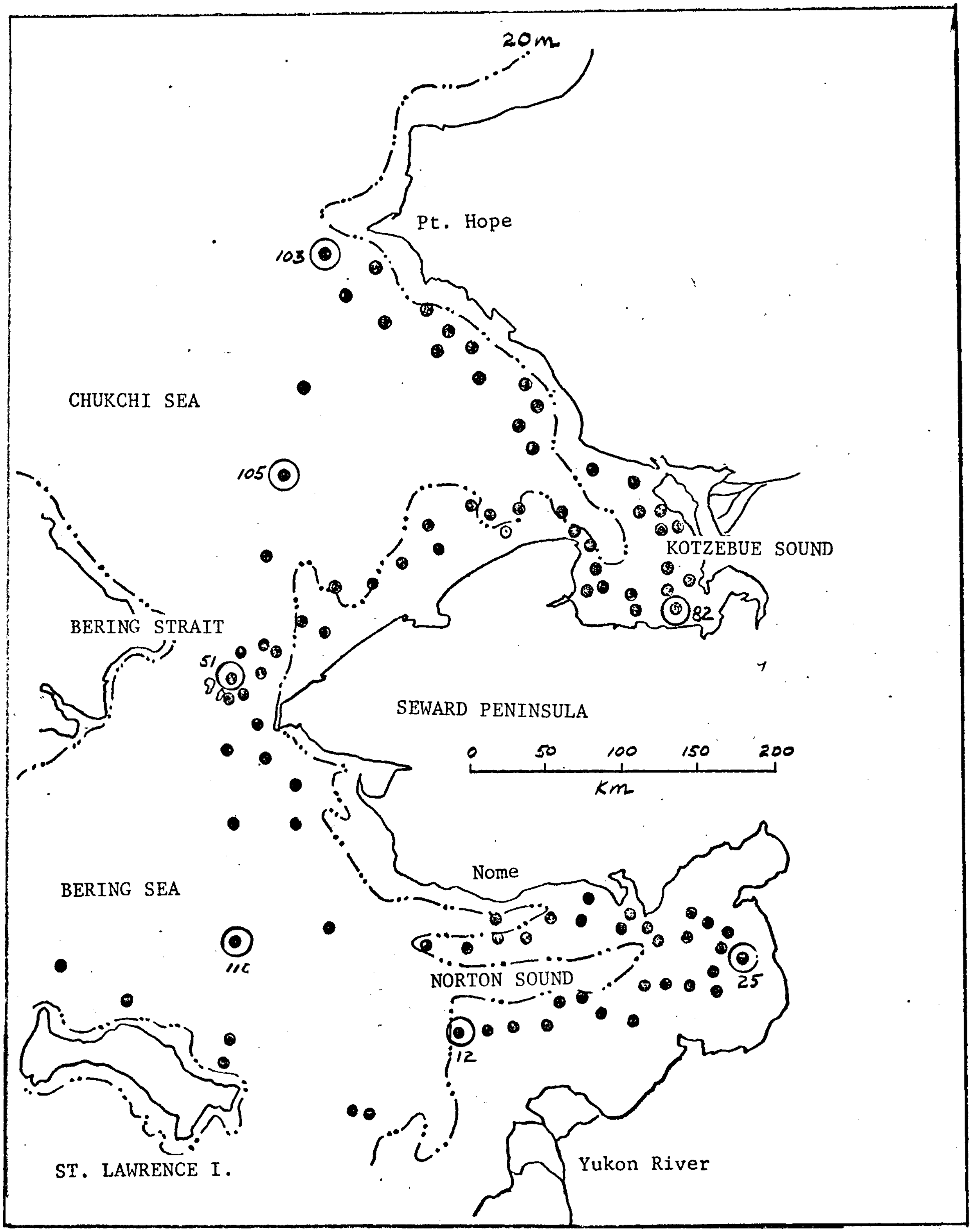

Figure 1. The location of stations occupied for samples of zooplankton and micronekton in the nearshore areas of the northern Bering Sea (Norton Sound) and southeastern Chukchi; August, 1976.

TABLE I

SPECIES COMPOSITION AT SELECTED STATIONS OCCUPIED BETWEEN THE YUKON RIVER AND POINT HOPE, AUGUST, 1976

	STATION*						
TAXON	12	25	51	82	103	105	110
Cnideria							
Hydrozoa							
Perigonimus multicirratus	–	–	–	–	–	–	X
P. yoldia-arcticae	–	–	–	X	–	–	–
Obelia longissima	–	–	–	X	–	–	–
Melicertum campanula	X	–	–	–	–	–	–
Aglantha digitale	X	X	X	X	X	X	X
Actinula	X	–	X	–	–	–	–
Polyp	–	–	–	X	–	–	–
Scyphlozoa							
Cyanea capillata	X	X	X	X	–	–	–
Ctenophora	–	–	–	X	X	–	–
Rhynchocoela							
Nemertine, juvenile & pilidia	–	–	X	X	X	X	X
Annelida							
Polychaeta							
Polynoidae	–	–	–	X	X	–	–
Phyllodocidae	–	–	–	–	X	–	–
Spionidae	–	X	X	X	X	–	–
Magelonidae	–	X	X	–	–	–	–
Capitellidae							
Pectinaria sp.	–	–	X	–	–	–	–
Oweniidae							
Mitraria larva	X	–	–	–	–	–	–
Unidentified larva+	X	X	X	–	X	–	X
Mollusca							
Pelecypoda							
Unidentified juvenile	X	X	X	–	–	–	–
Gastropoda							
Limacina helicina+	–	–	X	–	X	X	X
Clione limacina	–	–	X	–	X	X	X
Unidentified juvenile	–	X	–	–	–	–	–
Crustacea							
Cladocera							
Evadne sp.	X	X	X	X	–	–	–
Podon sp.	X	X	–	X	–	X	–
Copepoda							
Calanus cristatus	–	–	X	–	–	–	–
C. glacialis+	X	X	X	X	X	X	X
C. plumchrus	–	–	X	–	–	X	X

TABLE I

CONTINUED

TAXON	STATION*						
	12	25	51	82	103	105	110
Copepoda (con't)							
C. spp. juvenile	X	–	X	–	–	–	X
Eucalanus bungii bungii	–	–	X	–	X	X	X
Pseudocalanus spp.+	X	X	X	X	X	X	X
Microcalanus sp.	–	–	X	–	–	–	–
Eurytemora herdmani	–	–	–	–	–	X	–
E. pacifica	–	X	–	–	–	–	–
Mertridia lucens	–	–	X	–	–	X	X
Centopages abdominalis	–	X	X	X	–	X	–
Acartia longiremis	X	X	X	X	X	X	X
A. clausi+	–	X	X	X	–	X	–
Tortanus discaudatus	–	X	–	–	–	–	–
Oithona similis	X	–	X	X	–	–	X
Oncaea sp.	–	–	X	–	–	–	–
Copepod nauplius	X	–	–	–	X	–	–
Thoracica							
Barnacle nauplius	–	X	–	–	–	X	–
Barnacle cypris	X	–	X	X	X	X	X
Cumacea							
Diastylis sp.	–	–	X	–	–	–	–
Unidentified	–	–	–	–	–	X	–
Amphipoda							
Protomedia sp.	–	–	–	–	–	X	–
Oedicerotidae							
Bathymedon nanseni	–	–	–	–	–	X	–
Westwoodila coecula	–	–	X	–	–	–	–
Unidentified juvenile	X	–	–	–	–	–	–
Stenothoidae	–	–	–	–	–	–	X
Hyperiidae							
Parathemisto spp., juvenile	–	–	X	–	X	X	–
Euphausiacea							
Larval stages+	–	–	X	–	X	X	X
Decapoda							
Pandalidae	–	–	X	–	X	X	X
Hippolytidae	–	–	–	–	X	X	–
Crangonidae	–	X	–	–	–	–	–
Paguridae	X	X	–	X	–	X	–
Oregoniinae	–	–	X	X	–	X	X
Unidentified anomuran	–	–	X	–	X	X	–
Echinodermata							
Bipinnaria	X	–	–	–	–	–	–
Brachiolaria	–	X	–	–	–	–	–
Echinopluteus	X	–	–	–	–	–	–
Ophiopluteus	X	–	X	–	–	–	X

TABLE I

CONTINUED

TAXON	STATION*						
	12	25	51	82	103	105	110
Chaetognatha							
Sagitta elegans+	X	X	X	X	X	X	X
Eukrohnia sp.	-	-	X	-	-	-	X
Unidentified juvenile	X	-	X	X	X	X	X
Urochordata							
Ascidean larva	-	-	X	-	-	-	-
Oikopleura sp.	-	-	X	-	X	-	-
Fritillaria borealis+	X	-	X	X	X	X	X
Teleostei							
Eleginus gracilis	-	X	-	X	-	-	-
Fish egg	X	X	X	X	X	-	-
Unidentified trochophore	X	-	-	-	-	-	X
Total	26	23	41	25	25	29	24
Taxa in common with Station 51	17	14	-	17	20	21	21
Percent taxa in common with Station 51	65	61	-	68	80	72	88

*Refer to Figure 1 for location.

+Denotes numerically dominant taxa.

the hydrozoan, *Aglantha digitale*; the copepods, *Calanus glacialis, Acartia longiremis*, and *Pseudocalanus* spp.; and the chaetognath, *Sagitta elegans*. These organisms are also members of the dominant zooplankton community found over the southern Bering Sea shelf.

Mr. Lee Neimark examined the unobtrusive fauna very close to shore at 16 stations in Norton Sound between 23 June and 10 September (Fig. 2). A preliminary evaluation of a small portion of the 168 net tows taken during this time indicates few species, with dominance shared between the copepod *Acartia clausi* and the cladoceran *Evadne nordmanni*. Only eight of 20 categories occurred in common with the assemblage measured a few miles seaward at Station 25 (Table II).

To the south, observations were made at the edge of the seasonal ice pack in March and April aboard the NOAA vessel *Surveyor*. Four major locations were examined for species composition and standing stock (Fig. 3).

The most diverse community during the early spring was found in the ice edge zone at location A, northwest of the Pribilof Islands. The groupings at the other locations were less diverse, but contained a very high percentage (> 80) of taxa in common with location A (Table III). The numerically dominant species included *Aglantha digitale*, juvenile *Calanus* spp. (probably mostly *C. plumchrus*), *Pseudocalanus* spp., *Metridia lucens*, *Thysanoessa inermis* and *Sagitta elegans*.

The vertical distributions of temperature and salinity at these locations varied quite dramatically (Fig. 4). Temperatures were generally lower and the water more saline in the upper 50 m at the western stations, with a definite increase in both parameters with depth. Below about 70 m, conditions were relatively constant (locations A and B), with salinities

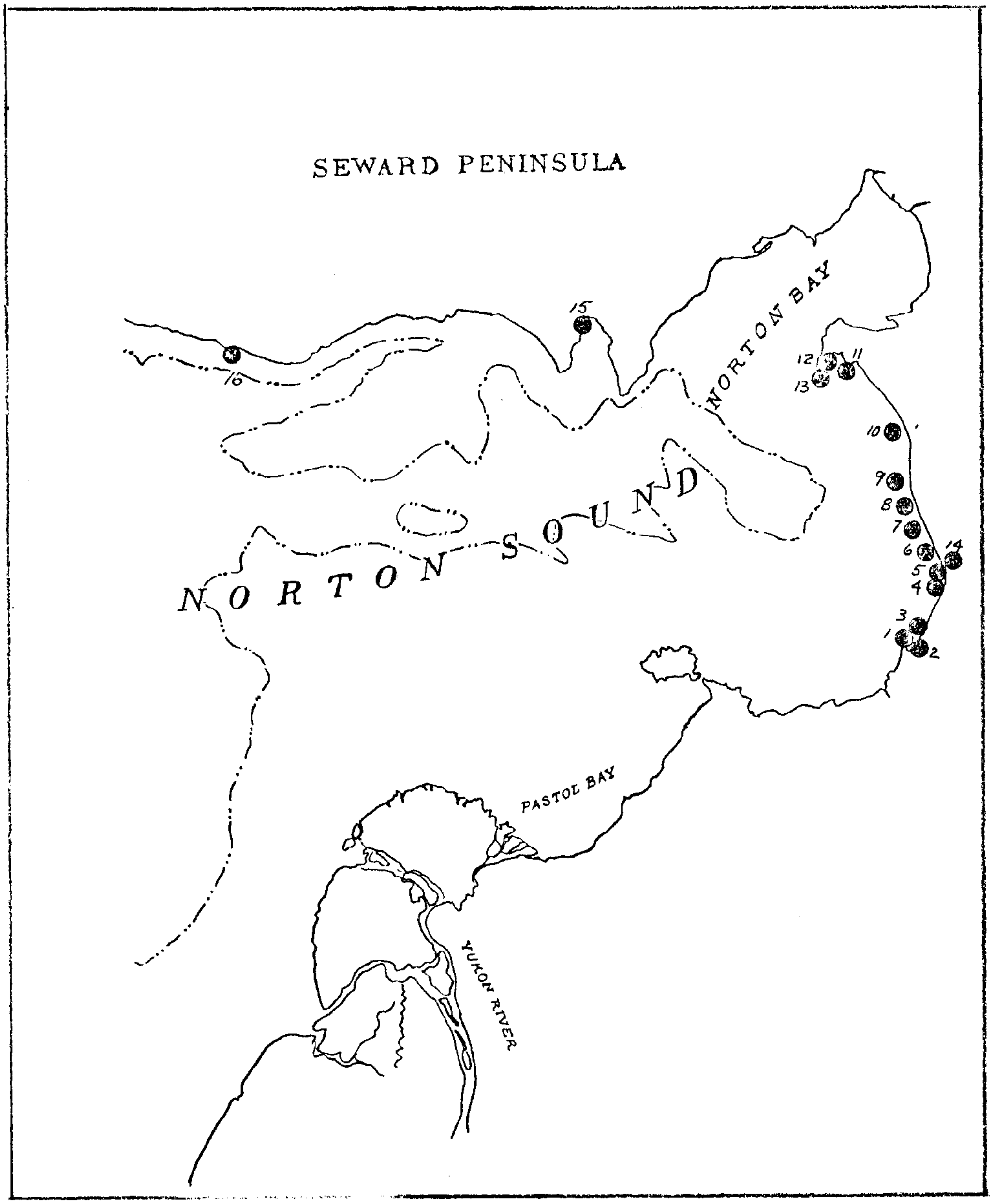

Figure 2. Sampling locations in the nearshore zone of Norton Sound: 1) north side of Tolstoi Point, 0.9 km southeast from tip; 2) 2.0 km south of Poker Creek; 3) Spruce Creek; 4) Jessie Creek; 5) 0.4 km south of Taket Creek; 6) 0.5 km north of the Unalakleet River mouth; 7) 0.7 km south of Powers Creek; 8) 1.0 km south of Egavik Creek mouth; 9) Junction Creek; 10) near Beeson slough 11.7 km south of Shaktoolik air strip; 11) immediately north of Shaktoolik River mouth; 12) 2.0 km west of the Sineak River mouth; 13) south side of Cape Denbigh, 1.5 km northeast from tip; 14) 0.9 km up into the south branch of the Unalakleet River; 15) Galovnin Bay near Golovin village; 16) mouth of the Nome harbor breakwater.

TABLE II

ZOOPLANKTON SORTED FROM SAMPLES TAKEN FROM THE NORTON SOUND NEARSHORE ZONE (NEIMARK, 1977)

TAXON
Hydrozoa
Unidentified medusae
Schyphozoa
Cyanea capillata
Polychaeta
Autolytus sp.
Mollusca
Gastropoda
Limacina helicina
Crustacea
Cladocera
Evadne nordmanni[+]
Podon leukartii
Copepoda
Acartia clausi[+]
Centropages abdominalis
Epilabidocera amphitrites
Eurytemora affinis
Eurytemora pacifica
Pseudocalanus spp.
Thoracica
Barnacle nauplii
Cumacea
Lamprops sp.
Amphipoda
Atylus sp.
Ichyrocerus sp.
Decapoda
Crangonidae (zoea)
Teleostei
Ammodytes hexapterus (juvenile)
Clupea harengus pallasi (larvae)
Platichthys stellatus (larvae)

[+]Indicates the numerically dominant taxa.

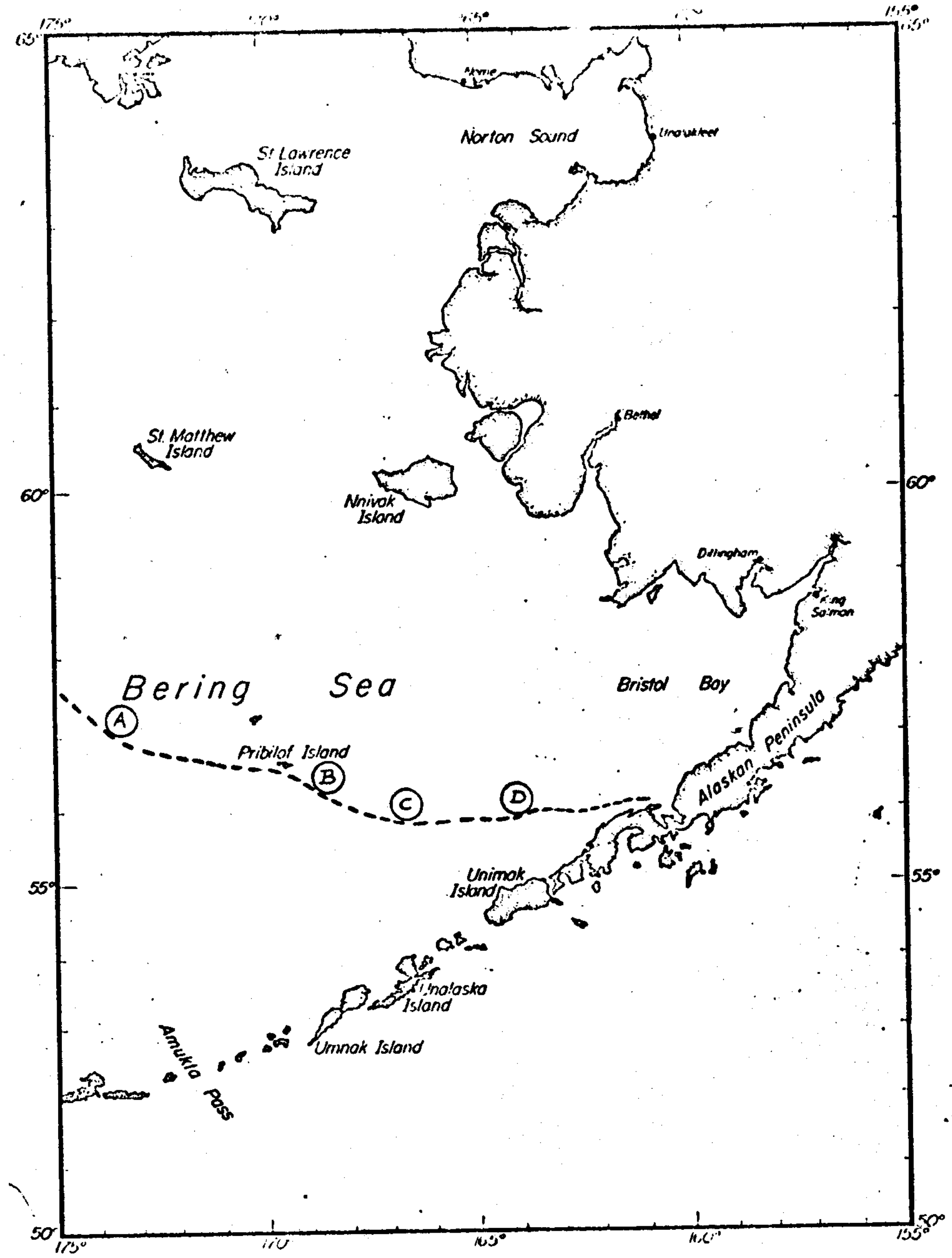

Figure 3. The locations of ice edge sampling stations, March and April, 1976.

TABLE III

SPECIES COMPOSITION AT 4 LOCATIONS ALONG THE EDGE OF THE BERING SEA SEASONAL ICE PACK, MARCH AND APRIL, 1976

TAXON	LOCATION* A	B	C	D
Foraminifera	-	X	-	-
Cnidaria				
Hydrozoa				
Ptychogena lactea	-	-	X	-
Aequorea forskalea	-	-	X	-
Aglantha digitale+	X	X	X	X
Aegina rosea	X	-	-	-
Dimophyes arctica	X	X	X	-
Unidentified hydromedusa	X	X	-	-
Unidentified siphonophore	X	X	-	-
Rhynchocoela				
Nemertine	X	-	-	-
Annelida				
Polychaeta				
Hesperone complanata	-	-	-	X
Typhloscolex mulleri	X	X	X	-
Tomopteris septentrionalis	X	-	-	-
Spionidae larva	X	-	-	-
Laonice cirrata	-	X	-	-
Mollusca				
Gastropoda				
Limacina helicina	X	X	X	-
Clione limacina	X	X	X	X
Unidentified juvenile	X	-	-	-
Cephalopoda				
Unidentified larva	X	-	-	-
Crustacea				
Ostracoda	X	X	-	-
Copepoda				
Calanus cristatus	X	X	-	-
C. marshallae	X	X	X	X
C. plumchrus	X	X	X	-
C. spp., juvenile+	X	X	X	-
Eucalanus bungii bungii	X	X	-	-
Pseudocalanus spp.+	X	X	X	X
Aetideus pacificus	X	-	-	-
Gaidius variabilis	X	-	-	-

TABLE III

CONTINUED

TAXON	LOCATION* A	B	C	D
Copepoda (con't)				
Euchaeta elongata	X	X	-	-
Scolecithricella minor	X	X	X	-
Racovitzanus antarcticus	X	-	-	-
Eurytemora herdmani	X	X	X	X
Metridia lucens+	X	X	X	-
M. okhotensis	X	X	-	-
Pleuromamma scutullata	X	-	-	-
Acartia longiremis	X	X	X	X
Oithona similis	X	X	X	X
O. spinirostris	X	X	-	-
Mysidacea				
Acanthomysis stelleri	-	-	X	X
Cumacea				
Eudorella emarginata	X	-	-	-
Amphipoda				
Hyperia medusarum	-	-	X	-
Hyperoche medusarum	X	-	X	-
Parathemisto pacifica	X	X	X	-
P. libellula	X	X	X	-
P. spp., juvenile	X	-	X	X
Primno macropa	X	X	-	-
Melphidippa sp.	X	-	-	-
Monoculodes intermedius	X	-	-	-
Metopa alderi	-	-	X	-
Westwoodilla coecula	X	-	-	-
Euphausiacea				
Euphausia pacifica	X	-	-	-
Thysanoessa spinifera	X	-	-	-
T. longipes	X	X	-	-
T. inermis+	X	X	X	X
T. raschii	X	-	X	X
Unidentified	-	-	X	-
Larval stages	X	X	-	X
Eggs	X	-	-	-
Decapoda				
Pandalidae zoea	X	X	X	-
Hippolytidae zoea	X	-	-	-
Crangonidae zoea	X	-	X	-
Paguridae zoea	X	-	X	-
Lithodidae				
Paralithodes camtschatica zoea	X	-	-	-
Majiidae				
Oregoniinae zoea	X	-	X	-
Chionoecetes spp. zoea	-	X	-	-

TABLE III

CONTINUED

TAXON	LOCATION* A	B	C	D
Echinodermata				
Ophiuroidea				
Unidentified juvenile	X	-	-	-
Ophiopluteus	X	-	-	-
Chaetognatha				
Sagitta elegans+	X	X	X	X
Eukrohnia sp.	X	X	X	-
Unidentified	X	-	X	X
Urochordata				
Oikopleura sp.	X	X	X	-
Unidentified juvenile	X	X	X	-
Teleostei				
Mallotus villosus	X	-	-	-
Bathylagus pacificus	X	-	-	-
B. stilbius	-	X	-	-
Gadidae	X	-	-	-
Theragra chalcogramma	X	-	-	-
Pleuronectidae				
Reinhardtius hippoglossoides	X	-	-	-
Fish eggs	X	-	X	X
Total	67	37	36	16
Taxa in common with Station A	-	33	30	14
Percent in common with Station A	-	89	83	88

*Refer to Figure 3 for location.

+Denotes numerically dominant taxa.

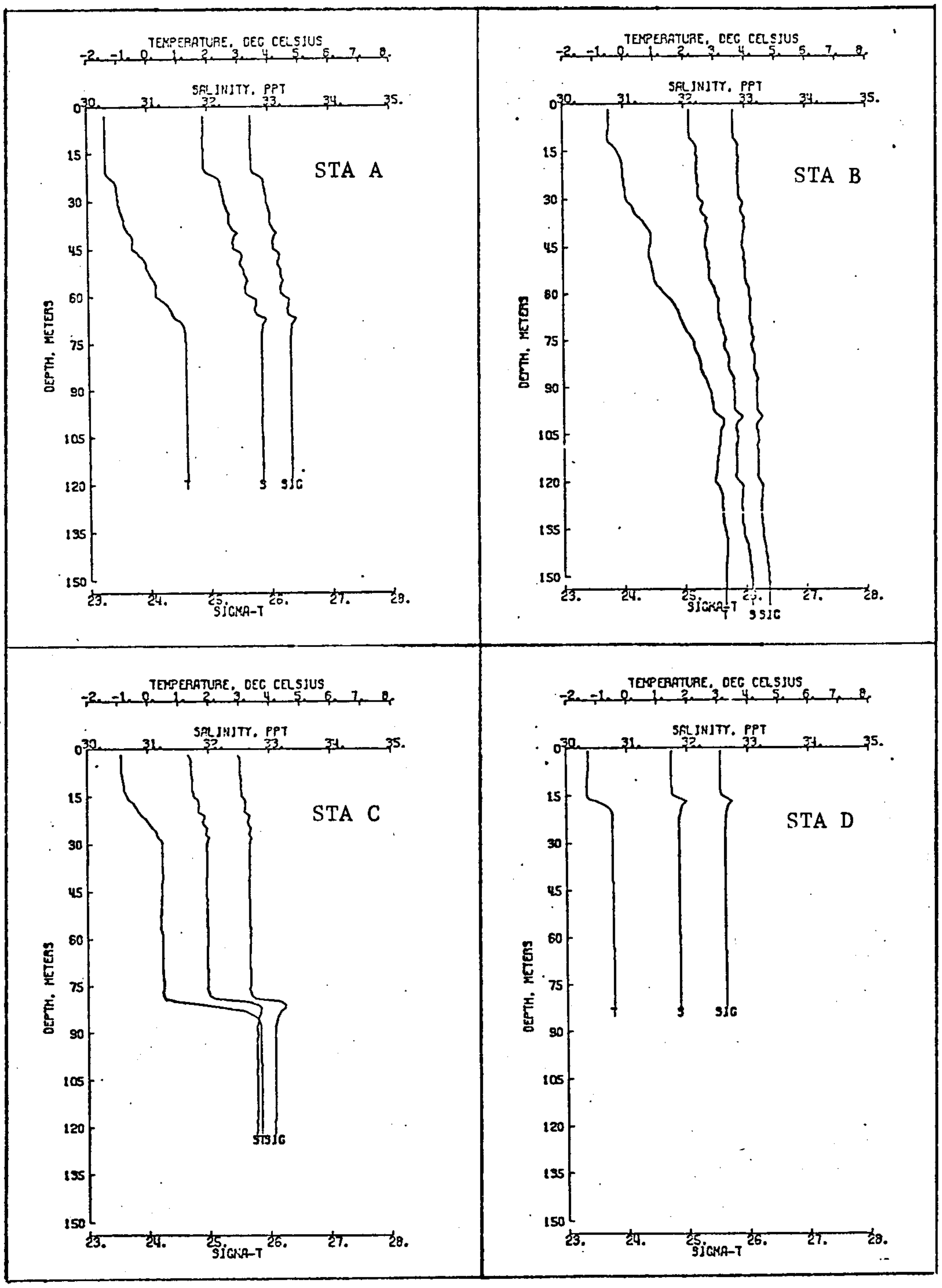

Figure 4. Distribution of temperature, salinity, and density at ice edge locations occupied in March and April, 1976.

at about 32.9°/₀₀ and temperatures ranging between 1.2 and 3.2°C. At location C a very pronounced two-layered system was evident with cold, less saline water overlying a deeper warmer layer. The shallow depth at location D prevented the intrusion of the deep warm layer. At these latter locations the salinity in the upper 70 m was consistently less than 32°/₀₀.

The ice-edge zone seemed to have little effect on the horizontal distributions of the dominant zooplankters (Figs. 5, 6 and 7). Some taxa (*Pseudocalanus* spp., *Calanus plumchrus*, and *Acartia longiremis*) exhibited a slight increase in standing stock just inside the ice edge at location B; while *Calanus* spp. juveniles, *Metridia lucens*, *Sagitta elegans*, and *Parathemisto pacifica* seemed to be less abundant at the same locations. Most of the horizontal variability was similar in magnitude to that observed in sample replicates at each of the individual ice locations over a 24 hour period (ranges indicated in Figs. 5, 6 and 7). The patterns of abundance were inconsistent for the two locations examined.

The distribution of organisms larger than 5-10 mm (total length) was examined acoustically at locations B, C, and D on the first leg of the *Surveyor* cruise (Fig. 8). The profile at location B included dense diffuse scattering layers at 60 and 110 m, with a less dense layer and returns from discrete targets (probably large fishes) found near the bottom (160 to 178 m). A less well-developed diffuse layer was present near the bottom (105 to 115 m) at location C. To the east at location D, a narrow band of dense diffuse scattering was present at about 90 m (approximately 10 m above the bottom). None of the layers demonstrated a distinct vertical migration at twilight. There was insufficient time to pursue the identification of these layers, a task which will be addressed this spring (1977).

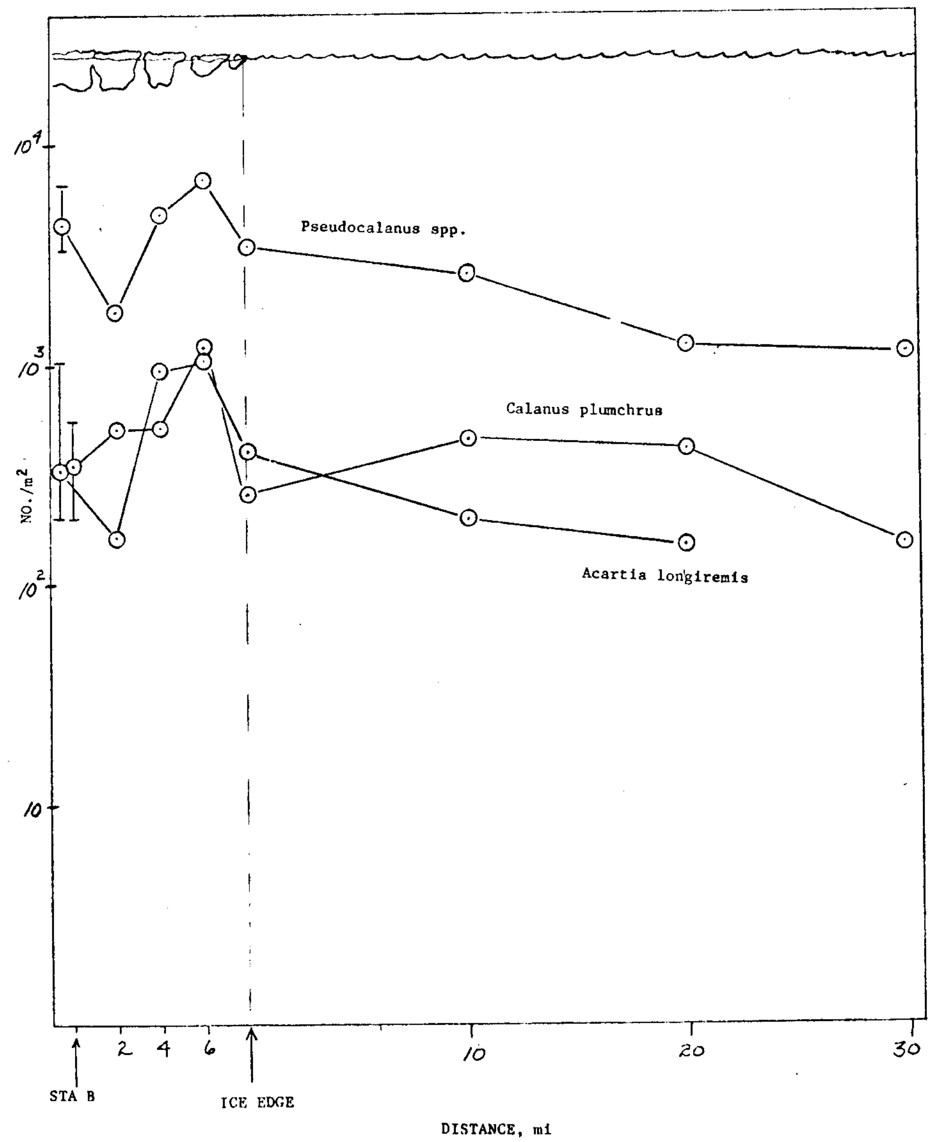

Figure 5. Distribution of selected species along a transect moving from open water into the ice edge zone to location B (see Fig. 3).

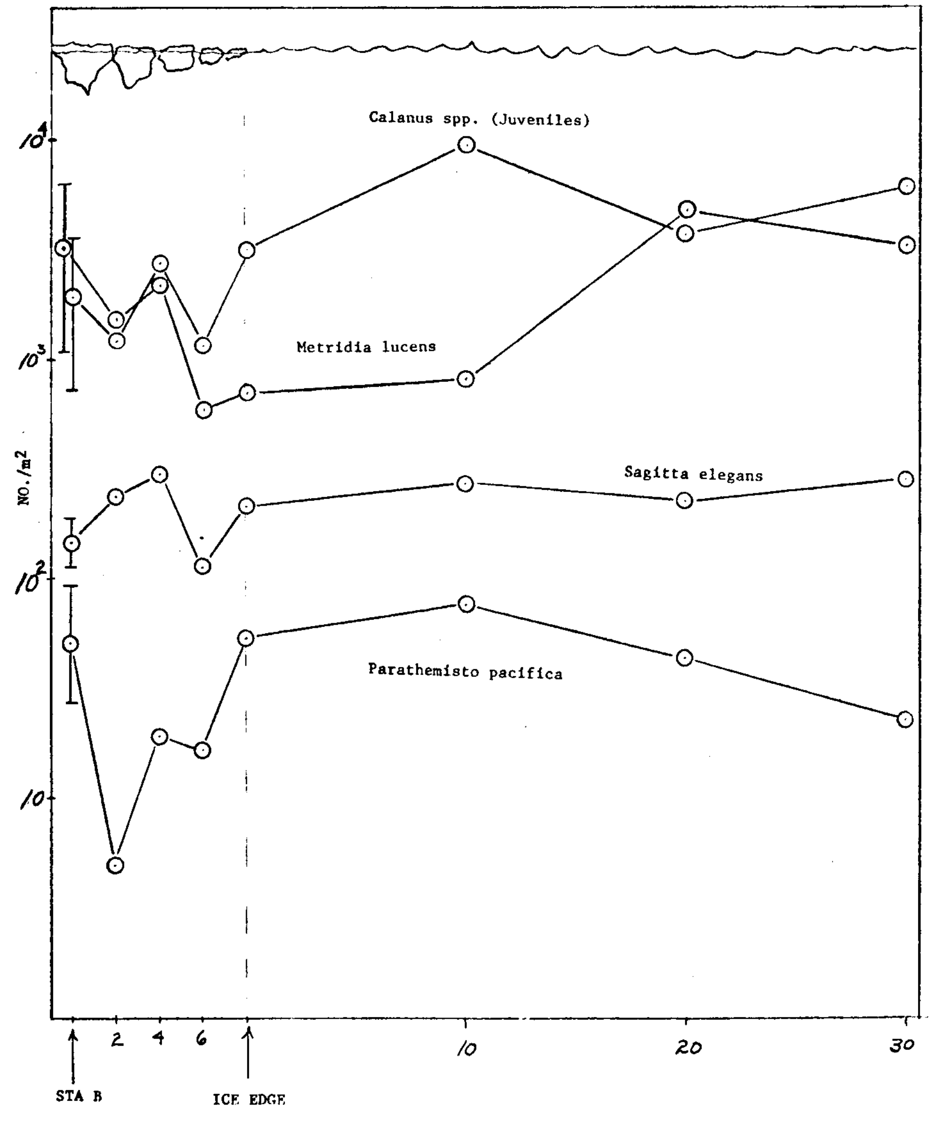

Figure 6. Distribution of selected species along a transect moving from open water into the ice edge zone to location B (see Fig. 3).

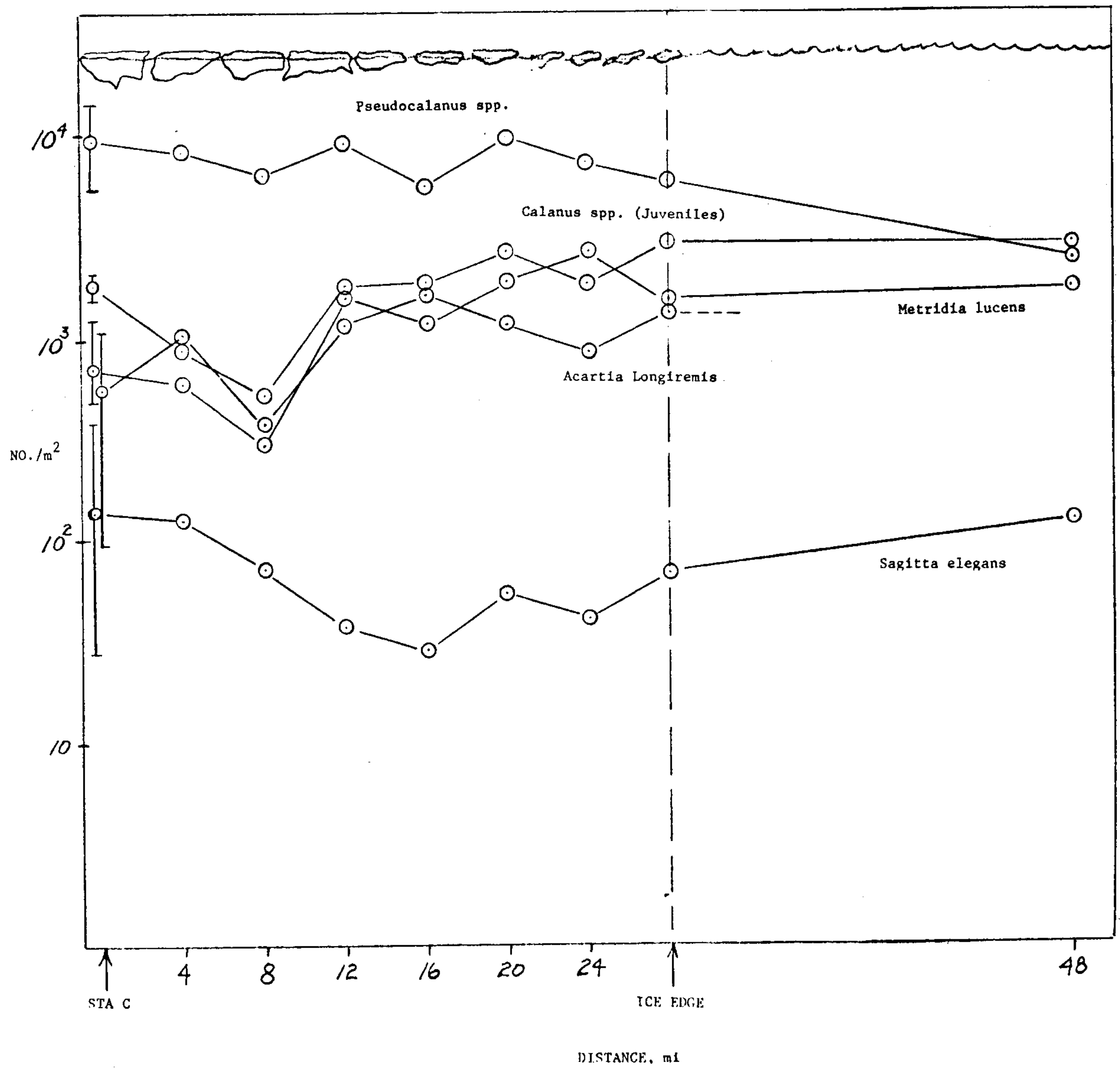

Figure 7. Distribution of selected species along a transect moving from open water into the ice edge zone to location C (see Fig. 3).

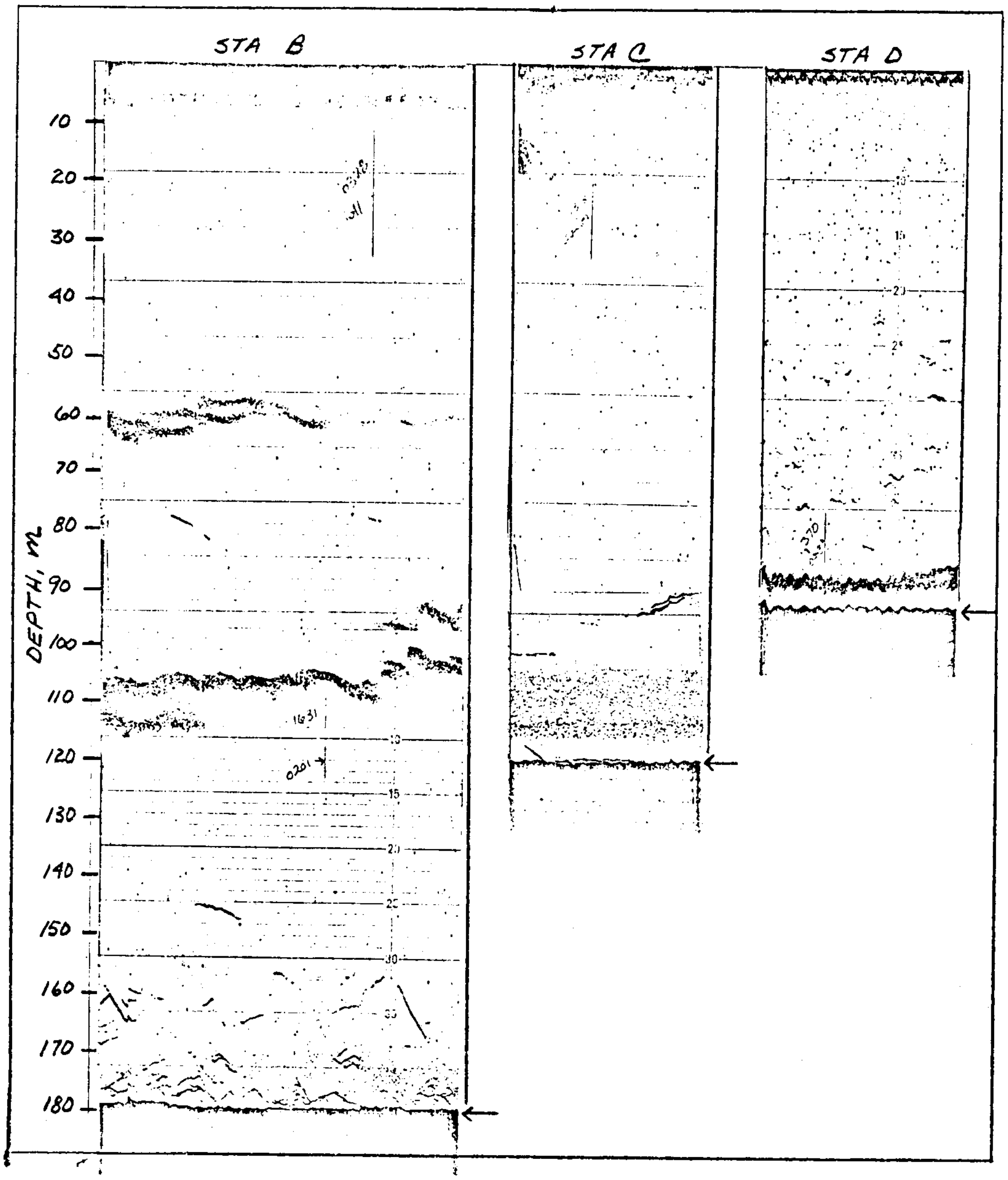

Figure 8. Representative echograms (100 kHz) taken at three of the ice edge locations in March, 1976 (the seabed is indicated by a small arrow).

The meroplankton in the Bering Sea is occasionally dominated by fish eggs and larvae. At locations B and C, large quantities of fish eggs were collected by short tows with a small neuston net in open leads (Dr. T. Nishiyama, personal communication). The condition, stage, and identity of these eggs has not yet been reported. A large Soviet trawl fishery was operating for Alaska pollock in this same area, and since this abundant species is reported to spawn from March through May, many of these eggs were probably *Theragra*. The frequency of occurrence of larvae and juvenile pollock from our reconnaissance indicates the shelf region near the Pribilof Islands and the adjacent slope and open ocean regimes are important habitats for the early life history stages of this valuable commercial species (Fig. 9).

Mr. Al Adams is completing a Master's thesis describing the feeding of some mesopelagic fishes collected in the north Pacific and Bering Sea. Copepods, amphipods, euphausiids, ostracods, larvaceans, chaetognaths, mysids, pelagic gastropods and polychaetes, and several unidentified fish eggs constitute the bulk of the food items consumed by these small, dielly migrating fish (Table IV). A surprising dependence on the Ostracoda and large Copepoda is demonstrated. The importance of these fishes in the slope ecosystem is yet to be determined.

Appendix III is a partial bibliography of published documents describing organic matter transfer processes and components of ecosystems found in the northern North Pacific and Bering Sea. The completed bibliography will be published with the end-of-contract report in September, 1977.

Work has begun on the formulation of a Bering Sea process simulation model. Approximately 31 state variables have been identified in the

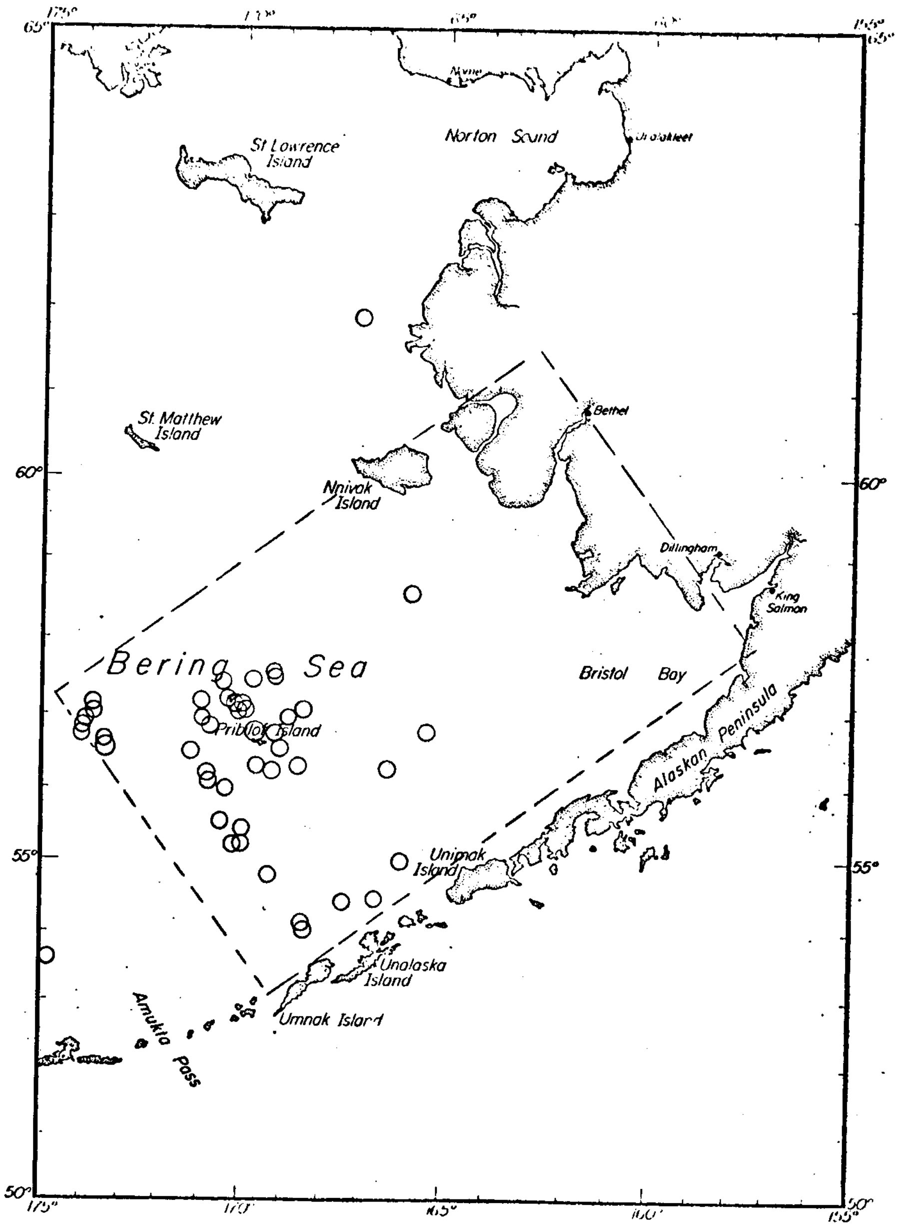

Figure 9. Occurrence of larval and juvenile Alaska pollock *Theragra chalcogramma*, in the southeastern Bering Sea study area.

TABLE IV

TAXA OCCURRING IN THE STOMACHS OF THREE PELAGIC FISHES SAMPLED IN THE NORTHERN NORTH PACIFIC OCEAN AND BERING SEA (ADAMS, 1977)

Food	Fish Species		
	Bathylagus stilbius schmidti	*Lampanyctus nannochir*	*Stenobrachius leucopsarus*
Copepoda			
Aetideus sp.	X	-	X
Calanus cristatus	X	X	X
C. plumchrus	X	X	X
Candacia columbiae	X	-	X
Eucalanus bungii bungii	X	-	X
Euchaeta elongata	-	X	X
Gaetanus intermedius	X	-	X
Gaidius variabilis	-	X	X
Heterorhabdus tanneri	X	-	X
Heterorhabdus spp.	X	-	X
Metridia lucens	X	X	X
Metridia okhotensis	-	-	X
Pleuromamma scutullata	-	X	X
Pseudocalanus spp.	X	X	X
Racovitzanus antarcticus	-	-	X
Oithona sp.	-	-	X
Oncaea spp.	-	X	X
Amphipoda			
Cyphocaris anonyx	-	-	X
Cyphocaris challengeri	-	-	X
Parathemisto pacifica	X	X	X
Euphausiacea			
Euphausia pacifica	-	-	X
Thysanoessa longipes	X	-	X
Thysanoessa sp.	-	-	X
Unidentified species in the furcilia and calyptopis stages	X	-	X
Ostracoda			
Conchoecia alata minor	X	X	X
C. borealis var. *antipoda*	X	-	X
C. borealis var. *maxima*	X	X	-
C. curta	-	X	-
C. pseudoalata	-	X	X
C. pseudodiscophora	X	X	X
C. skogsbergi	X	X	X
Larvacea			
Oikopleura spp.	X	X	X

TABLE IV

CONTINUED

Food	Fish Species		
	Bathylagus stilbius schmidti	*Lampanyctus nannochir*	*Stenobrachius leucopsarus*
Chaetognatha			
Sagitta elegans	-	-	X
Unidentified species	-	X	-
Mysidacea			
Boreomysis sp.	-	-	X
Eucopia sp.	-	X	-
Gastropoda			
Limacina helicina	X	-	X
Polychaeta			
Polynoidae (unid. species)	-	-	X
Teleostei			
Unidentified eggs	X	-	X
Radiolaria (unid. species)	X	-	-

preliminary stages of this description. A primary productivity submodel has been constructed which relates organic matter synthesis to seasonal variations in nutrients and available light. The present focus is on a description of energy transfer to pelagic grazers and additional refinements of the relationship of hydrographic stability and light to ice cover and season at the ice edge.

VII. DISCUSSION

Some trends in the diversity, distribution, and abundance of zooplankton and micronekton species are becoming apparent as more observations are evaluated for the variety of habitat types present in the Bering and southern Chukchi Seas. In general, the regional characteristics described by Motoda and Minoda (1974; see Appendix I) for copepod assemblages appear to be correct with some modifications for season and specific location.

The slope and open ocean regimes adjacent to the shelf in the southeast Bering Sea support high populations of the dominant north Pacific interzonal copepods, *Calanus plumchrus*, *Calanus cristatus*, and *Eucalanus bungii bungii*. These species overwinter at depths of 500 to 1000 m, then mature and reproduce at depth in late winter. The developing stages migrate to the surface waters where, as juveniles, they immediately begin feeding on phytoplankton. Cooney (1975) reports *C. plumchrus* was absent from the shelf regime of the northern Gulf of Alaska in October, but juveniles were abundant by February. *Calanus plumchrus* was abundant at the shelf break in the Bering Sea in mid-March of 1976; however, the northern extent of this species could not be determined at this time because the seasonal ice pack extended nearly to the shelf break. By August, *C. plumchrus* was present in the Bering Strait and north into the central Chukchi Sea.

The extent to which the sea ice regime may influence the distribution and abundance of the small pelagic fauna is unclear. For most dominant species, standing stocks were as high or higher in the ice-edge zone as in the open ocean to the south. One clue is available in this regard from location D, the most eastern ice location. This station was shallow enough (approximately 80 m) so that a warm, near bottom water layer, occurring at a depth of about 80 m at location C, was not present. No interzonal copepods occurred here and the total diversity was less than 50% of that at location C to the west. If the zooplankton community encountered here is representative of that occurring at similar depths (<80 m) over the shelf to the north, then the shallow, under-ice zooplankton community has a low diversity relative to the deeper (>80 m) community influenced by warmer slope water. *Pseudocalanus* spp., *Calanus marshallae* (and probably *C. glacialis* to the north), *Eurytemora herdmani*, *Acartia longiremis*, and *Oithona similis* were the copepod representatives of the cold, relatively low salinity under-ice regime; all occurred at the other locations as well.

The coastal and northern shelf (Bering and southern Chukchi Seas) regime supports fewer pelagic species than the shelf break and slope regimes to the south. This is to be expected to some extent since the water column shoals to less than 50 m for many hundreds of km^2 north of Nunivak and St. Matthew Island. The influence of fresh water runoff is also quite evident in the very nearshore and coastal areas. Here, the zooplankton and micronekton communities exhibit a distinctly neretic character; two cladoceran genera, *Evadne* and *Podon*, together with the copepods *Acartia*, *Pseudocalanus*, and *Centropages* dominate. The relatively low percentage

(<·70) of outer shelf species in the coastal zone indicates that unlike the under-ice fauna, the nearshore group is composed of some species which are endemic to this highly stressed environment (i.e., *Podon, Evadne, Acartia clausi*).

It should be noted that a few species or composites of the zooplankton group may be found in all habitat types. This eurythermal and euryhaline near surface assemblage includes *Pseudocalanus* spp., *Acartia longiremis, Sagitta elegans*, and *Aglantha digitale*. The genus *Calanus*, as previously mentioned, also exhibits a considerable adaptation to environmental types. *Calanus plumchrus* and *C. cristatus* must be considered seasonal residents of the shelf, being advected northward as developing juveniles during the spring and early summer months. *Calanus marshallae* prefers the Bristol Bay southern shelf region and can apparently tolerate the cold, relatively low salinity under-ice regime. *Calanus glacialis* is a shelf and coastal species becoming dominant north of St. Matthew Island. These copepods (genus *Calanus*) are all relatively large (2 to 8 mm) and thought to be primary consumers. As such, they probably represent critical species in the transfer of energy through the system.

Our preliminary evaluation of the quantitative acoustic data acquisition system indicates that it can detect structure in the water column with far more precision than direct sampling. Not only discrete targets (fishes) but narrow diffuse layers, probably composed of euphausiids or small fishes, were recorded and occurred over wide areas of the shelf. Although the identities of these phenomena are not yet determined, our effort this coming year will stress midwater trawling at depths of well-defined diffuse scattering layers to quantitatively sample these organisms.

The development of a computer simulation of the ice edge ecosystem was conceived as a tool for stimulating more precise field research and for testing hypotheses concerning the relative importance of biotic and abiotic factors in this regime. An increasingly representative simulation (the model) necessitates identification of principal components (ecologically critical species in terms of energy transfer) and determination of rates of exchange. In addition, the sequencing and timing of events are thought to be of considerable importance, particularly with regard to the annual success of species with meroplanktonic stages (eggs and larvae specifically). Most pelagic and many demersal fishes fit this category, passing through a so-called critical period following yoke sac absorption, during wich more than 95% of the total mortality for a year-class usually occurs. Since the potential for unusually high survival is always present (given proper food, lowered predation and competition pressure), some exceptional cohorts are to be expected; the fishery literature documents this phenomenon for most exploited stocks. The extent to which the seasonal ice pack may be a factor determining year-class strength is unknown, but probably not unknowable.

VIII. CONCLUSIONS

1. Some generalized distribution patterns can be described for numerically dominant zooplankton and micronekton species occurring adjacent to and over the shelf in the Bering and Chukchi Seas. An open ocean, near surface assemblage (upper 200 m) is advected over the shelf in the spring and early summer in association with the northward intrusion of oceanic water which apparently pushes under the cold, less saline, wind-mixed

or ice-influenced surface layer. The extent to which this community maintains its continuity northward with the season is unknown; some components (*Calanus plumchrus*, *Eucalanus bungii bungii*) can be found in the Bering Strait and the eastern Chukchi Sea in late summer and fall.

A coastal community is also present, with continuity of species found between Bristol Bay and Point Hope. Neritic copepods and two clodocerans, *Podon* and *Evadne*, together with numerous meroplanktonic species characterize the shallow water nearshore unobtrusive fauna.

2. The influence of the seasonal ice pack on the diversity, abundance and distributions of zooplankton and micronekton is seemingly related to the water mass characteristics found adjacent to and under the ice. In years when the ice edge extends to the shelf break, the under-ice water mass is a mixture of oceanic and shelf water, carrying a relatively diverse zooplankton community. To the north, beyond the intrusion of the warmer oceanic water (shelf depths shallower than about 80 m in 1976), the under-ice regime is cold, -1.3 to 0.5°C, and less than 32°/₀₀ salinity. The plankton community in this water is sparse, both in kinds and abundance, and probably representative of much of the shelf area during late fall, winter, and early spring. In years when the ice is less well-developed, this restrictive, very cold and relatively low salinity water mass would probably influence a much smaller portion of the shelf.

3. It has become necessary to order our vast number of observations in the framework of a formal hypothesis concerning distribution and abundance patterns as they relate to temporal, spatial, and other factors. The development and implementation of an ice-edge ecosystem simulation model (with Drs. Alexander, Green and Geist) has already been useful in

structuring our upcoming field work. The model will soon be operating with primary consumer (grazer) information resulting from rate measurement experiments and standing stock estimates now available.

IX. NEEDS FOR FUTURE STUDY

A close integration of effort between workers examining the various trophic levels (phytoplankton, zooplankton, micronekton including forage fishes, nekton, and marine birds and mammals) interacting at the ice edge would do much to further our understanding of the dynamics of this system. This field season (spring-summer, 1977) scientists working with both the plankton and micronekton communities, and marine birds and mammals will attempt to describe the feeding dependencies of species as they are collected, rather than preserving massive collections at sea for future examination. This approach will utilize the expertise of the investigators in a unique interaction that makes use of the vessel as both a sampling platform and laboratory.

One of the most interesting observations from last year's work was made on the basis of these kinds of shipboard analyses. During leg I of the March (1976) *Surveyor* cruise, large numbers of birds and mammals were encountered at several locations along the ice edge; most appeared to be vigorously feeding. At this time, the rates of organic matter synthesis in the photic zone were extremely low, as was the standing stock of phytoplankton. A number of preliminary stomach content analyses performed on birds revealed that they were feeding on organisms which were either overwintering populations of holoplanktonic species with life spans exceeding one year (amphipods and euphausiids) or micronekton which were previously planktonic (first year-class fishes, mostly Alaska pollock). Thus the upper level consumers during any spring are apparently dependent on the success of overwintering plankters and juvenile fishes from the previous year. This dependency seems very advantageous since the timing of the spring bloom may vary unpredictively (from the point of view of migrating birds) each year in response to shifts in hydrography and climate.

The results of this past year's observations also indicate that a knowledge of the vertical distribution of populations in the water column will greatly aid the interpretation of large-scale distribution patterns. Considerable effort will be taken this spring to describe vertical structure in the plankton community related to such variables as light, temperature and salinity. We also plan to occupy some locations in the ice-edge zone for periods long enough to identify the components of sonic phenomena (diffuse layers) detected between the seabed and the surface.

It seems obvious that the biological processes occurring annually in the Bering and Chukchi Seas are adapted to the physical constraints of these regimes. Although much physical oceanographic data has been collected and processed, exchange between plankton ecologists and the physical oceanographers is not occurring. The fact that some rewarding verbal exchanges have developed at the now more frequent synthesis meetings suggests that the efficiency of information exchange at the scientific level (as distinguished from management and reporting) would be greatly enhanced by scheduling regional workshops prior to annual report submission. At this time the various investigators could bring their observations and hypotheses for scientific evaluation in the context of an overall study. I suggest these meetings be convened by the scientists with no obligation on the attendees to provide documentation of the proceedings other than what they may wish to present in their subsequent annual reports. It is further suggested that administrative representatives from the various project offices be excluded unless they have some science to present or discuss.

X. SUMMARY OF FOURTH QUARTER OPERATIONS

Work this past quarter has been devoted almost exclusively to staging the extensive field work planned aboard the *Surveyor* and *Discoverer* this spring and early summer, 15 March through 9 July. A large inventory of samples collected in eastern Norton Sound (Neimark) is presently being analysed and will be included in the end-of-contract report this September.

Delays in funding OCSEAP Research Unit No. (156)427 - Bering Sea Ice Edge Ecosystem Study: Nutrient Cycling and Organic Matter Transfer (Alexander/Cooney) - have caused great difficulty in preparing for this proposed research, particularly in terms of major equipment purchases, even though most vendors have been extremely helpful in attempting to meet cruise deadlines. This last minute acquisition of equipment has hindered any rigorous evaluation in the laboratory prior to shipboard use, a situation which is extremely undesirable but apparently unavoidable at this time. We were fortunate to obtain a prototype demonstration model *in situ* fluorometer for use with the NOAA onboard CTD systems. Had this equipment not been available at the last minute, much of the detailed phytoplankton work we have proposed would not be possible.

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XI. APPENDIX I

CURRENT STATE OF KNOWLEDGE AS SUMMARIZED BY COONEY, 1976, FOR ANNUAL REPORT: ENVIRONMENTAL ASSESSMENT OF THE ALASKAN CONTINENTAL SHELF

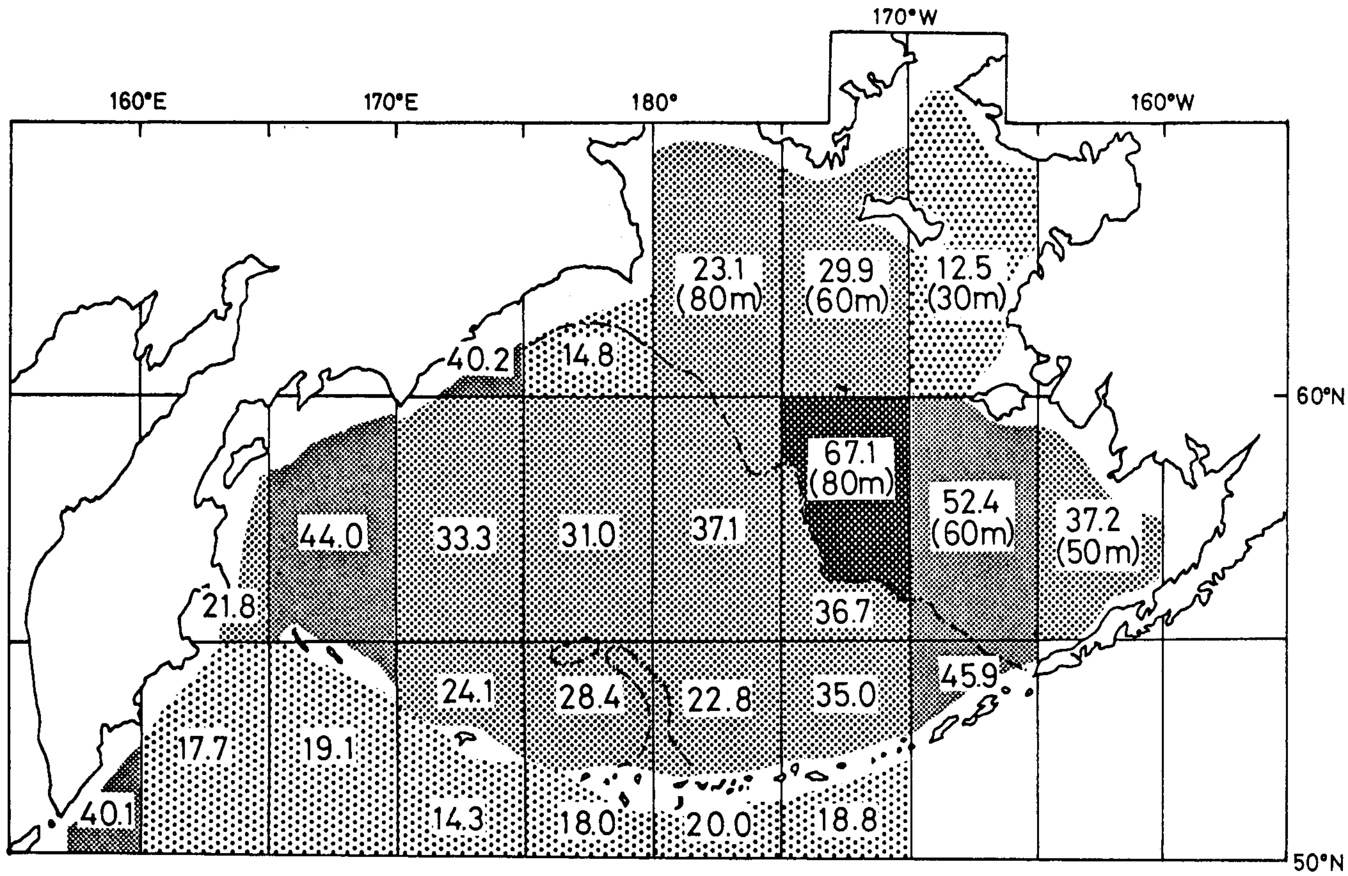
CONTRACT #03-5-022-56
TASK ORDER #13
RESEARCH UNIT #156/164
MARCH 31, 1976

CURRENT STATE OF KNOWLEDGE

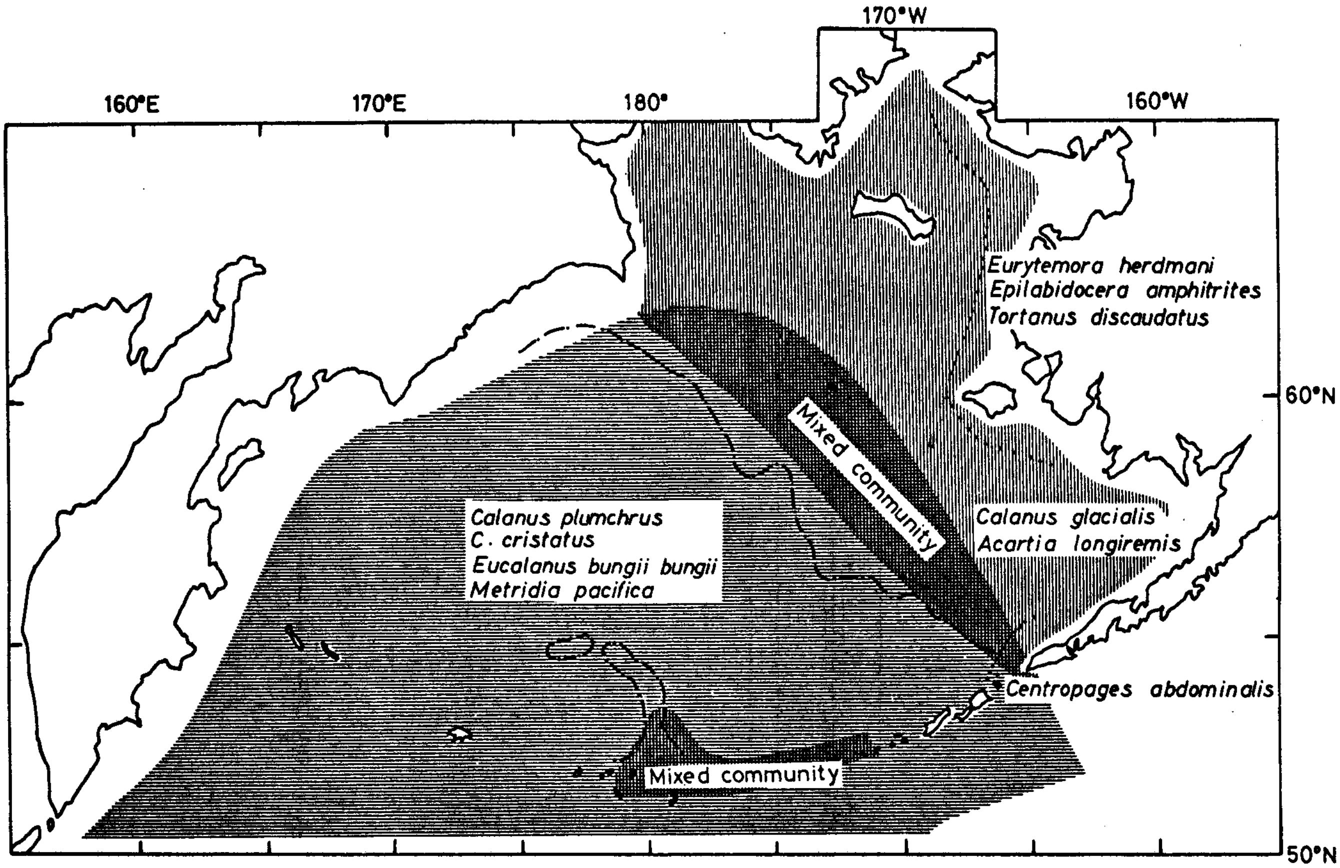
Much of the present state of knowledge concerning seasonal distributions of zooplankton and micronekton in the Bering Sea has been summarized in Hood and Kelley (1974) and Hood and Takenouti (1975). Although U.S. workers have been active in northern ocean studies, most of the recent descriptive information concerning the pelagic community is the result of Japanese efforts in conjunction with hydrographic and high-sea fishery surveys, 1956-1970. The bulk of these data is now available as generalized distributional maps for dominant species or composites occurring in the near surface (shelf) water during the summer season. The net zooplankton biomass is consistently highest over the shelf in the eastern Bering Sea (Appendix Fig. 1).

