THE CHUKCHI SEA CONTINENTAL SHELF: BENTHOS-ENVIRONMENTAL INTERACTIONS

by

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I. INTRODUCTION

A. General Nature and Scope of Study

The Chukchi Sea is a shallow sea which connects the Arctic Ocean and the Bering Sea. The continental shelf of the Chukchi Sea is relatively wide, and is ice covered 7 to 8 months of the year. Since the harvest of commercially-important species north of Bering Strait has historically been low, little emphasis has been placed on acquisition of environmental data typically used to manage fisheries. However, with the emergence of possible sites for offshore oil and gas development in this region, interest in marine resources has emerged with special emphasis on the occurrence of marine mammals and on their reliance on benthic food resources. Furthermore, as the importance of the transport of nutrients and particulate organic carbon from the Bering Sea to this region becomes more evident (McRoy, 1986; Walsh and McRoy, 1986; Grebmeier *et al.*, 1988), questions have arisen concerning the importance of this advected nutrient source to the eastern Chukchi Sea benthic biota. In particular, the biology, distribution, abundance, standing stock, and carbon mineralization (carbon demand) of the benthic organisms used seasonally as food by marine mammals in the northeast Chukchi Sea (the region considered in the investigation here) must be understood when assessing potential impacts of the oil and gas industry there.

The Chukchi Sea reflects a mixture of processes and fluxes from many sources. The most important flux is the outflow of water northward through the Bering Strait (Coachman *et al.*, 1975). In summer, this water is relatively warm, causing the Chukchi Sea to be ice free earlier in the year and remain ice free longer in the autumn than bodies of water further north. This water also brings nutrients and Bering Sea organisms with it, producing important ecological effects in the Chukchi Sea (Grebmeier et *al.*, 1988). Aagaard (1964) and Coachman *et al.* (1975) identified a number of water masses in the Chukchi Sea, including Bering Sea water, Alaska Coastal water, Chukchi resident water, and indications of Siberian Coastal water and Arctic Ocean water. The movement of these water masses is closely related to the sea-floor bottom topography with the northward flow through Bering Strait bifurcating northwest of Cape Lisburne, where part of the flow is northwestward and part northeastward along the Alaska coast (Figs. 1 and 2). The primary interest of our study was in the region of the northeastward branch of the flow over the shelf and along the Alaska coast. The flow along the coast may be characterized by high velocity currents (often more than 50 cm/s) and great variability in both speed and direction (Coachman and Aagaard, 1981; Aagaard, 1984).

The sources of energy supporting the marine biological system in the southern Chukchi Sea are suggested by the high primary productivity of water in the western Bering Strait (Sambrotto *et al.*, 1984). Nutrient-rich water from the Gulf of Anadyr moves northward across the northeastern Bering Sea shelf supporting high concentrations of phytoplankton in the water column, as well as in water moving through the Strait. This production supports a large zooplankton crop and a high benthic biomass north of the Strait (Stoker, 1978; Grebmeier, 1987; Grebmeier *et al.*, 1988). It is suggested by our study that the northward movement of the productive waters of the southern Chukchi, and its contained particulate organic carbon, provides a food resource to the benthos of the northern Chukchi Sea as well. The increased plankton volumes from inshore to offshore and from south to north from Bering Strait to Icy Cape (English, 1966) seem to support the suggestion that zooplankters are being advected northward by water currents

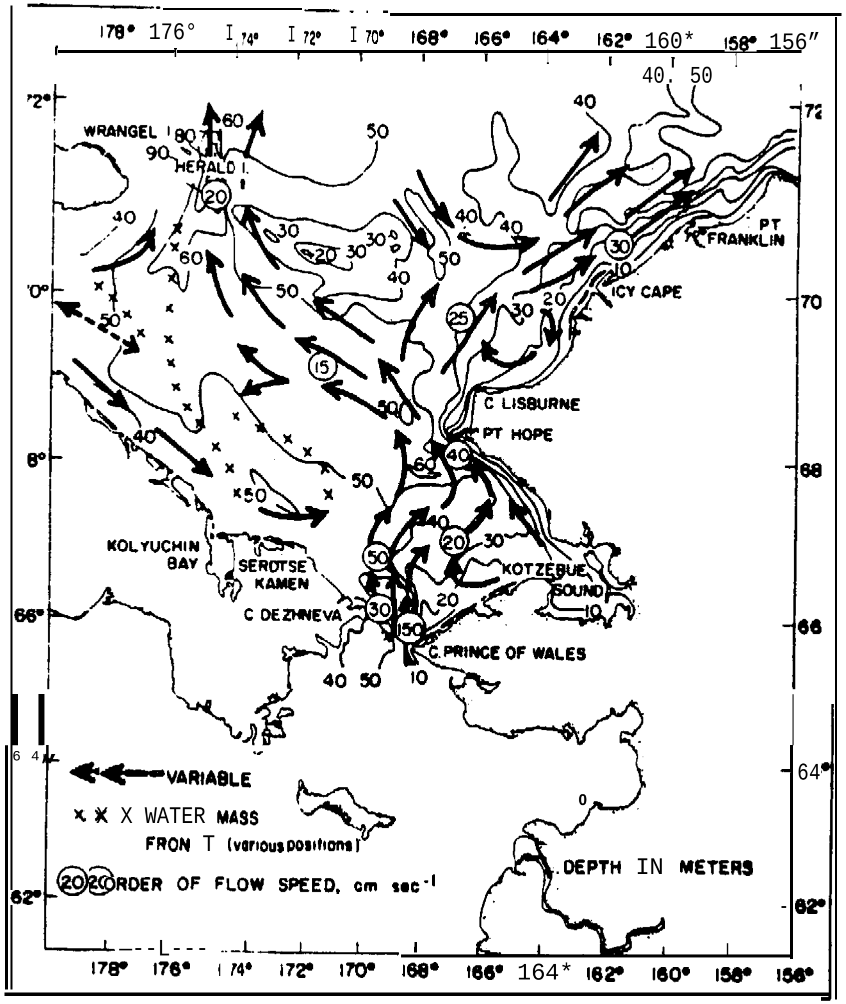

Figure 1. Schematic of upper layer flow in the Chukchi Sea. (Dotted arrows indicate variable currents. Various positions of water mass fronts are indicated and circled numbers are estimated flow speeds in cm/s.) (From Coachman *et al.*, 1975.)

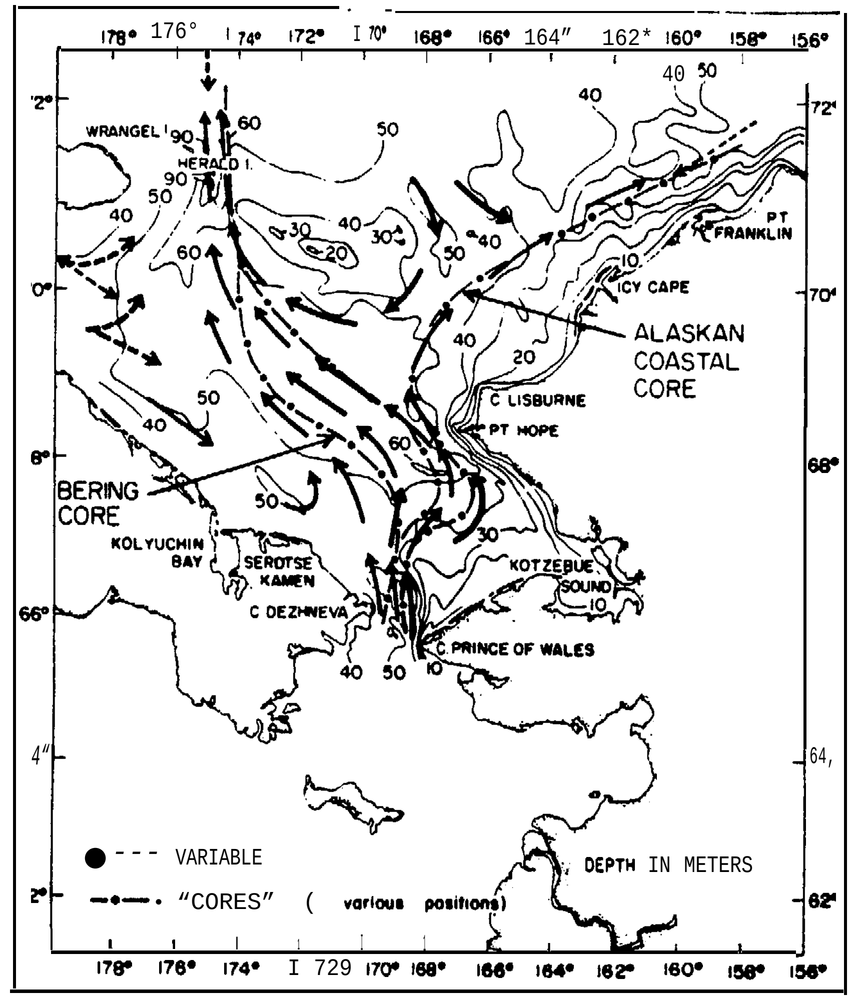

Figure 2. Schematic of lower layer flow in the Chukchi Sea. (Dotted arrows indicate variable currents. Various positions of "cores" of Bering Sea water masses are indicated.) (From Coachman et al., 1975.)

and are supplementing resident stocks in the Chukchi Sea. In the northern Chukchi Sea and regions of the Beaufort Sea that do not have perennial ice cover, the annual primary production ranges from 25-150 gC/m^2 with production lowest north of Point Barrow (Parrish, 1987). Presumably much of the initial pulse of water-column primary productivity in these northern waters remains ungrazed, similar to the situation described for the shallow shelf of the southeastern Bering Sea (Cooney and Coyle, 1982; Walsh and McRoy, 1986). The flux to the bottom of these ungrazed phytoplankters, as well as dead and dying zooplankters advected from more southerly waters, might be expected to enrich the benthic environment resulting in enhanced benthic standing stocks.

As stated earlier, high standing stocks of macrofauna are reported on the sea bottom north of Bering Strait. Grebmeier (1987) demonstrated that benthic biomass was significantly higher to the west of a hydrographic front between the Bering/Anadyr and the Alaska Coastal water. Although this frontal system has not been identified within the northern Chukchi Sea, the northward flow of the mixed Anadyr/Bering water after it passes through the Bering *Strait* has been traced as it moves northward toward Point Barrow. Data collected in our study suggest that this water approaches the Alaska coast just north of Icy Cape at approximately 70°30′ N latitude. The highest biomass values in our study were recorded for the region north and northwest of the 32.4 $^{o}/oo$ isohaline which occurs just north of this latitude. These high benthic biomass values were associated with large numbers of surface deposit and suspension-feeding organisms. These observations suggest that the high particulate organic carbon (POC) values in the water column identified in the southeastern Chukchi Sea by Grebmeier (1987) extend into the northern Chukchi and supply a rich and persistent food supply there.

The high standing stocks of benthic species in these waters presumably also explains, at, least in part, the success of summer-feeding populations of walrus and gray whales along the Alaska coast north of 70°30′ latitude (Fay, 1982; Moore and Clarke, 1986).

Sediment characteristics and sedimentary processes exert a powerful influence on the distribution and abundance of benthic organisms. One of the primary sediment factors affecting distribution of benthic organisms is the grain size of bed sediments, because this factor invariably controls benthic habitat attributes (e.g., sediment porosity, permeability, bearing strength, oxidation-reduction potential boundary, etc.). There are, of course, other important sedimentological factors that control distribution of benthic species, as for example, flux of POC to the bottom, sediment accumulation rates, sediment water content, and degree of water turbidity (McCave, 1976). In ice-stressed arctic areas such as the Chukchi Sea, the hazards posed by ice-gouging of bottom sediments can be an additional influencing factor (Phillips *et al.*, 1985). All of the above factors are directly or indirectly correlatable with the hydrodynamic conditions leading to the determination of flux of POC and sediment supply, erosion and deposition, all of which can vary significantly between regions and within any one region.

The benthic system of the northern Chukchi Sea shelf has some similarities to that of the Beaufort Sea (Carey *et al.*, 1974), but there are also some important differences between the two bodies of water. The Beaufort Sea is ice covered for longer periods of time than the Chukchi, primary production is reduced in the Beaufort, and polynyas occur along the Chukchi but not that of the Beaufort shelf.

In the northern Chukchi Sea, prior to the present study, little effort had been directed to understanding benthic organism-sediment interactions, although some preliminary data based on a local study were available (Phillips *et al.*, 1985). Therefore, in order to better *comprehend* the benthic environment t, the present investigation examined the areal distribution and dynamics of lithological and benthic facies, and the relationship of benthos to water-mass characteristics! sediment accumulation rates and fluxes of POC to the bottom sediments of the northeastern Chukchi Sea.

B. Goals of the Study

To determine the benthic community structure of the northeastern Chukchi Sea benthic ecosystem and relate benthic biomass stock and production to: (a) ocean circulation, sediment, and sea-ice distributions; and (b) feeding requirements of major vertebrate consumers.

C. Specific Objectives

1. Determine the distribution, abundance, biomass and community structure of the infaunal benthos and estimate infaunal production.
2. Relate benthic community structure, biomass, and production to environmental factors such as water depth, temperature, current velocity, salinity, sediment properties and dynamics, and organic carbon flux.
3. Identify, wherever possible, those bottom areas of the northern Chukchi Sea that are important as sources of food for gray whales and Pacific walrus.

II. CURRENT STATE OF KNOWLEDGE

A. Physical Oceanography

The circulation in the northeast Chukchi Sea near the Alaskan coast is dominated by time variable inflow through Bering Strait and wind forcing (Aagaard, 1964; Coachman *et al.*, 1975; Coachman and Aagaard, 1981). In addition, seasonal ice production and melting greatly modifies water mass properties (Aagaard, 1964; Coachman *et al.*, 1975). The prevailing interpretation of the flow between Cape Lisburne and Point Barrow is that the flow is generally northeastward, with the center of the transport roughly 50 km offshore (Figure 1; Aagaard, 1964; Paquette and Bourke, 1974; Coachman *et al.*, 1975). Near the coast, the flow may also be northeastward, although there are indications of recirculation systems "behind" the major capes, which interrupt this flow (Wiseman *et al.*, 1974). Farther offshore, the northeastward flow produces "bays" in the marginal ice zone, because of the melting action of the warm water in the flow (Paquette and Bourke, 1981). In the extreme northern part of the Chukchi, the circulation is influenced by the Beaufort Sea (Arctic Ocean).

Wind stress forcing from the east and northeast can also produce reversals of this prevailing northeastward flow toward the southwest. Time series current measurements in this region have supported this interpretation, although they have revealed large reversals in the alongshore flow in response to the wind (Mountain *et al.*, 1976; Wilson *et al.,* 1982; Aagaard, 1984, Hachmeister and Vinelli, 1985). These reversals account for a significant amount of the variance in current meter measurements. Current measurements from near the axis of Barrow Canyon showed mean current near the bottom of 25 cm/s, with 50 cm/s speeds being common, and many periods of upcanyon flow (Mountain et *al.*, 1976), They showed that a close relationship existed between the barometric pressure gradient and the currents. Coastal currents observed by Wilson *et al.* (1982) indicated both northeastward and southwestward flow along the "coast with speeds of up to 100 cm/s. The correlation between these currents and the winds were between 0.65 and 0.72. The currents along the coast between Barrow and Wainwright were highly correlated (0.90 and zero lag) (Wilson *et al.*, 1982).

The water masses which flow northeastward along the coast are the Bering Sea Water and Alaska Coastal Water, with Chukchi Resident Water found farther to the west (following the nomenclature of Coachman *et al.*, 1975). The Chukchi Resident Water is closely related to" the water mass also called Chukchi Bottom Water (Paquette and Bourke, 1974). Along the northern boundary of the Chukchi Sea in summer, evidence of water from the Arctic Ocean has been observed (Garrison and Becker, 1976). Barrow Canyon has been described as a "drain" for the Chukchi Sea (Paquette and Bourke, 1974; Garrison and Becker, 1976). The Chukchi Sea water described by Garrison and Becker (1976) and others for spring conditions was nearly at the freezing point for the entire water column. It is a result of the brine rejection during the freezing process of sea ice. It can be distinguished from the Beaufort Sea water because the Beaufort water is actually warmer.

The northeast Chukchi Sea from Cape Lisburne to Icy Cape is ice covered from late October/early November until early July, with large annual variations in these dates (Wiseman and Rouse, 1980). In addition, the length of the freeze up and break up periods and concentration of ice during them also varies considerably, with most of the short term changes produced by wind forcing. The flow of warmer water from the Bering Sea through Bering Strait delays the freeze up of the Chukchi Sea and promotes the melt back in the spring (Paquette and Bourke, 1981). Ice conditions were generally lighter in the Chukchi Sea in the summer of 1986 when the data described here were acquired.

Tidal heights and tidal currents are small. The tidal amplitude at Barrow is between 5 to 10 cm (Harris, 1911; Matthews, 1970). The observed mean tidal range at Peard Bay is 14 cm, with a spring range of 18 cm and a neap range of 9 cm, and tidal currents of less than 3 cm/s (Kinney, 1985). Tidal models have shown that the tide is produced by a progressive (Poincare) wave in the Arctic Ocean (Sverdrup, 1926; Kowalik, 1981; Kowalik and Matthews, 1982). The recent results of these models have positioned an amphidromic point southwest of Point Hope (Kowalik and Matthews, 1982). The tidal ellipse velocities are between 5 and 10 cm/s throughout the northeast Chukchi Sea. For tides as small as these, the meteorological tides (storm surges) are more significant as a source of sea level variations (Hunkins, 1965; Wiseman *et al.*, 1974; Kowalik, 1984).

B. Geological/Geochemical Oceanography

The continental shelf area of the northeastern Chukchi Sea is one of the most intensively sampled shelf areas of the world for surficial sediment samples. Several maps are available to depict the spatial distribution patterns of grain sizes of surficial sediments of the northeastern Chukchi Sea shelf. The sediment granulometric data generated for the area up until 1969 were summarized by McManus *et al.* (1969). In continuation of this work, Naidu (1987) has completed a composite map showing the distribution of sediment types and their sorting values for the contiguous area of the Bering-Chukchi-Beaufort Seas; this map updates the granulometric data including information published subsequent to 1969. The sediment types in Naidu's map are based on Folk's (1954) nomenclature and the map illustrates that all sediment types occur in the northeastern Chukchi Sea shelf. However, there is considerable spatial variation in sediment types. In fact, the patchy nature of sediment distribution observed in the Chukchi Sea is considered quite typical for the Alaskan arctic shelves. The entire continental shelf region of the Chukchi Sea is non-graded, inasmuch as there is no progressive decrease in overall particle size from the coast to the shelf edge (Fig. 3). In the northeastern Chukchi Sea the sediments are generally poorly to extremely poorly sorted.

As shown in Figure 3, there are three principal sediment types in the study area. The inner shelf of the northeastern Chukchi Sea and the shoals (e.g., Herald and Hanna shoals) are carpeted by relatively coarser material (e.g., muddy gravel, gravelly muddy sand or gravelly sand). Contiguous to the inner shelf and extending up to the middle of the study area are a variety of sandy substrates. Farther seaward of the coarse sediments are muds with various proportions of gravel and sand (Fig. 3). Acoustic records obtained in 1986 for the inshore area in the vicinity of Point Barrow, northeastern Chukchi Sea, provide evidence of the presence at the shelf of highly dipping folded rock outcrops (Naidu, unpub.). Additional high resolution seismic profiles show a thin sediment cover, generally less than 6 m thick, overlying folded bedrock over much of the northeastern Chukchi Sea (Phillips *et al.*, 1985; Phillips, 1987).

Factor analysis of granulometric data has been used by McManus *et al.* (1969) to explain the evolution of the distributional pattern of sediments. McManus *et al.* (1969) identified three factors that explained 92 percent of the aerial variations of ten granulometric variables. Factor I represented contemporary deposition of silts and clays from the water column,

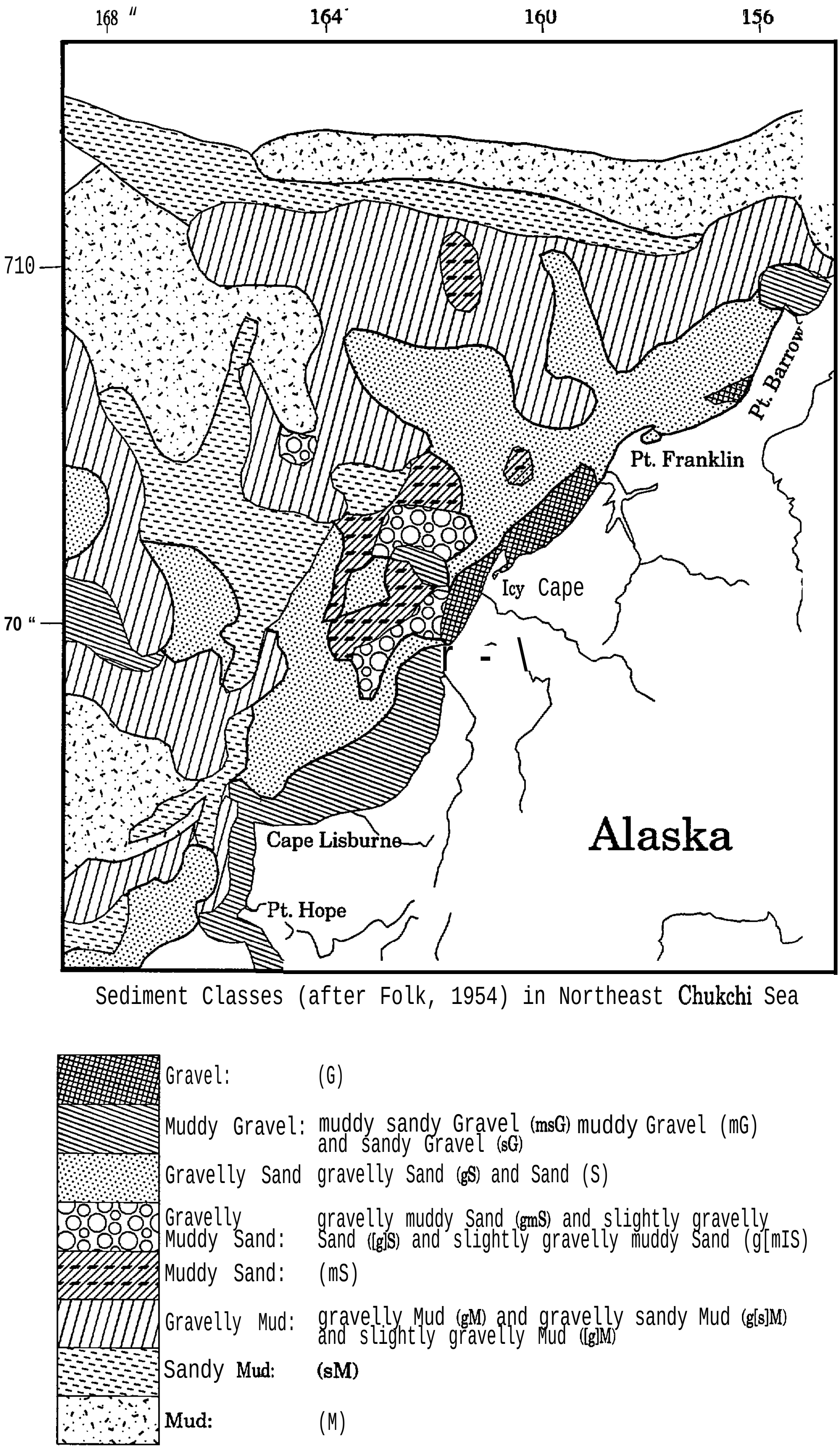

Figure 3. Distributional pattern of sediment classes in northern Chukchi Sea (after Naidu, 1987).

especially in areas of low-energy and abrupt decreases in transporting competency. Factor II represented areas of high supply and deposition of bed-load sand and/or where sands are modified under high energy hydrodynamic conditions, such as, the nearshore region. Sands grouped in this factor could be either modern, relic or palimpsest deposits. Sediments classified in Factor III represented deposits resulting primarily from beach processes. It was further surmised by McManus *et al.* (1969) that, although the Chukchi Sea is covered by ice for 8 to 9 months, ice plays an insignificant role as an agent of transport and deposition of sediments.

A few investigations have addressed the chemical properties of northeastern Chukchi Sea sediments. The concentrations of organic carbon in the surface sediments are reported to be low, about 1.0 % by weight (Creager and McManus, 1966). The distributions of a few major and minor elements in sediments of the Alaskan Chukchi Sea were mapped by Sharma (1979) and shown to correlate strongly with sediment types. Variations in the alkali and alkaline-earth elements in the sediment interstitial waters at selected stations of eastern Chukchi Sea were discussed by Naidu and Sharma (1972) in the context of possible sediment diagenesis. Golan-Bat (1985) analyzed hydrocarbon gas in surface sediments of the northeastern Chukchi Sea and concluded that the light hydrocarbons which are present in low concentrations most likely result from biological and/or very early diagenetic processes.

The intricate mosaic of surficial sediment types across the northeastern Chukchi Sea continental shelf is primarily related to the unique environmental setting (relatively wide shelf, ice cover for 7 to 8 months in a year and occasional storm surges), current regime, and complex

Pleistocene transgressive-regressive history (McManus *et al.*, 1969, 1983; Sharma, 1979; Hopkins *et al.*, 1982; Phillips et *al.*, 1985; Naidu, 1987). The general sediment patchiness is presumably a result of intense but haphazard reworking of the sea bottom by ice gouging (Toimil, 1978; Phillips et *al.*, 1985) and erratic transport and deposition of mud by ice. The gravelly beds in the northeastern Chukchi Sea shelf are most likely either relic ice-rafted dropstones and/or lag deposits and reflect areas of little deposition at the present time. The outer shelf is a trap for terrigenous mud presumably derived from the Bering Sea (Naidu and Mowatt, 1983).

More recently, additional data have been gathered that provide further insight into the sources and dynamics of sediments in Chukchi Sea. Naidu and Mowatt (1983), and the numerous references therein, have elucidated the sources, transport pathways and depositional sites of fine-grained particles as reflected by the distribution patterns of clay minerals. Presently the western portion of the study area of Chukchi Sea receives the major proportion of clayey sediments of Yukon River origin. The sediment is displaced from the Bering Sea via the net northward set Alaska Coastal Current (ACC), presumably as a nepheloid layer (McManus and Smyth, 1970). Evidence was also presented by Naidu and Mowatt (1983) to show that the primary trajectory of this sediment transport pathway is bifurcated westward and northeastward off Point Hope; this correlates closely with the regional water circulation pattern. It is speculated by Eittreim *et al.* (1982) *that a* portion of the northeastward sediment and water transport is funneled through the Barrow Canyon (Garrison and Becker, 1976; Eittreim *et al.*, 1982). The advective processes relative to the ACC play an important role in the production of bedforms near the canyon head (Eittreim *et* al., 1982). A study by Burbank (1974) involved mapping of the suspended sediments in the northeastern Chukchi Sea using satellite imagery. This study showed a narrow band of dense sediment plume adjacent to the coast, suggesting derivation of suspended particles locally from coastal erosion.

Barnes (1972), Phillips *et al.* (1985) and Phillips (1987), following a site-specific study in the region between Cape Lisburne and Point Franklin, delineated five lithological facies changes across the shelf in the eastern central Chukchi Sea between Cape Lisburne and Icy Cape. It was contended that these sediment changes and accompanied bed forms are influenced by contemporary processes such as intensity of ice gouging, wave/current action (especially sediment transport by the snore-parallel ACC and storm-generated currents), bioturbation and the redistribution of sediments by local eddies and gyres. Phillips (1987) has surmised that the ACC may rework the sediments of the northeast Chukchi Sea out to approximately 70 km from the shore. Further, the lag gravel deposits and northward migrating bed forms are associated with the ACC. The gravel deposits support a diverse and abundant benthic community (Phillips, 1987).

C. Biological Oceanography

1. Primary Production

The productivity levels in the eastern Chukchi Sea, in general, appear to be higher (in terms of the amount of carbon fixed annually) than those in the Beaufort, but considerably lower than in the Bering Sea (Truett, 1984). Insight into the sources of energy supporting the southern Chukchi Sea is evident from the high productivity of western Bering Strait (Sambrotto *et al.,* 1984). Upwelled nutrient-rich water from the Gulf of Anadyr moves northward across the shelf and supports high concentrations of phytoplankton as it moves through Bering Strait. Although Sambrotto *et al.* (1984) estimate as much as 324 gC/m^2/yr, it is evident that the data set for the estimate is limited. It has been hypothesized that if upwelling and current movements prevail throughout the winter season, providing a supply of nutrient-rich water to the southern Chukchi Sea, the spring formation of a stable surface layer coupled with the onset of ice melting and the increase of light intensity could result in a phytoplankton bloom of similar magnitude to that in the Bering Sea (Schell, 1987). No data exists to support or deny this hypothesis.

In the northern Chukchi and regions of the Beaufort Sea with perennial ice cover, the estimates of primary production are much more tenuous. Carey (1978) reviewed the literature and concluded that the primary production in the northeast Chukchi ranged from 18 to 28 gC/m^2/yr. However, Hameedi (1978) investigated summer production in the marginal ice zone of the Chukchi Sea and found values of 0.077-0.97 gC/m^2/half-day. Extrapolating from Hameedi's values and assuming that production in the water column occurs primarily over a two-month period, yearly production values can be estimated at approximately 9-116 gC/m^2/yr. More recently, Parrish (1987) described the seasonal production for the eastern Chukchi Sea and southern Beaufort Sea. He used instantaneous estimates and other rate measurements from Alexander *et al.*, (1975), Dawson (1965), Hameedi (1979), Homer (1981), and his own work to construct a synthesis of annual primary productivity in the Chukchi and Beaufort seas. Parrish estimated production from 25-150 gC/m^2/yr with values lowest north and northwest of Point Barrow (Figure 4).