Motoda and Minoda (1974) report the spatial characteristics of several zooplankton and micronekton species in the Bering Sea. A typical North Pacific oceanic community is described for the deep water south of the shelf break grading through a mixed assemblage to more neritic species occurring over the shelf to the north and east (Appendix Figs. 2, 3, and 4). The southeastern Bering Sea appears to be very complex in this respect, probably reflecting the nature of the oceanographic circulation and interaction with the north Pacific through the Aleutian passes to the south. For reasons not fully understood, the immense area of the shelf, the water circulation patterns, and possibly the presence of seasonal sea ice interact to make this region one of the most productive in the world.

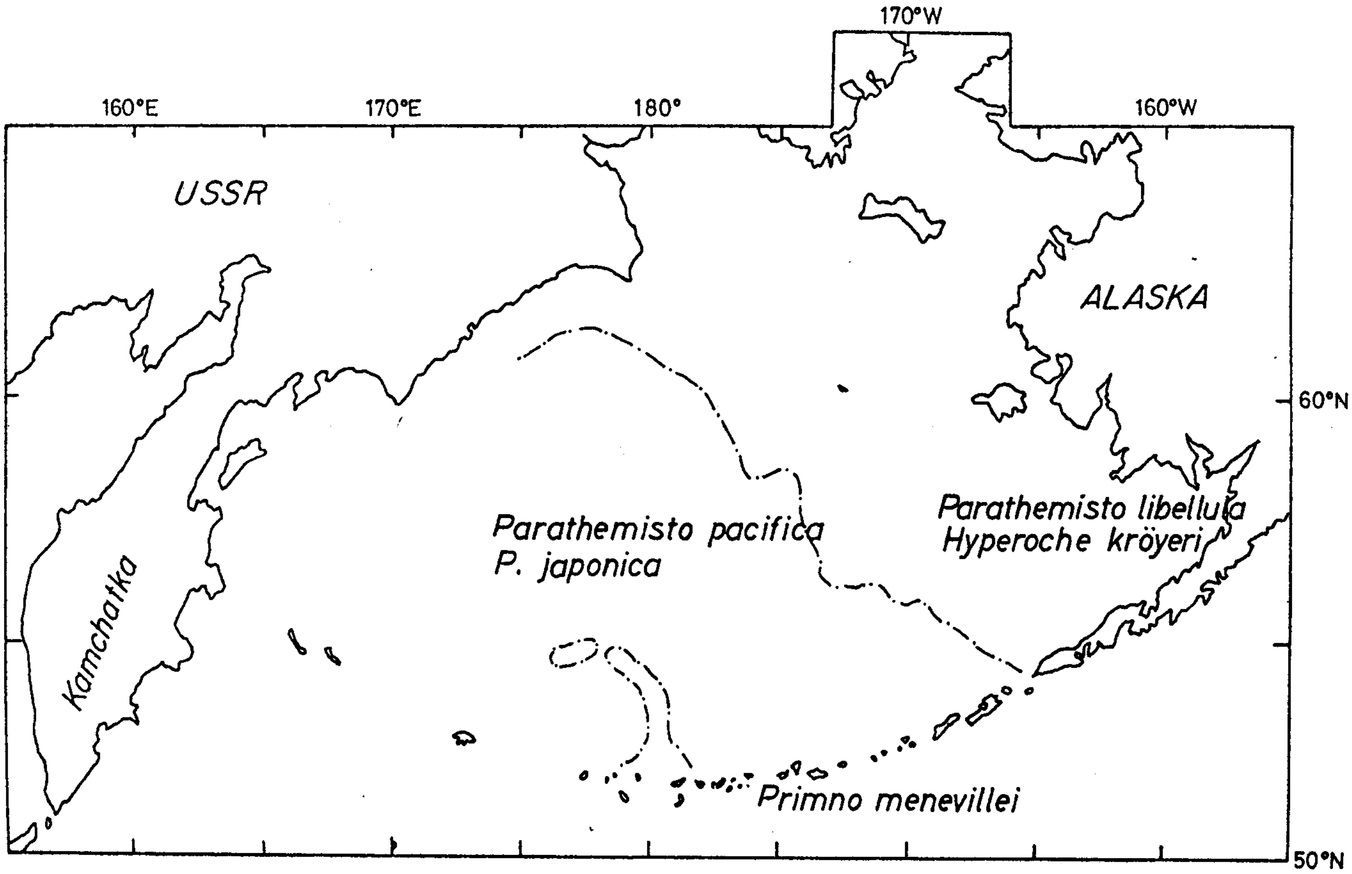
Trophic relationships are exceedingly complex in any marine system and the pelagial system of the southeast Bering Sea is no exception. Most organic matter synthesis occurs in the water column as a short period



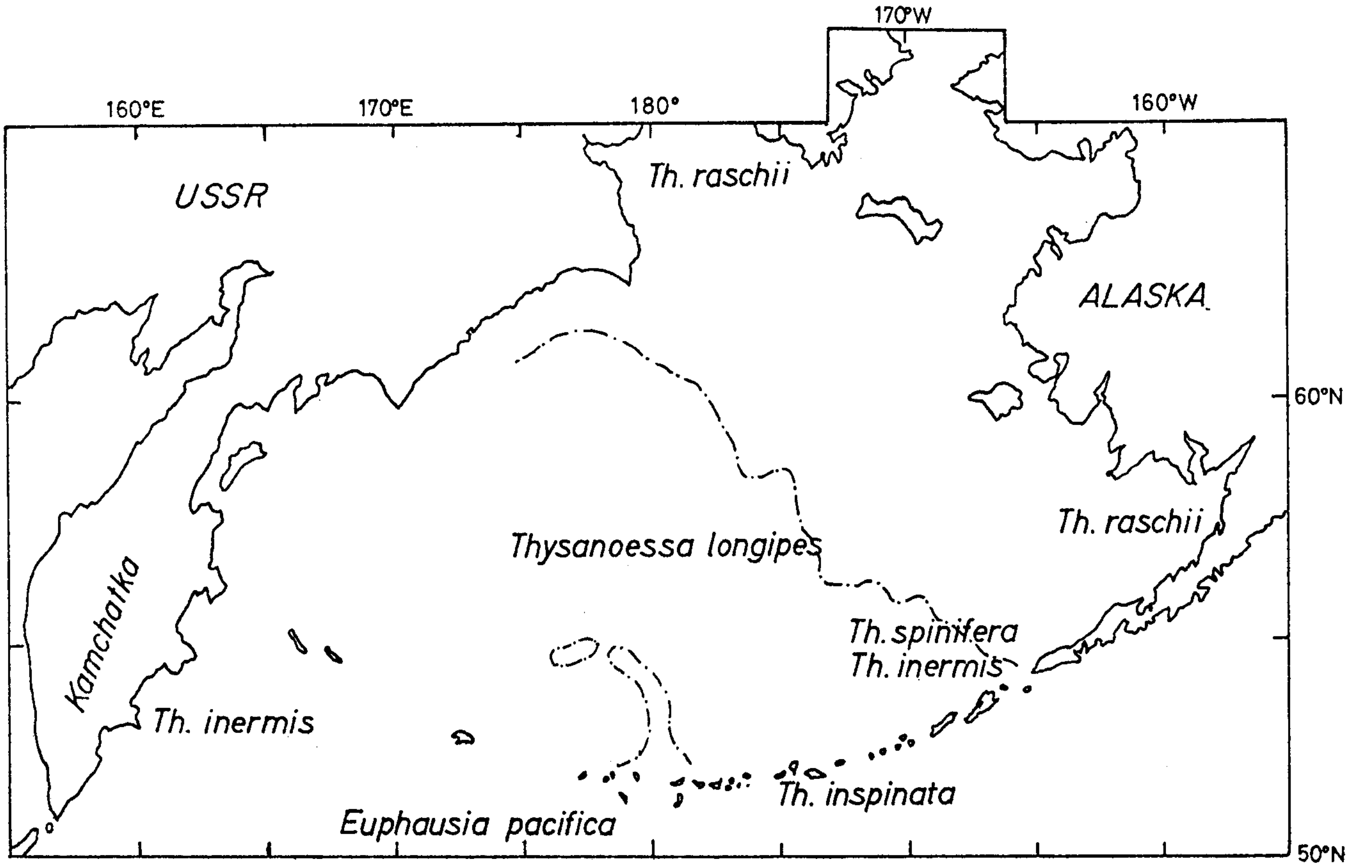
Appendix
Figure 1. Average summer zooplankton biomass for 15 years from 1956 to 1970 in each 5-degree grid. Values are expressed in wet wt. g/m^2 in 80-m water column (Motoda and Minoda, 1974).



Appendix
Figure 2. Composite figure showing regional characteristics of species composition of copepod communities in the upper water in early to mid-summer (Motoda and Minoda, 1974).



Appendix
Figure 3. Regional difference in dominant species of amphipods in early to mid-summer (Motoda and Minoda, 1974).



Appendix
Figure 4. Regional difference in dominant species of euphausiids in early to mid-summer (Motoda and Minoda, 1974).

pulse during the oceanographic spring season, but a "benthic" algal community developing on the undersurface of the sea ice in late winter together with seagrasses and nearshore epibenthic algae also contribute to the overall annual production. McRoy and Goering (1975) estimate the total shelf primary production to be approximately 140 million metric tons of carbon per year. A simple conversion of average wet weight standing stock per square meter to carbon (0.1 x wet weight) for net zooplankton provides an estimate of 5.2 million metric tons at this level consuming probably no more than 50 million tons of plant matter or about one-third of the yearly production. Thus, much of the organic matter synthesized in the water column (perhaps nearly two-thirds) is available for benthic filter and deposit feeders. Indeed, the shelf benthos is very abundant in the Bering Sea.

Measurements of secondary productivity are nearly non-existent for this region, although the very obvious populations of sea birds and marine mammals, coupled with the size of the historical commercial fisheries catch suggests a very efficient transfer mechanism to higher trophic levels. This problem will be the focus of an international study of processes and resources of the Bering Sea shelf (PROBES) scheduled to begin in the spring of 1976.

XII. APPENDIX II

AN INVENTORY OF SAMPLES TAKEN FOR ZOOPLANKTON, SALINITY, CHLOROPHYLL *a*, AND NUTRIENTS FROM THE NEARSHORE REGION OF EASTERN NORTON SOUND, JUNE THROUGH SEPTEMBER, 1976

ZOOPLANKTON

(0.5-m net, 0.333 mm Nitex)

Station*	Month				Total
	June	July	August	Sept.	
1	-	-	4	2	6
2	-	-	4	2	6
3	-	3	6	-	9
4	2	4	2	-	8
5	2	5	4	2	13
6	6	11	8	20	45
7	2	3	4	2	11
8	3	5	5	-	13
9	-	5	5	-	10
10	-	5	5	-	10
11	-	4	3	-	7
12	-	6	4	-	10
13	-	6	4	-	10
14	2	-	-	-	2
15	-	3	2	-	5
16	-	2	1	-	3
				Total	168

*Refer to Figure 2 for station locations.

SALINITY SAMPLES

(surface water)

Station*	June	July	August	Sept.	Total
	Month				
1	-	1	2	1	4
2	-	1	2	1	4
3	-	2	3	-	5
4	1	2	1	-	4
5	1	3	2	1	7
6	4	8	6	13	31
7	1	2	3	4	10
8	2	3	4	-	9
9	-	3	4	-	7
10	-	3	4	-	7
11	-	3	2	-	5
12	-	2	3	-	5
13	-	2	4	-	6
14	1	-	-	-	1
15	-	1	-	-	1
16	-	1	-	-	1
				Total	107

*Refer to Figure 2 for station locations.

CHLOROPHYLL *A*

(surface water)

Station*	June	July	August	Sept.	Total
	Month				
1	-	1	2	1	4
2	-	1	2	1	4
3	-	2	2	-	4
4	1	1	2	-	4
5	1	1	1	1	4
6	1	3	18	24	46
7	3	-	2	1	6
8	2	1	3	-	6
9	-	-	2	-	2
10	-	-	-	-	0
11	-	2	-	-	2
12	-	2	-	-	2
13	-	2	-	-	2
14	1	-	-	-	1
15	-	-	-	-	0
16	-	1	-	-	1
				Total	88

*Refer to Figure 2 for station locations.

NUTRIENTS

(surface water)

Station*	June	July	August	Sept.	Total
	Month				
1	-	1	1	1	3
2	-	1	2	1	4
3	-	2	2	-	4
4	1	1	2	-	4
5	1	1	2	1	5
6	3	3	17	24	47
7	1	-	3	1	5
8	2	1	3	-	6
9	-	-	2	-	2
10	-	-	-	-	0
11	-	2	-	-	2
12	-	2	-	-	2
13	-	2	-	-	2
14	1	-	-	-	1
15	-	-	-	-	0
16	-	-	-	-	0
				Total	87

*Refer to Figure 2 for station locations.

XIII. APPENDIX III

BIBLIOGRAPHY OF ARCTIC AND SUBARCTIC MARINE FLORA AND FAUNA WITH EMPHASIS ON THE PELAGIC COMMUNITY OF THE NORTH PACIFIC AND BERING SEA REGIONS

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OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 13 R.U. NUMBER: 156/164

PRINCIPAL INVESTIGATOR: Dr. R. T. Cooney

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]		
	From	To	Batch 1		
Discoverer Leg I #808	5/15/75	5/30/75	submitted		
Discoverer Leg II #808	6/2/75	6/19/75	submitted		
Discoverer Leg I #810	8/9/75	8/28/75	submitted		
Miller Freeman #815	11/10/75	11/26/75	submitted		
Contract #03-5-022-34	Last	Year	submitted		
Surveyor 001/2	3/76	4/76	submitted		
Discoverer 002	8/3/76	8/17/76	3/30/77[a]		

Notes: [1] Data Management Plan has been approved and made contractual. Format has been received and approved by all parties.

[a] Data is currently being transferred to magnetic tape, keypunching has been completed.

Contract #03-5-022-69
Research Unit #486
Reporting Period April 1, 1976-
March 31, 1977
Number of Pages: 53

Demersal Fish and Shellfish Assessment in Selected Estuary Systems of Kodiak Island

James E. Blackburn
Alaska Department of Fish and Game
P.O. Box 686
Kodiak, Alaska 99615

March 31, 1977

I SUMMARY

This is a report of progress achieved from the time of initial funding, May 1976, through March 31, 1977. During this time otter trawl cruises were conducted in Ugak and Alitak Bays in June, July, August, September 1976 and March 1977. Catches of fish and invertebrates were identified and enumerated as accurately as possible, length frequency measurements were made on selected taxa and stomach samples were collected for analysis of food habits.

The resulting catch information has been partially tabulated and portions are here presented to highlight relative abundance, distribution and seasonality by species. Length frequency analysis for growth, and food habits analyses are incomplete.

II INTRODUCTION

General Nature and Scope of Study

This study was intended to document the use of estuaries on Kodiak by fish and shellfish. The estuaries are generally known to be important to production of fisheries resources but the existing level of knowledge around Kodiak is extremely heterogeneous. Some commercial species have been studied extensively yet the area has been only superficially reconnoitered at best for many species.

This study and R.U. 485 are designed to sample virtually all the habitats within Ugak, Kaiugnak and Alitak bays. This study, however, is addressed to the demersal epifauna that are vulnerable to capture by otter trawl, specifically, fish and crustacean shellfish.

Specific Objectives

A. Determine the spatial and temporal (June-September) distribution, relative abundance and inter-relationships of the various demersal finfish and shellfish species in the study area.

B. Determine the growth rate and food habits of selected demersal fish species.

C. Conduct literature survey to obtain and summarize on ordinal level documentation of commercial catch, stock assessment data, distribution as well as species and age group composition of various shellfish species in the study area.

D. Obtain basic oceanographic and atmospheric data to determine any correlations between these factors and migrations and/or relative abundance of various demersal fish and shellfish species encountered.

Relevance to Problems of Petroleum Development

Petroleum development on the Kodiak Shelf is planned for the near future and it will have an impact on fish and fisheries of the area. The precise impact depends upon what takes place and when and where it occurs. This study is providing part of the basic data upon which to make decisions that may affect natural resources.

The placement of shore facilities may result in impact in their vicinity. Information that may provide perspective on site selection is of considerable importance and necessarily must be quite site specific. The inshore portion of this study, R.U. 485, will provide this type of information, more than this study.

Contamination by oil spill will affect certain resources most acutely. Floating oil will affect sea birds, marine mammals and intertidal life. It will have an unknown affect upon larvae and juveniles of demersal fish, especially those that occupy the near surface layers. Knowledge of demersa fishes is an important link in assessing this aspect of potential impact. Spilled oil may also reach the bottom of the sea, where it may collect and affect marine organisms.

Chronic contamination at low levels has a poorly understood affect upon biota but it is potentially hazardous. This may originate from permanent or semi-permanent facilities, such as drilling platforms and may affect demersal epifauna.

The activities of the drilling platforms may directly affect the sea bottom. Placement of structures, dumping of drilling mud and cuttings may affect seabed habitats and the biota that lives there.

Thus, many of the potential impacts of oil development may affect those resources that this study is addressed to investigate.

Acknowledgements

Mr. Peter Jackson, the OCS Coordinator for the Alaska Department of Fish and Game, must be given the credit for planning and implementing this study. The time between funding and study implementation, little more than one month, attests to the difficulties overcome. I also wish to thank him for the continuing guidance and encouragement. All of the accomplishments of this study are to the credit of Peter Jackson.

I would like to thank Al Carbary, Claudia Mauro, and Dan Wieczorek for their diligent work during and between cruises.

III CURRENT STATE OF KNOWLEDGE

Alaska in unique in the United States in that it remains poorly reconniotered icthyologically. Fish distributions, although a basic characteristic, are confusing and illogically discontinuous for many species. At the same time commercial utilization of several species is considerable and knowledge related to the fisheries is considerable. The overall knowledge of fish and shellfish resources of the Kodiak area is extremely variable.

Knowledge of fish in the Kodiak area is generally limited to distribtuion of commercial species during summer. A comprehensive survey of demersal fish resources in the Kodiak shelf area was conducted as part of a study by the International Pacific Halibut Commission during 1961-1963 (Hughes 1974). The National Marine Fisheries Service conducted extensive surveys around Kodiak during late spring, summer and into early fall of 1972 and 1973 (Hughes and Alton 1974). The Fisheries Research Board of Canada conducted otter trawl surveys of the Kodiak Shelf area with 81 samples in August and September 1963 and 15 samples in February 1965 (Westerheim 1967).

Comprehensive work on demersal fishes within the bays of Kodiak Island has not been conducted. The Alaska Department of Fish and Game has conducted research on commercial species and certain information is available, however, demersal fish dsitribution and abundance is not known.

Life historical information on demersal fish is generally available, however, it is generally not specific to the Kodiak area.

IV STUDY AREA

The study area for this project includes all water deeper than 10 fathoms and inside a line drawn between headlands of Ugak and Alitak bays on Kodiak Island (Figure 1).

Ugak Bay, located on the east side of Kodiak Island, is about 19 miles

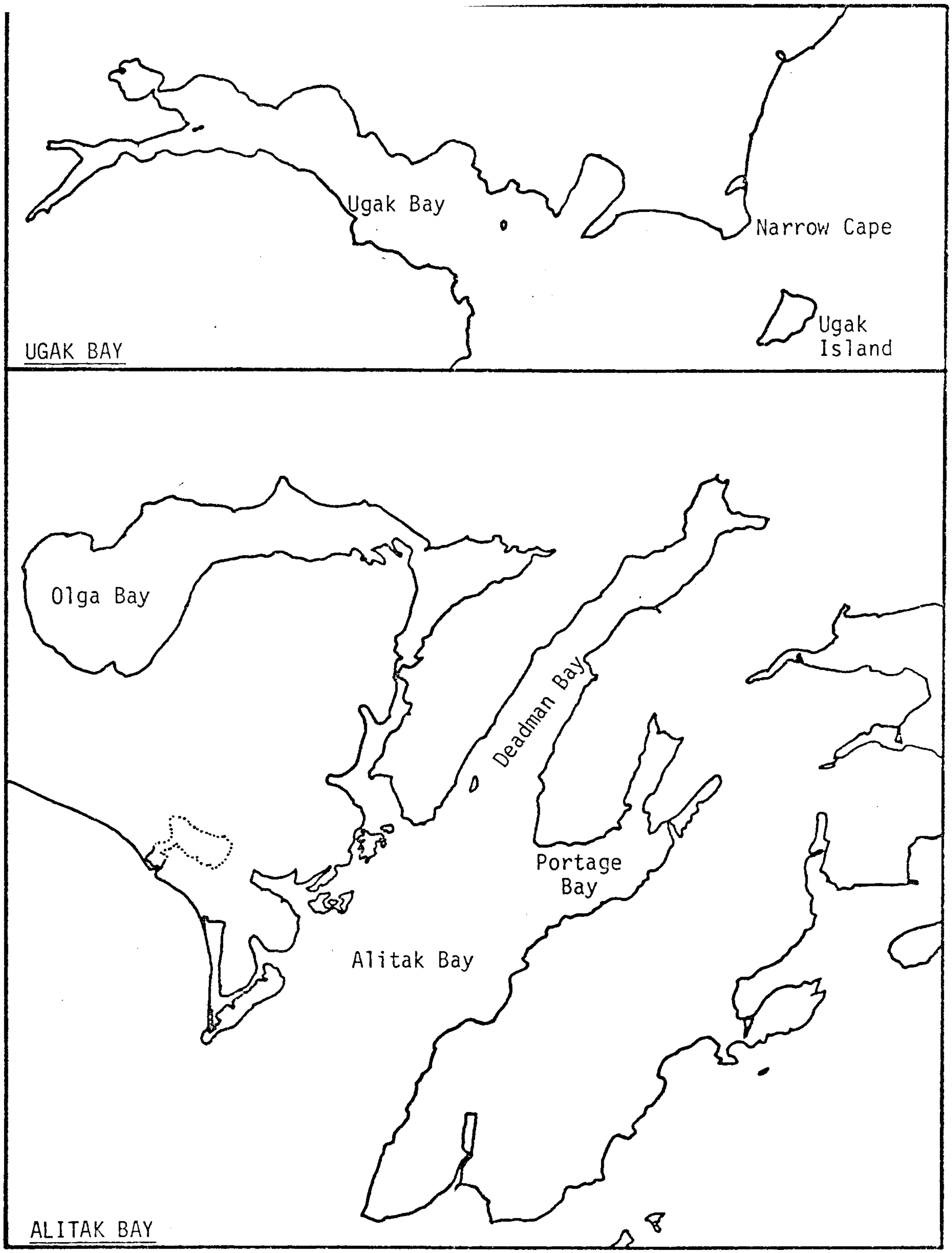

Figure 1. Diagram of the study areas, Ugak and Alitak bays on Kodiak Island.

long and gradually narrows from about 4 miles wide at its mouth to the very narrow extreme eastern end. The shoreline is rocky and precipitous and rocky outcrops occur throughout the bay. There is no sill at the mouth of Ugak Bay to influence bottom water conditions within the bay. A trough about 53 fathoms deep extends into Ugak Bay to about Eagle Harbor where the bottom shoals sharply to about 14 fathoms. West of Saltery Cove is a basin at the head of Ugak Bay with a maximum depth of 53 fathoms from which extend two arms each with sills at their mouths of 1½ and 9 fathoms and basins 25 fathoms deep.

Alitak Bay, located on the extreme southern end of Kodiak Island, is about 27 miles long and nearly 8 miles wide at its mouth. It narrows gradually to its head in Deadman Bay. Tributary to Alitak Bay about halfway along its length are Portage Bay on the east and Olga Bay through Moser Bay on the west. Olga and Moser bays were not included within the study area. The terrain varies from rolling tundra near the mouth of the bay to rocky with precipitous shorelines, reefs and rocky outcrops within the bay. There is a sill about 25 fathoms deep across the mouth of Alitak Bay, where mud and sandy shell bottom types are found. Depths increase into Portage, Sulua and Deadman bays. In Portage Bay and Sulua Bay the depths are 30 to 40 fathoms and 25 fathoms respectively. The bottom is muddy and rocky and modestly extensive littoral zones occur. From the shoreline in Deadman Bay the bottom descends precipitously to 60 to 98 fathom depths and has rocky ridges that necessitate trawling at one depth, generally along the axis of the bay.

V SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

A systematic random sampling scheme was chosen as the appropriate method of station selection as it was deemed desirable to be able to make population estimates from the data. Otter trawl stations were chosen by gridding the entire study area deeper than 10 fathoms (18m) into one nautical mile squares after eliminating areas known to be untrawlable. This yielded 30 blocks in Ugak Bay and 57 blocks in Alitak Bay. Based upon estimates of four days work in each bay and about eight stations per day, all areas in Ugak Bay and odd numbered areas in Alitak Bay were chosen as sampling stations.

Sampling was conducted with a 400 mesh eastern otter trawl which had a 30m footrope, a 27m headrope and was 26m in total length with a 4m long codend. The net was constructed with 4 inch mesh at the mouth and 3½ inch mesh in the body and cod end and had a 1¼ inch mesh cod end liner. It was equipped with 15 floats 20 cm in diameter on the headrope, and had no tickler or rollers. The bridles were 9m long and the doors were 2.1m (9ft) by 1.5m (7 ft) Astoria V design. This net is considered to open 1.5m high by 12.2m wide. The net was pulled with a 3 to 1 scope for 20 minutes at 3 knots so that 1 nautical mile (1.85km) was covered and approximately 0.02261 km^2 were covered in each standard haul. When the net was brought to the surface the cod end was retrieved with a lazy line and the catch was dumped in large tubs. Large catches, those over about 200kg, were subsampled by dumping them directly from the net into two tubs so that the catch was randomly split. The fuller tub was chosen for sorting. The percent of the total catch contained in the fuller tub was visually estimated by each crew member, the estimates were averaged and this figure was used to expand the sorted catch into the estimate of total catch.

Catches were sorted by species as possible and each species was weighed, counted and directly recorded on the keypunch data form. Unidentified species were preserved for later identification. Stomach samples and lengths were taken from selected taxa.

VI RESULTS

A total of 197 otter trawl hauls were satisfactorally completed in Ugak and Alitak bays from June through September 1976 (Table 1). An additional cruise was completed during March 1977 but the results are not yet available. The catches in both bays during all months consisted almost entirely of four major groups: flounders (Pleuronectidae), crustacea, sculpins (Cottidae) and cod (Gadidae) (Table 2).

Predominant taxa captured were snow crab (*Chionoecetes bairdi*), king crab (*Paralithodes camtschatica*), yellowfin sole, shrimp (Pandalidae), great sculpin, flathead sole, yellow Irish lord, Pacific cod, Pacific halibut, and walleye pollock (Table 2). A preliminary list of species captured is included (Table 3).

Table 1. Number of otter trawl hauls completed with satisfactory gear performance by bay and month.

	Ugak Bay	Alitak Bay
June	25	28
July	23	27
August	25	22
September	22	25

Table 2. Preliminary tabulation of otter trawl catch in kilograms per 20 minute haul in Ugak and Alitak bays on Kodiak Island, June, July, August and September, 1976.

	Ugak Bay				Alitak Bay			
	June	July	August	Sept.	June	July	August	Sept.
Crustaceans	50.7	84.4	78.3	80.17	95.6	132.4	69.2	109.2
Flounders	55.3	76.5	68.1	48.5	34.5	45.1	29.8	37.5
Sculpins	51.0	35.2	16.0	18.9	13.0	19.5	9.8	13.6
Cod	17.1	31.4	0.5	0.8	3.9	16.4	4.8	8.5
King crab	7.9	41.7	39.1	38.2	12.3	39.4	19.9	29.46
Tanner crab	35.4	36.9	18.5	28.0	71.1	61.0	28.0	47.2
Shrimp	7.4	5.4	21.1	12.2	12.2	31.7	21.2	32.4
Yellowfin sole	26.7	42.8	38.0	24.4	18.5	25.8	19.9	24.3
Irish Lord	33.0	11.0	2.4	2.5	0.4	1.7	0.5	0.6
Flathead sole	22.5	17.7	12.9	3.1	2.3	4.3	2.9	3.4
Great sculpin	11.2	14.8	8.6	11.9	12.2	16.8	9.2	13.29
Halibut	7.3	3.5	5.0	7.8	7.5	9.2	4.0	3.9
Pacific cod	16.7	30.5	0.3	0.7	T[1]	1.8	0.4	0.1
Rock sole	2.6	7.5	2.7	4.7	1.6	2.8	0.7	0.5
Butter sole	2.5	0.5	1.7	1.8	0.1	0.2	T[1]	T[1]
Starry flounder	0.4	0.2	0.7	4.5	2.9	1.2	1.8	5.0
Walleye pollock	0.2	0.6	0.1	0.1	3.9	14.6	4.0	8.4
Total Catch	186.5	252.0	183.1	162.6	151.3	219.5	118.5	182.4

[1] Trace, less than 0.1 kilogram per 20 minute haul.

Table 3. Preliminary list of species captured in Ugak and Alitak Bays on Kodiak Island by otter trawl during June, July, August and September, 1977.

Rajidae	
Big skate	*Raja binoculata*
Longnose skate	*Raja rhina*
Clupeidae	
Pacific herring	*Clupea harengus pallasi*
Osmeridae	
Capelin	*Mallotus villosus*
Eulachon	*Thaleichthys pacificus*
Gadidae	
Pacific cod	*Gadus macrocephalus*
Pacific tomcod	*Microgadus proximus*
Walleye pollock	*Theragra chalcogramma*
Zoarcidae	
Soft eelpout	*Bothrocara molle*
Shortfin eelpout	*Lycodes brevipes*
Wattled eelpout	*Lycodes palearis*
Trichodontidae	
Pacific sandfish	*Trichodon trichodon*
Bathymasteridae	
Searcher	*Bathymaster signatus*
Stichaeidae	
Longsnout prickleback	*Lumpenella longirostris*
Daubed shanny	*Lumpenus maculatus*
Stout eelblenny	*Lumpenus medius*
Snake prickleback	*Lumpenus sagitta*
Zaproridae	
Prowfish	*Zaprora silenus*
Scorpaenidae	
Pacific ocean perch	*Sebastes alutus*
Dusky rockfish	*Sebastes ciliatus*
Anoplopomatidae	
Sablefish	*Anoplopoma fimbria*

Hexagrammidae	
Masked greenling	*Hexagrammos octogrammus*
Whitespot greenling	*Hexagrammos stelleri*
Atka mackerel	*Pleurogrammus monopterygius*
Cottidae	
Crested sculpin	*Blepsias bilobus*
Silver spotted sculpin	*Blepsias cirrhosus*
Spinyhead sculpin	*Dasycottus settiger*
Antlered sculpin	*Enophrys diceraus*
	Gymnocanthus spp.
Red Irish Lord	*Hemilepidotus hemilepidotus*
Yellow Irish Lord	*Hemilepidotus jordani*
Bigmouth sculpin	*Hemitripterus bolini*
Thorny sculpin	*Icelus spiniger*
Staghorn sculpin	*Leptocottus armatus*
Great sculpin	*Myoxocephalus polyacanthocephalus*
Tadpole sculpin	*Psychrolutes paradoxus*
Ribbed sculpin	*Triglops pingeli*
Agonidae	
Sturgeon poacher	*Agonus acipenserinus*
Smooth alligatorfish	*Anoplagonus inermis*
Tubesnout poacher	*Pallasina barbata*
Cyclopteridae	
Smooth lumpsucker	*Aptocyclus ventricosus*
Marbled snailfish	*Liparis dennyi*
Slipskin snailfish	*Liparis fucensis*
Slimy snailfish	*Liparis mucosus*
Pleuronectidae	
Arrowtooth flounder	*Atheresthes stomias*
Rex sole	*Glyptocephalus zachirus*
Flathead sole	*Hippoglossoides elassodon*
Pacific halibut	*Hippoglossus stenolepis*
Butter sole	*Isopsetta isolepis*
Rock sole	*Lepidopsetta bilineata*
Yellowfin sole	*Limanda aspera*
Dover sole	*Microstomus pacificus*
Starry flounder	*Platichthys stellatus*
Alaska plaice	*Pleuronectes quadrituberculatus*
Sand sole	*Psettichthys melanostictus*

There were several differences in the catch in the two bays. The mean catch was generally greater in Ugak Bay for yellowfin sole, Irish Lord, flathead sole, rock sole and butter sole. The mean catch was generally greater in Alitak Bay for snow crab, shrimp, walleye pollock and slightly greater for great sculpin and starry flounder. In June and July in Ugak Bay Pacific cod, Irish Lord and flathead sole were all markedly more abundant than at any other time and place. In June in both bays the catch of king crab was considerably lower than in other months. In August the catch of snow crab was lower than in either months and in September the catch of starry flounder was considerably greater than in other months. Total catches were greatest during July in both bays.

The total catch of fish within both bays tended to be greatest near the mouth and decrease further within the bay (Figures 2 and 3).

Flounders, Family Pleuronectidae

Yellowfin Sole

Yellowfin sole was captured in greater abundance than any other fish species. It occurred in 94% of the hauls and the greatest catch was 127 kg per 20 minute tow in Ugak Bay.

In Ugak Bay, yellowfin sole occurred in greatest abundance in mid-bay, between Saltery cove and Eagle Harbor and near the north side of the mouth of Ugak Bay (Figure 4). In Alitak Bay yellowfin sole were most abundant southeast of Tanner Head (Figure 5), on the shallow area at the mouth of the bay. The average size of yellowfin sole was greater in deeper water (Depth range 33 to 168m) and it was greater nearer the mouth of the bays than further within them. Attempts to relate total catch to depth yielded confusing results.

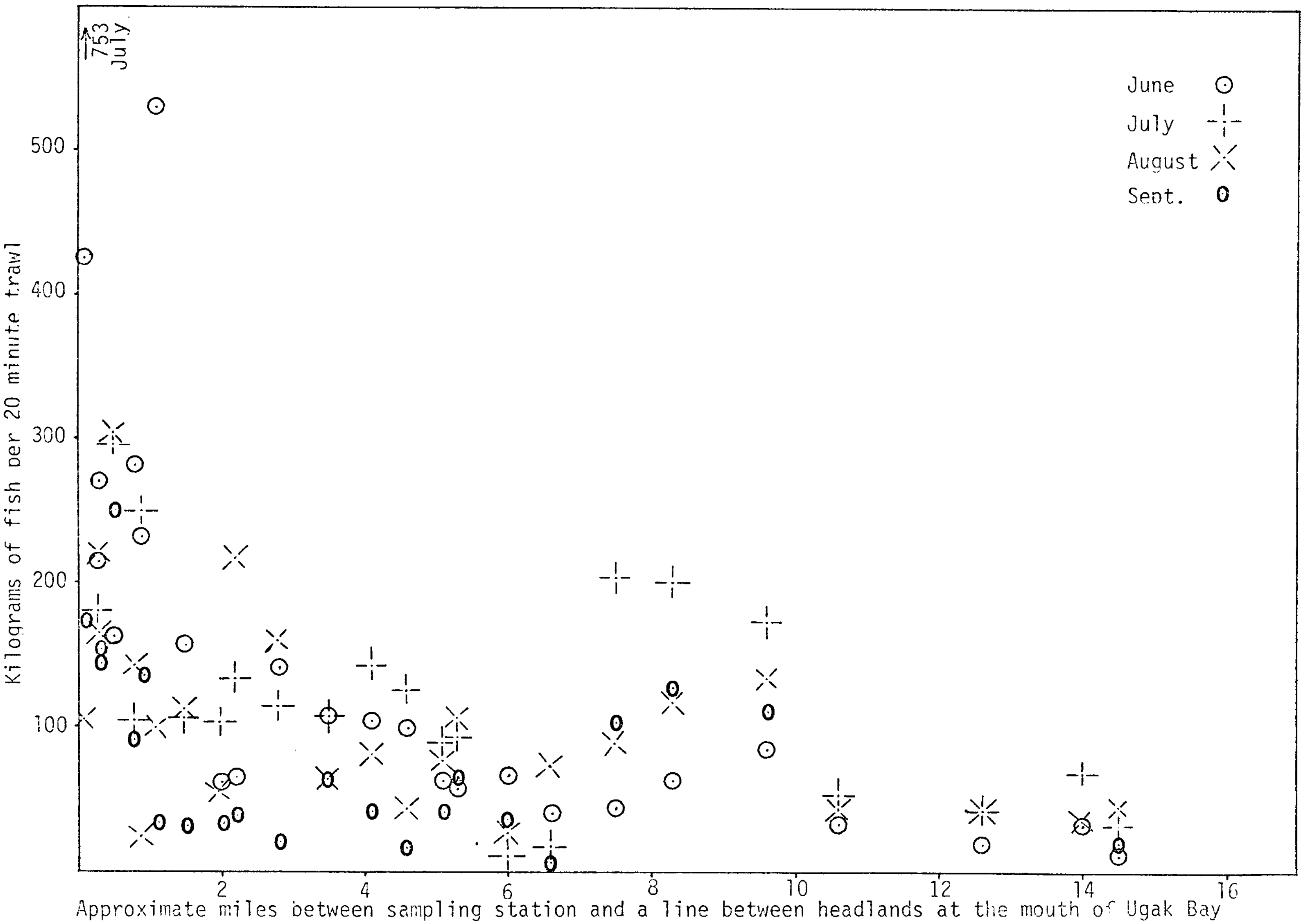

Figure 2. Otter trawl catch of fish in kilograms per 20 minute haul in Ugak Bay by approximate distance in miles between the area sampled and a line between the headlands of the bay.

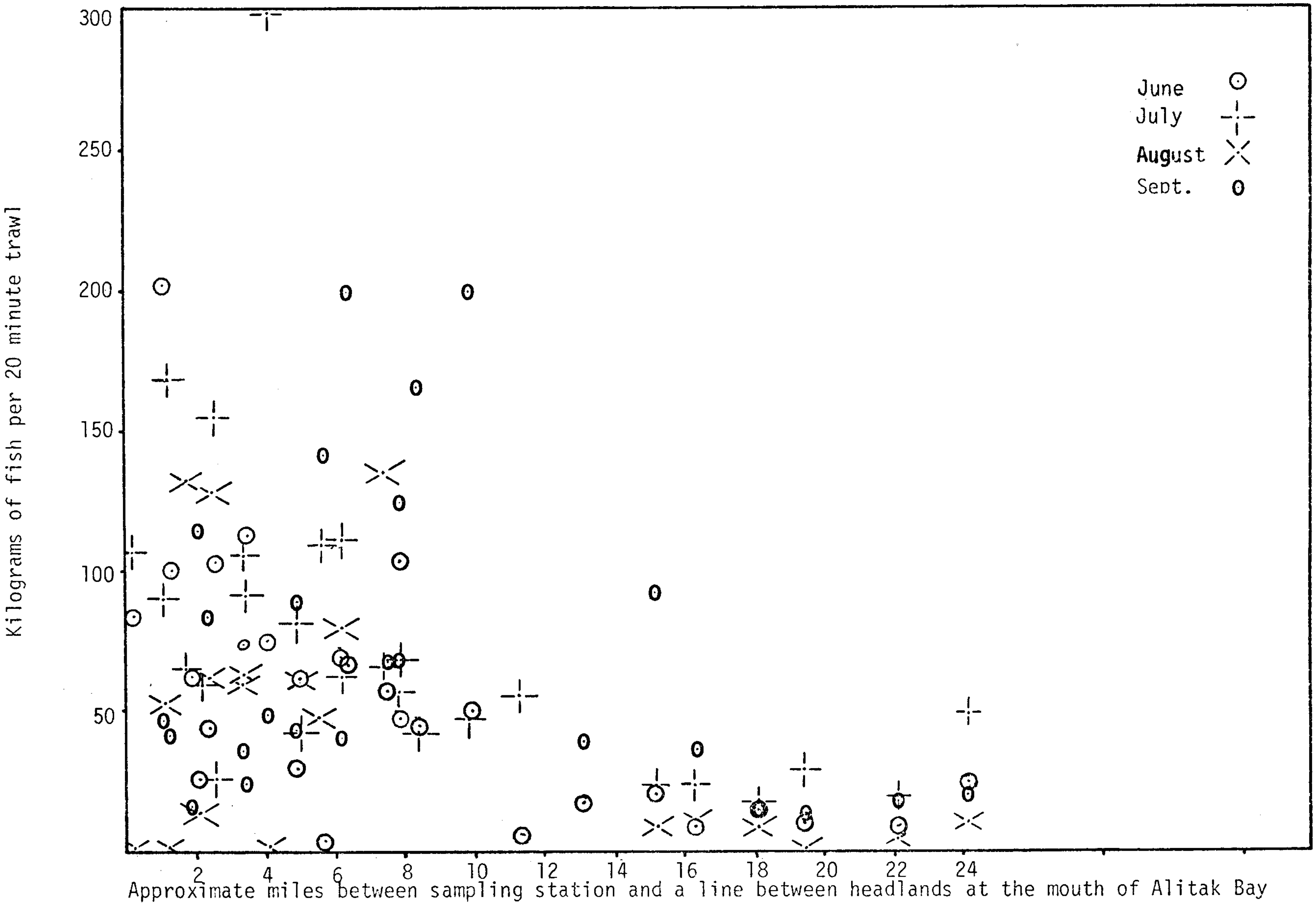

Figure 3. Otter trawl catch of fish in kilograms per 20 minute haul in Alitak Bay by approximate distance in miles between the area sampled and a line between the headlands of the bay.

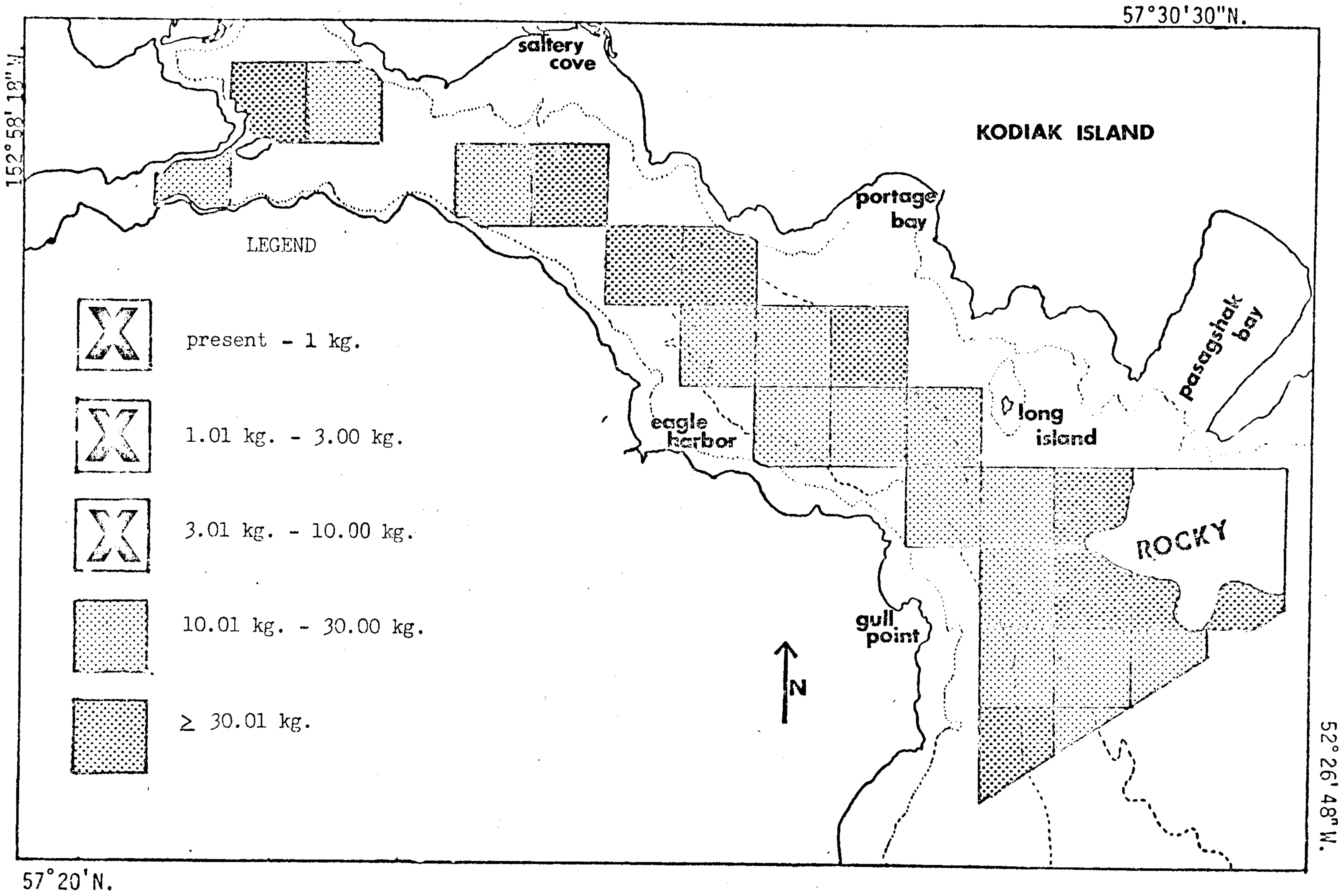

Figure 4. Distribution of yellowfin sole (*Limanda aspera*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

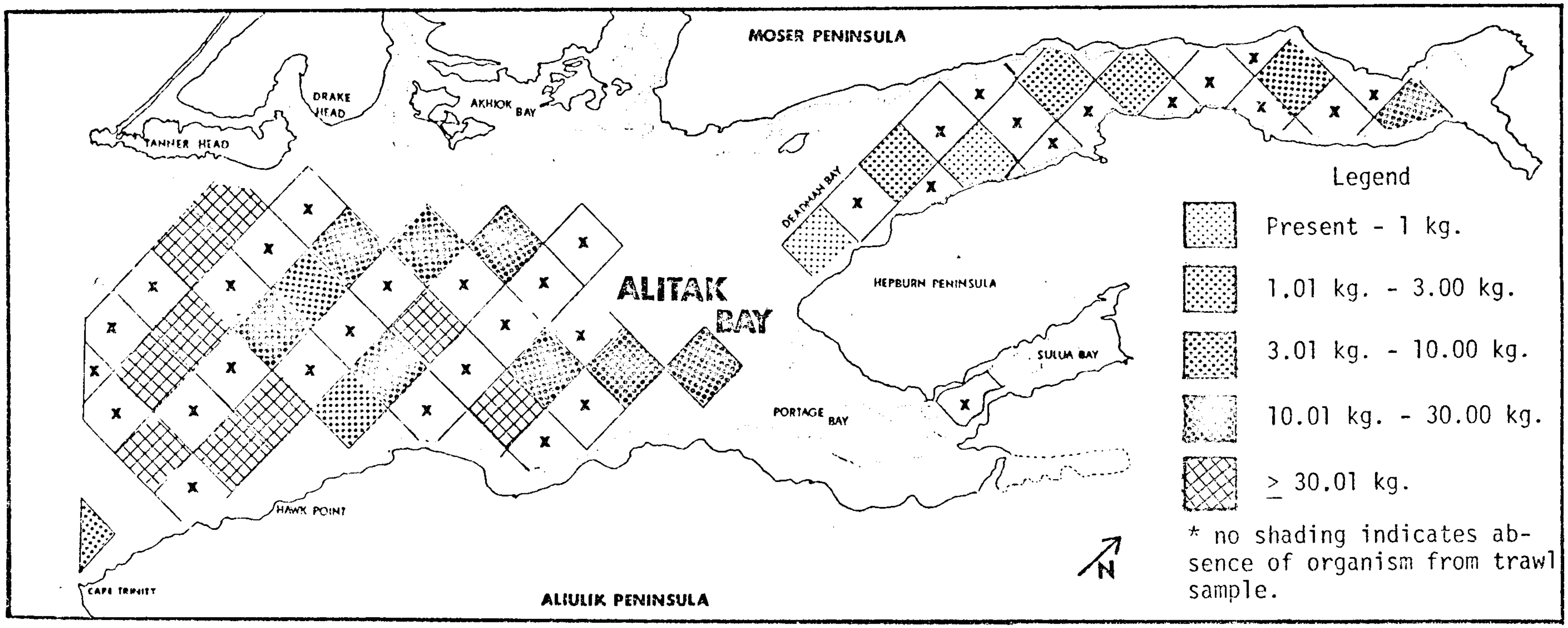

Figure 5. Distribution of yellowfin sole (*Limanda aspera*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

Flathead sole

Flathead sole was the second most abundant flounder by weight and it occurred in over 98% of the hauls. Catches were generally greater in Ugak than in Alitak Bay and they were greatest in the mouth of Ugak Bay, where the largest catch, 116 kg per 20 minute tow, occurred (Figures 6 and 7).

Pacific halibut

Pacific halibut was the third most abundant flounder by weight and it occurred in 68% of the hauls. Catch rates were similar in both bays (Figures 8 and 9) with greatest catches occurring near the mouth and smallest catches occurring near the head of the bays. The small number of halibut measured ranged from 30 to 120 cm in total length with mean sizes approximately the same in each bay (Figure 10). The mean weight per fish, which includes all fish captured, ranged from 1.03 to 1.09 kg in Ugak Bay and it ranged from 1.03 to 1.7 kg with 3 of 4 monthly means greater than 1.4 kg in Alitak Bay.

Rock sole

Rock sole was the fourth most abundant flounder by weight and it occurred in 59% of the hauls. Catch rates were slightly greater in Ugak than in Alitak Bay and catches were greater near the mouths of the bays (Figures 11 and 12). One station near Cape Trinity in the mouth of Alitak Bay yielded two catches greater than 44 kg per 20 minute tow.

Starry flounder

Starry flounder was the fifth most abundant flounder by weight and it occurred in 33% of the hauls. Catch rates were slightly greater in Alitak Bay and catches were generally larger near the mouths of the bays (Figures 13 and 14). One catch greater than 40 kg per 20 minute tow was made in each bay. The catch rates of starry flounder seem, subjectively, to vary

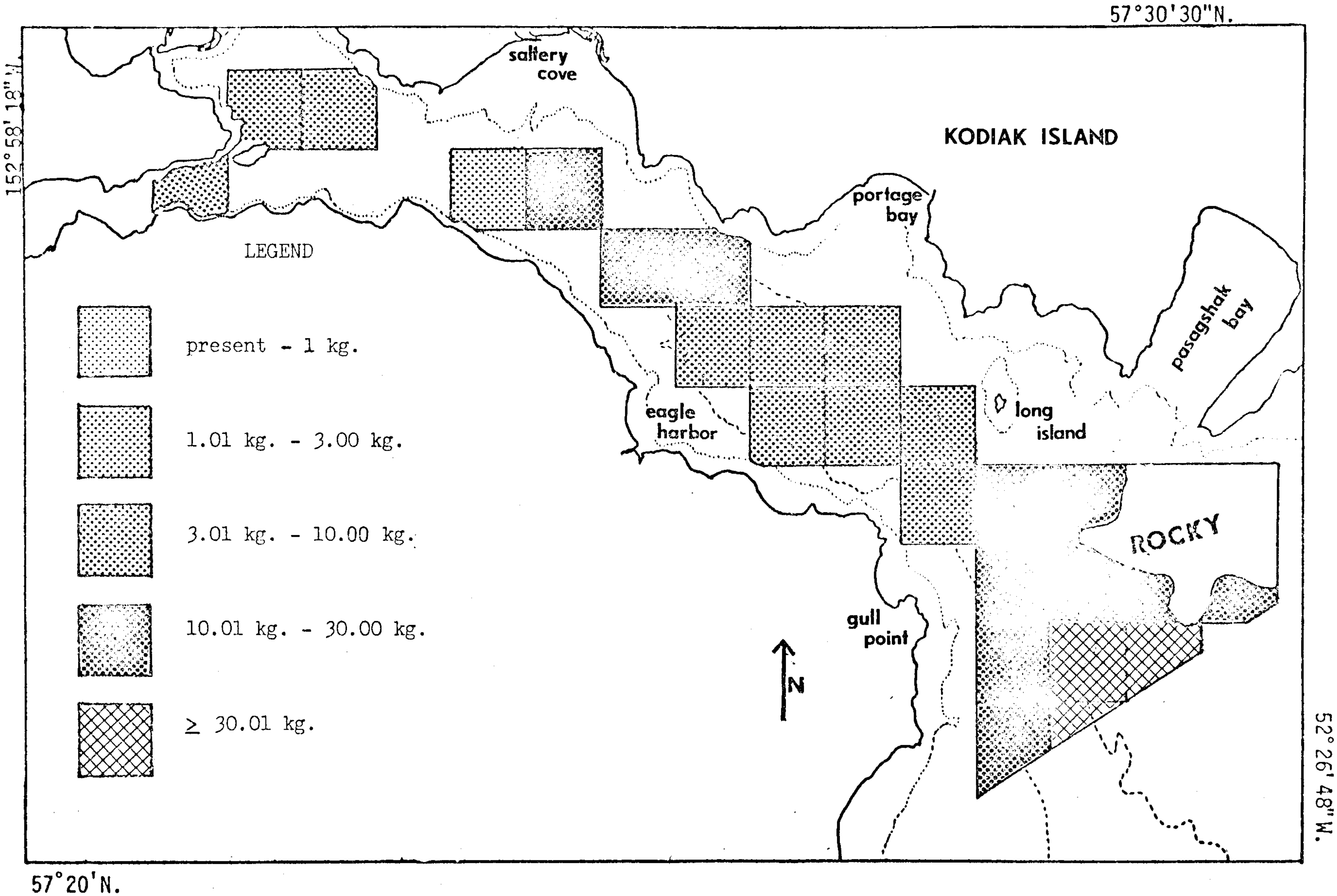

Figure 6. Distribution of flathead sole (*Hippoglossoides elassodon*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

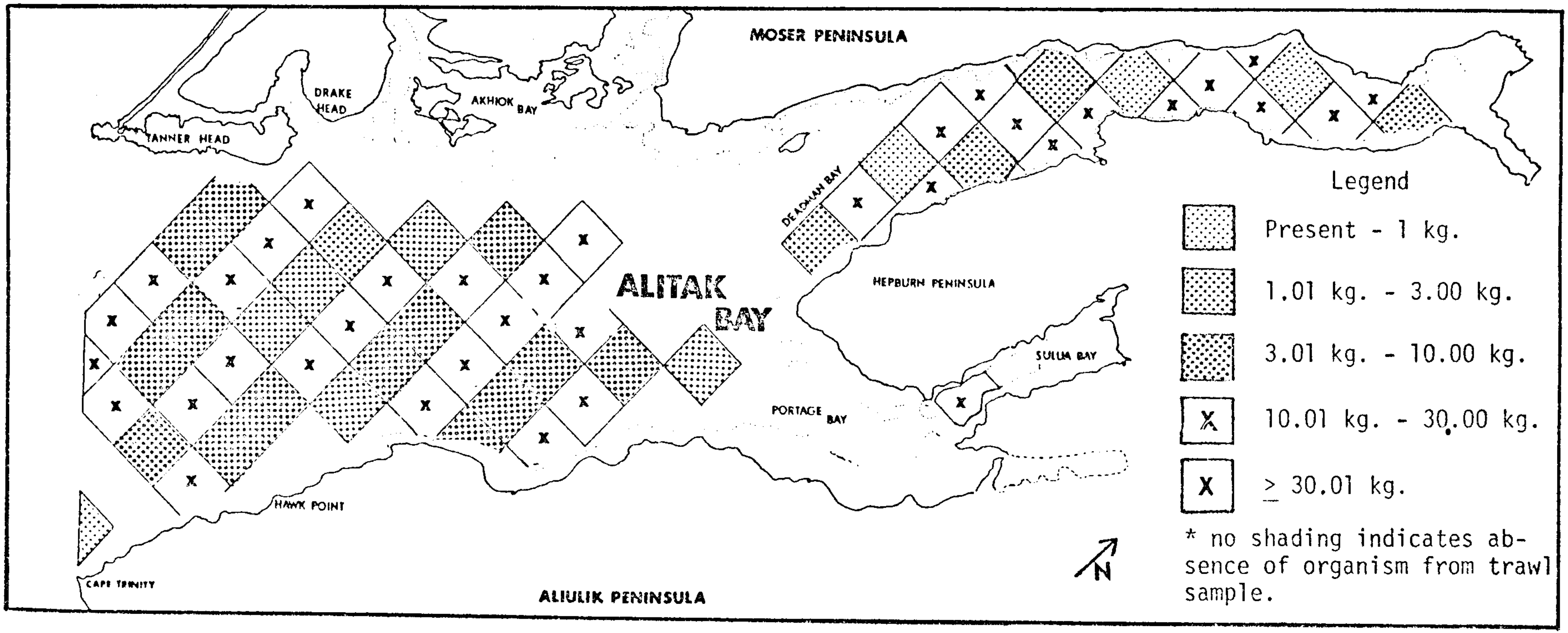

Figure 7. Distribution of flathead sole (*Hippoglossoides elassodon*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

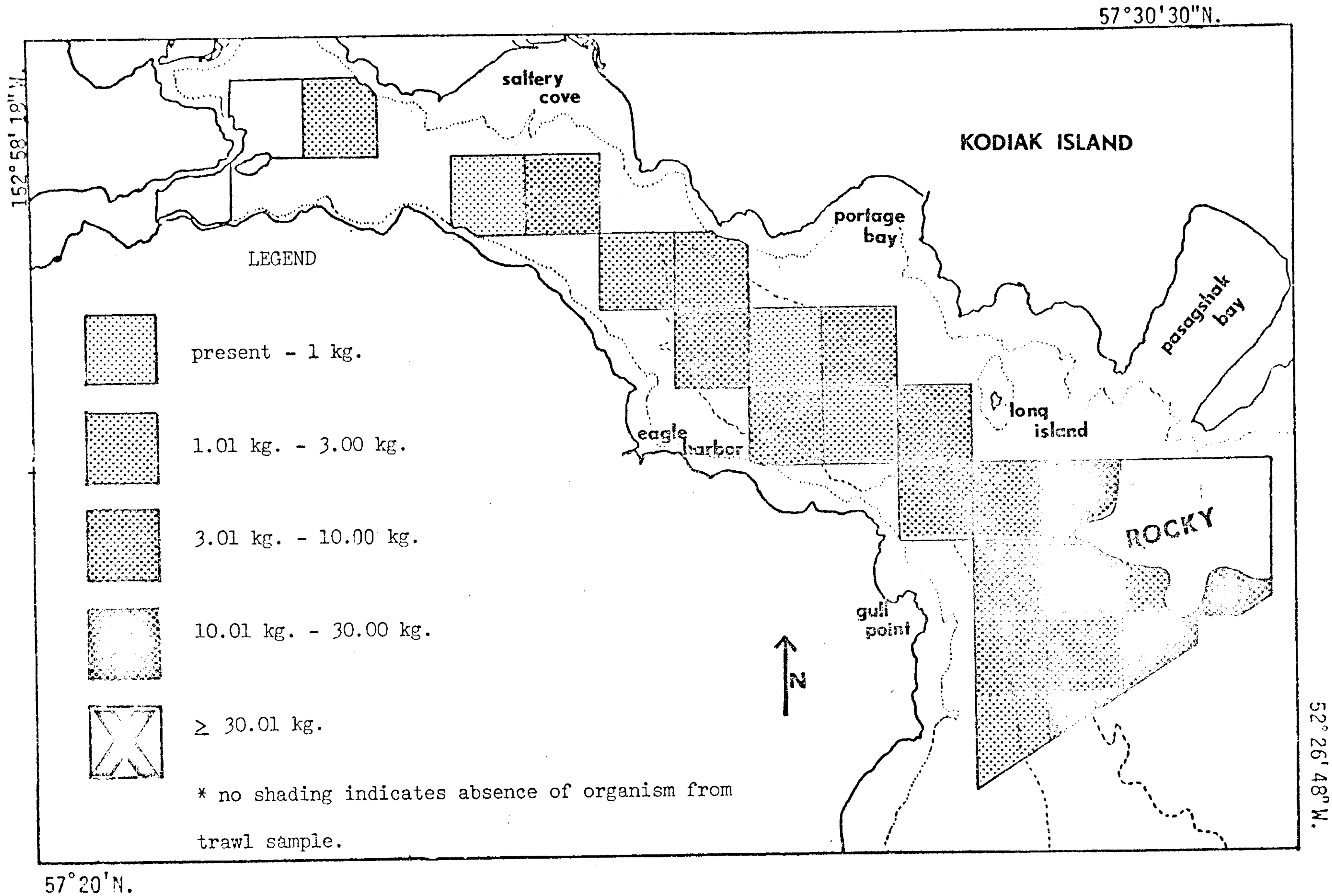

Figure 8. Distribution of Pacific halibut (*Hippoglossus stenolepis*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

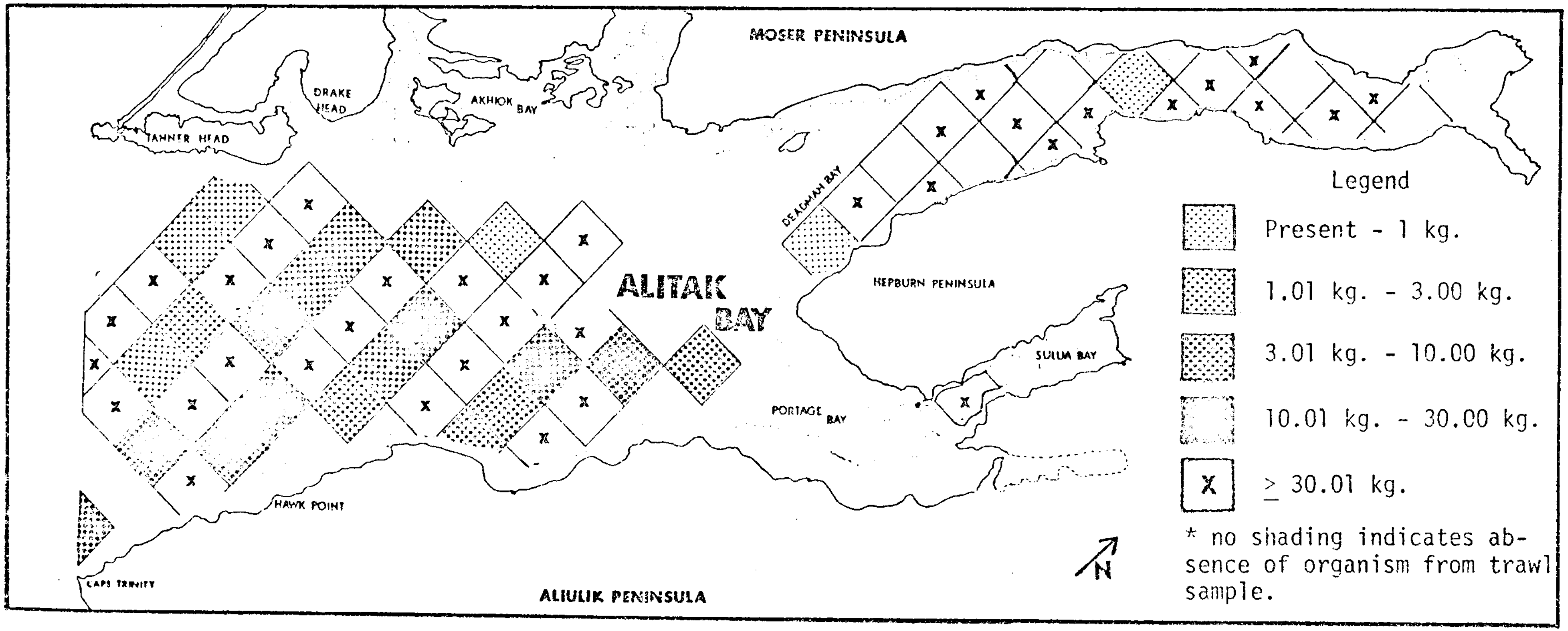

Figure 9. Distribution of Pacific halibut (*Hippoglossus stenolepis*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

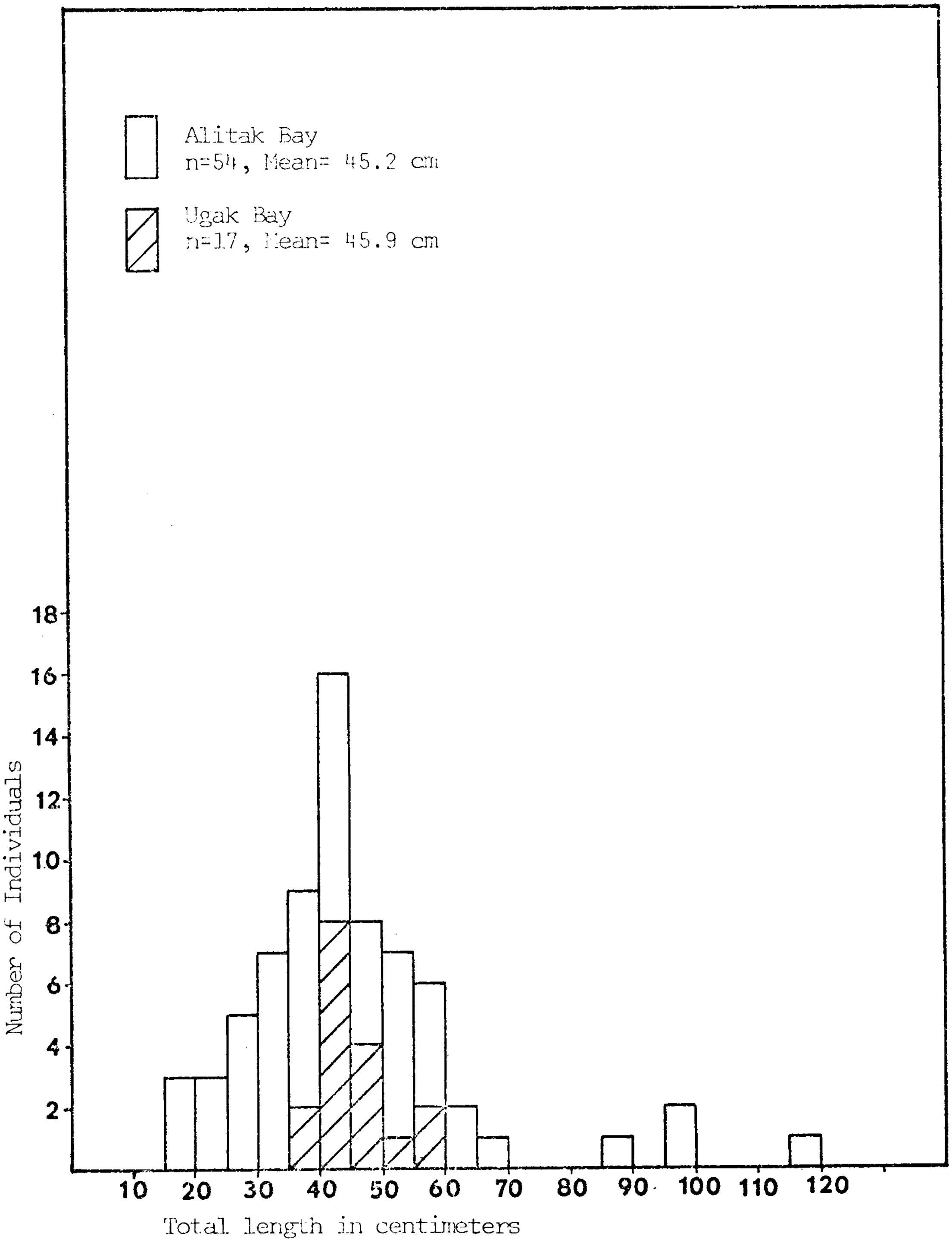

Figure 10. Count frequency of Pacific halibut(*Hippoglossus stenolepis*) total length by 5 cm intervals from Ugak and Alitak bays during July, August and September, 1976.

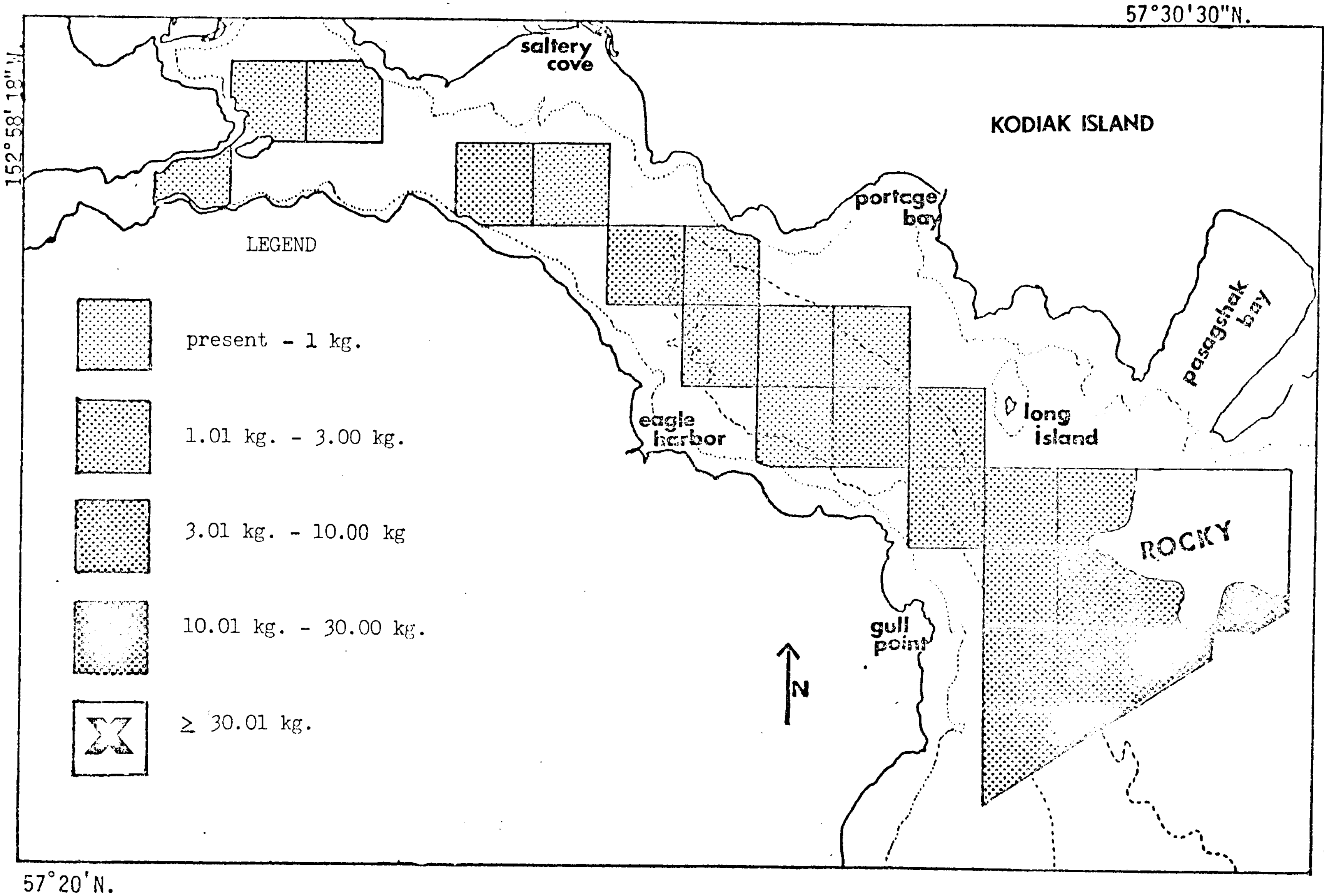

Figure 11. Distribution of rocksole (*Lepidopsetta bilineata*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

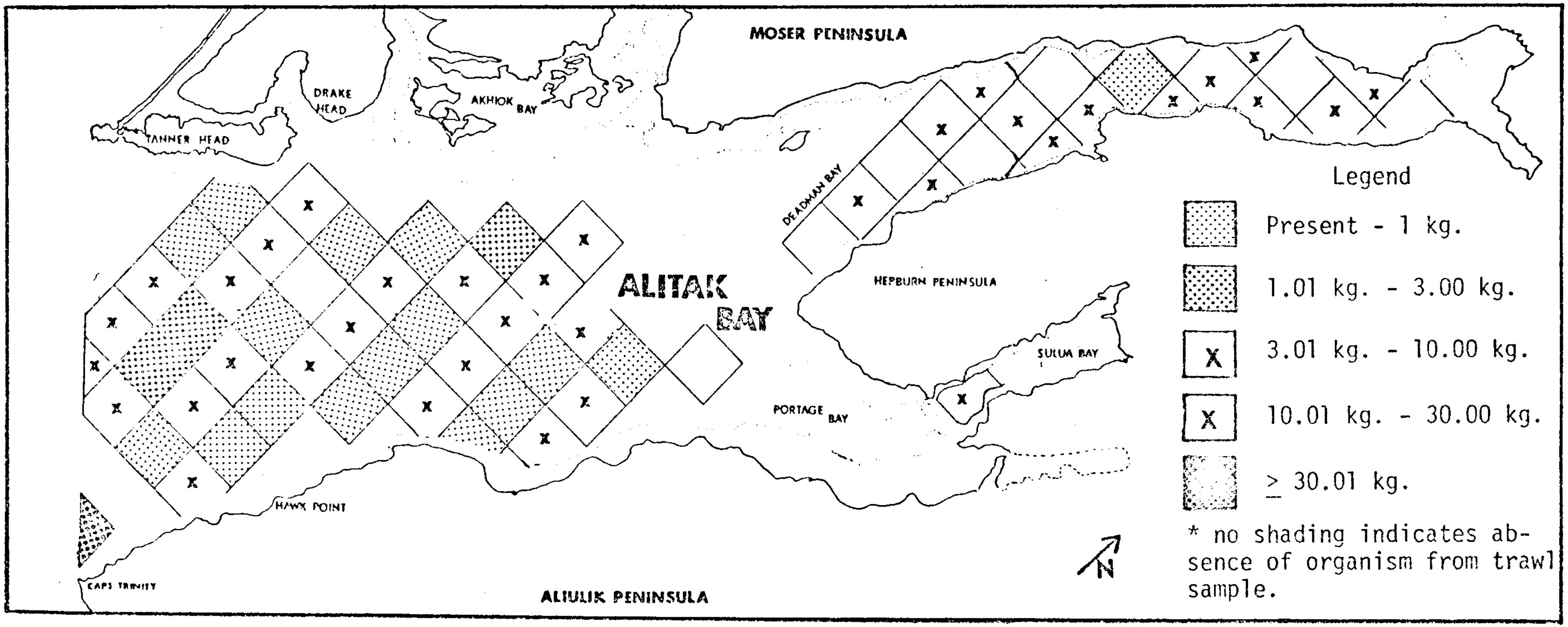

Figure 12. Distribution of rocksole (*Lepidopsetta bilineata*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

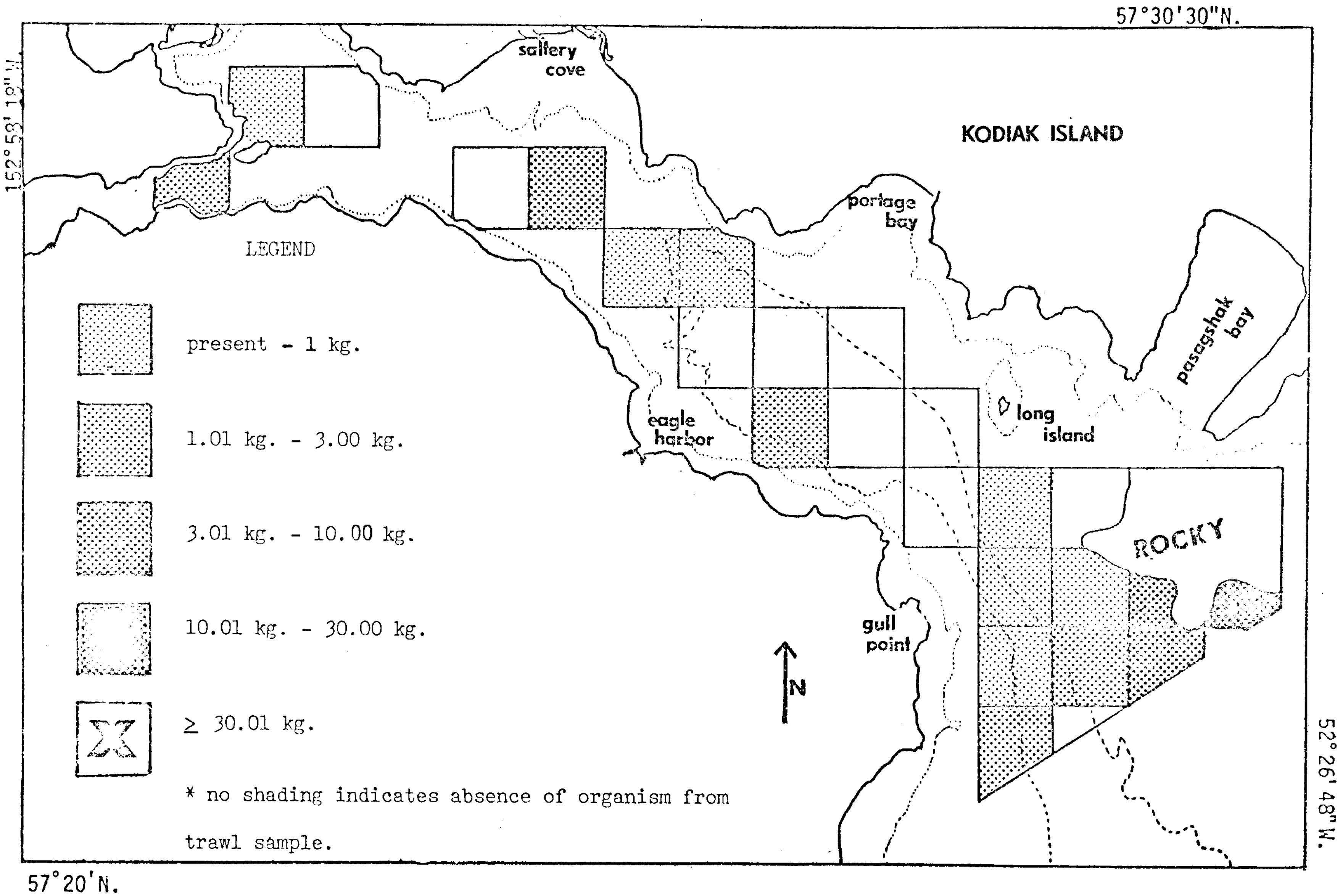

Figure 13. Distribution of starry flounder (*Platichthys stellatus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

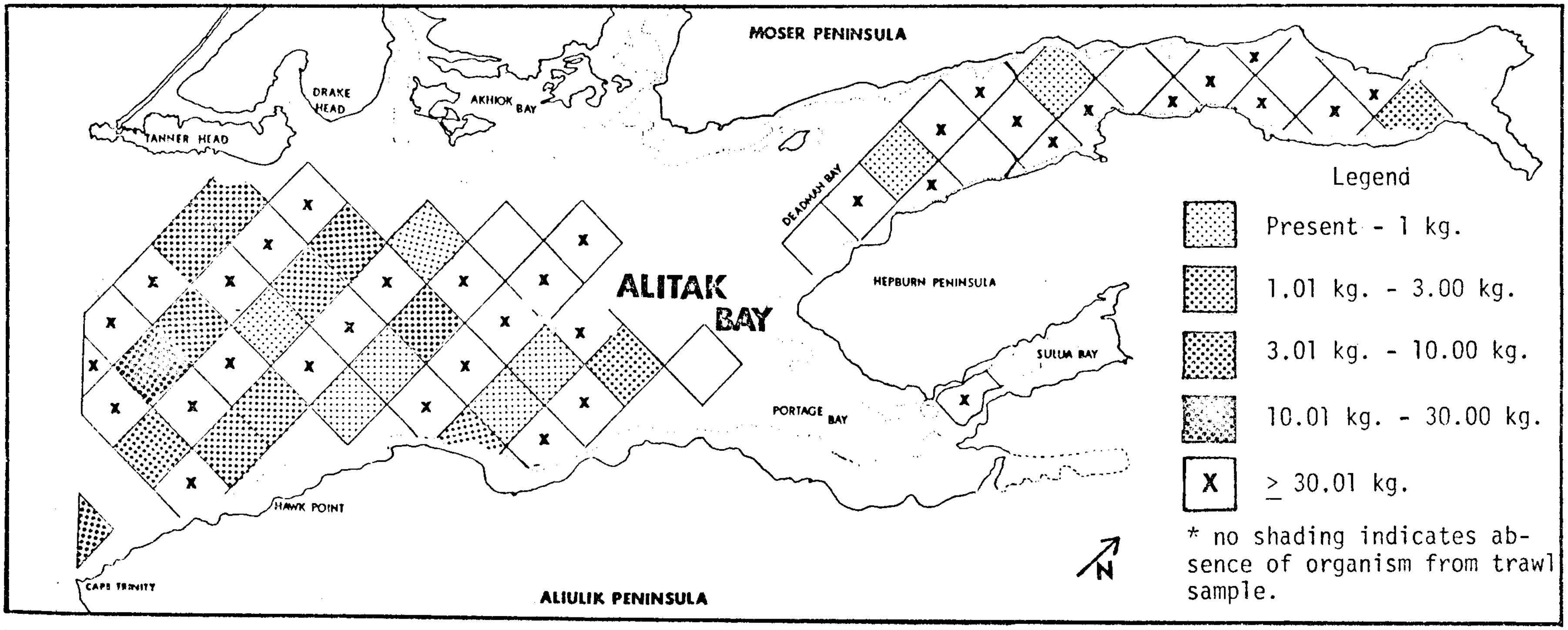

Figure 14. Distribution of starry flounder (*Platichthys stellatus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

much more than they do for other flounders.

Arrowtooth founder

Arrowtooth flounder was the sixth most abundant flounder by weight and it occurred in 55% of the hauls. Catch rates were greater in Ugak than Alitak Bay and the tendency for catch rates to be greater near the mouths of the bays appears weak (Figures 15 and 16). Only two hauls in Alitak Bay yielded catches greater than 1 kg but a catch of 23 kg was made in Ugak Bay.

Butter sole

Butter sole was the seventh most abundant flounder by weight and it occurred in 27% of the hauls. Catch rates were greater in Ugak than Alitak Bay and they were greater near the mouths of the bays (Figures 17 and 18). The largest catch, nearly 30 kg, occurred at the mouth of Ugak Bay.

Other flounders

Other flounders captured include sandsole, Alaska plaice, Dover sole and rex sole.

Cod, Family Gadidae

Pacific cod

Pacific cod was the most abundant cod captured and it occurred in 28% of the hauls. Catch rates were greater in Ugak than Alitak Bay and catches were quite variable, ranging as high as 43 kg in Alitak and 290 kg in Ugak Bay. Greatest catches were made near the mouth of the bays with complete absence in the head of the bays (Figures 19 and 20).

Walleye pollock

Walleye pollock was the second most abundant cod captured and it occurred in 70% of the hauls. Catch rates were much greater in Alit[illegible] than Ugak Bay and throughout Ugak catch rates were fairly uniform (Figure 21). Within Alitak Bay catches were greatest in the outer half of the bay (Figure 22).

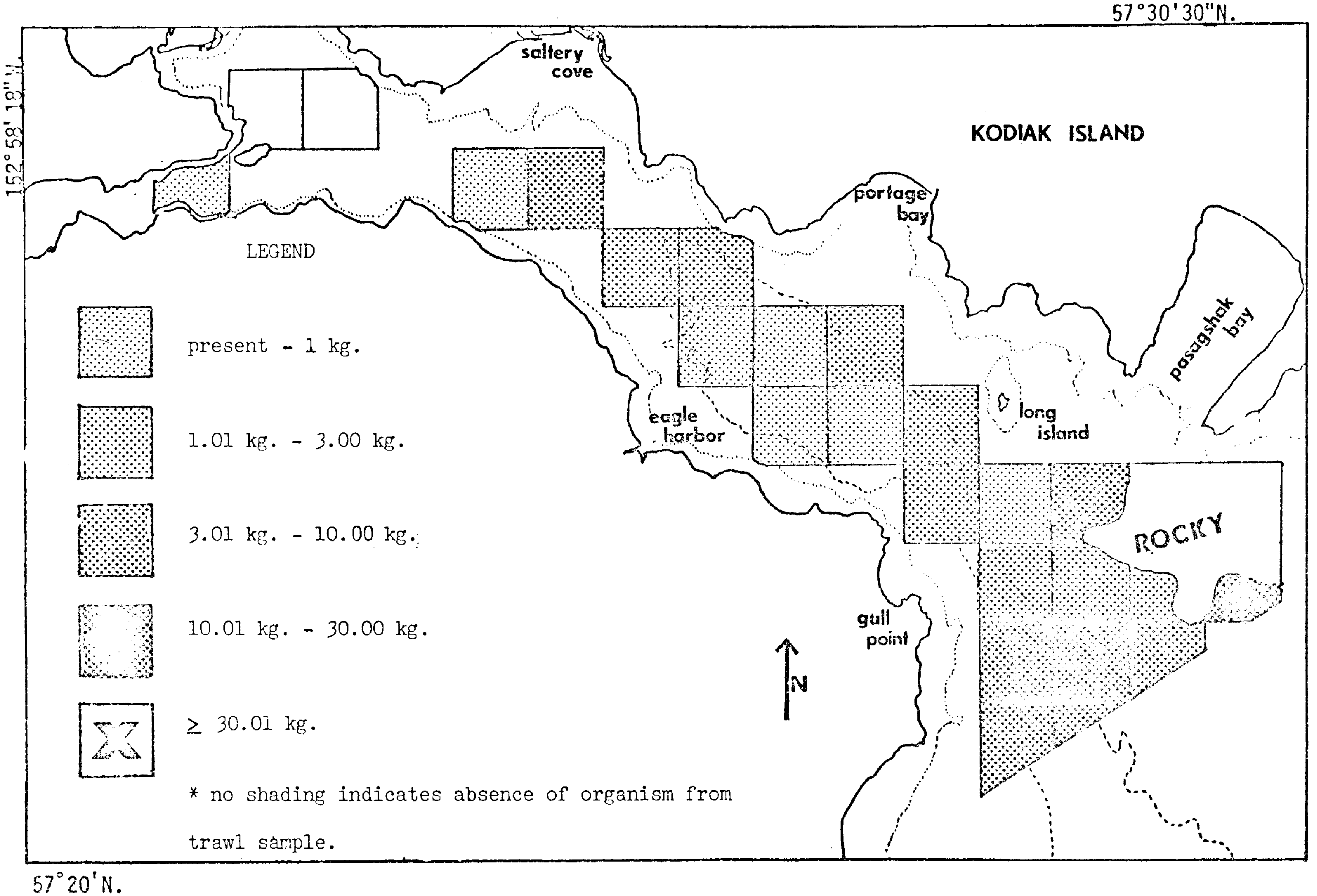

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Figure 15. Distribution of arrowtooth flounder (*Atheresthes stomias*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

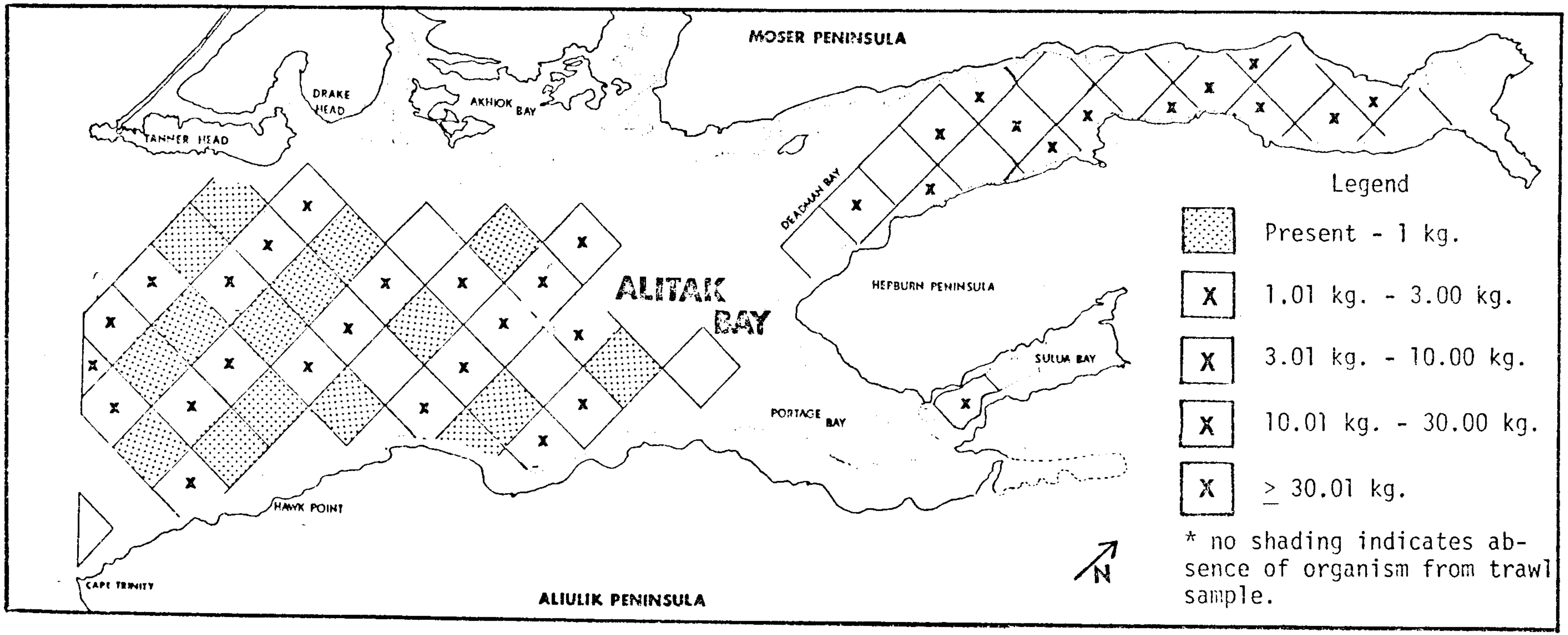

Figure 16. Distribution of arrowtooth flounder (*Atheresthes stomias*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

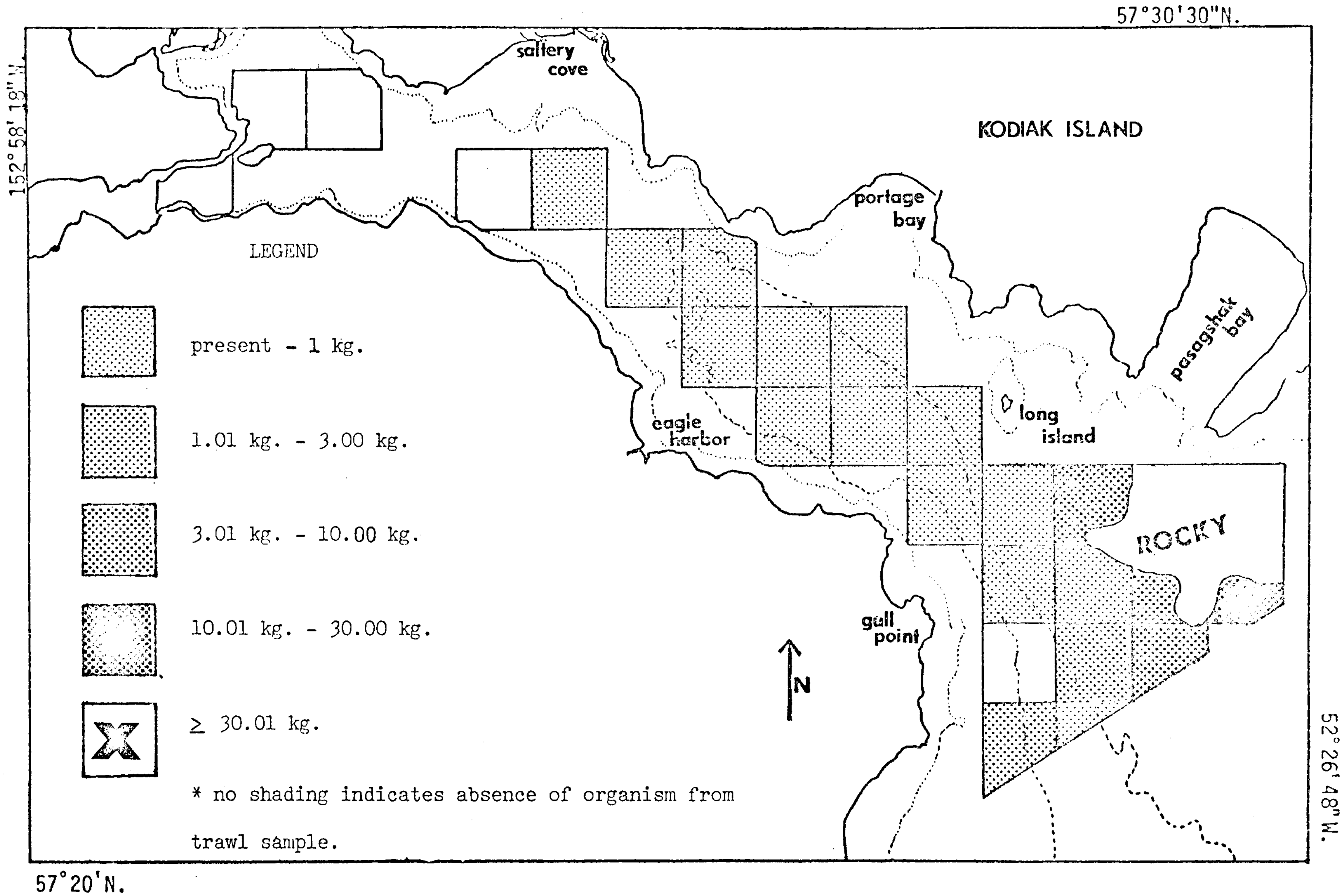

Figure 17. Distribution of butter sole (*Isopsetta isolepis*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

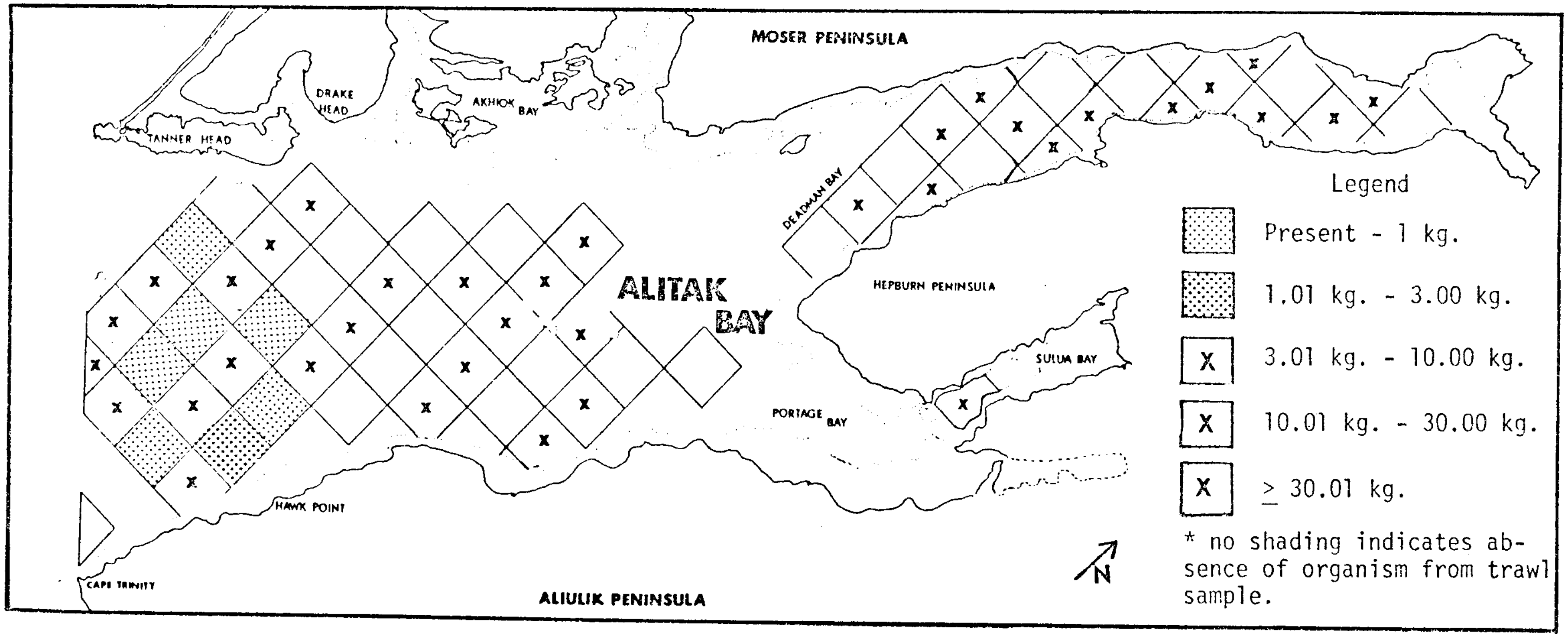

Figure 18. Distribution of butter sole (*Isopsetta isolepis*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

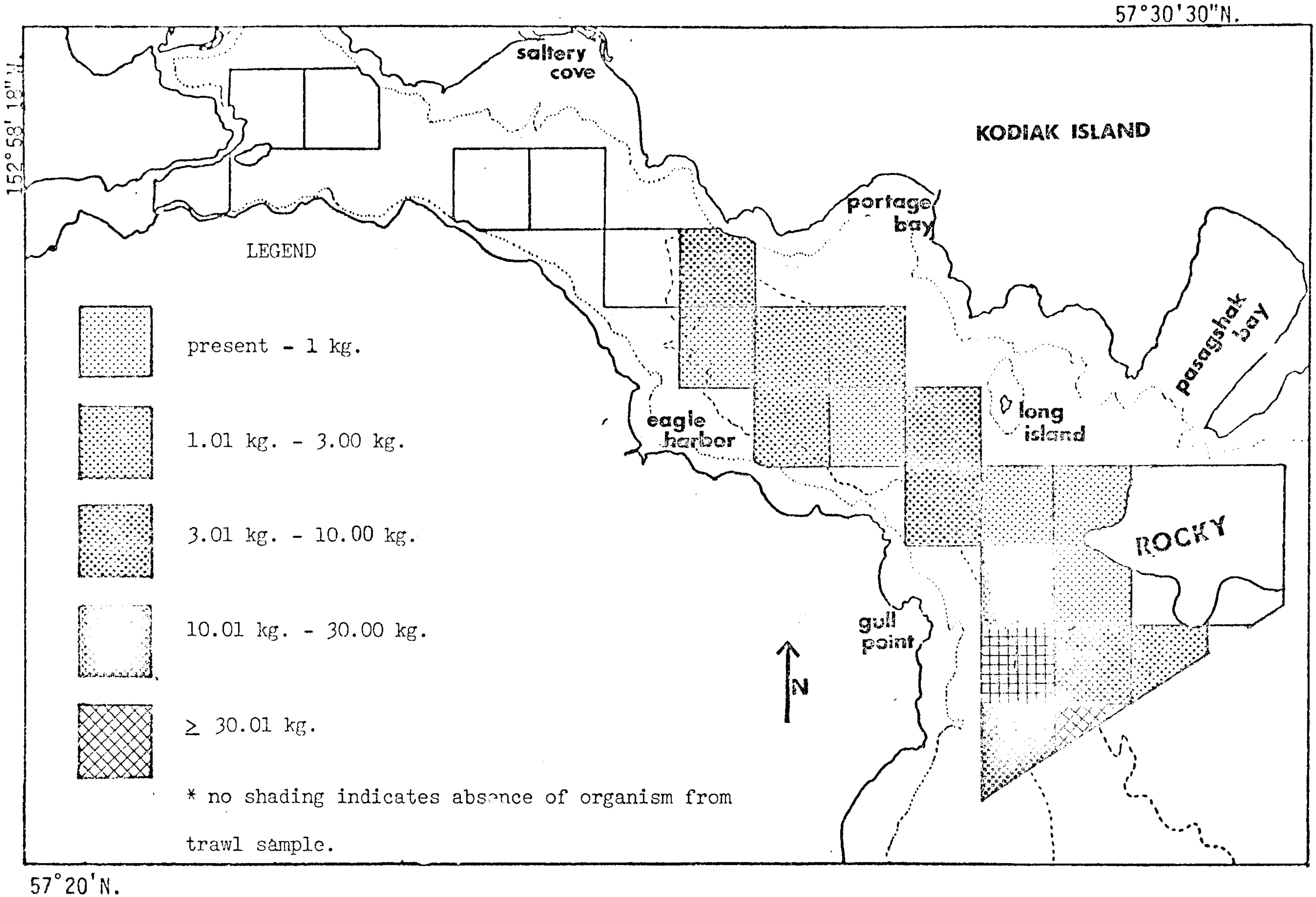

Figure 19. Distribution of Pacific cod (*Gadus macrocephalus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

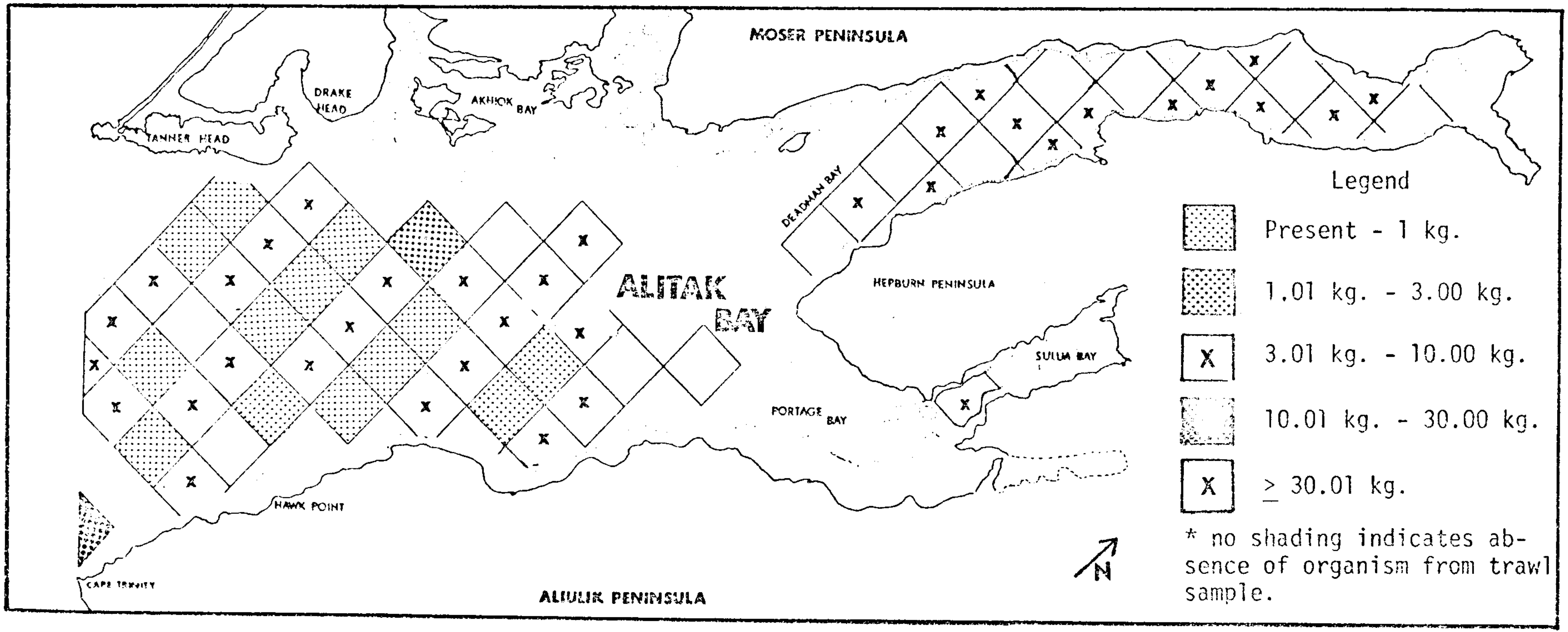

Figure 20. Distribution of Pacific cod (*Gadus macrocephalus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

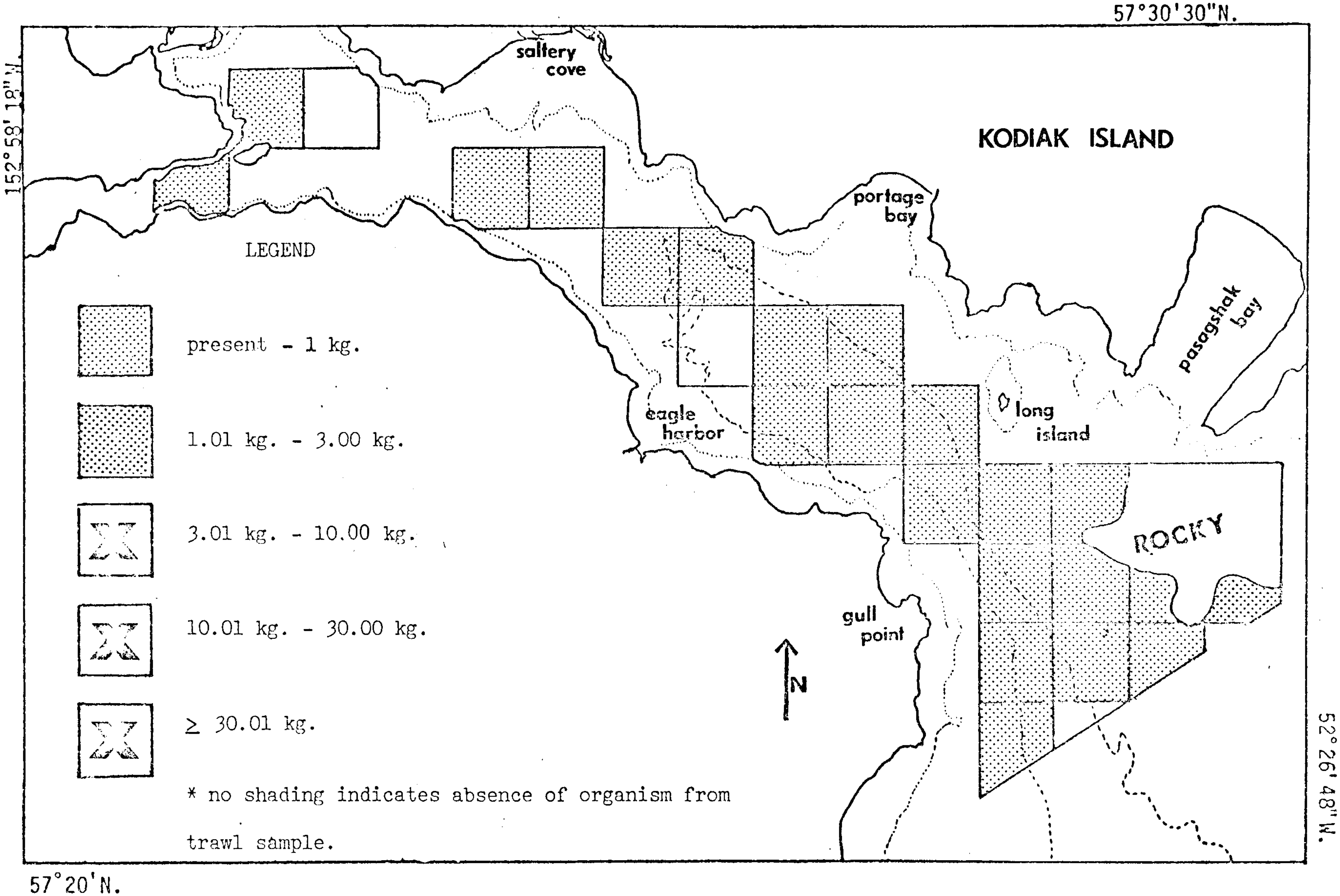

Figure 21. Distribution of Walleye pollock (*Theragra chalcogramma*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

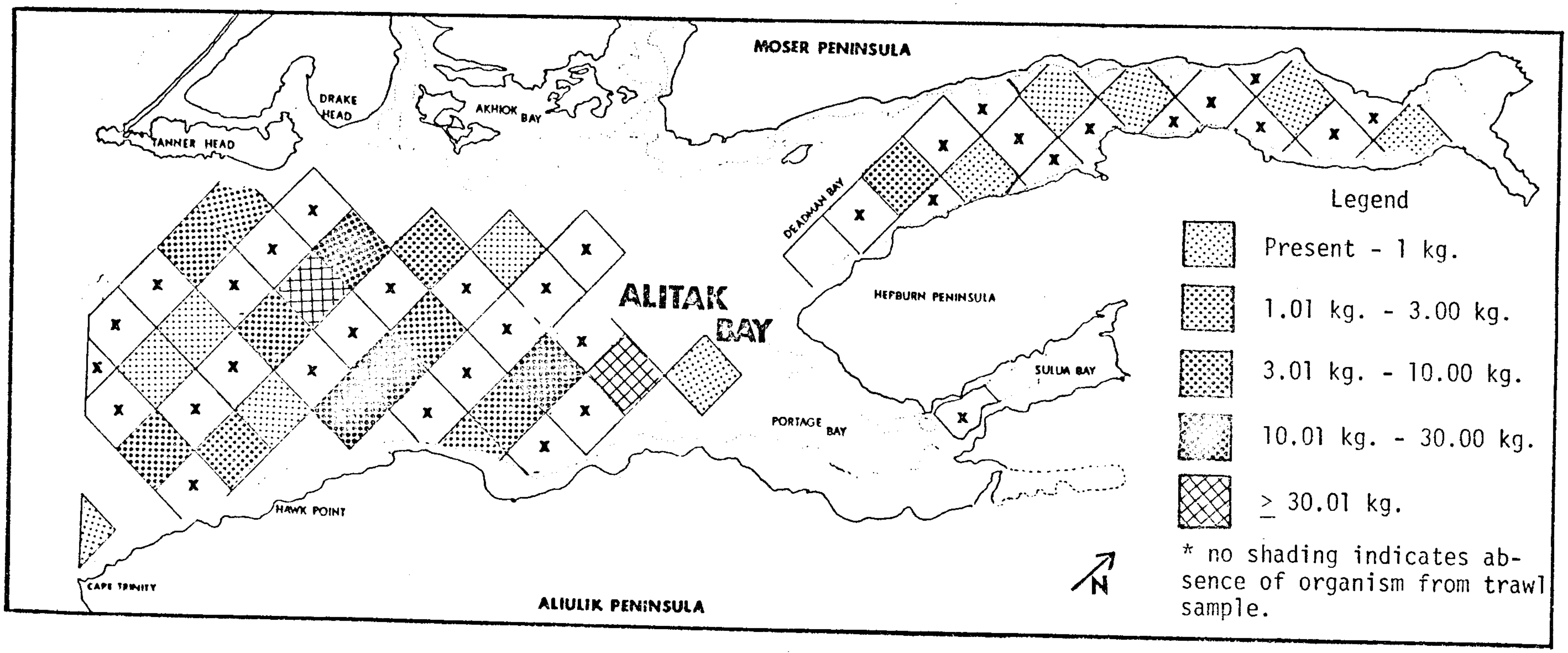

Figure 22. Distribution of Walleye pollock (*Theragra chalcogramma*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

The fish captured were almost entirely juveniles.

Pacific tomcod

Pacific tomcod was captured in small numbers in 19% of the hauls. They were evenly spread in the outer portion of Ugak Bay and occurred only in the outer portion of Alitak Bay (Figures 23 and 24).

Sculpins, Family Cottidae

Great sculpin

The great sculpin was the most abundant sculpin species captured it occurred in 93% of the hauls. Catch rates were approximately the same in both Ugak and Alitak bays and were fairly uniform within each bay (Figures 25 and 26).

Yellow Irish Lord

Yellow Irish Lords was the second most abundant sculpin captured and it occurred in 80% of the hauls. Catches were considerably greater in Ugak than in Alitak Bay and in both bays there was a tendency for greater catches to occur near the mouth of the bays (Figures 27 and 28). The greatest catch was 247 kg/20 min haul and occurred near the mouth of Ugak Bay in June. This species occurred in far greater abundance in June and July than in August and September. Some difficulties were encountered identifying this species and separating it from the red Irish Lord. In a few cases the red Irish Lord may have been combined with the yellow but since it occurred only in small numbers, there is likely very little bias in the weight information.

Gymnocanthus sp(p)

Gymnocanthus sp(p) was the third most abundant sculpin captured and it occurred in 55% of the hauls exclusive of June samples. During June this

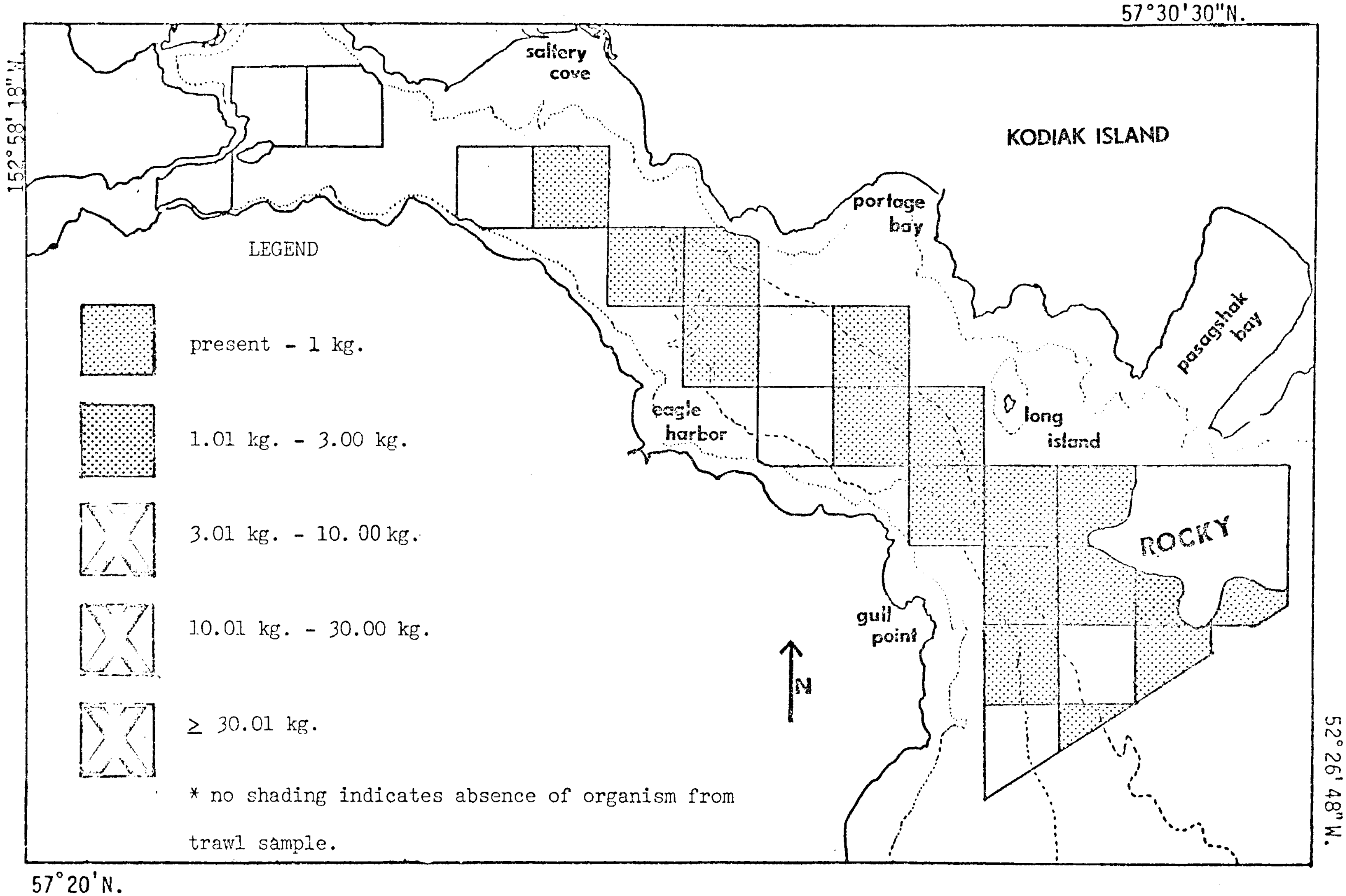

Figure 23. Distribution of Pacific tomcod (*Microgadus proximus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

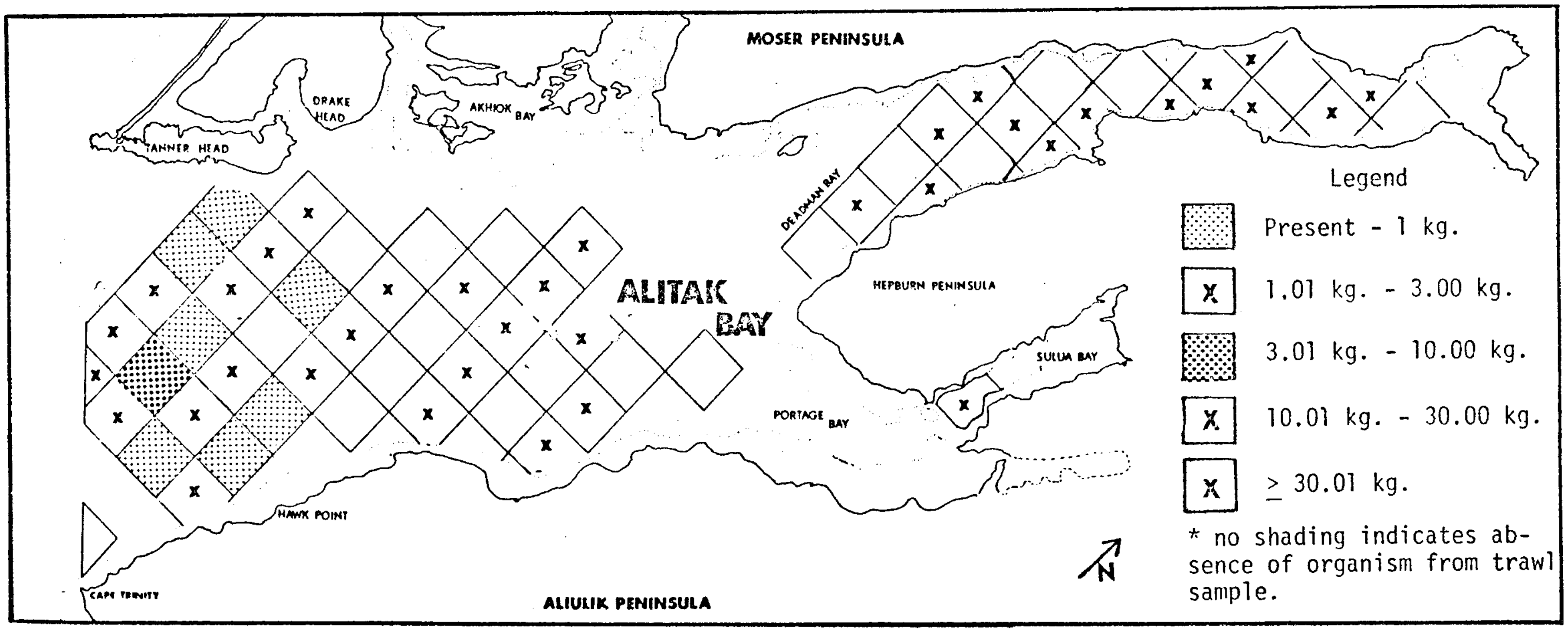

Figure 24. Distribution of Pacific tomcod (*Microgadus proximus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

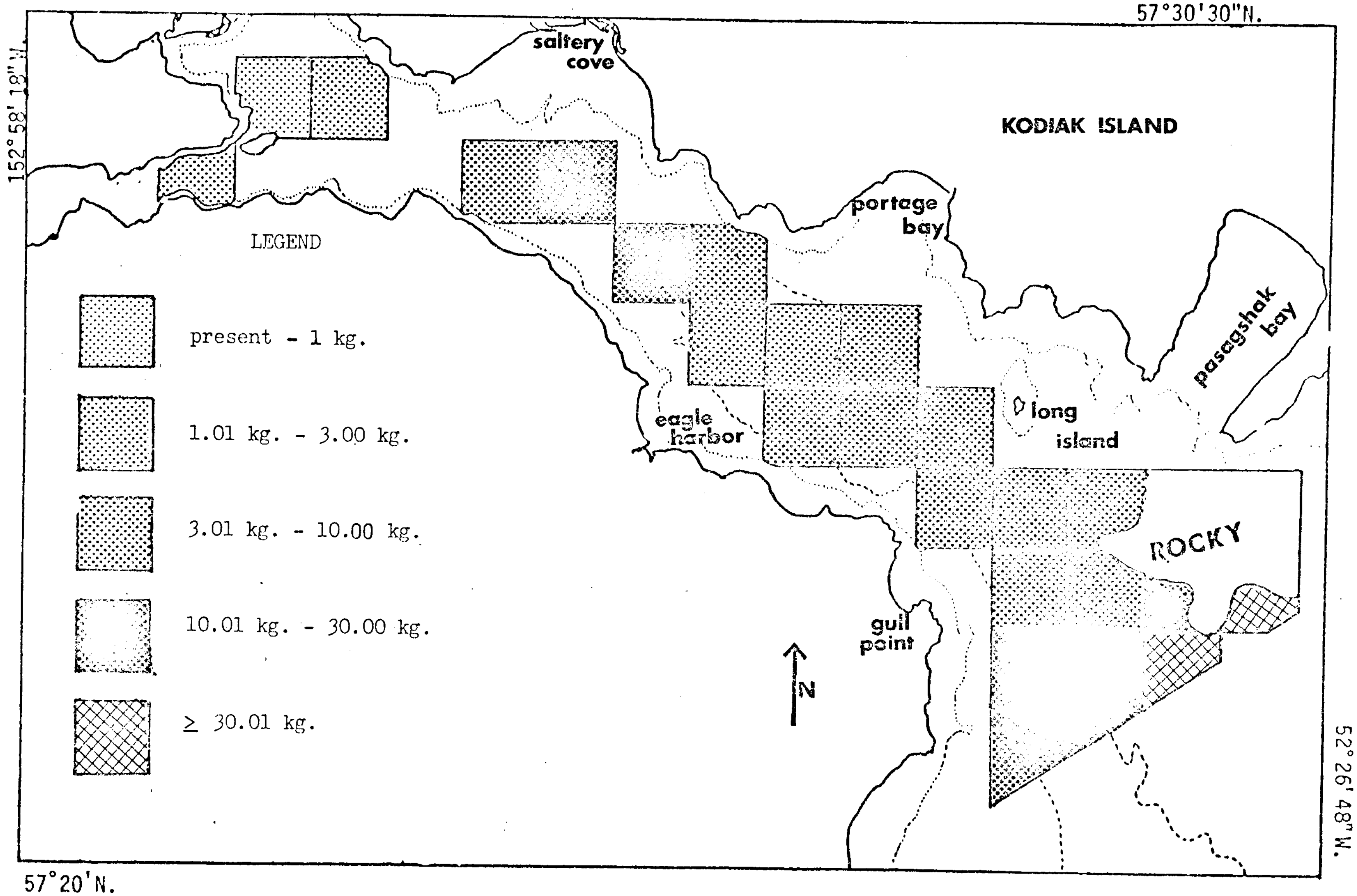

Figure 25. Distribution of Great sculpin (*Myoxocephalus polyacanthocephalus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

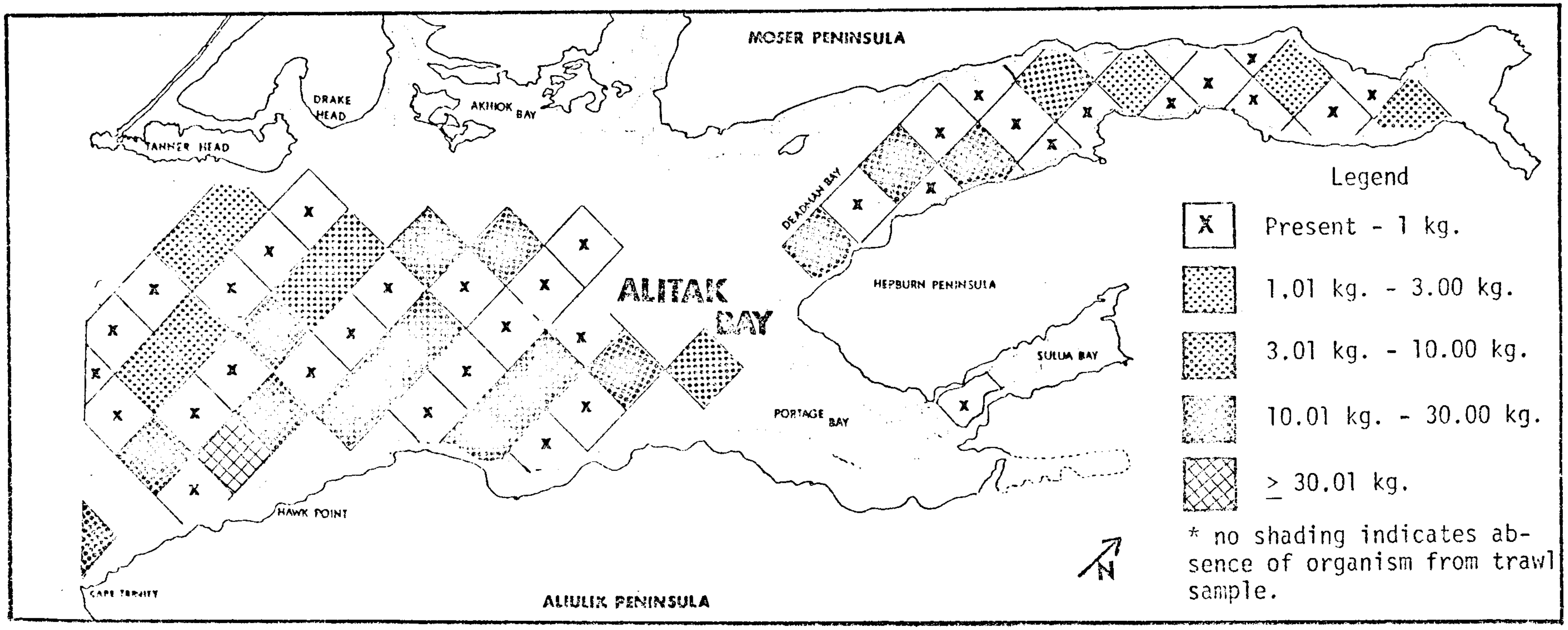

Figure 26. Distribution of Great sculpin (*Myoxocephalus polyacanthocephalus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

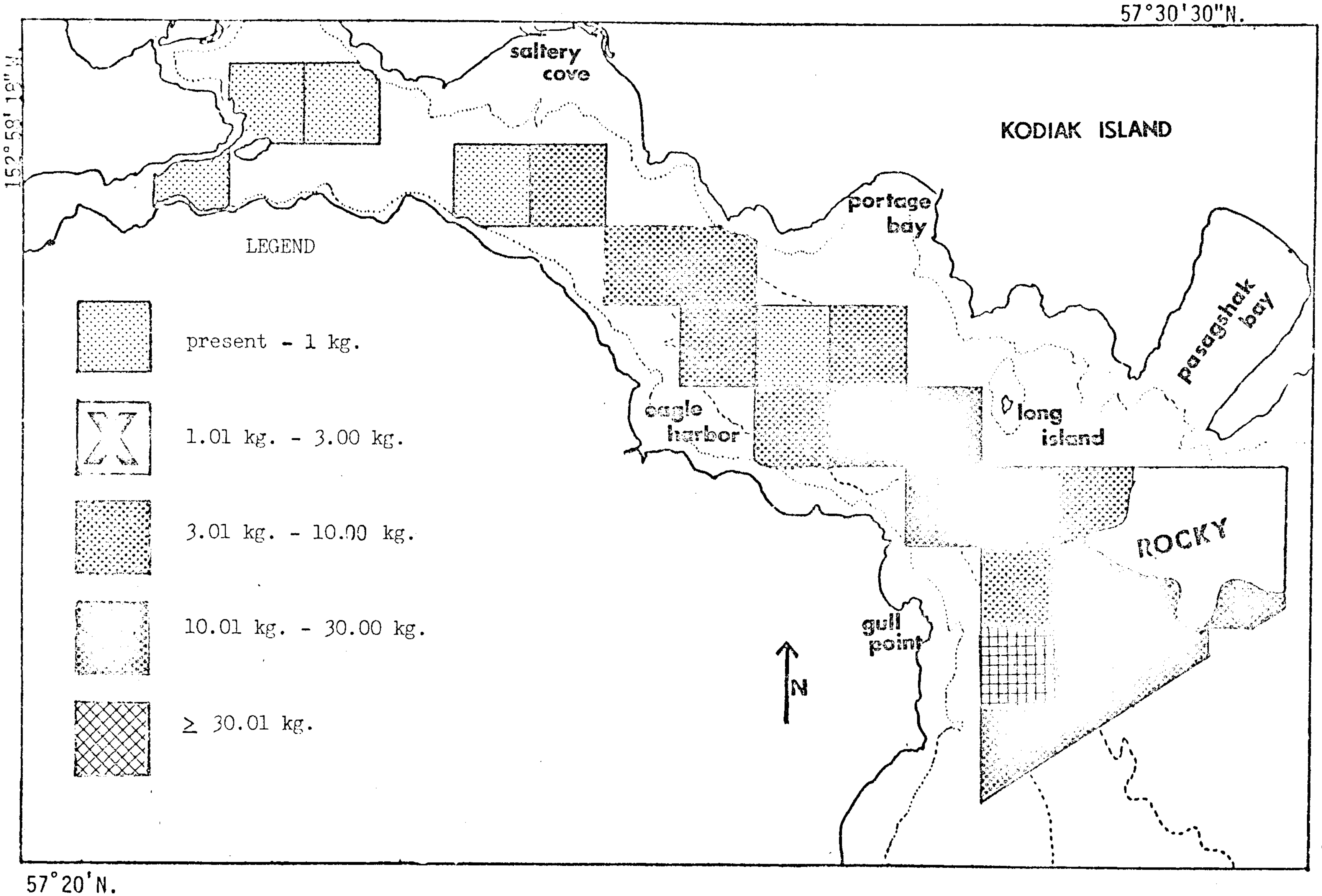

Figure 27. Distribution of Yellow Irish Lord (*Hemilepidotus jordani*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

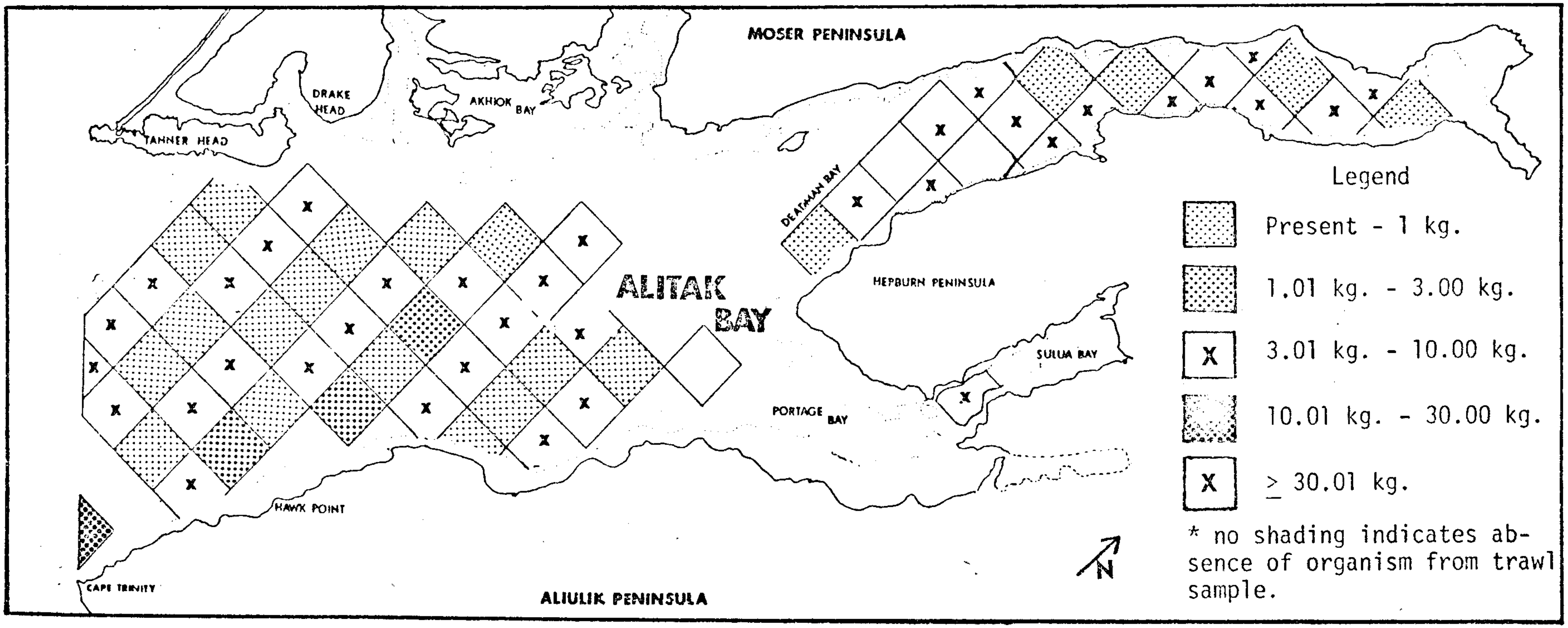

Figure 28. Distribution of Yellow Irish Lord (*Hemilepidotus jordani*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

taxon was not correctly identified or separated from other unidentif .culp-ins. This taxon was captured in much greater abundance and frequency in Ugak Bay where it occurred in 94% of the hauls and catches were as great as 34 kg/20 min tow.

Other sculpins

Several other sculpin species were captured in small numbers (Table 3), however, information on their distribution has not yet been tabulated.

Smelt, Family Osmeridae

Capelin

Capelin was the predominant smelt, occurring in 65% of the hauls. They were more frequent and abundant in Ugak than Alitak Bay. Within Ugak Bay capelin were most abundant in the middle portion of the bay (Figure 29) and within Alitak Bay capelin were most abundant at the head of Deadman Bay and on the eastern side outside of Portage Bay (Figure 30). Capelin catch was at a low during July with no catch over 0.6 kg/20 min tow while catches of 18, 19 and 49 kg/20 min tow occurred during June, August and September, respectively.

Eulachon

Eulachon occurred in 28% of the hauls and was slightly more abundant in Ugak Bay than in Alitak. It occurred without a strong pattern of abundance in either bay (Figure 31 and 32), however, there was a weak tendency for bigger catches in the middle portion of Ugak Bay. The largest catches of eulachon occurred in June with total catch in both bays in later months never exceeding 1 kg.