2. Zooplankton

Two surveys provide preliminary information of the zooplankton in the Chukchi Sea in the open-water period. Zooplankton samples were taken at a number of stations from Bering Strait to Icy Cape in 1959 and 1960 (English,

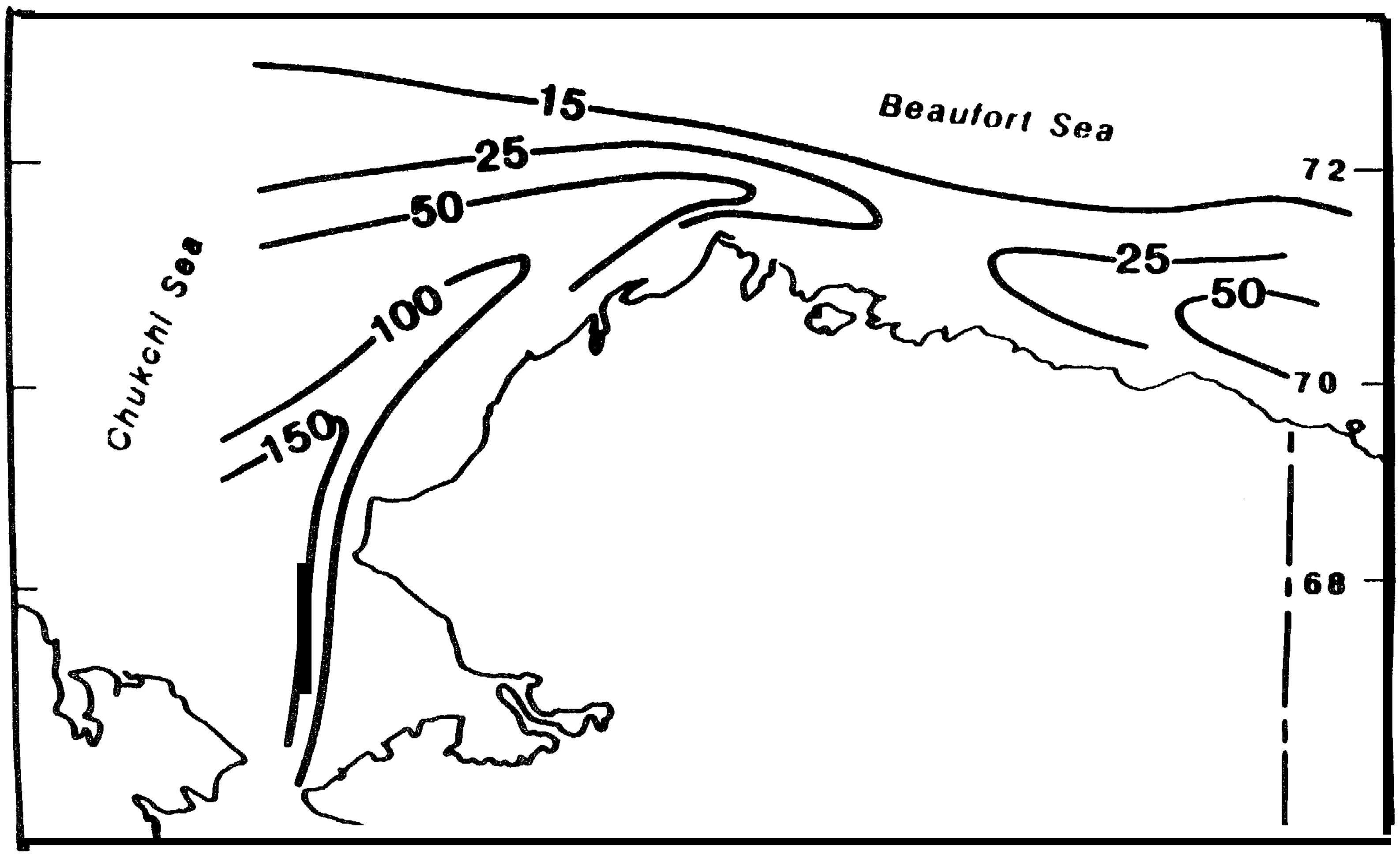

Figure 4. Projected annual primary production ($gC/m^2/yr$) in the Chukchi and Beaufort seas (Parrish, 1987).

1966). The data revealed trends of increasing plankton volumes from inshore to offshore and from south to north. In the offshore area where waters are stratified dominant species were the calanoid copepods *Metridia lucens, Calanus plumchrus*, and *Eucalanus bungii*. The major species nearshore, where the waters are relatively well-mixed, were the calanoids *Eurytemora pacifica* and *Acartia clausii* and t-he cladoceran *Evadne nordmani*.

Ten years later, in 1970, zooplankton was collected at a number of locations in the Cape Lisburne-Icy Cape region (Wing, 1972; 1974). Contour plots of zooplankton abundance indicated that three environments were sampled: 1) an area of high abundance and diversity northwest of Cape Lisburne; 2) an area of low abundance and diversity between Cape Lisburne and Point Lay; and 3) an area of rapid north-south variation but generally low abundance extending west along the 70° N parallel. The hydromedusan *Aglantha digitale* was the predominant zooplankter, both in numbers and biomass. Calanoid copepods were the second most abundant zooplankter; other taxa represented included Coelenterata, Nematoda, Annelida, Mollusca, and Truncata. Abundance distributions of calanoid copepods showed greater densities ($>1000/m^3$) in the region northwest of Cape Lisburne. Conversely, calanoid densities were lowest ($<100/m^3$) in the region northeast of Cape Lisburne and west of Icy Cape.

3. **Benthos**

Although studies of the benthos north of Bering Strait span nearly 30 years, few of these investigations were quantitatively oriented. The most comprehensive studies accomplished were those of Stoker (197S, 1981) who examined the distributional, biomass, trophic and productivity aspects of the bottom fauna (primarily infauna) of the eastern Chukchi Sea from 1970-74.

His data and insightful conclusions serve as a framework for understanding the benthic system of these waters.

Subsequent to Stoker's investigations, an infaunal study for NOAA/OCSEAP expanded Stoker's earlier quantitative work by focusing on the area from Bering Strait to Point Hope and extending into Kotzebue Sound (Feder et al., 1985).

More recently Grebmeier (Grebmeier, 1987; Grebmeier *et al.*, 1988, 1989), working with the benthic component of an NSF project (ISHTAR), studied how various environmental parameters influence benthic structure and biomass on either side of a frontal system between two water masses (the Bering Shelf/Anadyr water and the Alaska Coastal Water). Although her work was primarily conducted in the northeastern Bering Sea, she occupied stations in the southeastern Chukchi Sea as far north as Cape Lisburne. Earlier studies in the vicinity of Cape Thompson yielded a partial checklist and general discussion of the benthic fauna (mainly epifauna) there (Sparks and Pereyra, 1966). An ecological survey in the eastern Chukchi Sea (Point Hope to Point Barrow) yielded qualitative information on infaunal invertebrates, zooplankton, and fishes as well as pelagic birds and mammals (Ingham *et al.*, 1972). A trawl survey extending to Point Hope quantitatively assessed the epifaunal and fish fauna in the area (Feder and Jewett, 1978; Jewett and Feder, 1981; Wolotira et *al.,* 1977). Some semi-quantitative demersal trawling for invertebrates and fishes was conducted in 1977 in the area between Point Hope and Point Barrow known as Barrow Arch (Frost and Lowry, 1983). The biological utilization and comparison of vulnerabilities within the Peard Bay ecosystem are considered in Kinney (1985). Information on the biomass of infaunal and epifaunal invertebrates of the Bering, Chukchi, and Beaufort Seas has been summarized by Jewett (1988a,b) in a data atlas prepared under the auspices of NOAA/SAB.

The broad scale patterns of distribution, abundance, and zonation of benthic organisms across the Beaufort Sea Shelf, contiguous to the northeast Chukchi Sea, are now reasonably understood through the efforts of Carey *et al.* (1974), Carey and Ruff (1977) and Carey *et al.* (1984). Benthic community structure and diversity are related to water circulation, sediment distribution patterns, and impact of ice. Some aspects of these studies are applicable to the Chukchi Sea. However, in addition to this, data on primary production and flux of particulate organic carbon (POC) to the bottom are also essential for understanding the benthic system.

For an understanding of benthic biomass relationships in the northeastern Chukchi Sea, it is important to examine data available for other northern Alaska shelf areas. High benthic standing stocks of infaunal benthos are reported for Bering Strait, on the sea bottom north of the strait, and in the region adjacent to Kotzebue Sound (Stoker, 1978, 1981; Feder *et al.,* 1985; Grebmeier, 1987; Feder, unpub.). Further, the infauna in these regions is dominated by deposit (detrital) feeding organisms characteristic of organically-enriched areas. The source of the particulate organic carbon (POC) for the organisms north of the Strait is probably the highly productive Anadyr waters of the northeastern Bering Sea (Grebmeier *et al.*, 1988, 1989; Sambrotto et *al.*, 1984). The richness of the food benthos in the southeastern Chukchi Sea is suggested by the relatively large populations of Tanner crab (*Chionoecetes opilio*) and sea stars found in these regions (Feder and Jewett, 1981; Jewett and Feder, 1981) that feed on infaunal benthos. In years of low bottom-water temperatures, benthic-feeding fishes are excluded from the southeastern Chukchi Sea, thus reducing the predation pressure on the food benthos and contributing to the high benthic standing stocks (Neiman, 1963; Jewett and Feder, 1980). Benthic biomass values for the northeastern Chukchi Sea are presented in Stoker (1978, 1981). High biomass values for this northern region are shown in his figures but are not discussed.

4. Marine Mammals

Benthic-foraging populations of gray whales (*Eschrichtius robustus*) feed intensively in some regions of the northern Chukchi Sea. Large feeding populations of these whales are described on the inner Chukchi shelf west of Icy Cape to north off Point Franklin, although low densities of gray whales occur from Cape Prince of Wales to Point Barrow (Phillips *et al.*, 1985; Ljungblad, 1987; Moore and Clarke, 1986; Moore *et al.*, 1986a,b; Phillips and Colgan, 1987). Benthic amphipods typically dominate the diet of gray whales. A review of the marine mammals that utilize the nearshore Chukchi Sea is found in Kinney (1985).

Predation by Pacific walrus (*Odobenus rosmarus divergens*) is low in the southeastern Chukchi Sea, but once they move into the northeastern Chukchi feeding intensifies (Stoker, 1981; Fay, 1982). A close correlation occurs between the distribution of walrus populations and the extent and character of the pack ice. During August, the edge of the pack ice generally retreats northward to about 70°30' N in the Chukchi and Beaufort Seas while in September the mean position of the southern edge is about 74° N (Grantz *et al.*, 1982). Most of the walrus population along the northwestern coast of Alaska during these two months occur north of 71° N (Fay, 1982). Bivalve mollusks typically dominate their diet (Fay, 1982). See the I?iscussion (pp. 210-220) for additional information on gray whales and walruses.

The number of bearded seals (*Erignathus barbatus*) utilizing the waters off the coast of Alaska is presently thought to be in excess of 300,000 animals (Nelson *et al.*, 1985). In the Chukchi and Beaufort seas, winter habitat is relatively limited due to extensive unbroken heavy drifting ice. During summer the most favorable bearded seal habitat is found in the central or northern Chukchi Sea along the margin of the pack ice. Spider crabs (*Hyas*), crangonid shrimps, and clams (*Serripes*), and to a lesser extent Tanner crabs (*Chionoecetes*), make up the bulk of the bearded seal diet in the Chukchi Sea (Nelson *et al.*, 1985). Both bearded seals and walruses compete for clam resources (Lowry *et al.*, 1980).

III. STUDY AREA: LOCATION AND SETTING

The northeastern Chukchi Sea is an epicontinental sea on the continental shelf extending from Point Hope in the south to Point Barrow in the north. The study area (Fig. 5) is bounded by the Longitudes 156°W to 160°W (the U.S.-U.S.S.R. boundary line). With the exception of a few areas, all of the northeastern Chukchi Sea consists of a broad, relatively shallow (average depth of 50 m) and flat shelf with minor relief generated by ice gouging (Fig. 6). There are two prominent shoal areas: one, the Hanna Shoal/Bank, northwest of Point Franklin, which rises to within 25 m of the sea surface; and the other, the Blossom Shoals, situated off of Icy Cape, rising to within 10 m of the surface (Fig. 6; after Hill *et al.*, 1984). Another striking physiographic feature of the northeastern Chukchi Sea is the Barrow Canyon or Sea Valley, 25-50 km wide and about 100 m deep within the shelf region, trenching parallel to the coast and a head at the shelf edge off of Point Franklin at about 60 m depth (Eittreim et *al.*, 1982). The shelf edge is around 60-70 m depth. The coast is characterized

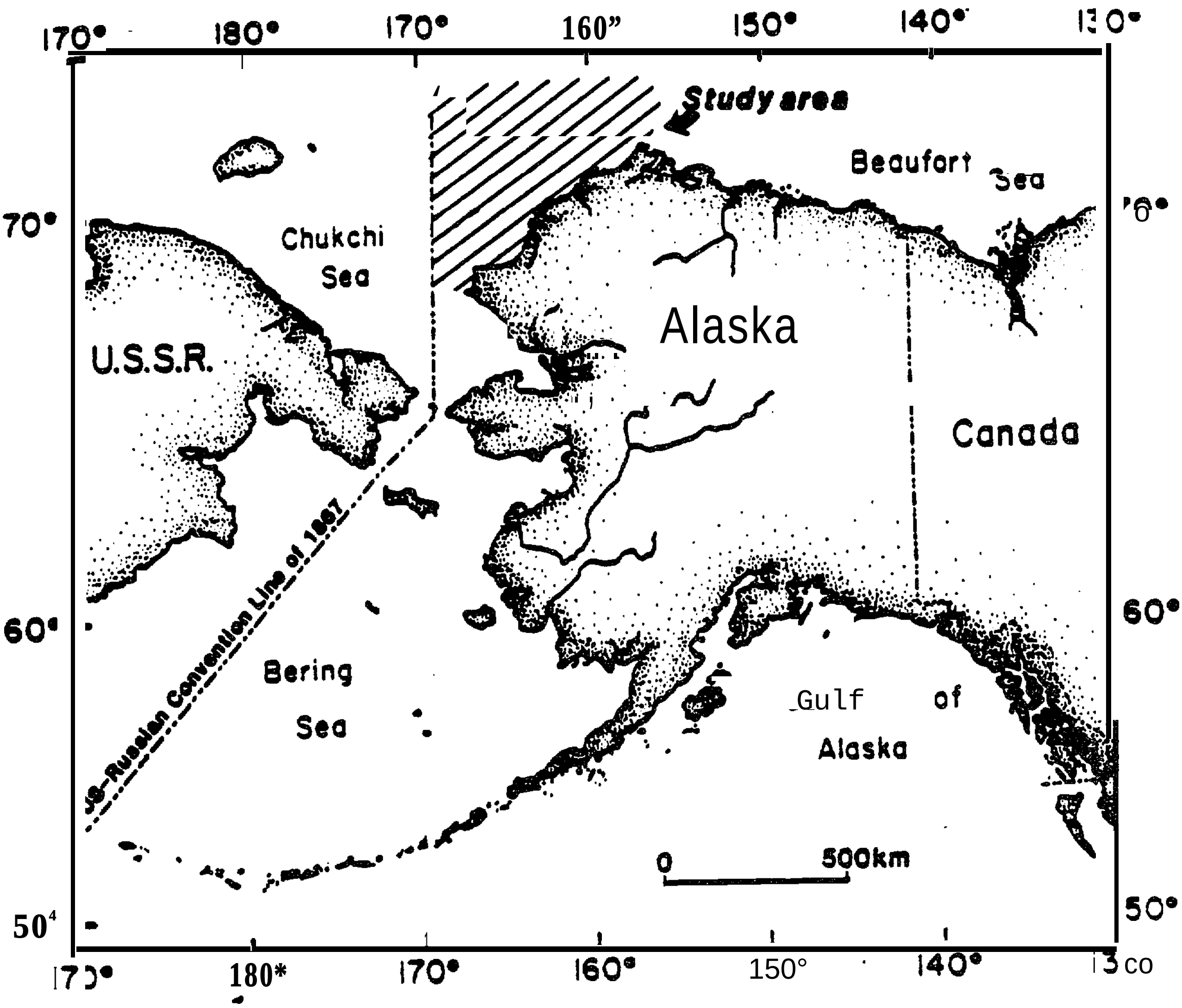

Figure 5. The study area in the northeastern Chukchi Sea as shown by the shading on the map.

by a number of promontories with embayed regions in between (Fig. 6). The coastal hinterland north of Cape Lisburne and extending up to Point Barrow is constituted of broad coastal plain while steep sea cliffs of Permian to Cretaceus age sedimentaries abut against the coast between Point Hope and Cape Lisburne.

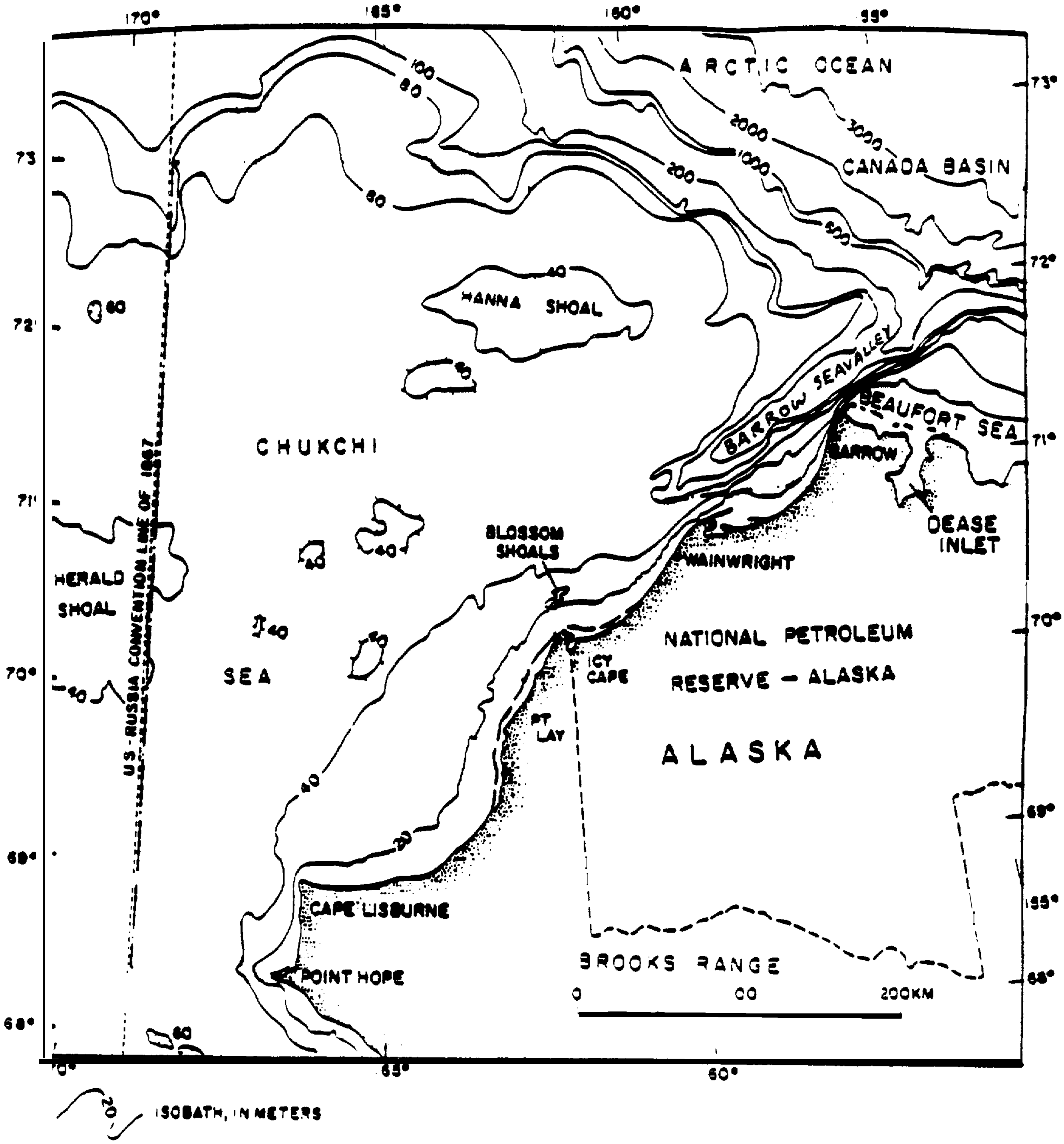

Figure 6. Map showing the bathymetry of northeast Chukchi Sea (after Hill *et al.*, 1984; Phillips *et al.*, 1985).

The most distinctive character of the climate of the study area is the presence of long, severely cold winters with ice cover for about 7 to 8 months and short, cool summers for the rest of the year. The mean annual temperature for the coastal plain hinterland is about -12°C and the mean annual precipitation is about 12 cm. The formation of sea ice begins in late September and the typical sea ice thickness is about 2 *m.* There appears to be a definite pattern of ice zonation. In Figure 7 are shown

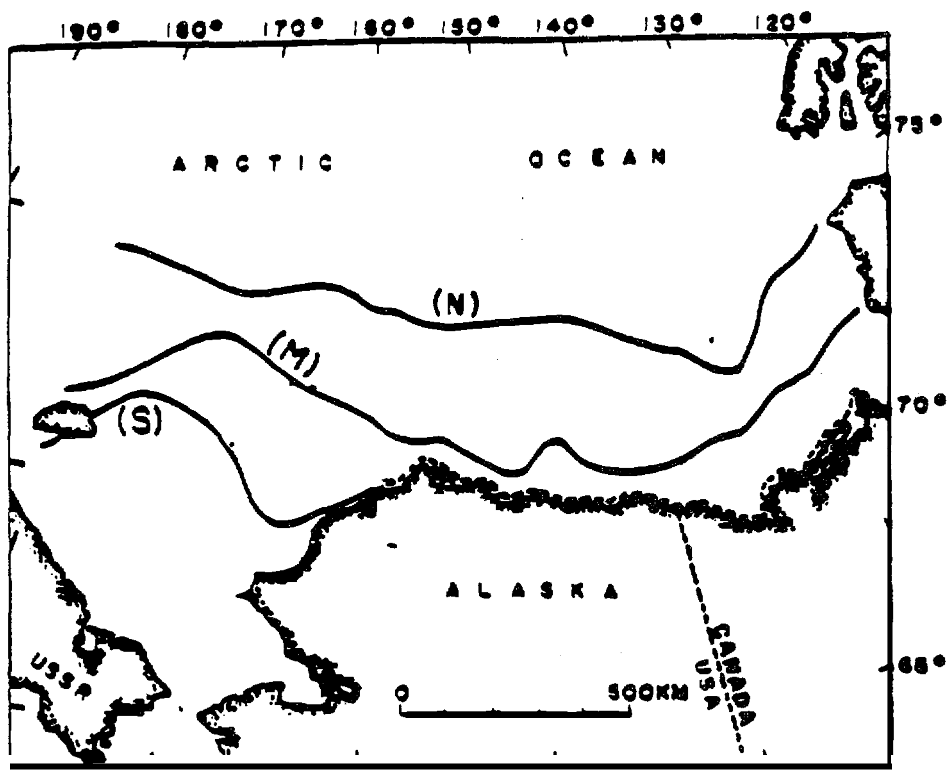

Figure 7. The northernmost (N), southernmost (S), and median (M) positions of pack ice in northeastern Chukchi Sea in September (map extracted from Grantz *et al.,* 1982).

the most southerly, northerly and median margins of the pack ice edge, based on data collected from 1954 through 1970 (Grantz *et al.*, 1982). In winter about 10-50 km of the inner shelf is dominated by the fast ice (Fig. 8; Phillips *et al.*, 1985), while farther offshore narrow, disjointed polynyas occur (Fig. 9, after Stringer, .1982). These polynyas are irregularly-shaped openings enclosed by ice which may contain brash or uniform ice which is markedly thinner ice than the surrounding ice (Stringer, 1982). The spring break is around late May and by late June almost all of the study area is free of ice.

The role of both pack and sea ice in the erosion, transport and deposition of sediments is now becoming clearer. Although ice-rafting of gravel appears insignificant in the Alaskan arctic shelves, the dispersal of silts and clays by ice is a dominant mechanism of sediment transport. Rex (1955), Toimil (1978) and Grantz *et al.* (1982) have provided comprehensive accounts of their investigations, including side-scan surveys, pertaining to ice gouge action on the northeastern Chukchi Sea floor. Toimil (1978) showed that although ice gouging is ubiquitous in the shelf, the density of ice gouges generally increased with increasing latitude, increasing slope gradients and decreasing water depth, and that the density of gouging varies widely (Fig. 10). The depth of gouge incisions ranges from 2 to 4 m. The inner shelf area between Point Lay and Point Barrow is the only area where the ice gouge azimuths are generally oriented parallel to the coastline and the Alaska Coastal Current (Grantz *et al.*, 1982). The total effect of the ice gouging is large-scale reworking and resuspension of the sea floor sediments, and possible deleterious impact on sedentary benthic organisms, resulting from bottom scoring. Additionally, bottomfast ice moves large volumes of sediments adjacent to the beach resulting in low ridges and mounds.

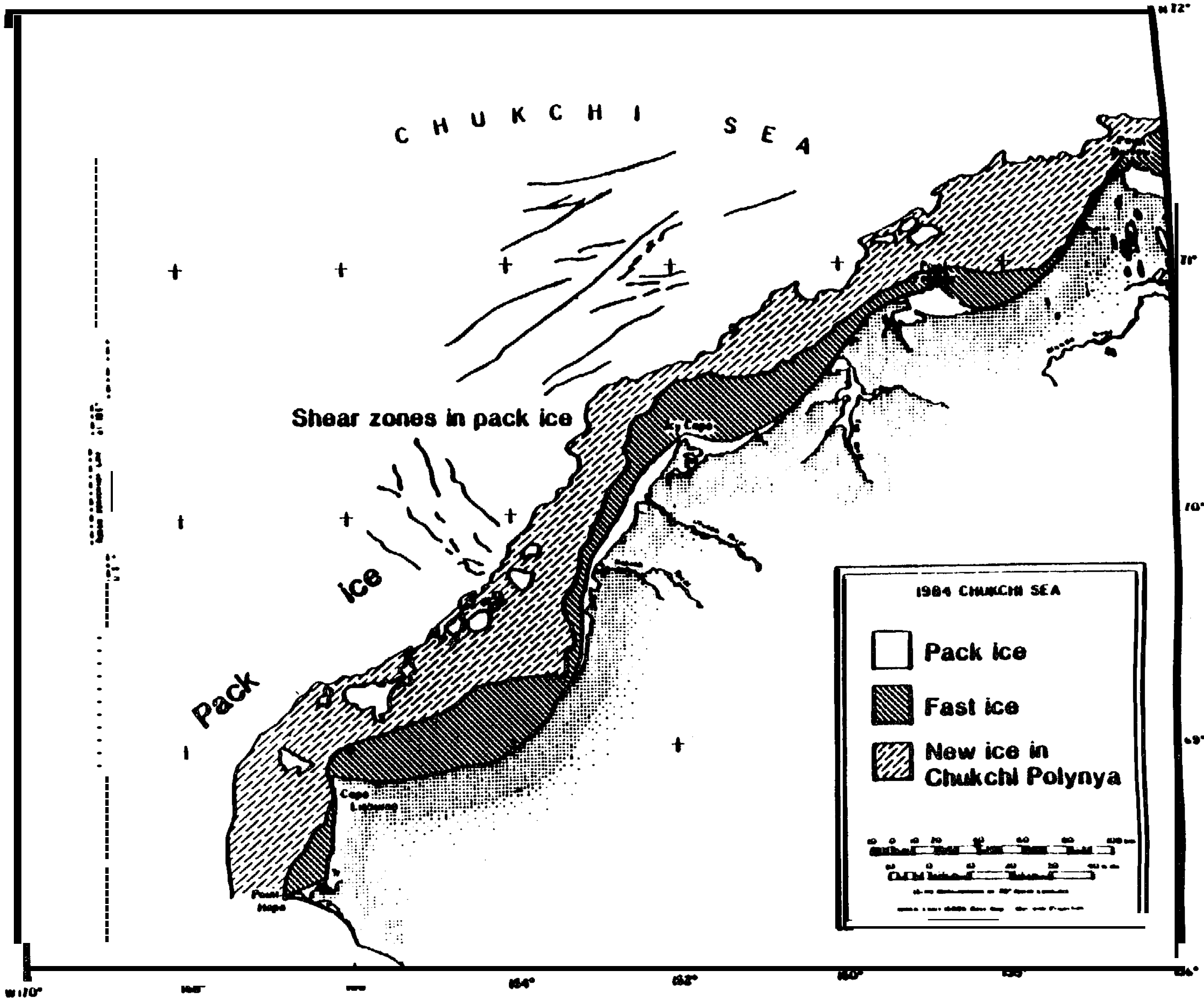

Figure 8. Zonation of pack, fast, and new ice in northeastern Chukchi Sea (after Phillips *et al.*, 1985).