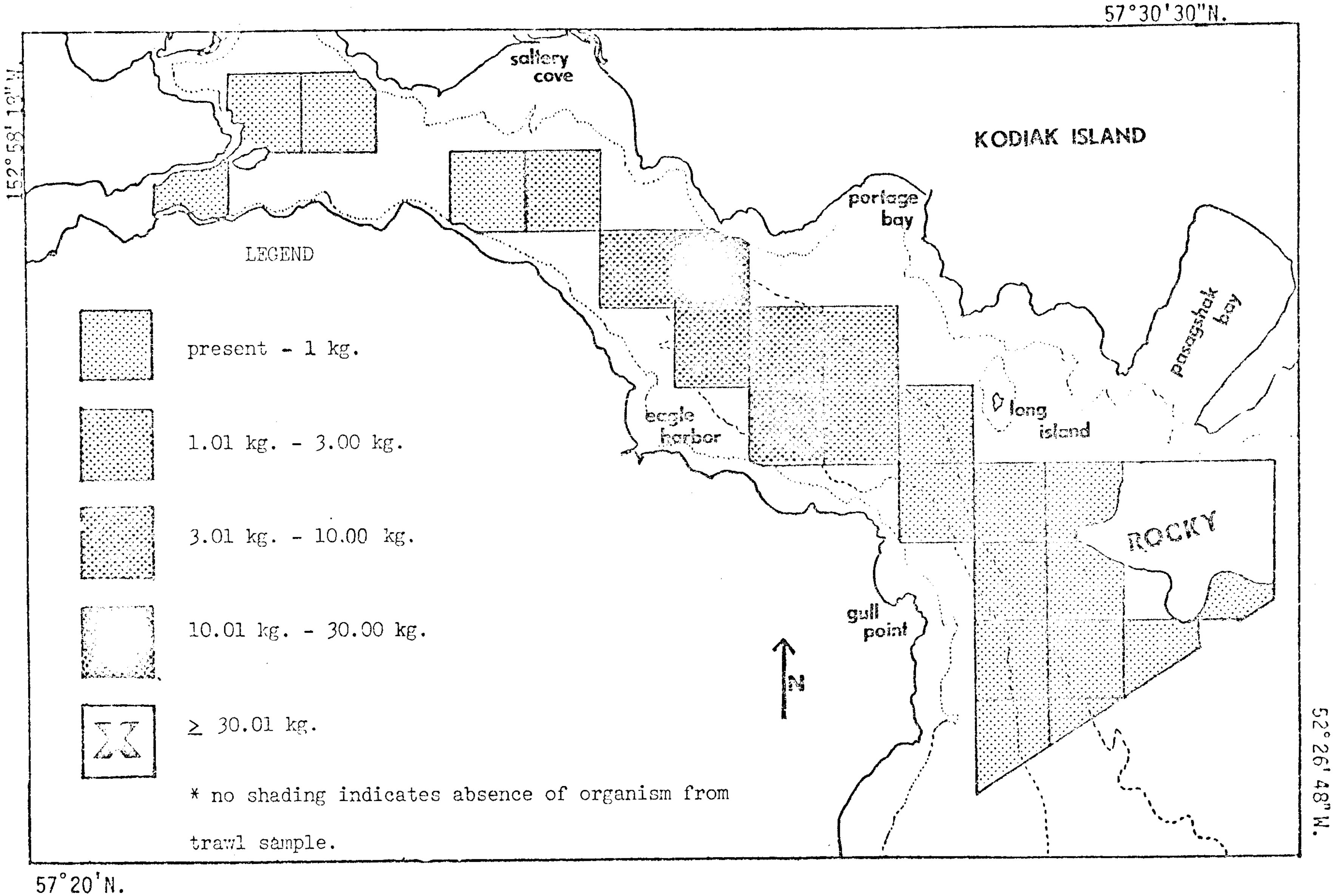

Figure 29. Distribution of Capelin (*Mallotus villosus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

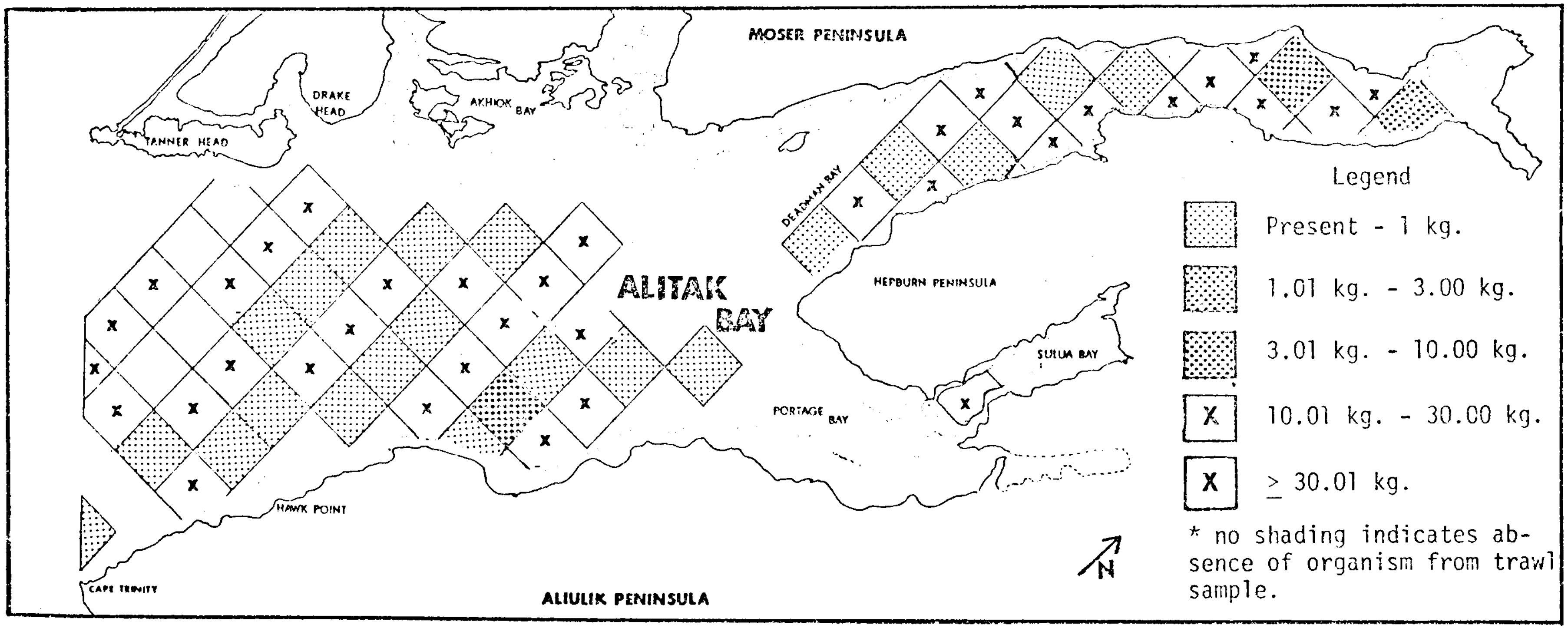

Figure 30. Distribution of Capelin (*Mallotus villosus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

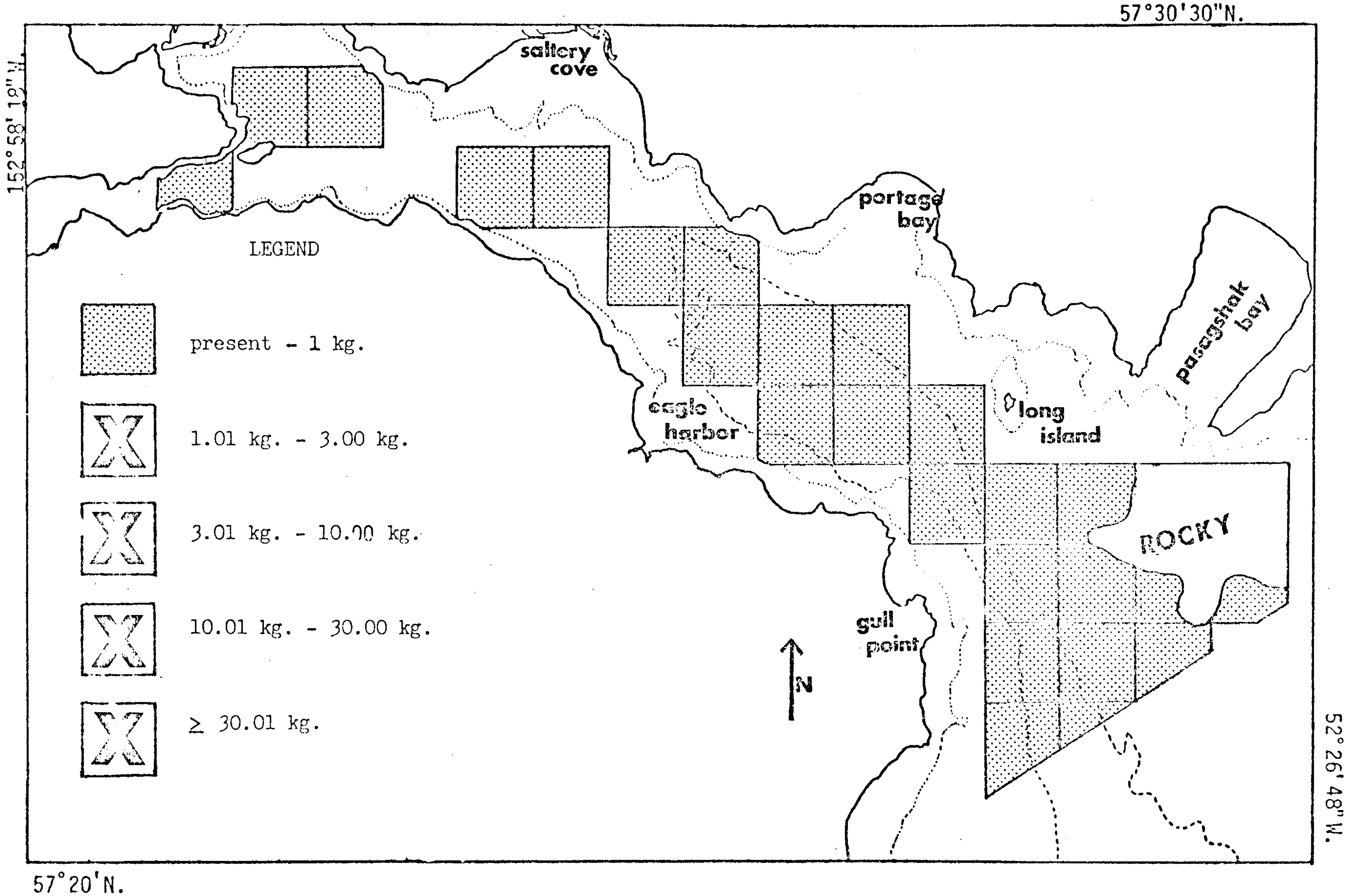

Figure 31. Distribution of Eulachon (*Thaleichthys pacificus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

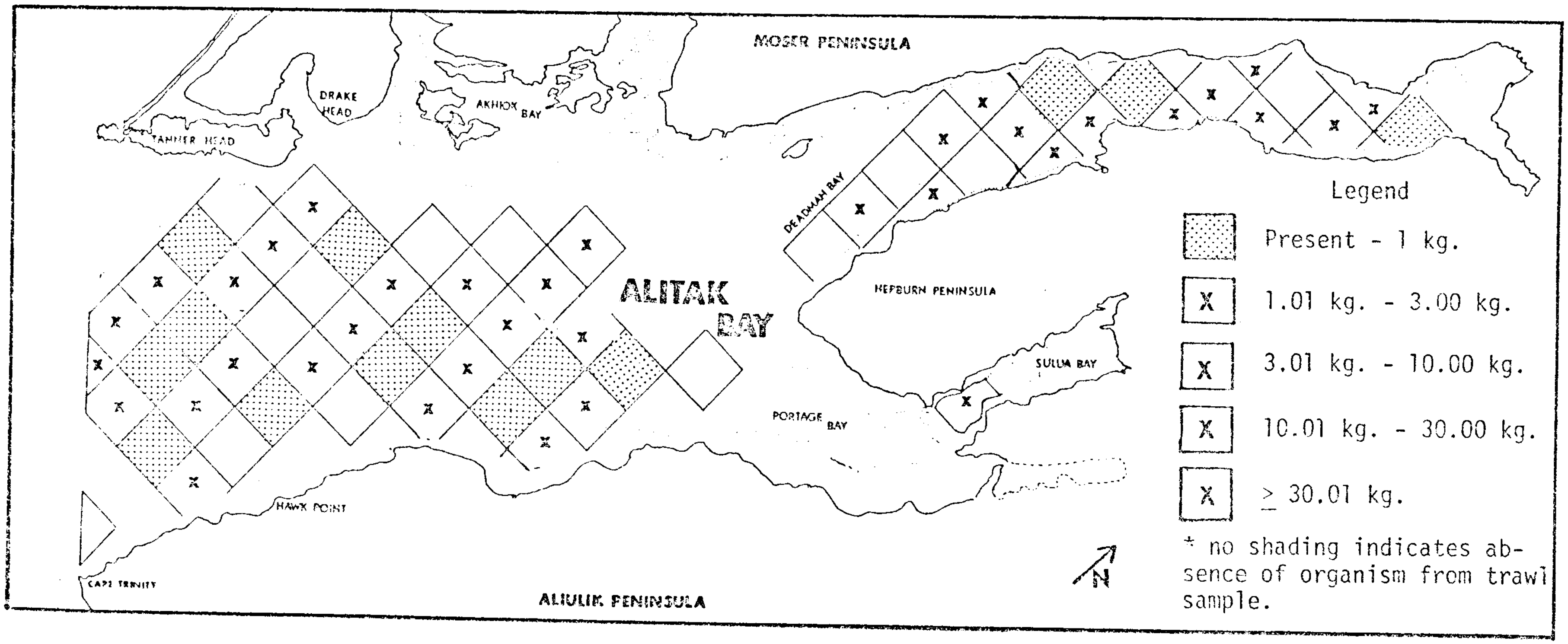

Figure 32. Distribution of Eulachon (*Thaleichthys pacificus*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

Other Taxa

Pacific sandfish occurred in 47% of the hauls, usually in small weight abundance but considerable numerical abundance. The largest weight catch was 81 fish weighing 3.6 kg/20 min tow and the largest numerical catch was 304 fish weighing 1.62 kg/20 min tow. It was present in similar abundance throughout both bays with the exception of the Deadman Bay portion of Alitak where it was never captured (Figures 33 and 34). It was least frequent and abundant in June, increasing in July, and in August the greatest frequenc occurred when it was present in 100% of the hauls in Ugak and 55% of the hauls in Alitak Bay. The mean catch per haul was greatest in August in Ugak Bay and was greatest in September in Alitak Bay. Average fish weight in Alitak Bay decreased from 56 g in June to 31 g in September. Average weight in Ugak Bay went from 77 g in June to 132 g in July to 9.5 g in August and 10.4 g in September.

Several other taxa occurred in modest frequency and abundance, notably the various pricklebacks, eelpouts, snailfish, and poachers, but this information is not yet tabulated.

The crustacean data is not covered in this report since it was gathered by R.U. 517, entitled "The Distribution, Abundance and Diversity of the Epifaunal Benthic Organisms in Two (Alitak and Ugak) Bays of Kodiak Island, Alaska."

VII Discussion

The distinct tendency for catch rates of fish to be greatest near the mouth and decrease further within the bays was displayed by nearly every species. A few small sized fish (snailfish, eelpouts, and pricklebacks) were more abundant

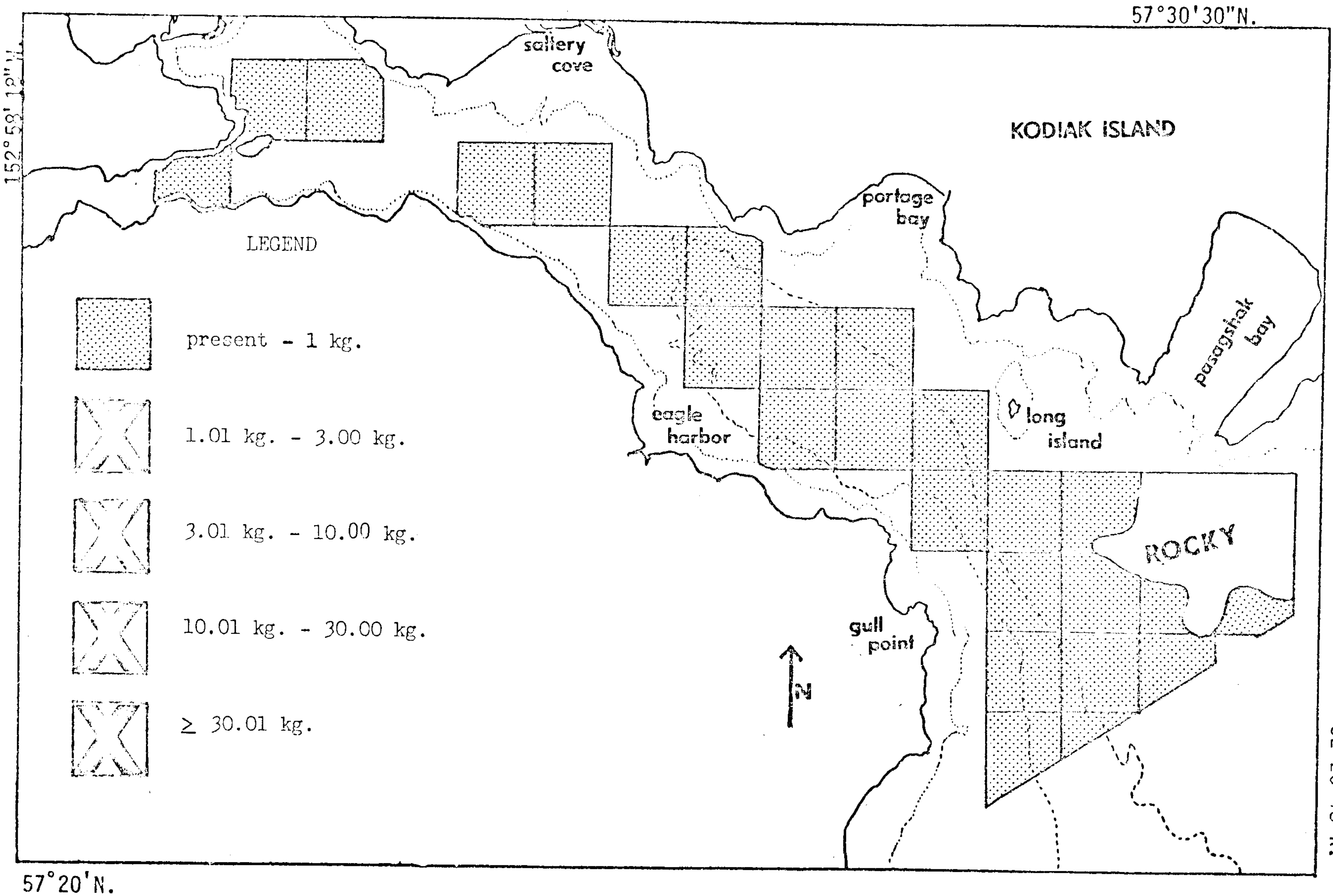

Figure 33. Distribution of Pacific sandfish (*Trichodon trichodon*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Ugak Bay.

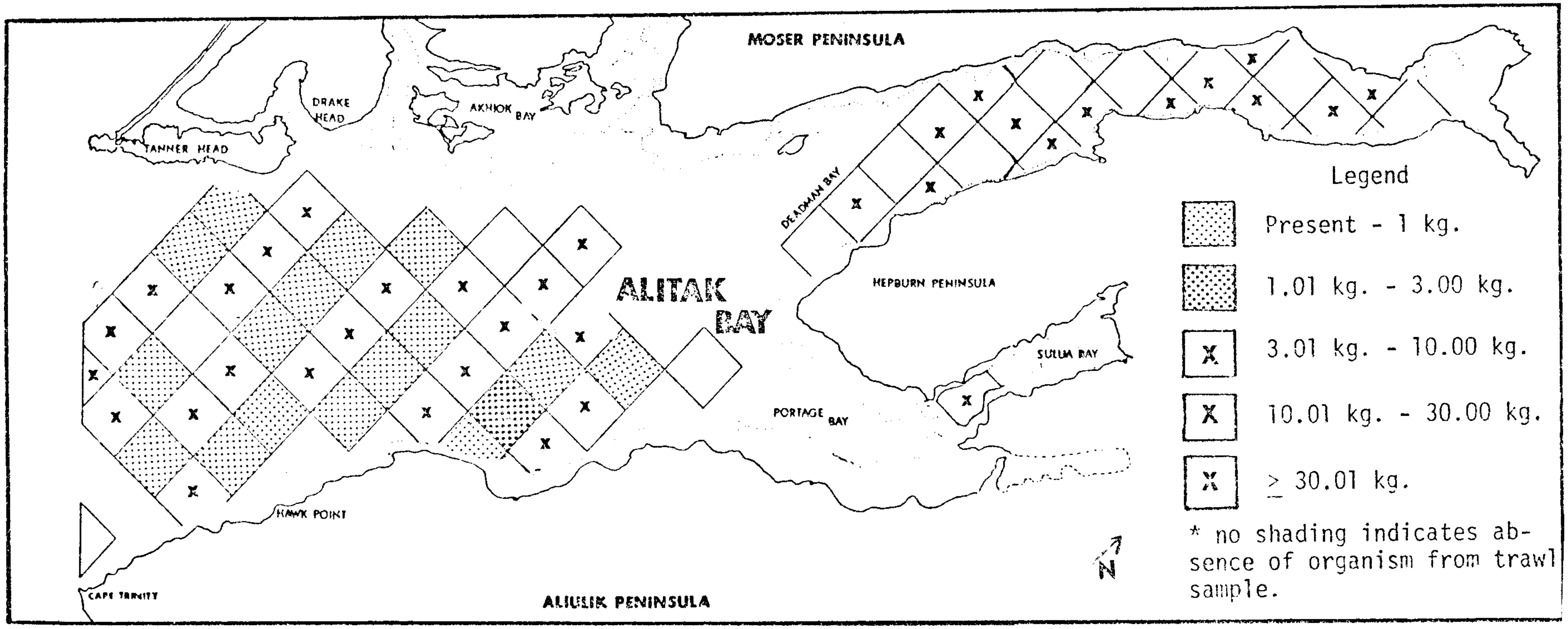

Figure 34. Distribution of Pacific sandfish (*Trichodon trichodon*) mean catch for the months June, July, August and September 1976 in kg/20 minute tow in Alitak Bay. Unsampled areas are marked with an x.

or only present in the heads of the bays. However, some shelf inhabiting species (Pacific cod, arrowtooth flounder, and Pacific halibut) were infrequent or absent from the heads of the bays. The general increase in fish catch closer to the mouth of the bay is provocative but without knowledge of catch rates around the mouth of the bays it is difficult to interpret. It is not possible to determine whether fish are more dense near the mouth of the bays or less dense within the bays. If the catch data presented by Hughes and Alton (1974) are comparable, which they should be, then the area off Ugak contains higher densities than were found in Ugak Bay or in the mouth of the bay.

A large number of juvenile walleye pollock, flathead sole, Pacific sandfish, and other species were captured. Since many of these juveniles especially young-of-the-year, were smaller than the net mesh, the catches underestimates of true density or relative abundance of juveniles. The extent to which net selectivity for larger fish contributed to the decrease in total fish catch within the bays cannot be estimated. The distribution within the bays has been examined for yellowfin sole and apparently average size of fish decreases with decreasing depth and also decreases further within a bay, at one depth. This has not yet been statistically tested, however. Preliminary examination of data for other species suggests that this tendency may be quite generally true.

VIII Conclusions

The biota of the demersal zone in Ugak and Alitak Bays in summer as reflected by otter trawl catches, consists of crustacea (48%), flounders (27%), sculpins (12%), and cod (6%).

The greatest biomass of fish was found nearest the mouths of Ugak and Alitak Bays and decreased within them. Most major species reflected this distribution pattern. Some taxa, notably cods, were fairly abundanct at the mouths of the bays but were infrequent or absent from the heads of the bays. A few taxa were more abundant within the bays. The distribution of yellowfin sole apparently was affected by both distance within the bay and depth, with smaller mean sizes occurring further within the bay (at one depth) and smaller mean sizes occurring at shallower depths.

IX NEEDS FOR FURTHER STUDY

Additional work should be done on biological characteristics of the resident species. Food habits will need more work than this project was able to complete. Spawning seasons and localities of fish need to be further documented. There may be locations where early juveniles of various species are abundant and these should be identified. Some of the species captured in this study were largely represented by juveniles and further work on nearshore and juvenile fish should be done. Age and growth studies of local fish would be of considerable value and should be pursued.

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Northwest and Alaska Fisheries Center Processed Report*

DISTRIBUTION OF KING CRAB, PANDALID SHRIMP, AND BRACHYURAN CRAB LARVAE IN KACHEMAK BAY, ALASKA, 1972

by

Evan B. Haynes and Bruce L. Wing

RESEARCH UNIT # 490

Northwest and Alaska Fisheries Center Auke Bay Fisheries Laboratory
National Marine Fisheries Service, NOAA
P.O. Box 155, Auke Bay, AK 99821

JANUARY 1977

*This report does not constitute a publication and is for information only. All data herein are to be considered provisional.

CONTENTS

MATERIALS AND METHODS

Plankton tows were made semi-monthly in Kachemak Bay beginning the latter half of March and extending through June 1972. Samples were collected using the National Marine Fisheries Service (NMFS) research vessel *Sablefish* except during the latter half of May when a few plankton tows were made with the University of Washington's research vessel *Commando*. At the end of June we lost use of the vessels and had to stop sampling even though zoeae were still in the water.

The station pattern consisted of 24 stations distributed somewhat evenly over an area of about 688 km^2 (266 square miles) (Fig. 1). Not all stations were sampled during each semi-monthly period because of inclement weather, especially at the beginning of the sampling season. The stations sampled during each semi-monthly sampling period are indicated in the figures showing zoeal distribution.

Plankton tows were made with Miller high-speed samplers (Miller 1961). Nets with No. 0 mesh (571 microns) were used throughout the study. This type of gear retains its theoretical filtering capacity up to three-fourths clogging and at speeds up to 10 knots (Miller 1961).

Four samplers were towed simultaneously in a step-oblique manner at each station. Each sampler sampled one-fourth of the water column in five step intervals of 2 min each regardless of station depth. For purposes of discussion, portions of the water column sampled are referred to in the text as strata A, B, C, and D from surface to bottom respectively. Tows were made in a circular manner to minimize effects of currents.

Because a disproportionate increase in length of wire would be necessary to reach greater depths, no samples were taken deeper than 100 m.

Theoretical computations show that at depths of 100 m or less, the percentage of the tow taken outside the desired sampling depth is 6% or less (Miller 1961). Based on Miller's calculations, we have assumed that sample contamination derived from a sampler fishing outside its intended stratum is negligible.

Estimates of water volume filtered during each tow were calculated from a Rigosha flow meter. The flow meter was enclosed in a PVC housing fitted with stabilization fins and attached at the wire stop along with the top sampler. Adjustments for water filtered by the deeper samplers were obtained by making repeated tows at various depths with flow meters attached at each sampler position. Once these corrections were obtained, only the top flow meter was used. Flow meters were calibrated by towing them over a known distance at sampling speed. The meters performed consistently over the entire sampling period.

DISTRIBUTION OF KING CRAB, PANDALID SHRIMP, AND BRACHYURAN CRAB LARVAE IN KACHEMAK BAY, ALASKA, 1972

Evan B. Haynes and Bruce L. Wing[1]

INTRODUCTION

Shrimp and crab support major fisheries in Alaska. Research designed to provide management programs for optimum utilization of these stocks has dealt mainly with the adults and pre-recruits. The only published studies on the larvae of these forms in Alaska have been those of Takeuchi (1962, 1968), Rodin (1966), and Haynes (1974) on the geographical distribution of zoeae of the king crab, *Paralithodes camtschatica*, in the southeastern Bering Sea and Hoffman (1968) on the morphology of larvae of the blue king crab, *P. platypus*. Recently Haynes (In press) has described the larval development of the coonstripe shrimp, *Pandalus hypsinotus*, and other pandalid shrimp species.[2] Lastly, Jewett and Haight have studied the morphology of the megalopa of *Chionoecetes bairdi*.[3]

In 1971 the Northwest Fisheries Center Auke Bay Fisheries Laboratory began a comprehensive study on the larvae of king crab and shrimp in Kachemak Bay, Alaska. In general, the study was designed to determine the distribution, abundance, and survival of the larvae and to develop appropriate methods for raising the larvae for laboratory studies. The first phase of the study was to determine the locations in Kachemak Bay where larvae are released and their subsequent dispersal from the releasing areas. Preliminary sampling began in spring 1971, primarily to standardize sampling techniques and to verify expected seasonal occurrence of larval release. Sampling in 1972 was more extensive and was designed to determine the areas of release and the dispersal of larvae from the releasing areas. In this report we describe the distribution and dispersal of king crab zoeae in Kachemak Bay and compare their distribution with known patterns of water movement. We also comment on the distribution of pandalid shrimp and brachyuran zoeae in Kachemak Bay.

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[1]Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 155, Auke Bay, AK 99821.

[2]Haynes, Evan. Description of zoeae of the humpy shrimp, *Pandalus goniurus*, reared in situ in Kachemak Bay, Alaska. Unpubl. manuscr. 25 p. Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, Auke Bay, AK 99821.

[3]Jewett, S. C., and R. E. Haight. Description of megalopa of snow crabs, *Chionoecetes bairdi* Rathbun (Majidae, subfamily Oregoniinae). Unpubl. manuscr., 10 p. Northwest Fisheries Center Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, Auke Bay, AK 99821.

Plankton tows were made during daylight except on May 10-11, when a 24-h station was occupied for the purpose of studying the diel vertical distribution of zoeae. At this station, tows were made every 2 h beginning at noon on May 10 and ending at noon on May 11. In addition to the four samplers towed in the usual manner, another sampler was towed just under the surface at each 2-h interval from 8 pm May 10 to 8 am May 11. During the 24-h station, total radiation was measured with a Belfort pyrheliograph. Water temperatures were taken at 10-m intervals after each tow using a calibrated Beckman Model RS5-3 induction salinometer. For this aspect of the study, only data on the king crab zoeae are presented; the samples were not processed for other larvae.

In the laboratory, samples containing about 400 larvae or less were examined in their entirety; when the sample contained more than about 400 larvae, it was divided into equal portions using a splitter similar to that described by Cooney (1971). The splitter showed no significant differences (P = 0.05) among either individual or pooled aliquot counts.

The charts showing distribution and abundance of zoeae were made by plotting the number of zoeae at each station and then drawing isopleths. Identification of zoeal stages was based on descriptions given by Sato and Tanaka (1949), Marukawa (1933), and Kurata (1964).

GEOGRAPHICAL DISTRIBUTION

King Crab Zoeae

King crab zoeae occurred in the 1972 plankton collections from late April to the end of June, when sampling terminated. During this time, the distribution and abundance of zoeae varied considerably, reflecting the period of zoeal release, changes in distribution of zoeae by water movements, and settling (Figs. 2-8). The locations of both positive tows (containing king crab zoeae) and negative (not containing king crab zoeae) are indicated in the charts showing zoeal distribution. The terms "outer bay" and "inner bay" refer to the area of the bay from Homer Spit seaward to the outermost transect of stations and from Homer Spit to the head of the bay, respectively.

No king crab zoeae were captured at stations occupied the last half of March and the first half of April (Figs. 2 and 3). King crab zoeae first occurred in the plankton samples during the latter half of April. Area of greatest abundance occurred as a band extending seaward from off Bluff Point to station 17. Abundance decreased rapidly on either side of this band. All other tows were negative except for a few zoeae collected at station 9 (near Kasitsna Bay) (Fig. 4).

During the first half of May, zoeal abundance increased markedly in the outer bay. Greatest abundance occurred in the northern half of the outer bay and was centered at station 17 (Fig. 5). Dispersal of zoeae extended eastward to Homer Spit and then southward to China Poot Bay. Lower levels of abundance were found throughout the remainder of the outer bay and at the entrance to the inner bay. A few zoeae were also caught at the head of the bay (station 1). No zoeae were caught during this sampling period in either Tutka Bay or Sadie Cove.

During the latter half of May, abundance remained highest in the outer bay (Fig. 6). The most obvious feature of zoeal distribution at this time was the band of highest abundance that extended across the outer bay from south of Anchor Point to Seldovia Bay. Abundance decreased rapidly seaward of this band but remained relatively high shoreward and throughout most of the inner bay.

Both distribution and abundance of zoeae continued to change throughout the bay during the first half of June. Two areas of highest abundance existed in the outer bay, one that included stations 16 and 17 (in the center of the bay) and extended as a tail in a southwesterly direction to include station 23 (Fig. 7), and another extended as a band of abundance from Homer Spit southward to Kasitsna Bay. High abundance occurred between these two areas, and in the inner bay. Zoeal abundance along the outer transect of stations was relatively low except at stations 23 and 24. Low zoeal abundance also occurred along Bluff Point, at station 14, in Tutka Bay, and at the head of the bay.

A striking change in zoeal distribution and abundance occurred during the latter half of June in the northern portion of the outer bay between Anchor Point and Homer Spit. In this area, zoeal abundance had increased markedly, particularly at stations 12, 13, 17, and 18 (Fig. 8). Catches of zoeae throughout the remainder of the outer bay, although still high, had decreased from the previous sampling period, especially along the southern shore. A sharp reduction of zoeae had occurred in the inner bay.

In general, concentrations of Stage I larvae provide evidence of the location of releasing sites. In this study, the zoeae caught during April and nearly all of those caught during the first half of May were Stage I (Fig. 9). The initial occurrence and high abundance of these zoeae off Bluff Point indicate that this area is the major releasing area in Kachemak Bay for king crab zoeae. This assumption is supported by studies of female king crabs in Kachemak Bay by the State of Alaska Department of Fish and Game which show that egg-bearing king crab congregate in this area during spring at the time zoeae are released. Zoeae also occurred in other areas of the bay at this time, but their relatively low abundance and pattern of dispersal likely reflect transportation from the primary releasing area by tidal action and water currents rather than indicating additional release sites.

It is not known where the large numbers of zoeae that occurred off Bluff Point in late June were released.

Sampling during early May, the major period of zoeal release, did not extend seaward far enough to define the outer limits of the releasing area. It is possible, therefore, that some of the zoeae released off Bluff Point were carried seaward to return later along the northern shore of the bay. On the other hand, subsequent sampling seemed to indicate that the releasing area had not extended to the outer transect of stations (stations 19-24). The nearest known population of king crab occurs about 70 miles distant along the northern shore of Cook Inlet. It is not known if zoeae from this population are dispersed in such a manner that they would eventually be carried by currents into Kachemak Bay.

The present study was inadequate to determine areas where the zoeae settle. Although glaucothoe possess swimming capabilities (Sato 1958), they are characteristically a bottom-dwelling stage and not usually caught with conventional plankton gear. The few glaucothoe caught in this study were taken in the outer bay at stations 12, 17, 18, 22, and 23 during the latter half of June. The occurrence of glaucothoe at these locations may indicate areas of zoeal settling. The fact that glaucothoe were not caught elsewhere does not mean that zoeal settling was restricted to the outer bay. Unfortunately, there are as yet no practical means to sample glaucothoe quantitatively and attempts to determine their distribution and abundance must await development of appropriate sampling equipment.

Pandalid Zoeae

The geographical and seasonal distribution of pandalid zoeae in 1972 was similar to that of king crab zoeae. No pandalid zoeae were caught until the first half of April when they appeared at stations 13 and 17 (Fig. 10). By the latter half of April abundance of pandalid zoeae at these two stations had increased considerably. Lower levels of zoeal abundance occurred throughout the remainder of the bay (Fig. 11).

During the first half of May, abundance of pandalid zoeae was generally high throughout the outer bay but still low in the inner bay (Fig. 12). Zoeal abundance was highest at station 17, having increased from 208 zoeae/100 m^3 during the latter half of April to nearly 5,000 zoeae/100 m^3 during the first half of May. Zoeal abundance shifted slightly toward the inner bay during the second half of May, being highest at station 13, and had dropped considerably along the outer sample transect (Fig. 13).

Pandalid zoeal abundance during the first half of June was essentially identical to the previous sampling period except for a band of high abundance extending from the center of Kachemak Bay southwestward past Point Pogibshi (Fig. 14). During the latter half of June, pandalid zoeal abundance was highest in the northwestern quarter of the outer bay and relatively low elsewhere in the bay (Fig. 15).

Brachyuran Zoeae

The geographical distribution of brachyuran zoeae in 1972 was similar to king crab and pandalid shrimp zoeal distributions. No brachyuran zoeae were caught until the last half of April, when a few were collected in Tutka Bay and at stations 11 and 14 (Fig. 16). During the first half of May, brachyuran zoeae were distributed throughout most of the bay but were in low numbers (Fig. 17). During the last half of May, abundance of brachyuran zoeae increased markedly, being highest in a band from station 17 to Homer Spit, in Sadie Cove, and at station 2 (Fig. 18). The rest of the bay had intermediate numbers of brachyuran zoeae except the outermost bay where abundance was lowest. In the first half of June, numbers of brachyuran zoeae generally increased throughout the outer bay, with highest concentrations in the band between stations 17 and Homer Spit (Fig. 19).

In the first half of June, numbers of brachyuran zoeae generally increased throughout the outer bay, with highest concentrations in the band between station 17 and Homer Spit. The inner bay had a relatively low number of zoeae (Fig. 19).

Zoeal abundance remained high throughout the outer bay but conspicuously so at station 17 during the latter half of June (Fig. 20). Samples for the inner bay for the latter half of June were not processed because of lack of time.

Brachyuran megalopae were present in low numbers from late April through the end of sampling in late June. Megalopae were captured at 12 of 24 stations in the first half of June and at only 5 or 6 stations during other sampling periods.

Comparison of Geographical Distribution of King Crab, Pandalid Shrimp, and Brachyuran Zoeae

Geographical distribution of king crab, pandalid shrimp and brachyuran zoeae in Kachemak Bay were similar in area and times of occurrence in 1972. For each group initial high abundance, which indicates area of larval release, was in the middle outer bay near station 17. As the season progressed, abundance of larvae continued to increase in the outer bay, especially near station 17. Abundance of larvae in inner Kachemak Bay, Sadie Cove, and Tutka Bay remained relatively low compared to the outer bay. During the latter half of June, abundance of king crab and pandalid shrimp zoeae was highest in the northwestern quarter of the outer bay. Brachyuran zoeae in late June were somewhat uniformly distributed in the outer bay with high abundance near station 17.

VERTICAL DISTRIBUTIONS

The younger larval stages of many bottom invertebrates are positively phototactic, whereas older larvae approaching the stage of metamorphosis are increasingly negatively phototactic (Thorson 1950, p. 17). This implies that the younger larvae of these forms will be caught nearer the surface and the older larvae nearer the bottom. Takeuchi (1962) suggested that this phenomenon is true for zoeae of *P. camtschatica* but his data are too meager to substantiate his claim. In the present study the vertical depth distribution of *P. camtschatica* zoeae is similar regardless of age of zoeae.

Seasonal Vertical Distributions

To determine the vertical depth distribution of zoeae, we ranked by depth the midpoints of positive samples and tabulated the number of zoeae in the positive samples by stage. The resulting data were plotted as curves smoothed by averaging the number of zoeae in various depth intervals, the interval size depending on the depth and number of samples.

The vertical depth distribution was similar for all zoeal stages (Fig. 21). Zoeal abundance was low near the surface. Most zoeae were captured between 10 and 35 m depth. Few zoeae were found greater than 40 m.

Diel Vertical Migration

King crab zoeae in Kachemak Bay migrate vertically in a diel cycle. In the 24-h study of May 10-11, 1972, the percentage of king crab zoeae in the surface 15 m was highest between 1800 and 0800, corresponding to the hours of darkness and lower light levels (Fig. 22). During the hours of higher light levels (0800-1800), the percentage of zoeae was greatest in the 15-30 m depth stratum. In general the proportion of king crab zoeae in the lower strata, C and D (30-60 m), follows a pattern of being lowest during the period of low light levels and high during the period of high light levels.

It is not known if all four stages of king crab zoeae undergo diel vertical migration. The small percentage (1.1%) of stage II king crab zoeae in the 24-h samples precluded a meaningful depth comparison of this stage with stage I zoeae. Takeuchi (1962) sampled king crab zoeae both day and night at the surface and at 50 m depth in the southeastern Bering Sea. He found a slightly greater percentage of stage I and II zoeae at the surface during nighttime than stage III zoeae, but his data were insufficient to determine if this difference in zoeal abundance by depth was real.

Vertical migration of some zooplankton may be hindered or prevented by a thermocline (Mauchline and Fisher 1969, p. 163; Vinogradov 1968, p. 104). Temperature profiles throughout the 24-h sampling period were essentially identical to the temperature profile for midnight (Fig. 22). A pronounced thermocline occurred from the surface to 10 m depth with near isothermal waters from 10 m to the bottom. The occurrence of zoeae in all strata and the rise of king crab zoeae toward the surface at night imply that the thermocline did not prevent their vertical migration to the surface.

COMPARISON OF WATER CURRENT PATTERNS IN KACHEMAK BAY WITH DISTRIBUTION OF DECAPOD LARVAE

The most complete study on water circulation in Kachemak Bay is that of Wennekens et al.[4] They used drogues deployed at the surface and subsurface levels (15-30 m) for seven time series of 4-17 days duration between May and November 1975. Our summary of their subsurface drogue data (Fig. 23) shows that water enters the bay along the southern shore and exits along the northern shore. Two gyres, one clockwise and the other counter clockwise, exist in the outer bay. These gyres apparently persist at subsurface depth, although their positions may be shifted by tidal action. Strong wind conditions may temporarily change the net circulation and surface portion of the gyres.

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[4]Wennekens, M. P., L. B. Flagg, L. Trasky, D. C. Burbank, R. Rosenthal, and F. F. Wright. Kachemak Bay--A status report. Alaska Dep. Fish Game, Habitat Protection Section, Coastal Habitat Protection Programs, Anchorage. 228 p. (Dec. 1975--unpublished)

The distribution of king crab, pandalid shrimp and brachyuran larvae observed in Kachemak Bay in 1972 may be related to the water circulation patterns in the bay. In 1972, the major release area for the three groups of larvae appeared centered near the northern edge of the outer gyre in the area of north westward transport observed by Wennekens et al. in 1975. Assuming a similar transport pattern in 1972, larvae from the release area would likely have been carried north out of the bay shortly after release. Immigrations of larvae released outside the bay would have occurred from the southwest, the larvae becoming concentrated in the gyres. With such a water circulation pattern, early stage larvae would be most abundant in the northwest quadrant of the outer bay and older stage larvae more abundant in the southwest quadrant and in the gyres.

The above theoretical pattern of larval distribution was not observed in our data. In 1972 larvae were released primarily in the northwest quadrant and the areas of highest abundance for early and late stage larvae generally remained in the northwest quadrant throughout the April-June sampling period. Dispersal of larvae from the release area was predominantly toward the gyres and not northwestward out of the bay.

Continued zoeal abundance in the outer bay likely reflects entrainment of the zoeae in the gyres. Wennekens et al. (see footnote 4) note that variations in tidal oscillations and weather conditions may affect the size, strength, and position of the gyres. Annual variations of Kachemak Bay circulation have not been verified. A slight northward extension of the gyres in 1972 would have included the release site area and resulted in a pattern of zoeal distribution commensurate with the 1972 data. Immigration of zoeae out of the bay along the northern shore undoubtedly occurred, but would have been minimized. It is not known if immigration of larvae into Kachemak Bay occurred along the southern shore in 1972. There was no evidence of a relatively large influx of larvae in this area in 1972 and no obvious differences from other areas of the bay in the expected progression of larval stages with time.

The question of whether Kachemak Bay is an "open" or "closed" system in regard to decapod larval migration cannot be answered at this time. Our station pattern did not extend far enough seaward to determine the existence of other areas of larval abundance and no samples were taken after the end of June when larvae were still present. Also the studies of larval distribution and of circulation in Kachemak Bay were separated in time, and annual variation of both are unknown. Behavioral patterns of the larvae are poorly known, especially whether or not they have the ability to maintain their geographic position in spite of net transports. Quite likely migration of decapod larvae into and out of Kachemak Bay occurs, but its importance in relation to maintenance of the decapod populations within the bay has not been determined.

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Figure 1. Location of sampling stations to determine the relative abundance and distribution of king crab, pandalid shrimp, and brachyuran crab zoeae in Kachemak Bay, March-June 1972.

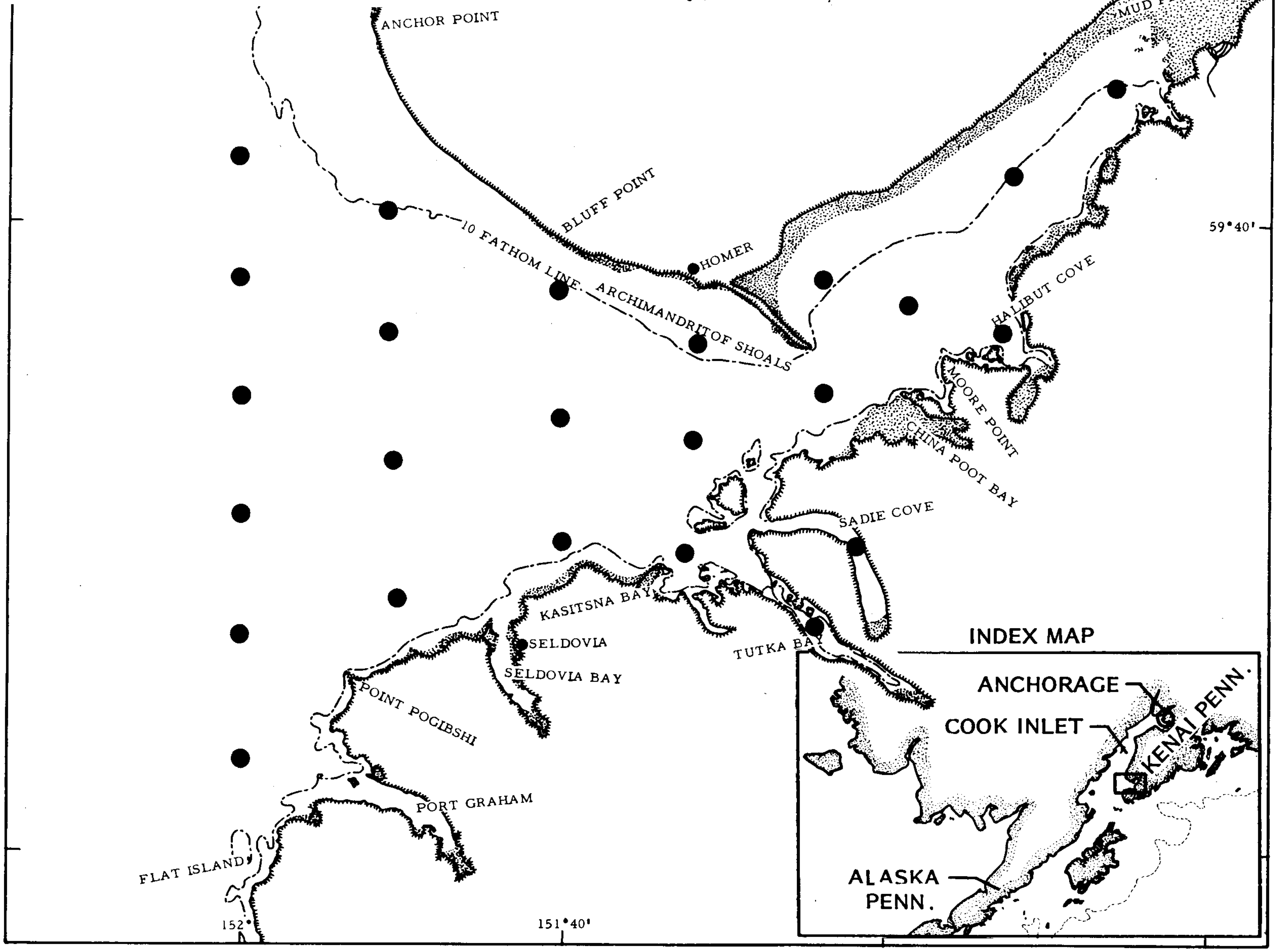


Figure 2. Location of sampling stations for king crab zoeae, March 16-31, 1972.

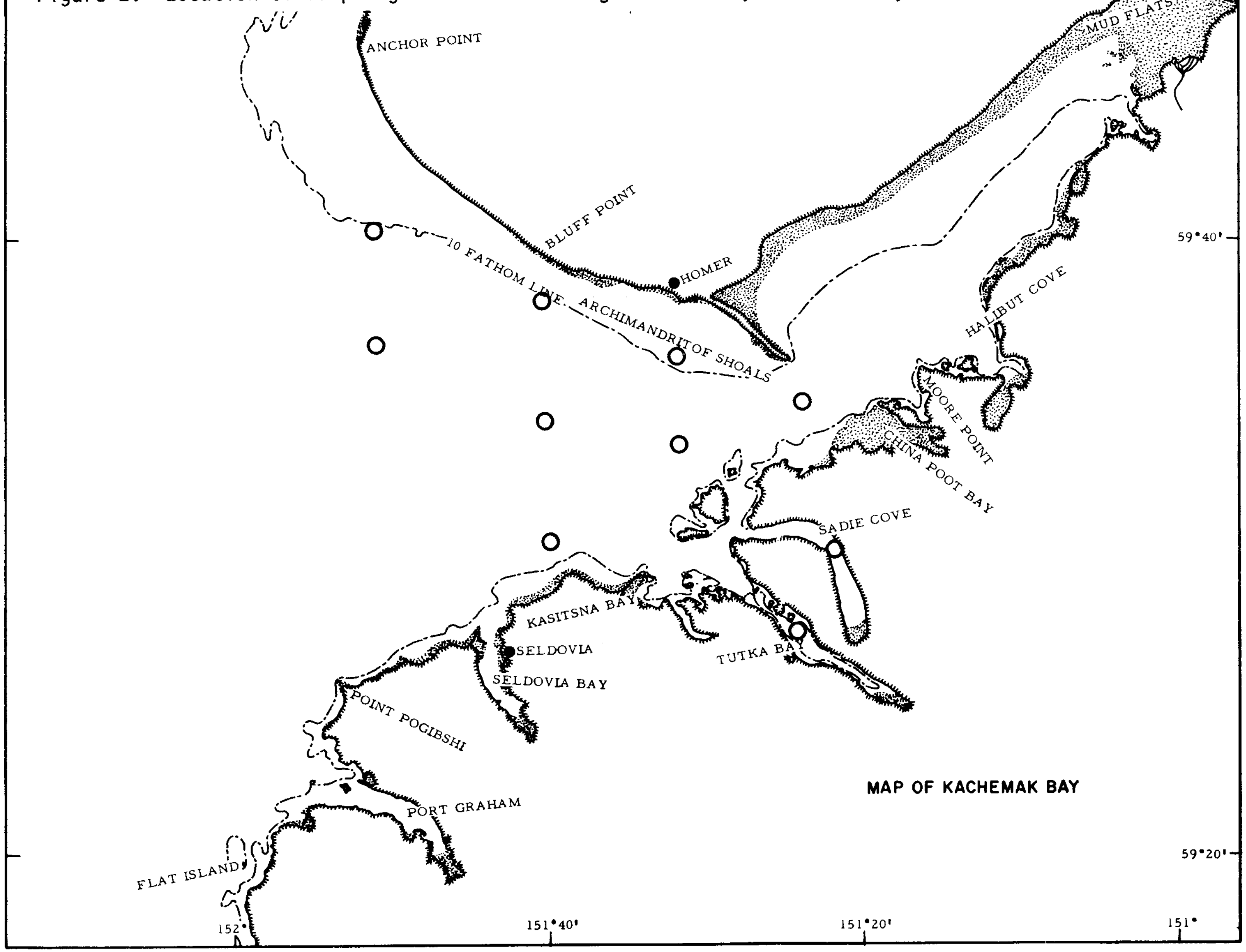
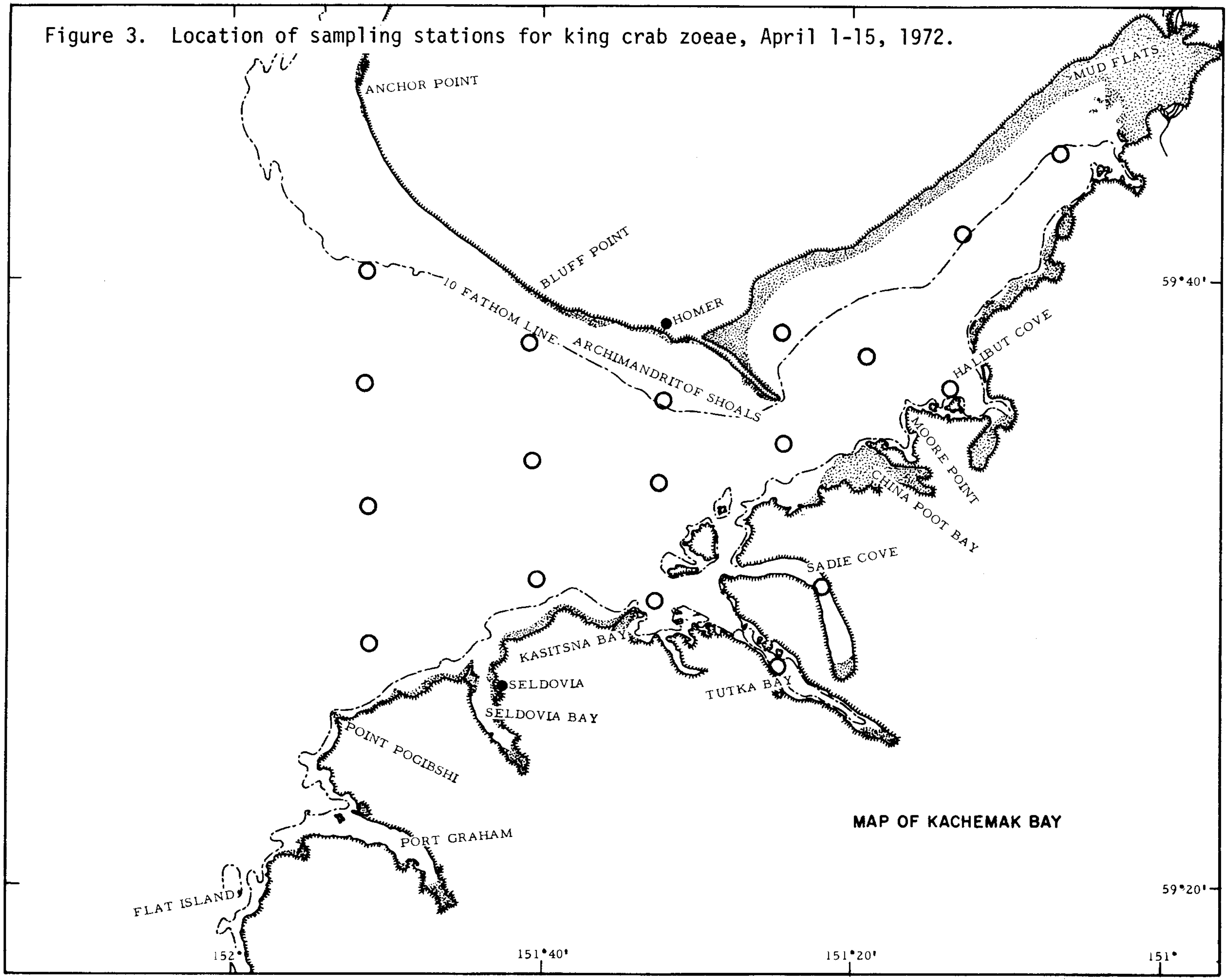


Figure 3. Location of sampling stations for king crab zoeae, April 1-15, 1972.



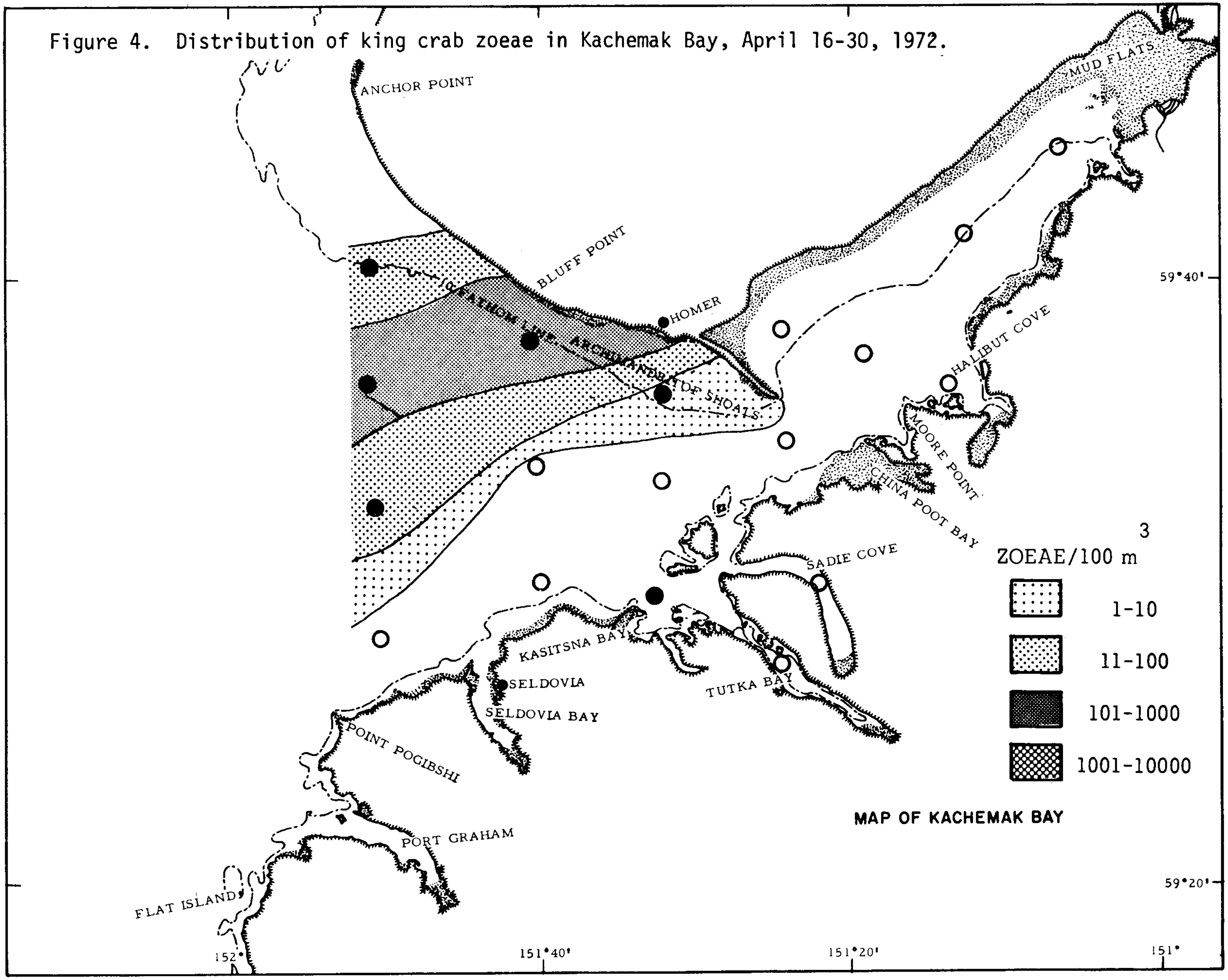


Figure 4. Distribution of king crab zoeae in Kachemak Bay, April 16-30, 1972.

Figure 5. Distribution of king crab zoeae in Kachemak Bay, May 1-15, 1972.

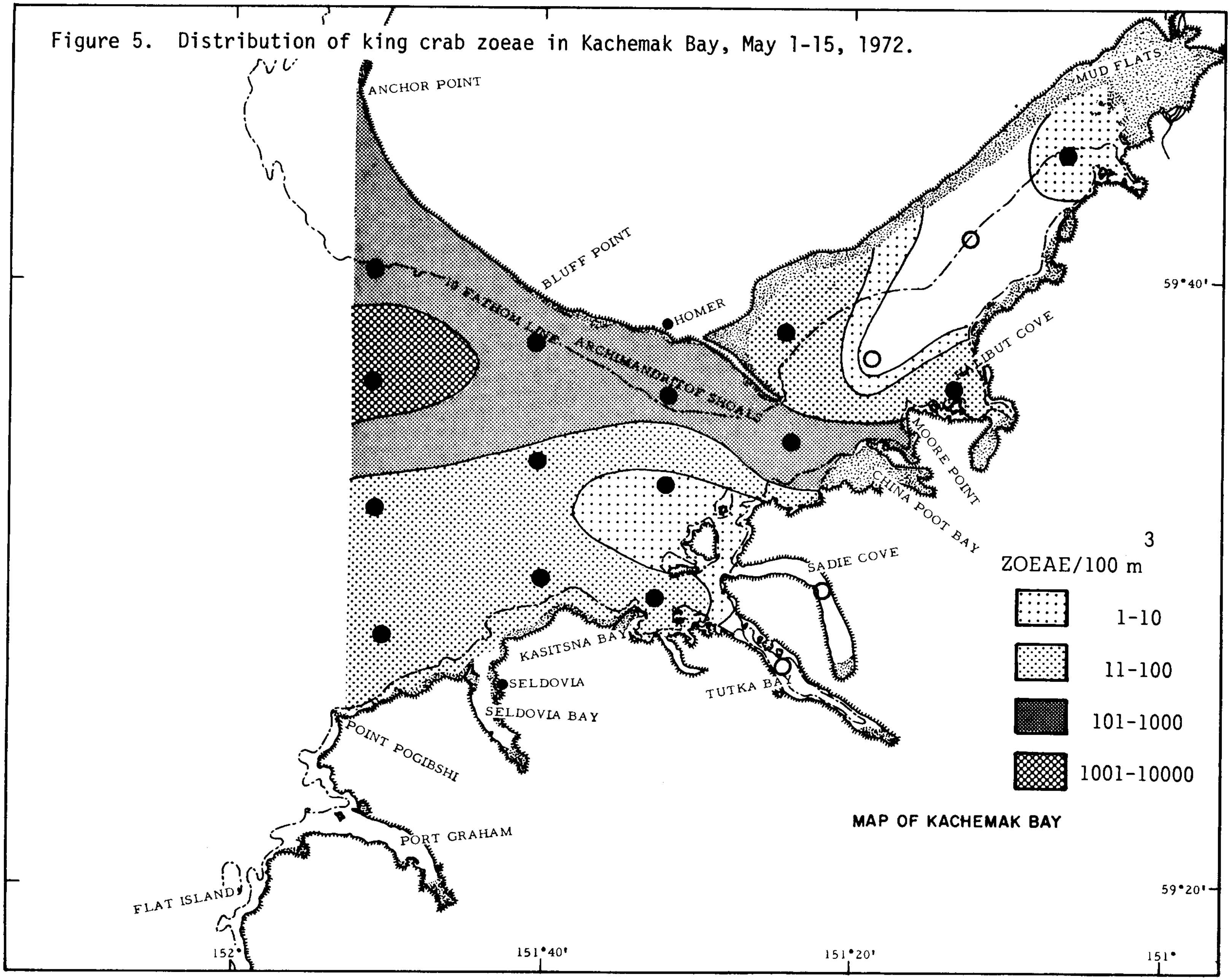


Figure 6. Distribution of king crab zoeae in Kachemak Bay, May 16-31, 1972.

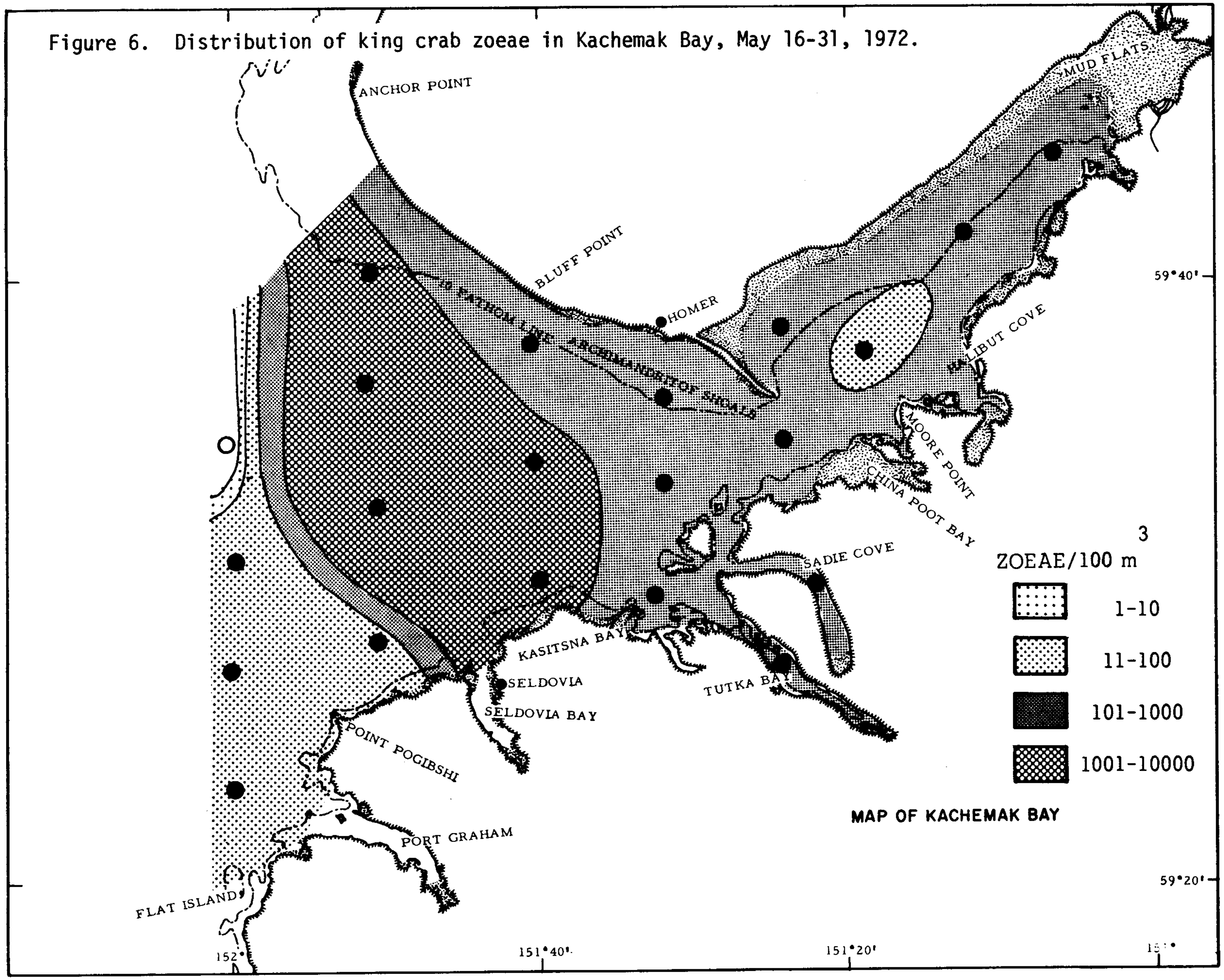


Figure 7. Distribution of king crab zoeae in Kachemak Bay, June 1-15, 1972.

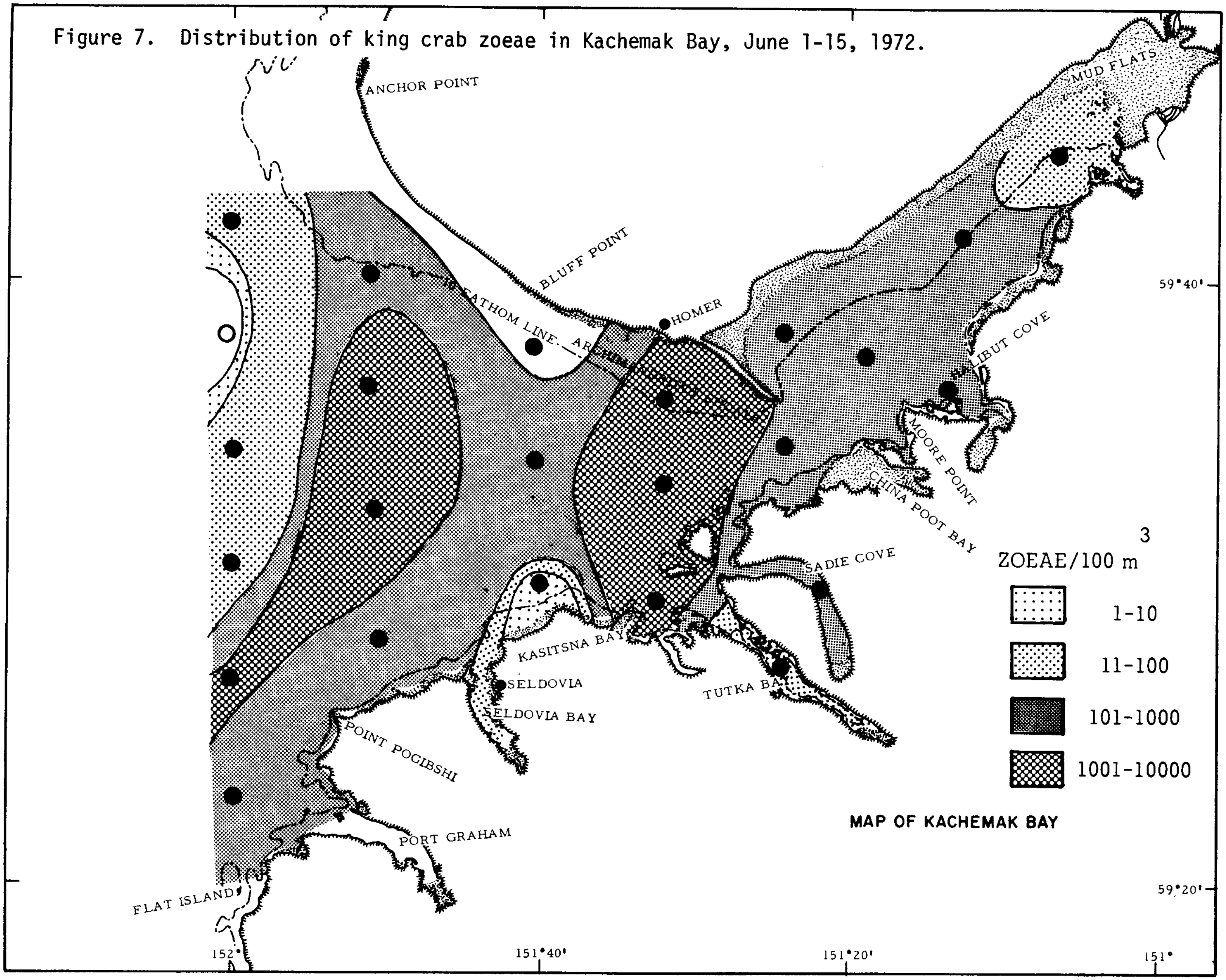


Figure 8. Distribution of king crab zoeae in Kachemak Bay, June 16-30, 1972.

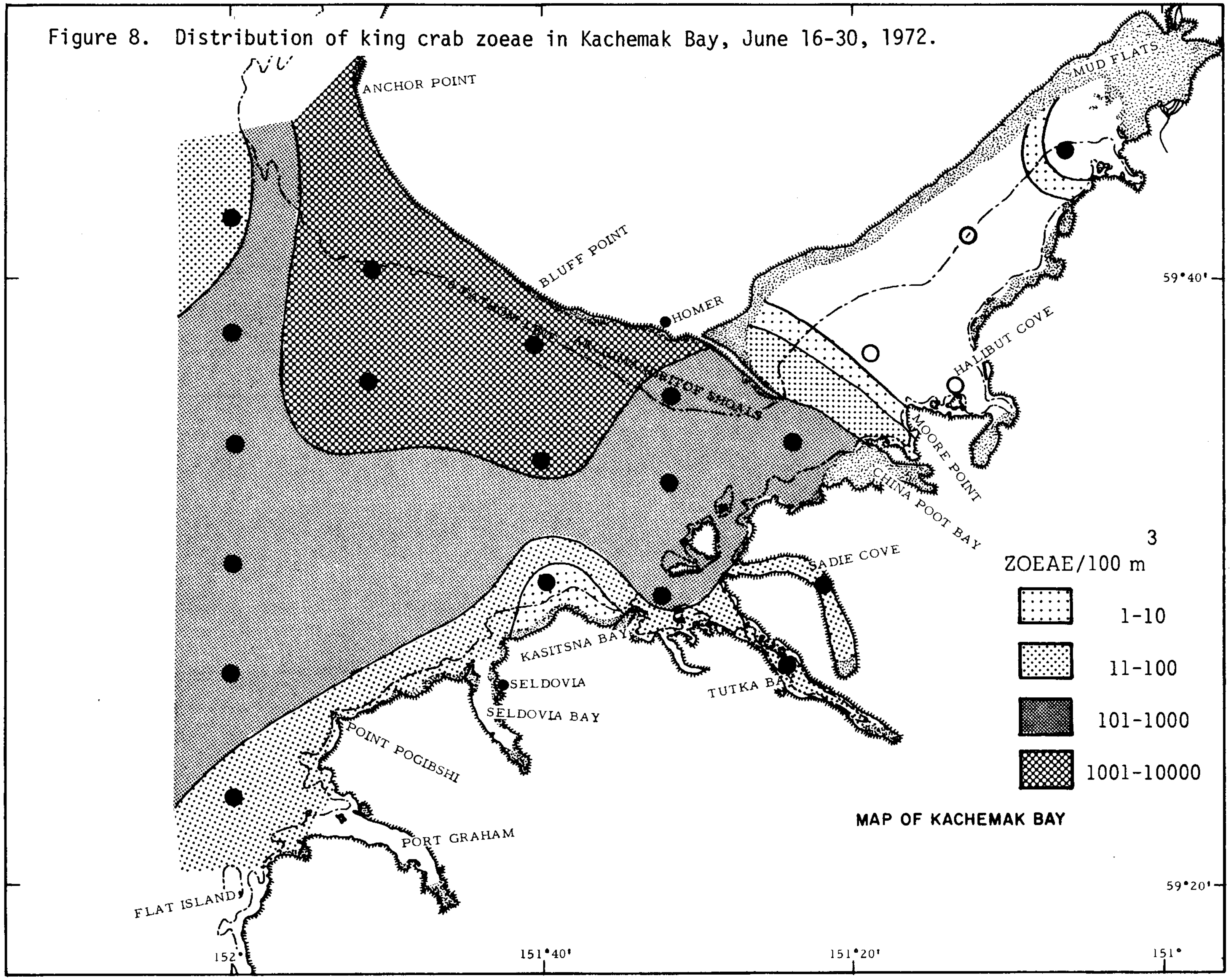


Figure 9. Percentage composition of king crab zoeal stages in Kachemak Bay, April-June 1972.

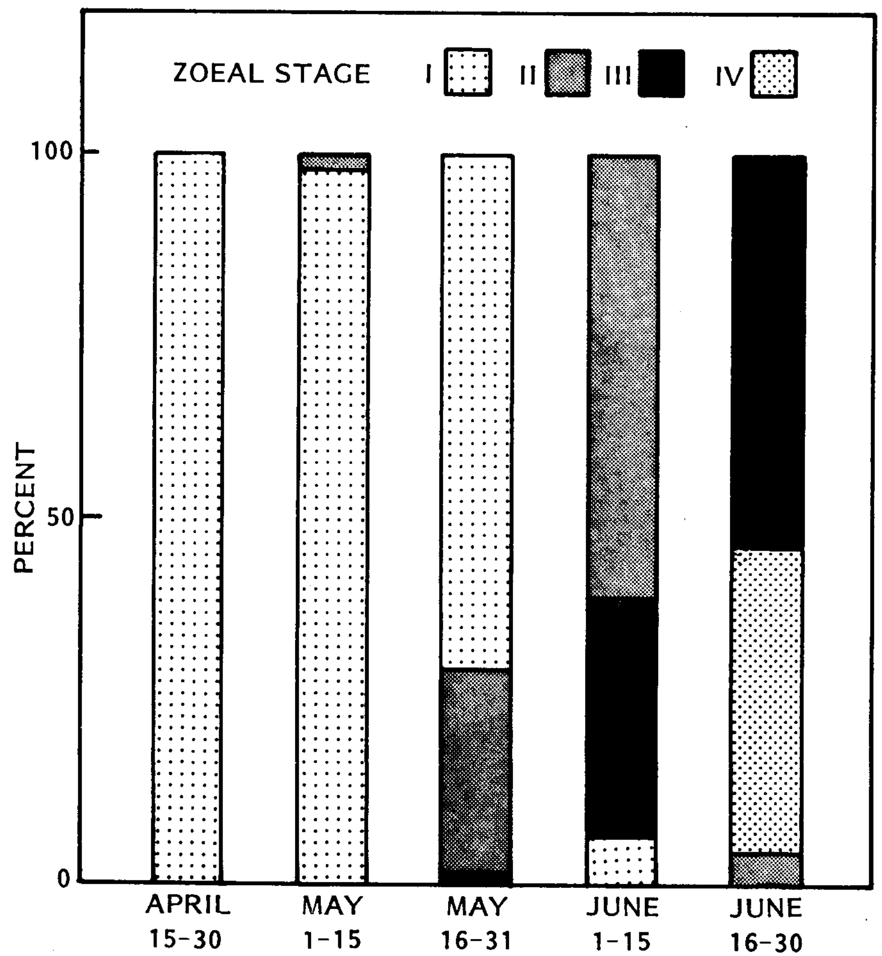


Figure 10. Distribution of pandalid shrimp zoeae in Kachemak Bay, April 1-15, 1972.

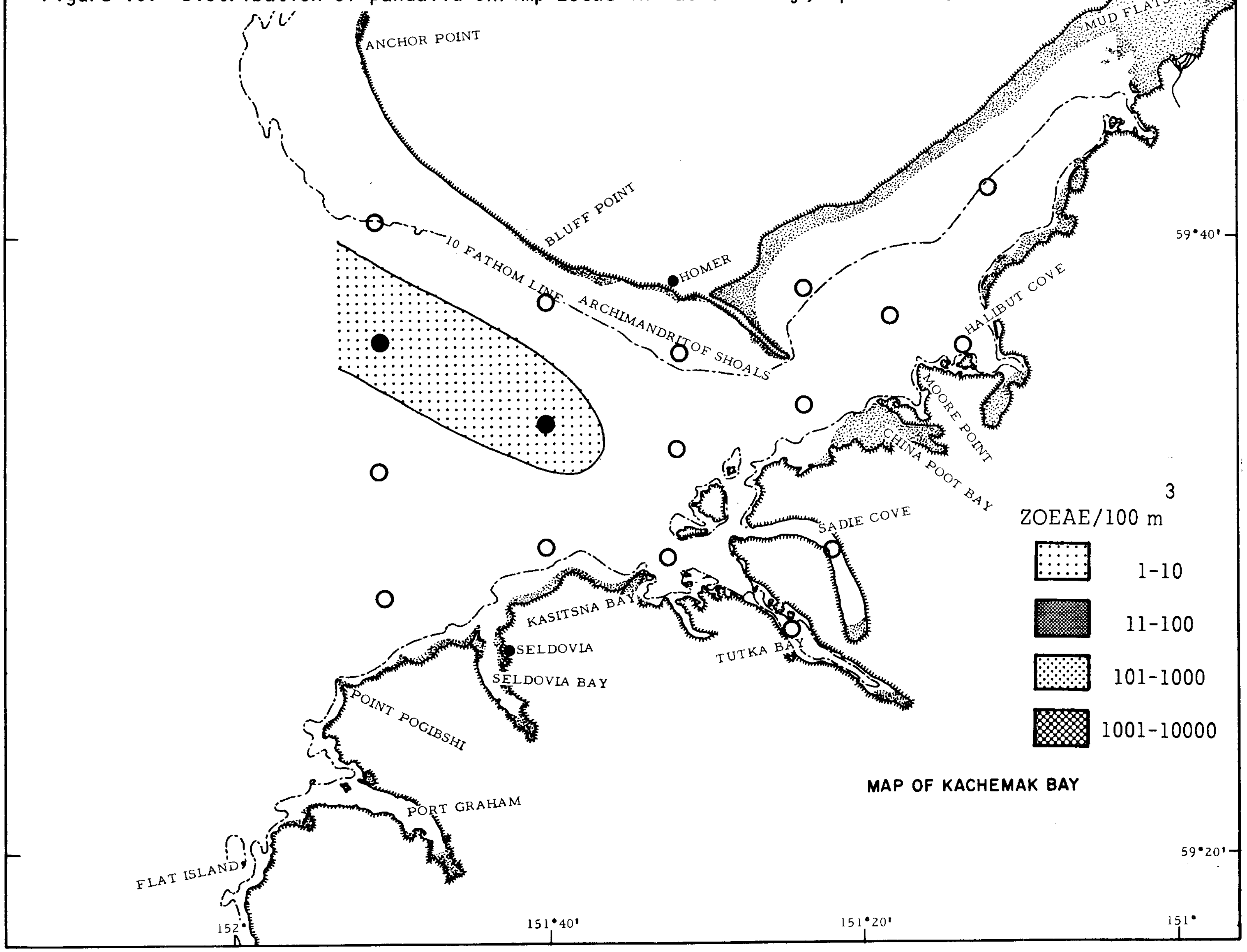


Figure 11. Distribution of pandalid shrimp zoeae in Kachemak Bay, April 16-30, 1972.

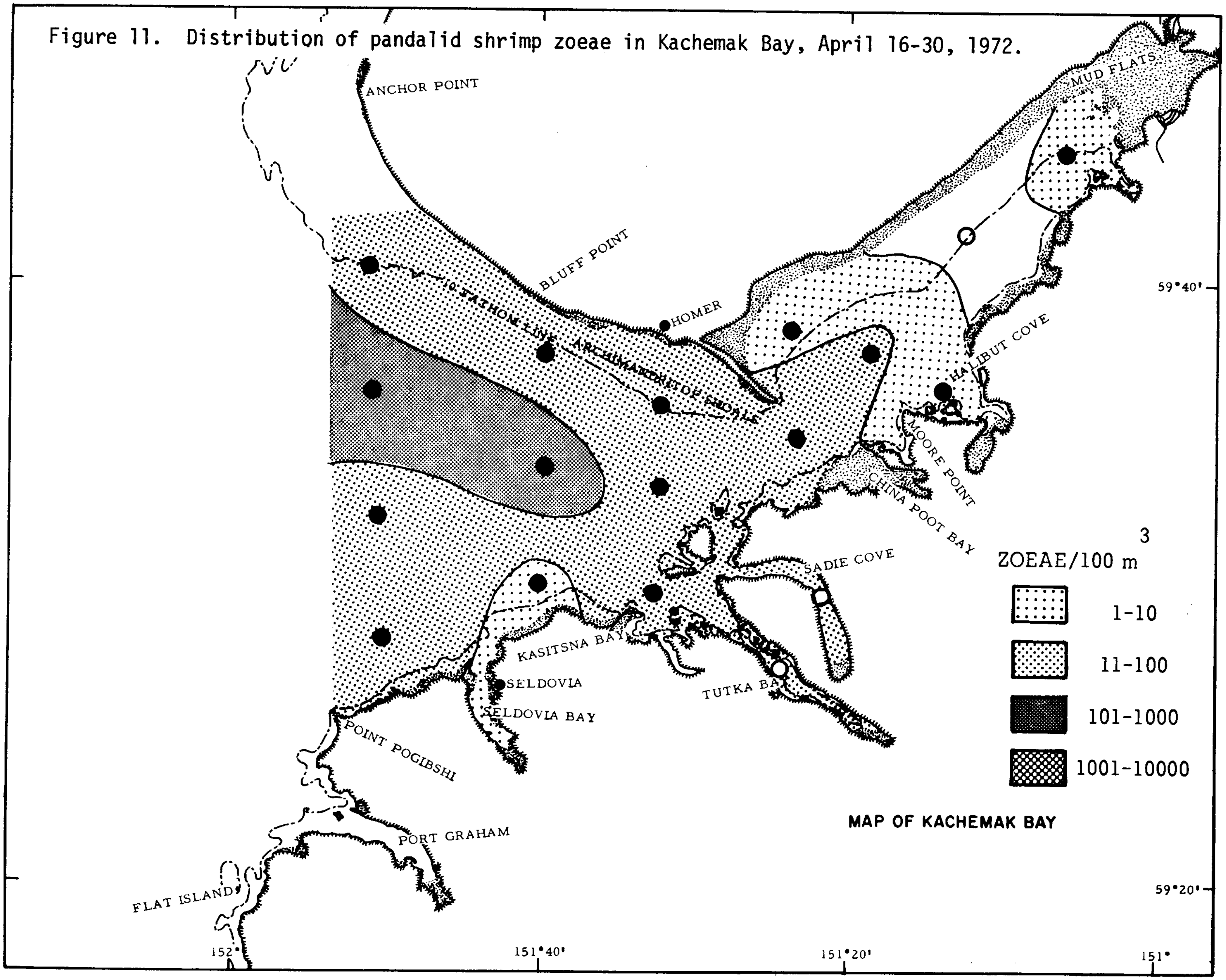
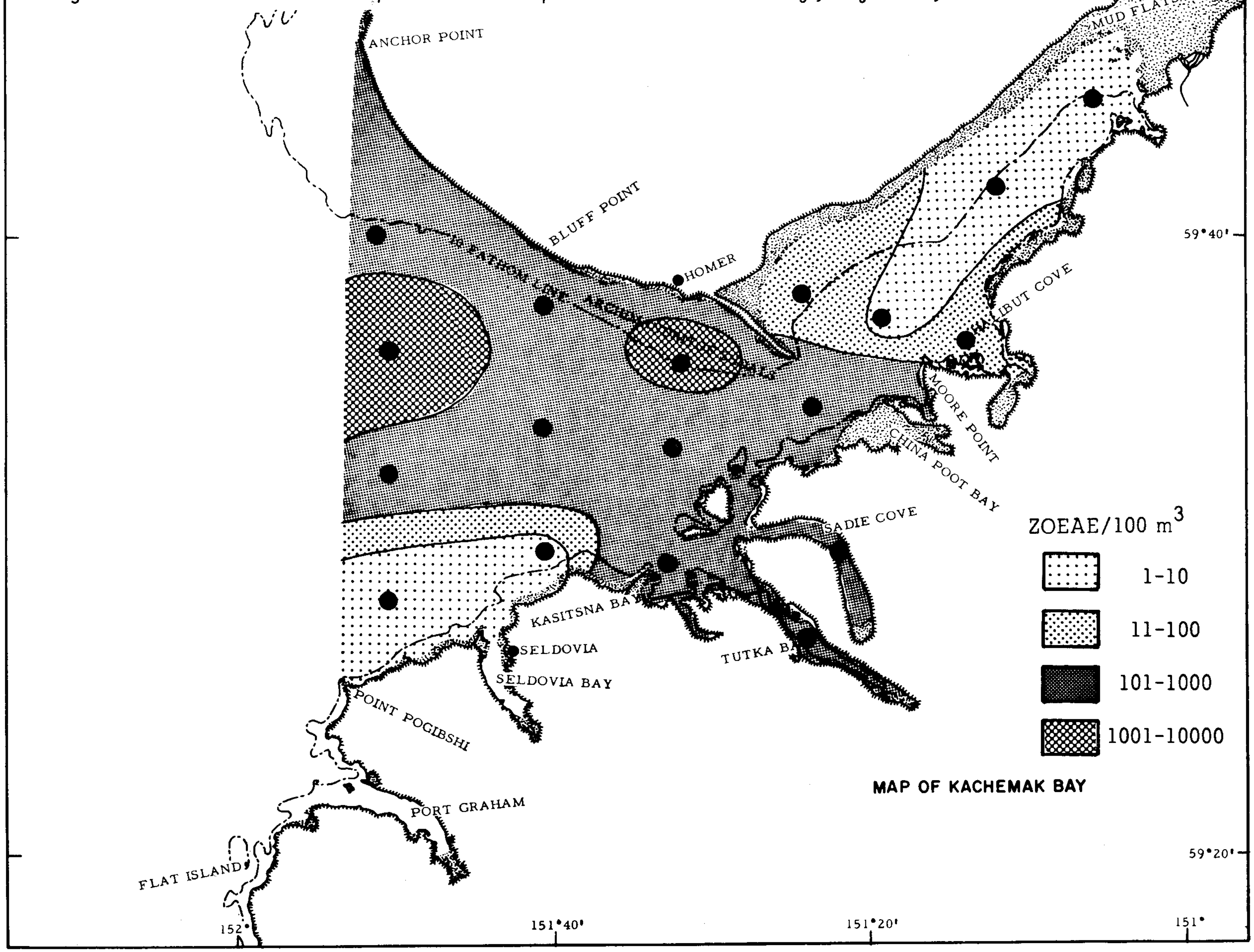


Figure 12. Distribution of pandalid shrimp zoeae in Kachemak Bay, May 1-15, 1972.



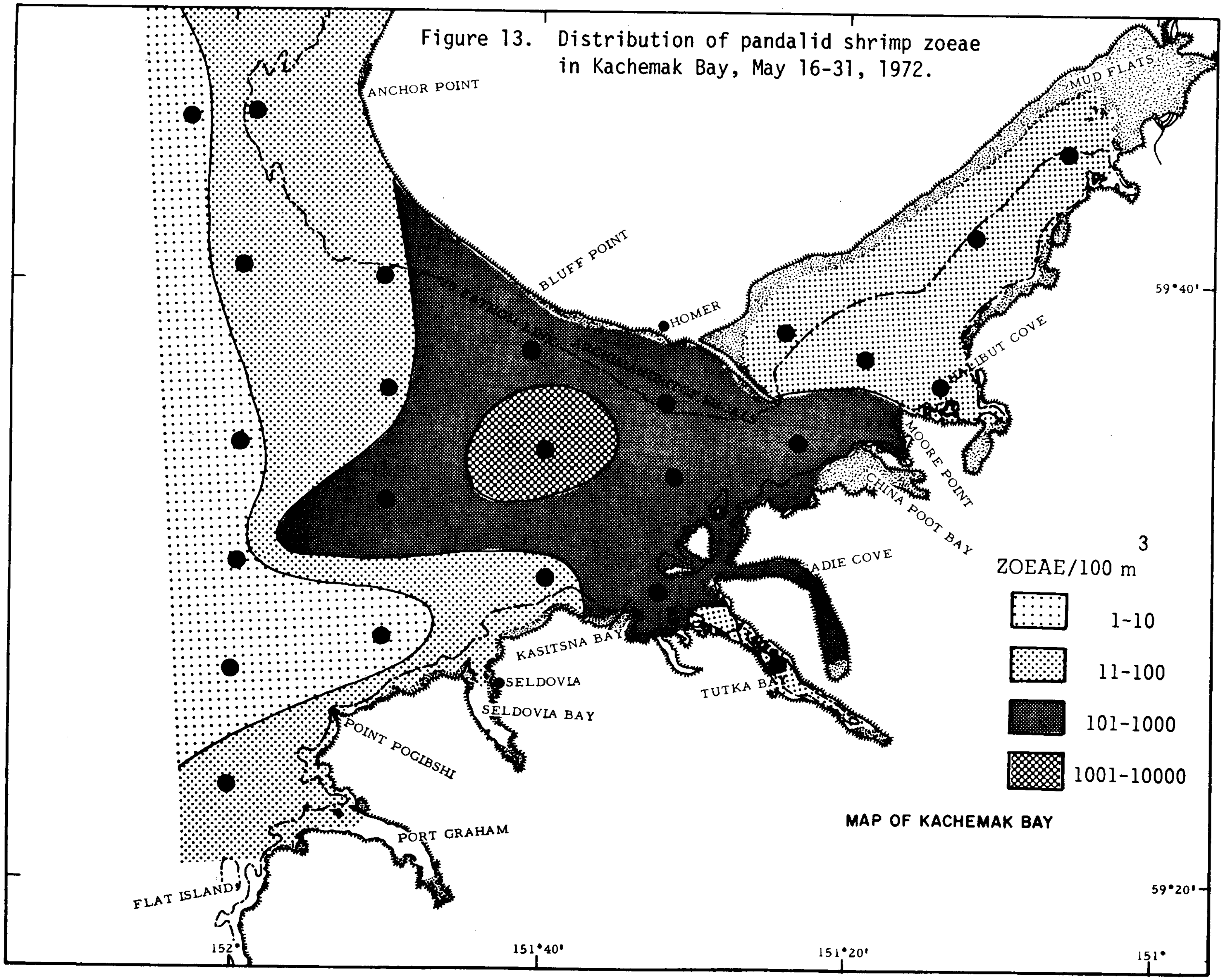


Figure 13. Distribution of pandalid shrimp zoeae in Kachemak Bay, May 16-31, 1972.

Figure 14. Distribution of pandalid shrimp zoeae in Kachemak Bay, June 1-15, 1972.

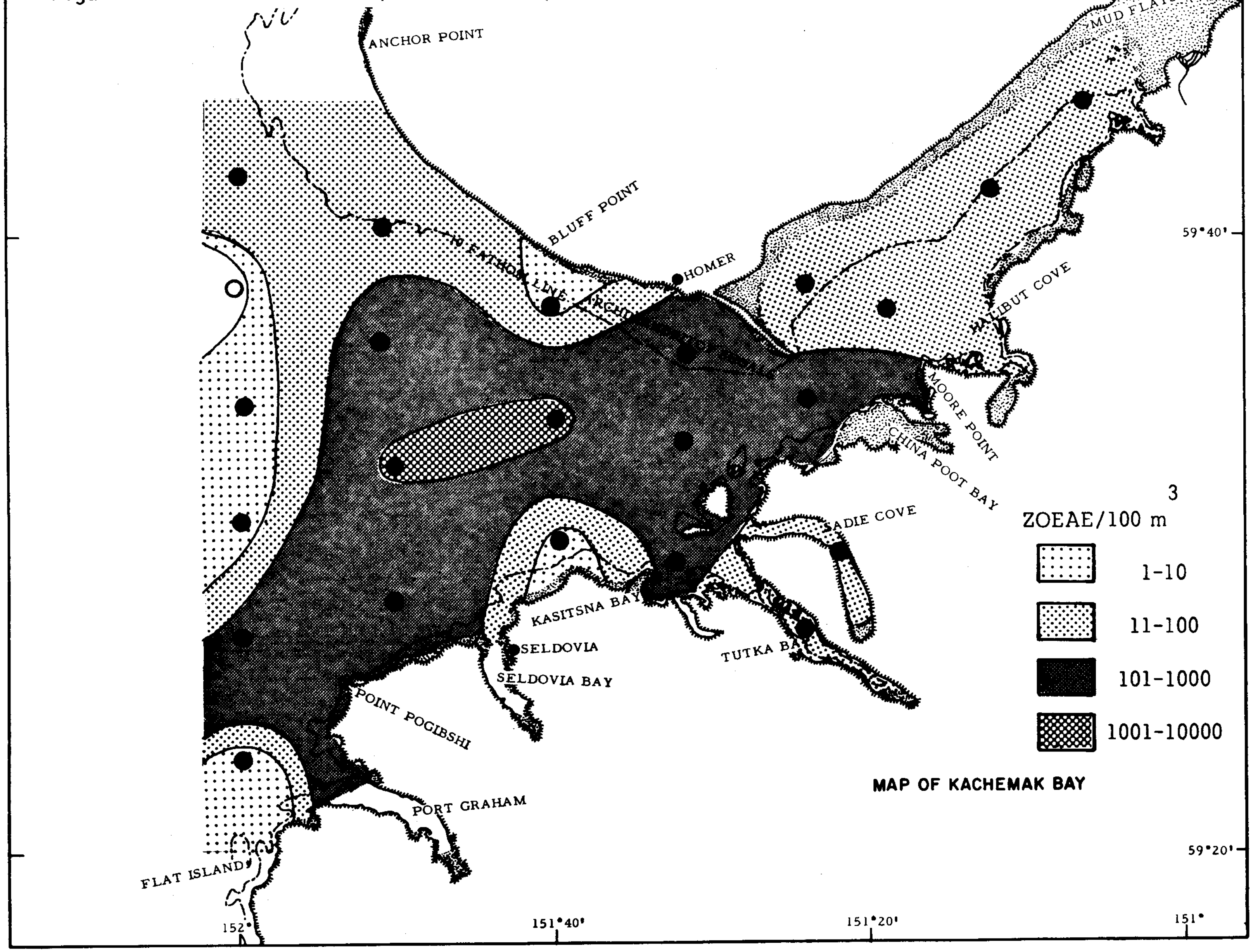


Figure 15. Distribution of pandalid shrimp zoeae in Kachemak Bay, June 16-30, 1972.

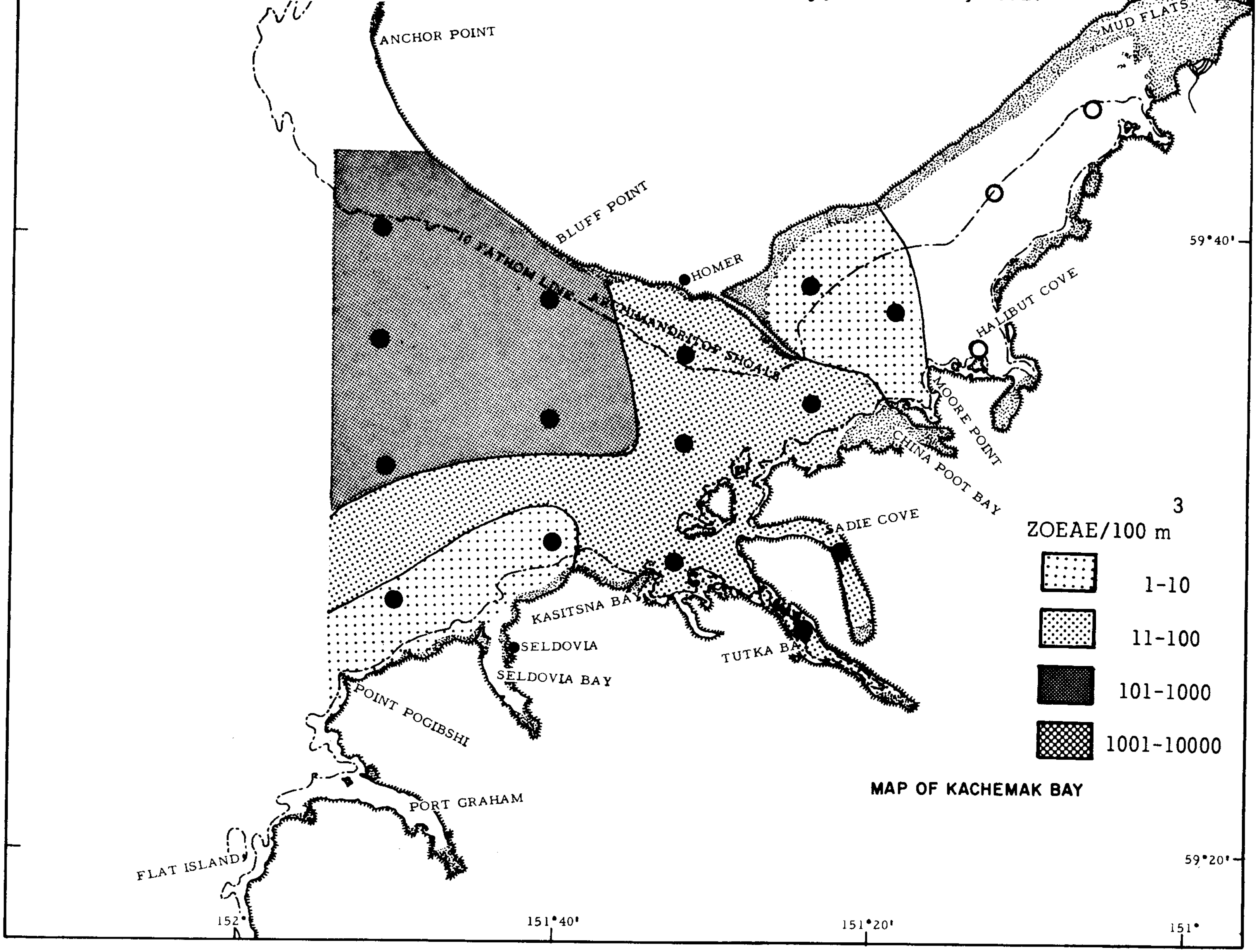


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Figure 16. Distribution of brachyuran crab zoeae in Kachemak Bay, April 16-30, 1972.

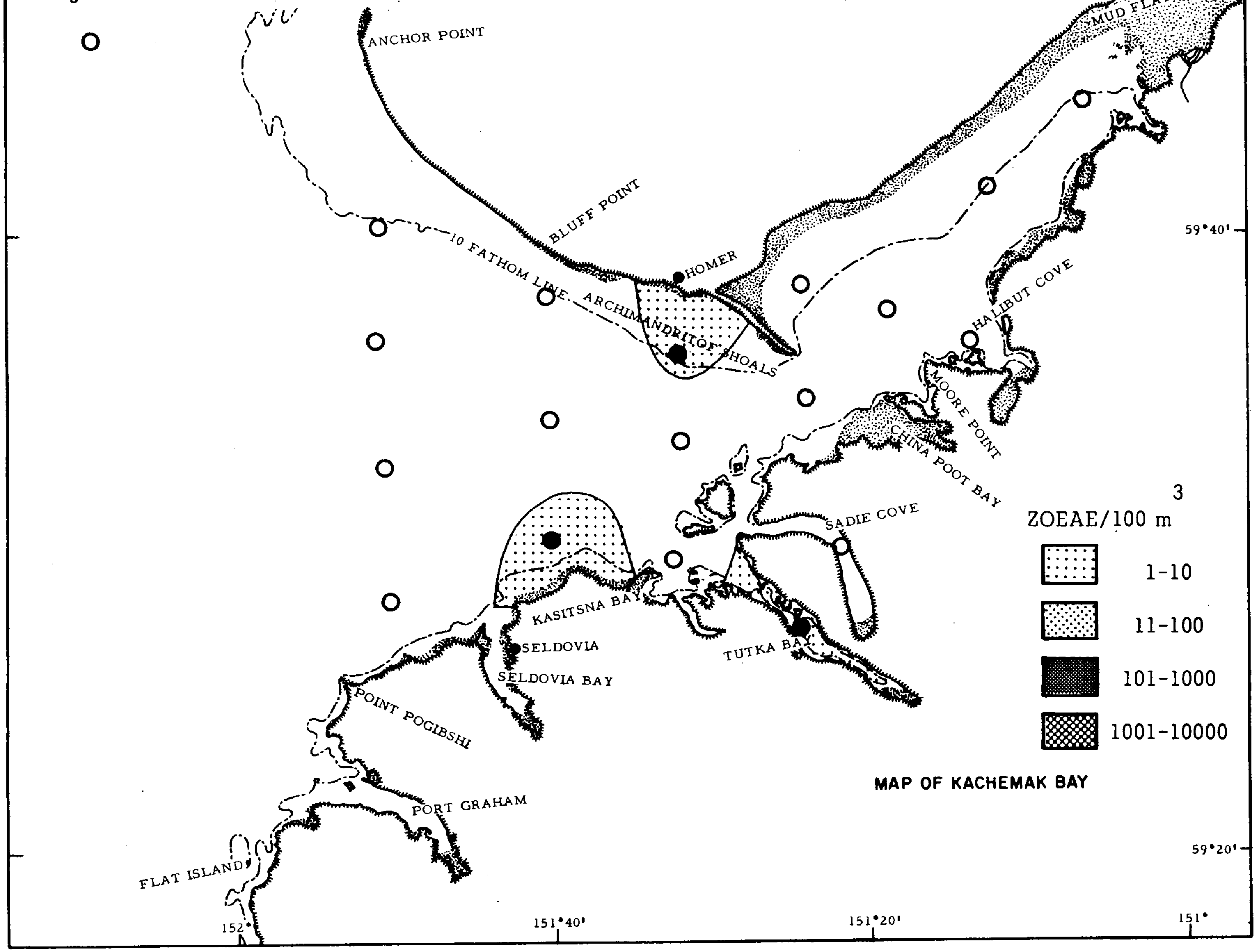


Figure 17. Distribution of brachyuran crab zoeae in Kachemak Bay, May 1-15, 1972.

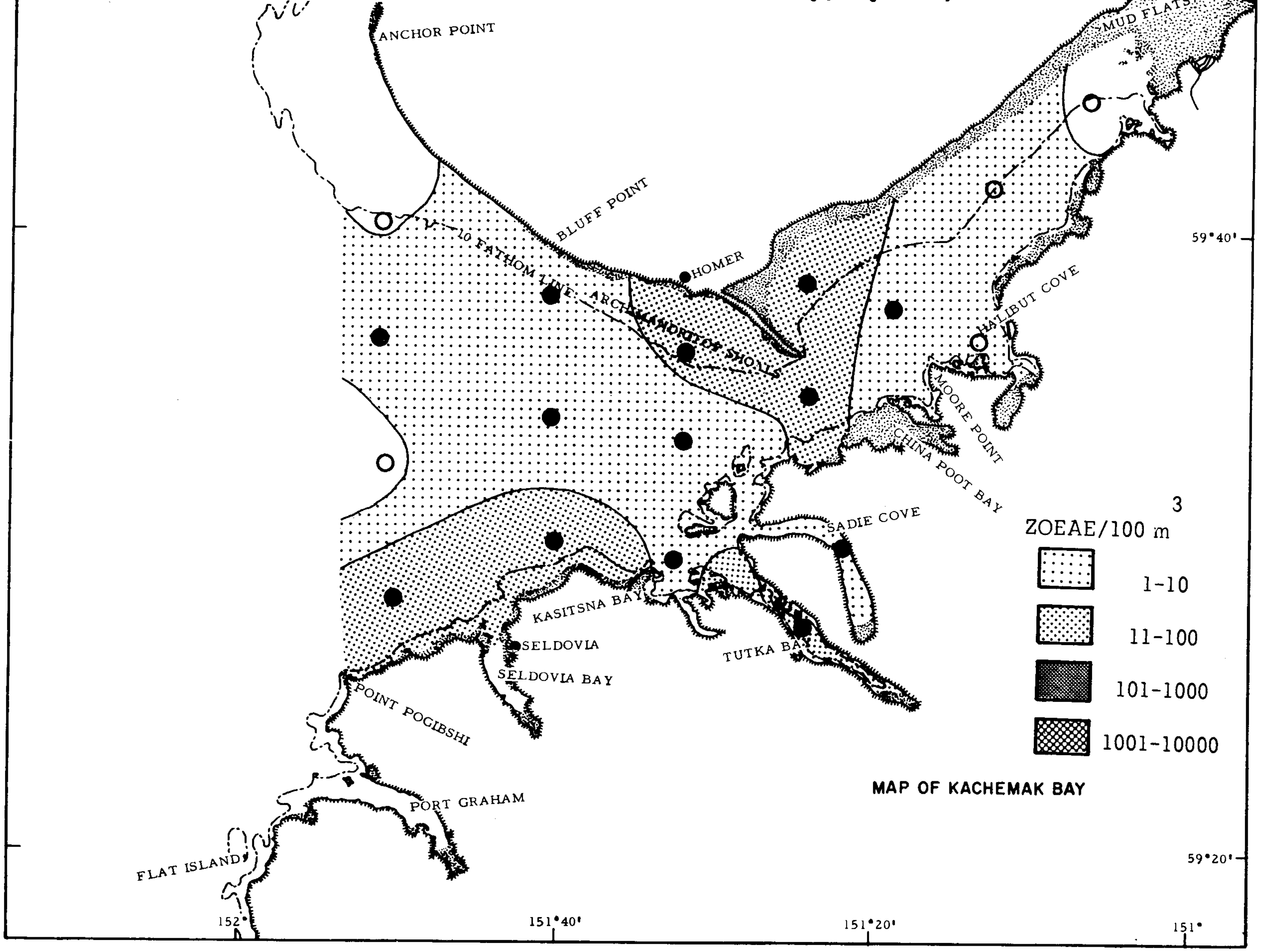


Figure 18. Distribution of brachyuran crab zoeae in Kachemak Bay, May 16-31, 1972.

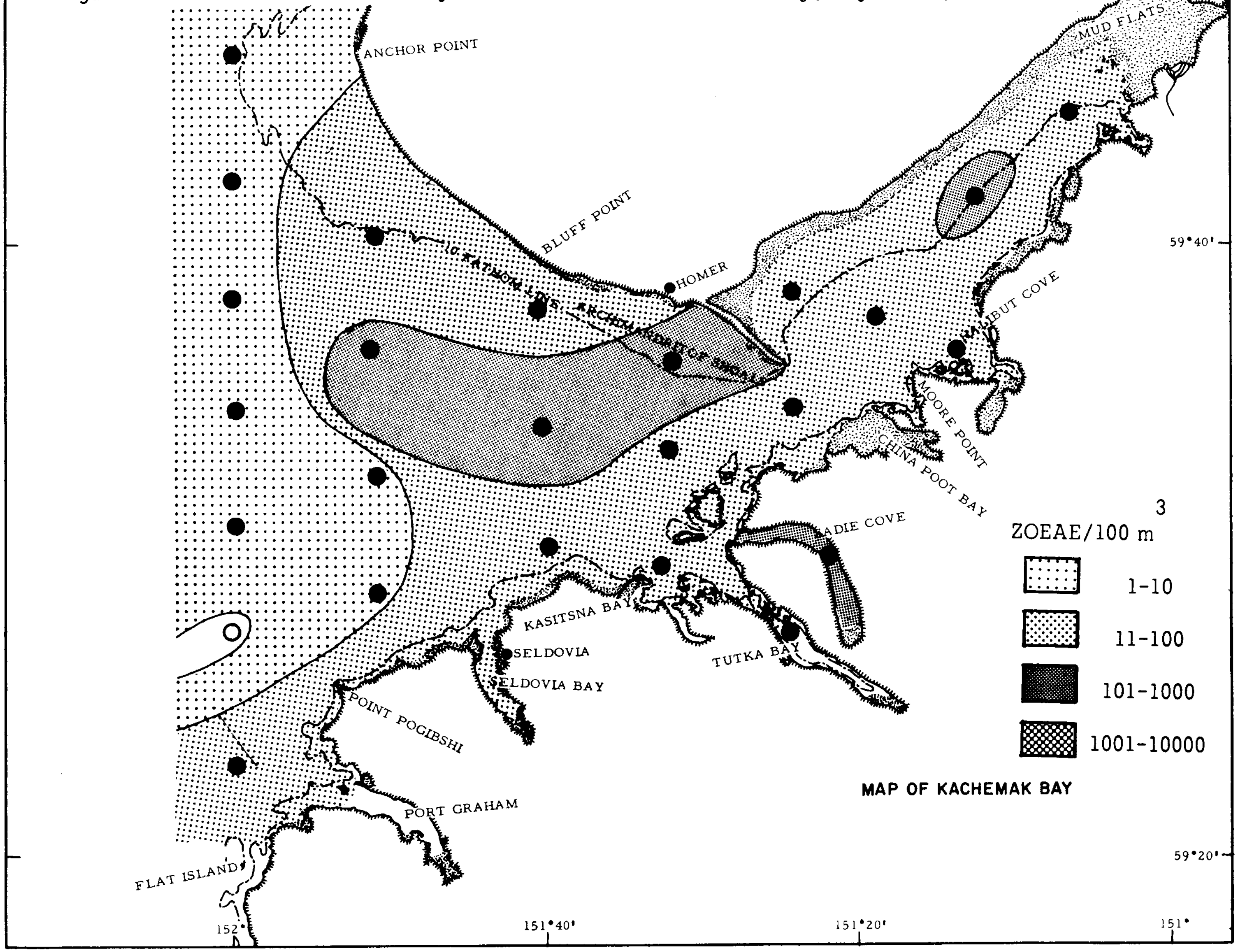


Figure 19. Distribution of brachyuran crab zoeae in Kachemak Bay, June 1-15, 1972.

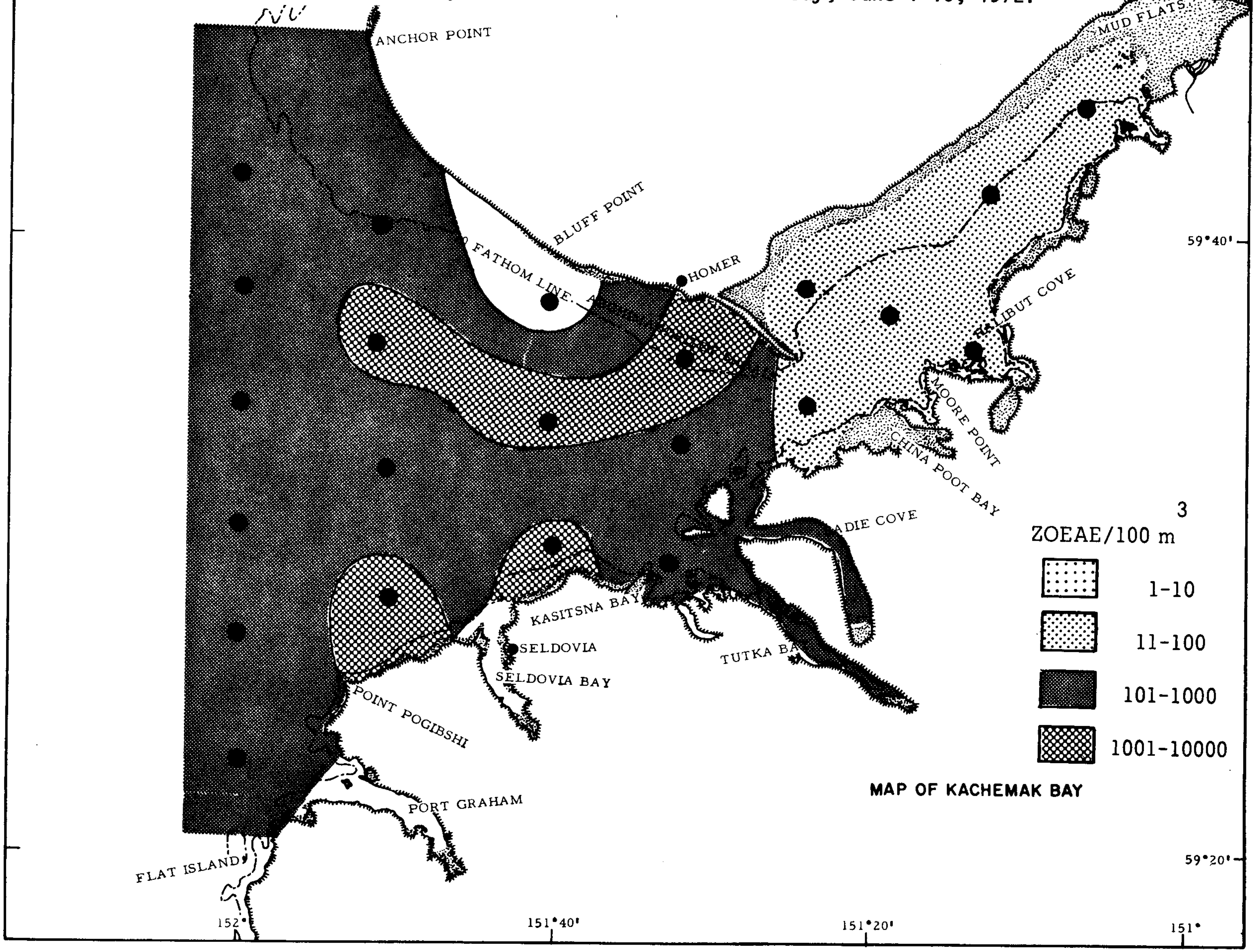
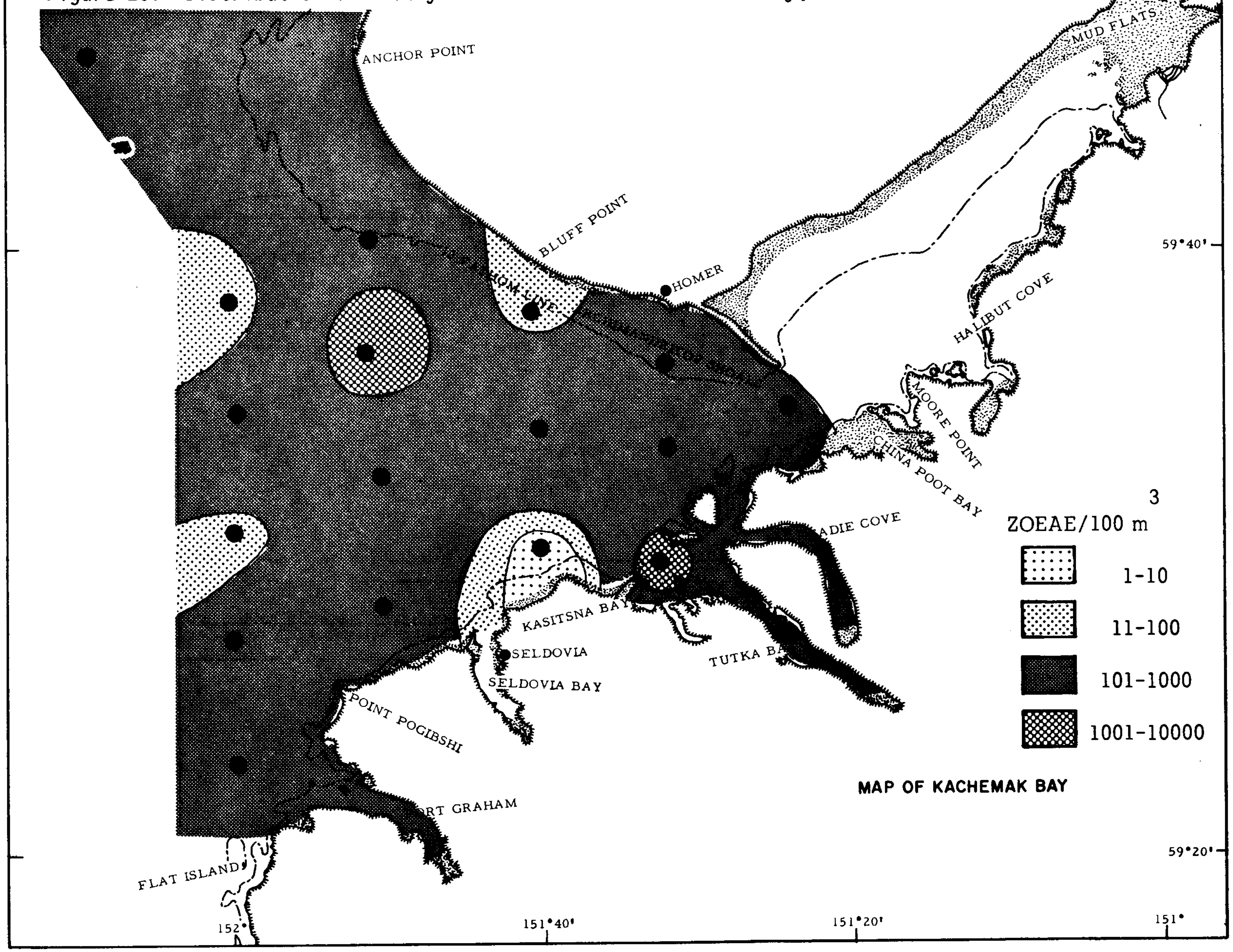


Figure 20. Distribution of brachyuran crab zoeae in Kachemak Bay, June 16-30, 1972.



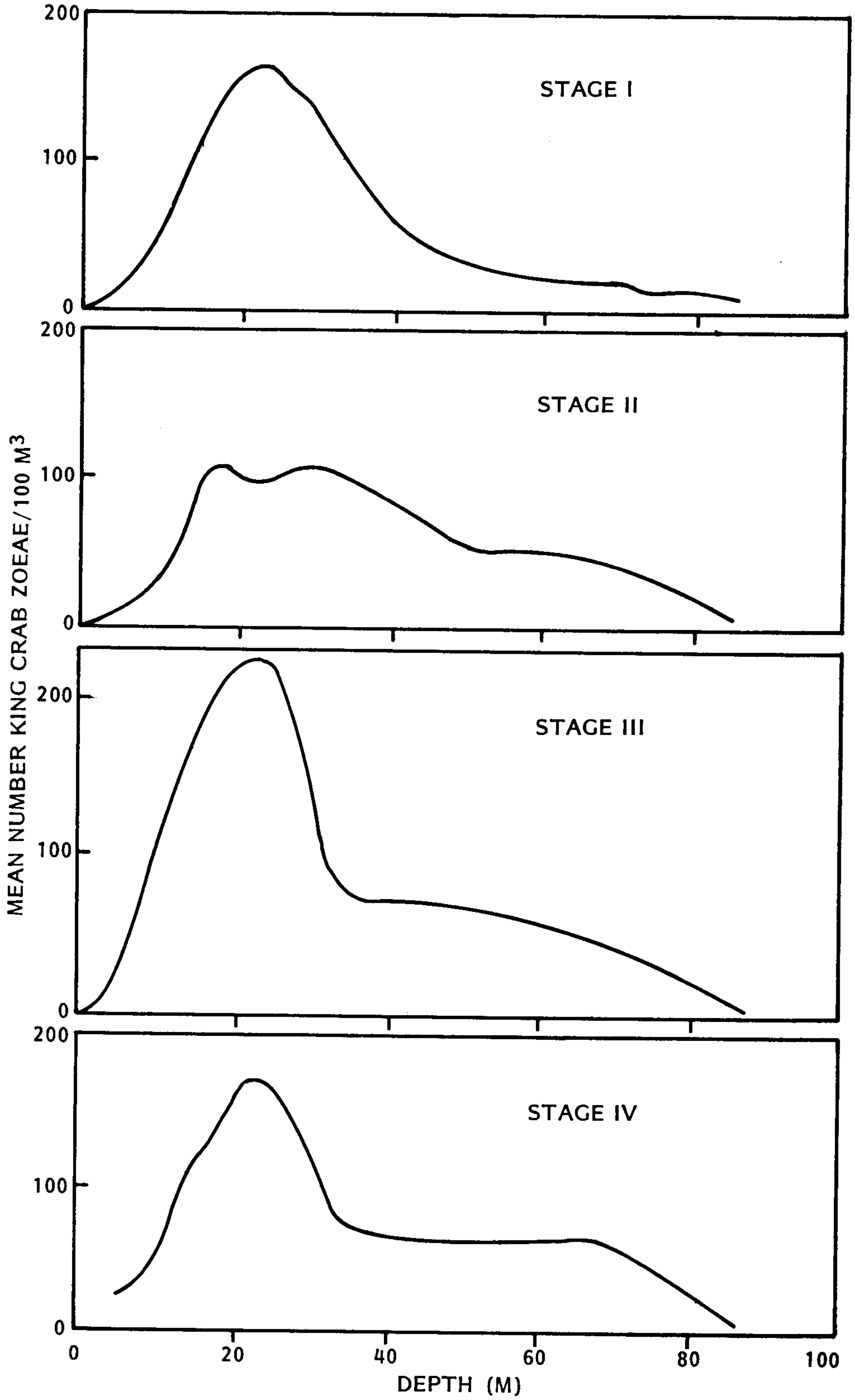


Figure 21. Average depth distribution of king crab zoeae in Kachemak Bay, April 16-June 30, 1972.

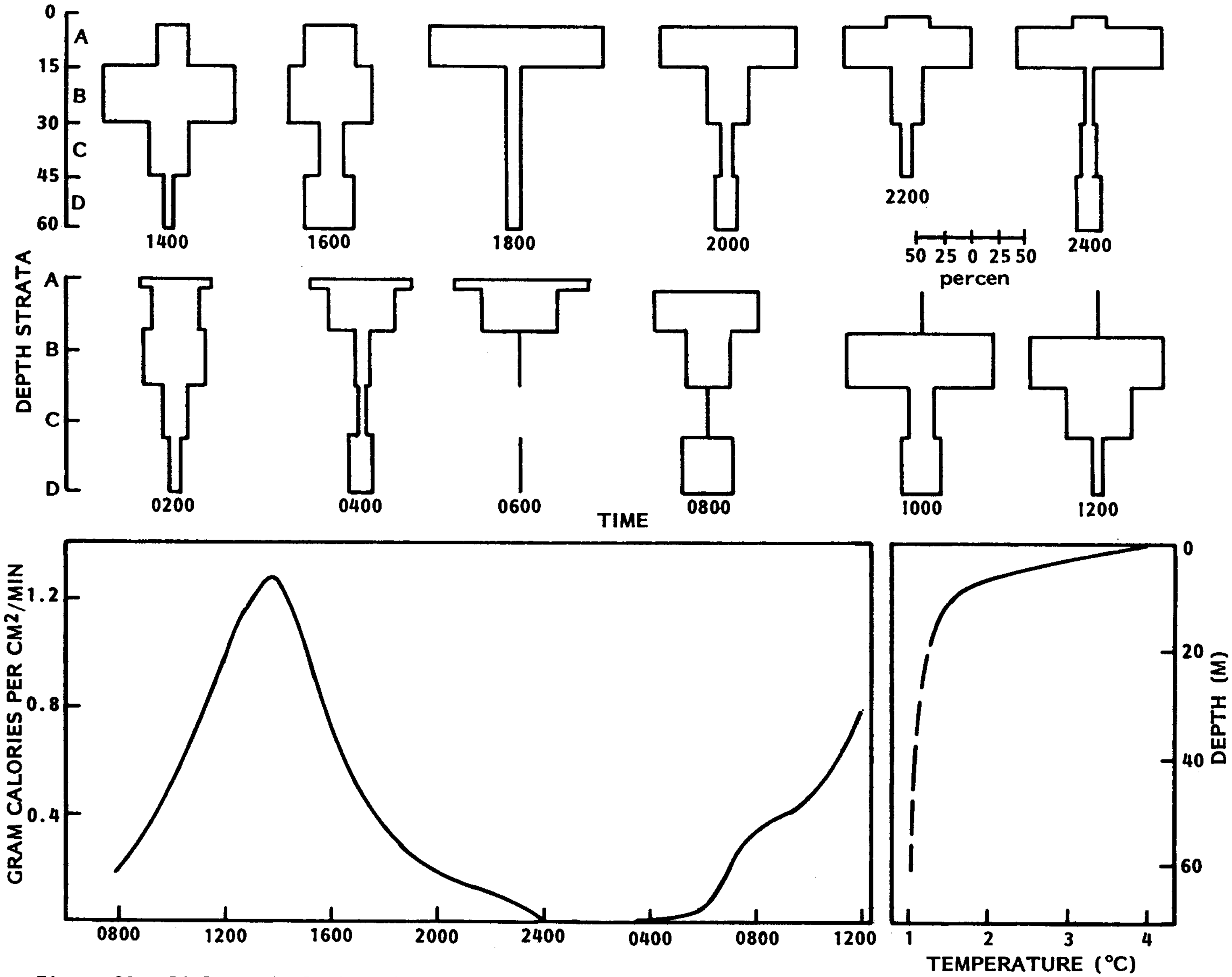
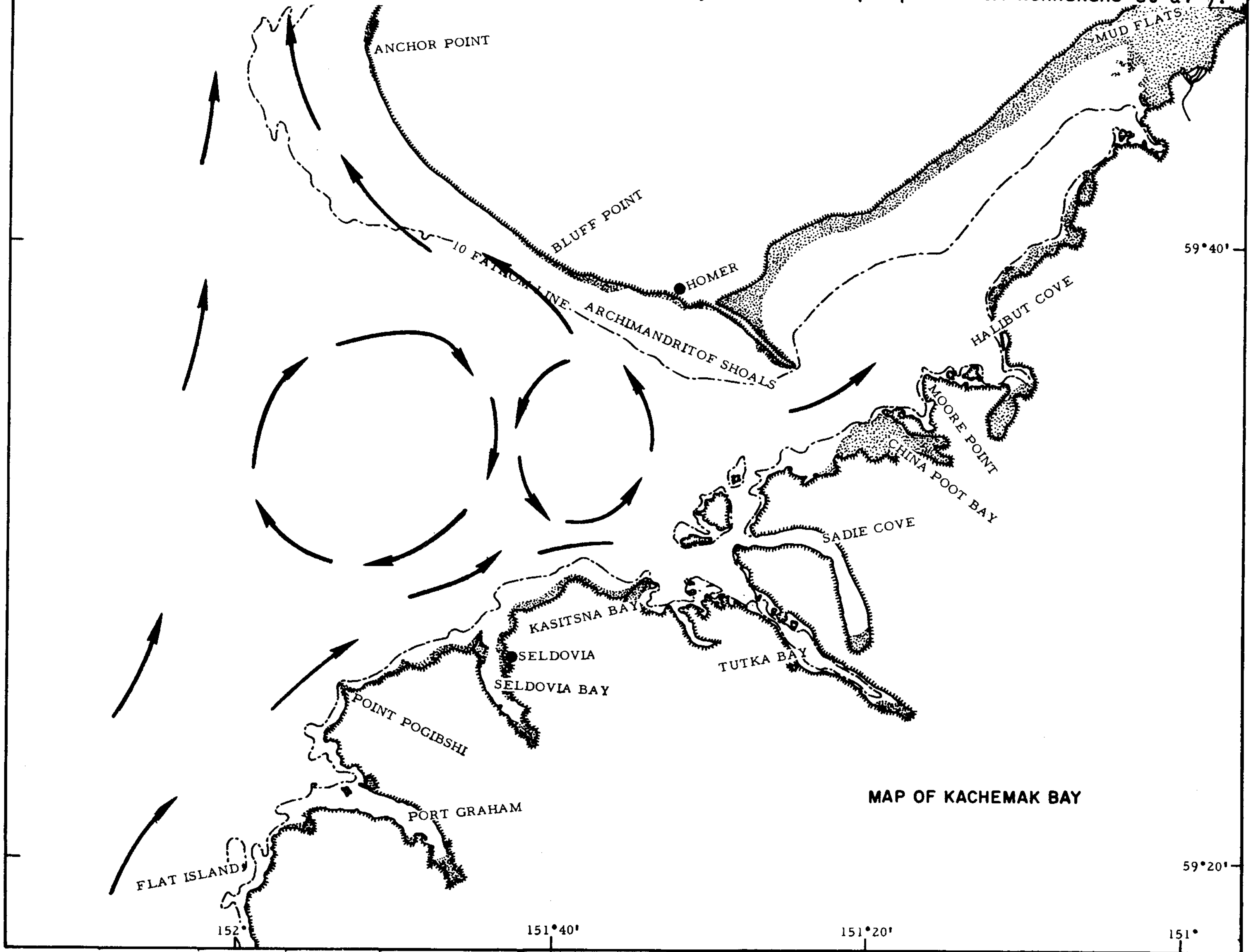


Figure 22. Diel vertical migration of king crab zoeae, incident surface sunlight, and water temperature profile in Kachemak Bay, 10-11 May 1972. The widths of the blocks are proportional to the percent of zoeae collected within the depth strata.

Figure 23. Generalized circulation pattern in Kachemak Bay at 15-30 m (adapted from Wennekens et al[4]).



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TRAWL SURVEY OF THE BENTHIC EPIFAUNA OF THE CHUKCHI SEA AND NORTON SOUND

Dr. H. M. Feder, Principal Investigator

With:

John Hilsinger

Max Hoberg

Stephen C. Jewett

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objectives of this study are: (1) a qualitative inventory of dominant benthic invertebrate epifaunal species (exclusive of gastropods) within the study sites, (2) a description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites, and (3) preliminary observations of biological interrelationships between selected segments of the benthic biota in the designated study areas.

Analysis of data on biomass, abundance, and distribution of benthic epifaunal invertebrates as well as tabulation of species for Norton Sound and the Chukchi Sea will be available in the Final Report. Each area will be treated and discussed separately in that report. Currently available data include a species list for the combined areas, and feeding data for the starry flounder (*Platichthys stellatus*), 6 sea stars (*Leptasterias* sp., *Leptasterias polaris ascervata, Lethasterias nanimensis, Solaster endeca, Evasterias echinosoma,* and *Asterias amurensis*), and 2 ophiuroids (*Ophiura sarsi* and *Gorgonocephalus caryi*). Mollusca, Crustacea, and Echinodermata were the dominant phyla in the study area in terms of number of species with 91, 41, and 23 species respectively. Mollusca and Echinodermata were the major food items taken by the species selected for food-habit studies.

The joint National Marine Fisheries Service trawl survey for investigation of demersal fishes and epifaunal invertebrates was effective, and excellent spatial coverage of the shelf of the northeastern Bering Sea and southeastern Chukchi Sea was obtained. Integration of information on these two faunal groups will enhance our understanding of the shelf ecosystem there.

A large number of the species collected in the study area were either sessile or slow moving forms. Many important food organisms were deposit feeders or were species capable of using this feeding method part of the time. Both these groups would be greatly affected by oil spills in the area because of their inability to leave the area or because of their dependence on the sediments for feeding.

II. INTRODUCTION

Little is known about the biology of the epifaunal invertebrate components of the shallow, nearshore benthos of Norton Sound and the Chukchi Sea, and yet many of these components may be the ones most affected by the impact resulting from offshore petroleum operations. Some basic data on species composition is essential before industrial activities take place in the above areas. It is the intent of this investigation to conduct a qualitative survey of the benthic epifaunal invertebrates in conjunction with the Northwest Fisheries Center (National Marine Fisheries Service) demersal fish trawl survey within the identified oil-lease sites.

The specific objectives of this study are:

1. A qualitative inventory of dominant benthic invertebrate epifaunal species (exclusive of gastropods) within the study sites.
2. A description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites.
3. Preliminary observations of biological interrelationships between selected segments of the benthic biota in the designated study areas.

III. CURRENT STATE OF KNOWLEDGE

Few studies of benthic invertebrates have been made in the Norton Sound-Chukchi Sea area. Sparks and Pereyra (1966) present a partial species list and general discussion of the benthos near Cape Thompson. Feder and Mueller (1974) present extensive data including species lists, population density, biomass, and feeding methods for invertebrates collected by otter trawl, van Veen grab, and dredge in Norton Sound near Nome. Ellson *et al.* (1950) present results of an exploratory fishing survey in the Nome area in 1949.

Most of the species collected in the present investigation were known; also similar species have been reported for other regions of the northeastern Bering Sea shelf by Soviet investigations (Neyman, 1960).

IV. STUDY AREA

The area for the present investigation included Norton Sound, the eastern Bering Sea north of St. Lawrence Island, and the eastern Chukchi Sea south of Point Hope (Figs. 1-3). All stations completed were east of the USA-USSR boundary line.

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

Data was collected in conjunction with trawling activities of the National Marine Fisheries Service. All collections were made during 30 minute tows using a 400-mesh Eastern otter trawl aboard the NOAA ship *Miller Freeman*.

Invertebrates, except for gastropods, were enumerated, weighed, and given tentative identifications onboard ship by Institute of Marine Science

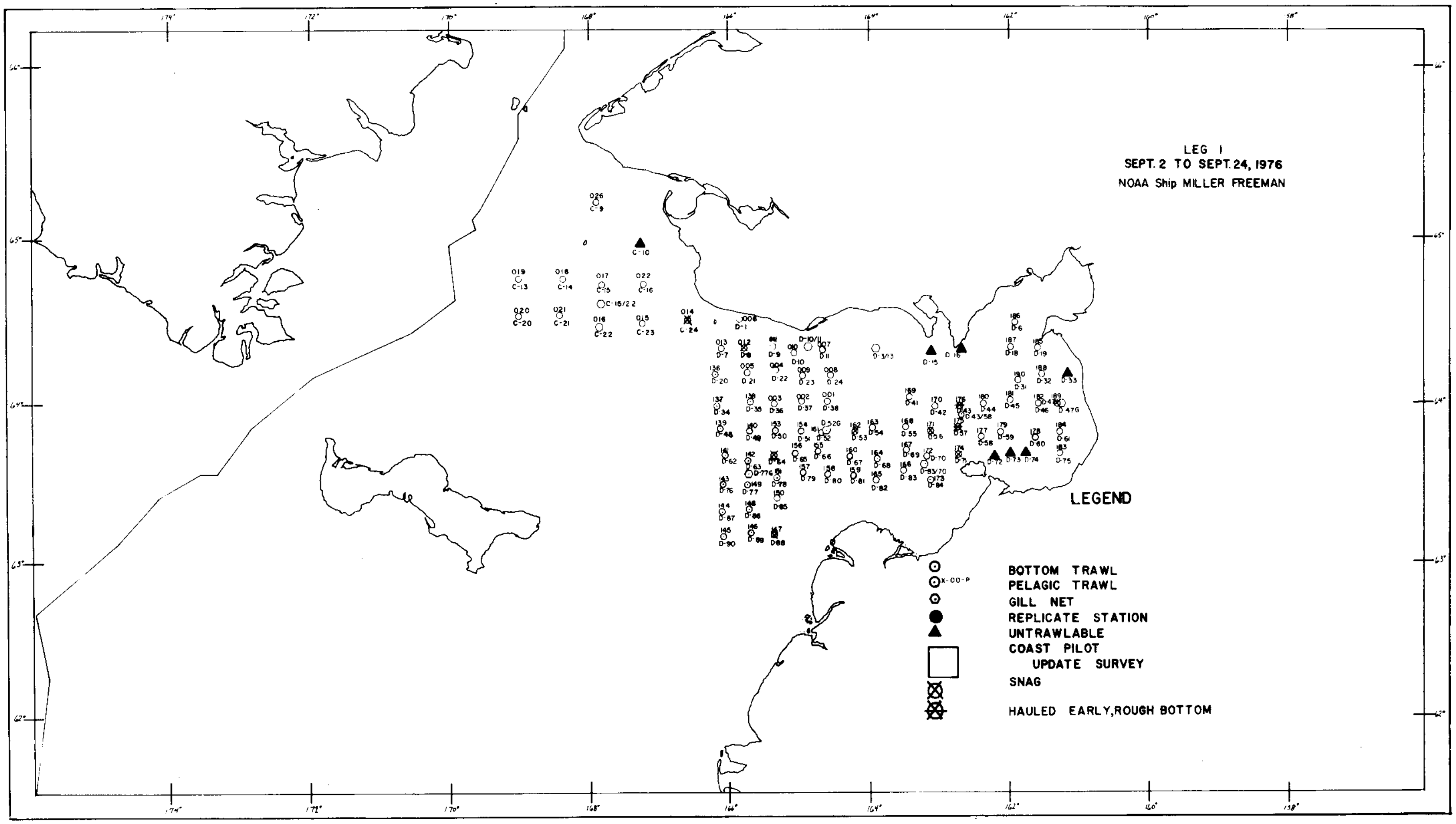

Figure 1. Northeast Bering Sea and Norton Sound station locations occupied by NOAA ship *Miller Freeman*, September 2 to September 24, 1976.

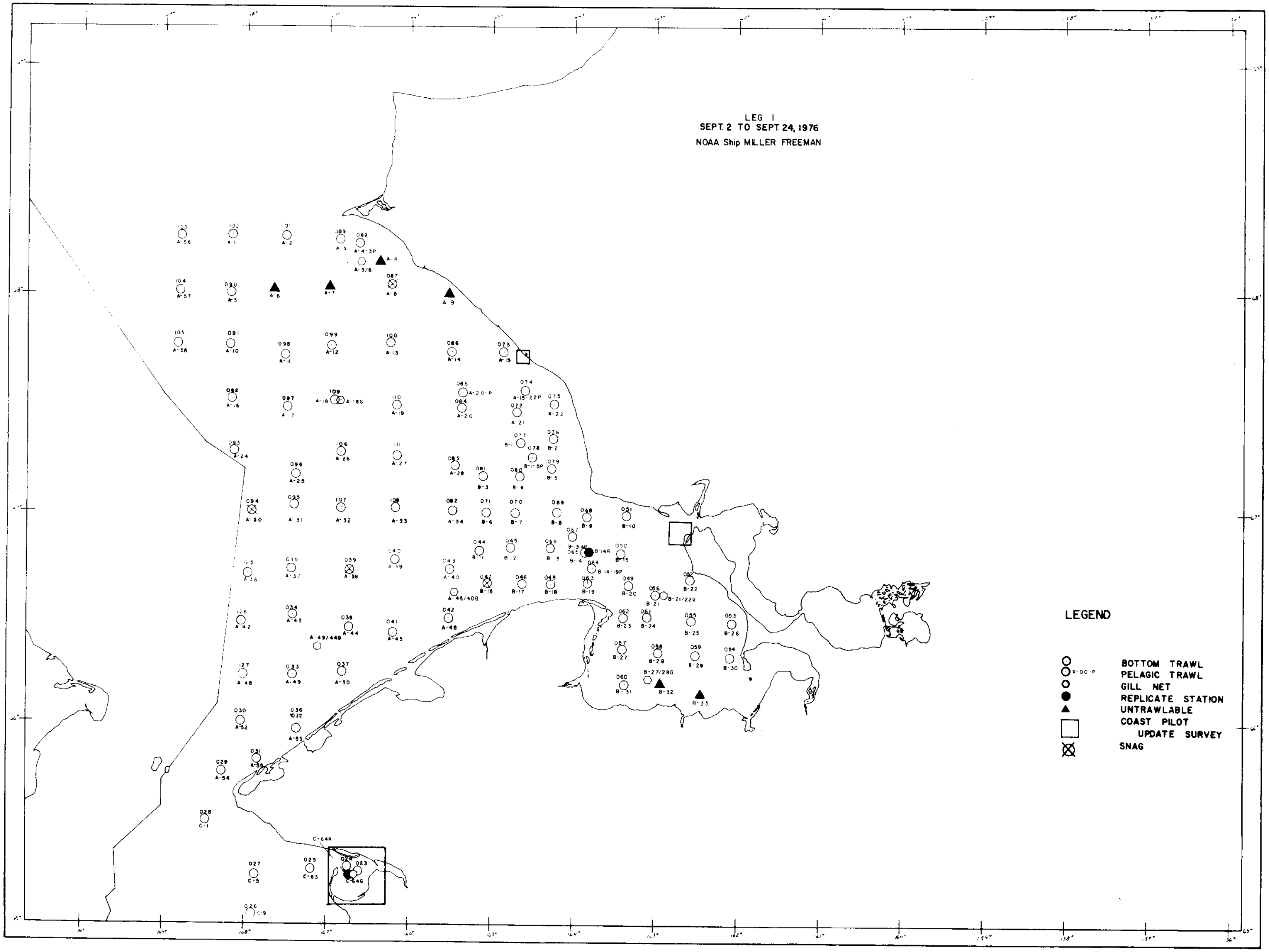

Figure 2. Eastern Chukchi Sea station locations occupied by NOAA ship *Miller Freeman*, September 2 to September 24, 1976.

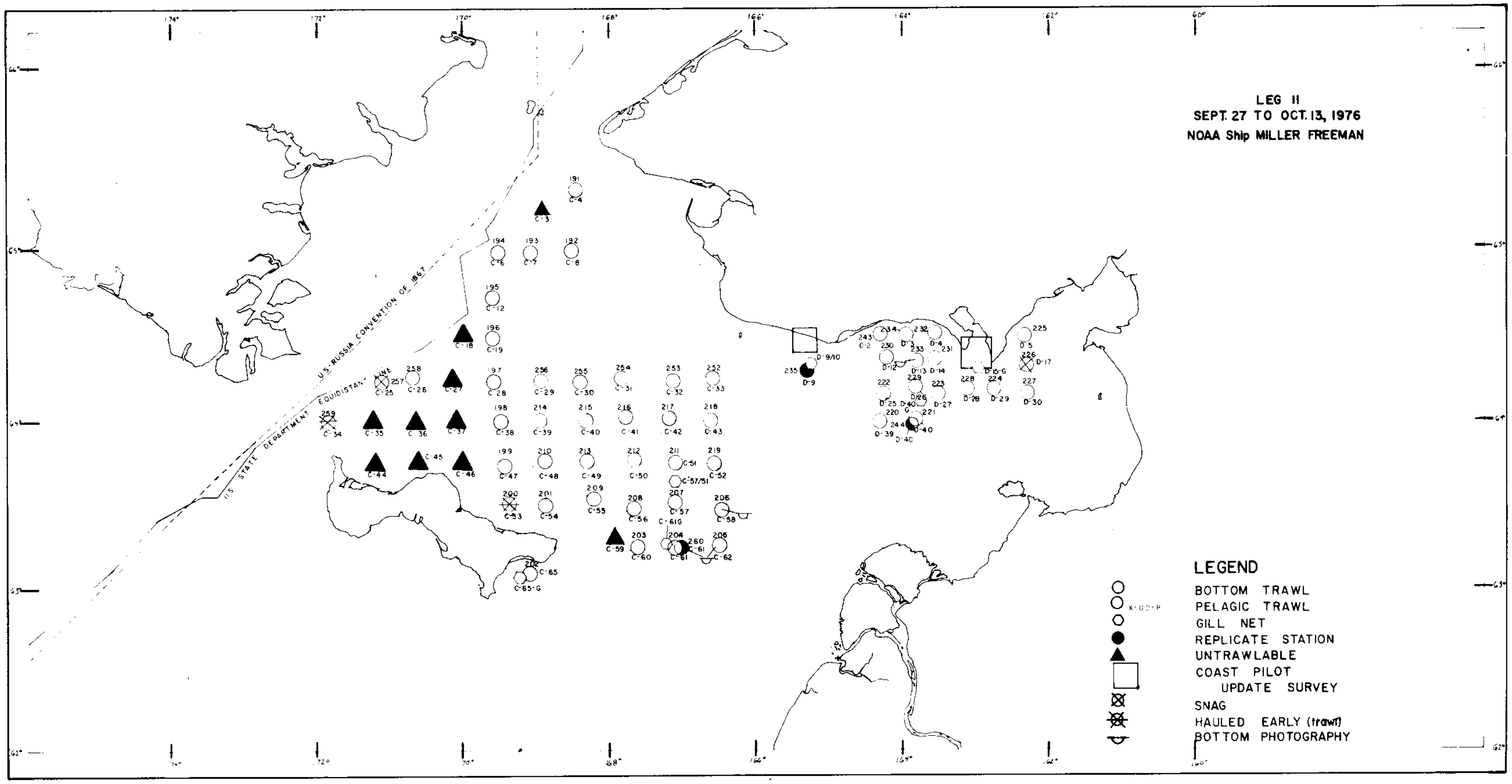

Figure 3. Northeast Bering Sea and Norton Sound station locations occupied by NOAA ship *Miller Freeman*, September 27 to October 13, 1976.

personnel. The bulk of the gastropod data were collected by National Marine Fisheries Service personnel, and taxonomic and distributional information for this group are to be supplied by them for our Final Report. Aliquot samples and voucher specimens of all invertebrates were preserved, and taken to the University of Alaska for positive identification.