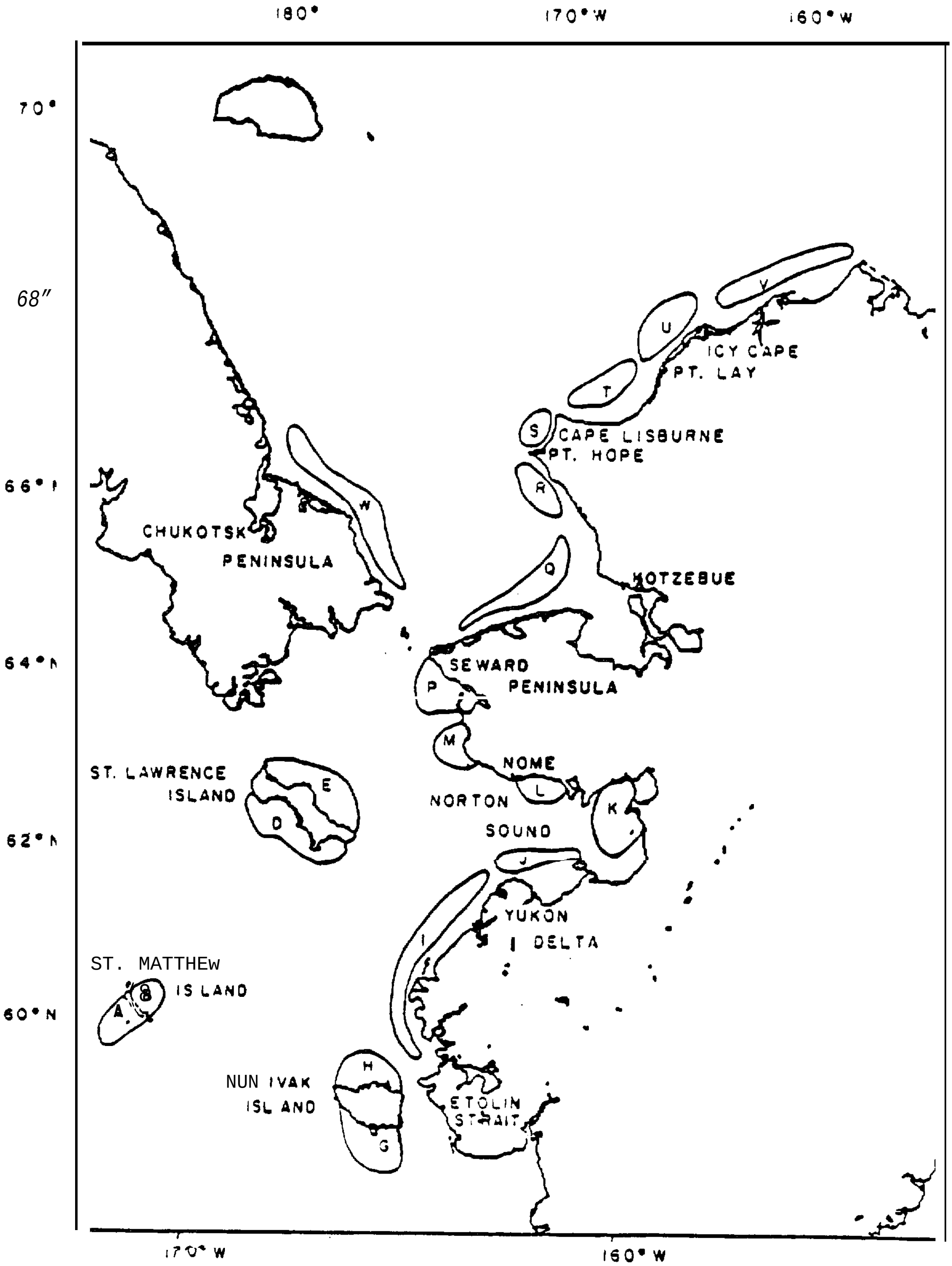

Figure 9. Distribution of polynyas in northeastern Chukchi Sea and adjacent areas (after Stringer, 1982).

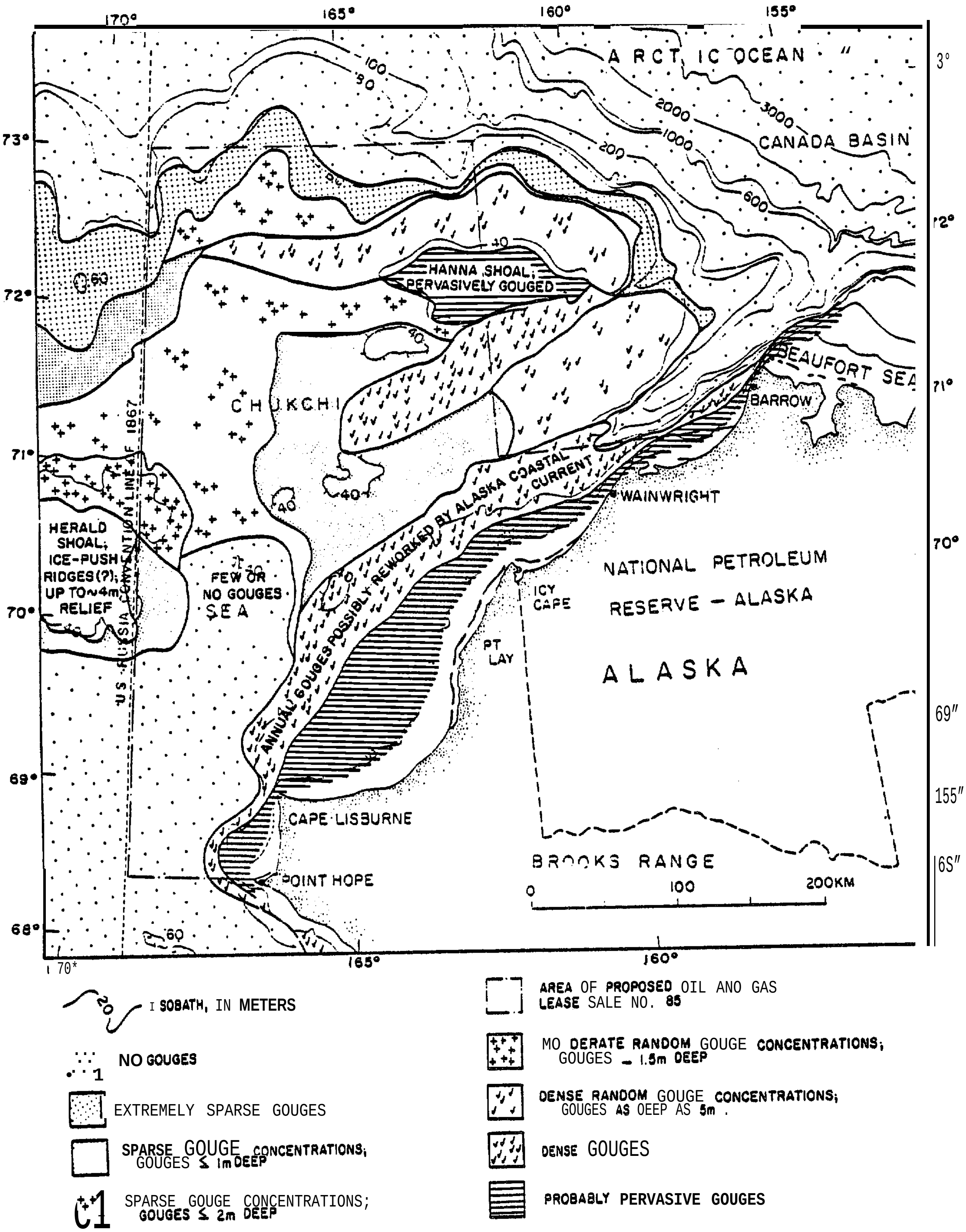

Figure 10. Map of northeastern Chukchi Sea showing the regional variation in the intensity of ice gouging (after Grantz *et al.*, 1982).

No quantitative data on an extensive seals are available "on the erosional rate of the coastline of the northeastern Chukchi Sea. Harper (1978) has estimated a rate of 0.31 m/yr for Peard Bay to the Barrow coast and Grantz *et al.* (1982) have reported a 2 to 6 m/yr coastal erosion rate from Icy Cape to Point Barrow. The latter rate is similar to that observed along the adjacent Beaufort Sea coast (Naidu *et al.*, 1984; Reimnitz and Barnes, 1987) and is the highest on the earth. Gravel and sand yielded from this mass wasting is deposited as a lag along the beach and nearshore.

Astronomical tides of the northeastern Chukchi Sea are generally mixed semidiurnal with mean ranges from 10-30 cm.

The flow directions and speeds of the upper and bottom water layers in the Chukchi Sea are shown in Figures 1 and 2. A detailed description of these flows and their velocities are provided in the section on Physical Oceanography. It may suffice to mention that these flows can play an important role in the distribution of sediments, particulate organic carbon, ice and in the formation of northward migrating bedforms (especially by the Alaska Coastal Current off Icy Cape; Grantz et al., 1982; Phillips *et al.*, 1985). Additionally, the presence of a net northeastward alongshore current has been a critical factor for the development of the extensive barrier island system along the northeastern Chukchi Sea coast (Short, 1979). Few estimates of the alongshore sediment transport rate by littoral currents are available. In August 1977 Nummedal (1979) estimated an average rate of 1663 m/day in the vicinity of Point Barrow, but this rate can be augmented by several factors during occasional summer storms (Hume, 1964), resulting in large-scale changes in coastal morphology and beach sediment budget.

IV. SOURCES, RATIONALE, AND METHODS OF DATA COLLECTION

A. Sources and Rationale

It is known that a number of oceanographic factors and sedimentary properties influence the density and distribution of marine benthic organisms. As succinctly stated by Webb (1976), "Most classical marine ecology implies that similar groups or species consistently occur on similar substrata." The selection of a settlement site by larvae of benthic species based on substrate character is more critical for sedentary than adult mobile species. However, the total interaction between benthic organisms and the inorganic sediment fractions is not well understood. As mentioned earlier, one of the primary sediment factors generally affecting distribution of benthic species is the grain-size of the bed sediments, in addition to flux of POC, sediment accumulation rates, water mass characteristics, degree of water turbidity, and others (McCave, 1976). In ice-stressed arctic areas such as the Chukchi Sea, ice-gouging of bottom sediments can be an additional limiting factor for distribution of benthic species (Barnes and Reimnitz, 1985; Barnes *et al.,* 1984; Phillips *et al.*, 1985; Phillips and Reiss, 1985a, b; Carey and Ruff, 1977; Carey *et al.*, 1974).

The design for sampling the benthos was tailored in such a way that an adequate number of samples was collected from various representative environments of the northeastern Chukchi Sea. The sampling sites were selected on the basis of known distribution patterns of sediment types, water mass characteristics, ice gouge densities, and the mean ice-edge position during the summer (Figure 3). The most northerly stations occupied were limited by the southern margin of pack ice during the sampling period, while the western most stations were at the U.S.-U.S.S.R.

boundary. In order to examine temporal variability of fauna in the study area, four additional benthic stations were occupied to coincide with those stations sampled for benthos by Stoker (1978). Three additional stations were selected in the vicinity of Point Franklin and Peard Bay, a region identified as an important summer feeding ground for gray whales (Phillips *et al.,* 1985).

It was assumed that all important environmental parameters (e.g., water mass characteristics, ice zonation, polynyas, suspended particulate load, etc.) could be assessed in terms of their effects on the benthic system in the framework of the station locations established as above.

Water mass characteristics were included in the sampling plan for the cruise' on the NOAA ship Oceanographer in 1986. The sampling plan was keyed principally to the sediment type, but the close relationship between sediment type, prevalent currents and the water mass structure was recognized. Thus, while all the stations were not occupied in a sequential cross section fashion, many were, and other stations were grouped into logical cross section units for analysis. The principal water masses which were designated for analysis were the Bering Water, Alaska Coastal Water, Chukchi Resident Water (Modified Bering Water) and the Beaufort Sea Water. The precise definitions of these water masses have been described as varying interannually, so that the bounds on temperature and salinity is a function of an individual year (Coachman *et al.,* 1975). The separation of what has been defined as Chukchi Resident Water, Chukchi Bottom Water, Siberian Coastal Water, and some of the descriptions of nearshore Beaufort Sea Water adds additional complexity to the individual designation of water masses.

B. Methodology

1. Field Sampling and Measurements

a. Physical

A Grundy (Plessy; Bissett-Berman) Conductivity-Temperature-Depth (CTD) Model 9040 system was used during the oceanographer cruise. This instrument was owned, maintained and operated by NOAA. The CTD was lowered at most of the stations, and the data recorded on computer tape. On three casts, stations CH1, CH12, and CH33 the data were not recorded, either due to instrument malfunction or human error. The CTD system was calibrated at the Pacific Northwest Regional Calibration Center in October, 1985. Field calibration samples for salinity and reversing thermometer measurements were collected near the bottom on most casts. The salinity samples were analyzed on the ship using an Autosal laboratory salinometer. CTD profiles were acquired after deployment of the moorings and after their recovery. The CTD tapes were processed at NOAA Pacific Marine Environmental Laboratory (PMEL) in Seattle Washington. One meter averages of the temperature and salinity were calculated and the data then sent to the University of Alaska. These one meter average data were then appended to the CTD data base on the Geophysical Institute VAX 780 computer. The data base uses the INGRES relational data management system for access and retrieval of the data.

The Oceanographer has an RD Instruments Acoustic Doppler Current Profiling (ADCP) system which was operated during the cruise. This system sends out a 150 kHz acoustic pulse and measures the Doppler shift of frequency of the backscattered sound received at the four beam transducer. The Doppler shifted frequency of the pulse is proportional to the relative speed of the ship over the water. The system transmits a pulse at the rate of one per second and two minutes worth of data were averaged together for each ensemble. To determine the ship's speed, a ❑edified acoustic pulse is sent, and the directly reflected Doppler shift from the bottom reflection is measured. The ship's motion is then subtracted and the water motion over the bottom is determined in a range of bins beneath the ship, from 5 m to about 80 percent of the water depth at 2 m intervals. The data were recorded on an IBM PC on the ship. The data *were* processed at the Institute of Marine Science, University of Alaska. The positions of the ship for each ensemble were determined by interpolation between satellite fixes. Normally, LORAN C is used for relative positioning, but LORAN C cannot be used for navigation in the northern Chukchi Sea due to the radio propagation characteristics and the placement of the master and slave stations. Since the ship speed was determined by bottom tracking as described above, the relative error of interpolating the position of the ship does not affect the value of the current measured, and probably represents less than a mile error in position.

Cooperation with the scientists on the previous cruise (particularly Dr. James Overland of PMEL) allowed us to deploy four moorings (Table 1; Fig. 11). Each mooring consisted of a railroad wheel anchor (approximately 300 kg), an acoustic release, an Aanderaa RCM4 Current meter, sediment trap and eight plastic Viny floats (Fig. 12). Since the moorings were to be in place less than a month, the current meters were deployed primarily to obtain estimates of the current velocities that the sediment traps were experiencing during their sampling. Very little in the way of significant statistics were expected from the current records with durations between 5 and 8 days. However, as is often the case, these short time series sampled an interesting and significant wind forcing event. To determine the source of the variations in the currents, the winds from the NWS station at Barrow

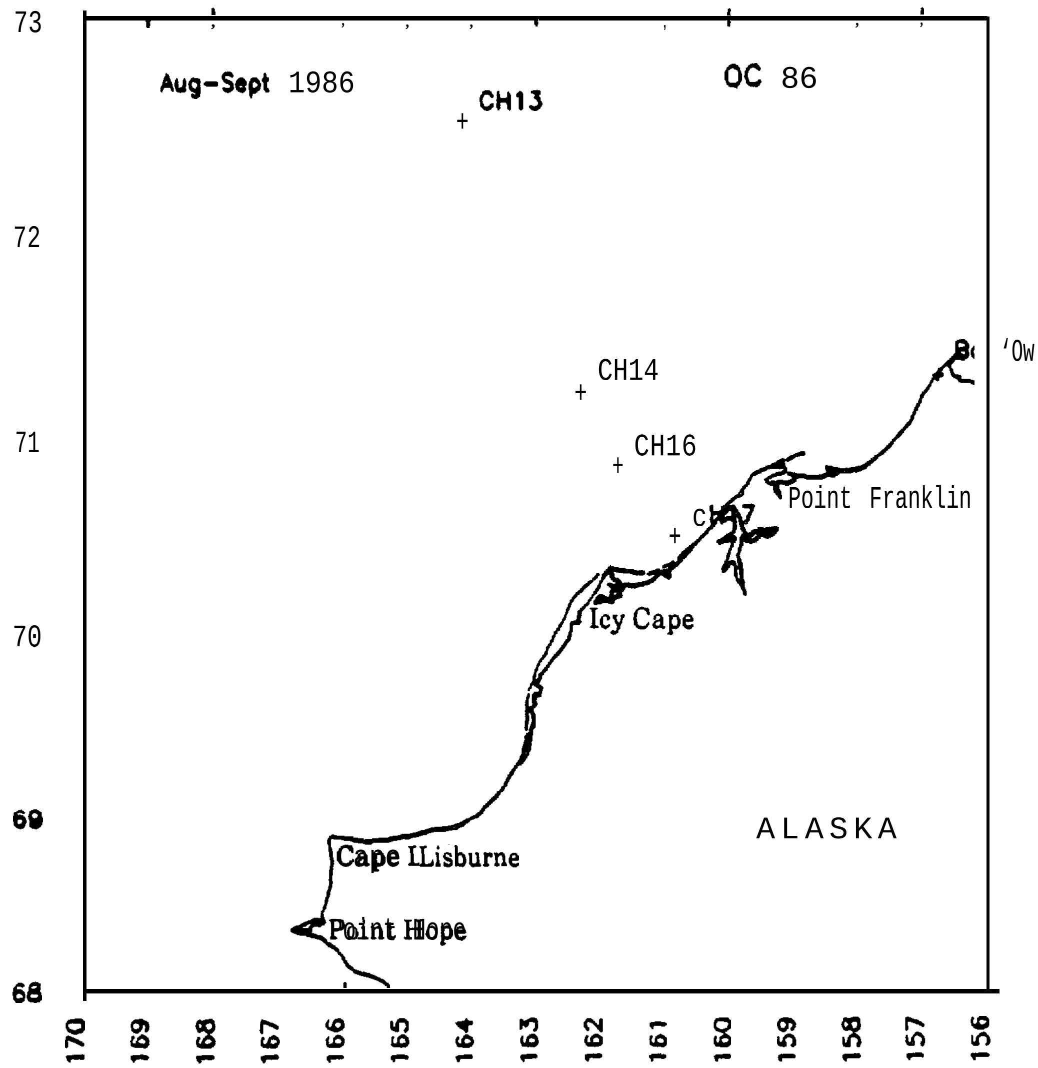

Figure 11. Locations of the current meter-sediment trap moorings, August-September 1986, in northeastern Chukchi Sea.

Table 1. *Oceanographer* 1986 UAF/NOAA Mooring Deployments

Mooring	Lat(N)	Len(W)	Start Date	GMT Time	End Date	Depth (m)	Meter Depths	15 min Samples
CH13/1	72 30.6	164 09.0	27-Aug	0117	31-Aug	49	47	388
CH14/1	71 12.6	162 19.2	26-Aug	1815	2-Sep	44	42	616
CH16/1	70 50.4	161 45.0	26-Aug	1521	2-Sep	44	42	612
CH17/1	70 28.8	160 51.0	26-Aug	1234	1-Sep	22	20	609

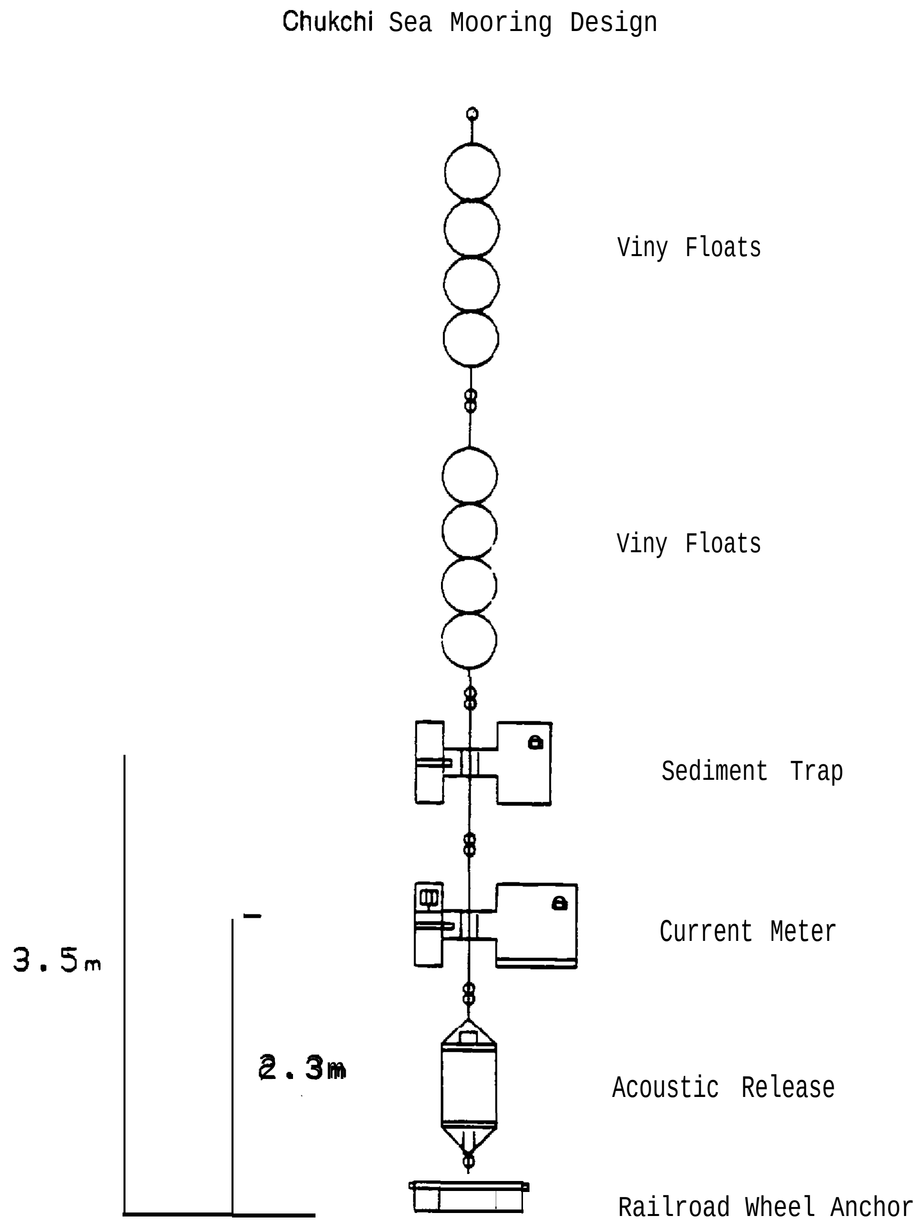

Figure 12. The vertical array of instruments and floats on a typical mooring deployed in the study area.

were obtained from the Local Climatic Summary. The tapes were read and processed at Aanderaa Instruments, Canada. To compare to the Barrow winds, a 2.86 hour half power point low pass filter was applied to the original data, the values at the whole hour were interpolated, and then the series were decimated to three hourly samples.

b. Geological and Biological

Sediment, water and benthic biological samples were collected during a cruise extending between 22 August to 1 September, 1986 on board the NOAA vessel R/V *Oceanographer.* For the purpose of characterizing the benthic substrate habitats, bottom surficial sediment samples were collected at 47 stations using a 0.1 m^2 van Veen grab sampler (Table 2, Fig. 13). Each of these samples were split into two subsamples which were then placed in two separate freezer boxes. One box of samples was to be used for analysis of granulometric composition, and the other for the analysis of organic carbon and nitrogen. The latter subsamples were maintained in a frozen state for shipment to the laboratory in Fairbanks. At the 47 stations two liter water samples were retrieved from the Niskin bottles that were attached to the CTD system that was programmed to obtain samples at selected water depths (e.g., at surface, mid depth and near bottom). Each of the water samples was split into two 1 liter subsamples, each of which in turn was filtered separately through preweighed and precombusted Gelman glass filters (pore size approximately 0.45 pm) and preweighed Nucleopore membranes (pore size 0.45 pm), using a suction device. The sediment particles trapped on the glass filter were used for organic carbon and nitrogen analysis, whereas the particles on the Nucleopore membranes were used for the purpose of estimating the vertical distribution of the suspended particulate

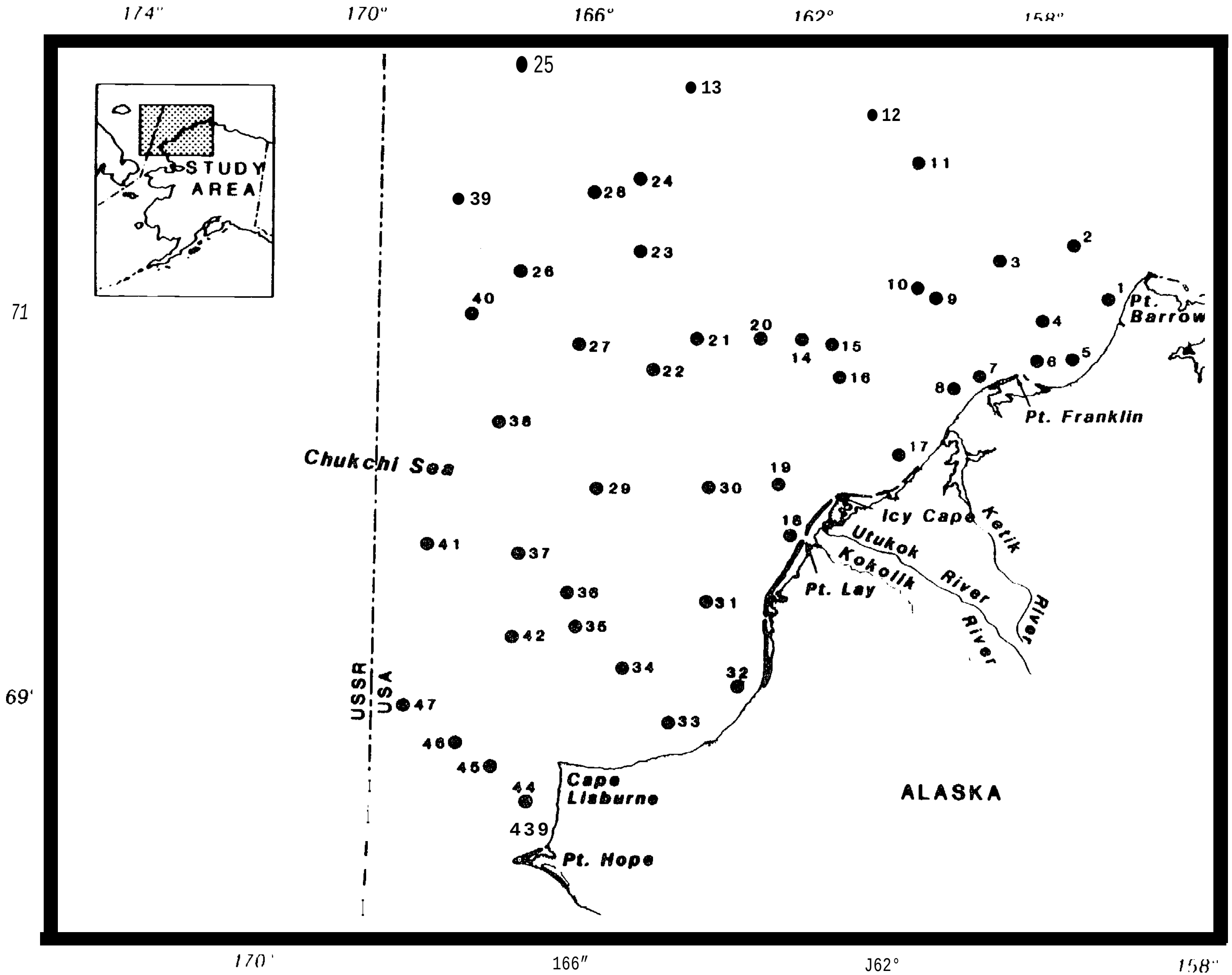

Figure 13. Map of northeastern Chukchi Sea showing station (CH) locations where physical oceanographic, geological, and biological samples were collected in August-September 1986 aboard the NOAA Ship *Oceanographer.*

Table 2. Summary of events at stations occupied in the eastern Chukchi Sea (north of Point Hope) aboard the NOAA Ship Oceanographer, Cruise OC862, August and September 1986.

Sta. Name	Latitude	Longitude	Depth m)	CTD	Van Veen grab	Susp. Sediment	Benthos core	Piston core	Mooring	Nut./chyll. Prim. Prod.	Ben. Trawl	Bongo Tow
CH1	71 17.4 N	157 4.8 W	46	X	X	X					X	
CH2	71 34.4 N	157 40.4 W	62	X	X	X	X				X	
CH3	71 31.2 N	158 56.4 W	51	X	X	X	X					
CH4	71 11.2 N	158 9.3 W	42	X	X	X				X		
CH5	70 57,5 N	157 50.4 W	19	X	X	X						
CH6	70 57.3 N	159 0.2 W	27	X	X	X						
CH7	70 52.6 N	159 30.9 W	31	X	X	X						
CH8	70 50.3 N	159 59.0 W	46	X	X	X						
CH9	71 18.6 N	160 4.7 W	50	X	X	X						
CH10	71 23.1 N	160 17.1 W	47	X	X	X	X					
CH11	72 4.6 N	160 7.3 W	32	X	X	X	X			X		
CH12	72 25.3 N	160 54.0 W	44	X	X	X						
CH13	72 31.1 N	164 8.0 W	48	X	X	X			X	X		
CH14	71 12.7 N	162 19.7 W	47	X	X	X	X		X			
CH15	71 10.4 N	161 54.1 W	47	X	X	X						
CH16	70 50.2 N	161 45.3 W	43	X	X	X			X			
CH17	70 30.9 N	160 54.5 W	23	X	X	X			X	X		
CH18	70 7.9 N	162 43.2 W	18	X	X	X						
CH19	70 22.2 N	162 53.1 W	30	X	X	X						
CH20	71 12.1 N	163 5.3 W	46	X	X	X						
CH21	71 12.2 N	164 12.0 W	42	X	X	X	X					
CH22	71 3.2 N	164 56.0 W	38	X	X	X	X					
CH23	71 37.0 N	165 6.4 W	42	X	X	X				X	X	
CH24	72 2.1 N	165 6.7 W	43	X	X	X						
CH25	72 37.6 N	167 4.5W	51	X	X	X	X	X				
CH26	71 32,2 N	167 5.6 W	47	X	X	X	X			X	X	
CH27	71 9.6 N	166 6.5 W	42	X	X	X	X	X				
CH28	70 50.7 N	165 51.5 W	41	X	X	X						
CH29	70 21.2 N	165 46.5 W	43	X	X	X	X			X		
CH30	70 22.6 N	164 0.7 W	39	X	X	X					X	X
CH31	69 45.3 N	164 5.0 W	26	X	X	X					X	
CH32	69 17.3 N	163 39.7 W	15	X	X	X						
CH33	69 5.9 N	164 40.7 W	18	X	X	X						
CH34	69 23.7 N	165 22.4 W	32	X	X	X	X			X		
CH35	69 35.2 N	166 2.3W	39	X	X	X	X				X	
CH36	69 46.8 N	166 15.3 W	44	X	X	X					X	
CH37	70 0,2 N	167 0.2W	47	X	X	X	X				X	
CH38	70 42.0 N	167 22.9 W	52	X	X	X	X					
CH39	71 52,2 N	168 15.4 W	48	X	X	X	X	X				
CH40	70 16.7 N	167 54.3 W	45	X	X	X		X				
CH41	70 2.2 N	168 27.9 W	42	X	X	X						
CH42	69 33.6 N	167 4.9 W	47	X	X	X	X					
CH43	68 29.9 N	166 29.9 W	23	X	X	X						
CH44	68 36.9 N	166 46.0 W	31	X	X	X						
CH45	68 49.3 N	167 24.7 W	45	X	X	X	X					
CH46	68 58.1 N	167 52.9 W	47	X	X	X						
CH47	.0 N	37.2		X								

concentrations within the water column. Both of these filtered samples were washed with double distilled deionized water to free them of salts and stored frozen for subsequent analysis in Fairbanks.