When laboratory examination revealed more than a single species in a field identification, the counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to encompass the entire catch of the trawl.

Information on feeding, reproduction, parasites and general ecology of the invertebrates collected was recorded whenever time permitted. Data on occurrence of man-made debris in the trawl was also recorded.

VI. RESULTS

Trawl Study

Trawling operations in the Norton Sound-Chukchi Sea area resulted in collection of a diverse invertebrate fauna. The invertebrate species list (excluding gastropods) (Table I), combined for these two areas, shows 13 phyla, 81 families, and 135 species. The gastropods collected primarily by National Marine Fisheries Service (NMFS) personnel, are listed in Table II. Fifty gastropod species were identified by NMFS and an additional eight species were identified in our laboratory. Thus, bringing the total number of species (including gastropods) to 193. Mollusca, Crustacea, and Echinodermata were the most heavily represented phyla with 91, 41, and 23 species respectively. Separate species lists for the two areas will be available in the Final Report.

TABLE I

PRELIMINARY SPECIES LIST FOR NORTON SOUND-CHUKCHI SEA BENTHIC TRAWL STUDY, LEG I-II *MILLER FREEMAN*, 2 SEPT-13 OCT 1976 SPECIES LIST FOR GASTROPODA IN TABLE 2

Phylum Porfera
- Class Demospongiae
  - Sub-class Ceractinomorpha
    - Family Myxillidae
      - *Myxilla* sp.
      - *Stelodoryx* sp.
    - Family Microcionidae
      - *Microciona* sp.
    - Family Ciocaliptidae
      - *Halichondria* sp.
  - Sub-class Tetractinomorpha
    - Family Axinellidae
      - *Phakellia* sp.

Phylum Cnidaria
- Class Hydrozoa
  - Unidentified species
- Class Scyphozoa
  - Sub-class Alcyonaria
    - Family Nephtyidae
      - *Eunephthya rubiformis* (Pallas)
    - Family Actiniidae
      - *Stomphia coccinea* (O. F. Müller)

Phylum Rhynchocoela
- Unidentified species

Phylum Annelida
- Class Polychaeta
  - Family Polynoidae
    - Unidentified species
  - Family Nereidae
    - *Nereis* sp.
  - Family Chloraemidae
    - *Brada sachalina* (Annenkova)
  - Family Sternaspididae
    - *Sternaspis scutata* (Ranzani)
  - Family Pectinariidae
    - *Cistenides hyperborea* (Malmgren)
  - Family Sabellidae
    - *Bispira* sp.
    - *Bispira polymorpha* Johnson
- Class Hirudinea
  - *Carcinobdella* sp.
  - *Carcinobdella cyclostomum*
  - *Notostomobdella* sp.

Phylum Mollusca
- Class Polyplacophora
  - Family Mopaliidae
    - *Amsicula* sp.

TABLE I

CONTINUED

Family Cryptoplacidae
- *Cryptochiton* sp.
- *Cryptochiton stelleri* (Middendorff)

Family Ischnochitonidae
- *Ischnochiton albus* (Linné)

Class Pelecypoda

Family Nuculidae
- *Nucula tenuis* Montagu

Family Nuculanidae
- *Nuculana fossa* Baird
- *Yoldia* sp.

Family Glycymeridae
- *Glycymeris* sp.

Family Mytilidae
- *Mytilus edulis* Linnaeus
- *Musculus discors* (Linné)
- *Musculus niger* (Gray)
- *Modiolus modiolus* (Linnaeus)

Family Pectinidae
- *Chlamys* sp.
- *Chlamys islandica* (Müller)

Family Astartidae
- *Astarte* sp.
- *Astarte borealis* (Schumacher)

Family Carditidae
- *Cyclocardia* sp.
- *Cyclocardia crassidens* (Broderip and Sowerby)

Family Cardiidae
- *Clinocardium ciliatum* (Fabricius)
- *Clinocardium nuttallii* (Conrad)
- *Clinocardium californiense* Deshayes
- *Serripes groenlandicus* (Bruguiére)

Family Veneridae
- *Liocyma fluctuosa* (Gould)

Family Mactridae
- *Spisula polynyma* (Stimpson)

Family Tellinidae
- *Macoma* sp.
- *Macoma calcarea* (Gmelin)
- *Macoma brota* Dall

Family Myidae
- *Mya arenaria* Linné
- *Mya japonica* Jay

Family Hiatellidae
- *Hiatella* sp.
- *Hiatella arctica* (Linné)
- *Panomya arctica* (Lamarck)

TABLE I

CONTINUED

- Class Gastropoda*
- Class Cephalopoda
  - Family Octopodidae
    - *Octopus* sp.

Phylum Arthropoda

- Class Pycnogonida
  - Family Ammotheidae
    - *Ammothea alaskensis* Cole
- Class Crustacea
  - Order Thoracica
    - Family Balanidae
      - *Balanus* sp.
      - *Balanus hesperius*
  - Order Isopoda
    - Family Sphaeromidae
      - *Tecticeps alascensis*
    - Family Idotheidae
      - *Sadiura entomon* (Gurjanova)
      - *Synidotea bicuspida* (Owen)
  - Order Amphipoda
    - Family Lysianassidae
      - *Anonyx* sp.
      - *Socarnes* sp.
    - Family Stegocephalidae
      - *Stegocephalopsis ampulla* (Phipps)
    - Family Eusiridae
      - *Rhachotropis* sp.
    - Family Gammaridae
      - *Melita* sp.
    - Family Podoceridae
      - *Dulichia spinosissima* Kröyer
    - Family Caprellidae
      - Unidentified species
    - Family Hyperiidae
      - *Parathemisto japonica* Bovallius
  - Order Cumacea
    - Unidentified species
  - Order Decapoda
    - Family Pandalidae
      - *Pandalus goniurus* Stimpson
      - *Pandalus hypsinotus* Brandt
    - Family Hippolytidae
      - *Spirontocaris arcuata* Rathbun
      - *Spirontocaris murdochi* Rathbun
      - *Lebbeus* sp.
      - *Eualus* sp.
      - *Heptacarpus* sp.

*Gastropod species list in Table 2.

TABLE I

CONTINUED

Family Crangonidae
- *Crangon dalli* Rathbun
- *Sclerocrangon* sp.
- *Sclerocrangon boreas* (Phipps)
- *Argis lar* (Owen)
- *Argis crassa* Rathbun

Family Paguridae
- *Pagurus* sp.
- *Pagurus ochotensis* (Benedict)
- *Pagurus capillatus* (Benedict)
- *Pagurus trigonocheirus* (Stimpson)
- *Pagurus rathbuni* (Benedict)
- *Labidochirus splendescens* (Owen)

Family Lithodidae
- *Sculptolithodes derjugini* Makarov
- *Hapalogaster grebnitzkii* Schalfeew
- *Paralithodes camtschatica* (Tilesius)
- *Paralithodes platypus* Brandt

Family Majidae
- *Hyas coarctatus alutaceus* Brandt
- *Chionoecetes* sp.
- *Chionoecetes opilio* (Fabricius)

Family Atelecyclidae
- *Telmessus cheiragonus* (Tilesius)

Phylum Sipunculida
- *Phascolosoma* sp.

Phylum Echiurida

Class Echiurdia

Family Echiuridae
- *Echiurus echiurus* Pallas

Phylum Priapulida
- *Priapulus caudatus* Lamarck

Phylum Ectoprocta

Class Cheilostomata

Family Diastoporidae
- *Mesenteripora* sp.

Family Heteroporidae
- *Heteropora* sp.

Family Flustrellidae
- *Flustrella gigantea* Silen

Family Vesiculariidae
- *Bowerbankia composita* Kluge

Family Flustridae
- *Flustra* sp.

Phylum Brachipoda

Class Articulata

Family Dallinidae
- *Laqueus californicus* Koch

TABLE I

CONTINUED

Family Rhynchonellidae
: *Hemithyris psittacea* Gmelin

Phylum Echinodermata
- Class Asteroidea
  - Family Echinasteridae
    - *Henricia* sp.
  - Family Pterasteridae
    - *Pteraster obscura* (Perrier)
  - Family Solasteridae
    - *Crossaster papposus* (Linnaeus)
    - *Solaster endeca* Verrill
  - Family Asteriidae
    - *Asterias amurensis* Lütken
    - *Leptasterias* sp.
    - *Leptasterias polaris ascervata* (Stimpson)
    - *Lethasterias nanimensis* (Verrill)
    - *Evasterias echinosoma* Fischer
    - *Evasterias troschelii* Fisher
- Class Echinoidea
  - Family Echinarachniidae
    - *Echinarachnius parma*
  - Family Strongylocentrotidae
    - *Strongylocentrotus droebachiensis* (O. F. Müller)
- Class Ophiuroidea
  - Family Gorgonocephalidae
    - *Gorgonocephalus caryi* (Lyman)
  - Family Ophiactidae
    - *Ophiopholis aculeata* (Linnaeus)
  - Family Ophiuridae
    - *Ophiura sarsi* Lütkin
    - *Stegophiura* sp. (Lütkin)
  - Family Amphiuridae
    - *Amphipholis pugetana* (Lyman)
- Class Holothuroidea
  - Family Cucumariidae
    - *Cucumaria* sp.
    - *Cucumaria calcigera* (Stimpson)
  - Family Stichopodidae
    - *Parastichopus* sp.
  - Family Psolidae
    - *Psolus japonicus* Östergren
  - Family Synaptidae
    - *Chiridota* sp.
    - *Myriotrochus* sp.

Phylum Chordata
- Subphylum Urochordata
  - Class Stolidobranchia

TABLE I

CONTINUED

Family Pyuridae
- *Boltenia ovifera* (Linné)
- *Boltenia echinata* Linné
- *Halocynthia aurantium* (Pallas)

Family Styelidae
- *Pelonaia* sp.
- *Pelonaia corrugata* Forbes et Goods

Family Rhodosomatidae
- *Chelyosoma* sp.
- *Chelyosoma orientale* Redikorzev
- *Chelyosoma columbianum* Huntsman

Family Salpidae
- Unidentified species

TABLE II

LIST OF GASTROPOD MOLLUSCS COLLECTED ON *MILLER FREEMAN* CRUISE 76 IN NORTON SOUND AND THE CHUKCHI SEA, 1976

Collection and Identification by National Marine Fisheries Service Except for those species marked with an asterisk which were collected and identified by the Institute of Marine Science

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Phylum Mollusca
- Class Gastropoda
  - Family Trochidae
    - *Margarites giganteus* (Leche, 1878)
    - *Solariella obscura* (Couthouy, 1838)
    - *S. varicosa* (Mighels and Adams, 1842)
    - *Solariella* sp.
  - Family Turritellidae
    - *Tachyrhynchus erosus major* Dall, 1919
    - *T. reticulatus* (Mighels, 1841) (Dead shell only)
  - Family Calyptraeidae
    - *Crepidula grandis* Middendorff, 1849
  - Family Trichotropidae
    - *Trichotropis bicarinata* (Sowerby, 1825)
    - *T. insignis* Middendorff, 1849
    - *T. kroyeri* Philippi, 1848 (Dead shell only)
  - Family Naticidae
    - *Natica russa* Gould*
    - *N. clausa* Broderip and Sowerby, 1829
    - *Natica* sp.*
    - *Polinices pallidus* (Broderip and Sowerby, 1829)
  - Family Lamellariidae
    - *Velutina plicatilis* (Müller, 1776)
    - *V. undata* (Brown)*
    - *V. velutina* (Müller)*
    - *Velutina* sp.*
  - Family Muricidae
    - *Boreotrophon clathratus* (Linnaeus, 1758)
  - Family Buccinidae
    - *Buccinum angulossum* Gray, 1839
    - *B. glaciale* Linnaeus, 1761
    - *B. fringillus* Dall, 1877
    - *B. polare* Gray 1839
    - *B. scalariforme* Möller, 1842
    - *B. solenum* Dall, 1919
    - *B. tenellum* Dall, 1883
  - Family Neptuneidae
    - *Clinopegma* sp. (cf. *buccinoides* Habe and Ito, 1965)
    - *C. magna* (Dall, 1875)
    - *Beringius beringii* (Middendorff, 1849)
    - *B. stimpsoni* (Gould, 1860)

TABLE II

CONTINUED

Family Neptuneidae (con't)
- *C. hypolispus*(Dall, 1891)
- *C. ombronius* (Dall, 1919)
- *C. spitzbergensis* (Reeve, 1855)
- *Colus* sp.
- *Liomesus ooides* (Middendorff, 1848) (Dead shell only)
- *Neptunea borealis* (Philippi, 1850)
- *N. heros* (Gray, 1850)
- *N. lyrata* (Gmelin, 1791)
- *N. ventricosa* (Gmelin, 1791)
- *N. ventricosa* form *beringiana* (Middendorff)
- *Plicifusus brunneus* (Dall, 1877)
- *P. kroyeri* (Möller, 1842)
- *P. verkruzeni* Kobelt, 1876
- *Pyrulofusus deformis* (Reeve, 1847)
- *Volutopsius filosus* Dall, 1919
- *V. fragilis* (Dall, 1891)
- *V. stefanssoni* Dall, 1919

Family Cancellaridae
- *Admete couthouyi* (Jay, 1839) (Dead shell only)

Family Turridae
- *Oenopota harpa* (Dall, 1885)
- *O. nazanensis* (Dall, 1919) (Dead shell only)
- *Oenopota* sp.
- *Obesotoma simplex* (Middendorff, 1849)

Family Pyramidellidae
- *Odostomia arctica* Dall and Bartsch, 1909 (Dead shell only)

Family Scaphandridae
- *Cylichna* sp. (cf. *occulta* Mighels and Adams, 1842) (Dead shell only)

Family Dorididae
- Unidentified species*

Family Dendronotidae
- *Dendronotus arborescens* (Müller)*

Family Tritoniidae
- *Tochuina tetraquetra* (Pallas)*

Abundance and distribution data for most invertebrates are not available at this time, but will be included in the Final Report. Numbers and weight of gastropods collected by NMFS are included in Table III.

Food Studies

Analysis of stomach contents of the starry flounder (*Platichthys stellatus*) and sea star (*Leptasterias polaris ascervata*) (Tables IV and V) showed many differences in the feeding habits of these animals between Norton Sound and the Chukchi Sea. Starry flounders from Norton Sound used mainly the deposit-feeding clam *Yoldia* sp. and the small brittle star *Amphipholis pugetana* as food while starry flounders from the Chukchi Sea concentrated on the worm *Echiurus echiurus* and the prickleback fish *Lumpenus fabricii*. *Leptasterias polaris ascervata*, the only sea star for which sufficient data exists to compare areas, fed primarily on sand dollars (*Echinarachnius parma*) and barnacles (*Balanus* sp.) in Norton Sound while in the Chukchi Sea it fed on the snail *Natica* sp. and the polychaete worm *Cistenides* sp.

Only general comments on feeding are possible for the other species examined (Tables IV and V). Both *Evasterias echinosoma* and *Lethasterias nanimensis* fed primarily on molluscs. The brittle star *Ophiura sarsi* was taking small crustacea while the single *Solaster endeca* and the single *Asterias amurensis* examined were using *Gorgonocephalus caryi* and *Echinarachnius parma* respectively. All *Gorgonocephalus caryi* had empty stomachs.

VII. DISCUSSION

Station Coverage

Station coverage was relatively uniform over the study area with Norton Sound covered more intensively than other areas (see Figs. 1-3).

TABLE III

SNAIL SPECIES LISTED IN ORDER OF DECREASING ABUNDANCE BY BOTH NUMBER AND WEIGHT - *MILLER FREEMAN* CRUISE, SEPT 2 - OCT 13, 1976

Include Duplicated Stations

Species	Number Caught	Percent Total Number
Neptunea heros	9,707	64
N. ventricosa	2,280	15
Beringius beringii	859	6
Pyrulofusus deformis	392	3
Neptunea borealis	277	2
Buccinum scalariforme	271	2
Natica clausa	250	2
Buccinum polare	243	2
Volutopsius fragilis	212	1
Buccinum angulossum	191	1
All Other Species		<1

Species	Pounds Caught	Percent Total Weight
Neptunea heros	2,886	78
N. ventricosa	439	12
Beringius beringii	179	5
Pyrulofusus deformis	94	3
Volutopsius fragilis	26	1
All Other Species		<1

TABLE IV

PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS (LISTED ACCORDING TO LOWEST LEVEL OF TAXONOMIC IDENTIFICATION) FOUND IN THE STOMACHS OF FISHES AND INVERTEBRATES FROM THE CHUKCHI SEA, 1976 (N=NUMBER OF STOMACHS EXAMINED)

Food Item	Percent frequency of occurrence of food items in the stomachs of:				
	Platichthys stellatus N=30	*Leptasterias polaris ascervata* N=28	*Evasterias echinosoma* N=19	*Lethasterias nanimensis* N=9	*Asterias amurensis* N=1
Cistenides sp.	-	25.0	-	-	-
Nuculana fossa	-	3.6	-	-	-
Cyclocardia sp.	-	3.6	-	-	-
Cyclocardia crebricostata	-	3.6	-	-	-
Serripes groenlandicus	-	-	68.4	55.6	-
Astarte borealis	-	3.6	15.8	-	-
Mya truncata	-	-	5.3	-	-
Clinocardium ciliatum	-	-	5.3	11.1	-
Macoma calcarea	-	17.9	-	-	-
Musculus niger	-	-	5.3	-	-
Natica sp.	-	32.1	-	-	-
Natica clausa	-	-	-	11.1	-
Boreotrophon pacificus	-	7.1	-	-	-
Buccinum polare	-	3.6	-	-	-
Crustacea	3.3	-	-	-	-
Balanus sp.	3.3	-	-	-	-
Amphipoda	3.3	-	-	-	-
Anonyx sp.	3.3	-	-	-	-

TABLE IV

CONTINUED

	Percent frequency of occurrence of food items in the stomachs of:				
Food Item	*Platichthys stellatus* N=30	*Leptasterias polaris ascervata* N=28	*Evasterias echinosoma* N=19	*Lethasterias nanimensis* N=9	*Asterias amurensis* N=1
Caridea	3.3	-	-	-	-
Crangonidae	6.7	-	-	-	-
Echiurus echiurus	46.7	-	-	-	-
Echinarachnius parma	-	-	-	22.2	100.0
Stegophiura sp.	3.3	-	-	-	-
Holothuroidea	3.3	-	-	-	-
Teleostei	3.3	-	-	-	-
Myoxocephalus sp.	3.3	-	-	-	-
Lumpenus fabricii	23.3	-	-	-	-
Eleginus gracilis	3.3	-	-	-	-
Liparis sp.	3.3	-	-	-	-
Gymnocanthus galeatus	3.3	-	-	-	-
Empty stomach	20.0	-	-	-	-

TABLE V

PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS (LISTED ACCORDING TO LOWEST LEVEL OF TAXONOMIC IDENTIFICATION) FOUND IN THE STOMACHS OF FISHES AND INVERTEBRATES COLLECTED IN NORTON SOUND, 1976 (N=number of stomachs examined)

	Percent frequency of occurrence of food items in the stomachs of:							
Food Item	*Platichthys stellatus* N=238	*Leptasterias polaris ascervata* N=31	*Leptasterias* sp. N=1	*Lethasterias nanimensis* N=6	*Evasterias echinosoma* N=2	*Solaster endeca* N=1	*Ophiura sarsi* N=7	*Gorgonocephalus caryi* N=10
Hydrozoa	0.4	-	-	-	-	-	-	-
Annelida	0.4	-	-	-	-	-	-	-
Polychaeta	10.5	6.5	-	-	-	-	-	-
Polynoidae	0.4	-	-	-	-	-	-	-
Pectinaridae	5.9	-	-	-	-	-	-	-
Sternaspis scutata	6.7	-	-	-	-	-	-	-
Pelecypoda	5.0	-	-	-	-	-	-	-
Yoldia sp.	55.9	-	-	-	-	-	-	-
Cyclocardia sp.	-	6.5	-	-	-	-	-	-
Serripes groenlandicus	14.7	6.5	-	83.3	-	-	-	-
Mya sp.	1.7	-	-	-	-	-	-	-
Cardiidae	0.8	-	-	-	-	-	-	-
Clinocardium californiense	0.4	-	-	16.7	-	-	-	-
Macoma sp.	-	3.2	100.0	-	-	-	-	-
Musculus sp.	2.9	-	-	-	-	-	-	-
Musculus discors	0.8	-	-	-	-	-	-	-
Musculus niger	5.9	-	-	-	-	-	-	-
Gastropoda	0.8	6.5	-	-	-	-	-	-

TABLE V

CONTINUED

Food Item	Percent frequency of occurrence of food items in the stomachs of: *Platichthys stellatus* N=238	*Leptasterias polaris ascervata* N=31	*Leptasterias* sp. N=1	*Lethasterias nanimensis* N=6	*Evasterias echinosoma* N=2	*Solaster endeca* N=1	*Ophiura sarsi* N=7	*Gorgonocephalus caryi* N=10
Margarites sp.	-	-	-	-	50.0	-	-	-
Naticidae	0.4	-	-	-	-	-	-	-
Natica sp.	-	3.2	-	-	-	-	-	-
Oenopota sp.	0.4	-	-	-	-	-	-	-
Crustacea	-	-	-	-	-	-	100.0	-
Balanus sp.	0.4	19.4	-	-	-	-	-	-
Diastylidae	2.9	-	-	-	-	-	-	-
Isopoda	9.7	-	-	-	-	-	-	-
Sadiura entomon	0.4	-	-	-	-	-	-	-
Synidotea bicuspida	0.4	-	-	-	-	-	-	-
Amphipoda	2.1	3.2	-	-	-	-	-	-
Argis lar	1.3	-	-	-	-	-	-	-
Eualus sp.	-	3.2	-	-	-	-	-	-
Chionoecetes opilio	0.4	-	-	-	-	-	-	-
Hyas coarctatus alutaceus	-	3.2	-	-	-	-	-	-
Labidochirus splendescens	0.4	-	-	-	-	-	-	-
Priapulus caudatus	7.6	-	-	-	-	-	-	-
Echiurus echiurus	3.8	-	-	-	-	-	-	-
Ectoprocta	-	3.2	-	-	-	-	-	-

TABLE V

CONTINUED

Food Item	Percent frequency of occurrence of food items in the stomachs of:							
	Platichthys stellatus N=238	*Leptasterias polaris ascervata* N=31	*Leptasterias* sp. N=1	*Lethasterias nanimensis* N=6	*Evasterias echinosoma* N=2	*Solaster endeca* N=1	*Ophiura sarsi* N=7	*Gorgonocephalus caryi* N=10
Echinarachnius parma	2.9	35.5	-	-	50.0	-	-	-
Amphipholis pugetana	37.8	-	-	-	-	-	-	-
Stegophiura sp.	2.1	-	-	-	-	-	-	-
Gorgonocephalus caryi	-	-	-	-	-	100.0	-	-
Teleostei	2.9	-	-	-	-	-	-	-
Myoxocephalus sp.	0.8	-	-	-	-	-	-	-
Lumpenus fabricii	1.7	-	-	-	-	-	-	-
Empty stomachs	8.4	-	-	-	-	-	-	100.0

Trawl Study

Available computer programs will be used to generate separate species lists for Norton Sound and the Chukchi Sea as well as distribution, frequency of occurrence, and biomass estimates for all epibenthic invertebrates collected in the study area.

The combined-area species list shows that Mollusca, Arthropoda, and Echinodermata, in that order, are the dominant phyla based on number of species. Jewett and Feder (in press) showed similar dominance in number of species for these groups in trawl samples from the northeast Gulf of Alaska.

Biomass and abundance data, available for the Final Report, will allow analysis of species dominance by number of organisms and weight.

Food Studies

Primary food items of the starry flounder (*Platichthys stellatus*) and the sea star (*Leptasterias polaris ascervata*) differed between Norton Sound and the Chukchi Sea. Due to lack of dredge or grab data on the abundance of infauna in the area it is not known whether these differences in food items are due to preference or availability of the items.

The dominant items in the stomachs of all organisms examined were molluscs and echinoderms. Crustaceans were a food source little used by the organisms examined.

VIII. CONCLUSIONS

Trawling operations in the Norton Sound-Chukchi Sea area have resulted in the collection of 13 phyla and 193 species. Mollusca, Crustacea, and Echinodermata are the most heavily represented phyla with 91, 41, and 23 species respectively.

Distribution and abundance data for invertebrates are not available at this time, but will be included in the final report.

Analysis of stomach contents of the starry flounder *Platichthys stellatus* and sea star *Leptasterias polaris ascervata* show many differences in the feeding habits between Norton Sound and the Chukchi Sea. Starry flounders from Norton Sound use mainly the deposit-feeding clam *Yoldia* sp. and the small brittle star *Amphipholis pugetana* as food, while starry flounders from Chukchi Sea mainly consume the worm *Echiurus echiurus* and the prickleback fish *Lumpenus fabricii*. *Leptasterias polaris ascervata*, the only sea star for which sufficient data exists to compare areas, feed primarily on sand dollars, *Echinarachnius parma*, and barnacles, *Balanus* sp. in Norton Sound while in the Chukchi Sea it feeds on the snail *Natica* sp. and the polychaete worm *Cistenides* sp..

Further stomach analysis of starry flounder and the brittle star *Ophiura sarsi* will appear in the final report and should broaden our understanding of benthic trophic interactions of these areas.

The importance of deposit-feeding clams in the diet of starry flounders from Norton Sound is demonstrated; this situation is also true for starry flounder observed elsewhere. A high probability exists that oil hydrocarbons will enter crabs *via* these deposit-feeding molluscs, suggesting that studies interrelating sediment, oil, deposit-feeding clams, and appropriate predator species should be initiated soon.

IX. NEEDS FOR FURTHER STUDY

1. Although the trawling activities were expected to be satisfactory for determination of the distribution and abundance of epifauna, a substantial component of both areas - the infauna - was not sampled. Since

infaunal species represent important food items, it is essential that dredging be accomplished here in the near future.

2. Additional studies are needed during other seasons and years to describe seasonal and year-to-year variations in the distribution and relative abundance of the epifauna.

3. Seasonal predator-prey relationships should be examined in conjunction with simultaneous infaunal sampling.

4. It is essential that large samples of the dominant clam prey species be obtained to initiate recruitment, age, growth, and mortality studies. These data will then be comparable to similar data being collected for clams of Cook Inlet and the Bering Sea (Feder *et al.*, 1977). Any future modeling efforts concerned with carbon or energy flow in the Norton Sound-Chukchi Sea area will need this type of information.

5. No physical and chemical data are currently available. This information should be obtained in the future in conjunction with all biological sampling efforts.

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X. SUMMARY OF THE 4th QUARTER OPERATIONS

A. Ship or Laboratory Activities

1. No ship activity
2. Scientific party - not applicable
3. Methods - laboratory analysis
   a. Verification of field identifications is underway at Institute of Maine Science, University of Alaska, Fairbanks.
   b. Further examination of predator-prey relationships is in progress.
   c. Cluster analysis techniques are being developed.
4. Sample localities - not applicable
5. Data analyzed

Approximately 75 starry flounder stomachs were examined in the laboratory. Analysis of prey data included frequency of occurrence and numerical and volumetric determinations.

6. Distribution and abundance data, cluster analysis, predator-prey relationships and reproductive notes will be included in the Final Report. Data will be examined within and between Norton Sound and Chukchi Sea. See data submission schedule.

B. Problems Encountered/Recommended Changes

During the present study National Marine Fisheries Service collected data on commercial crabs and all gastropod molluscs. To insure accuracy and consistency of identification of species as well as biological and biomass data, it is suggested that Institute of Marine Science personnel be responsible for collection of all data on benthic invertebrates.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 30 R.U. NUMBER: 502

PRINCIPAL INVESTIGATOR: H. M. Feder
University of Alaska

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]		
	From	To	Batch 1		
Miller Freeman	9/1/76	10/15/76	7/30/77[a]		

Note: [1] Data management plan was submitted on 8/30/76, approved by M. Pelto on 9/13/76; we await approval by the contracting officer.

[a] Raw field data was submitted at the end of the cruise. Verified and formated data will be submitted on above date.

Contract # 03-5-022-69
Research Unit # 512
Reporting Period April 1, 1976 -
March 31, 1977
Number of Pages: 43

Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System

James E. Blackburn
Alaska Department of Fish and Game
P.O. Box 686
Kodiak, Alaska 99615

March 31, 1977

I SUMMARY

This is a report of progress achieved from the time of initial funding, April 1976, through March 31, 1977. During this time sampling was conducted with otter trawl, beach seine, tow net, purse seine and gill net throughout most of lower Cook Inlet from late May through early October 1976 and in March 1977 otter trawling was conducted. Catches of fish and invertebrates were identified and enumerated as accurately as possible, and on selected taxa length weight and length frequency measurements were taken and stomach samples were collected.

The resulting catch information has been partially tabulated and 'ions are here presented to highlight relative abundance, distribution and seas ty by species. Length frequency analyses for growth, and food habits analyse are incomplete. Additional objectives concerning literature surveys are not yet complete.

Information gathered was inadequate to fully accomplish two of the objectives. The purse seine did not produce sufficient data to adequately assess pelagic fish abundance or locations. Information on these fish is provided by beach seine and tow net. The oceanographic and atmospheric data collected was insufficient to attempt correlation with fish distribution or movement.

II INTRODUCTION

General Nature and Scope of Study

This study was intended to document the use of lower Cook Inlet by fish and shellfish and its use by the fishery. Few such studies have been done in Alaska and there has been very little work conducted in lower Cook Inlet, except in Kachemak Bay.

This study was formulated to sample virtually all the depth zones and habitats within lower Cook Inlet with the practical limitation of a limited budget in this logistically difficult area to work. Beach seines and surface tow nets were used from 17 ft Boston Whalers to cover the shoreline to 3 m deep and the surface 3 m in the less than 18 m depth zone. A power purse seine was used to sample the surface beyond 18 m depth and an otter trawl was used to sample the bottom community at depths beyond 18 m.

The scope of the study, however broad, was affected by limitations of the gears. Sampling the shore zone on the west side of the inlet proved to be expensive since it required two Boston Whalers with a crew of four camping on the beach and the chartered vessel readily available for support. Thus, areas where the chartered vessel was working dictated the shoreline areas that were sampled.

The well known currents in lower Cook Inlet severely restricted areas where the power purse seine could be used just as weather affected the time that it could be used. The otter trawl was restricted by rocky bottom to area south of 59°50'N and a fair portion of the inlet in this area was too rocky to sample.

Specific Objectives

A. Determine the spatial and temporal (May-September) distribution, relative abundance and inter-relationships of the various pelagic and demersal finfish and shellfish species in the study area.

B. Determine when, where, at what rate and in what relative abundance pleagic fish species (primarily salmonids) migrate into and through the study area.

C. Determine the growth rate and food habits of selected pelagic and demersal fish species.

D. Survey the literature to obtain and summarize an ordinal level documentation of commercial catch, stock assessment data, distribution, as well as species and age group composition of various shellfish species in the study area.

E. Survey the literature to inventory and characterize salmon spawning streams as well as timing of fry and smolt migrations.

F. Obtain basic oceanographic and atmospheric data to determine any correlations between these factors and migrations and/or relative abundance of various pelagic and demersal fish and shellfish species encountered.

Relevance to Problems of Petroleum Development

Petroleum development in lower Cook Inlet is planned for the near future wnd it will have an impact on fish and fisheries of the area. The precise impact depends upon what takes place and when and where it occurs. This study is providing part of the basic data upon which to make decisions that may affect natural resources.

The placement of shore facilities may result in impact in their vicinity. Information that may provide perspective on site selection is of considerable importance and necessarily must be quite site specific. The inshore portion of this study will provide this type of information.

Contamination by oil spill will affect certain resources most acutely. Floating oil will affect sea birds, marine mammals and intertidal life. It will have an unknown affect upon larvae and juveniles of demersal fish, especially those that occupy the near surface layers. Knowledge of demersal fishes is an important link in assessing this aspect of potential impact. Spilled oil may also reach the bottom of the sea, where it may collect and affect marine organisms.

Chronic contamination at low levels has a poorly understood affect upon biota but it is potentially hazardous. This may originate from permanent or semi-permanent facilities, such as drilling platforms and may affect demersal epifauna.

The activities of the drilling platforms may directly affect the sea bottom. Placement of structures, dumping of drilling mud and cuttings may affect seabed habitats and the biota that lives there.

Thus, many of the potential impacts of oil development may affect those resources that this study is addressed to investigate.

Acknowledgements

Mr. Peter Jackson, the OCS Coordinator for the Alaska Department of Fish and Game, must be given the credit for planning and implementing this study. The time between funding and study implementation, little more than one month, attests to the difficulties overcome. I also wish to thank him for the continuing guidance and encouragement. All of the accomplishments of this study are to the credit of Peter Jackson.

I would like to thank Wes Bucher who served very ably as assistant project leader and field crew leader. I express appreciation to the field crew that put up with the discomforts and collected all the data. They were Dave Anderson, Bob Mielke, Steve Pint, Don Seagren and Phil Smith.

III CURRENT STATE OF KNOWLEDGE

Alaska is unique in the United States in that it remains poorly reconnoitered, ichthyologically. Fish distributions, although a basic characteristic, are confusing and illogically discontinuous for many species. At the same time commercial utilization of several species is considerable and knowledge related to the fisheries is considerable. The knowledge of fish and shellfish resources of lower Cook Inlet is variable, but largely lacking.

The National Marine Fisheries Service conducted approximately 85 otter trawl hauls in Cook Inlet during 1958, 1961 and 1963, however, they were rigged for shrimp or crab and operated only between mid-July and late September. In addition, the International Pacific Halibut Commission conducted 26 otter trawl hauls in July of 1974 and 1976 in the mouth of Kachemak Bay.

Rounsfell (1929) documented the fishery and presented biological data for herring of the south Kenai Peninsula and Kachemak Bay. Alaska Department of Fish and Game has conducted research on invertebrate resources of lower Cook Inlet. In 1974 a pot index program for king and tanner crab abundance was initiated in Kachemak Bay and in 1975 the program was expanded to the Kamishak Bay area (Davis 1975 and 1976a). Tagging studies of Dungeness crab in Kachemak Bay were conducted in 1963 and 1975, providing migration and fishing mortality information (Davis 1976b). Shrimp research in Kachemak Bay has included fishery documentation and since 1971 trawl surveys have been conducted during May (Davis 1976c).

IV STUDY AREA

The study area for this project includes lower Cook Inlet from the Forelands to 59°N latitude. Across Kennedy Entrance south of Pt. Bede it is bounded on the east by 152°W longitude. This encompasses approximately 4400 square miles.

Cook Inlet receives the waters of several substantial rivers including the Susitna, Matanuska, Knick, 20-mile, Kenai and Kasilof. These and others are glacier fed and contribute sufficient suspended material to the inlet that the entire upper inlet and a substantial portion of lower Cook Inlet contains intensely silty waters. The shorelines around Anchorage and into lower Cook Inlet consist of vast deposits of silt. Apparently, considerable areas of the bottom of lower Cook Inlet are covered by sand which apparently shifts with the tide. This factor may be of overriding importance in the ecology of considerable portions of the inlet.

Water circulation in lower Cook Inlet was recently discussed at the BLM/OCSEAP lower Cook Inlet Synthesis workshop November 16-18, 1976 and was discussed again in March. Water circulation is not well understood but several points are clear. There is a substantial net flow through Kennedy Entrance into lower Cook Inlet and a general southerly flow in the vicinity of Kamishak Bay. North of approximately Anchor Pt. (59°46'N) the currents are stronger than to the south and in the center of the inlet south of Kalgin Island is a pronounced tide rip, which is poorly understood. The water in Kachemak Bay, in contrast, is to some extent confined within the bay.

Tidal currents are superimposed upon the above current patterns and are substantial since tidal excursions are well in excess of 30 ft. Velocities up to 12 knots have been reported in the vicinity of the Forelands. The extremely dynamic current is an important marine habitat factor in lower Cook Inlet, as is the generally modest depth.

Only a small area in Kennedy Entrance is over 100 fathoms deep. The 50 fathom contour extends only to 59°18'N although other localized areas deeper than 50 fathoms occur, notably within Kachemak Bay. Virtually the entire inlet is less than 50 fathoms deep and all shallower depth zones are extensive throughout its length.

V SOURCES METHODS AND RATIONALE OF DATA COLLECTION

The study area was artificially divided into the following areas according to the suitability of gear to that area. Beach seines were used to sample the 0 to 3 m depth zone for pelagic and demersal fish. A surface tow net was used to sample the surface 3 m in water 3 to 18 m deep. A small mesh purse seine and variable mesh gill nets were used to sample pelagic fish in surface waters over depths greater than 18 m and an otter trawl was used to sample demersal epifauna at depths greater than 18 m.

Otter Trawl

A systematic random sampling scheme was chosen as the appropriate method of station selection as it was deemed desirable to be able to make population estimates from the data.

Otter trawling stations were initially chosen by gridding the entire study area deeper than ten fathoms (18 M) into one nautical mile squares, and numbering the squares beginning in the northwest corner and progressing west to east and north to south. The study area contained 3,337 square miles, each representing a potential station. The first station was chosen by randomly selecting a number between one and ten, and every 95th square thereafter was chosen systematically as a station, yielding 35 sampling stations. This sampling intensity was based on estimated sampling rate and time available. As initial trawl hauls resulted in torn nets and lost time due to rocky bottom, a field decision was made to redefine the sampling area to exclude obviously untrawlable bottom types. This redefinition of the trawl area to be considered, accomplished with the advice of local fishermen, resulted in a reduction of the size of the total area to 795 mi^2. A second field decision to reduce the total number of stations sampled per survey within this redefined area from 35 to 20 was necessitated by the excessive running time required between stations. Trawl stations within this redefined area (Figure 1) were selected by the same procedure originally employed.

Sampling was conducted with a 700 mesh eastern otter trawl which had a 30 m footrope, a 27 m headrope, and was 26 m in total length with a 4 m long cod end. The net was constructed with 4 inch mesh at the mouth and 3½ inch mesh in the body and cod end and had a 1¼ inch mesh cod end liner. It was equipped with 15 floats 20 cm in diameter on the headrope, and had no tickler or rollers. The bridles were 9 m long and the doors were 2.7 m (9 ft) by 1.8 m (7 ft) Astoria V design. This net is considered to open 1.5 m high by 12.2 m wide. The net was pulled with a 3 to 1 scope for 30 minutes at 3 knots so that 1 nautical mile (1.85 km) was covered and 0.02261 km^2 were covered in each standard haul. When the net was brought to the surface, the cod end was retrieved with a lazy line and the catch was dumped in large tubs. Catches were sorted by species as possible and each species was weighed, counted and directly recorded on the keypunch data form. Unidentified species were preserved for later identification. Stomach samples and lengths were taken from selected taxa.

Tow Net

The tow net sampled the surface pelagic fish in the 3 to 10 fathom depth zone and over deeper waters in the deep estuaries around Kachemak Bay. Stations were selected informally to cover the length of this area. The net was 9 ft by 9 ft (square) at the mouth by 27 ft long. It was made of an 8 ft forward section of 1½ inch mesh, a 9 ft midsection of ½ inch mesh, a 10 ft cod end of ¼ inch mesh with a 1/8 inch mesh liner in the last 2 ft and a zipper on the cod end. The net was held open vertically by spreader bars and horizontally by a towing vessel on each side. The net was pulled for standard 10 minute tows at approximately 3 knots by two 17 ft skiffs with 70 hp outboards using 20 m of cable. Catches were immediately sorted by species, counted, weighed, recorded and samples preserved.

Beach Seine

The beach seine was 155 ft long by 12 ft deep in the middle and tapered to 3 ft deep at the ends and dyed green. It was constructed of knotless nylon throughout with 12 ft by 35 ft rectangular ¼ inch stretch measure (sm) midsection, two 20 ft long by 12 ft by 10 ft tapered inner wings of ½ inch sm and two 40 ft long by 10 ft by 3 ft tapered outer wings of 1½ inch sm. Approximately 50 ft lines with anchors were attached to each end. The net was set from the skiff by approaching the beach as closely as possible, tossing the anchor onto the beach, usually with 10 to 30 ft of line between the edge of the water and the end of the net. The net was set in an arc roughly parallel to the beach and the boat beached and the net immediately retrieved by the two crew members. Catches were immediately sorted by species, counted, weighed, recorded and samples preserved.

Purse Seine

Purse seine locations were selected at five mile intervals along transect lines (Figure 2) located between major salmon spawning areas. This strategy was chosen to cover lower Cook Inlet and facilitate delineation of in and out migrants of major tributaries. The number of stations was based on an estimate of 9 sampling days each month and 4 sets each day.

The purse seine was 200 fm (366 m) long by 10 fm (18 m) deep. Mesh size was 1 1/8 inch stretch measure throughout the body and 1 inch stretch measure in the bunt. The seine was set in a circle and immediately pursed. This round haul procedure was utilized in preference to holding the net open at all stations. All catches were immediately sorted, identified, counted weighed and recorded on fish resource format (file type 023) key punch data forms.

Gill Nets

There were 4 monofilament and 4 multifilament experimental gill nets used. They were constructed of 8 ft by 25 ft panels with a total of 8 panels of 1 inch sm, 4 panels of 1½ inch sm, 8 panels of 2 inch sm, and 4 panels each of 2½ inch, 3 inch, 4 inch and 5 inch sm. These nets were fastened together and used as a unit. The nets were drifted for four hours, attached to the M/V BIG VALLEY. Catches were immediately sorted by species, counted, weighed, recorded and samples preserved.

VI RESULTS

A total of 58 otter trawl hauls, 22 purse seine hauls, 215 tow net tows, 262 beach seine hauls and 58 gill net sets were completed in lower Cook Inlet during May through October 1976 (Table 1). An additional cruise was completed during March 1977 but the results are not yet available. A total of 76 species of fish were identified in lower Cook Inlet (Table 2) and several of the prominent invertebrates were identified.

Otter Trawl

The otter trawl catch consisted almost entirely of flounders, crustacea, cod, and sculpins. Predominant species captured were snow crab (*Chionoecetes bairdi*), walleye pollock, yellowfin sole, Pacific halibut, rock sole, Pacific cod, king crab (*Paralithodes camtschatica*), butter sole, Irish Lord, great sculpin and arrowtooth flounder (Table 3).

Crustaceans, Order Decapoda

Snow Crab. Snow crab occurred in greater abundance than any other taxon and occurred in 86% of the hauls. They occurred in greatest biomass at one station near Seldovia and in the western half of lower Cook Inlet south

Table 1. Preliminary list of number of hauls completed with satisfactory gear performance by gear type and month during 1976 in lower Cook Inlet.

	Otter Trawl	Beach Seine	Tow Net	Purse Seine	Gill Net[1]
May-June	10	56	[illegible]	0	0
July	15	66	79	13	0
August	19	70	62	9	0
Sept.-Oct.	14	70	55	0	58

[1]Number of 4 hour sets of variable mesh experimental gill nets.

Table 2. Preliminary list of fish species captured in Cook Inlet by otter trawl, beach seine, surface tow net, purse seine and gill net during summer 1976.

Petromyzontidae	
Arctic lamprey	*Lampetra japonica*
Squalidae	
Spiny dogfish	*Squalus acanthias*
Rajidae	
Big skate	*Raja binoculata*
Black skate	*Raja kincaidi*
Longnose skate	*Raja rhina*
Clupeidae	
Pacific herring	*Clupea harengus pallasi*
Salmonidae	
Bering cisco	*Coregonus laurettae*
Pink salmon	*Oncorhynchus gorbuscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Sockeye salmon	*Oncorhynchus nerka*
Chinook salmon	*Oncorhynchus tshawytscha*
Dolly Varden	*Salvelinus malma*
Osmeridae	
Surf smelt	*Hypomesus pretiosus*
Capelin	*Mallotus villosus*
Longfin smelt	*Spirinchus thaleichthys*
Eulachon	*Thaleichthys pacificus*
Gadidae	
Saffron cod	*Eleginus gracilis*
Pacific cod	*Gadus macrocephalus*
Pacific tomcod	*Microgadus proximus*
Walleye pollock	*Theragra chalcogramma*
Zoarcidae	
Shortfin eelpout	*Lycodes brevipes*
Wattled eelpout	*Lycodes palearis*
Gasterosteidae	
Threespine stickleback	*Gasterosteus aculeatus*
Trichodontidae	
Pacific sandfish	*Trichodon trichodon*
Bathymasteridae	
Searcher	*Bathymaster signatus*

Stichaeidae	
Daubed shanny	*Lumpenus maculatus*
Snake prickleback	*Lumpenus sagitta*
Pholidae	
Crescent gunnel	*Pholis laeta*
Anarhichadidae	
Bering wolffish	*Anarhichas orientalis*
Cryptacanthodidae[1]	
Zaproridae	
Prowfish	*Zaprora silenus*
Ammodytidae	
Pacific sand lance	*Ammodytes hexapterus*
Scorpaenidae	
Hexagrammidae	
Masked greenling	*Hexagrammos octogrammus*
Whitespotted greenling	*Hexagrammos stelleri*
Lingcod	*Ophiodon elongatus*
Cottidae	
Silverspotted sculpin	*Blepsias cirrhosus*
Spinyhead sculpin	*Dasycottus settiger*
Buffalo sculpin	*Enophrys bison*
Soft sculpin	*Gilbertidia sigalutes*
	Gymnocanthus sp(p.)
Red Irish Lord	*Hemilepidotus hemilepidotus*
Yellow Irish Lord	*Hemilepidotus jordani*
Bigmouth sculpin	*Hemitripterus bolini*
Northern sculpin	*Icelinus borealis*
Thorny sculpin	*Icelus spiniger*
Staghorn sculpin	*Leptocottus armatus*
Blackfin sculpin	*Malacocottus kincaidi*
Great sculpin	*Myoxocephalus polyacanthocephalus*
Eyeshade sculpin	*Nautichthys pribilovius*
Tadpole sculpin	*Psychrolutes paradoxus*
Scissortail sculpin	*Triglops forficata*
Ribbed sculpin	*Triglops pingeli*

[1]Larvae of unidentified Cryptacanthodid captured. Specimen no longer on hand.

Agonidae	
Northern spearnose poacher	*Agonopsis emmelane*
Sturgeon poacher	*Agonus acipenserinus*
Smooth alligatorfish	*Anoplagonus inermis*
Aleutian alligatorfish	*Aspidophoroides bartoni*
Gray starsnout	*Asterotheca alascana*
Fourhorn poacher	*Hypsagonus quadricornis*
Tubenose poacher	*Pallasina barbata*
Sawback poacher	*Sarritor frenatus*
Cyclopteridae	
Leatherfin lumpsucker	*Eumicrotremus derjugini*
Pacific spiny lumpsucker	*Eumicrotremus orbis*
Spotted snailfish	*Liparis callyodon*
Ribbon snailfish	*Liparis cyclopus*
Marbled snailfish	*Liparis dennyi*
Pleuronectidae	
Arrowtooth flounder	*Atheresthes stomias*
Rex sole	*Glyptocephalus zachirus*
Flathead sole	*Hippoglossoides elassodon*
Pacific halibut	*Hippoglossus stenolepis*
Butter sole	*Isopsetta isolepis*
Rock sole	*Lepidopsetta bilineata*
Yellowfin sole	*Limanda aspera*
Dover sole	*Microstomus pacificus*
English sole[1]	*Parophrys vetulus*
Starry flounder	*Platichthys stellatus*
Alaska plaice	*Pleuronectes quadrituberculatus*
Sand sole[1]	*Psettichthys melanostictus*

[1]Reported but not substantiated by specimen.

Table 3. Preliminary tabulation of otter trawl catch in kilograms per haul in lower Cook Inlet in June, July, August and September 1976.

	June	July	August	Sept.
Flounders	19.8	25.1	40.1	60.0
Crustacea	14.7	27.3	32.5	18.6
Cod	10.1	20.5	31.2	4.9
Sculpins	7.5	11.1	23.8	6.7
Snow Crab	9.9	23.2	23.2	10.8
Pacific cod	9.4	6.2	7.0	2.4
Halibut	8.6	5.2	8.6	5.1
Butter sole	5.7	6.4	4.1	7.4
King crab	4.4	4.1	8.6	6.9
Yellowfin sole	1.9	7.0	4.7	22.1
Rock sole	1.8	2.6	10.4	11.4
Walleye pollock	0.9	11.3	24.2	2.4
Arrowtooth flounder	0.4	3.0	7.6	2.3
Great sculpin	3.7[1]	3.3[1]	7.2	5.2
Irish Lord[2]	0.9[1]	5.2[1]	15.2	1.2
Total Catch	53.4	84.6	137.4	92.6

[1]Conservative figures; all individuals may not have been identified
[2]Essentially all were yellow Irish Lord

of about 59°25'N (Figure 1).

The average catch per haul by month shown in Table 3 is strongly affected by which stations were sampled. The stations at which the greatest catches occurred were not all sampled in June or September. Frequency of occurrence was similar in June, July, and August but declined in September, especially in the inshore and more northerly areas. At several stations, catches were greater in July than in June; catches were similar in July and August but had a tendency to increase in the south and decrease in the north; and in September catches were generally less than in August.

King Crab. King crab was the second most abundant crustacean and the seventh most abundant taxon captured. It occurred in 60% of the hauls. Like snow crab, king crab occurred in greatest biomass at one station near Seldovia and in the western half of lower Cook Inlet south of about 59°25'N (Figure 2). Unlike snow crab, king crab occurred in Kennedy Entrance and was uncommon at the most southwestern two stations. Seasonal patterns of catch distribution are not apparent, partly due to high variability of the catch.

Flounders, family Pleuronectidae

Yellowfin Sole. Yellowfin sole was the most abundant flatfish and it occurred in 58% of the hauls. This species was most abundant in several areas: the central inlet east of Augustine Island where water depths were 55 to 100 m, at a station south of Oil Bay in 29 m deep water, at one station off Seldovia, and only during June at one station in the cen' Inlet west of Anchor Point. They never occurred at the most norther station, which was 82 to 91 m deep, were not common in the central inlet north of Augustine Island and they infrequently occurred in the southern

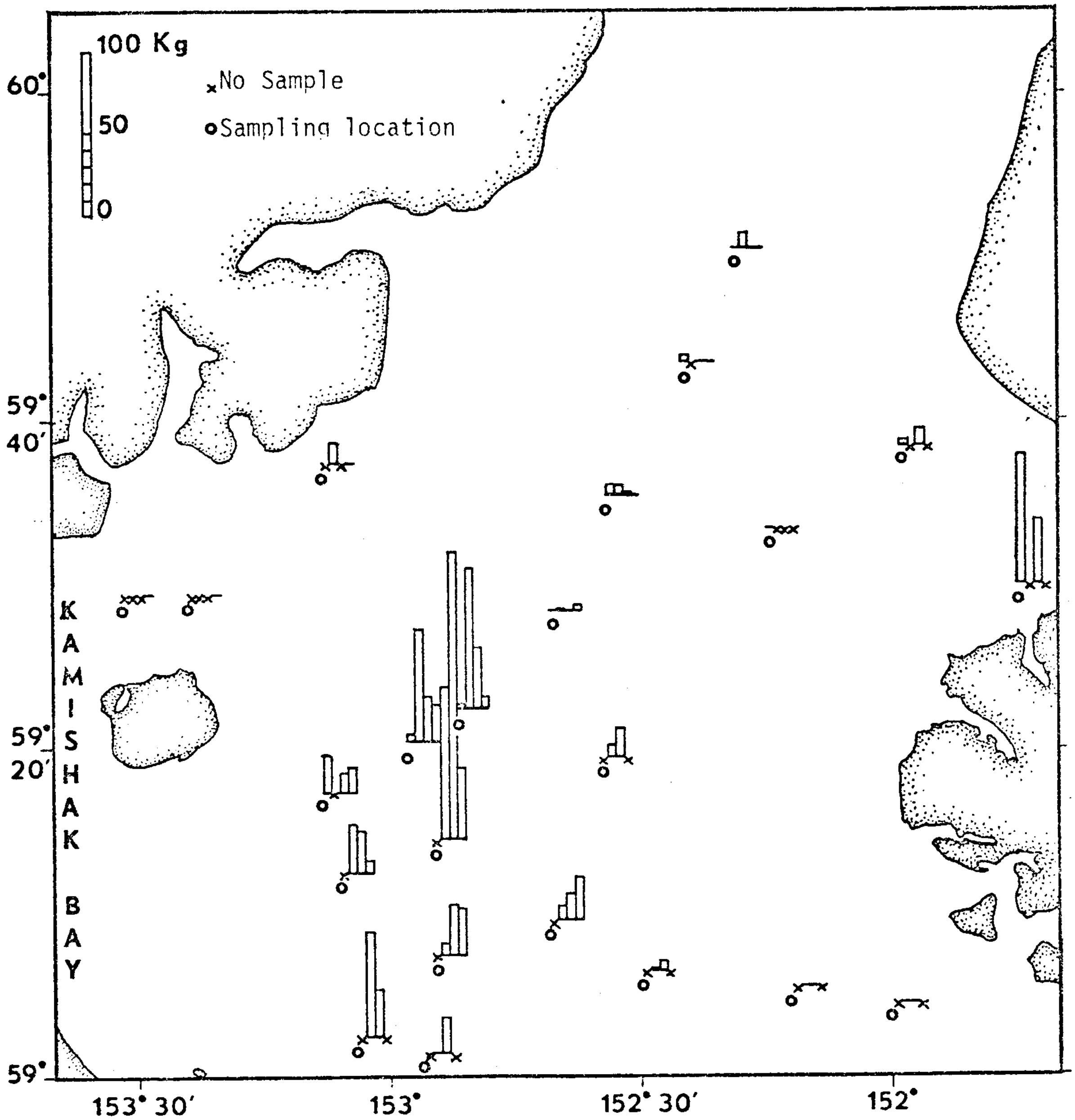

Figure 1. Preliminary presentation of 20 minute otter trawl catch of snow crab (*Chionoecetes bairdi*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

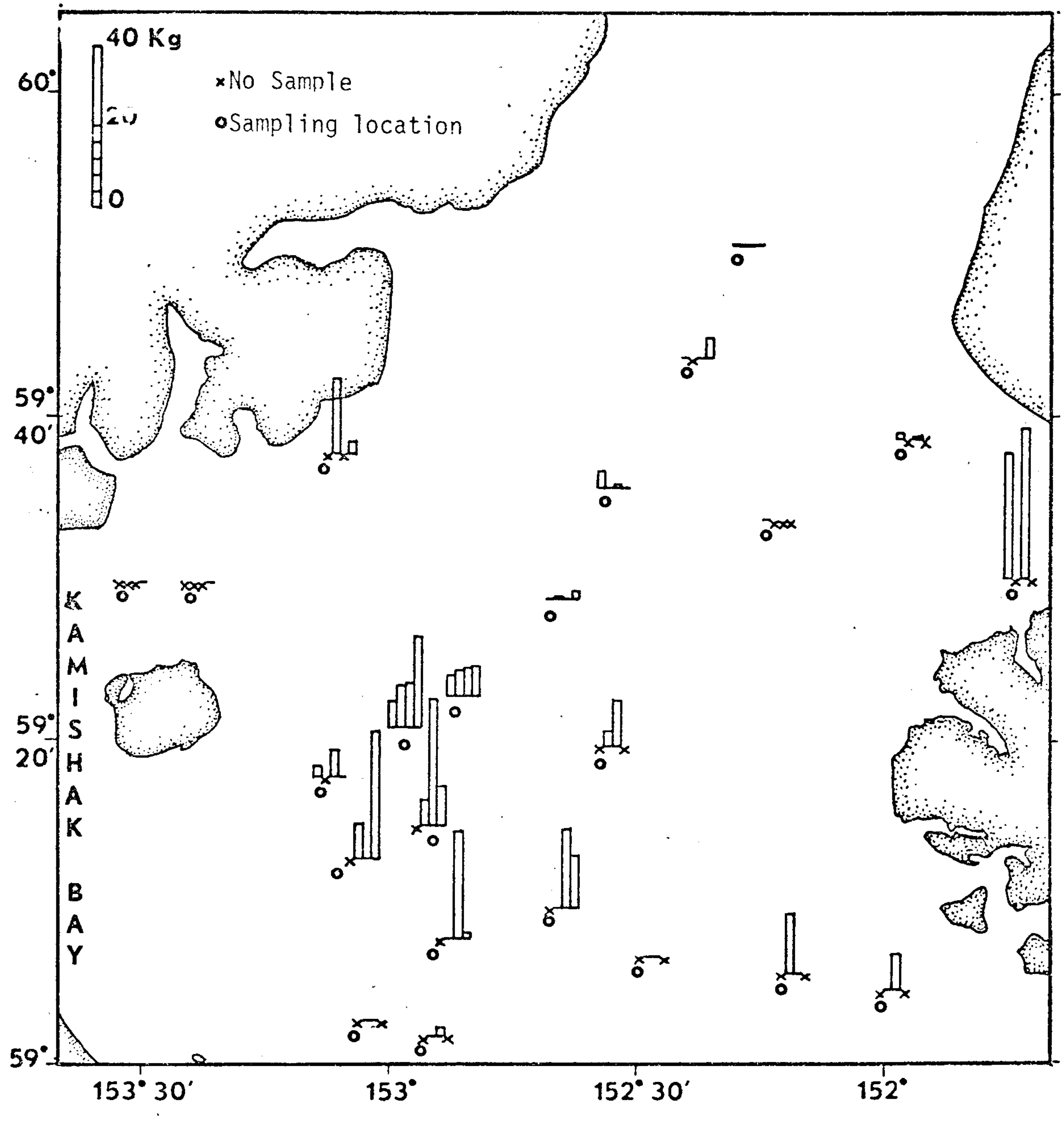

Figure 2. Preliminary presentation of 20 minute otter trawl catch of king crab (*Paralithodes camtschatica*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

portion of the inlet where water depths exceeded 125 m.

The catch of yellowfin sole at the 29 m deep station off Oil Bay was 90 kg/20 min tow in July and 24 kg/20 min tow in September. At the stations in the central inlet east of Augustine Island the catch increased each month to a maximum in September. The increases were most pronounced in the westerly and southerly stations where catches increased from 5 and 6 kg/20 min tow in June and July to 87 and 143 kg/20 min tow in September. The same information expressed differently: greatest catches in July, August and September were in 29 m, 57 m and 76 m, respectively, suggesting movement into deeper water. (No catches of comparable magnitude were made during June.

Small samples of yellowfin sole were measured at some stations during August and September. Lengths ranged from 135 mm to 345 mm (Figure 3).

Pacific Halibut. Pacific halibut was the second most abundant flatfish and it occurred in 66% of the hauls. Pacific halibut were most numerous nearer shore, in the mouth of Kachemak Bay and in Kamishak Bay. Modest numbers occurred in mid-inlet north 59°10'N (Figure 4). Only 3 individuals were captured south of this latitude. There was a tendency for smaller individuals to occur near shore, especially on the west side of the inlet.

Rock Sole. Rock sole was the third most abundant flatfish and it occurred in 79% of the hauls. They were fairly widespread in distribution but abundance was definitely greatest in the central inlet east of Augustine Island and north of 59°15'N. North of Augustine Island in the central inlet they occurred in 100% of the hauls but the maximum catch was 13 kg/20 min tow and most tows yielded considerably less. South of 59°15'N one catch of 26 kg/20 min tow was made in Kennedy Entrance at 113 m in August but all other tows were 2.5 kg/20 min tow or less. Within the area of greatest

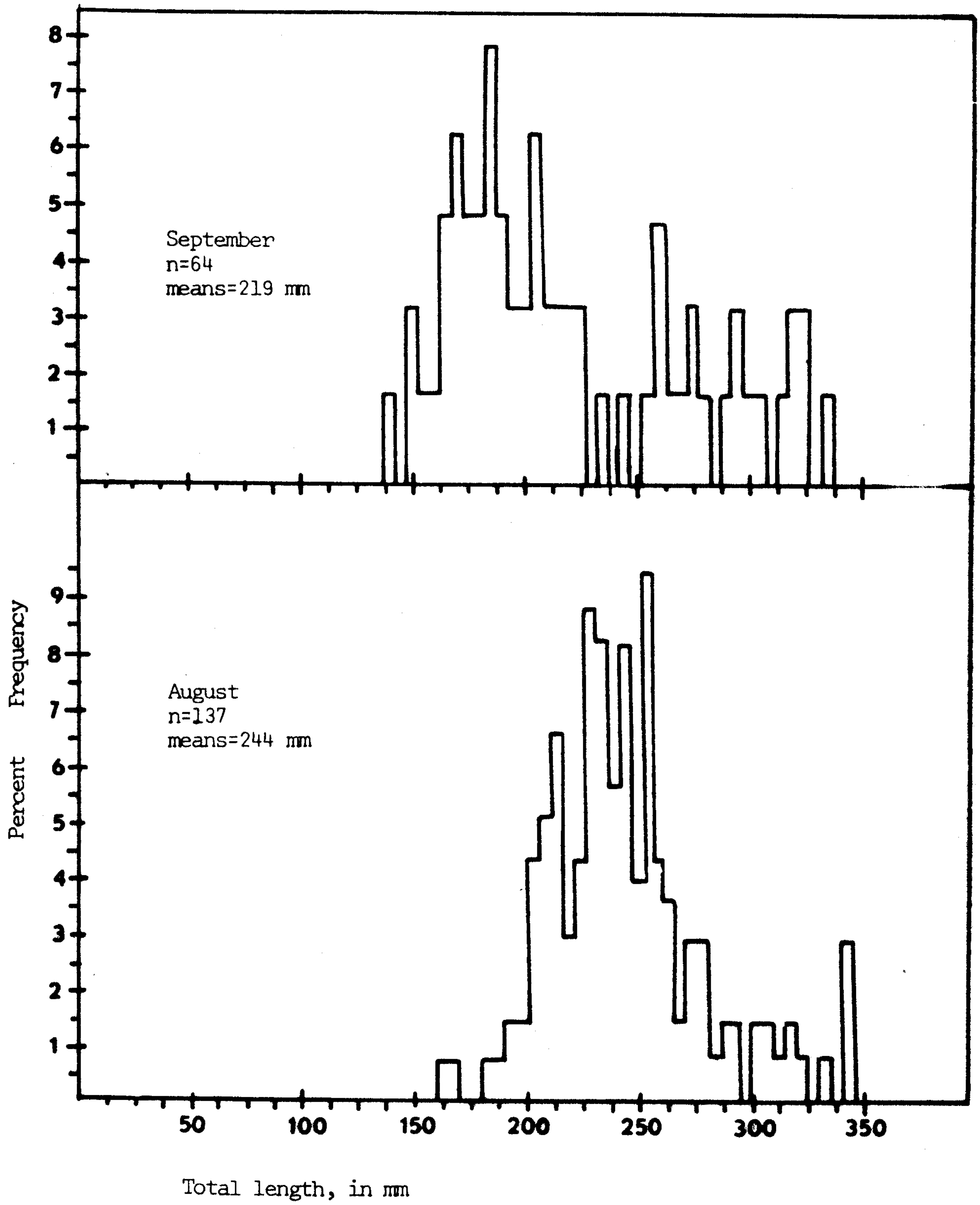

Figure 3. Percent frequency of yellowfin sole (*Limanda aspera*) total length by 5 mm intervals from lower Cook Inlet during August and September, 1976.

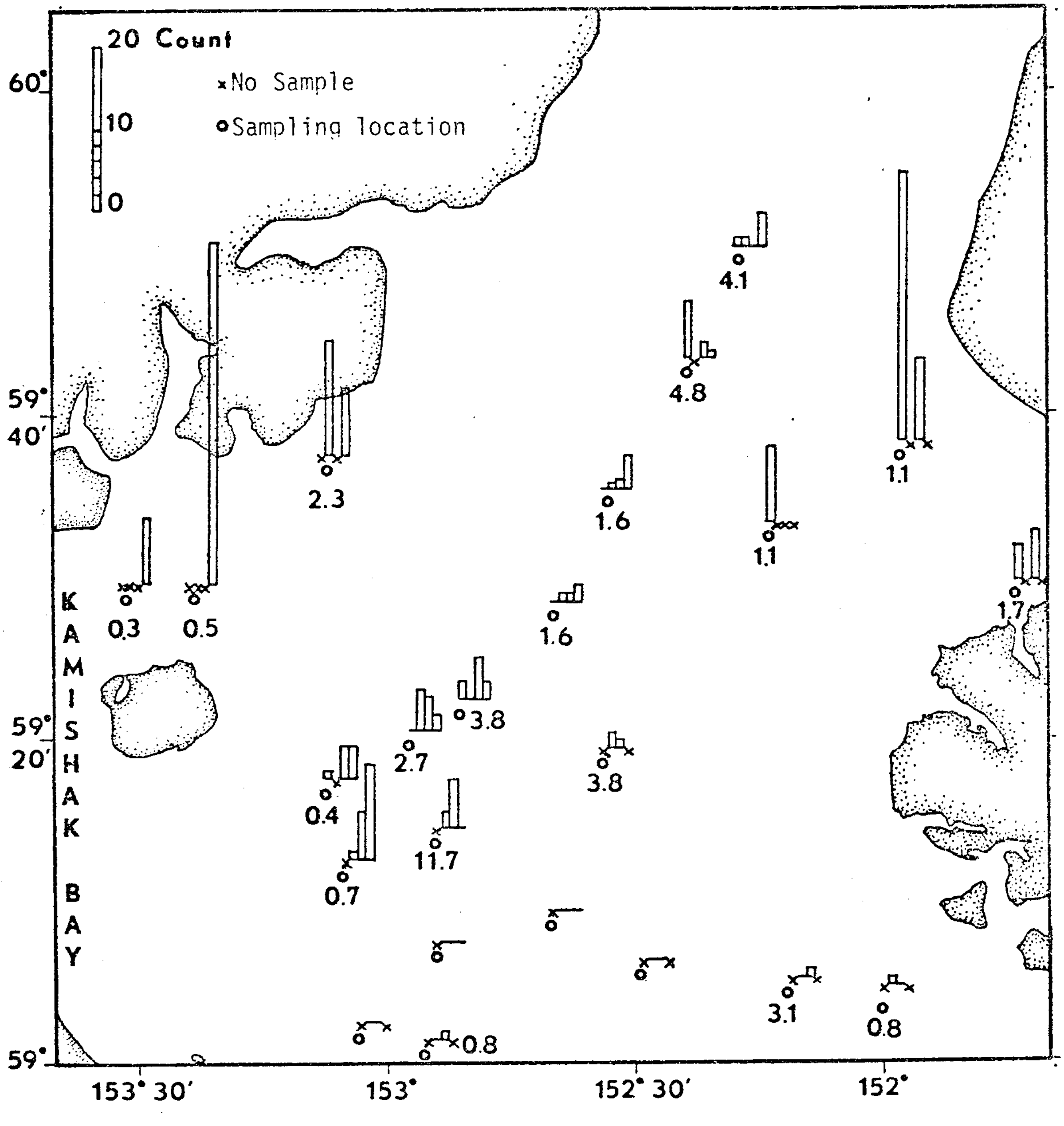

Figure 4. Preliminary presentation of 20 minute otter trawl catch of Pacific halibut (*Hippoglossus stenolepis*) numbers by location and month. Catches in early June, July, August and September are shown left to right respectively and mean weight in Kg is given for each location.

abundance the largest catch, 83 kg/20 min tow, was made at the eastern most station in August.

Catch rate of rock sole in August and September was approximately 4 times that of the first two months. At virtually all stations south of the northern shore of Augustine Island the catch was greater in August than in June and July and in September the catch was greater than in August, with one exception.

Butter Sole. Butter sole was the fourth most abundant flatfish and it occurred in 59% of the hauls. They were not as widespread in distribution as were rock sole, occurring in 81% of the hauls shallower than 100 m and in 6% of the hauls deeper than 100 m. They occurred in greatest concentrations in the 50 to 100 m deep area southeast of Augustine Island and at the second most northerly station in mid-inlet which was 60 to 80 m deep (Figure 5). The only seasonal trend identifiable is the complete absence of butter sole in June from 3 hauls in the area southeast of Augustine Island, where they occurred in all subsequent hauls, averaging 13.6 kg/20 min haul.

Mean weight of butter sole in the area southeast of Augustine Island ranged from 69 to 130 gm in the various hauls. At the three stations north of Augustine Island in less than 30 m depth, the mean weight ranged from 54 to 60 or 70 gms. At the other stations in the northern and eastern areas of the inlet mean weights were generally greater than 130 gms, ranging from 108 to 494 gms.

Miscellaneous. Other flounders captured include arrowtooth flounder, starry flounder, flathead sole, rex sole, Dover sole, Alaska plaice and sand sole.