In addition to the sediment grabs, samples of 18 Benthos gravity cores and five Benthos piston cores were collected at selected stations (Table 2; Fig. 13) for the estimation of sediment accumulation rates. These core samples were transferred to Fairbanks in plastic liners. As mentioned earlier, the sediment trap was attached to each of the four current meter moorings (for station locations see Table 1 and Fig. 11) at about five meters above the sea floor. The purpose of the sediment trap deployment was to estimate the gross fluxes of sediments, and particulate organic carbon and nitrogen to the sea bottom during the summer (August-September). The traps were deployed for 5-8 days (Table 1). Following recovery of the moorings, particulate collected in the individual traps were quickly transferred into polyethylene bottles and stored frozen.

Thirty-seven (37) stations *were* established (Table 2; Fig. 13) to represent variable benthic biological environments in the northeast Chukchi Sea based mainly on a range of sediment types (Fig. 3; after Naidu, 1987), bathymetric characteristics (Fig. 6), and marine mammal distributions (e.g., Fay, 1982; Phillips *et al.*, 1985). At each station, five replicate biological bottom samples were collected with a 0.1 m^2 van Veen grab. Material from each grab was washed on a 1.0 mm stainless steel screen, and the biological material preserved in 10% buffered formalin. Benthic trawling was accomplished at ten stations. A small try net (4 m net opening) was towed 10-15 minutes at 2-4 kts.

2. Laboratory Analysis

Sediments from the grab samples were analyzed for their grain sizes by the usual pipette-sieve method, and the sediment types and grain size distributions defined statistically following the conventional grain size parameters stated in Folk (1980). The Nuclepore filter membranes with filtered sediments were dried in an oven at 80°C, cooled and weighed in a Cahn balance in order to estimate the suspended particulate concentrations. The Gelman glass filters were first exposed to 2N HCl acid vapors in a desiccator to dissolve carbonates, then dried in an oven and weighed in a Cahn balance. The carbonate-free sediment sample on the glass filter was analyzed for organic carbon (OC) and Nitrogen (N), using a Perkin-Elmer Model 240B CHN analyzer. Urea was used as the reference standard. The precision of analysis was 8%. The relative abundance of organic carbon and nitrogen (mg/g) thus estimated on each glass filter was then computed against the total weight of sample of dry suspended particles estimated per liter of sea water as obtained on the Nucleopore membrane corresponding to the same water depth and station as the glass filter. The OC and N estimates were prorated to the suspension weights on the Nucleopore membranes because these membranes provide more accurate suspension weight data by virtue of better precision obtained using them. This finally also provided the concentration of OC and N in suspended sediments on a carbonate weight basis. Organic carbon and nitrogen in bottom sediments were estimated on dry carbonate-free sample powders using the CHN analyzer. All OC/N ratios in this report are computed on a weight to weight basis of OC and N. The carbonate-free bottom surficial sediment powders were submitted to Coastal Science Laboratories, Inc. (Austin, Texas) for the analysis of stable carbon isotopes (e.g., ^{12}C and ^{13}C) by mass spectrometry. The stable carbon isotopic ratios received from the above laboratory were expressed as $\delta^{13}C$ and corrected to the PDB standard. The standard error of the $\delta^{13}C$ determination was 0.2 $^{o}/oo$.

The samples collected from the sediment traps were centrifuged and the solids collected, dried and accurately weighed to estimate the flux of particulate to the bottom for the duration of the time that the traps were deployed. From the above, the flux per day was calculated. The dry particulate were treated with 10% HCl to remove carbonates. The carbonate-free sample was analyzed for OC and N as per the method outlined above.

The linear sediment accumulation rates (cm/yr) were estimated by the ^{210}Pb geochronological method following the steps outlined in Nittrouer *et al.* (1979) and Naidu and Klein (1988). The mass sedimentation rate ($g/m^2/yr$) was calculated from the linear sedimentation rate and by taking into account the sediment porosity and density (2.56 gC/cm^3). The sediment porosity, in turn, was estimated on the basis of the mean fractional water content of all the sections in an individual core (see Appendix I). The core samples were extruded out of the plastic liners and quickly split into l-cm sections. The water content was determined on these sectioned samples after drying at 90°C for 24 hrs. The dry sections were pulverized using an agate mortar and pestle. Two grams of each of these powders were taken into solution by digestion in HF, HNO_3 and HCl. Prior to the digestion, ^{208}Po spike was added to the powder. The polonium was electroplated onto silver planchets following the method of Flynn (1968), and then assayed by using an alpha spectrometer with a surface barrier detector coupled to a 4096 channel analyzer. The concentration of ^{210}Pb excess was estimated by measuring ^{226}Ra (Rn emanation method, Mathieu, 1977) in the solution left after polonium plating. The annual accumulation rates of OC and N for selected stations were estimated by multiplying the ^{210}Pb-based annual mass sediment accumulation rates ($g/m^2/yr$) with the concentrations (mg/g) of OC and N in surficial sediments at the selective stations.

In the laboratory, biological samples were rewashed and transferred to a 70% ethanol solution. All specimens were identified, counted, and weighed after excess moisture was removed.

3. Data Analysis

Cross correlation time-series analysis was performed to obtain time lag estimates for the maximum correlation between the wind at the National Weather Service station at Barrow and the currents measured at the current meter/sediment trap moorings.

All data on sediment granulometric compositions, including the sediment types and the conventional statistical grain size parameters (Folk, 1954), were digitized using standard NODC formats (073). Groupings of data on sediment grain sizes, OC, N, and OC/N were established based on cluster analysis. In this analysis the log transformed data were used. To elucidate the relationship between granulometric composition, OC, N, OC/N, and sediment water contents, correlation coefficients *among* the various variables were established. Additionally the correlation coefficients between the $\delta^{13}C$ and OC/N values against benthic biomass were obtained. The purpose of the latter analysis was to check if any covariance occurs between the benthic biomass and the quality of OC accumulating at the sea floor, as reflected by the $\delta^{13}C$ and OC/N values.

The data base used in the classification and ordination of stations consisted of taxon abundance at 37 *stations.* In *many* benthic biological studies, species collected by grab and subsequently used in analyses include slow-moving surface dwellers and small, sessile epifauna. These organisms are grouped with other fauna taken by grab to permit a more accurate assessment of the composition and production of the benthic fauna. This approach was used here. Highly motile epifauna such as large gastropod, shrimps, crabs, and sea stars (except the infaunal sea star *Ctenodiscus crispatus*) were excluded from analyses.

Station groups were delineated using a hierarchical cluster analysis. Data reduction prior to calculation of similarity coefficients eliminated fragments of specimens. The Czekanowski coefficient was used to calculate similarity matrices for cluster analysis routines (Bray and Curtis, 1957; Boesch, 1977). Since the latter coefficient emphasizes the effect of dominant (i.e., numerically abundant) taxa on classification, a log transformation (Y=*ln* [X+11) of all data was applied prior to analysis. Principal coordinate analysis (Gower, 1967, 1969) was also used as an aid to interpret the cluster analysis (Stephenson and Williams, 1971; Boesch, 1973). The Czekanowski similarity coefficient was also applied to calculate the similarity matrix used in principal coordinate analysis (Probert and Wilson, 1984). Dominant taxa *were* determined by a ranking program (a list of all taxa is available from the Institute of Marine Science, University of Alaska). Two diversity indices, H′ (Shannon and Weaver, 1963) and H (Brillouin, 1962), a dominance index, D (Simpson, 1949), and species richness, SR (Margalef, 1958) were calculated. The Shannon (H') and Brillouin (H) indices calculated were closely correlated (r = 0. 97), indicating that either index is acceptable, as Loya (1972) and Nybakken (1978) suggest. The Shannon Index is presented here.

Wet weight biomass values were converted to carbon by applying the conversion values of Stoker (1978) determined for taxa in the same region. Benthic carbon production was calculated from these carbon values by applying conservative P/B values available for northern species (Curtis, 1977; Stoker, 1978; Walsh *et al.,* 1988; Grebmeier, 1987; and R, Highsmith, unpubl.) (Appendix II).

Programs were developed by Chirk Chu (IMS Data Management Group) for ranking taxa by abundance, wet-weight biomass, carbon biomass, and carbon production. These programs were used to determine the top-ranked taxa in stations and station groups established by cluster analysis, and to calculate the percent fidelity of these taxa to stations in each station group. An additional program calculated the percentage of higher taxa by abundance and carbon biomass present within each station and each station group.

The trophic structure of each station group was classified in two ways: (1) by grouping the taxa in each station group into five feeding classes: suspension feeders, surface deposit feeders, subsurface deposit feeders, predators, and scavengers; and (2) by grouping taxa in each station group into four feeding classes (Josefson, 1985): interface feeders (surface deposit + suspension feeders) that utilize particulate organic carbon at the sediment-water interface, subsurface deposit feeders, predators, and scavengers. Each taxon was assigned to a feeding class based on the literature and personal observations (Appendix 11). All taxa were combined by station or major station group, and the percentage of individuals belonging to each feeding classification calculated for each group. Taxa were also classified into three classes of motility: sessile, discretely motile (generally sessile but capable of movement to escape unfavorable environmental conditions: Jumars and Fauchald, 1977), and motile (Appendix II). The percentage of individuals belonging to each motility class was also calculated for each station and station group.

Stepwise multiple discriminant analysis, using the BMDP7M program, was applied to the biological data to correlate (1) station group separation by cluster analysis and (2) regional separation according to biomass, with the environmental variables measured. Three separate analyses *were* performed using (1) sediment variables based on dry weight determinations [% gravel, % sand, % mud, mean sediment size, sorting, sediment organic carbon and nitrogen, and sediment OC/N], (2) sediment variables based on wet weight [% gravel + % sand, % mud, % water in sediment, organic carbon and nitrogen in sediment, and sediment OC/N], and (3) physical oceanographic variables [surface and bottom temperature, and current velocity]. The percentage values for sediment variables were arc sine transformed. Multiple discriminant analysis (canonical variate analysis) is a statistical method which determines functions whose application to the original data maximizes the observed variations among different groups (Cooley and Lohnes, 1971). Unlike classification and ordination, the method begins with a set of stations which have already been grouped and aims only to search for the relationships between these groups. *Since* the procedure starts with already defined clusters, multiple discriminant analysis is not a pattern analysis method and has not been widely employed in benthic studies. However, multiple discriminant analysis has been used by several authors to test a biological model (i.e., benthic station groups) with environmental parameters (Flint and Rabalais, 1980; Flint, 1981: Gulf of Mexico outer continental shelf benthos; Shin, 1982: Galway Bay benthos) and seems applicable to our studies.

Two grain size parameters (mean size and sorting), the percentage of sediment size classes (e.g. , gravel %, sand %, etc.), suspended particle concentrations in the surface and near-bottom waters, OC, N, OC/N, and carbon isotopic ratios were first individually computer plotted on standard base maps of the study area and isopleths hand drawn to bring out the regional distributional patterns in the above parameters. These plots were made to determine if any relationships exists between stations or station groups and sediment types and fluidity. Binary plots including percentages of mud and water contents, and ternary plots including percentages of gravel + sand, mud + water contents were obtained (see Boswell, 1961, *for* the rationale of the ternary plots).

V. RESULTS

A. Physical Oceanography

1. Time Series

A time series plot of sticks proportional to the wind and current strength and direction demonstrates a relationship between the wind and currents (Fig. 14). The currents at the three moorings near the Alaskan coast indicate a reversal of the normal northeastward flow to southwestward. This reversal was produced by wind, which had begun to blow from the east northeast at up to *4* m/s (30 miles per hour). The nearshore mooring (CH17) had the largest amplitude variation of currents and the largest temperature variation. The amplitude of the reversal decreased offshore, from CH17 to CH14 . The station farther from the coast, CH13, was near the ice-edge and on the other side of Barrow Canyon and a sub-sea bank (Hanna Shoal). The flow at CH13 was consistently toward the east, and is not related to the

Barrow wind. The alongshore component of the flow was estimated to be along the 60° axis, and this component of the flow clearly demonstrates the reversal (Fig. 15).

Cross correlation analysis was performed to obtain time lag estimates for the maximum correlation between the wind at the National Weather Service (NWS) Station at Barrow and the currents measured at the moorings (Table 3, Figs. 16-19). The calculations were performed for the component of current or wind along 60° axis, roughly the angle of the coastline orientation. The highest correlation was observed at CH17 with a value of 0.88 at 6 hours lag. The correlation decreased with distance offshore and the time lag of the highest correlation increased (Table 3).

The temperature time series from the current meters supports the hypothesis that the wind was producing upwelling (Fig. 20). The temperature

Table 3. Maximum cross correlation coefficients (at lag in hours).

Station	CH17	CH16	CH14	CH13
Barrow	0.883 (6)	0.800 (12)	0.708 (12)	0.986 (-27)†
CH17		0.985 (6)	0.935 (3)	0.925 (-21)†
CH16			0.991 (3)	
CH14				1.033 (-18)†

†Near zero at zero lag, not significant. The significance level for an effective number of degrees of freedom was estimated to be: critical $r_{0.05}$ = 0.755.

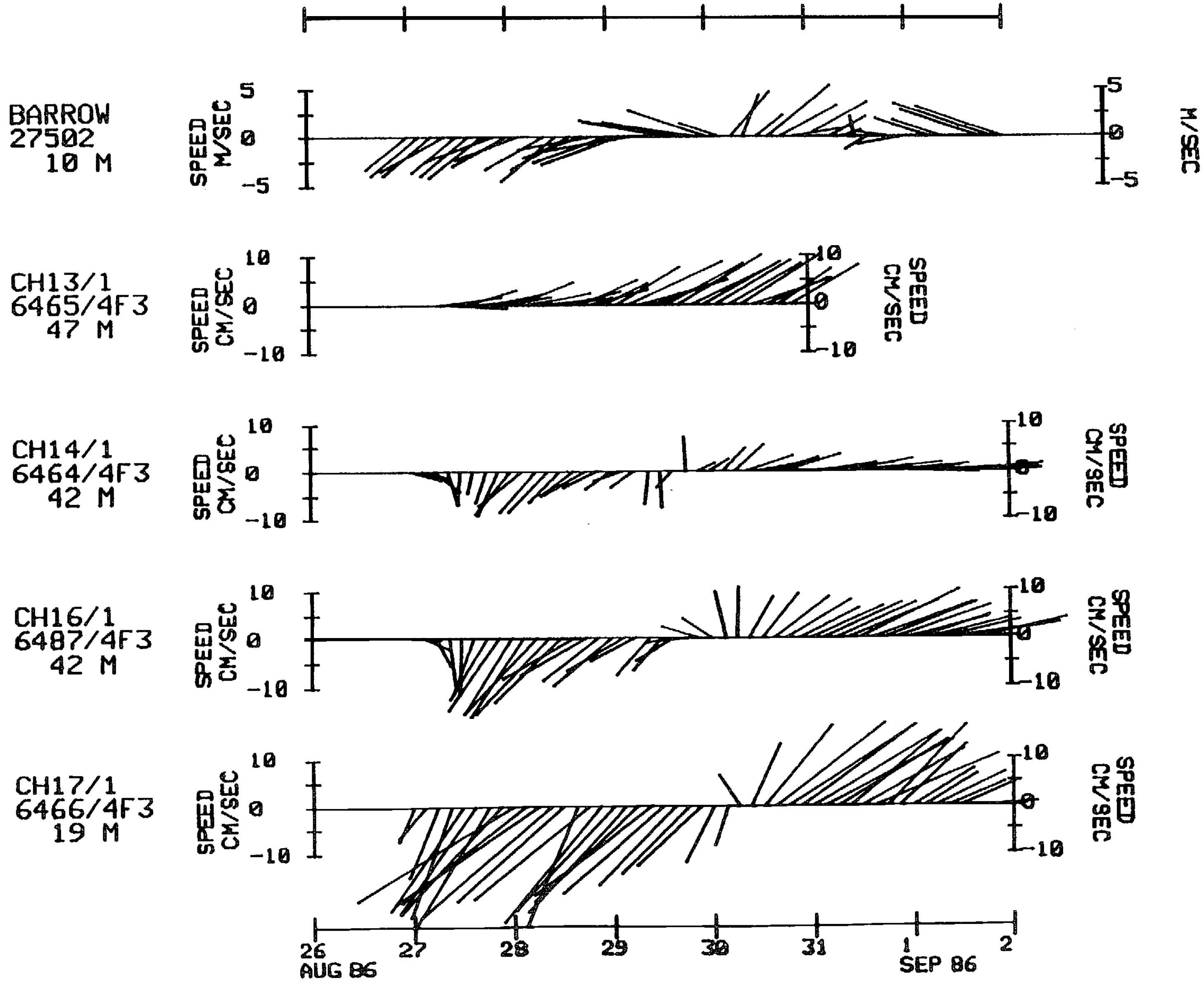

Figure 14. Vector plot of the wind measured at Barrow and the currents measured at the mooring locations.

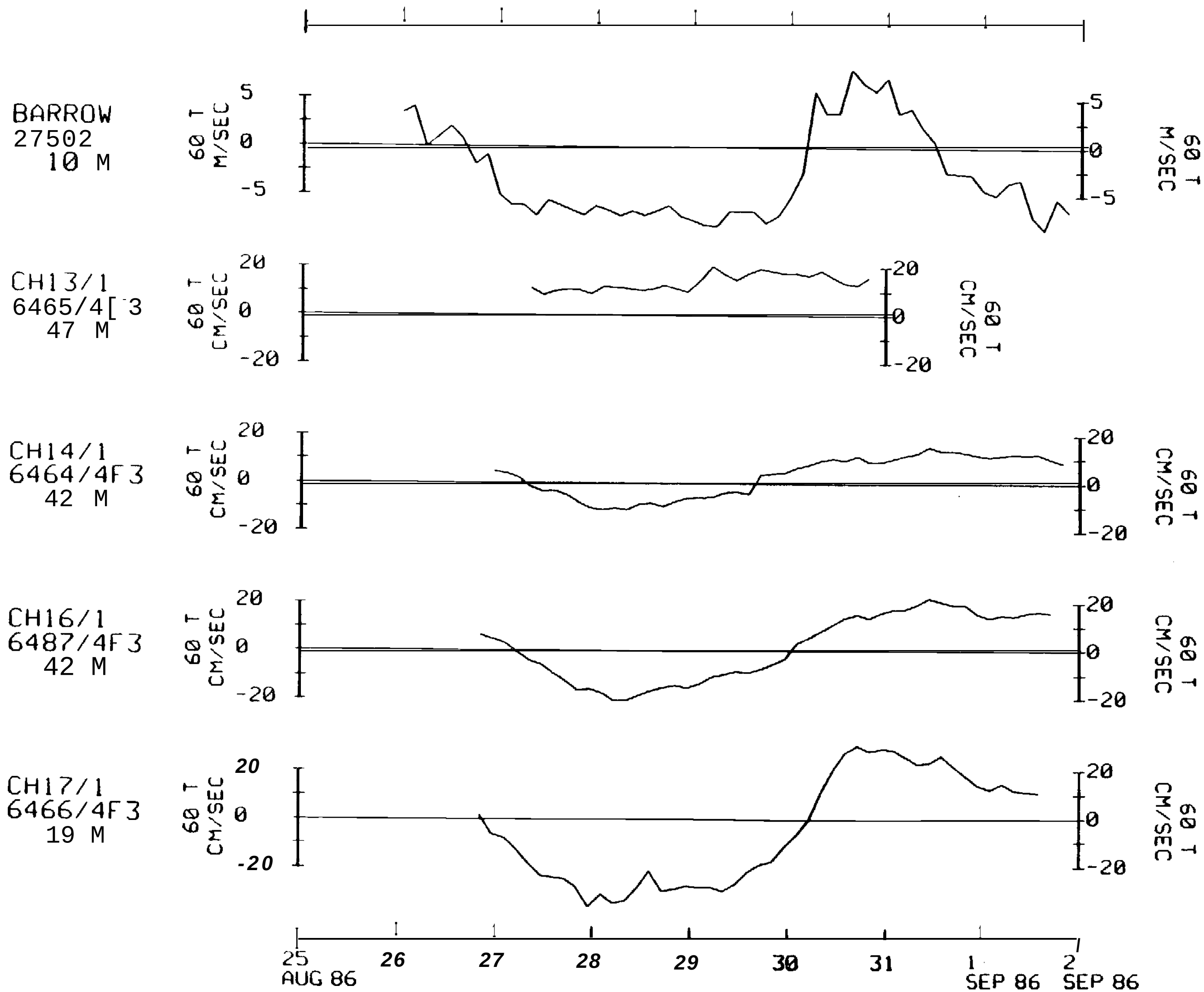

Figure 15. Time series of the wind and current along the 60°T axis, approximately alongshore at Barrow and the current meter moorings.

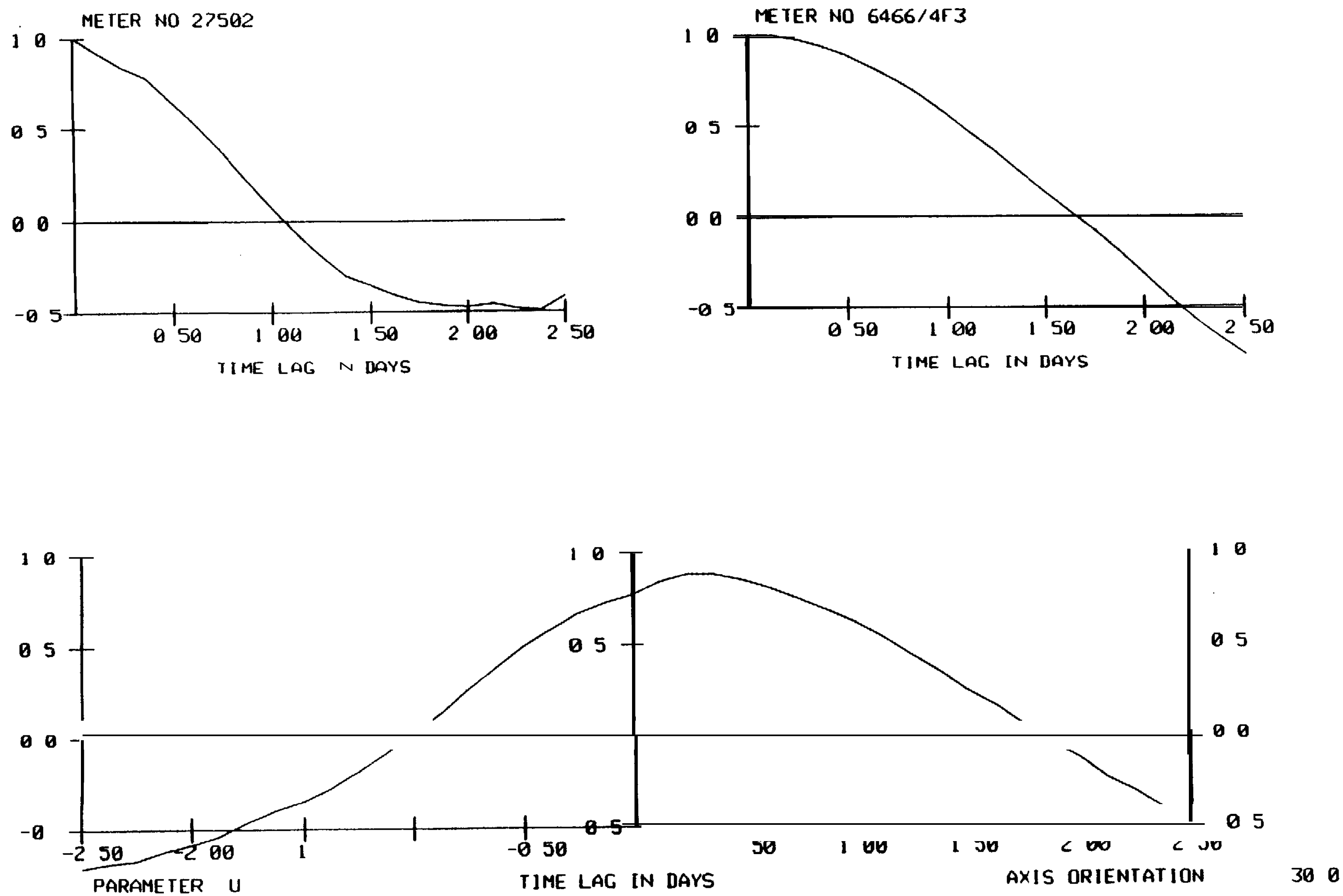

Figure 16. Lag autocorrelation and cross correlation functions for Barrow and CH17, calculated for the time sezies along the $60^{\circ}T$ axis (30° rotation).

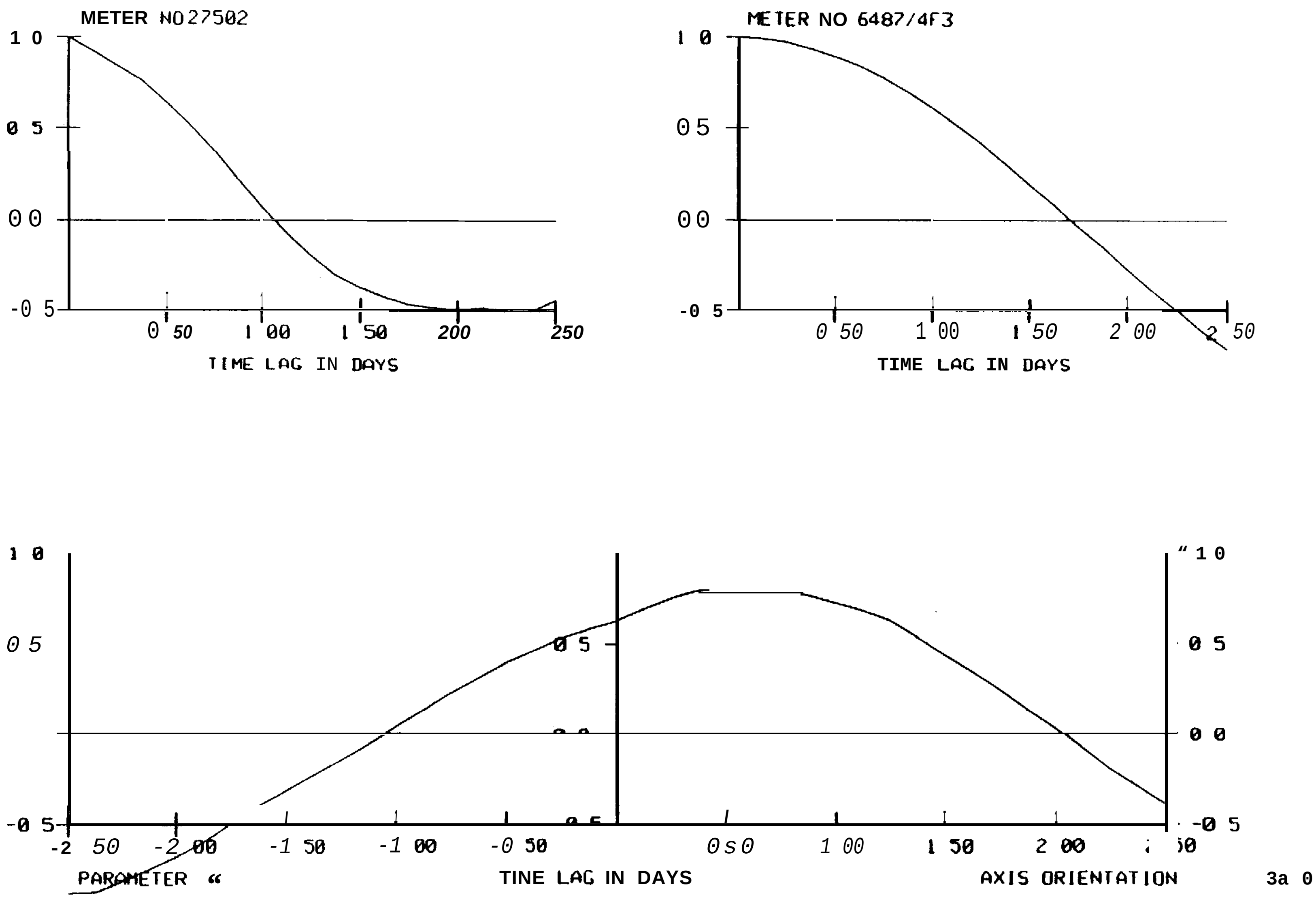

Figure 17, Lag autocorrelation and cross correlation functions for Barrow and CH16, calculated for the time series along the 60°T axis (30° rotation) .

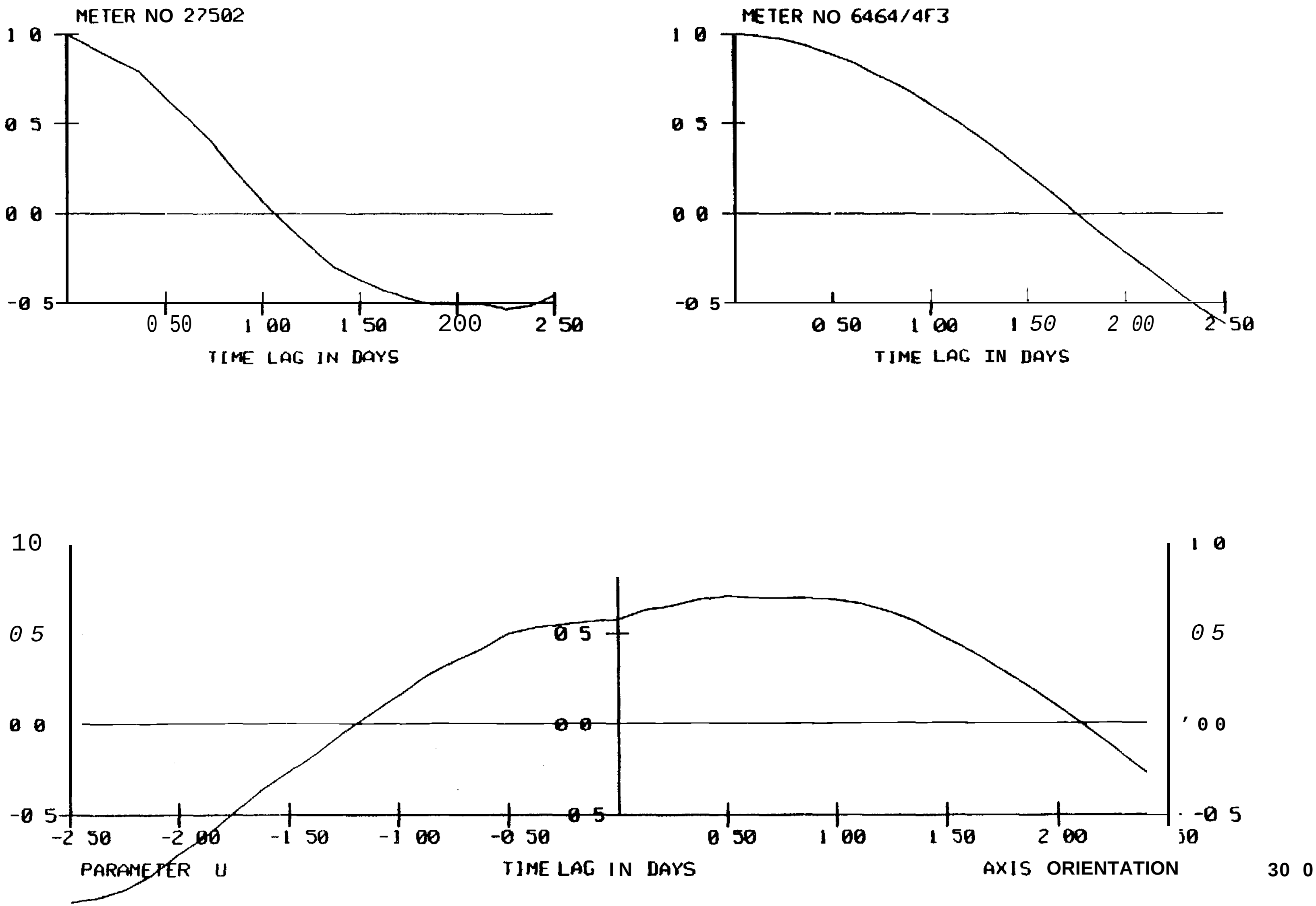

Figure 18. Lag autocorrelation and cross correlation functions for Barrow and CH14, calculated for the time series along the 60°T axis (30° rotation) .

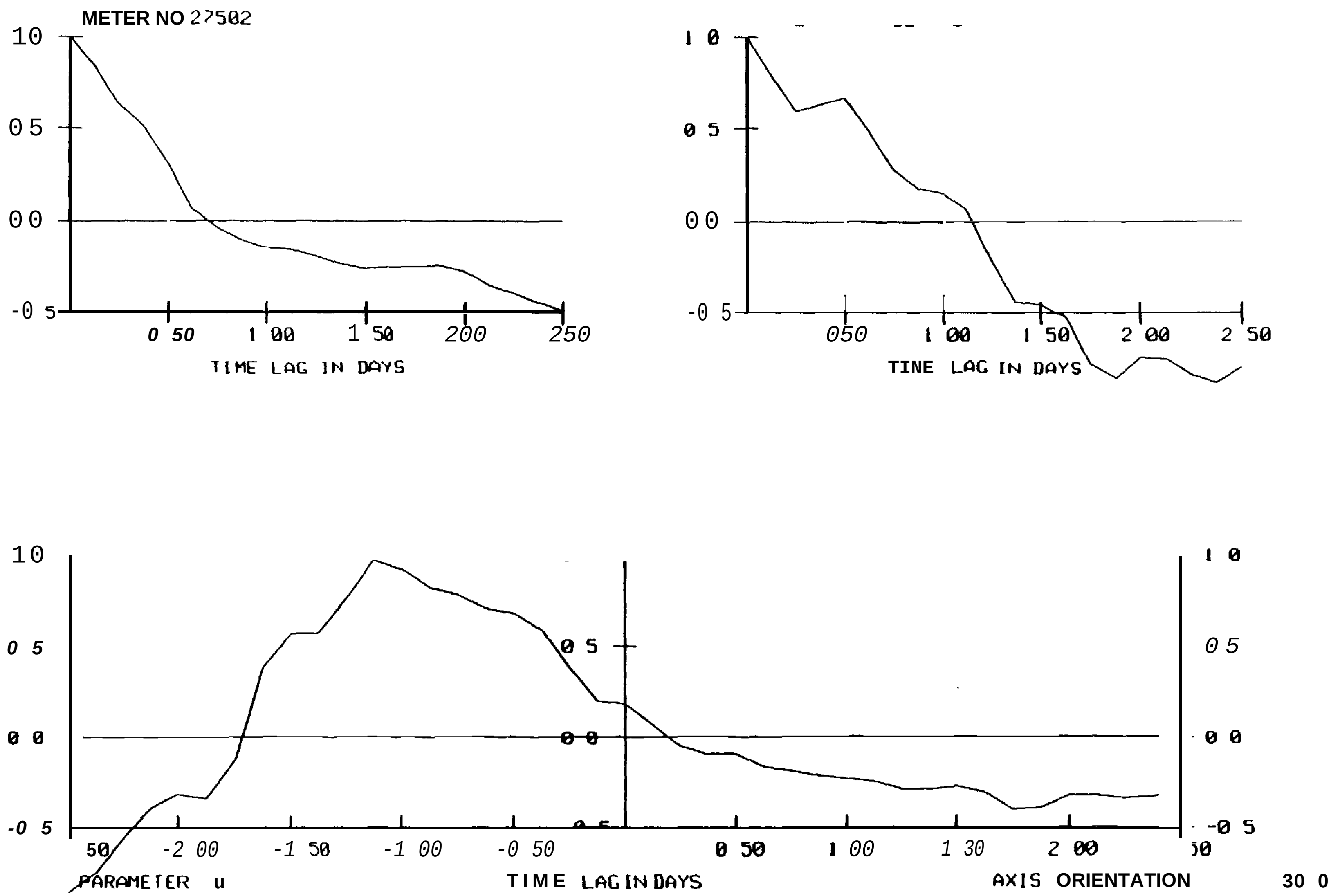

Figure 19. Lag autocorrelation and cross correlation functions for Barrow and CH13, calculated for the time series along the 60°T axis (30° rotation) .

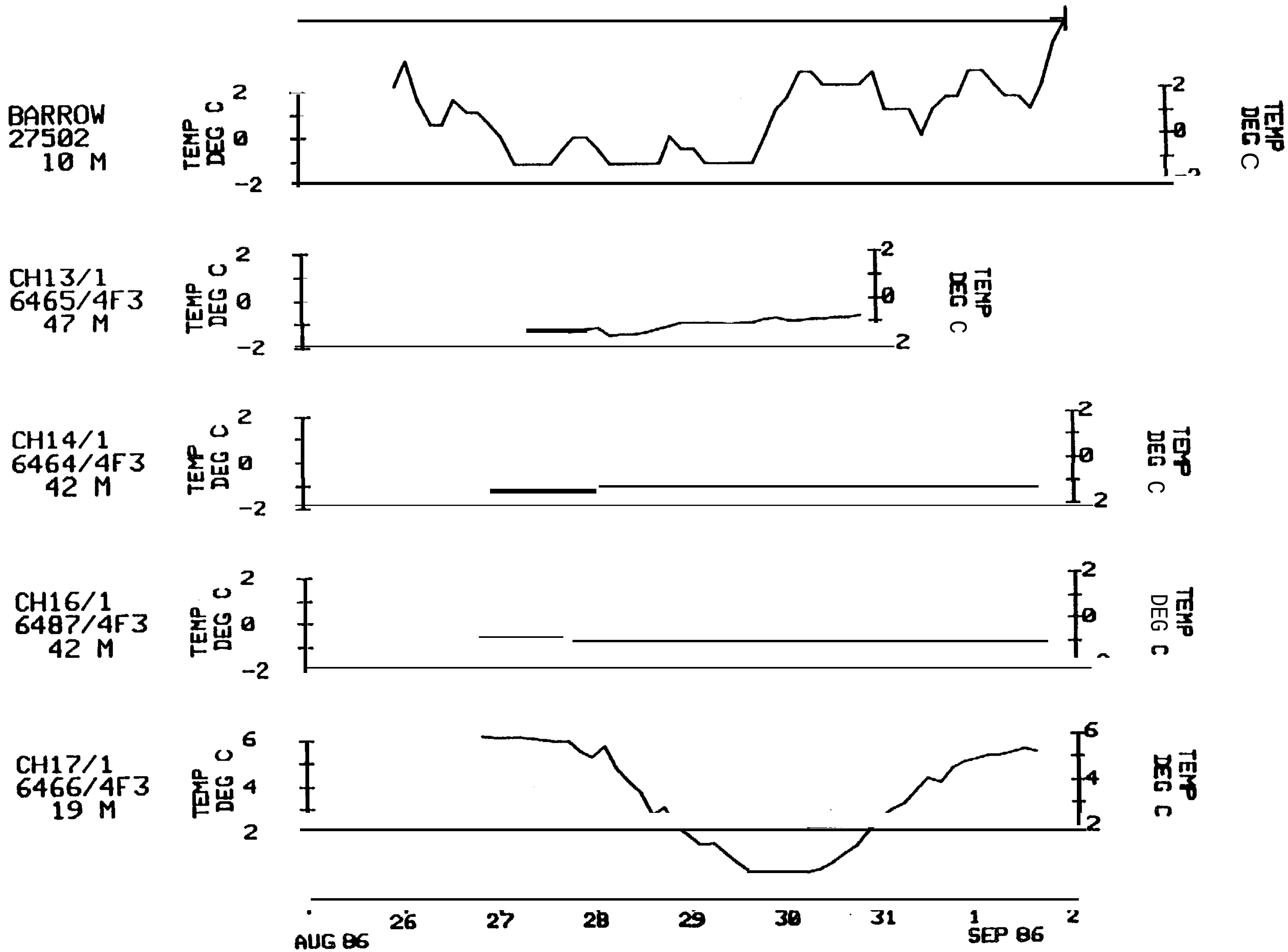

Figure 2o Time series of temperature measured at the moorings

at CH17 decreased from warmer than 6°C before the wind reversal to less than 0° on August 30. The two current meters at CH16 and CH14 showed very slight decreases, but they were near the bottom and were measuring less than 0°C prior to the wind event. The timing of the temperature response produced the minimum temperature coincident with the reversal of the current from the anomalous southwestward flow to northeastward. From the CTD cross section, the 0° isotherm occurred at about 30 m depth following the event, when the moorings were recovered (Fig. 21)". Thus, the upwelling resulted in lifting this isotherm at least 10 m to the 19 m depth of the CH17 current meter. The salinity cross section indicates that the coastal water had higher salinity than the surface water adjacent offshore (Fig. 22).

2. Acoustic Doppler Currents

The ADCP currents from the ship mounted system give an idea of the horizontal extent of the current response. The ADCP data were acquired from a point near Barrow on the cruise continuously throughout the cruise at two minute intervals. These data were smoothed with a 61 point triangular filter and then subsampled at one hour intervals. The smoothed data show strong southwestward flow near Barrow at the same time and at roughly the same distance offshore as CH17 (Fig. 23). Subsequently, as the ship proceeded offshore, the current velocities must be interpreted with both the wind event time history and the spatial current distribution. The pattern of currents measured with the system does reproduce many of the features of the earlier descriptions of the flow (Figs. 'l-2; Fleming and Heggarty, 1966; Creager and McManus, 1966; Coachman *et al.*, 1975). In particular, the recirculation in the major embayment behind Point Hope is indicated, as well as the northeastward flow in the band offshore, associated with the Bering

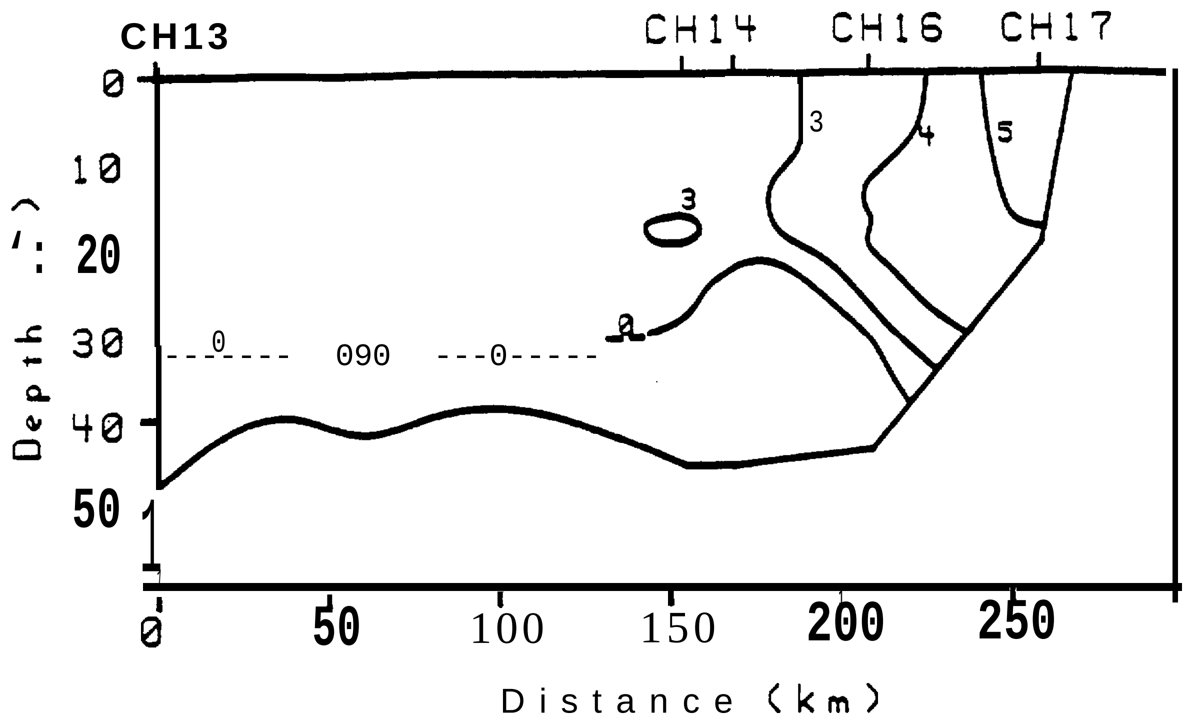

Figure 21. Cross section of temperature. Note that the contour interval is not constant.

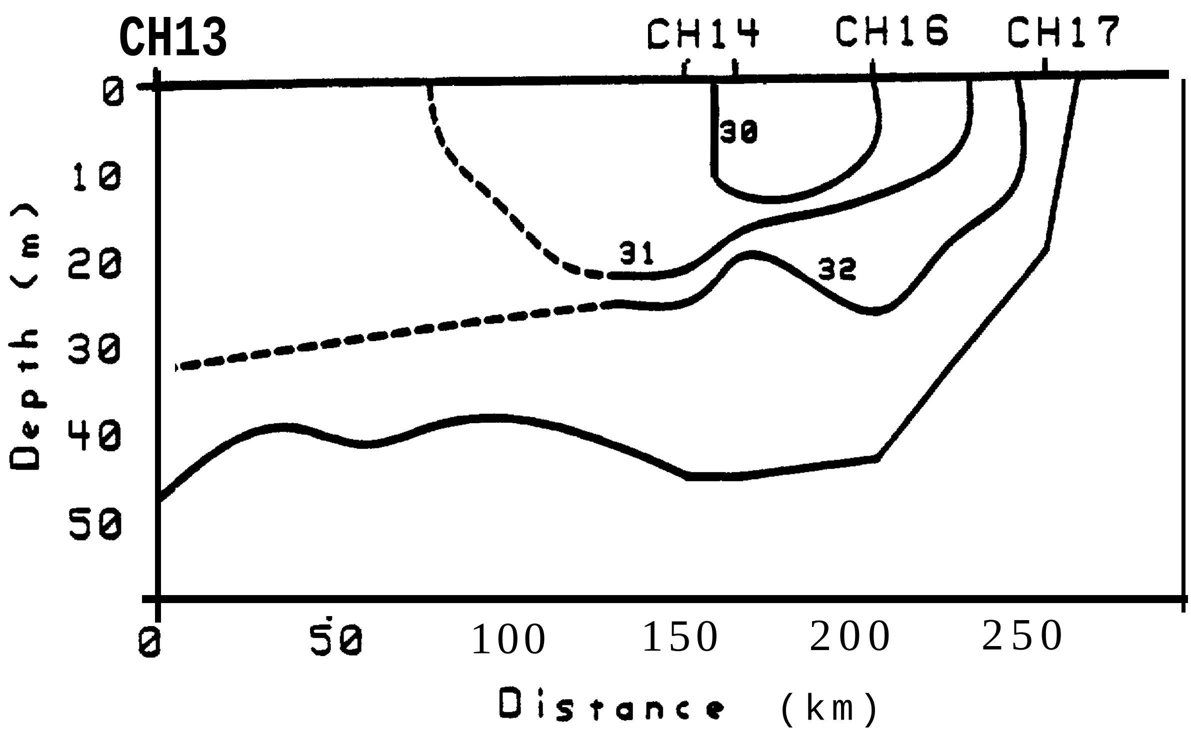

Figure 22. Cross section of salinity.

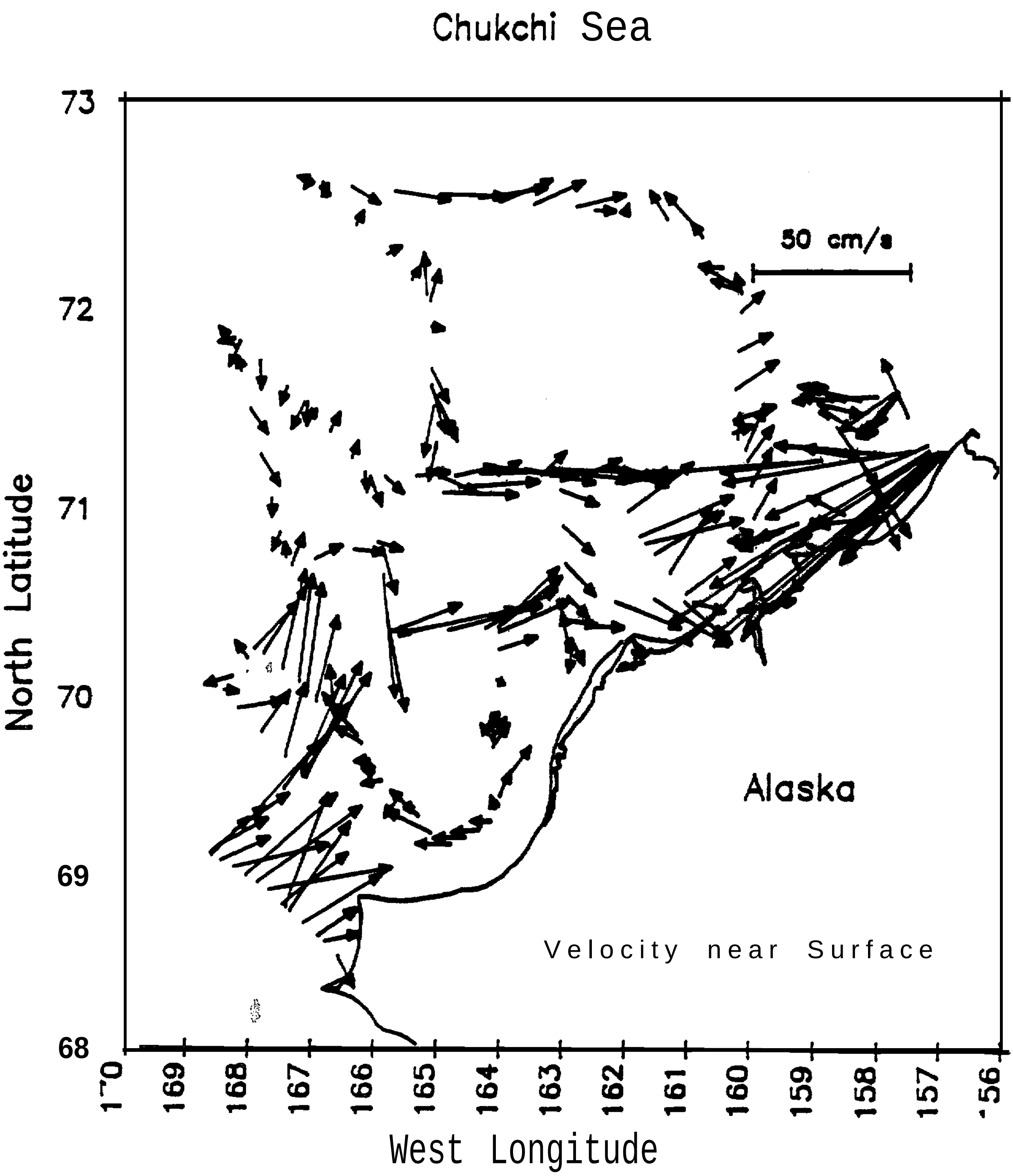

Figure 23. ADCP current estimates plotted on a chart. The estimates represent approximately one hour averages of the near surface current.

Sea Water. North of 70°30'N the currents are predominantly eastward and northeastward.

The ADCP results of a current reversal at Barrow (Fig. 24) coincident with the reversal event at CH17 is consistent with the observations made by Wilson et *al.* (1982) at Barrow and Wainwright. They found that the alongshore current within the coastal flow had a correlation coefficient of 0.90 at zero time lag. These results imply that the length scales of the alongshore flow is long compared to the distance between Barrow and Wainwright (700 km). Thus, the coastal "region of the northeast Chukchi Sea responds rapidly (within 6 hours) to wind forcing nearly as a unit from Point Barrow to Point Hope.

3. Water Mass Analysis

Water mass analysis was conducted using two techniques, the first was a traditional T-S diagram method and the second was a cluster analysis on T-S pairs for the surface and near bottom waters. The cluster analysis was employed because it is less subject to bias by the analyst. A T-S diagram of all the stations indicates that the ranges 01 the temperatures and salinities are consistent with those observed earlier (Fig. 25; Coachman et *al.,* 1975). Stations sampled within the coastal domain often had a limited range of temperature and salinity. The separation of the Chukchi Resident Water and the Beaufort Sea Water is a subjective one near the end point (i.e., the freezing point curve). Garrison and Becker (1976) use a line across the base of the T-S diagram (from -1.6, 31.7 to -1.78, 34.0) to define the Chukchi Water. Paquette and Bourke (1981) use a similar range of T.-S to define "northern water", which could be Chukchi or Beaufort derived. Garrison and Becker (1976) used "warm" differences from the Chukchi Water line to show the influence of the Beaufort Water. The late

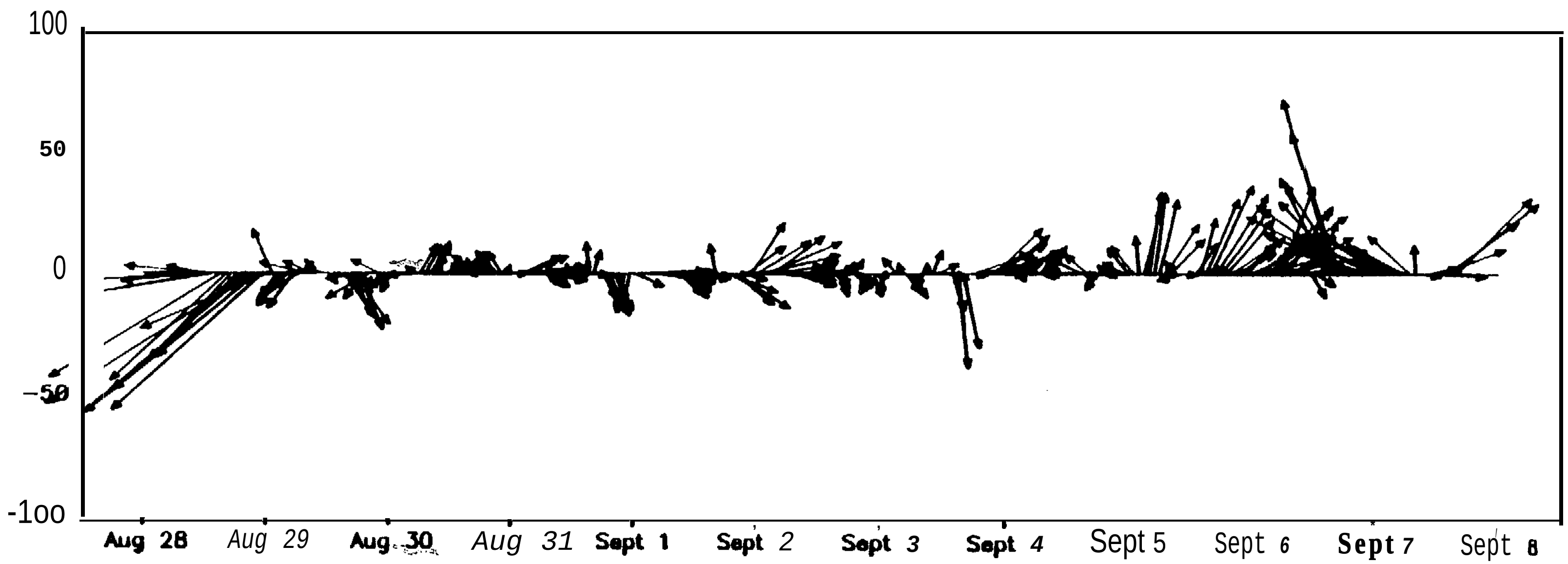

Figure 24. ADCP cut-rent estimates plotted from the ship as a time series. The vectors represent time and spatial variation since the ship was moving during most of the measurements. The estimates were averaged and then interpolated to one-hour intervals. See Figure 23 for the map showing the ADCP vectors.

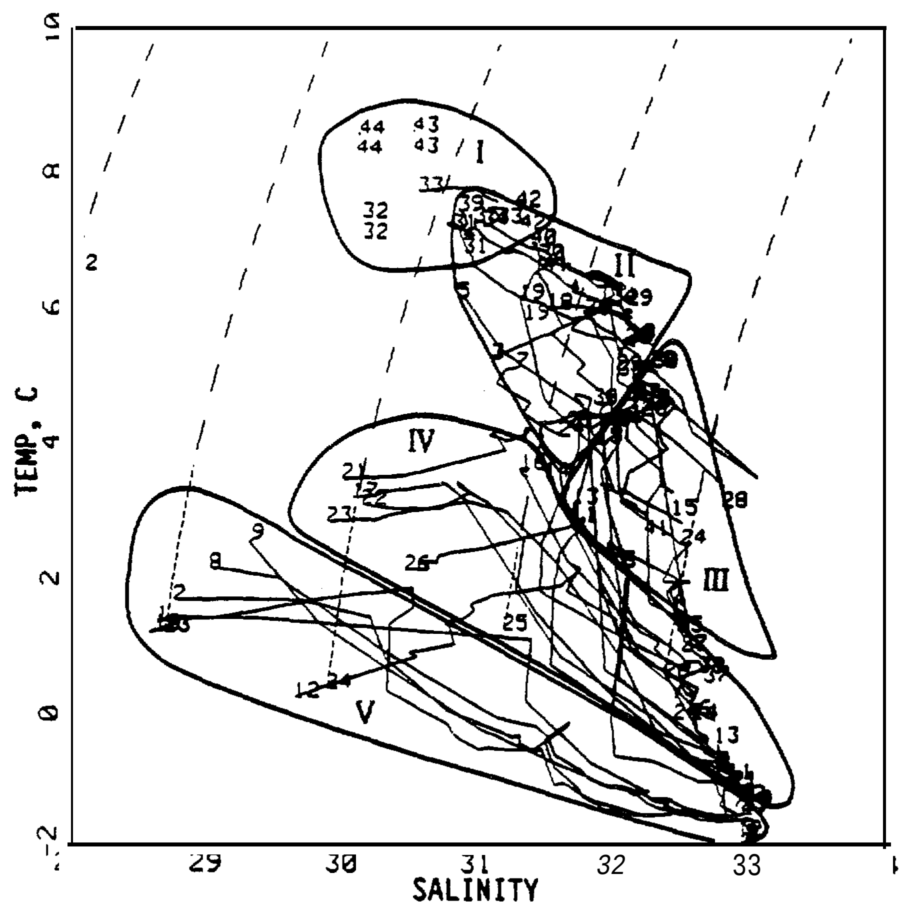

Figure 25. T-S (temperature-salinity) diagram for all of the CTD stations. The lines indicate the water mass designations in the text.

summer-autumn conditions of the *Oceanographer* cruise also meant that the definitions used for the spring (ice-edge) conditions are not always applicable. To avoid adding to a pantheon of water mass names, very general (inclusive) categories were established and the stations were assigned to them (Table 4). The major groups are shown in Figures 26-31. Based on the shapes of the T-S curves and their positions on the T-S diagrams, a map of the water masses was constructed (Fig. 32). Water masses designated I and II constitute water derived from the Alaska coast and Bering Shelf,

TABLE 4. Water mass groupings based on T-S diagram analysis

Mass I	Mass II	Mass III	Mass IV	Mass V
CH18	CH17	CH22	CH4	CH2
CH31	CH19	CH26	CH5	CH3
CH32	CH29	CH27	CH6	CH9
CH34	CH30	CH28	CH7	CH10
CH43	CH35	CH38	CH8	CH11
CH44	CH36	CH40	CH13	
CH4S	CH37		CH14	
	CH42		CH15	
	CH46		CH16	
	CH47		CH20	
			CH21	
			CH23	
			CH24	
			CH25	
			CH39	

without significant modification. Mass I is Coastal Water and has warm temperatures. Mass II has warm temperatures connected to the coastal water, but has bottom salinities in the range of 32.0 to 32.2. The adjacent water mass, designated III, has generally lower temperatures and slightly higher bottom salinities. The two northernmost masses, IV and V, show significant influence of the Beaufort Sea or residence in the Chukchi Sea. These designations represent part of the mixing continuum from the Bering Sea water to the Beaufort Sea/Chukchi Sea water (Fig. 32).