Cod, family Gadidae

Walleye Pollock. Walleye pollock was the most abundant cod, and occurred

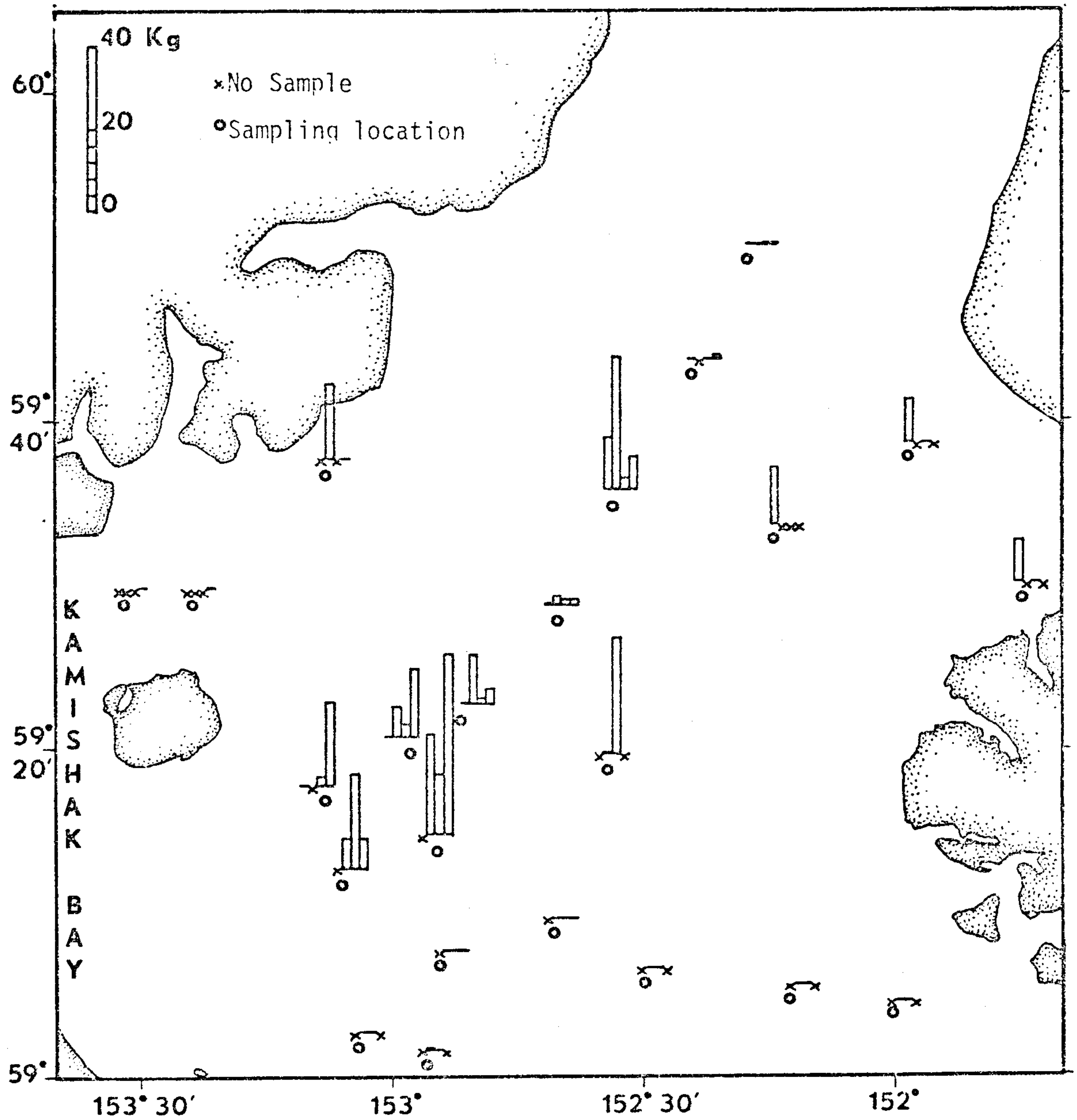

Figure 5. Preliminary presentation of 20 minute otter trawl catch of butter sole (*Isopsetta isolepis*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

in 69% of the hauls. Pollock occurred in nearly every area, however, catches greater than 5 kg/20 min tow were restricted to stations deeper than 100 m in the southern inlet (Figure 6) and one contiguous 73 m deep station.

The average catch per haul by month shown in Table 3 is strongly affected by which stations were sampled. Stations sampled in June did not include any of those where pollock were ever taken in quantity while all of these stations were sampled in July and August and four of them were sampled in September. Comparing station by station, pollock were clearly more abundant in August than in July and less abundant in September than in August.

Pacific Cod. Pacific cod was the second most abundant cod and occurred in 67% of the hauls. They occurred in greatest abundance in the southern portion of Cook Inlet and in the central inlet at the latitude of Homer to Anchor Pt. (Figure 7). The more northerly area yielded large catches only in June when average size was unusually great, up to 7.8 kg per fish in this area. All stations in the southern area of cod abundance were deeper than 135 m while the two big catches in the northerly area were made in 69 and 73 m. Seasonality is not apparent in the distribution of catches.

Sculpins, family Cottidae

Numerous sculpins were captured (Table 3) of which the Irish Lords, primarily yellow Irish Lord, occurred in greatest abundance. They occurred in 64% of the hauls and greatest catch was 137 kg/20 min tow. Abundance was markedly greater near Kennedy Entrance (Figure 8).

Other Families

A number of other families were represented in the catches, however, the information is not yet tabulated.

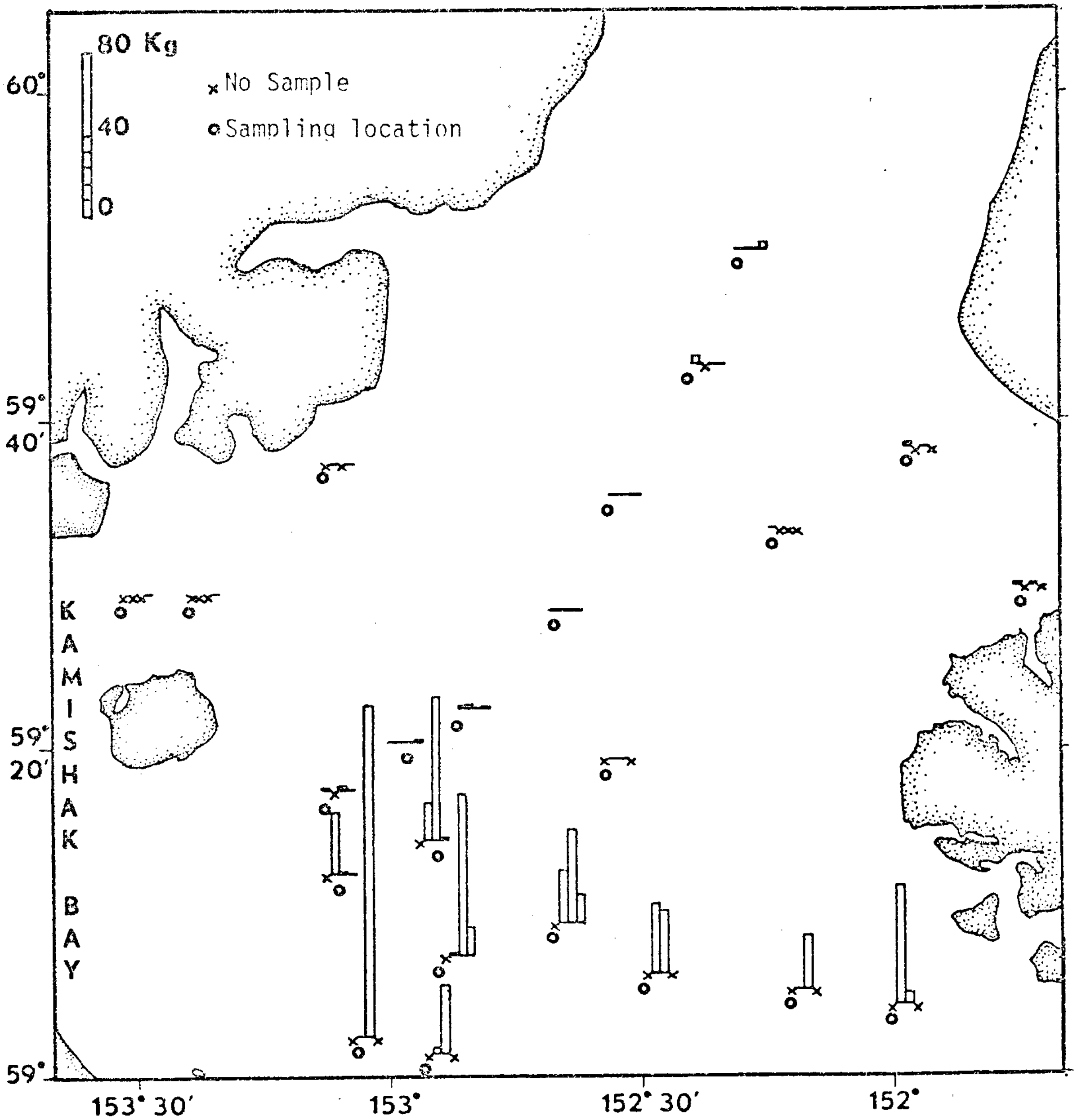

Figure 6. Preliminary presentation of 20 minute otter trawl catch of walleye pollock (*Theragra chalcogramma*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

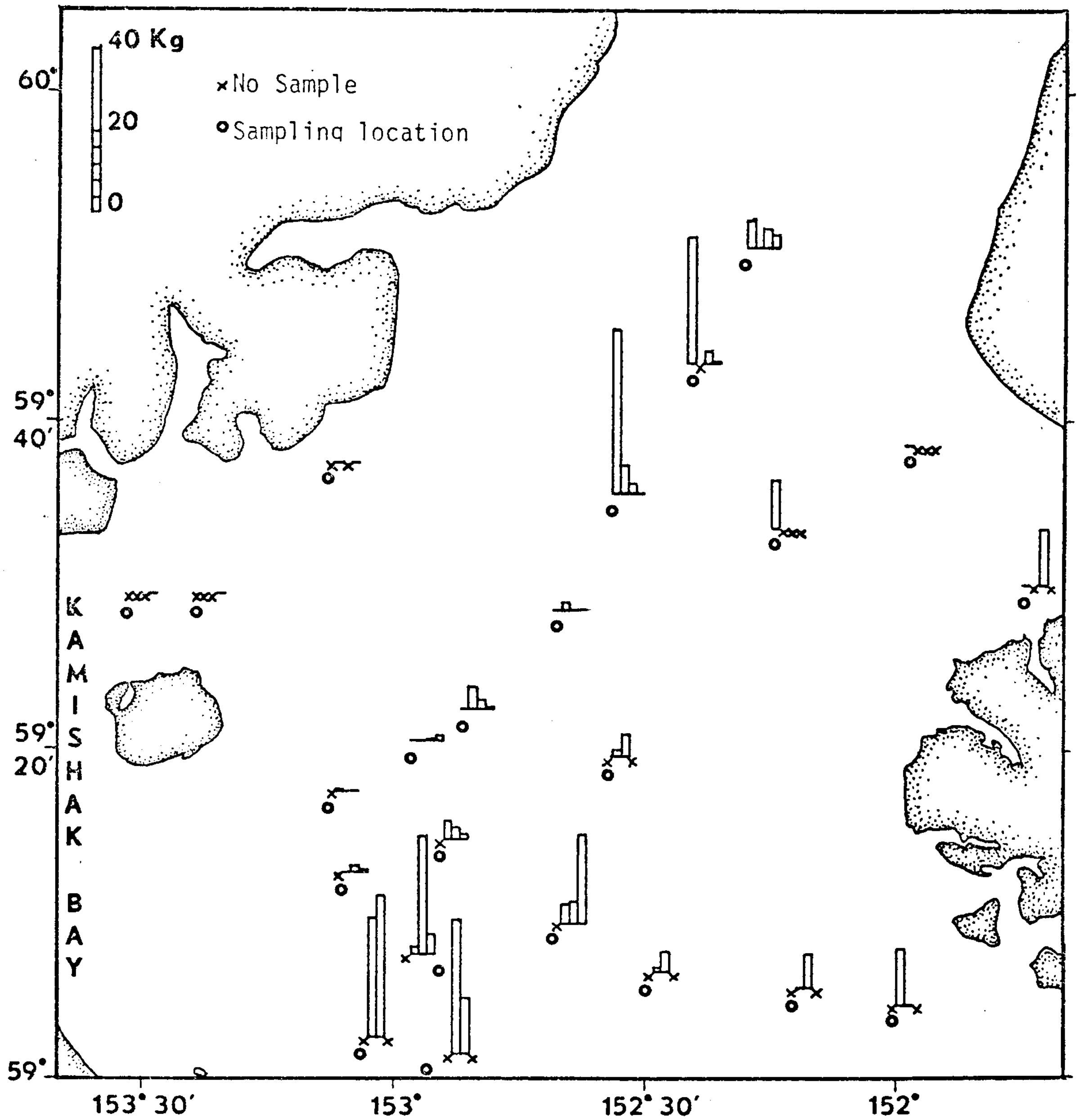

Figure 7. Preliminary presentation of 20 minute otter trawl catch of Pacific cod (*Gadus macrocephalus*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

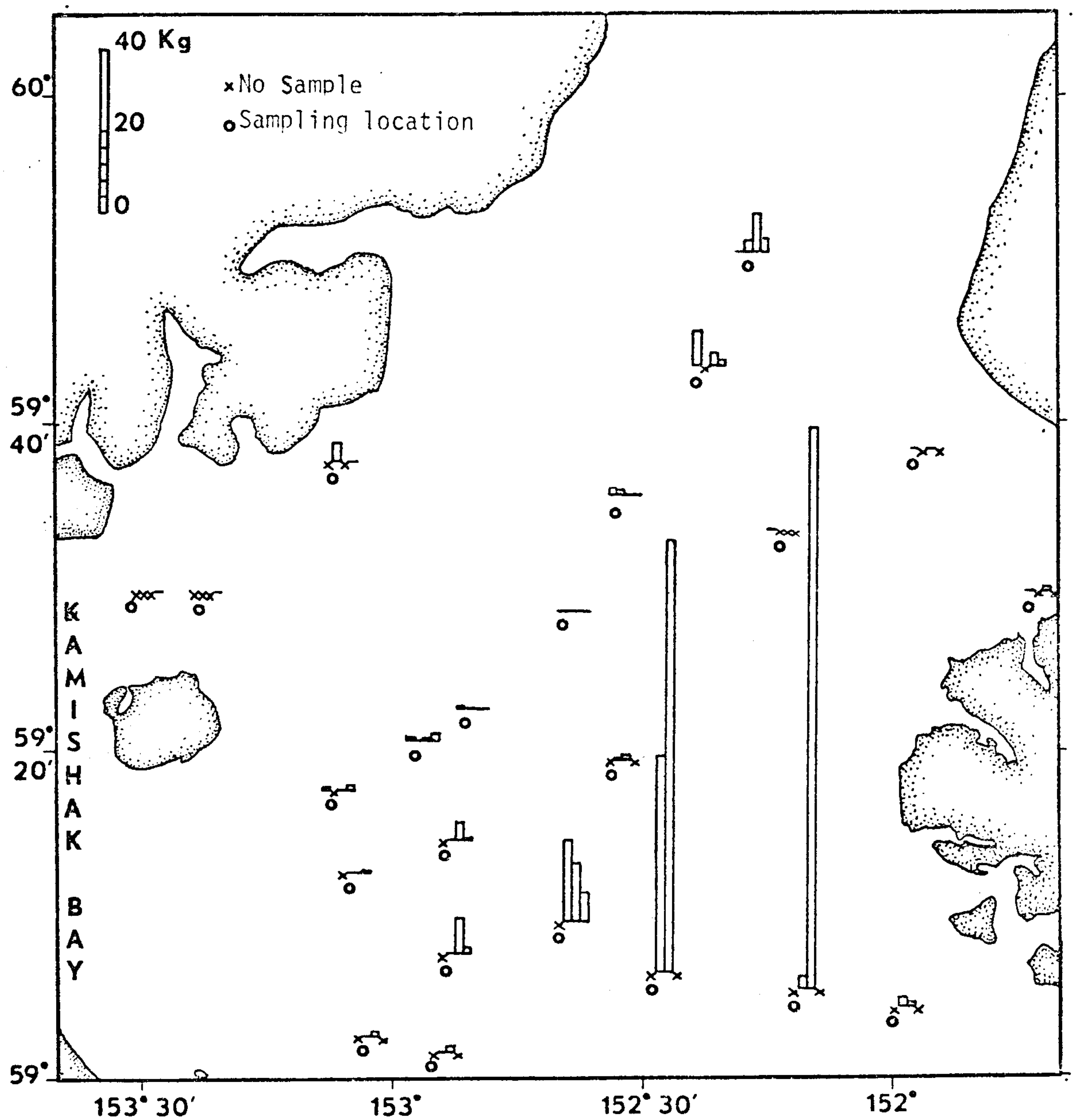

Figure 8. Preliminary presentation of 20 minute otter trawl catch of Irish Lord (*Hemilepidotus sp*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

Beach Seine

Pink Salmon

Pink salmon outmigrants were captured in 30% of the beach seine hauls. They occurred in concentrations at some time in most areas sampled with the conspicuous exception of the east shore of lower Cook Inlet between the Forelands and Anchor Point (Table 4). A total of 12 juvenile pinks were taken in 49 beach seine hauls in this area.

Within Kachemak Bay juvenile pinks were captured in 20% of the beach seine hauls. Catches were made in Coal Bay, in the Glacier Spit-Halibut Cove-Peterson Bay area and in the Eldred Passage-Sadie Cove area.

In the Coal Bay area samples were taken more frequently than monthly during May and June. A total of 11 samples were made at three locations there between May 21 and June 23 (Table 5). The five hauls between May 21 and May 24 were the only ones which yielded juvenile pinks.

In the Glacier Spit-Halibut Cove-Peterson Bay area eight hauls were made on June 18 with juvenile pinks occurring in six and a maximum catch of 390 occurred at Peterson Bay. In later months juvenile pinks occurred in only two more hauls in this area.

In the Eldred Passage-Sadie Cove area, 11 hauls were made on July 27 and 28 with juvenile pinks occurring in 8. This was the only time pinks were captured in this area, although it was sampled in June, August and September also. The catches were greater in Eldred Passage than Sadie Cove.

On August 3 and 4 beach seine samples were taken south of Tutka Bay for the first time resulting in the largest catches of juvenile pinks made in August. Within Port Graham and in English Bay five of six hauls contained juvenile pinks and two hauls in Seldovia Bay both yielded pinks. Of six hauls

Table 4. Number of pink salmon outmigrants captured per beach seine haul by cruise and area in lower Cook Inlet.

	May-June	July	August	September
West Side of C.I.	1.0	16.8	3.6	0.3
East Side of C.I. North of Anchor Pt.	0.8	0.2	0.0	0.1
Kachemak Bay	18.0	3.5	0.1	0.0
Kenai Peninsula South of Tutka Bay	NS	NS	9.4	0.6

Table 5. Beach seine catch in numbers of juvenile pink salmon during May and June at three stations around Coal Bay, in Kachemak Bay.

	Homer Spit Outside Boat Harbor 59°36'28"N 151°25'15"W	Homer Spit Near Power Box 59°36'40"N 151°26'08"W	Coal Bay Near Airport 59°38'55"N 151°26'47"W
May 21	67	15	NS
May 24	0	0	63
June 8	0	0	NS
June 21,22,23	0,0	0	0

made in the more exposed areas between Dangerous Cape and Barabara Pt, none yielded pinks.

The juvenile pinks captured in Coal Bay on May 21 and 24 averaged 33 to 37 mm in fork length and 0.27 gm to 0.39 gm. Those captured in the Glacier Spit-Halibut Cove-Peterson Bay area on June 18 averaged approximately 0.8 gm to perhaps as much as 1.7 gm (lengths were not taken). Those captured in the Eldred Passage-Sadie Cove area on July 27 and 28 averaged 77 to 91 mm and 3.8 to 6.9 gms. Juvenile pinks captured in the Port Graham-English Bay-Seldovia Bay area on August 3 and 4 averaged about 78 to 82 mm and about 4.0 to 5.0 gms. The one catch of pinks outside Seldovia Bay on September 2 averaged 103 mm and 9.8 gms.

On the west side of lower Cook Inlet juvenile pinks occurred in 52% of the beach seine hauls with 42%, 72%, 63% and 13% of the hauls containing pinks in June, July, August and September, respectively. Three sites in Chinitna Bay were sampled in June, July and September yielding juvenile pinks only in July when mean catch was 15 and all three hauls contained them. One haul in Dry Bay in June yielded 7 juvenile pinks but this site was too exposed to repeat sampling. At six sites in Oil Bay, Iniskin Bay and Iliamna Bay catches in July and August averaged smaller and less frequent than catches overall. Three sites near Ursus Head sampled in July and two sampled in August yielded small catches of juvenile pinks but these were not sampled in June and only one haul was made in September.

Four samples in Ursus Cove, two in Rocky Cove and two about two miles north of Bruin Bay all yielded juvenile pinks in July with an average catch of 38 per haul, more than twice the overall average (Table 4). In August six of these eight stations yielded juvenile pinks with an average catch of six per haul, again somewhat greater than the overall average (Table 4). In September all these stations were sampled and the only juvenile pinks caught on the west side were taken in two of four hauls in Ursus Cove. This area was sampled in June.

Three stations were sampled at Amakdedori Beach in July and August resulting in average catches of juvenile pinks.

Juvenile pinks captured south of Ursus Head on the west side in July averaged 1.1 to 2.2 gms. Those captured in Chinitna Bay in July averaged about 3.5 to 4.0 gms. Juvenile pinks captured on the west side of Cook Inlet on August 9 to 13 averaged from 1.2 gms and 51 mm to 6.3 gms. One haul in Iliamna Bay contained the small ones while two other hauls there yielded 3.5 gm pinks. The largest August catches, in Bruin Bay, contained 1.7 to 2.5 gm pinks. Most other areas yielded pinks 3.7 to 4.0 gms but samples at Amakdedori Beach yielded 5.2 add 6.2 gm pinks. The few pinks captured in Ursus Cove on September 10 averaged about 1.8 gms.

Saffron Cod

Saffron cod (Figure 9, which also includes tow net captured fish) occurred in three discreet locations: north of Cape Ninilchik on the eastern shoreline, on the south side of Kachemak Bay from Sadie Cove west, and in Kamishak Bay. They were in most samples taken north of the Kenai River with frequency decreasing toward the east Forelands and they occurred frequently south of the Kenai River to Cape Ninilchik. They occurred occasionally in Kachemak Bay and only one individual was captured in Kamishak Bay, on Amakdedori Beach. Young-of-the-year through adult fish were captured.

Longfin Smelt

Longfin smelt (Figure 10, which also includes tow net captured fish)

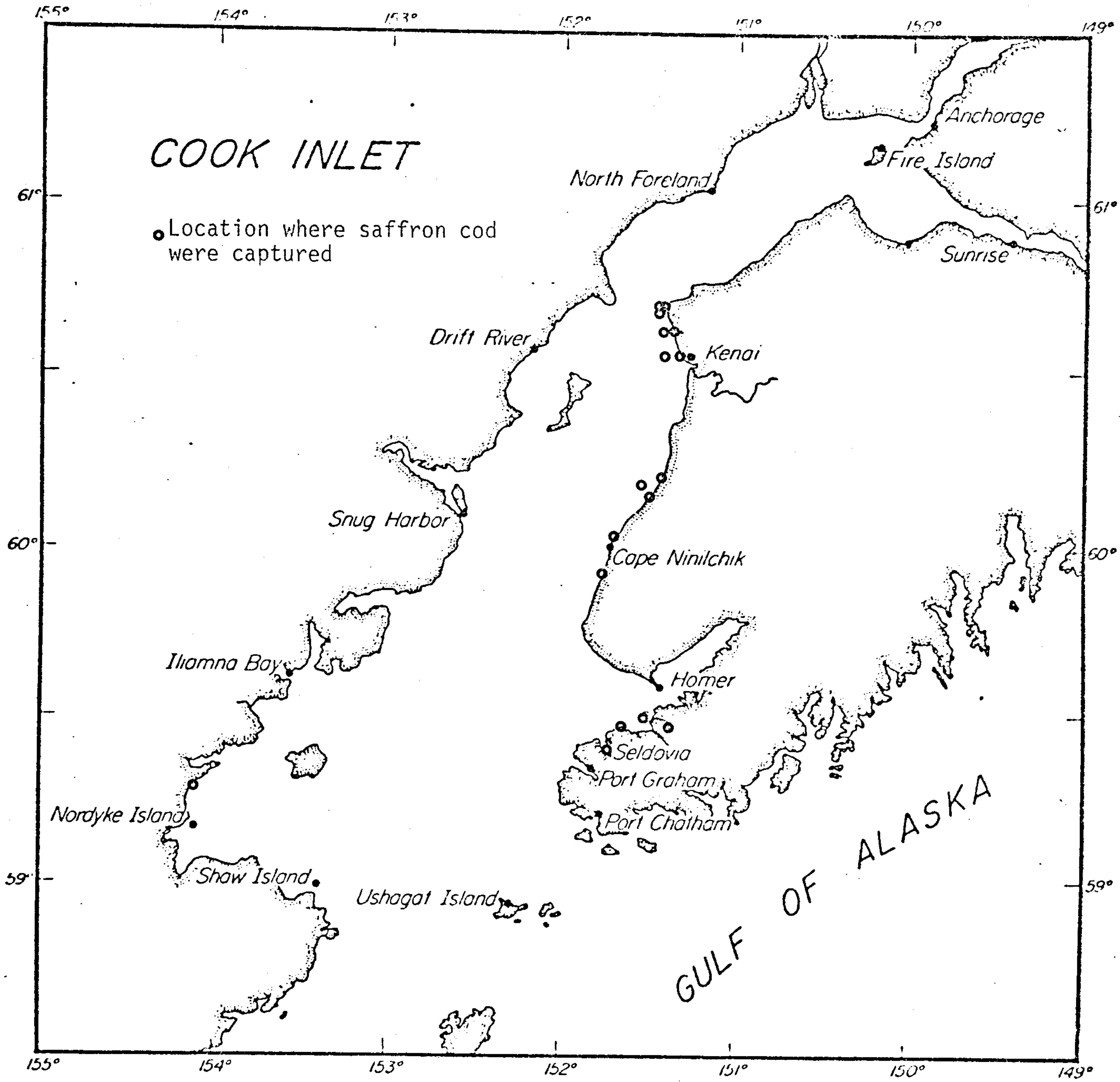

Figure 9. Locations of capture of saffron cod (*Eleginus gracilis*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

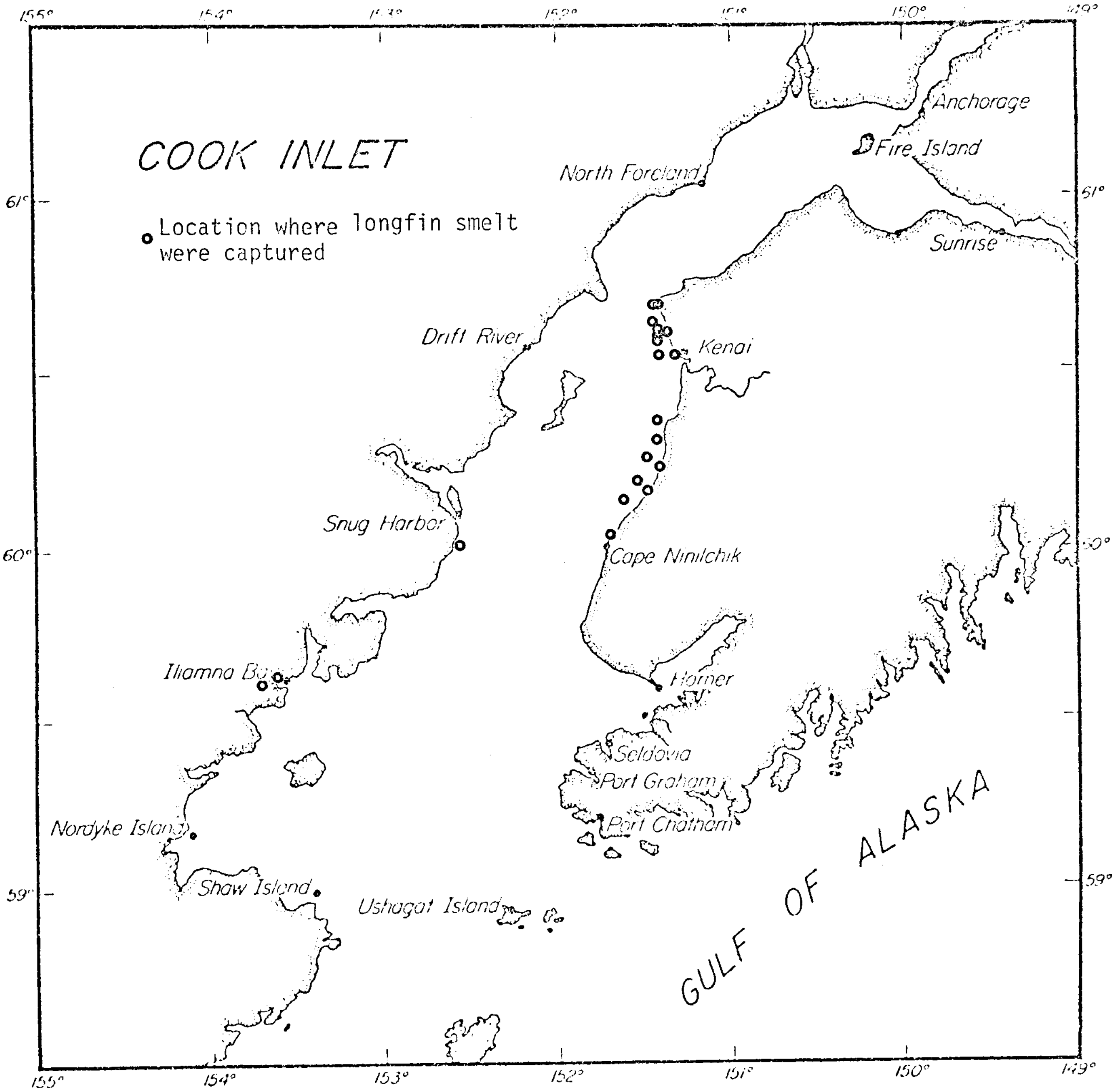

Figure 10. Locations of capture of longfin smelt (*Spirinchus thaleichthys*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

occurred, as did saffron cod, very frequently north of Cape Ninilchik. It occurred also at one station south of Snug Harbor and at two locations in Iliamna Bay. Late stage larvae, juveniles, and adults of this species were captured.

Sampling at Oil Spill Site

During the first part of October a spill of JP-4 occurred in lower Cook Inlet near the east Forelands in the immediate vicinity of routinely sampled stations. The field crew took advantage of this opportunity and sampled at the site of the spill.

These samples resulted in capture of fish at the site of the spill (Table 6). Catches before and after the spill are similar, however, more species were caught in fewer hauls before the spill; and both saffron cod (*Eleginus gracilis*) and longfin smelt (*Spirinchus thaleichthys*) catches tended to be greater after the spill. These trends could be random, related to seasonality, or they may be related to effect of oil on the fish and on the catchability of those fish. Saffron cod, longfin smelt, one pink salmon (*Oncorhynchus gorbuscha*) and one Dolly Varden (*Salvelinus malma*) were captured in a visible oil slick and they appeared to be unusually sluggish, that is they did not flop around much when captured.

Purse Seine and Gill Net

The purse seine was not received early enough to be used in June. In July one practice set was made near the boat harbor at Homer on July 6. July 7 was spent crossing the inlet and July 8 one set was made, the net was torn, the day was spent repairing it and one satisfactory set was made late in the even-

Table 6. Beach seine catch at the area of an oil spill in Cook Inlet at East Foreland with comparative before spill catches.

	E. Forelands 60°43'10"N 151°24'30"W	Between Forelands and Kenai River 60°37'30"N 151°20'45"W	Near Kenai River 60°34'45"N 151°19'25"W
Before Spill			
Date of haul	9-27	9-28	9-28
Time of haul, Zulu	2345	0150	0245
Saffron cod	1	5	4
Longfin smelt	14	13	
Coho salmon, Juv.	1	1	2
Dolly Varden	1		
Bering cisco		2	
Starry flounder	1		
Snailfish sp.			1
Pacific herring	1	2	

	E. Forelands 60°43'10"N 151°24'30"W			Between Forelands and Kenai River 60°37'30"N 151°20'45"W		Near Kenai River 60°34'45"N 151°19'25"W
After Spill						
Date of haul	10-9	10-9 1/	10-13	10-9	10-14	10-10
Time of haul, Zulu	2140	2205	2330	2335	0100	0015
Saffron cod	4	4	7	10	7	23
Longfin smelt	11	23	45	20	20	14
Pink salmon, Juv.		1				
Dolly Varden		1				
Bering cisco						1
Unidentified larval fish				+		

1/ Oil was observed in shallow water and saffron cod and longfin smelt were abnormally sluggish when captured.

ing. On July 9, the first set was east of Augustine Island in about 15 knot winds and the net collapsed before it could be pursed. Two successful sets were then made in quiet water near Oil Bay. July 10 was spent rendezvouing with the beach seine crew. On July 11 four sets were made, two of which were satisfactory. On July 12 the beach seine crew was transported to Homer from Chinitna Bay. July 13 was spent modifying equipment so that the operation would run more smoothly and on July 14, three successful sets were made in the mouth of Kachemak Bay. Hauls were recorded on five days.

In August similar problems were encountered and hauls were recorded on August 10, 11, 12, 13. The decision was made to use the gill nets in place of the purse seine in September due to repeated difficulty in handling the seine. In September weather conditions were so severe (the weather report called for 36 ft seas in the area) that this was accomplished with difficulty. Sets were only recorded on two days and had the purse seine been used, probably no sets would have been completed.

The purse seine and gill net captured herring and chinook salmon in greatest abundance and frequency. The majority of fish captured were larger than about 125 mm in length (Table 7).

The stations designated for sampling were never completed thus distributions of fish were insufficiently documented. Three sets across the mouth of Kachemak Bay in July yielded the largest catches and greatest number of species, however, weather and current provided minimal problems here while they provided substantial problems elsewhere. Thus the greater catches may be due to different abundance or to more efficient gear handling, or to both.

Table 7. Total number of fish captured in the purse seine (July and August) and in the gill net (September) by month and by species.

	July	August	September
Chinook Salmon	11	36	1
Pink Salmon		1	1
Red Salmon	1		
Coho Salmon	3		
Dolly Varden	2		
Pacific Herring	149	55	18
Pacific sand lance		1	
Soft sculpin	10		
Bering wolffish	3		

VII DISCUSSION

Purse Seine and Gill Net

The purse seine sampling did not provide adequate catches to make conclusions regarding pelagic fish. This failure was ascribed almost immediately to current velocities being too great for this gear. Even before the net was wet, current velocities were recognized as a problem and the decision was made to round haul the net so that all hauls would be similarly executed. The problem was not as simple as excessive current.

The sets made in different areas had somewhat different degrees of difficulty. Sets made across the mouth of Kachemak Bay in July all were executed smoothly. Sets made northeast and east of Augustine Island were generally executed with difficulty while sets made east of Chinitna Bay encountered severe and repeated problems; the net was repeatedly caught in the propeller and torn. The area where the greatest difficulty was encountered, in a general sense, had the strongest currents. Apparently success of setting and hauling was related to general current intensity of an area.

The presentation of the results show quite clearly that there were a lot of time limitations placed upon the purse seining. The net wasn't received early enough to use it in June, due to late receipt of funding. Each subsequent month 10 days were committed to use of the purse seine, however, the first and last days were spent changing the rigging of the boat between otter trawl and purse seine. The charter vessel was also committed to placing and supporting the beach seine crew on the west side of the inlet while it was purse seining. This cost one day each way plus at least one day rendezvous time. Only 5 days at most were available for purse seining each month.

This discussion has not touched on the finer points of purse seining. It is limited by suitable weather, to which time was lost, but more important, round hauling is not recommended. By holding the net open for 20 minutes considerably larger catches are made since pelagic fish are generally moving and collect near the net (Hartt 1975). When this is done the set is highly directional, if the fish are predominantly moving in one direction. Thus to sample one location requires 3 or 4 directional sets, at least until an understanding of the direction of movement is gained. Since the gear requires a fair amount of time to place and retrieve, only about 4 sets can be made in a day (5 were completed one day in lower Cook Inlet). All this adds up to a lot of time for a little coverage. Hartt (1975) states that the purse seine is not a good synoptic sampling tool. However, the purse seine is more efficient and less selective than longline or gill net (Hartt 1975). From the data gathered by the purse seine samples in Cook Inlet it is my impression that if greater catches and more of them were made, this would be a powerful sampling tool.

Beach Seine

The beach seine catches of pink salmon fry displayed an apparent movement out of KatchemakBay as the summer progressed. Since the number of samples taken was small and the offshore or pelagic habitat information is not sufficiently strong to support the pattern, the apparent trend must be considered only as a possiblility. That the pink fry do move out of Kachemak Bay during summer can be accepted as fitting available knowledge. However, the organized manner in which fish seemed to be only at certain locations on certain dates may well be an artifact.

Large numbers of pink salmon fry were found in Kamishak Bay (Bruin Bay, Ursus Cove and Rocky Cove). Quite good returns of adults to streams in this area were recorded during 1975 (Tom Schroeder, personal communication) thus the pink fry probably originated from streams in the vicinity where they were captured.

The pink fry in the Kamishak Bay area appeared to be a little later than those in other portions of the inlet. The catches peaked in July while those in other areas were greatest in June. This could be an artifact of inadequate June sampling in Kamishak Bay or it could be related to the colder climate in the Kamishak Bay area, which would retard development. Other researchers of the Cook Inlet Synthesis meeting in November, 1976 stated that biological events in Kamishak Bay were later than in other areas of lower Cook Inlet.

There were some unusually small pink salmon fry captured in the Kamishak Bay area during the summer. There are some late spawning runs of pinks in Cottonwood Bay (tributary to Iliamna Bay) and Ursus Cove (Tom Schroeder, personal communication) which would explain the small fish.

Otter Trawl

The otter trawl catches displayed distinct and repeated patterns of distribution. Certain taxa were primarily or exclusively found in certain areas of the inlet. Some areas always had poor catches. The catch information appears to correlate with physical features on the bottom. Sand waves have been reported and mapped (Hampton and Bauma, uncitable information obtained from U.S. Geological Survey, Anchorage) on the bottom of lower Cook Inlet. The small catches apparently occurred in areas of large sand wave size.

The two most northerly stations apparently occur in areas where sand waves are absent. Catches at these stations were larger than in areas where sand waves apparently occurred but were not as large as was taken in the southern portion of the inlet. In this area, north of Anchor Point, current conditions may be sufficiently severe to reduce habitable area or food supply.

It should also be mentioned that the efficiency of an otter trawl may be reduced where either sand waves or excessive current conditions occur. The reduced catches in the northern portion of the inlet probably reflect lower densities of fish and crabs but also may be partially caused by sand waves or excessive currents.

VIII CONCLUSIONS

The biota of the demersal zone of lower Cook Inlet in summer, as reflected by otter trawl catches, consists of flounders (39%), crustacea (25%), cod (18%) and sculpins (13%). Catch rates were highly variable and appeared to be related to physical factors in the environment. Spatial distribution of benthic species was determined.

Pelagic fish were sampled with the power purse seine and gill net. The purse seine proved to be a difficult piece of gear to employ, requiring a lot of time for a little information. Predominant species captured in the pelagic zone were adult Pacific herring and juvenile chinook salmon.

Beach seine samples yielded large numbers of outmigrant pink salmon. This species was encountered in greatest abundance in Kachemak Bay in June and in Kamishak Bay (Bruin Bay, Rocky Cove and Ursus Cove) in July. These areas are near spawning streams for this species.

IX NEEDS FOR FURTHER STUDY

The needs for further study of fish and demersal shellfish in lower Cook Inlet are many. However, this is an extremely complex area where hastily conceived and executed studies could be unusually futile. The density of animals within the inlet varies from extremely low to extremely high. Areas of disparate densities may be separated by only a relatively small distance. Habitat factors play a major role in these variations and thus these factors must be studied before any sampling scheme is finalized.

The demersal resources on the west side of the inlet need further study. Kamishak Bay south of Augustine Island was never sampled with the otter trawl. North of Augustine Island in Kamishak Bay a few otter trawl hauls were made which suggest that large numbers of juvenile halibut may be present. Some other observations suggest that this area is highly productive but the area has not been sufficiently explored.

East of Chinitna Bay is a modest area between 10 and 20 fathoms and to 30 fathoms deep which has not been sampled. Trawling may not be possible in this area but that has not been adequately determined. Pelagic fish have received attention in the current study but their distribution and movements have not been adequately documented. They certainly require more study. Salmon and herring are obvious members of this group of fish but sandlance are unique in that little or no information on their biology is available from any location and they are a highly important forage fish species.

The biological characteristics of fishes in lower Cook Inlet needs further study. Food habits information is limited as is age and growth information. The location of spawning and nursery areas for demersal stocks is not known. The salmon stocks on the west side of lower Cook Inlet are poorly known and need study.

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THE DISTRIBUTION, ABUNDANCE AND DIVERSITY OF THE EPIFAUNAL BENTHIC ORGANISMS IN TWO (ALITAK AND UGAK) BAYS OF KODIAK ISLAND ALASKA

Dr. H. M. Feder, Principal Investigator

With:

Max Hoberg

Stephen C. Jewett

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

March 31 1977

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Rosemary Hobson, Institute of Marine Science, University of Alaska, assisted in data processing. Nora Foster, Marine Sorting Center, Institute of Marine Science, University of Alaska, determined some of the mollusc species identified by our group. We especially appreciate the biological skills and organizational abilities of John Hilsinger, Institute of Marine Science, University of Alaska which were of so much value in all phases of manuscript preparation.

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

Little is known about the biology of the non-commercially important invertebrate components of the shallow, nearshore benthos of bays of Kodiak Island, and yet these components may be the ones most significantly affected by the impact of oil resulting from offshore petroleum operations. Some baseline data on species composition is essential before industrial activities take place in waters adjacent to Kodiak Island. It is the intent of this investigation to collect information on the composition, distribution, and biology of the epifaunal invertebrate components of two bays of Kodiak Island.

The specific objectives of this study are:

1. A qualitative inventory of dominant benthic invertebrate epifaunal species within two study sites (Alitak and Ugak bays).
2. A description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites.
3. Observations of biological interrelationships between segments of the benthic biota in the designated study areas.

Fifty-three permanent stations have been established in the two bays - 28 stations in Alitak Bay and 25 stations in Ugak Bay. These stations have been occupied with a 400-mesh Eastern otter trawl on three separate cruises in June, July and August of 1976. Taxonomic analysis of the epifauna collected has delineated 10 phyla, 20 classes, 54 families, 68 genera and 89 species. The Arthropoda (Crustacea) dominated species composition and biomass. Porifera, Cnidaria, and Mollusca, were also important, but accounted for only 1.1% of the biomass collected.

Differences in sex composition and stage of maturity of king and snow crab between and within the two bays were noted. King crab occurred mainly at the outer stations of Alitak Bay and consisted mostly of egg-bearing females and juveniles. The crab were well dispersed throughout Ugak Bay, and mainly consisted of juveniles. Snow crab in Alitak Bay were primarily juveniles; snow crab in Ugak Bay were primarily adult males. Life history data for these crabs for the summer months is now available.

Food data for king and snow crabs for the two bays is available, and this data in conjunction with similar data from Cook Inlet and the Bering Sea should contribute to a fuller understanding of the trophic role of these crustaceans in their respective ecosystems. Additional food data for three species of demersal flatfishes, as well as an assessment of the literature, have made it possible to develop a preliminary food web for Alitak and Ugak bays and inshore waters around Kodiak Island. Comprehension of basic food interrelationships is essential for assessment of the potential impact of oil on the crab-dominated benthic systems of the near-shore waters of Kodiak.

The importance of deposit-feeding clams in the diet of crabs in the two Kodiak bays has been demonstrated by feeding studies there. It is suggested that an understanding of the relationship between oil, sediment, deposit-feeding clams, and crabs be developed in a further attempt to understand the possible impact of oil on the two commercially important species of crab in the Kodiak area.

Initial assessment of data suggests that a few unique, abundant, and/or large invertebrate species (king crab, snow crab, several species of clams) are available in the bays under investigation and that these species may represent organisms that could be useful for monitoring purposes.

It is suggested that a complete understanding of the benthic systems in both bays can only be obtained when the infauna is assessed in conjunction with the epifauna. Infaunal species are important food items for king and snow crabs. A program designed to examine the infauna should be initiated in the near future.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the Gulf of Alaska present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse affects on a marine environment cannot be assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development.

Insufficient long-term information about an environment, and the basic biology and recruitment of species in that environment can lead to erroneous interpretations of changes in species composition and abundance that might occur if the area becomes altered (see Nelson-Smith, 1973; Pearson, 1971, 1972; Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas). Populations of marine species fluctuate over a time span of a few to 30 years (Lewis, 1970).

Benthic organisms (primarily the infauna and sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975; and Rosenberg, 1973, for discussions on usage of benthic organisms for monitoring pollution). The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (crabs, shrimps, scallops, snails, fin fishes) in the shelf ecosystem of Kodiak Island further dictates the necessity of understanding benthic communities since many commercial species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963, and this report for a discussion of the interaction of commercial species and the benthos). Thus, drastic changes in density of the food benthos would affect the health and numbers of these fisheries organisms.

Experience in pollution-prone areas of England (Smith, 1968), Scotland (Pearson, 1972), and California (Straughan, 1971) suggests that at the completion of an initial exploratory study, selected stations should be examined regularly on a long-term basis to determine any changes in species composition, diversity, abundance, and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration. An intensive investigation of the benthos of the Kodiak shelf as well as its bays, is essential to an understanding of the trophic interactions involved there and the potential changes that may take place once oil-related activities are initiated. An ongoing benthic biological program in the Gulf of Alaska has emphasized the development of a qualitative and quantitative inventory of prominent species of the benthic infauna and epifauna there (Feder *et al.*, 1976). In addition, a developing investigation concerned with the biology of selected benthic species from the northeast Gulf of Alaska and lower Cook Inlet will further our understanding of the overall Gulf of Alaska benthic system (Feder *et al.*, 1977). Initiation of a program designed to examine the subtidal benthos of the Kodiak shelf will expand the coverage of the Gulf of Alaska benthic system, and specifically an assessment of the fauna of shallow bays of Kodiak will extend the investigation into little-studied shallow-water benthic systems. The study reported here then, is a preliminary assessment of two shallow bays of Kodiak Island, and is intended to precede a greater overall investigation of the Kodiak Island shelf.

The objectives of this investigation are:

1. A qualitative inventory of dominant benthic invertebrate epifaunal species within two study sites (Alitak and Ugak bays).
2. A description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites.
3. Observations of biological interrelationships between segments of the benthic biota in the designated study areas.

Relevance to Problems of Petroleum Development

The effects of oil pollution on subtidal benthic organisms have been seriously neglected, although a few studies, conducted after serious oil spills, have been published (see Boesch *et al.*, 1974 for review of these papers). Thus, lack of a broad data base elsewhere makes it difficult at present to predict the effects of oil-related activity on the subtidal benthos of the Kodiak continental shelf and the two Kodiak bays investigated. However, the expansion of research activities into Kodiak waters should ultimately enable us to identify certain species or areas that might bear closer scrutiny once industrial activity is initiated. It must be emphasized that a considerable time span is needed to understand fluctuations in density of marine benthic species, and it cannot be expected that a short-term research program will result in total predictive capabilities. Assessment of the environment must be conducted on a continuing basis.

Data indicating the effects of oil on most subtidal benthic invertebrates are fragmentary (Nelson-Smith, 1973). The tanner or snow crab (*Chionoecetes bairdi*) is a conspicuous member of the shallow shelf of Kodiak Island and its bays, and supports a commercial fishery of considerable importance there. Laboratory experiments with this species have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil; obviously this aspect of the biology of the snow crab must be considered in the continuing assessment of this benthic species in the Gulf of Alaska (Karinen and Rice, 1974). Little other direct data based on laboratory experiments is available for subtidal benthic species (see Nelson-Smith, 1973). Experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged for the near future in Kodiak waters as well as for the overall OCS area of investigation. In addition, potential effects of the loss of sensitive species to the trophic structure of the shelf must be examined. The latter problem can be addressed once benthic food studies are made available as a result of OCS studies (e.g., the following annual reports: Feder *et al.*, 1977, and Smith *et al.*, 1977).

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated by Rhoads (see Rhoads, 1974 for review). They describe a diesel-fuel oil spill that resulted in oil becoming adsorbed on sediment particles which in turn caused death of deposit feeders living on sublittoral muds. Bottom stability was altered with the death of these organisms, and a new complex of species became established in the altered substratum. Many common members of the infauna of the Gulf of Alaska are deposit feeders; thus, oil-related mortality of these species could result in a changed near-bottom sedimentary regime with alteration of species composition there. In addition, the commercially important king crab and snow crab and some bottom fishes use deposit feeders as food (Feder *et al.*, 1977 and present report); thus, oil hydrocarbons might indirectly affect fisheries for these species around Kodiak Island.

As suggested previously, on completion of initial baseline studies in pollution-prone areas, selected stations should be examined on a long-term basis. Cluster analysis methods (see further discussion under Methods; also see Feder *et al.*, 1976, 1977, for a detailed discussion on methodology) might provide good techniques for the selection of stations for continuous monitoring of the Kodiak Shelf and its bays. In addition, these techniques could provide insights into normal ecosystem variation (Clifford and Stephenson, 1975; Williams and Stephenson, 1973; Stephenson *et al.*, 1974).

III. CURRENT STATE OF KNOWLEDGE

Little is known about the biology of the invertebrate benthos of the Gulf of Alaska, although a compilation of some relevant data on the Gulf of Alaska is available (Rosenberg, 1972). The exploratory fishing drag program of the National Marine Fisheries Service (undated) is the most extensive investigation of the benthic epifauna of the Kodiak shelf.[1] Caution must be exercised in interpreting data from these trawl studies. Results from these surveys, directed toward different groups and/or species, are not typically comparable due to the alteration of gear and sampling effort from one cruise to another. Some unpublished information on the epifauna in the vicinity of Kodiak Island is available (i.e., Alaska Department of Fish and Game King Crab Indexing Surveys).[2] The International Pacific Halibut Commission surveys parts of the Kodiak shelf annually but only records commercially important crabs (see Intl. Pac. Halibut Comm., 1961). A compilation of some relevant data on renewable resources of the Kodiak shelf is available (AEIDC, 1975).

IV. STUDY AREA

A large number of stations were occupied in two Kodiak Island bays in conjunction with the Alaska Department of Fish and Game. Alitak Bay and Ugak Bay, located on the south and east side of the Island respectively, were the sites of benthic trawling activities during the summer of 1976 (Figs. 1 and 2).

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[1] Unpublished data. Reports available from the National Marine Fisheries Service Laboratory, Kodiak, Alaska.

[2] Unpublished data. Inquiries may be directed to Alaska Department of Fish and Game, Box 686, Kodiak, Alaska 99615.

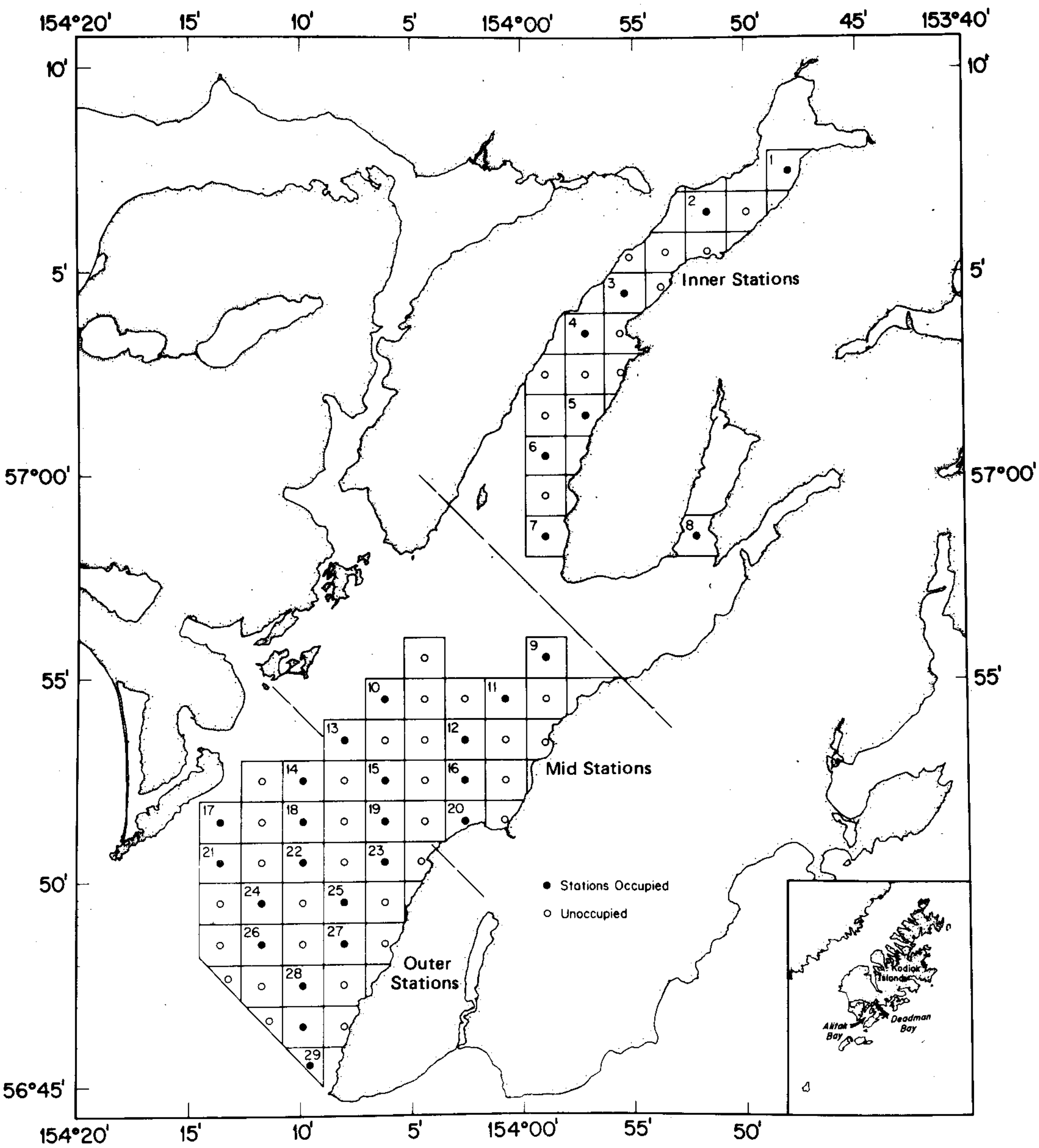

Figure 1. Trawl station grid and stations occupied in Alitak Bay, Kodiak Island, Alaska. June, July, and August, 1976. The oblique lines drawn across the bay divides it into three sections referred to in the text.

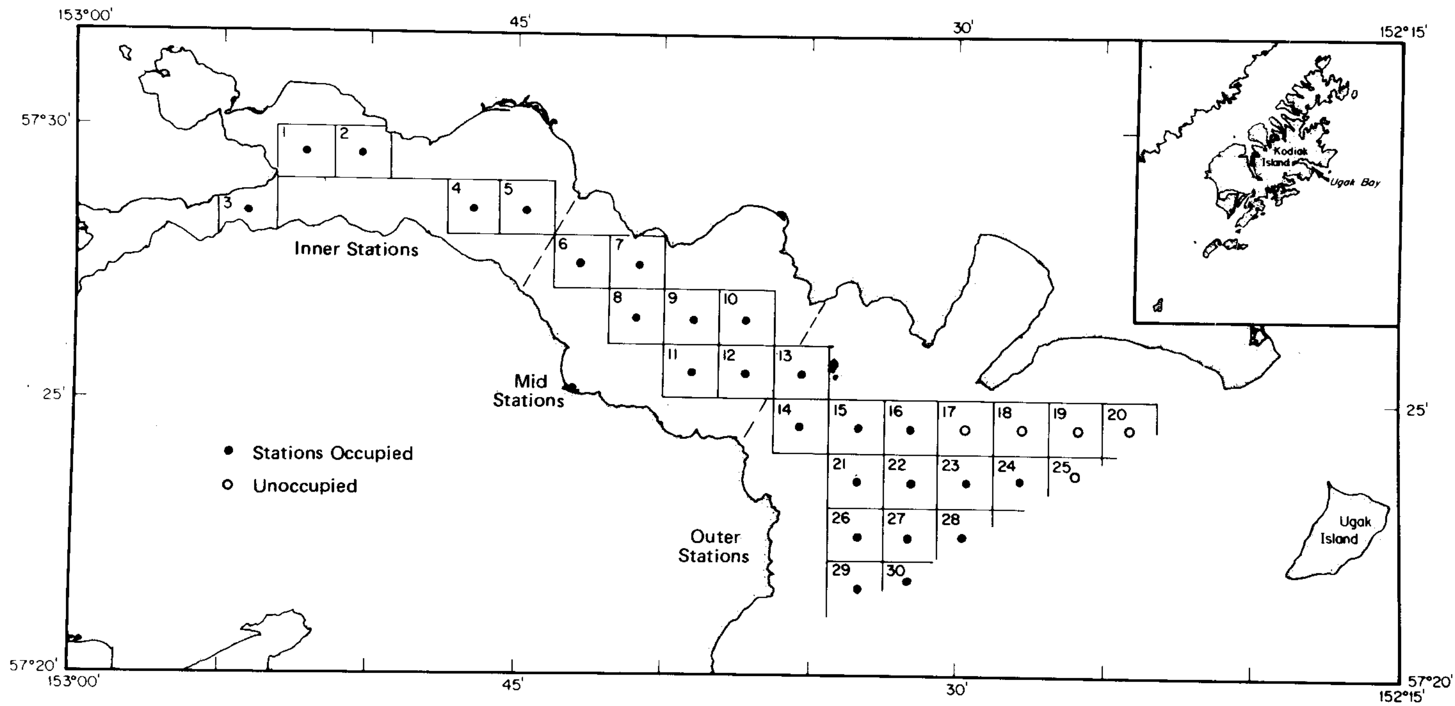

Figure 2. Trawl station grid in Ugak Bay, Kodiak Island, Alaska. June, July, and August, 1976. The oblique, dashed lines drawn across the bay divide it into three sections referred to in the text.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Benthic epifauna was collected onboard the M/V *Big Valley* in 1976 during June 17-22, July 18-28 and August 19-29. Thirty-minute tows were made at predetermined stations (Figs. 1 and 2) using a commercial size 400-mesh Eastern otter trawl with a 12.2 m horizontal opening.

The number of stations occupied in each bay by cruise are as follows:

Cruise Date	Alitak Bay	Ugak Bay	Total Stations
June 17-22	28	25	53
July 18-28	28	25	53
August 19-29	22	25	47
TOTAL	78	75	153

Bay stations were arbitrarily divided into three sections; inner stations, mid-bay stations, and outer stations.

Invertebrates were sorted on shipboard, given tentative identifications, counted, and weighed. Aliquot samples of individual species were preserved and labeled for final identification at the Institute of Marine Science, University of Alaska. Laboratory examination occasionally revealed more than one species in a sample that had been identified in the field (e.g., field identifications of *Eualus macilenta* were later found to also contain *E. gaimardii belcheri*). The counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to encompass the entire catch of the trawl.

After final identification, all invertebrates were assigned code numbers to facilitate data analysis by computer (Mueller, 1975). Representative and voucher samples of invertebrates are stored at the Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

The major limitations of the survey were those imposed by the selectivity of the otter trawl used and the seasonal movements of certain species taken. In addition, rocky-bottom areas could not be sampled since otter trawls of the type used can only be fished on relatively smooth bottoms. Due to the location of stored commercial crab gear in Alitak Bay, six stations (9 through 13) had to be eliminated during the August sampling period.

Food data was collected by examination of stomachs either on shipboard or in the laboratory of two species of crab (snow crab, *Chionoecetes bairdi* and king crab, *Paralithodes camtschatica*) and three species of flatfishes (*Limanda aspera, Hippoglossoides elassodon* and *Lepidopsetta bilineata*). Only male snow crab between 75 and 180 mm carapace width were examined; only male king crab between 90 and 200 mm carapace width were examined. Food organisms are expressed in frequency of occurrence, i.e., the percent of stomachs containing various food items from the total number of stomachs analyzed. Empty stomachs were included in making calculations of frequency of occurrence.

King crab and snow crab were separated by weight, sex, and state of maturity. Male king crab were considered sexually mature if their wet weight was at least 2.2 kg. Male snow crab were considered mature if their wet weight was at least 0.45 kg. Weight criteria established for maturity of both crab species are approximations (J. Hilsinger and S. Jewett, unpublished). Female crab were classified as immature (pre-reproductive) or mature (reproductive or post-reproductive) based on the enlarged abdomen, modified pleopods, and egg clutch of the adults.

Data tables consist primarily of data pooled from all cruises from both bays. These data are used as the bases for biological generalizations about the Kodiak bays studied. Selected biological aspects of each bay are treated separately in the text. Separate tables and discussions for each bay will be available in the Final Report, and will contain additional information from a fourth cruise in March 1977.

Data referred to in the text is generally from field notebooks and is not available to NODC at the time of this Annual Report. Complete station data will be available to NODC at the time of the final report.

VI. RESULTS

Distribution and Abundance

Taxonomic analysis of epifaunal invertebrates from 153 stations delineated 10 phyla, 20 classes, 54 families, 68 genera and 89 species (Table I; Appendix I). Arthropoda (Crustacea) and Mollusca dominated species representation with 36 and 28 species respectively (Table I, Appendix I). Arthropod crustaceans accounted for 97.3% of the total invertebrate biomass (Table II; Appendix II) and 96% of the total weight was made up of the families Pandalidae, Lithodidae, and Majidae (Table III; Appendix I). The leading species in each of these families respectively was the pink shrimp, *Pandalus borealis*; the king crab, *Paralithodes camtschatica*; and the snow (tanner) crab, *Chionoecetes bairdi* (Table IV; Appendix I). Although 28 species of molluscs were present, they only accounted for 0.1% of the total invertebrate biomass (Table II; Appendix I).

The average catch of *Pandalus borealis* for all stations was 9.9 kg per tow. Abundant catches of pink shrimp were obtained from Alitak Bay stations 11 through 16 (Fig. 1) and Ugak Bay stations 10 through 14, 22 and 23 (Fig. 2). The greatest single catch of pink shrimp was obtained in July at Alitak Bay station 23; 426.0 kg.

TABLE I

A LIST OF SPECIES TAKEN BY TRAWL FROM ALITAK AND UGAK BAYS, KODIAK ISLAND, ALASKA IN JUNE, JULY AND AUGUST, 1976

Phylum Porifera
- Unidentified species

Phylum Cnidaria
- Class Hydrozoa
  - Unidentified species
- Class Scyphozoa
  - Unidentified species
- Class Anthozoa
  - Subclass Alcyonaria
    - Family Pennatulidae
      - *Ptilosarcus gurneyi* (Gray)
    - Family Actinostolidae
      - *Stomphia coccinea* (O. F. Müller)
    - Family Actiniidae
      - Unidentified species

Phylum Annelida
- Class Polychaeta
  - Family Polynoidae
    - Unidentified species
  - Family Nereidae
    - *Nereis* sp.
  - Family Serpulidae
    - *Crucigera irregularis* Bush
- Class Hirudinae
  - Family Acanthochitonidae
    - *Notostomobdella* sp.

Phylum Mollusca
- Class Pelecypoda
  - Family Nuculanidae
    - *Nuculana fossa* Baird
    - *Yoldia hyperborea* Lovén in Torell
    - *Yoldia thraciaeformis* Storer
  - Family Mytilidae
    - *Mytilus edulis* Linnaeus
    - *Musculus discors* (Gray)
    - *Modiolus modiolus* (Linnaeus)
  - Family Pectinidae
    - *Pecten caurinus* Gould
    - *Chlamys rubida* Hinds
  - Family Anomiidae
    - *Pododesmus macrochisma* Deshayes
  - Family Astartidae
    - *Astarte rollandi* Bernardi
    - *Astarte esquimalti* Baird
  - Family Cardiidae
    - *Clinocardium ciliaatum* (Fabricius)
    - *Clinocardium nuttallii* Conrad
    - *Serripes groenlandicus* (Bruguiére)

TABLE I

CONTINUED

- Family Veneridae
  - *Saxidomus gigantea* (Deshayes)
  - *Protothaca staminea* (Conrad)
- Family Tellininidae
  - *Macoma calcarea* (Gmelin)
  - *Macoma moesta* (Deshayes)
- Family Hiatellidae
  - *Hiatella arctica* (Linnaeus)
- Family Teredinidae
  - *Bankia setacea* Tryon

Class Gastropoda
- Family Calyptraeidae
  - *Crepidula nummaria* Gould
- Family Velutinidae
  - *Velutina* sp.
- Family Cymatiidae
  - *Fusitriton oregonensis* (Redfield)
- Family Thaididae
  - *Nucella lamellosa* (Gmelin)
- Family Neptunidae
  - *Neptunea lyrata* (Gmelin)
- Family Dorididae
  - Unidentified species

Class Cephalopoda
- Family Gonatidae
  - *Gonatus* sp.
- Family Octopodidae
  - *Octopus* sp.

Phylum Arthropoda

Class Crustacea
- Family Balanidae
  - *Balanus balanus* Pilsbury
  - *Balanus hesperius* Pilsbury
  - *Balanus rostratus* Pilsbury

Class Isopoda
- Unidentified species

Class Amphipoda
- Unidentified species

Class Decapoda
- Family Pandalidae
  - *Pandalus* sp.
  - *Pandalus borealis* Kröyer
  - *Pandalus goniurus* Stimpson
  - *Pandalus hypsinotus* Brandt
  - *Pandalopsis dispar* Rathbun
- Family Hippolytidae
  - *Eualus biunguis* Rathbun
  - *Eualus gaimardii belcheri* (Bell)
  - *Eualus macilenta* (Kröyer)

TABLE I

CONTINUED

Family Crangonidae
- *Crangon dalli* Rathbun
- *Crangon communis* Rathbun
- *Sclerocrangon boreas* (Phipps)
- *Argis lar* (Owen)
- *Argis dentata* (Rathbun)
- *Argis crassa* Rathbun

Family Paguridae
- *Pagarus* sp.
- *Pagurus ochotensis* Brandt
- *Pagurus aleuticus* (Benedict)
- *Pagurus capillatus* (Benedict)
- *Pagurus kennerlyi* (Stimpson)
- *Pagurus beringanus* (Benedict)
- *Elassochirus tenuimanus* (Dana)
- *Labidochirus splendescens* (Owen)

Family Lithodidae
- *Paralithodes camtschatica* (Tilesius)

Family Majidae
- *Oregonia gracilis* Dana
- *Hyas lyratus* Dana
- *Chionoecetes bairdi* Rathbun
- *Pugettia gracilis* (Dana)

Family Cancridae
- *Cancer* sp.
- *Cancer magister* Dana
- *Cancer oregonensis* (Dana)

Family Atelecyclidae
- *Telmessus cheiragonus* (Tilesius)

Family Pinnotheridae
- *Pinnixa occidentalis* Rathbun

Phylum Echiurida

Class Echiuroidea

Family Echiuridae
- *Echiurus echiurus* Fisher

Phylum Ectoprocta
- Unidentified species

Phylum Brachiopoda

Class Articulata

Family Cancellothridae
- *Terebratulina unguicula* Carpenter

Family Dallinidae
- *Terebratalia transversa* (Sowerby)

Phylum Echinodermata

Class Asteroidea

Family Echinasteridae
- *Henricia* sp.

Family Solasteridae
- *Solaster stimpsoni* Verrill

TABLE I

CONTINUED

Family Asteridae
- *Stylasterias forreri* (de Loriol)
- *Evasterias echinosoma* (Stimpson)
- *Evasterias troschelii* (Stimpson)
- *Pycnopodia helianthoides* (Brandt)

Family Strongylocentrotidae
- *Strongylocentrotus droebachiensis* (O. F. Müller)

Class Ophiuroidae

Family Gorgoncephalidae
- *Gorgonocephalus caryi* (Lyman)

Class Holothuroidea

Family Molpadiidae
- *Molpadia* sp.

Family Cucumariidae
- *Cucumaria* sp.

Phylum Chordata

Class Ascidiacea

Family Styelidae
- *Pelonaia corrugata* Forbes Goods

TABLE II

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE PHYLA OF ALITAK AND UGAK BAYS, 1976

(Trawl survey pooled data from cruises in June, July, and August)

Phylum	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams per Square Meter
Porifera	1650	102.03	0.7	0.18
Cnidaria	241	45.67	0.3	0.08
Mollusca	570	19.30	0.1	0.03
Arthropoda (Crustacea only)	319120	12619.44	97.3	22.36
Echinodermata	297	157.70	1.2	0.28
TOTAL	321878	12944.14	99.6	22.93

TABLE III

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF ALITAK AND UGAK BAYS, 1976

(Trawl survey, pooled data from cruises in June, July, and August)

Family	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams per Square Meter
Actiniidae	195	41.41	0.3	0.07
Pandalidae	281899	2372.66	18.3	4.20
Hippolytidae	12827	89.77	0.7	0.15
Crangonidae	7733	53390.66	0.4	0.09
Lithodidae	4420	3668.80	28.3	6.50
Majidae	11397	6403.41	49.4	11.34
Asteridae	232	150.02	1.1	0.26
TOTAL	318703	66116.73	98.5	22.61

TABLE IV

NUMBERS, WEIGHT, AND DENSITY OF THE MAJOR EPIFAUNAL SPECIES OF ARTHROPODA (CRUSTACEA) FROM ALITAK AND UGAK BAYS, 1976

(Trawl survey, pooled data from cruises of June, July, and August)

Species	Number of Organisms	Weight (kg)	Percent of Total Weight	Percent of Phylum Weight	Mean Grams per Square Meter
Pandalus borealis	79312	1528.02	11.8	12.11	2.70
Pandalus goniurus	38671	311.90	2.4	2.47	0.55
Pandalus hypsinotus	61470	493.38	1.1	3.91	0.87
Pandalopsis dispar	2446	39.35	0.3	0.31	0.06
Eualus gaimardii belcheri	10292	71.99	0.5	0.57	0.12
Argis dentata	3676	25.83	0.2	0.20	0.04
Paralithodes camtschatica	4420	3668.80	28.3	29.07	6.50
Chionoecetes bairdi	11287	6399.84	49.4	50.71	11.33
TOTAL	211574	12539.11	94.0	99.35	22.17

The average catch of *Paralithodes camtschatica* for all stations was 23.97 kg. Alitak Bay stations 21 through 29 and Ugak Bay stations 1 and 3 had the highest catches. The single largest catch was obtained at Alitak Bay station 28 during July.