As an objective approach to the problem of designating water masses, a cluster analysis was performed on the surface T-S pairs from each station and separately for the bottom T-S pairs. A similar cluster analysis with all of the T-S pairs for all the depths at each station produced results which were difficult to interpret, This was because many of the stations have temperature inversions or indications of interleaving water masses. Thus, only the results of the surface and bottom calculations will be used.

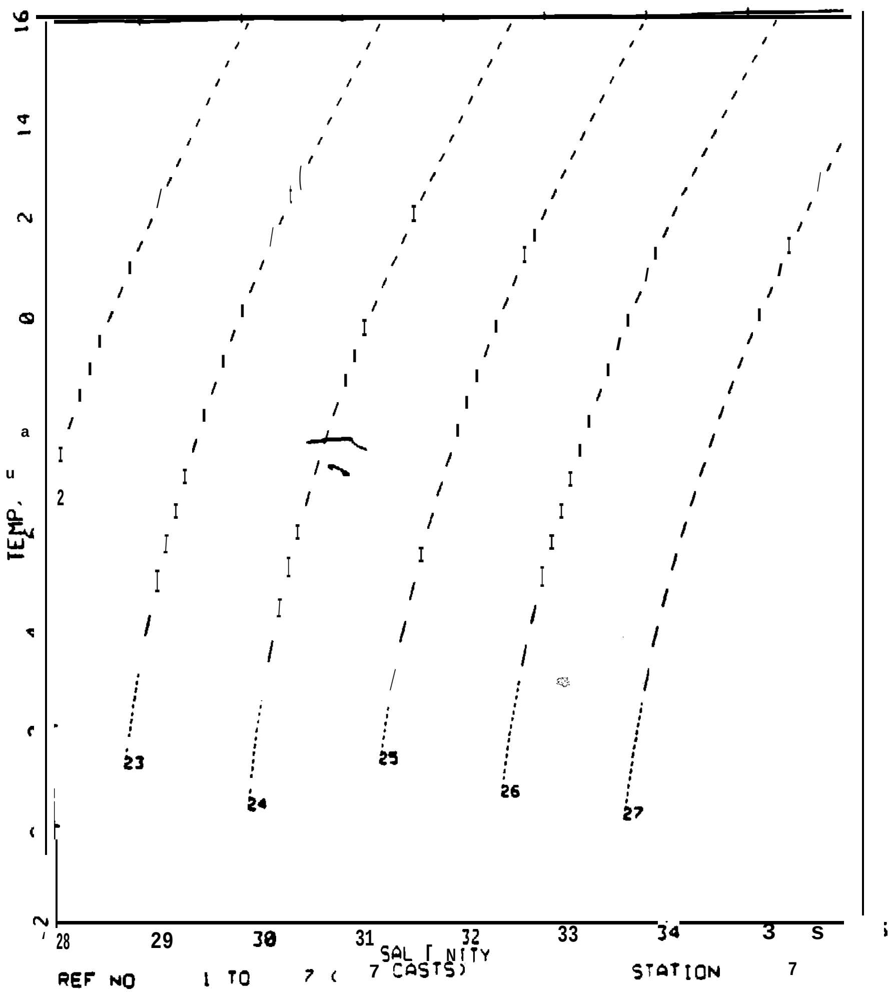

Figure 26. T-S diagram of the Coastal Water, Mass I.

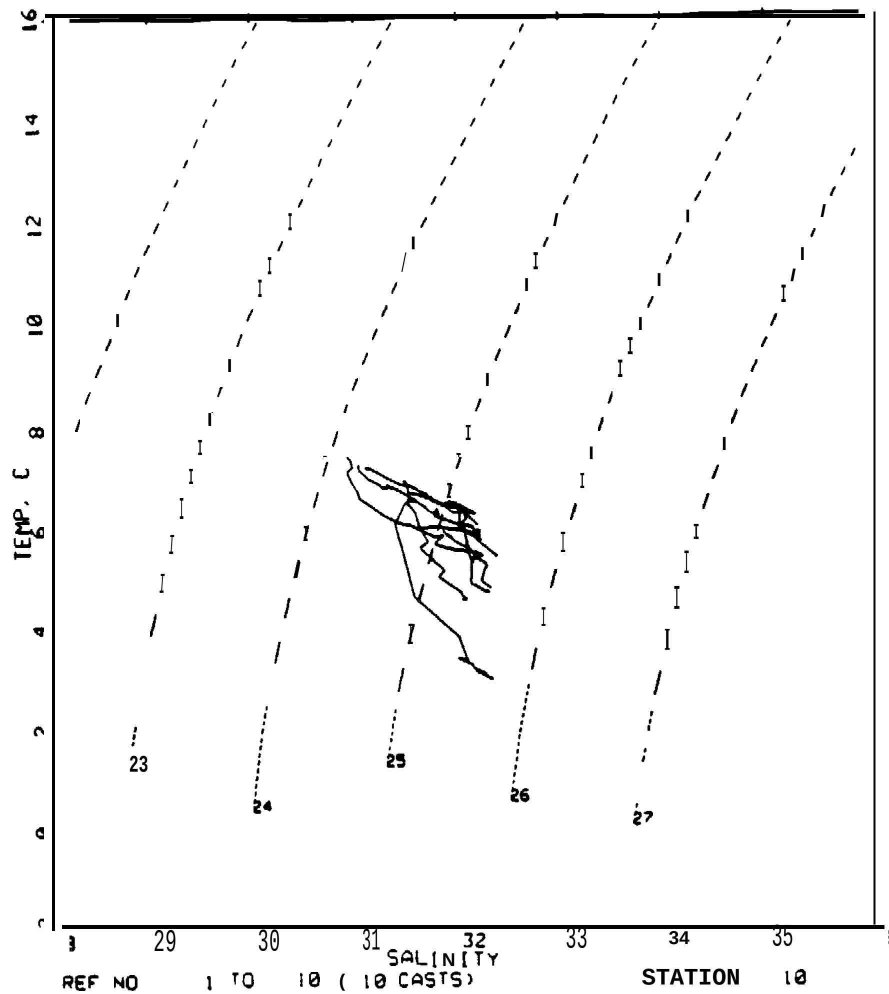

Figure 27. T-S diagram of the Bering Sea Water, Mass II.

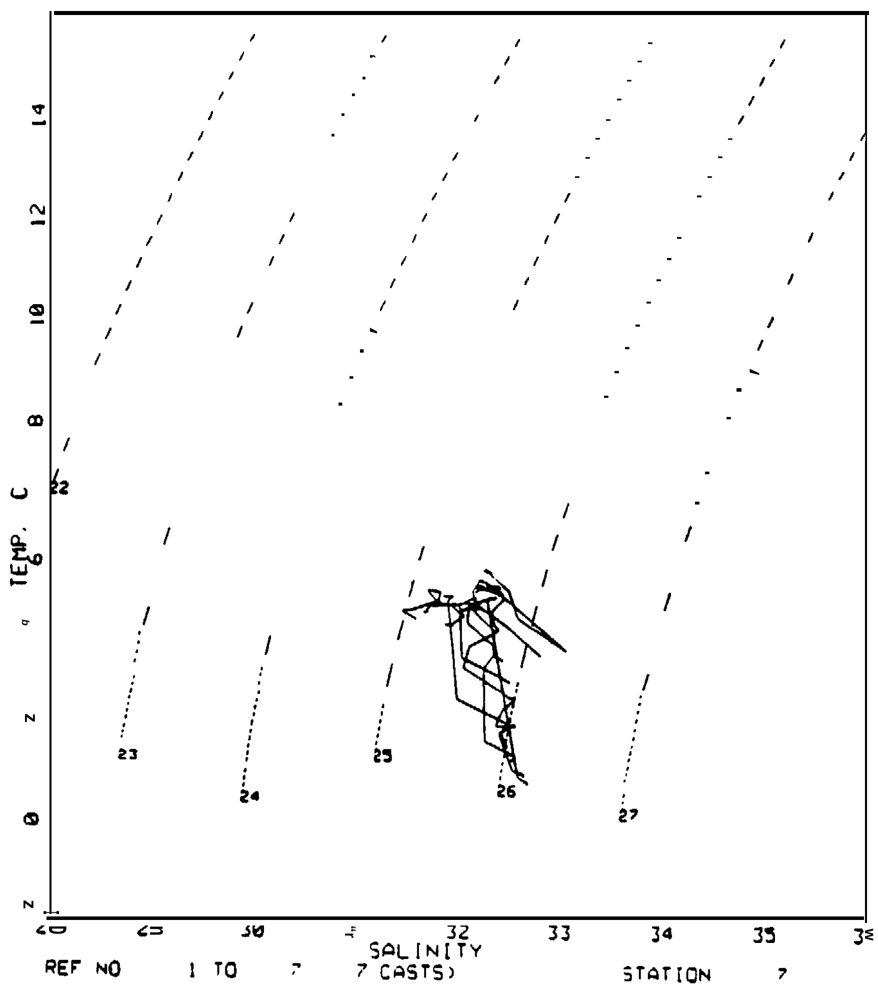

Figure 28. T-S diagram of the Chukchi Water, Mass III.

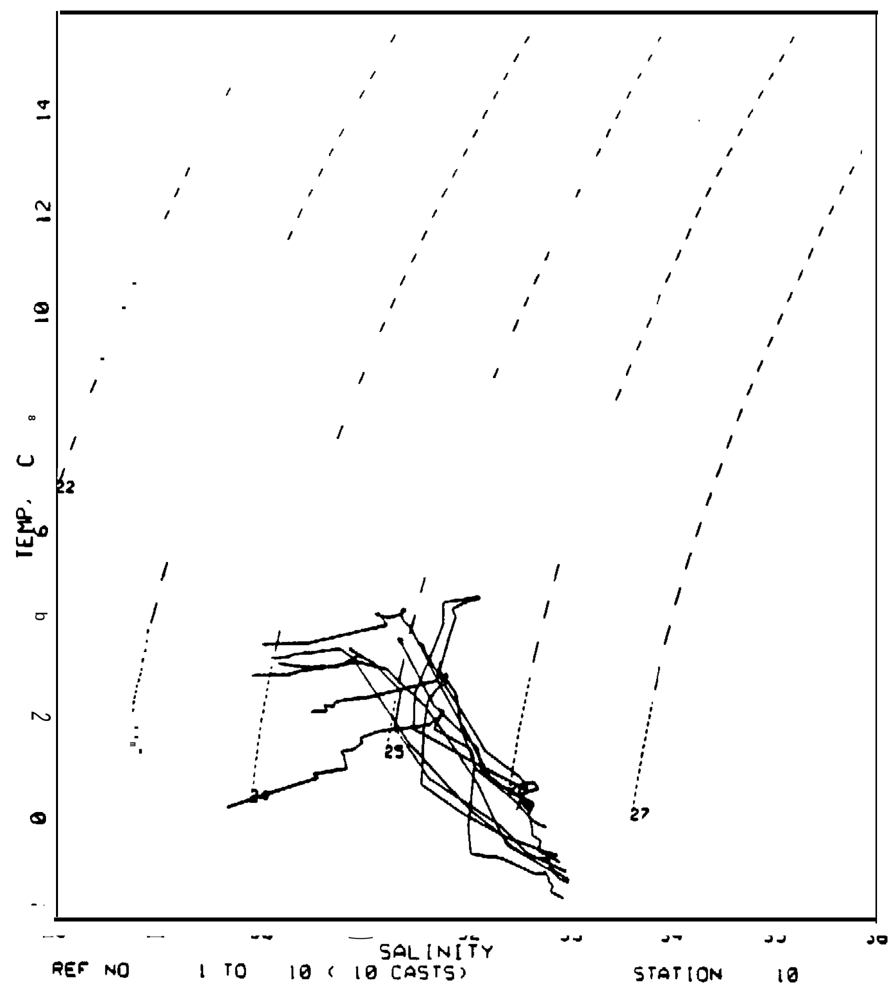

Figure 29. T-S diagram of the Chukchi Water, Mass IVa.

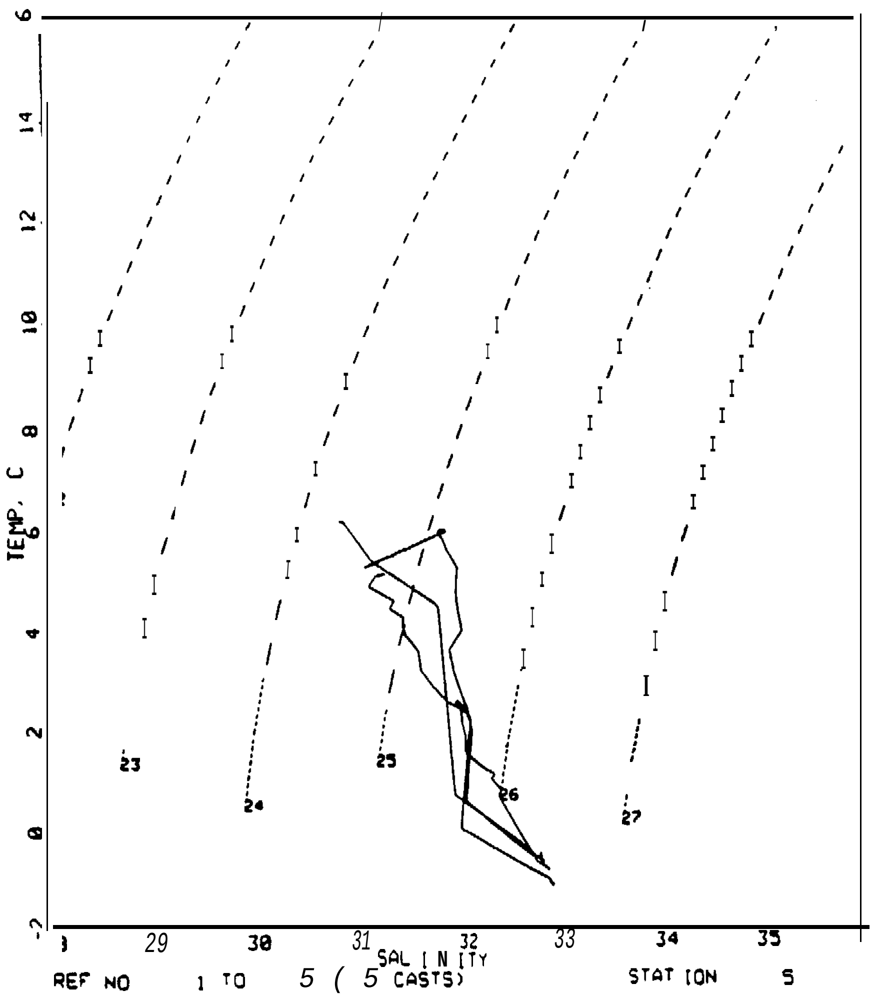

Figure 30. T-S diagram of the Chukchi Water, Mass IVb.

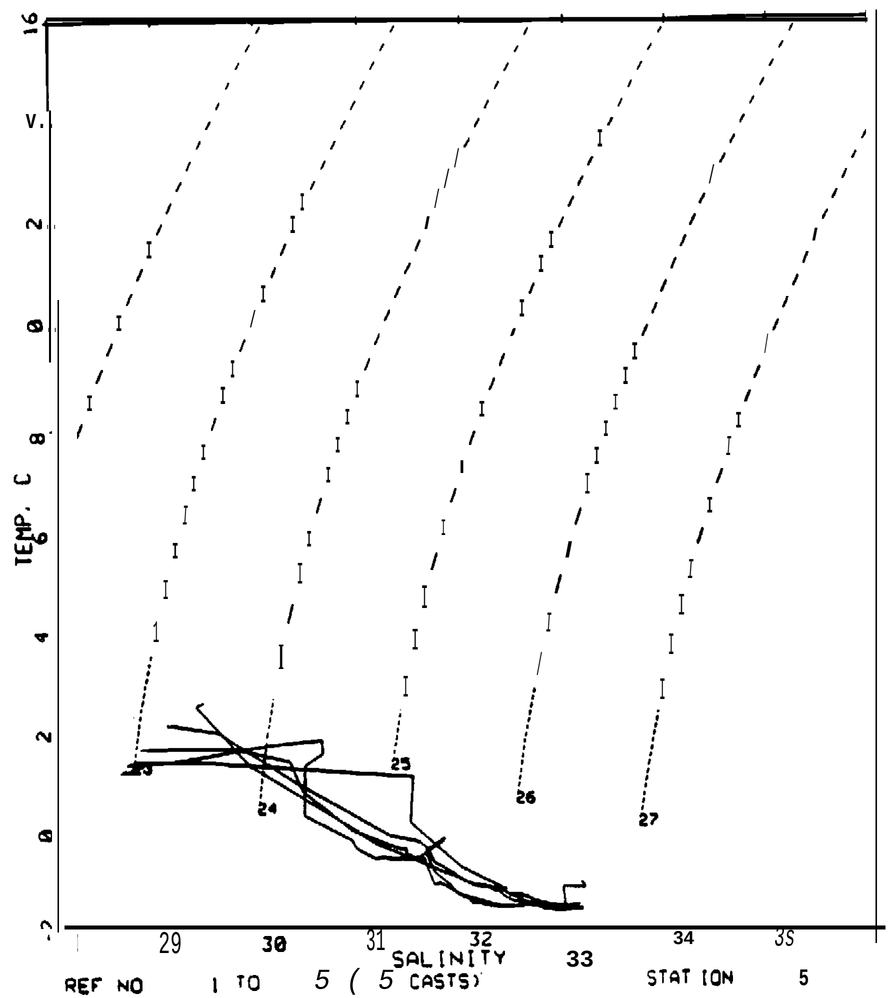

Figure 31. T-S diagram of the Beaufort Water, Mass V.

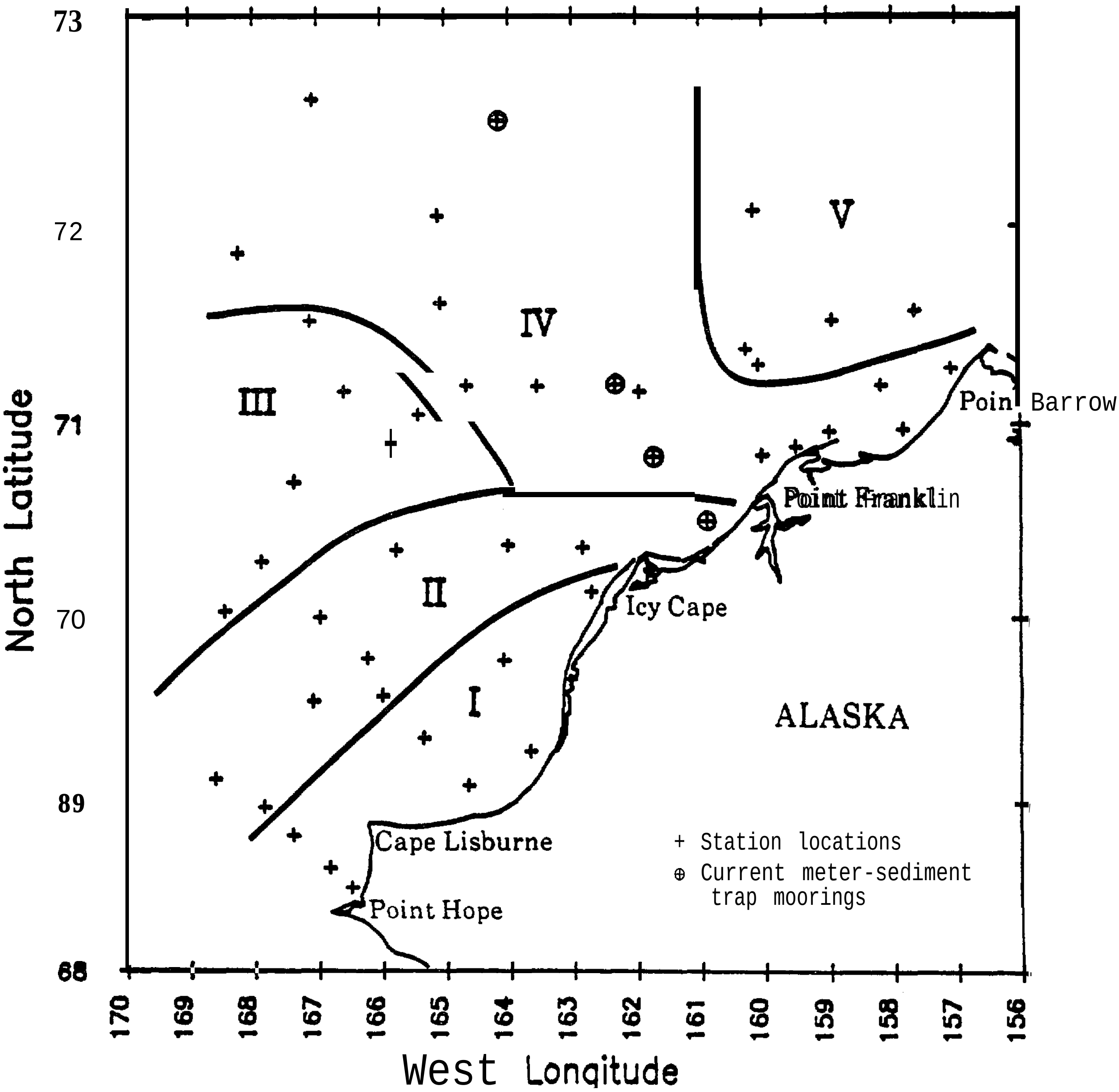

Figure 32. Chart of the water mass groupings based on the T-S diagrams.

The surface analysis (Fig. 33) yielded four groups at a 0.995 similarity index. Group I represents the Coastal-Bering Sea water, with warm temperatures and lower salinities. Group II is the **Chukchi** Water, with higher salinities and intermediate temperatures. Group III is the Beaufort

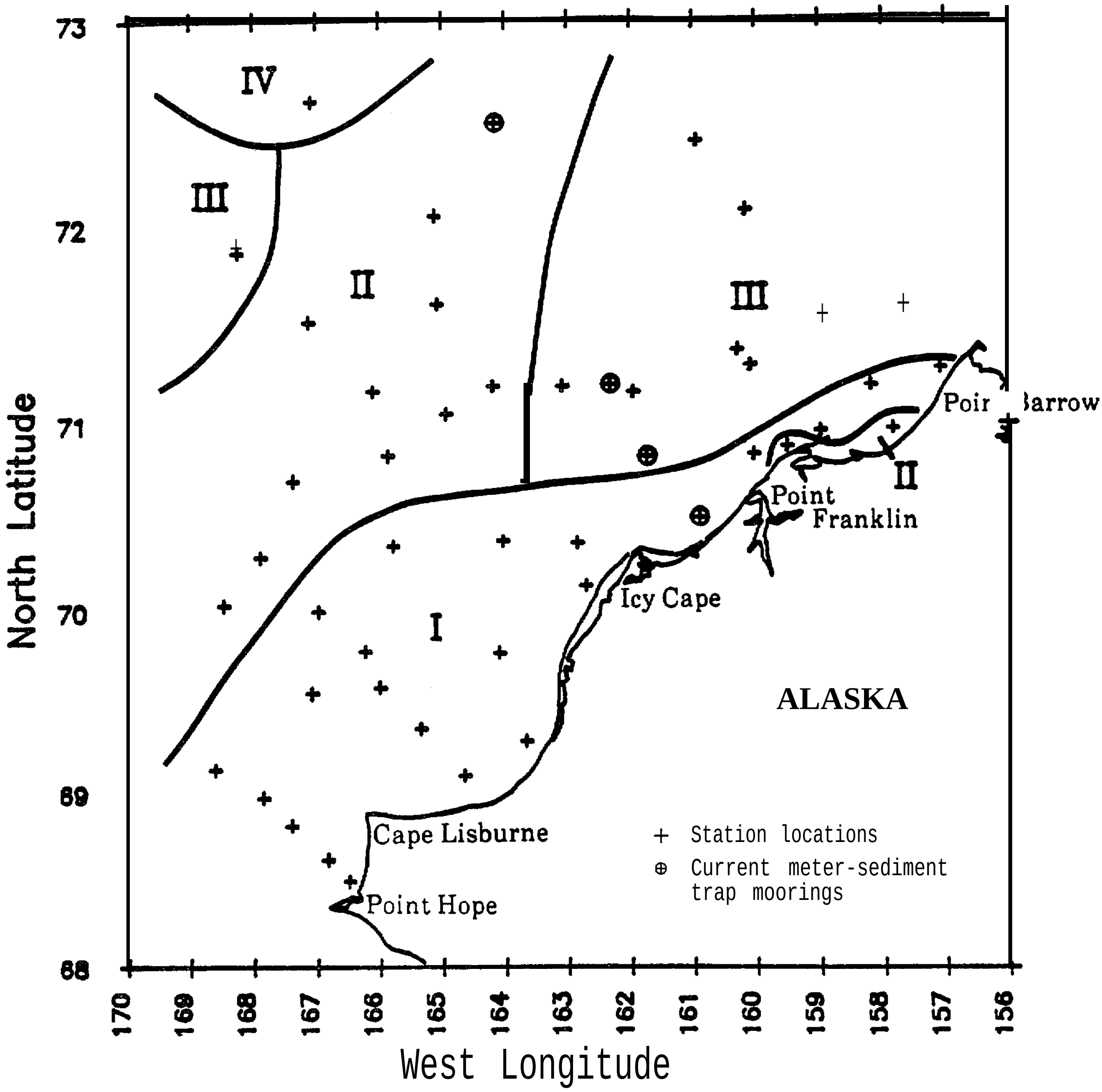

Figure 33. Chart of the water mass groupings based on the surface temperature and salinity cluster analysis.

Water, with most of the contributing stations in the northeast Portion Of the domain. The Group IV consists of a single station at the ice-edge, which had low temperature and salinity.

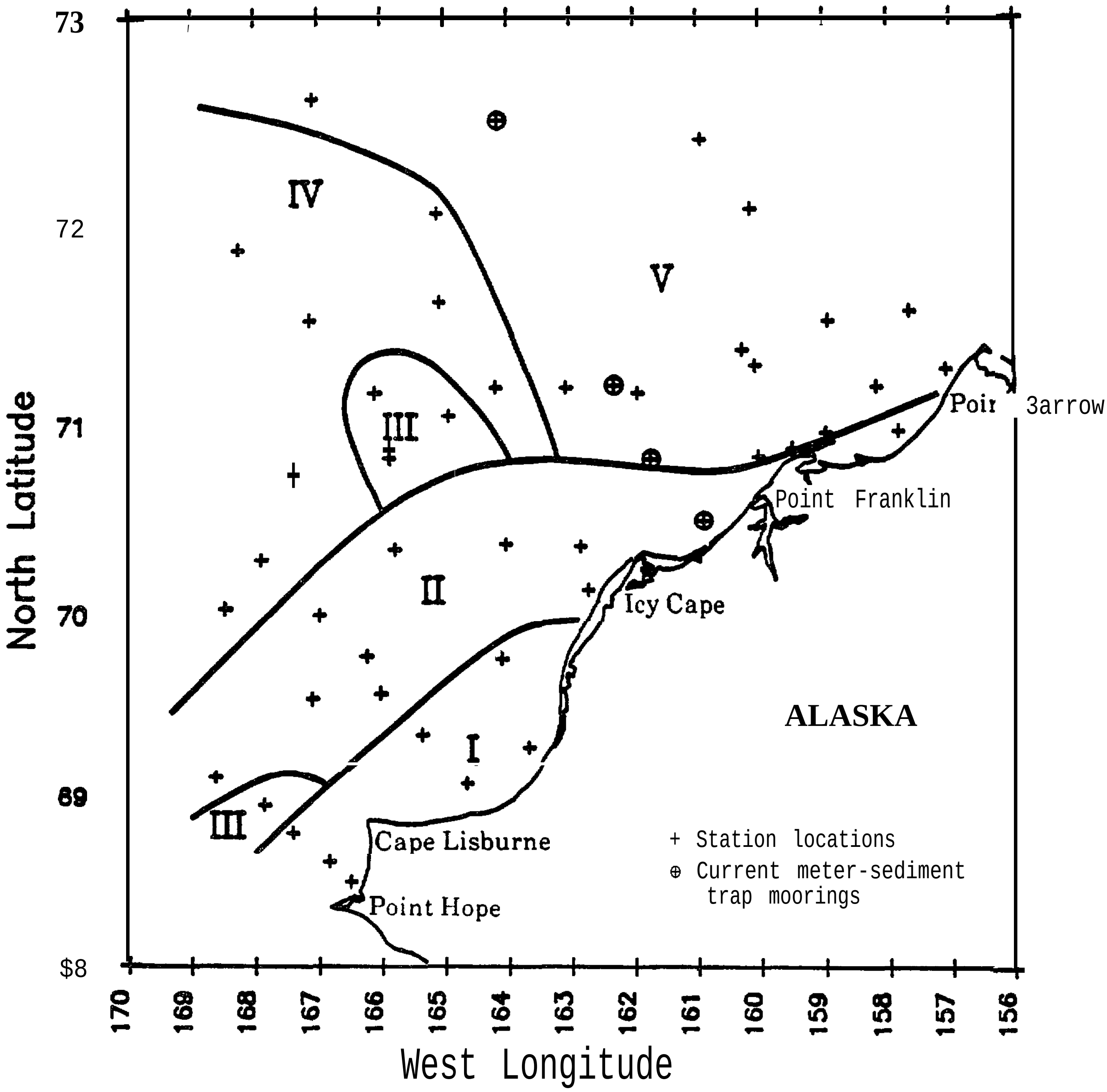

Figure 34. Chart of the water mass groupings based on the bottom temperature and salinity cluster analysis.