Chionoecetes bairdi was normally dominant at all stations. The average catch was 41.8 kg. Large catches were obtained in Alitak Bay stations 2 through 5 and Ugak Bay stations 9, 10, 13 and 22. The largest catch was recorded at Alitak Bay station 3.

Differences in sex composition and stage of maturity of king crab and snow crab were evident between and within bays (Table V). During the three sampling periods in Alitak Bay, king crab were found mainly in the outermost stations (stations 14, 17, 18, 19, and 21 through 29) (Table V; Fig. 1). These outer stations were mainly composed of adult egg-bearing females and juveniles. The sex ratio of king crabs in the outer Alitak stations for the present study as well as from other studies (Gray and Powell, 1966; Kingsbury and James, 1971) is presented in Table VI. The sex ratio for king crab obtained in Ugak Bay for the present study is presented in Table VII.

King crab were well dispersed throughout Ugak Bay in all months. The composition was mainly juveniles (Table V).

The trend for the catch of snow crab in Alitak Bay declined from June to August. Adult males were the main component of the population during all sampling periods (Table V).

Snow crab were most abundant in the outer Ugak Bay stations (stations 13 through 30) (Fig. 2). The composition was mainly adult males (Table V).

TABLE V

SEX-MATURITY COMPOSITION OF KING CRAB AND SNOW CRAB IN ALITAK AND UGAK BAYS, JUNE, JULY, AND AUGUST, 1976

Alitak Bay Stations	Composition	June King crab No.	June King crab %	June Snow crab No.	June Snow crab %	July King crab No.	July King crab %	July Snow crab No.	July Snow crab %	August King crab No.	August King crab %	August Snow crab No.	August Snow crab %
1-7 (inner)	Adult males	0	0	1148	98	0	0	653	97	3	30	417	95
	Adult females w/eggs	0	0	8	1	0	0	16	2	7	70	11	3
	Juvenile males	0	0	0	0	0	0	0	0	0	0	2	<1
	Juvenile females	0	0	8	1	0	0	6	1	0	0	9	2
	Total	0	0	1164	100	0	0	675	100	10	100	439	100
9-13, 15, 16, 20 (mid-bay)	Adult males	0	0	603	88	41	67	895	92	6	15	84	92
	Adult females w/eggs	1	100	55	8	4	6	53	6	16	39	4	4
	Juvenile males	0	0	0	0	13	21	14	1	14	34	2	2
	Juvenile females	0	0	27	4	4	6	8	1	5	12	2	2
	Total	1	100	685	100	62	100	970	100	41	100	92	100
14, 17, 18, 19, 21-29 (outer)	Adult males	25	7	1037	76	28	4	583	61	21	8	178	67
	Adult females w/eggs	165	50	319	23	244	35	271	28	100	37	69	26
	Juvenile males	87	26	8	1	236	34	12	1	92	34	9	3
	Juvenile females	56	17	4	<1	186	27	93	10	56	21	11	4
	Total	333	100	1368	100	694	100	959	100	269	100	267	100
Ugak Bay Stations													
1-5 (inner)	Adult males	8	7	180	87	23	2	214	42	20	5	190	77
	Adult females w/eggs	1	1	16	8	2	<1	59	12	5	1	19	8
	Juvenile males	43	38	0	0	397	43	196	38	193	50	18	7
	Juvenile females	61	54	11	5	511	55	42	8	169	44	21	8
	Total	113	100	207	100	933	100	511	100	387	100	248	100
6-12 (mid-bay)	Adult males	7	29	567	90	23	6	212	56	2	1	213	81
	Adult females w/eggs	3	13	31	5	9	2	33	9	1	1	8	3
	Juvenile males	12	50	0	0	189	50	109	29	76	45	25	10
	Juvenile females	2	8	35	5	159	42	25	6	88	53	16	6
	Total	24	100	633	100	380	100	379	100	167	100	262	100

TABLE V

CONTINUED

Ugak Bay Stations	Composition	June King crab No.	June King crab %	June Snow crab No.	June Snow crab %	July King crab No.	July King crab %	July Snow crab No.	July Snow crab %	August King crab No.	August King crab %	August Snow crab No.	August Snow crab %
13-30 (outer)	Adult males	21	29	591	83	21	8	728	62	2	<1	339	76
	Adult females w/eggs	7	10	38	5	36	13	61	5	9	1	23	5
	Juvenile males	29	40	0	0	149	53	189	16	379	57	59	14
	Juvenile females	15	21	79	12	73	26	200	17	282	42	24	5
	Total	72	100	708	100	279	100	1178	100	672	100	445	100

Stations 9-13 in Alitak Bay were not sampled during August due to the presence of stored crab gear.

TABLE VI

SEX RATIOS OF KING CRAB IN OUTER ALITAK BAY[1]

Date	Mature Crabs			Immature Crabs		
	Male	Female	Ratio[2]	Male	Female	Ratio[2]
April 1970[3]	390	1419	3.63	60	76	1.26
May 1962[4]	366	584	1.59	28	21	0.75
June 1970[3]	198	359	1.81	103	66	0.64
June 1976	25	165	6.60	87	56	0.64
July 1976	28	244	8.71	236	186	0.78
August 1976	21	100	4.76	92	56	0.60

[1]Additional data not reported here is found in Kingsbury *et al.*, 1974.

[2]Females per male.

[3]Kingsbury and James, 1971.

[4]Gray and Powell, 1966.

TABLE VII

SEX RATIOS OF KING CRAB IN UGAK BAY JUNE, JULY, AND AUGUST 1976

Date	Mature Crabs			Immature Crabs		
	Male	Female	Ratio[1]	Male	Female	Ratio[1]
June	36	11	0.30	84	78	0.92
July	67	47	0.70	735	743	1.01
August	24	15	0.60	648	539	0.83

[1]Females per male

Feeding Data

Food contents were examined from 67 snow crab (*Chionoecetes bairdi*), 17 king crab (*Paralithodes camtschatica*), 17 yellowfin sole (*Limanda aspera*), 5 flathead sole (*Hippoglossoides elassodon*) and 4 rocksole (*Lepidopsetta bilineata*) (Table VIII).

The two commercial crabs, *P. camtschatica* and *C. bairdi*, were feeding on different items with little overlap. *Paralithodes camtschatica* concentrated on *Nuculana fossa*, miscellaneous clam species, *Margarites* sp., and miscellaneous fishes. *Chionoecetes bairdi* fed primarily on polychaetes, Nuculanidae, miscellaneous clam species (consumed about equally by both crabs), caridean shrimps, and plant matter. Sediment was found in 44.8% of snow crab stomachs. Although the latter item had the highest frequency of occurrence in snow crab stomachs, it is not clear if sediment actually represents a food source for *Chionoecetes bairdi* or is incidentally taken in the feeding process.

Among the fishes examined for stomach contents, *Limanda aspera* used fishes, *C. bairdi*, and clams, including the deposit-feeding *Macoma* as major food items; *Hippoglossoides elassodon* concentrated on euphausids and caridean shrimps; *Lepidopsetta bilineata* fed primarily on polychaetes and *Nuculana fossa*.

The Kodiak Island food web (Fig. 3) is based on data presented in this report, information from McDonald and Peterson (1976) and Feder *et al.* (1977) which presents some Pacific cod data from Kodiak. The food web (Fig. 3) is presented so that carbon flow is generally from bottom to top and always in the direction of the arrows. Data was insufficient to clearly identify major food pathways. Polychaetes, gastropods (snails), pelecypods (clams), amphipods, anomurans (hermit crabs), brachyurans (true

TABLE VIII

PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS (LISTED ACCORDING TO LOWEST LEVEL OF TAXONOMIC IDENTIFICATION) FOUND IN STOMACHS OF INVERTEBRATES AND FISHES FROM ALITAK AND UGAK BAYS, KODIAK ISLAND, 1976

Food Item	Percent frequency of occurrence of food items found in stomachs of:				
	Paralithodes camtschatica N=17	*Chionoecetes bairdi* N=67	*Limanda aspera* N=17	*Hippoglossoides elassodon* N=5	*Lepidopsetta bilineata* N=4
Polychaeta	–[1]	11.9	–	–	75.0
Nuculanidae	–	9.0	–	–	–
Nuculana fossa	47.1	–	–	–	50.0
Yoldia sp.	–	–	–	–	25.0
Pelecypoda	29.4	29.9	17.7	–	25.0
Axinopsida sp.	–	–	–	–	25.0
Macoma sp.	–	–	11.8	–	25.0
Tellina sp.	–	1.5	–	–	–
Spisula polynyma	5.9	–	5.9	–	–
Siliqua alta	–	–	5.9	–	–
Mytilus edulis	–	1.5	–	–	–
Gastropoda	5.9	–	–	–	–
Margarites sp.	11.8	–	–	–	–
Fusitriton oregonensis	5.9	–	–	–	–
Crustacea	–	3.0	–	–	–
Euphausiacea	–	–	–	60.0	–
Caridea	–	16.4	–	14.2	25.0
Crangonidae	–	1.5	–	–	–

TABLE VIII

CONTINUED

Food Item	Percent frequency of occurrence of food items found in stomachs of:				
	Paralithodes camtschatica N=17	*Chionoecetes bairdi* N=67	*Limanda aspera* N=17	*Hippoglossoides elassodon* N=5	*Lepidopsetta bilineata* N=4
Brachyura	-	9.0	-	-	-
Majidae	5.9	-	-	-	-
Chionoecetes bairdi	-	-	11.8	-	25.0
Atelecyclidae	5.9	-	-	-	-
Echiurus echiurus	-	1.5	-	-	-
Teleostei	17.7	3.0	17.7	-	25.0
Osmeridae	-	-	5.9	-	-
Mallotus villosus	-	-	5.9	-	-
Unidentified plants	5.9	31.3	-	-	-
Sediment	-	44.8	-	-	-
Empty stomachs	23.5	22.4	47.1	-	-

[1] All dashes indicate food item not present

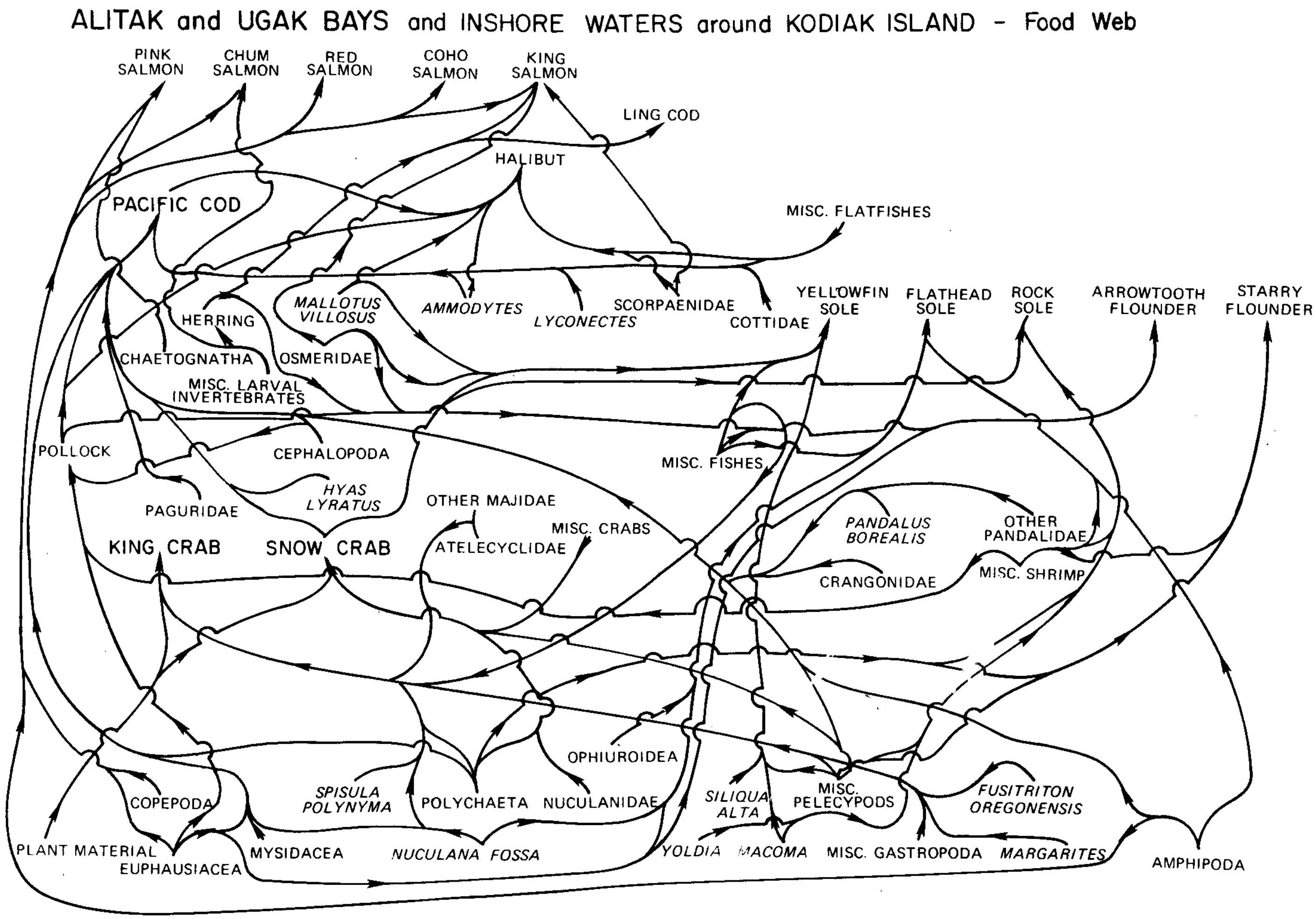

Figure 3. A food web based on the epibenthic species taken from Alitak and Ugak Bays and inshore waters around Kodiak Island, Alaska.

crabs), and carideans (shrimps) are the major invertebrate food items in the web. Shrimps and crabs are important food items for most fishes as well as some of the crabs. Small fishes such as herring, capelin and sandlance are important as food for the larger predatory fishes such as Pacific cod, king salmon and halibut (see Feder *et al.*, 1977 for additional Gulf of Alaska food data).

Feeding relationships for snow crab, king crab, and Pacific cod (data from Feder *et al.*, 1977 and S. Jewett, unpublished data for Kodiak) are shown in more detail in Figures 4, 5, and 6, respectively. The snow and king crabs (two of the most important commercial organisms on the Kodiak shelf) feed heavily on animals relying in whole or in part on deposited organics, detritus, bacteria, benthic diatoms, and meiofauna (Figs. 5 and 6, Table IX). Pacific cod feeds primarily on animals that are feeding on small benthic invertebrates or scavenging on animal remains (Fig. 6; Table IX). The invertebrates in the two bays relied on a variety of feeding methods (Table IX) while the fishes tended to be predators.

Number, weight and frequency of occurrence calculations used in this report are based on Appendix Tables 1-4.

VII. DISCUSSION

Station Coverage

The trawl program discussed in this report represents the first intensive coverage of epifaunal invertebrates of Alitak and Ugak Bays. Preliminary plans called for 28 stations to be occupied monthly in Alitak Bay and 25 stations in Ugak Bay for June, July, and August 1976. August sampling in Alitak Bay was hampered when stored crab gear prevented sampling

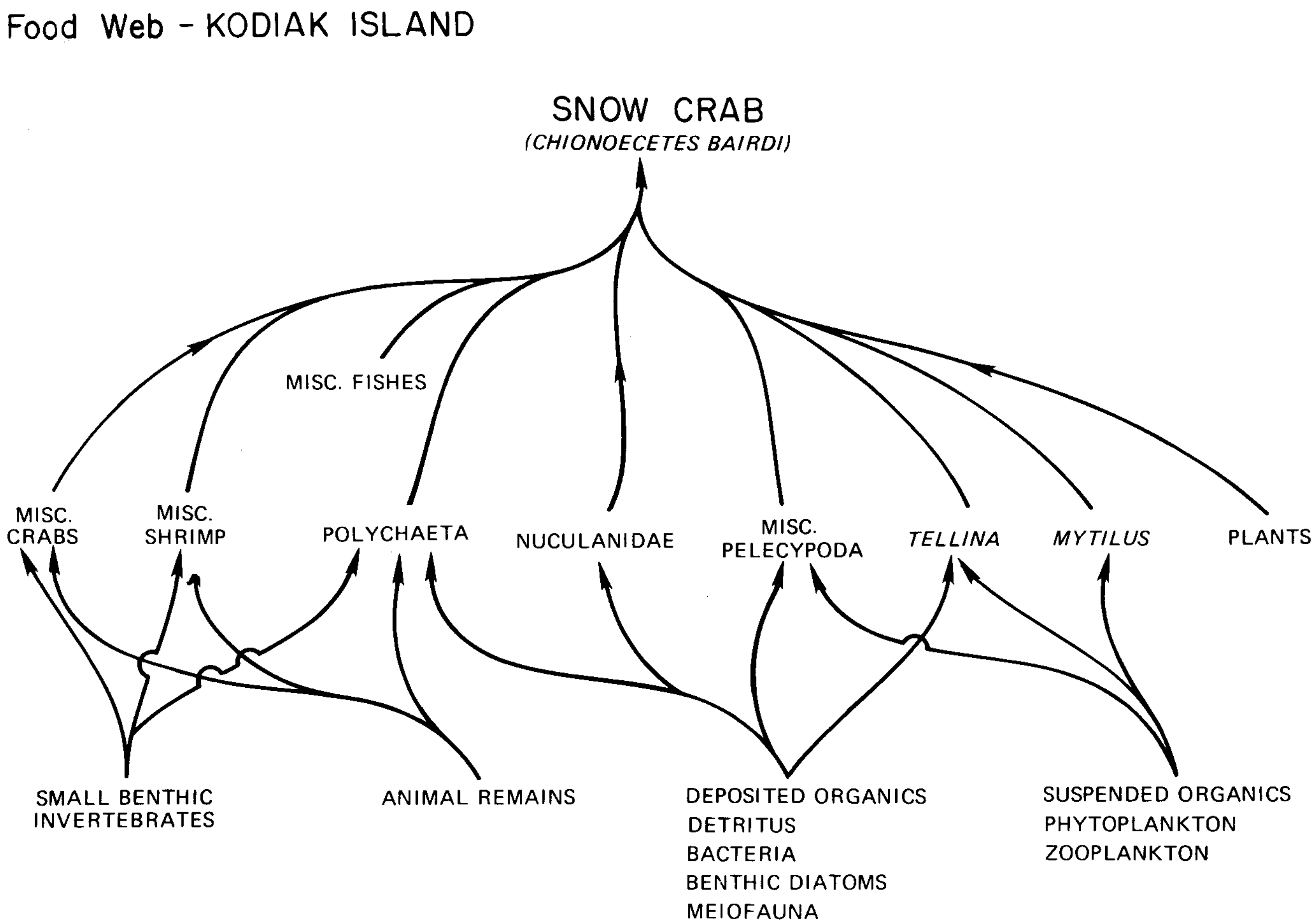

Figure 4. Food web showing carbon flow to snow crab (*Chionoecetes bairdi*) in Alitak and Ugak Bays and inshore waters around Kodiak Island, Alaska.

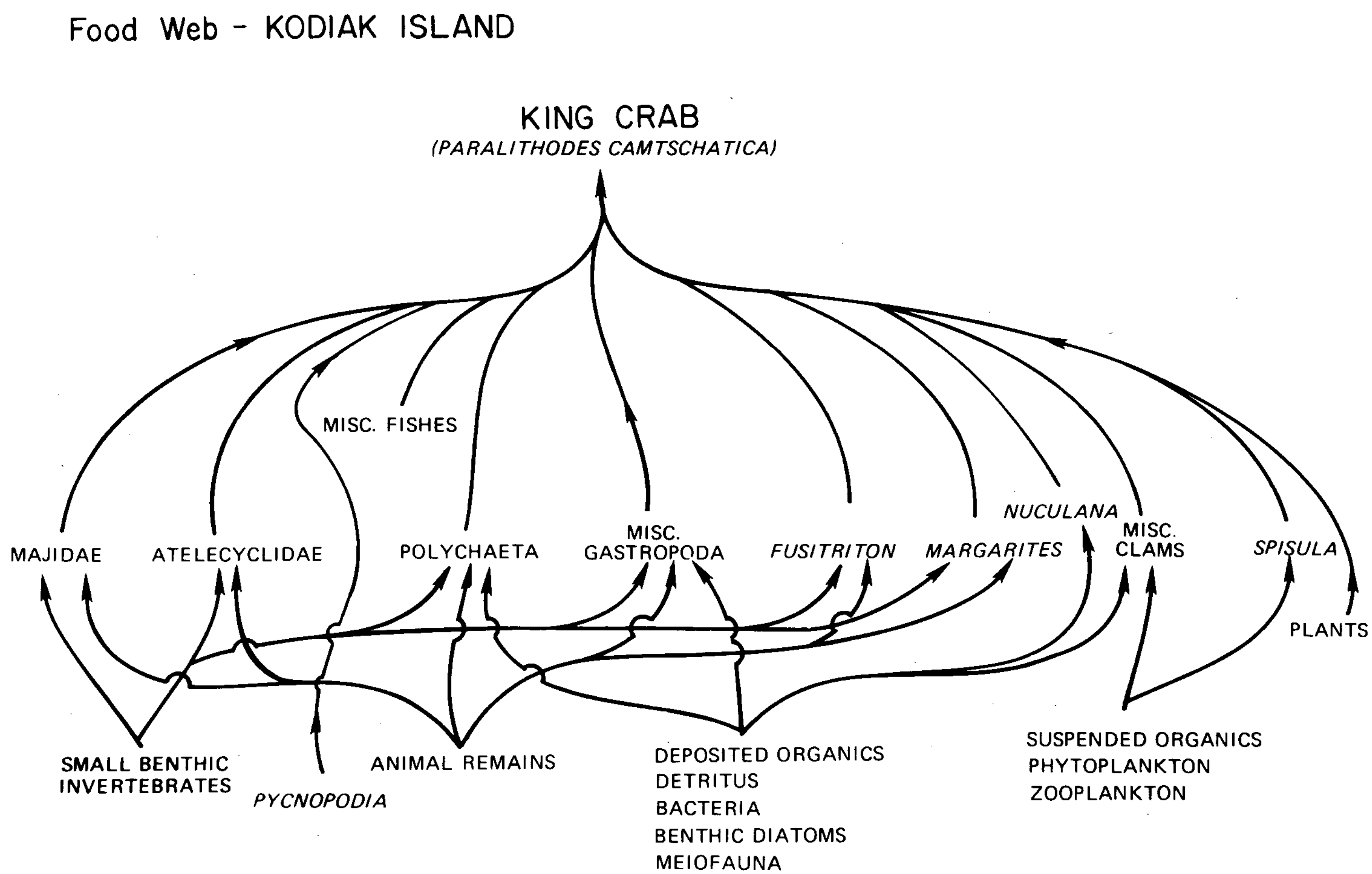

Figure 5. Food web showing carbon flow to king crab (*Paralithodes camtschatica*) in Alitak and Ugak Bays and inshore waters around Kodiak Island, Alaska.

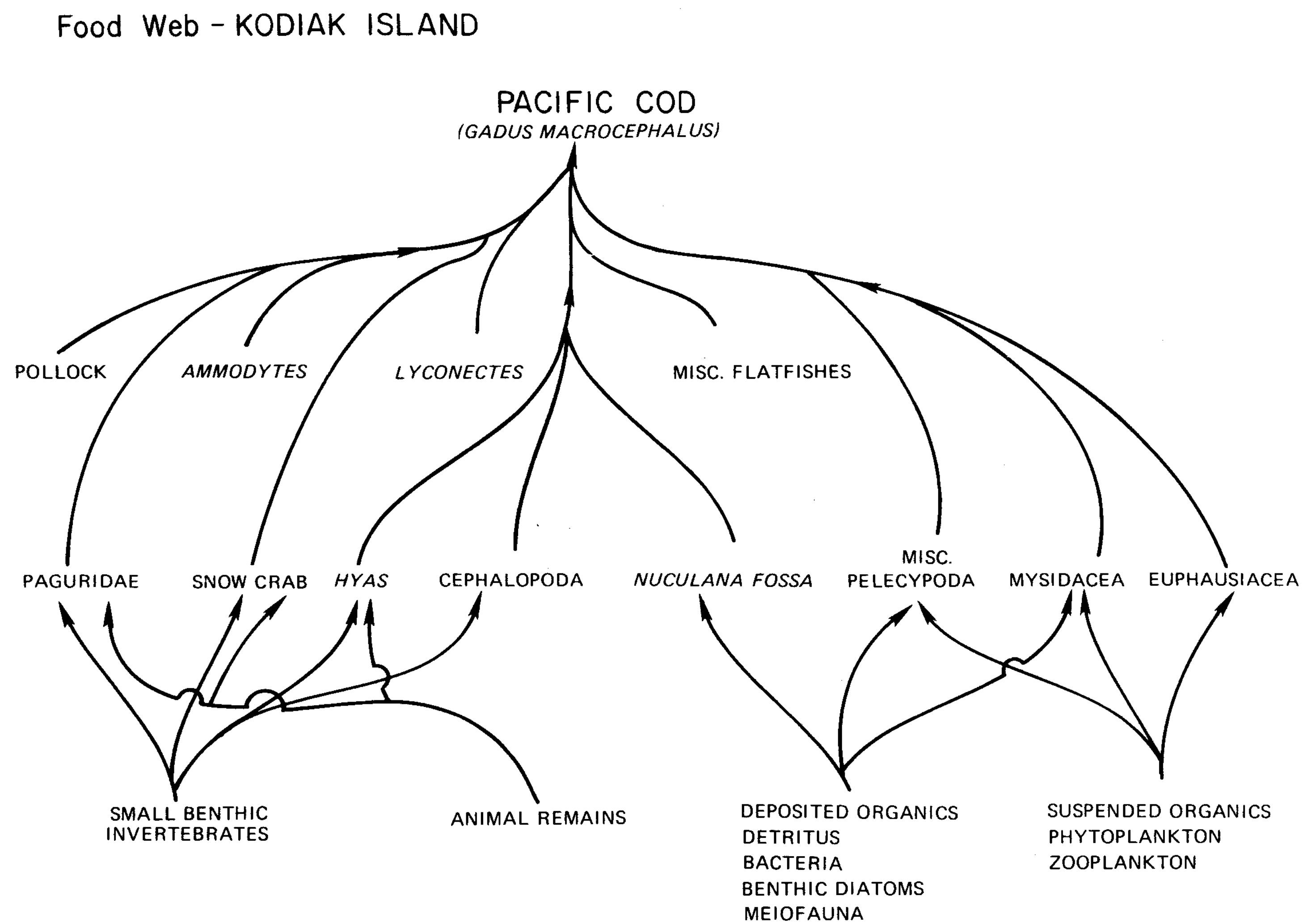

Figure 6. Food web showing carbon flow to Pacific cod (*Gadus macrocephalus*) from inshore waters around Kodiak Island, Alaska. (Also see Feder *et al.*, 1977 for comments on cod food habits in the Gulf of Alaska).

TABLE IX

FEEDING METHODS[1] OF ORGANISMS INCLUDED IN THE KODIAK ISLAND (ALITAK AND UGAK BAYS AND OTHER INSHORE WATERS) FOOD WEB

Phylum abbreviations: A=Annelida; M=Mollusca; Art=Arthropoda; Ecd=Echinodermata
Ctn=Chaetognatha; Cho=Chordata; X=dominant feeding method; O=other feeding method

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Polychaeta	A	X	X	X	X	–
Gastropoda	M	X	–	X	X	–
Margarites	M	–	–	–	–	X
Fusitriton oregonensis	M	–	–	X	X	–
Nuculana fossa	M	X	–	–	–	–
Yoldia sp.	M	X	–	–	–	–
Spisula polynyma	M	–	X	–	–	–
Axinopsida sp.	M	–	–	–	–	X
Siliqua alta	M	–	–	–	–	X
Macoma sp.	M	X	O	–	–	–
Cephalopoda	M	–	–	X	X	–
Mysidacea	Art	–	X	X	X	–
Amphipoda	Art	X	–	X	X	–
Euphausiacea	Art	–	X	–	–	–
Pandalidae	Art	–	–	X	X	–
Pandalus borealis	Art	–	–	X	X	–
Crangonidae	Art	–	–	X	X	–
Paguridae	Art	–	–	X	X	–
Paralithodes camtschatica	Art	–	–	X	X	–
Majidae	Art	–	–	X	X	–

TABLE IX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Hyas lyratus	Art	–	–	X	X	–
Chionoecetes bairdi	Art	–	–	X	X	–
Atelecyclidae	Art	–	–	–	–	X
Ophiuroidea	Ecd	X	X	X	X	–
Chaetognatha	Ctn	–	–	–	X	–
Clupea harengus pallasi (herring)	Cho	–	–	–	X	–
Oncorhynchus gorbuscha (pink salmon)	Cho	–	–	–	X	–
O. keta (chum salmon)	Cho	–	–	–	X	–
O. kisutch (coho salmon)	Cho	–	–	–	X	–
O. nerka (red salmon)	Cho	–	–	–	X	–
O. tshawytscha (King salmon)	Cho	–	–	–	X	–
Osmeridae	Cho	–	–	–	X	–
Mallotus villosus (capelin)	Cho	–	–	–	X	–
Theragra chalcogramma (pollock)	Cho	–	–	–	X	–
Gadus macrocephalus (Pacific cod)	Cho	–	–	X	X	–
Lyconectes sp.	Cho	–	–	–	X	–

TABLE IX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Ammodytes sp. (sand lance)	Cho	–	–	–	X	–
Scorpaenidae	Cho	–	–	–	X	–
Ophiodon sp. (lingcod)	Cho	–	–	–	X	–
Cottidae	Cho	–	–	–	X	–
Atheresthes stomias (arrowtooth flounder)	Cho	–	–	–	X	–
Hippoglossoides elassodon (flathead sole)	Cho	–	–	–	X	–
Hippoglossus stenolepis (Pacific halibut)	Cho	–	–	–	X	–
Lepidopsetta bilineata (rock sole)	Cho	–	–	–	X	–
Limanda aspera (yellowfin sole)	Cho	–	–	–	X	–
Platichthys stellatus (starry flounder)	Cho	–	–	–	X	–

[1] Based on Barnes, 1968; Feder, unpublished data; Hart, 1973; Newell, 1970; Pearce and Thorson, 1967; and Rasmussen, 1973.

of five stations. During the three sampling periods, 78 stations were occupied in Alitak Bay covering a total of 1.76 km^2. Station coverage in Ugak Bay was 1.69 km^2. The average distance fished at each station was 1.85 km.

Species Composition and Diversity

Examination of the species composition of both bays revealed crustaceans and molluscs to be the major epifaunal invertebrates present. In general, epifaunal diversity was similar to that reported in Feder *et al.* (1976) for the northeast Gulf of Alaska. Major differences between the northeast Gulf of Alaska and the Kodiak bay fauna were the low numbers of species of annelids and echinoderms found in the bays. Coverage of the northeast Gulf of Alaska revealed 30 species of annelids and 36 species of echinoderms; however, these phyla in Alitak and Ugak Bays only comprised 4 and 10 species respectively. *Pagurus* was the most diverse genus present with six species collected.

Alitak Bay has a past history as a king crab mating ground (Kingsbury and James, 1971), and has been a major producer of commercial-sized crab in the Kodiak Island area since 1953 (Gray and Powell, 1966). Outer Alitak Bay was also the site of king crab distribution, abundance, and composition studies (Gray and Powell, 1966; Kingsbury *et al.*, 1974) conducted by the Alaska Department of Fish and Game during the summer months of 1962 and 1970.

King crab live most of their lives on the deeper part of the continental shelf, coming into the shallows once a year to mate. Except during the mating season (mid-March to June), the sexes remain apart in deep water (Iverson, 1966). However, changing physical conditions from year to year may alter the periodicity of migration and breeding. The documented-life history of the king crab reported elsewhere is reflected in the observations made for this crab in the two Kodiak bays discussed in this report. Examination of sex composition and stage of maturity of king crab from the past and present studies in outer Alitak Bay indicate a low ratio of adult females to adult males during the mating season (Tables V and VI). After mating has presumably occurred and sexes separate the ratio increases (Tables V and VI). The absence of adult males from the bays in the latter part of the present study reflects their departure following spawning. Segregation between sexes in juveniles is not apparent (Tables V and VI; Powell and Nickerson, 1965).

Catches of king crab and snow crab in Ugak Bay during the present study reflect a similar sex-maturity composition to that found during A.D.F. & G. crab indexing studies in this bay, i.e., a predominance of juvenile king crab of both sexes and adult male snow crab. Although Ugak Bay does not typically yield commercial-size king crab, the outer bay is often fished for snow crab (A.D.F. & G., Kodiak, Alaska snow crab catch statistics).

Food Habits

The main species examined for stomach contents (*Chionoecetes bairdi* and *Paralithodes camtschatica*) in the present study were the most abundant and widely dispersed organisms present. Important food items consumed by Alitak Bay and Ugak Bay snow crab differed from food items used by this crab in Cook Inlet. Feder *et al.* (1977) examined 715 snow crab in Cook Inlet, and found the main items in order of decreasing percent frequency of occurrence in stomachs were *Macoma* spp. (clams), *Pagurus* spp. (hermit crabs), *Balanus* spp. (barnacles), and sediment. The only similar stomach item in the present study was sediment. The role of sediment in crab feeding is not known. However, regardless of whether or not sediment is taken incidentally or selectively, Yasuda (1967) found benthic diatoms to be abundant in *Chionoecetes opilio elongatus* in the Bering Sea. Yasuda (1967) postulated that diatoms were taken indirectly with food and sediment. Inferences from the present study, as well as other snow crab food data (Feder *et al.*, 1977; Yasuda, 1967; Feder, unpublished data) concerning prey species, suggest that the foods used by snow crab are area specific.

Food items among king crab appear to be similar at different geographic locations. McLaughlin and Hebard (1961) found molluscs to be the most frequently consumed food group (69.0%) in Bering Sea king crab (with pelecypods more frequent than gastropods). Echinoderms ranked second, appearing in 42.2% of the crabs. Bering Sea king crab examined by Feder (Feder *et al.*, 1977) also showed pelecypod molluscs to be the dominant food, specifically *Clinocardium* sp. and *Nuculana* sp. *Nuculana*, a deposit feeder, is the most frequently occurring food used by king crab in Alitak and Ugak Bays. Gastropods were food items of secondary importance in the present study. Although echinoderms were absent from the 17 king crab examined, sand dollars (Echinoidea) are occasionally consumed by king crab occupying the outer continental shelf between Alitak and Ugak Bays (Guy C. Powell, A. D. F. and G., personal communication).

The two commercially important animals of great abundance near Kodiak Island (king crab and snow crab) feed on a wide variety of organisms. The king crab, with its large claws, is taking snails, clams, and fishes, while the snow crab with its long, thin, curved claws is better able to remove plant material, polychaetes, shrimps, and small clams from the bottom. Post larval stages of king crab were not preyed upon by any of the fishes examined. However, the soft-shelled stage of king crab is probably preyed on since soft-shell snow crab are known prey of *Octopus* and sea stars (John Hilsinger, unpublished data).

The use of deposit-feeding animals as food, as well as the consistent uptake of sediments, by king and snow crabs in the Kodiak area may be critical in the event of oil contamination of sediments on crab feeding grounds.

VIII. CONCLUSIONS

Fifty-three permanent stations have been established in two bays of Kodiak Island - Alitak (28 stations) and Ugak (25 stations) bays. These stations have been occupied in conjunction with Alaska Department of Fish and Game personnel.

There is now a satisfactory knowledge, on a station basis (for the months sampled), of the distribution and abundance of epifaunal invertebrates (89 species identified to date) of the two study bays. Ten phyla are represented in the collection. The important groups, in terms of species, in descending order of importance are the Arthropoda (Crustacea), Mollusca, Echinodermata and Annelida. The latter three groups only accounted for 1.3% of the biomass collected, while the Arthropoda accounted for 97.3% of the biomass.

Additional seasonal data are essential. It is only when such continuing information is available that a reasonable biological assessment of the effect of an oil spill on these bays can be made. An additional cruise carried out in March 1977 should furnish vitally needed mid-year data.

Differences in sex composition and stage of maturity of king and snow crab between and within the two bays were evident. Throughout the sampling period in Alitak Bay, king crab occurred mainly at the outer stations and consisted primarily of egg-bearing females and juveniles of both sexes. King crab were well dispersed throughout Ugak Bay during this period, and consisted mainly of juveniles. Snow crab in Alitak Bay were primarily juvenile while mainly adult males inhabited Ugak Bay. Life history data for these crabs for the summer months are now available.

Preliminary feeding data for the most common epifaunal species of the two bays is presented in this report. Of special importance is the food data compiled for the two commercially important crabs of the Kodiak area - snow and king crabs. These data in conjunction with similar data compiled for these two species in Cook Inlet and the Bering Sea (Feder *et al.*, 1977) should contribute to an understanding of the trophic role of the crabs in their respective ecosystems and the impact of oil on crab dominated systems such as those found in Alitak and Ugak Bays.

The importance of deposit-feeding clams in the diet of crabs is demonstrated for the two bays; this situation is also true for crabs observed elsewhere. A high probability exists that oil hydrocarbons will enter crabs *via* these deposit-feeding molluscs, suggesting that studies interrelating sediment, oil, deposit-feeding clams, and crabs should be initiated soon.

Sampling crabs and fishes using trawls and stomach analysis has made it possible to understand a major component (the epifauna) of two Kodiak bays. However, a full comprehension of the benthic system there will only be achieved when these studies are expanded to include an assessment of infauna as well. Data available to date suggest that adequate numbers of unique, abundant, and/or large species are available to permit nomination of likely monitoring candidates. Presumably a monitoring program would be based primarily on recruitment, growth, reproduction, and food habits of the chosen species.

IX. NEEDS FOR FURTHER STUDY

1. Although the trawling activities were satisfactory for determination of the distribution and abundance of epifauna, a substantial component of both bays - the infauna - was not sampled. Since infaunal species represent important food items, it is essential that dredging be accomplished at the bay stations in the near future.

2. The present study has produced a data base describing the abundance, density, and distribution of epibenthic invertebrates as well as notes on reproductive biology of commercially important crabs during June, July, and August 1976. Additional studies are needed during other seasons and years to describe seasonal and year-to-year variations in the distribution and relative abundance of the epifauna.

3. Seasonal predator-prey relationships should be examined in conjunction with simultaneous infaunal sampling.

4. It is essential that large samples of the dominant clam prey species be obtained to initiate recruitment, age, growth, and mortality studies. These data will then be comparable to similar data being collected for clams of Cook Inlet and the Bering Sea (Feder *et al.*, 1977). Any future modeling efforts concerned with carbon or energy flow in the Kodiak area will need this type of information.

5. No physical and chemical data are currently available. This information should be obtained in the future in conjunction with all biological sampling efforts.

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X. SUMMARY OF 4TH QUARTER OPERATIONS

Ship or Laboratory Activities

1. During 3-18 March 1977 the M/V *Big Valley* conducted benthic trawling in Ugak and Alitak Bay.

2. Scientific party:

   Stephen Jewett, Research Assistant, collected data on distribution and abundance, trophic relationships and reproductive activity.

3. Methods - field sampling:

   Benthic trawling was conducted with a 400-mesh Eastern otter trawl. Stations selected from a sampling grid typically were sampled for 20 minutes or 1.85 kilometers.

4. Sample localities:

   See text figures 1 and 2

5. Data collected:

   Twenty-three stations were occupied in Ugak Bay and 21 stations were occupied in Alitak Bay.

6. Distribution and abundance data, cluster analysis, predator-prey relationships and reproductive notes will be included in the Final Report. Data will be examined within and between Ugak and Alitak Bay.

XI. APPENDIX

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES AS WELL AS PERCENT COMPOSITION BY PHYLA, FAMILY AND SPECIES

APPENDIX TABLE I

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES IN ALITAK AND UGAK BAYS, KODIAK ISLAND, JUNE, JULY, AND AUGUST, 1976

OCCURENCES OF EACH SPECIES

SPECIES CODE	TAXANOMIC NAME	OCCURS	% OF ALL OCCUR	% OF ALL STATIONS	DIST KM
3200000000	PORIFERA	41.	3.116	26.974	70.27
3301000000	HYDROZOA	6.	0.456	3.947	10.17
3302000000	SCYPHOZOA	2.	0.152	1.316	3.70
3303480101	PTILOSARCUS GURNEYI	8.	0.608	5.263	12.94
3303540101	STOMPHIA COCCINEA	1.	0.076	0.658	1.85
3303550000	ACTINIIDAE	24.	1.824	15.789	38.36
4801000000	POLYCHAETA	4.	0.304	2.632	5.54
4801010000	POLYNOIDAE	3.	0.228	1.974	3.69
4801230400	NEREIS SP.	3.	0.228	1.974	3.69
4801700201	CRUCIGERA IRREGULARIS	3.	0.228	1.974	3.69
4803000000	HIRUDINEA	1.	0.076	0.658	1.85
4803010100	NOTOSTOMOBDELLA SP.	8.	0.608	5.263	12.94
4904030203	NUCULANA FOSSA	14.	1.064	9.211	20.32
4904030502	YOLDIA HYPERBOREA	4.	0.304	2.632	6.47
4904030507	YOLDIA THRACIAEFORMIS	1.	0.076	0.658	1.85
4904070101	MYTILUS EDULIS	2.	0.152	1.316	3.70
4904070402	MUSCULUS DISCORS	3.	0.228	1.974	3.69
4904070601	MODIOLUS MODIOLUS	1.	0.076	0.658	1.85
4904080102	CHLAMYS RUBIDA	5.	0.380	3.289	6.00
4904080401	PECTIN CAURINUS	4.	0.304	2.632	5.54
4904100101	PODODESMUS MACROCHISMA	1.	0.076	0.658	0.92
4904110106	ASTARTE ROLLANDI	1.	0.076	0.658	0.92
4904110108	ASTARTE ESQUIMALTI	1.	0.076	0.658	0.92
4904200101	CLINOCARDIUM CILIATUM	11.	0.836	7.237	17.56
4904200102	CLINOCARDIUM NUTTALLII	1.	0.076	0.658	1.85
4904200201	SERRIPES GROENLANDICUS	7.	0.532	4.605	11.09
4904210201	SAXIDOMUS GIGANTEA	1.	0.076	0.658	0.92
4904210701	PROTOTHACA STAMINEA	1.	0.076	0.658	1.85
4904240101	MACOMA CALCAREA	8.	0.608	5.263	14.80
4904240107	MACOMA MOESTA	3.	0.228	1.974	4.62
4904290201	HIATELLA ARCTICA	9.	0.684	5.921	14.79
4904310101	BANKIA SETACEA	2.	0.152	1.316	3.70
4905230201	CREPIDULA NUMMARIA	3.	0.228	1.974	3.69
4905270200	VELUTINA SP.	1.	0.076	0.658	0.92
4905290101	FUSITRITION OREGONENSIS	12.	0.912	7.895	19.41
4905310102	NUCELLA LAMELLOSA	2.	0.152	1.316	2.77
4905330801	NEPTUNEA LYRATA	7.	0.532	4.605	12.02
4905570000	DORIDIDAE	1.	0.076	0.658	1.85
4907050200	GONATUS SP.	2.	0.152	1.316	3.70
4907120200	OCTOPUS SP.	2.	0.152	1.316	3.70
5318020102	BALANUS BALANUS	10.	0.760	6.579	15.71
5318020108	BALANUS HESPERIUS	3.	0.228	1.974	3.69
5318020110	BALANUS ROSTRATUS	1.	0.076	0.658	0.92
5330000000	ISOPODA	1.	0.076	0.658	1.85
5331000000	AMPHIPODA	1.	0.076	0.658	0.92
5333040101	PANDALUS BOREALIS	113.	8.587	74.342	198.35
5333040102	PANDALUS GONIURUS	45.	3.419	29.605	78.60
5333040106	PANDALUS HYPSINOTUS	114.	8.663	75.000	197.85
5333040204	PANDALOPSIS DISPAR	24.	1.824	15.789	41.61
5333050402	EUALUS BIUNGUIS	53.	4.027	34.868	91.08
5333050406	EUALUS GAIMARDII BELCHERI	20.	1.520	13.158	37.00
5333050412	EUALUS MACILENTA	14.	1.064	9.211	25.90
5333060107	CRANGON DALLI	35.	2.660	23.026	57.78

APPENDIX TABLE I

CONTINUED

OCCURENCES OF EACH SPECIES

SPECIES CODE	TAXANOMIC NAME	OCCURS	% OF ALL OCCUR	% OF ALL STATIONS	DIST KM
5333060111	CRANGON COMMUNIS	44.	3.343	28.947	76.75
5333060201	SCLEROCRANGON BOREAS	2.	0.152	1.316	1.84
5333060301	ARGIS LAR	23.	1.748	15.132	42.55
5333060302	ARGIS DENTATA	65.	4.939	42.763	112.81
5333060305	ARGIS CRASSA	3.	0.228	1.974	2.76
5333110200	PAGURUS SP.	1.	0.076	0.658	0.92
5333110202	PAGURUS OCHOTENSIS	32.	2.432	21.053	50.83
5333110203	PAGURUS ALEUTICUS	43.	3.267	28.289	70.25
5333110205	PAGURUS CAPILLATUS	18.	1.368	11.842	28.65
5333110207	PAGURUS KENNERLYI	3.	0.228	1.974	3.69
5333110209	PAGURUS BERINGANUS	3.	0.228	1.974	4.62
5333110301	ELASSOCHIRUS TENUIMANUS	3.	0.228	1.974	4.16
5333110401	LABIDOCHIPUS SPLENDESCENS	3.	0.228	1.974	3.69
5333120701	PARALITHODES CAMTSCHATICA	122.	9.271	80.263	202.89
5333170101	OREGONIA GRACILIS	19.	1.444	12.500	32.36
5333170201	HYAS LYRATUS	8.	0.608	5.263	12.01
5333170302	CHIONOECETES BAIRDI	150.	11.398	98.684	253.76
5333170503	EPIALTUS GRACILIS	10.	0.760	6.579	15.71
5333180100	CANCER SP.	1.	0.076	0.658	1.85
5333180104	CANCER MAGISTER	9.	0.684	5.921	15.72
5333180106	CANCER OREGONENSIS	10.	0.760	6.579	14.78
5333190101	TELMESSUS CHEIRAGONUS	4.	0.304	2.632	6.47
5333210303	PINNIXA OCCIDENTALIS	1.	0.076	0.658	1.85
6001020101	ECHIURUS ECHIURUS	1.	0.076	0.658	1.85
6600000000	ECTOPROCTA	2.	0.152	1.316	2.77
6702030101	TEREBRATULINA UNGUICULA	1.	0.076	0.658	0.92
6702050401	TEREBRATALIA TRANSVERSA	2.	0.152	1.316	1.84
6801080100	HENRICIA SP.	2.	0.152	1.316	2.77
6801110304	SOLASTER STIMPSONI	2.	0.152	1.316	3.70
6801120301	EVASTERIAS ECHINOSOMA	18.	1.368	11.842	30.51
6801120302	EVASTERIAS TROSCHELII	10.	0.760	6.579	15.71
6801121101	STYLASTERIAS FORRERI	2.	0.152	1.316	2.77
6801121201	PYCNOPODIA HELIANTHOIDES	3.	0.228	1.974	4.62
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	19.	1.444	12.500	32.36
6803040201	GORGONOCEPHALUS CARYI	1.	0.076	0.658	0.92
6804050100	MOLPADIA SP.	1.	0.076	0.658	1.85
6804100100	CUCUMARIA SP.	4.	0.304	2.632	7.40
7200000000	CHORDATA:ASCIDIACEA	22.	1.672	14.474	36.05
7203020501	PELONAIA CORRUGATA	1.	0.076	0.658	1.85

TOTAL DISTANCE FISHED = 256.53 KM

APPENDIX TABLE II

NUMBERS, WEIGHT, AND DENSITY OF EPIFAUNAL INVERTEBRATE PHYLA IN ALITAK AND UGAK BAYS, KODIAK ISLAND, JUNE, JULY, AND AUGUST, 1976

PERCENTAGE COMPOSITION BY WEIGHT - ALL PHYLA

TAXON CODE		COUNT	% COUNT	WEIGHT	% WEIGHT	GM/M SQ ALL STA	% BIOMASS
32	PORIFERA	1650.34	0.5109	102028.55	0.7874	0.18078	0.79
33	CNIDARIA	240.97	0.0746	45673.81	0.3525	0.08093	0.35
48	ANNELIDA	1014.83	0.3142	1082.45	0.0084	0.00192	0.01
49	MOLLUSCA	570.40	0.1766	19304.36	0.1490	0.03421	0.15
53	ARTHROPODA:CRUSTACEA	319120.64	98.7922	12619440.75	97.3945	22.36038	97.39
60	ECHIUROIDEA	1.67	0.0005	25.00	0.0002	0.00004	0.00
66	ECTOPROCTA	3.00	0.0009	227.00	0.0018	0.00040	0.00
67	BRACHIOPODA	5.00	0.0015	33.00	0.0003	0.00006	0.00
68	ECHINODERMATA	297.10	0.0920	157709.22	1.2172	0.27944	1.22
72	CHORDATA:ASCIDIACEA	118.12	0.0366	11507.90	0.0888	0.02039	0.09

APPENDIX TABLE III

NUMBERS, WEIGHT, AND DENSITY OF EPIFAUNAL INVERTEBRATE FAMILIES IN ALITAK AND UGAK BAYS, KODIAK ISLAND, JUNE, JULY, AND AUGUST, 1976

COMPOSITION OF ALL PHYLA BY FAMILY

TAXON CODE		COUNT	% COUNT	WEIGHT	% WEIGHT	GM/M SQ ALL STA	% BIOMASS
370000	PORIFERA	1650.34	0.5109	102028.55	0.7874	0.18078	0.79
330100	HYDROZOA	8.67	0.0027	2154.33	0.0166	0.00382	0.02
330200	SCYPHOZOA	2.00	0.0006	145.00	0.0011	0.00026	0.00
330348	PENNATULACEA PENNATULIDAE	30.33	0.0094	597.00	0.0046	0.00106	0.00
330354	ACTINOSTOLIDAE	4.00	0.0012	1360.00	0.0105	0.00241	0.01
330355	ACTINIIDAE	195.97	0.0607	41417.48	0.3197	0.07339	0.32
490100	POLYCHAETA	813.57	0.2519	821.57	0.0063	0.00146	0.01
490101	POLYNOIDAE	5.33	0.0017	6.67	0.0001	0.00001	0.00
490123	NEREIDAE	12.50	0.0039	24.50	0.0002	0.00004	0.00
490170	SERPULIDAE	172.43	0.0534	206.71	0.0016	0.00037	0.00
490300	HIRUDINEA	1.67	0.0005	1.67	0.0000	0.00000	0.00
490301	ACANTHOCHITONIDAE	9.33	0.0029	21.33	0.0002	0.00004	0.00
490403	NUCULANIDAE	83.33	0.0258	122.83	0.0009	0.00022	0.00
490407	MYTILIDAE	53.00	0.0164	759.00	0.0059	0.00134	0.01
490408	PECTINIDAE	16.61	0.0051	2978.11	0.0230	0.00528	0.02
490410	ANOMIIDAE	4.00	0.0012	80.00	0.0006	0.00014	0.00
490411	ASTARTIDAE	4.00	0.0012	8.00	0.0001	0.00001	0.00
490420	CARDIIDAE	49.00	0.0152	1550.00	0.0120	0.00275	0.01
490421	VENERIDAE	3.00	0.0009	128.00	0.0010	0.00023	0.00
490424	TELLINIDAE	23.10	0.0071	880.62	0.0068	0.00156	0.01
490429	HIATELLIDAE	96.61	0.0299	56.61	0.0004	0.00010	0.00
490431	TEREDINIDAE	104.00	0.0322	14.00	0.0001	0.00002	0.00
490523	CALYPTRAEIDAE	5.43	0.0017	4.43	0.0000	0.00001	0.00
490527	VELUTINIDAE	1.00	0.0003	1.00	0.0000	0.00000	0.00
490529	CYMATIIDAE	106.33	0.0329	11413.67	0.0881	0.02022	0.09
490531	THAIDIDAE	4.22	0.0013	43.33	0.0003	0.00008	0.00
490533	NEPTUNEIDAE	11.00	0.0034	610.00	0.0047	0.00108	0.00
490557	DORIDIDAE	1.43	0.0004	1.43	0.0000	0.00000	0.00

APPENDIX TABLE III

CONTINUED

TAXON CODE		COUNT	% COUNT	WEIGHT	% WEIGHT	GM/M SQ ALL STA	% BIOMASS
490705	GONATIDAE	2.00	0.0006	70.00	0.0005	0.00012	0.00
490712	OCTOPODIDAE	2.33	0.0007	583.33	0.0045	0.00103	0.00
531802	BALANIDAE	290.33	0.0899	3887.67	0.0300	0.00689	0.03
533000	ISOPODA	1.00	0.0003	1.00	0.0000	0.00000	0.00
533100	AMPHIPODA	2.00	0.0006	1.00	0.0000	0.00000	0.00
533304	PANDALIDAE	281899.36	87.2694	2372664.38	18.3118	4.20412	18.31
533305	HIPPOLYTIDAE	12827.39	3.9711	89775.28	0.6929	0.15907	0.69
533306	CRANGONIDAE	7733.40	2.3941	53390.66	0.4121	0.09460	0.41
533311	PAGURIDAE	486.44	0.1506	12108.47	0.0935	0.02145	0.09
533312	LITHODIDAE	4420.62	1.3685	3668800.53	28.3151	6.50075	28.32
533317	MAJIDAE	11397.49	3.5284	6403419.25	49.4204	11.34622	49.42
533318	CANCRIDAE	53.18	0.0165	13803.52	0.1065	0.02446	0.11
533319	ATELECYCLIDAE	6.93	0.0021	1586.43	0.0122	0.00281	0.01
533321	PINNOTHERIDAE	2.50	0.0008	2.50	0.0000	0.00000	0.00
600102	ECHIURIDAE	1.67	0.0005	25.00	0.0002	0.00004	0.00
660000	ECTOPROCTA	3.00	0.0009	227.00	0.0018	0.00040	0.00
670203	CANCELLOTHYRIDIDAE	1.00	0.0003	1.00	0.0000	0.00000	0.00
670205	DALLINIDAE	4.00	0.0012	32.00	0.0002	0.00006	0.00
680108	ECHINASTERIDAE	3.00	0.0009	180.00	0.0014	0.00032	0.00
680111	SOLASTERIDAE	4.17	0.0013	275.00	0.0021	0.00049	0.00
680112	ASTERIDAE	232.68	0.0720	150020.95	1.1578	0.26582	1.16
680204	STRONGYLOCENTROTIDAE	48.41	0.0150	777.27	0.0060	0.00138	0.01
680304	GORGONOCEPHALIDAE	1.33	0.0004	80.00	0.0006	0.00014	0.00
680405	MOLPADIIDAE	1.00	0.0003	20.00	0.0002	0.00004	0.00
680410	CUCUMARIIDAE	6.50	0.0020	6356.00	0.0491	0.01126	0.05
720000	CHORDATA:ASCIDIACEA	117.12	0.0363	11499.90	0.0888	0.02038	0.09
720302	STYELIDAE	1.00	0.0003	8.00	0.0001	0.00001	0.00

APPENDIX TABLE IV

NUMBERS, WEIGHT, AND DENSITY OF EPIFAUNAL INVERTEBRATE SPECIES IN ALITAK AND UGAK BAYS,

KODIAK ISLAND, JUNE, JULY, AND AUGUST, 1976

Composition of all phyla by species

TAXON CODE	TAXONOMIC NAME	COUNT	% COUNT	WEIGHT	% WEIGHT	GM M SQ OCC STA	GM M SQ ALL STA	BIOM %	PHYL C %	PHYL W
3200000000	PORIFERA	1650.3	0.5	102028.55	0.79	0.6600	0.18078	0.79	100.00	100.00
3301000000	HYDROZOA	8.7	0.0	2154.33	0.02	0.0963	0.00382	0.02	3.60	4.72
3302000000	SCYPHOZOA	2.0	0.0	145.00	0.00	0.0178	0.00026	0.00	0.83	0.32
3303480101	PTILOSARCUS GURNEYI	30.3	0.0	597.00	0.00	0.0210	0.00106	0.00	12.59	1.31
3303540101	STOMPHIA COCCINEA	4.0	0.0	1360.00	0.01	0.3342	0.00241	0.01	1.66	2.98
3303550000	ACTINIIDAE	196.0	0.1	41417.48	0.32	0.4908	0.07339	0.32	81.33	90.68
4801000000	POLYCHAETA	813.6	0.3	821.57	0.01	0.0674	0.00146	0.01	80.17	75.90
4801010000	POLYNOIDAE	5.3	0.0	6.67	0.00	0.0008	0.00001	0.00	0.53	0.62
4801230400	NEREIS SP.	12.5	0.0	24.50	0.00	0.0030	0.00004	0.00	1.23	2.26
4801700201	CRUCIGERA IRREGULARIS	172.4	0.1	206.71	0.00	0.0255	0.00037	0.00	16.99	19.10
4803000000	HIRUDINEA	1.7	0.0	1.67	0.00	0.0004	0.00000	0.00	0.16	0.15
4803010100	NOTOSTOMOBDELLA SP.	9.3	0.0	21.33	0.00	0.0007	0.00004	0.00	0.92	1.97
4904030203	NUCULANA FOSSA	71.7	0.0	44.17	0.00	0.0010	0.00008	0.00	12.56	0.23
4904030502	YOLDIA HYPERBOREA	10.7	0.0	28.67	0.00	0.0020	0.00005	0.00	1.87	0.15
4904030507	YOLDIA THRACIAEFORMIS	1.0	0.0	50.00	0.00	0.0123	0.00009	0.00	0.18	0.26
4904070101	MYTILUS EDULIS	19.0	0.0	80.00	0.00	0.0098	0.00014	0.00	3.33	0.41
4904070402	MUSCULUS DISCORS	30.0	0.0	668.00	0.01	0.0823	0.00118	0.01	5.26	3.46
4904070601	MODIOLUS MODIOLUS	4.0	0.0	11.00	0.00	0.0027	0.00002	0.00	0.70	0.06
4904080102	CHLAMYS RUBIDA	8.8	0.0	194.44	0.00	0.0147	0.00034	0.00	1.54	1.01
4904080401	PECTIN CAURINUS	7.8	0.0	2783.67	0.02	0.2284	0.00493	0.02	1.37	14.42
4904100101	PODODESMUS MACROCHISMA	4.0	0.0	80.00	0.00	0.0395	0.00014	0.00	0.70	0.41
4904110106	ASTARTE ROLLANDI	2.0	0.0	4.00	0.00	0.0020	0.00001	0.00	0.35	0.02
4904110108	ASTARTE ESQUIMALTI	2.0	0.0	4.00	0.00	0.0020	0.00001	0.00	0.35	0.02
4904200101	CLINOCARDIUM CILIATUM	34.3	0.0	351.67	0.00	0.0091	0.00062	0.00	6.02	1.82
4904200102	CLINOCARDIUM NUTTALLII	1.7	0.0	366.67	0.00	0.0901	0.00065	0.00	0.29	1.90
4904200201	SERRIPES GROENLANDICUS	13.0	0.0	831.67	0.01	0.0341	0.00147	0.01	2.28	4.31

APPENDIX TABLE IV

CONTINUED

ALL PHYLA BY SPECIES. CONTINUED.

TAXON CODE	TAXONOMIC NAME	COUNT	% COUNT	WEIGHT	% WEIGHT	GM M SQ OCC STA	GM M SQ ALL STA	BIOM %	PHYL C %	PHYL W
4904210201	SAXIDOMUS GIGANTEA	2.0	0.0	118.00	0.00	0.0583	0.00021	0.00	0.35	0.61
4904210701	PROTOTHACA STAMINEA	1.0	0.0	10.00	0.00	0.0025	0.00002	0.00	0.18	0.05
4904240101	MACOMA CALCAREA	17.1	0.0	698.95	0.01	0.0215	0.00124	0.01	3.00	3.62
4904240107	MACOMA MOESTA	6.0	0.0	181.67	0.00	0.0179	0.00032	0.00	1.05	0.94
4904290201	HIATELLA ARCTICA	96.6	0.0	56.61	0.00	0.0017	0.00010	0.00	16.94	0.29
4904310101	BANKIA SETACEA	104.0	0.0	14.00	0.00	0.0017	0.00002	0.00	18.23	0.07
4905230201	CREPIDULA NUMMARIA	5.4	0.0	4.43	0.00	0.0005	0.00001	0.00	0.95	0.02
4905270200	VELUTINA SP.	1.0	0.0	1.00	0.00	0.0005	0.00000	0.00	0.18	0.01
4905290101	FUSITRITION OREGONENSIS	106.3	0.0	11413.67	0.09	0.2673	0.02022	0.09	18.64	59.12
4905310102	NUCELLA LAMELLOSA	4.2	0.0	43.33	0.00	0.0071	0.00008	0.00	0.74	0.22
4905330801	NEPTUNEA LYRATA	11.0	0.0	610.00	0.00	0.0231	0.00108	0.00	1.93	3.16
4905570000	DORIDIDAE	1.4	0.0	1.43	0.00	0.0004	0.00000	0.00	0.25	0.01
4907050200	GONATUS SP.	2.0	0.0	70.00	0.00	0.0086	0.00012	0.00	0.35	0.36
4907120200	OCTOPUS SP.	2.3	0.0	583.33	0.00	0.0717	0.00103	0.00	0.41	3.02
5318020102	BALANUS BALANUS	213.3	0.1	2176.67	0.02	0.0630	0.00386	0.02	0.07	0.02
5318020108	BALANUS HESPERIUS	24.0	0.0	111.00	0.00	0.0137	0.00020	0.00	0.01	0.00
5318020110	BALANUS ROSTRATUS	53.0	0.0	1600.00	0.01	0.7905	0.00284	0.01	0.02	0.01
5330000000	ISOPODA	1.0	0.0	1.00	0.00	0.0002	0.00000	0.00	0.00	0.00
5331000000	AMPHIPODA	2.0	0.0	1.00	0.00	0.0005	0.00000	0.00	0.00	0.00
5333040101	PANDALUS BOREALIS	79312.4	55.5	1528021.17	11.79	3.5017	2.70750	11.79	56.19	12.11
5333040102	PANDALUS GONIURUS	38671.0	12.0	311903.00	2.41	1.8037	0.55266	2.41	12.12	2.47
5333040106	PANDALUS HYPSINOTUS	61470.0	19.0	493387.20	3.81	1.1335	0.87423	3.81	19.26	3.91
5333040204	PANDALOPSIS DISPAR	2446.0	0.8	39353.00	0.30	0.4299	0.06973	0.30	0.77	0.31
5333050402	EUALUS BIUNGUIS	1979.4	0.6	13861.28	0.11	0.0692	0.02456	0.11	0.62	0.11
5333050406	EUALUS GAIMARDII BELCHERI	10292.0	3.2	71990.00	0.56	0.8844	0.12756	0.56	3.23	0.57
5333050412	EUALUS MACILENTA	556.0	0.2	3924.00	0.03	0.0689	0.00695	0.03	0.17	0.03
5333060107	CRANGON DALLI	869.6	0.3	5655.61	0.04	0.0445	0.01002	0.04	0.27	0.04

APPENDIX TABLE IV

CONTINUED

ALL PHYLA BY SPECIES. CONTINUED.

TAXON CODE	TAXONOMIC NAME	COUNT	% COUNT	WEIGHT	% WEIGHT	GM M SQ OCC STA	GM M SQ ALL STA	BIOM %	PHYL C %	PHYL W
5333060111	CRANGON COMMUNIS	1455.7	0.5	10179.47	0.08	0.0603	0.01804	0.08	0.46	0.08
5333060201	SCLEROCRANGON BOREAS	87.0	0.0	289.00	0.00	0.0714	0.00051	0.00	0.03	0.00
5333060301	ARGIS LAR	1638.0	0.5	11410.00	0.09	0.1219	0.02022	0.09	0.51	0.09
5333060302	ARGIS DENTATA	3676.1	1.1	25833.57	0.20	0.1041	0.04577	0.20	1.15	0.20
5333060305	ARGIS CRASSA	7.0	0.0	23.00	0.00	0.0038	0.00004	0.00	0.00	0.00
5333110200	PAGURUS SP.	2.0	0.0	2.00	0.00	0.0010	0.00000	0.00	0.00	0.00
5333110202	PAGURUS OCHOTENSIS	254.7	0.1	6205.82	0.05	0.0555	0.01100	0.05	0.08	0.05
5333110203	PAGURUS ALEUTICUS	154.4	0.0	5044.39	0.04	0.0326	0.00894	0.04	0.05	0.04
5333110205	PAGURUS CAPILLATUS	41.2	0.0	544.68	0.00	0.0086	0.00097	0.00	0.01	0.00
5333110207	PAGURUS KENNERLYI	21.4	0.0	218.57	0.00	0.0269	0.00039	0.00	0.01	0.00
5333110209	PAGURUS BERINGANUS	5.7	0.0	50.00	0.00	0.0049	0.00009	0.00	0.00	0.00
5333110301	ELASSOCHIRUS TENUIMANUS	4.0	0.0	20.00	0.00	0.0022	0.00004	0.00	0.00	0.00
5333110401	LABIDOCHIRUS SPLENDESCENS	3.0	0.0	23.00	0.00	0.0028	0.00004	0.00	0.00	0.00
5333120701	PARALITHODES CAMTSCHATICA	4420.6	1.4	3668800.53	28.32	8.2194	6.50075	28.32	1.39	29.07
5333170101	OREGONIA GRACILIS	47.7	0.0	613.57	0.00	0.0086	0.00109	0.00	0.01	0.00
5333170201	HYAS LYRATUS	45.9	0.0	2882.29	0.02	0.1091	0.00511	0.02	0.01	0.02
5333170302	CHIONOECETES BAIRDI	11287.4	3.5	6399840.69	49.39	11.4637	11.33987	49.39	3.54	50.71
5333170503	EPIALTUS GRACILIS	16.4	0.0	82.71	0.00	0.0024	0.00015	0.00	0.01	0.00
5333180100	CANCER SP.	2.5	0.0	2.50	0.00	0.0006	0.00000	0.00	0.00	0.00
5333180104	CANCER MAGISTER	15.8	0.0	13667.02	0.11	0.3952	0.02422	0.11	0.00	0.11
5333180106	CANCER OREGONENSIS	34.8	0.0	134.00	0.00	0.0041	0.00024	0.00	0.01	0.00
5333190101	TELMESSUS CHEIRAGONUS	6.9	0.0	1586.43	0.01	0.1115	0.00281	0.01	0.00	0.01
5333210303	PINNIXA OCCIDENTALIS	2.5	0.0	2.50	0.00	0.0006	0.00000	0.00	0.00	0.00
6001020101	ECHIURUS ECHIURUS	1.7	0.0	25.00	0.00	0.0061	0.00004	0.00	100.00	100.00
6600000000	ECTOPROCTA	3.0	0.0	227.00	0.00	0.0372	0.00040	0.00	100.00	100.00
6702030101	TEREBRATULINA UNGUICULA	1.0	0.0	1.00	0.00	0.0005	0.00000	0.00	20.00	3.03

APPENDIX TABLE IV

CONTINUED

ALL PHYLA BY SPECIES, CONTINUED.

TAXON CODE	TAXONOMIC NAME	COUNT	% COUNT	WEIGHT	% WEIGHT	GM M SQ OCC STA	GM M SQ ALL STA	BIOM %	PHYL C %	PHYL W
6702050401	TEREBRATALIA TRANSVERSA	4.0	0.0	32.00	0.00	0.0079	0.00006	0.00	80.00	96.97
6801080100	HENRICIA SP.	3.0	0.0	180.00	0.00	0.0295	0.00032	0.00	1.01	0.11
6801110304	SOLASTER STIMPSONI	4.2	0.0	275.00	0.00	0.0338	0.00049	0.00	1.40	0.17
6801120301	EVASTERIAS ECHINOSOMA	91.4	0.0	17571.27	0.14	0.2618	0.03113	0.14	30.77	11.14
6801120302	EVASTERIAS TROSCHELII	61.7	0.0	18598.57	0.14	0.5381	0.03295	0.14	20.77	11.79
6801121101	STYLASTERIAS FORRERI	3.0	0.0	1270.00	0.01	0.2084	0.00225	0.01	1.01	0.81
6801121201	PYCNOPODIA HELIANTHOIDES	76.6	0.0	112581.11	0.87	11.0765	0.19948	0.87	25.77	71.39
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	48.4	0.0	777.27	0.01	0.0109	0.00138	0.01	16.30	0.49
6803040201	GORGONOCEPHALUS CARYI	1.3	0.0	80.00	0.00	0.0395	0.00014	0.00	0.45	0.05
6804050100	MOLPADIA SP.	1.0	0.0	20.00	0.00	0.0049	0.00004	0.00	0.34	0.01
6804100100	CUCUMARIA SP.	6.5	0.0	6356.00	0.05	0.3904	0.01126	0.05	2.19	4.03
7200000000	CHORDATA:ASCIDIACEA	117.1	0.0	11499.90	0.09	0.1450	0.02038	0.09	99.15	99.93
7203020501	PELONAIA CORRUGATA	1.0	0.0	8.00	0.00	0.0020	0.00001	0.00	0.85	0.07

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 29

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
Big Valley 001	6/17/76	6/23/76	5/30/77			
Big Valley 002	7/18/76	7/28/76	5/30/77			
Big Valley 003	8/19/76	8/29/76	5/30/77			
Big Valley 004	3/3/77	3/18/77	6/30/77			

NOTE: [1] Data Management Plan submitted August 16, 1976, we await formal approval by Contracting Officer.

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