The bottom analysis indicated suggested five **groups** at the 0.97 similarity index, in a consistent pattern with the surface groups (**Fig.** 34). Groups I and II represent the Coastal water and Bering Sea water as before, although they can be separated based on the salinity at the bottom. Group III is a transitional group, representing a mixed water mass.

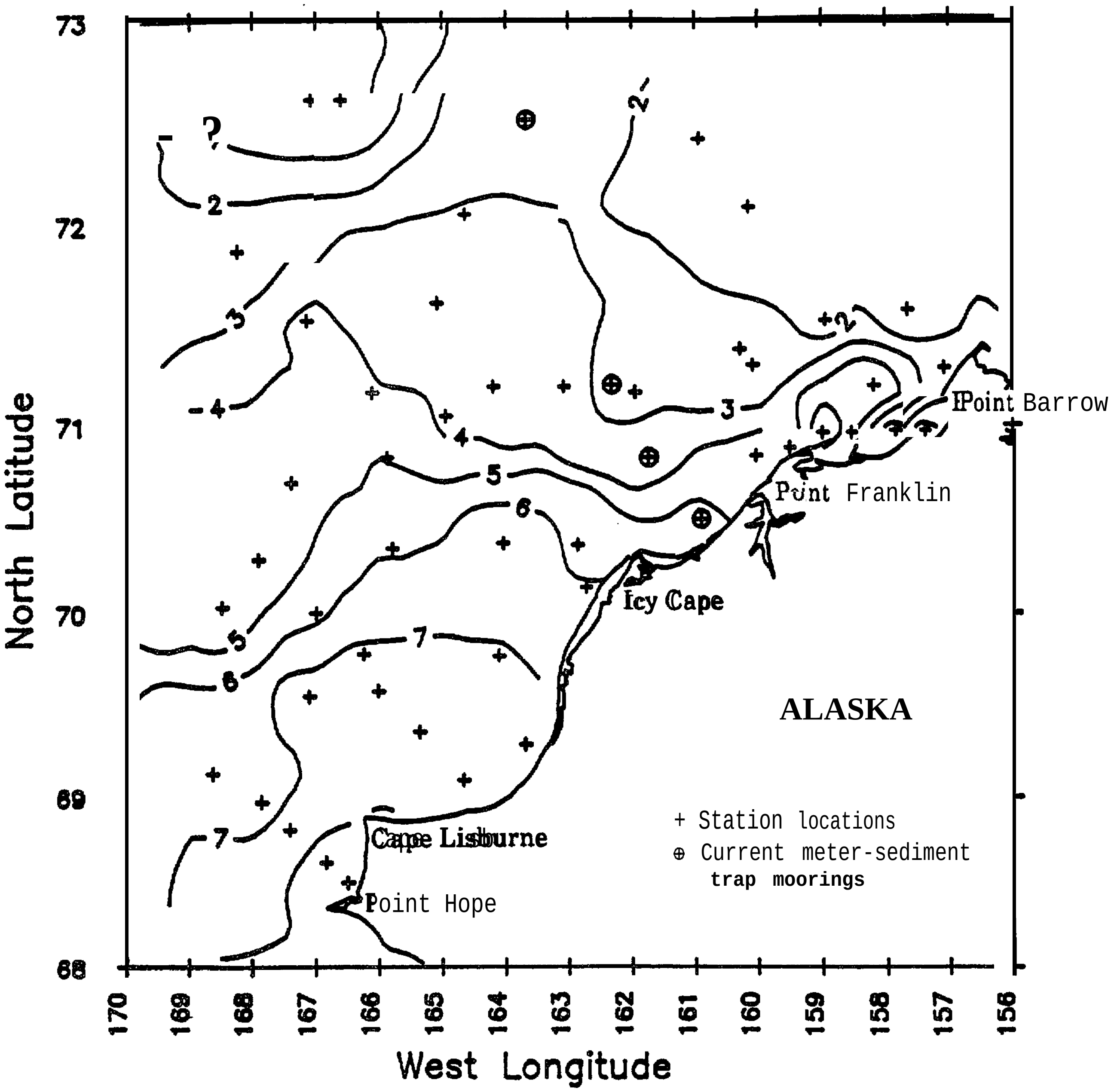

Figure 35. Chart of the surface temperature (“C) from the *Oceanographer, 1986.*

Groups IV and V are the northernmost groups, indicating the influence of the **Beaufort** Sea and the ice formation processes in the **Chukchi** Sea. The two northern groups (IV and V) merge in the next lower level of similarity, and then groups II and **III** merge. The coastal water remains distinct from all the other stations due to the warm **temperature, low** salinity conditions.

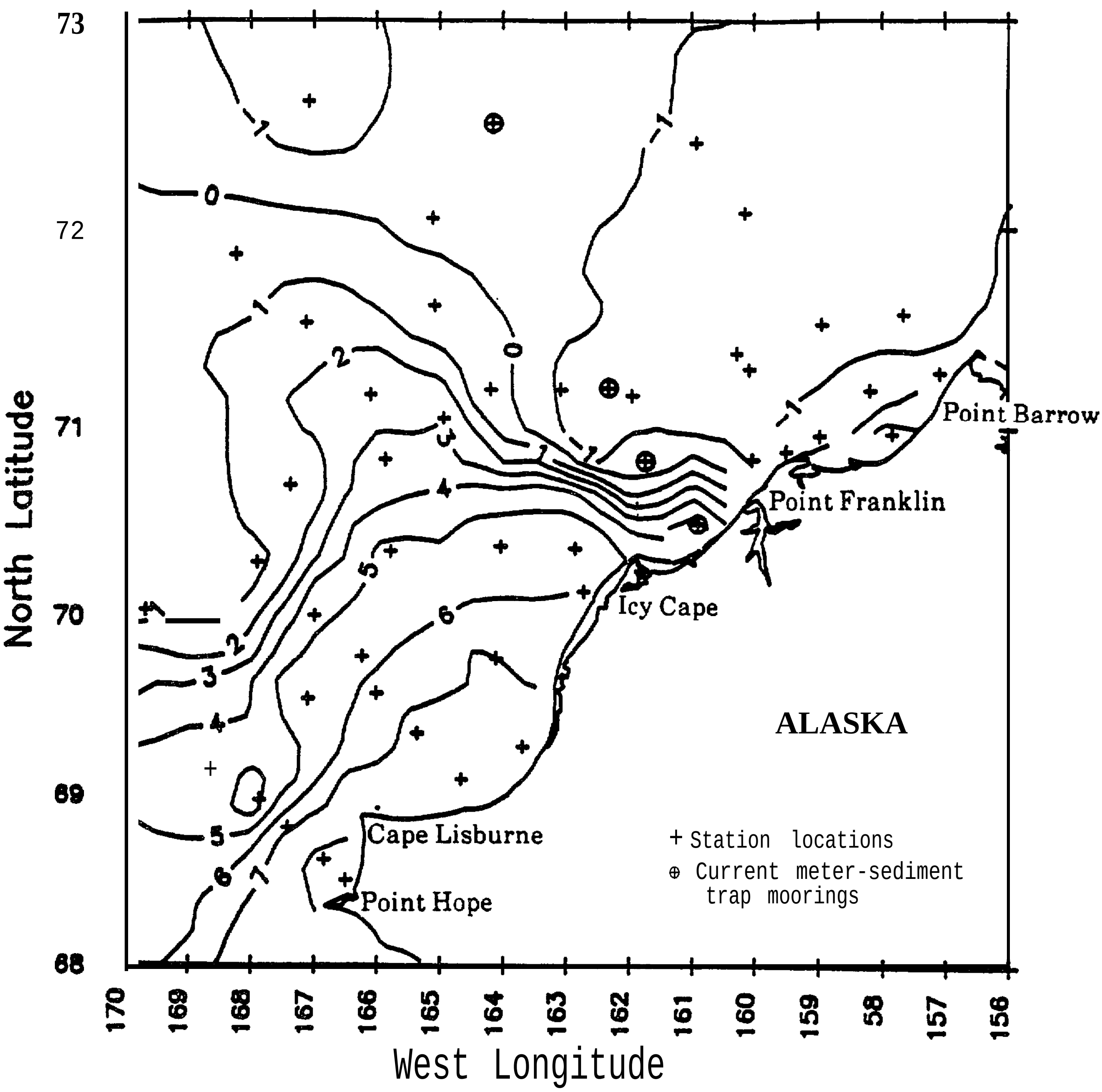

Figure 36. Chart of the bottom temperature (“C) from the *Oceanographer, 1986.*

For both of these techniques, the line separating the groupings follows the temperature contours (5°C at the surface, Fig. 35, and 4°C at the bottom, Fig. 36) and the bottom salinity contours (32.5 ‰, Fig. 37). The surface salinity differs from the other slightly, and appears to suggest a

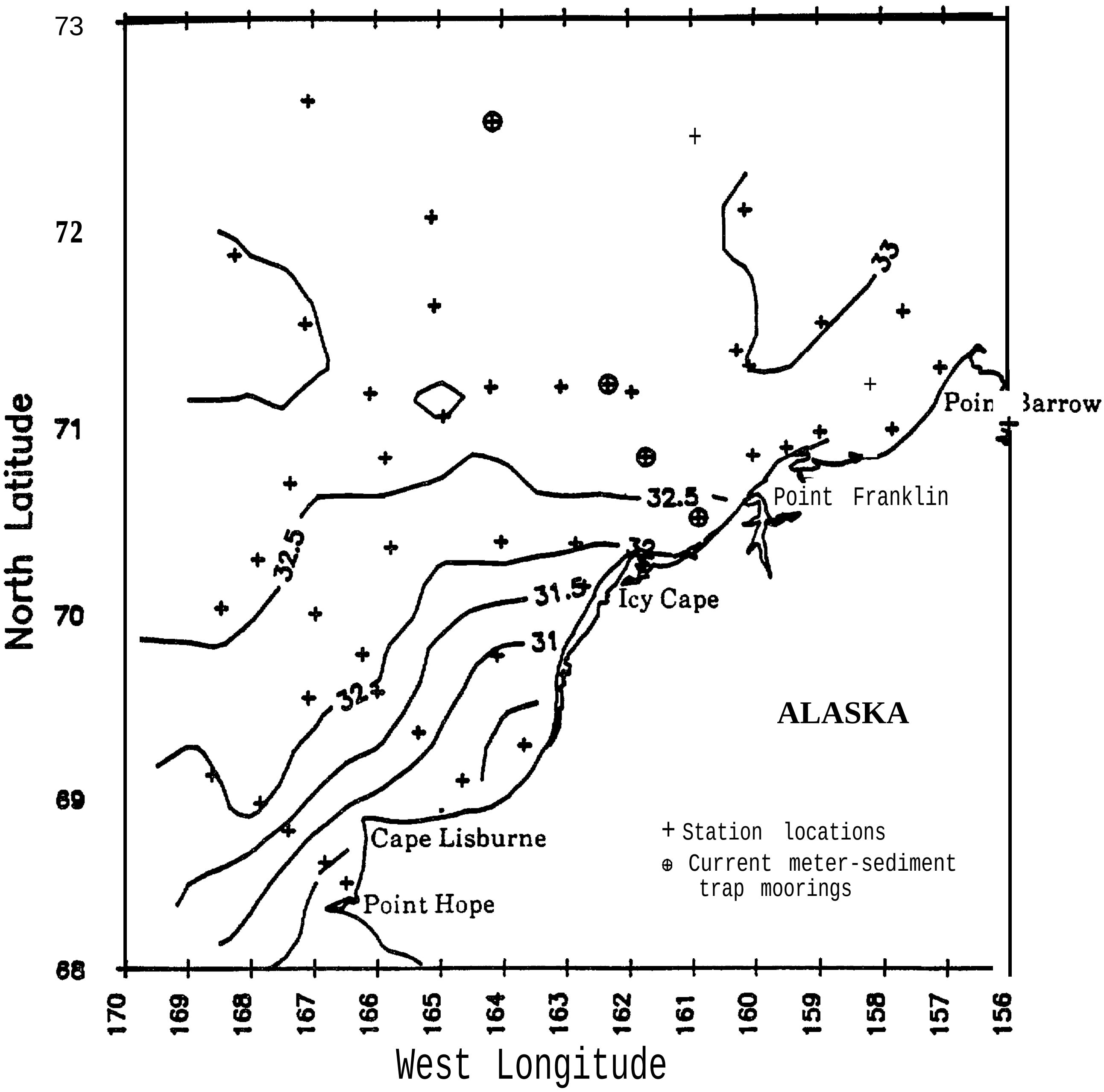

Figure 37. Chart of the bottom salinity from the *Oceanographer, 1986.*

connection of higher salinity surface waters (>32.0) to waters in the central Chukchi Sea (Fig. 38).

B. Geological Oceanography

The results of the grain size analyses of bottom sediments on a dry weight basis are listed in Table 5 and the regional distributional pattern

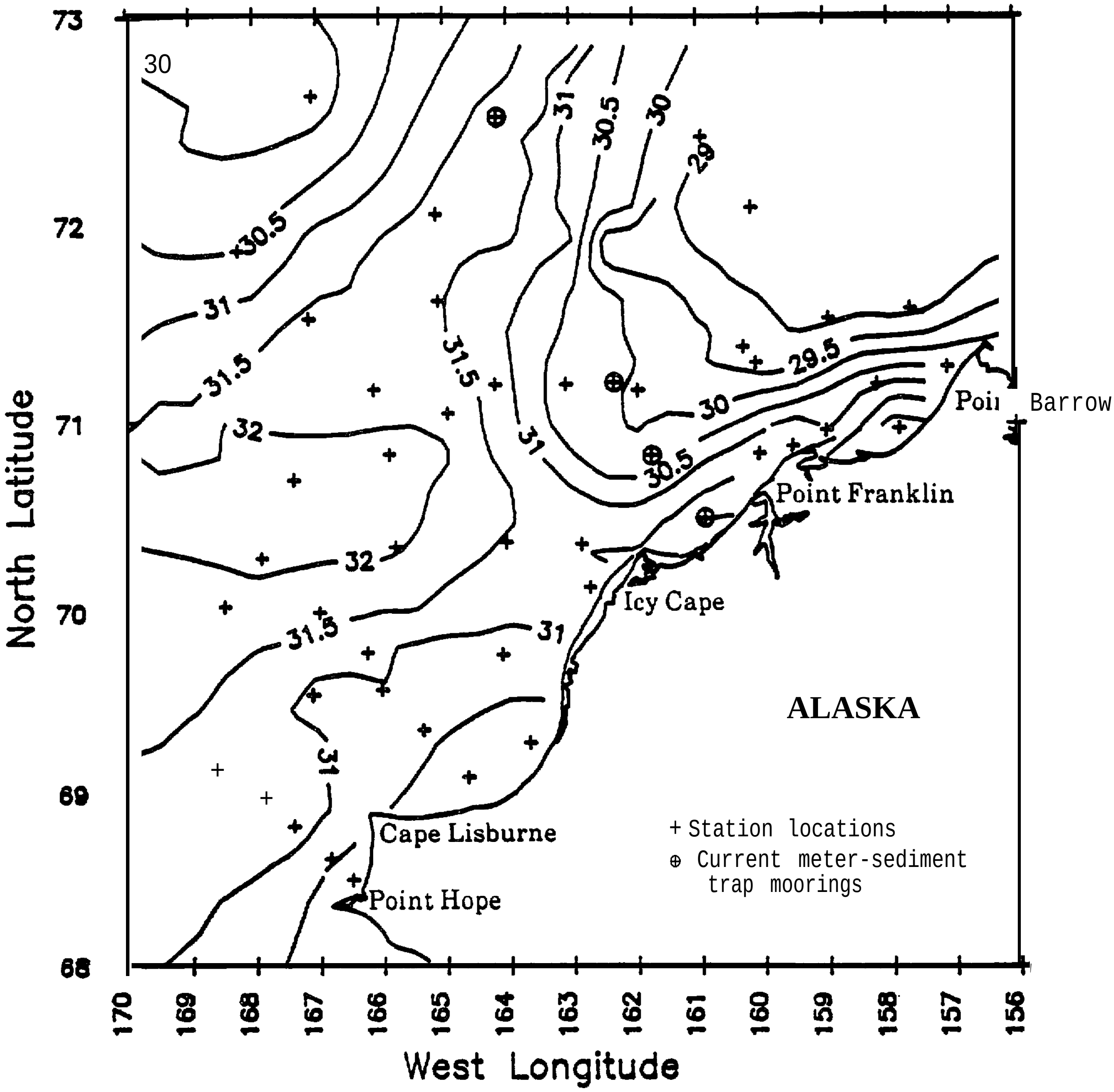

Figure 38. Chart of the surface salinity from the *Oceanographer, 1986.*

of the size parameters within the study are shown in Figures 39 to 45. It is quite clear that, with the exception of a few stations (e.g., CH18, CH19, CH22, CH30 and CH31), all stations have very-poorly- to extremely-poorly-sorted sediment size distributions (Fig. 13). Within the study area essentially three major sediment types (gravels, sands and muds) can be

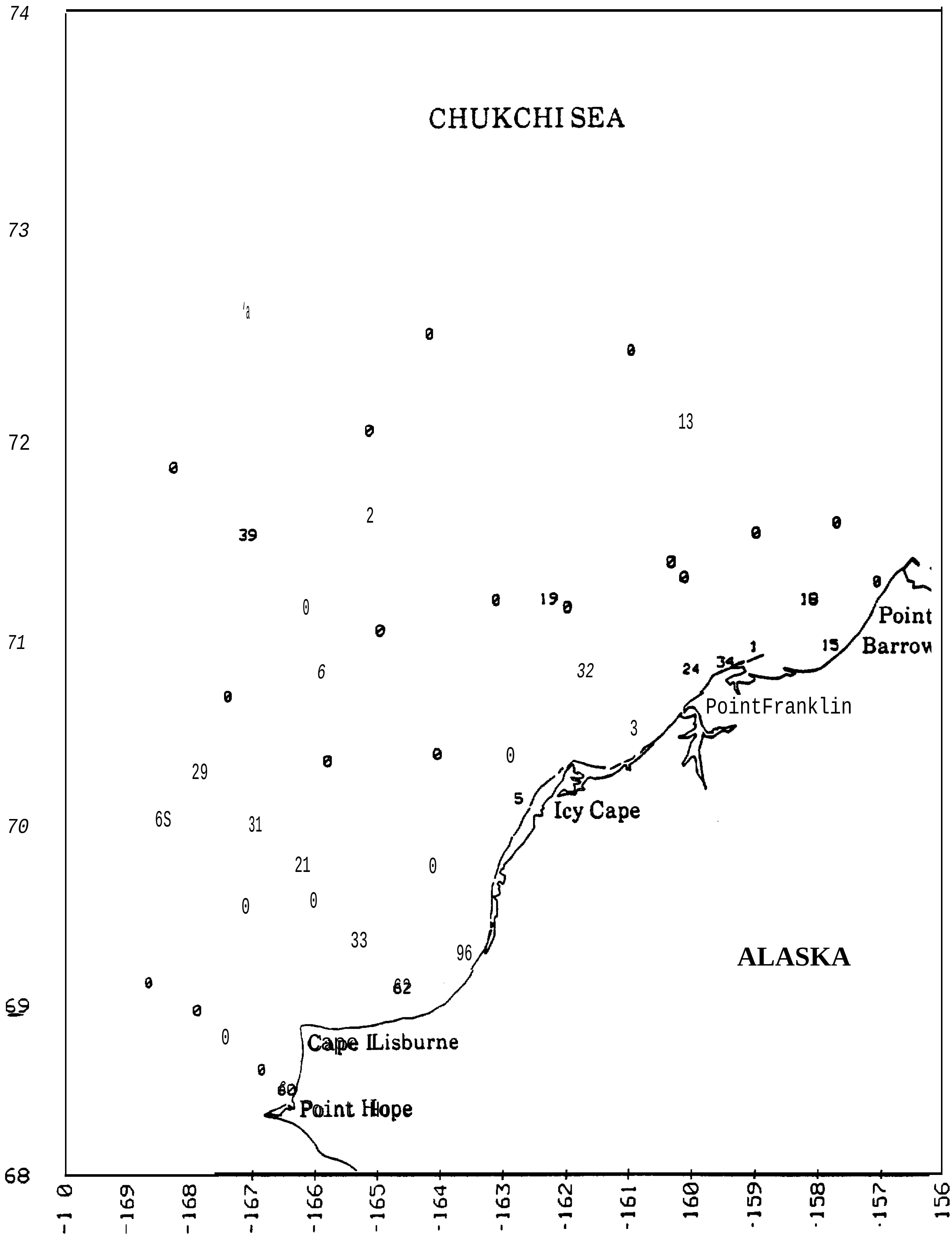

Figure 39. Gravel percentages in surficial sediments of the northeastern Chukchi Sea.

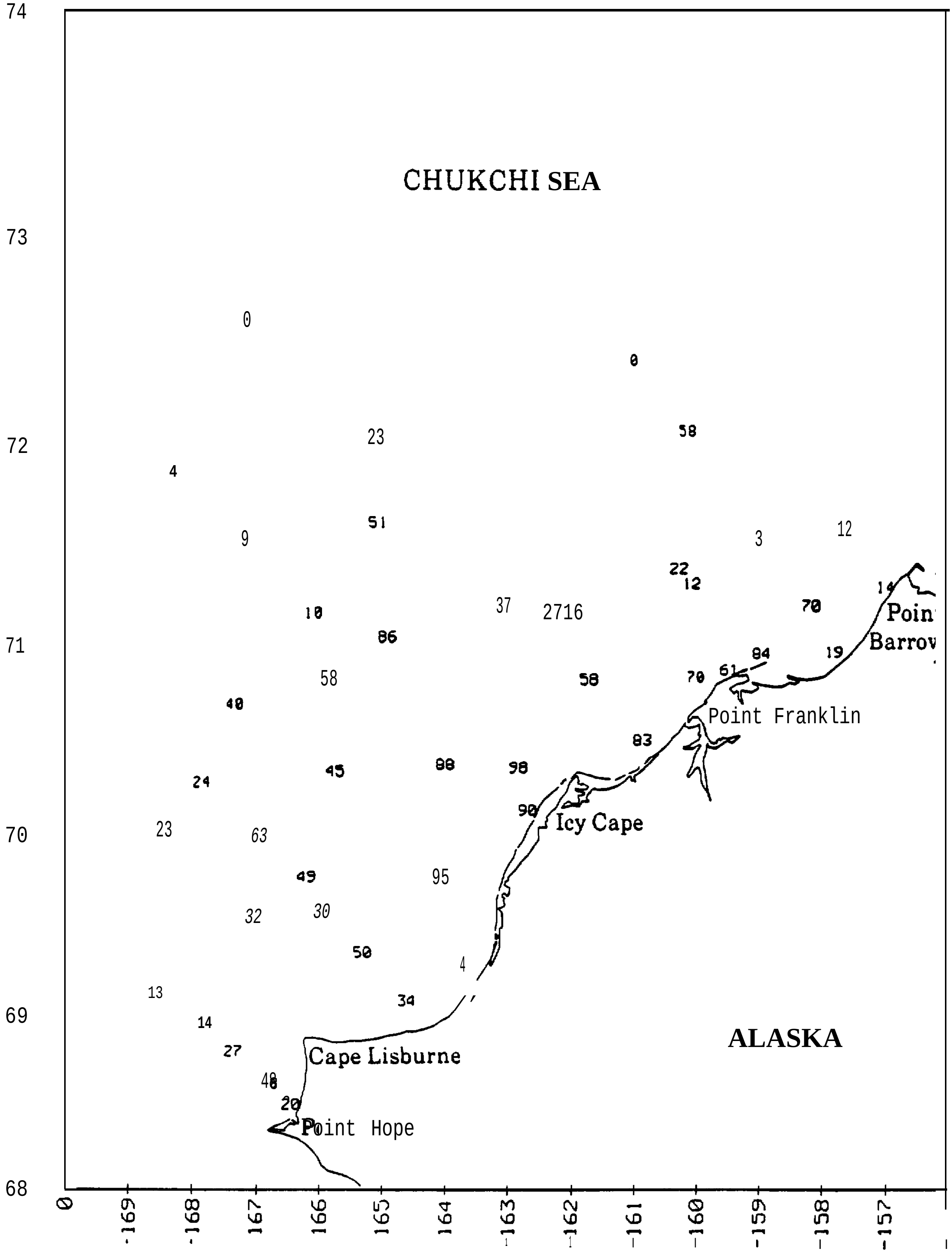

Figure 40. Sand percentages in surficial sediments of the northeastern Chukchi Sea.

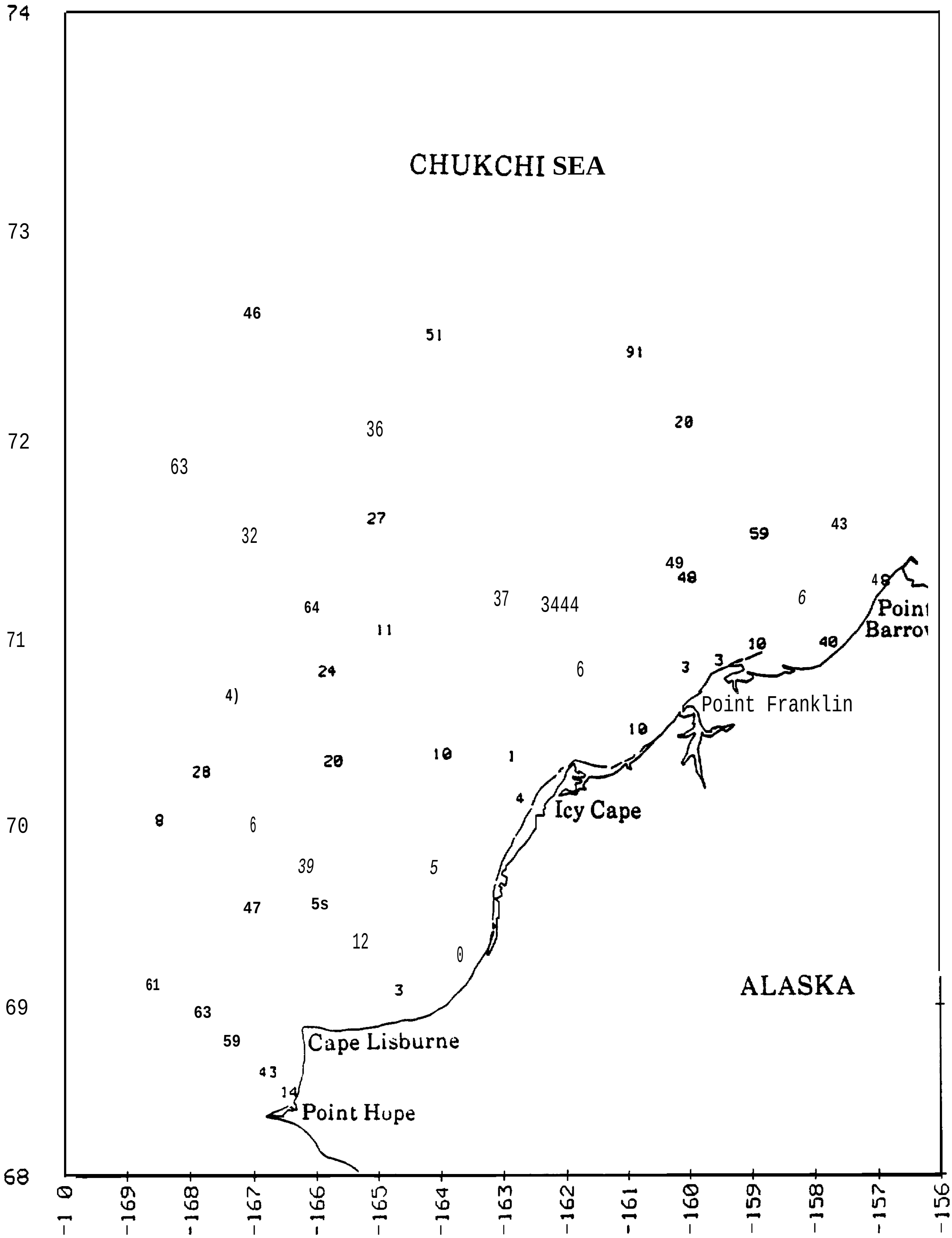

Figure 41. Silt percentages in surficial sediments of the northeastern Chukchi Sea.

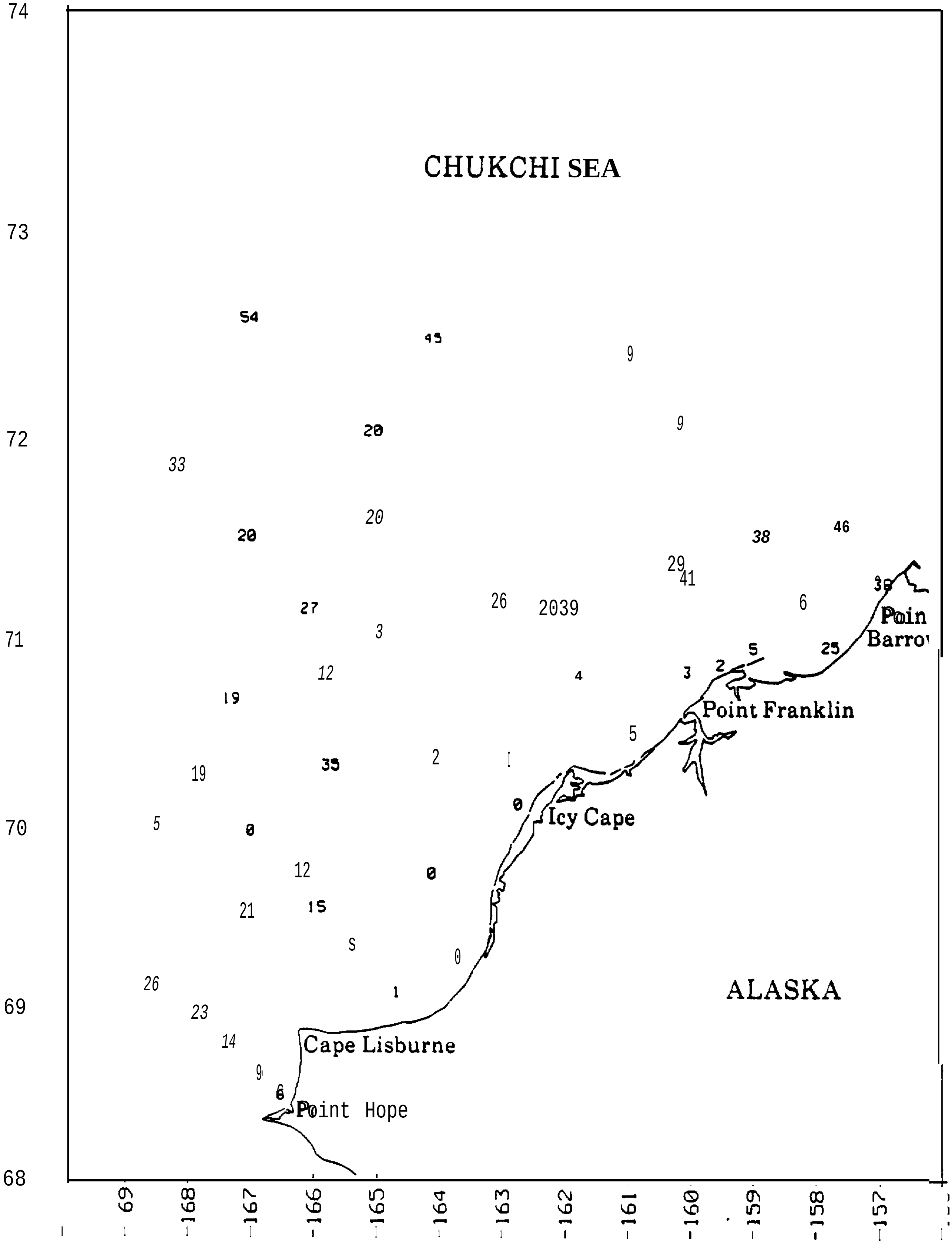

Figure 42. Clay percentages in surficial sediments of the northeastern Chukchi Sea.

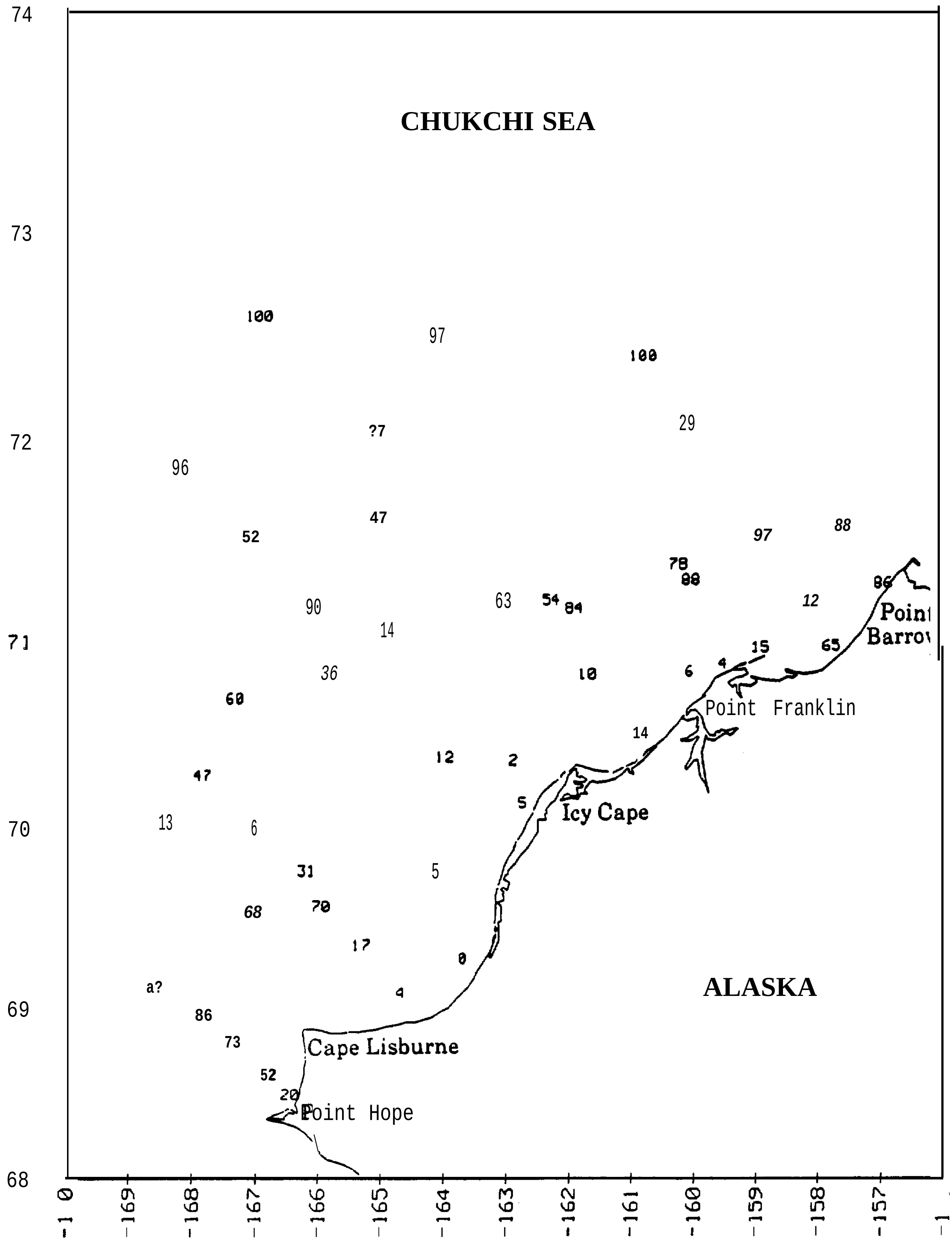

Figure 43, Mud percentages in surficial sediments of the northeastern Chukchi Sea.

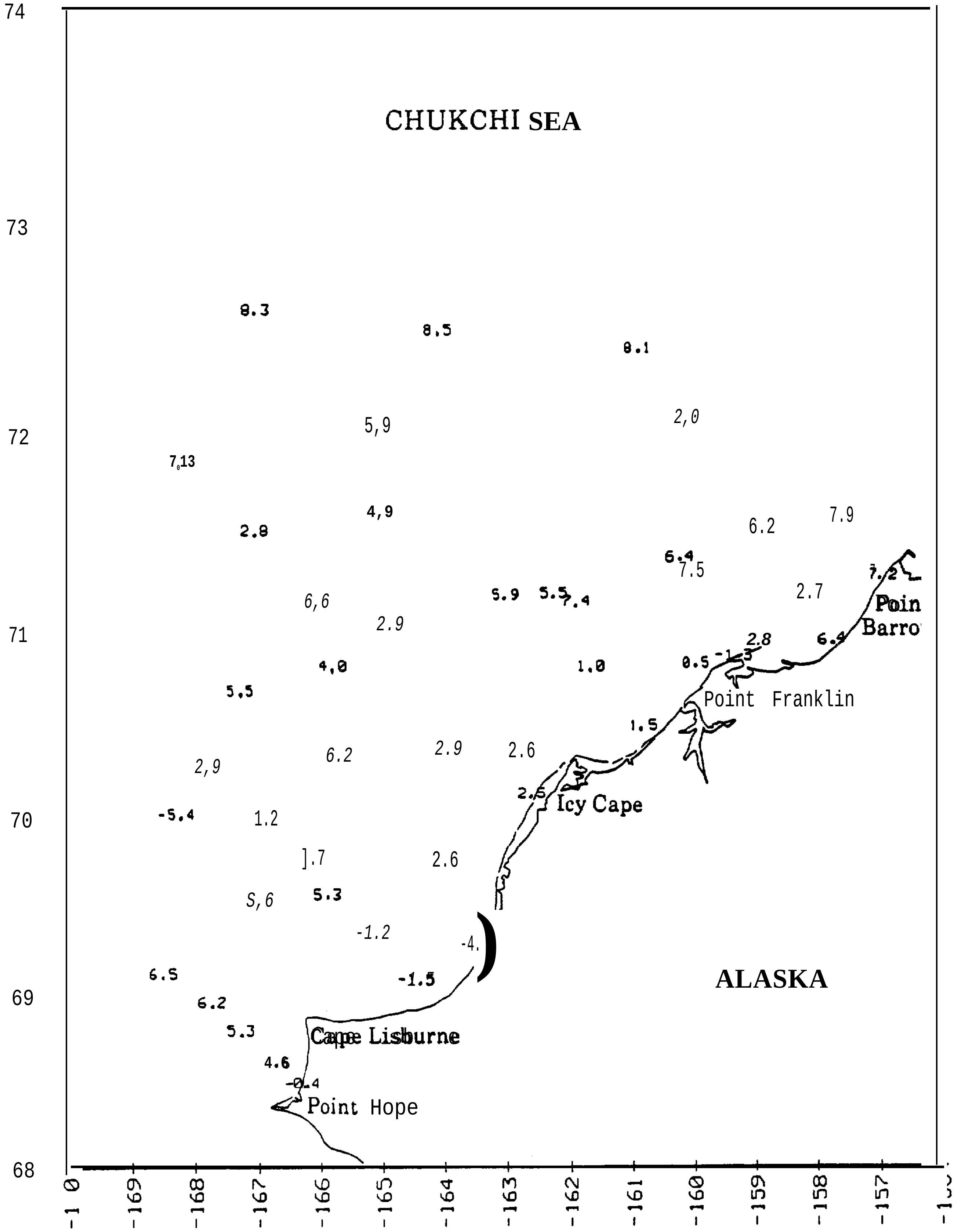

Figure 44. Mean size of surficial sediments of the northeastern Chukchi Sea.

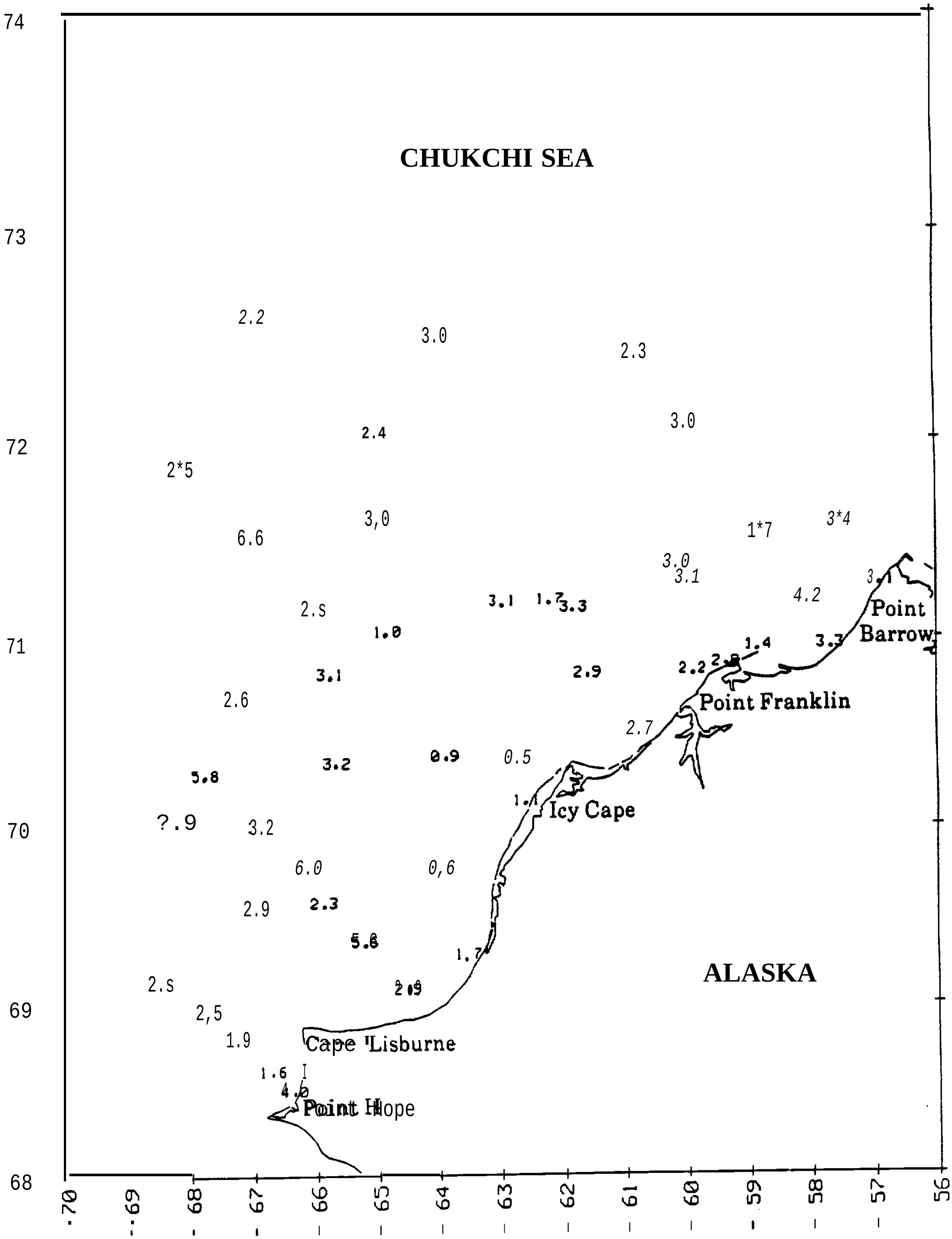

Figure 45. Grain-size sorting values (δ) of surficial sediments of the northeastern Chukchi Sea.

Table 5. Granulometric data of surficial sediments of the northeastern Chukchi Sea.

Station Name	Gravel %	Sand %	Silt %	Clay %	Mud %	Mz ϕ	Sorting δ
CH1	0.00	13.51	48.37	38.12	86.49	7.19	3.06
CH2	0.00	11.86	42.59	45.55	88.14	7.85	3.38
CH3	0.00	3.16	58.75	38.09	96.84	6.23	1.68
CH4	18.14	70.19	5.64	6.03	11.67	2.67	4.19
CH5	15.37	19.20	40.01	25.43	65.44	6.37	3.33
CH6	1.03	84.19	10.16	4.62	14.78	2.85	1.43
CH7	34.21	61.38	2.60	1.80	4.40	-1.34	2.85
CH8	23.94	70.46	2.78	2.82	5.60	0.47	2.24
CH9	0.00	11.53	47.73	40.74	88.47	7.47	3.12
CH10	0.00	22.31	49.04	28.64	77.68	6.40	2.97
CH11	12.64	58.49	20.04	8.83	28.87	1.99	2.99
CH12	0.00	0.21	90.92	8.87	99.79	8.09	2.32
CH13	0.00	3.42	51.30	45.28	96.58	8.46	2.96
CH14	18.55	27.29	34.01	20.06	54.16	5.45	1.75
CH15	0.00	16.26	44.49	39.25	83.74	7.41	3.27
CH16	32.13	57.78	6.18	3.91	10.09	1.00	2.92
CH17	2.71	82.89	9.63	4.78	14.41	1.49	2.72
CH18	4.79	90.45	4.41	0.35	4.76	2.54	1.11
CH19	0.00	97.60	1.39	1.01	2.40	2.60	0.47
CH20	0.00	37.05	37.18	25.77	62.95	5.86	3.08
CH21	.....	.....	.....	.....	.....	....	....
CH22	0.00	86.22	10.89	2.88	13.77	2.89	1.00
CH23	1.52	51.49	27.28	19.71	46.99	4.93	3.00
CH24	0.00	23.21	56.48	20.31	76.79	5.92	2.40
CH25	0.00	0.45	45.78	53.77	99.55	8.28	2.23
CH26	39.01	9.48	31.79	19.71	51.51	2.80	6.61
CH27	0.00	9.82	63.52	26.66	90.18	6.57	2.49
CH28	5.80	57.85	24.42	11.94	36.36	4.02	3.06
CH29	0.00	44.53	20.40	35.07	55.47	6.17	3.24
CH30	0.00	88.07	9.70	2.22	11.92	2.90	0.86
CH31	0.00	95.35	4.65	0.00	4.65	2.58	0.56
CH32	95.69	3.91	0.39	0.00	0.39	-4.33	1.69
CH33	62.09	33.79	2.87	1.25	4.12	-1.52	2.93
CH34	32.87	50.40	11.55	5.19	16.78	-1.19	5.60
CH35	0.00	29.84	54.80	15.36	70.16	5.26	2.29
CH36	20.53	48.96	18.66	11.85	30.51	1.67	6.02
CH37	31.09	62.54	6.37	0.00	6.37	1.25	3.25
CH38	0.00	39.63	41.09	19.28	60.37	5.52	2.56
CH39	0.00	4.32	63.15	32.54	95.69	7.00	2.46
CH40	28.59	24.25	27.95	19.21	47.16	2.86	5.77
CH41	64.50	22.99	7.93	4.57	12.50	-5.36	7.89
CH42	0.00	31.76	47.29	20.95	68.24	5.57	2.90
CH43	60.33	19.65	14.23	5.79	20.02	"0.39	4.01
CH44	0.00	47.92	43.01	9.07	52.08	4.57	1.56
CH45	0.00	26.74	59.43	13.83	73.26	5.32	1.92
CH46	0.00	14.18	63.17	22.65	85.82	6.19	2.48
CH47	0.00	12.80	60.93	26.28	87.21	6.47	2.55

Table 5. (continued)

Station Name	SWSP (mg/l)	BWSP (mg/l)	OCSWSP (µg/l)	OCBWSP (µg/l)	NSWSP (µg/l)	NBWSP (µg/l)	OC/N SWSP	OC/N BWSP
CH 1								
CH2	0.61	2.37						
CH3	0.34	0.95						
CH4	2.52	1.06						
CH5	3.21	3.63						
CH6	4.60	1.83	147.6	86.3	26.3	20.9	5.6	4.1
CH7	3.84	2.03	154.5	102.8	26.5	15.2	5.8	6.8
CH8	3.36	1.91	148.6	98.4	24.2	14.1	6.1	7.0
CH9	0.43	1.46	57.1	83.7	8.9	14.1	6.4	5*9
CH10	0.77	3.37	51.5	128.3	7.4	18.1	7.0	7.1
CH11	0.34	1.57	88.8	93.1	13.0	14.8	6.8	6.3
CH12	0.96	4.42	134.4	145.0	14.7	15.8	9.1	9.2
CH13	0.03	3.17	111.3	191.1	12.5	27.7	8.9	6.9
CH14	0.37	2.57	119.8	211.5	15.4	38.5	7.8	5.5
CH15	2*22	0.62	1"44.5	106.1	26,1	16.4	5.5	6.5
CH16	0.50	0.58	135.2	88.0	22.5	15.6	6.0	5.6
CH17	1.16	1.05	120,6	95.0	22.9	16.3	5.3	5.8
CH18	1.80	1.75		146.6		25.7		5.7
CH19	1.33	1.60		80.1		13.8		5.8
CH20		2.53						
CH21	0.96	1.76	163.7	132.6	30.1	23.1	5.4	5.7
CH22	0.85	1.40	151.2	133.6	21.5	21.3	7.0	6.3
CH23	0.71	1.21	119.1		18.6		6.4	
CH24	0.45	2.11	108.4	149.2	16.9	25.1	6.4	5.9
CH25	0.93	2.58	102.8	105.7	14.8	14.4	7.0	7.3
CH26	0.47	0.61						
CH27	0.69	2.26	843.2		137.3		6.1	
CH28	0.65	3.82						
CH29	1.13	0.78		78.5		15.4		10.2
CH30	0.85	2.35	170.6		32.6		5.2	
CH31	0.87	1.26	118.7	130.0	20.9	23.9	5*7	5.4
CH32	4.45		197.1		30.9		6.4	
CH33	3.08		196.5		36.0		5.5	
CH34	1.55	2.14	127.3	111.5	28.0	20.3	4.6	5.5
CH35	0.81	1.35	135.2	58.8	33.4	14.9	4.1	4.0
CH36	1.22	1.36						
CH37	0.80	1.26		72.9		13.3		5.5
CH38	0.35	3.52						
CH39		1.30						
CH40	0.44	0.72						
CH41	0.28	0.94						
CH42	"0.03	0.72	96.0	135.5	21.9	19.9	4.4	6.8
CH43	3.72	2.47	197.4		40.1		4.9	
CH44	4.18	3.94						
CH45	4.31	3.82	106.4	185.1	16.5	26.2	6.5	7.1
CH46	0.29	0.51		220.5		32.5		6.8
CH47	1.25	0.78	248.7		28.4		8.8	

Table 5. (continued)

Station Name	Oc (mg/g)	N (mg/g)	OC/N	δ13C o/oo
CH1	5.11	0.53	9.60	
CH2	6.90	0.88	7.80	
CH3	5.32	0.66	8.10	-21,9
CH4	11.86	1.55	7.70	
CH5	5.98	0.75	8.00	-24.2
CH6	4.31	0.51	8.50	
CH7	8.24	1.02	8.08	
CH8	10.02	1.25	8.00	
CH9	8.60	1.07	8.00	
CH10	3.76	0.44	8.60	
CH11	7.25	0.88	8.20	-22.2
CH12	4.43	0.57	7.80	-21.5
CH13	13.76	1.92	7.20	-21.0
CH14	9.62	0.82	11.70	-19.3
CH15	13.54	0.81	16.70	
CH16	5.71	0.51	11.20	-16.0
CH17	6.21	0.48	12.90	-23.7
CH18	7.30	0.48	15.20	
CH19	4.86	0.34	14.10	
CH20	7.25	0.84	8.60	
CH21	10.46	1.38	7.60	
CH22	2.36	0.31	7.60	
CH23	13.79	1.70	8.10	-20.5
CH24	9.79	1.08	9.10	-20.6
CH25	15.74	2.12	7.40	-20.9
CH26	10.11	0.78	13.00	-19.6
CH27	1.65	0.22	7.50	
CH28	2.19	0.28	7.80	-21.5
CH29	6.63	0.83	8.00	-21.7
CH30	1.21	0.19	6.30	
CH31	5.88	0.32	18.40	-22.6
CH32	....	....	....	
CH33	5.23	0.39	13.40	-21.6
CH34	2.59	0.30	8.60	
CH35	4.20	0.48	8.80	
CH36	1.82	0.23	7.90	-21.9
CH37	2.73	0.30	9.10	
CH38	2.25	0.29	7.80	
CH39	1.58	0.21	7.50	-21.2
CH40	10.04	1.25	8.00	-22.6
CH41	4,48	0.55	8.20	
CH42	2.40	0.40	6.00	
CH43	8.89	1.01	8.00	
CH44	7.73	0.99	7.80	-22.4
CH45	9.46	1.18	8.00	
CH46	2.29	0.28	8.20	
CH47	11.79	1.55	7.60	-21.5

delineatea (Fig. 3). However, under these major sediment types are embraced a number of Folk's (1954, 1980) sediment classes (Fig. 3). As depicted in Figure 3, there is apparently a broad seaward fining of sediment types. However, further examination of the granulometric variations suggests that within the broad lithologic units mosaics of different sub-types of sediments are observed; thus , such a distributional pattern generally conforms to the lithofacies changes previously discussed for the northeastern Chukchi Sea by Naidu (1987) and shown in Figure 3.

The concentrations of suspended particles for August 27-September 17, 1986, at selected depths of the water column of the northeastern Chukchi Sea are shown in Table 6. The distributional patterns of the suspended particles in water samples collected at the sea surface and near the sea floor are depicted in Figures 46 and 47. It is clearly shown that the particulate concentrate ions in the surface waters progressively decrease seaward from the coast (Fig. 46) up to the northern margin of the study area where slightly increased concentrations are locally observed. In the near bottom waters the concentration gradient is apparent only within the innershore region, beyond which there appears to be a reversal in the concentration trend (Fig. 47). These trends are generally substantiated in the vertical profiles of suspensate loads along a seaward transect extending from Station CH17 through Stations CH16 and CH14 to Station CH13 (Fig. 48).

The concentrations of organic carbon (OC) and nitrogen (N), the OC/N and the stable carbon isotopic ratios ($\delta^{13}C$) in sea floor surficial sediments are shown in Table 7 and their distributional patterns depicted in Figures 49, 50, 51, and 52, respectively. The distributional patterns of OC and N in bottom sediments are very similar (Figs. 49 and 50), indicating that there are relatively large concentrations of OC and N in two areas:

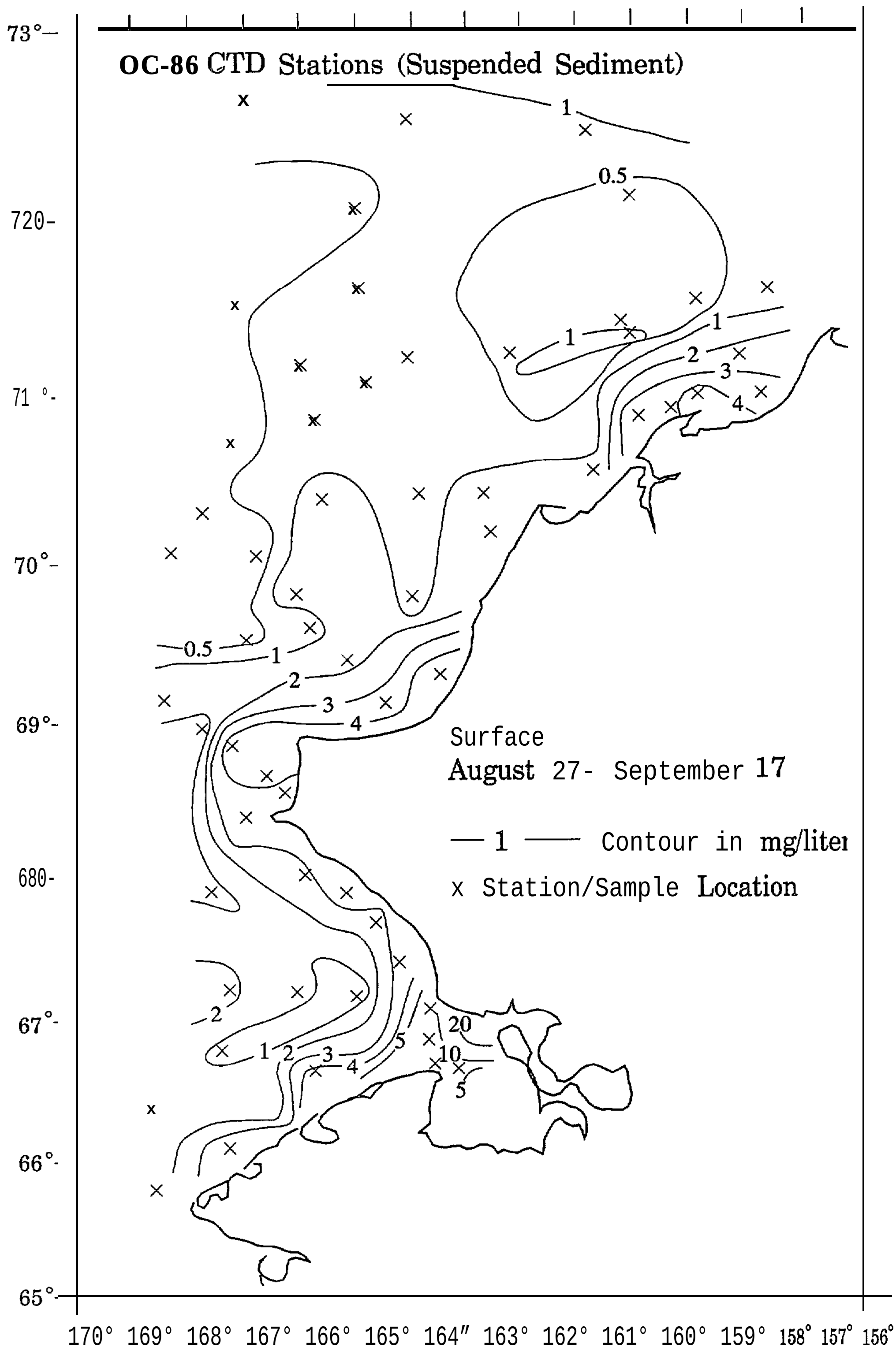

Figure 46. Surface water suspended sediment concentration.

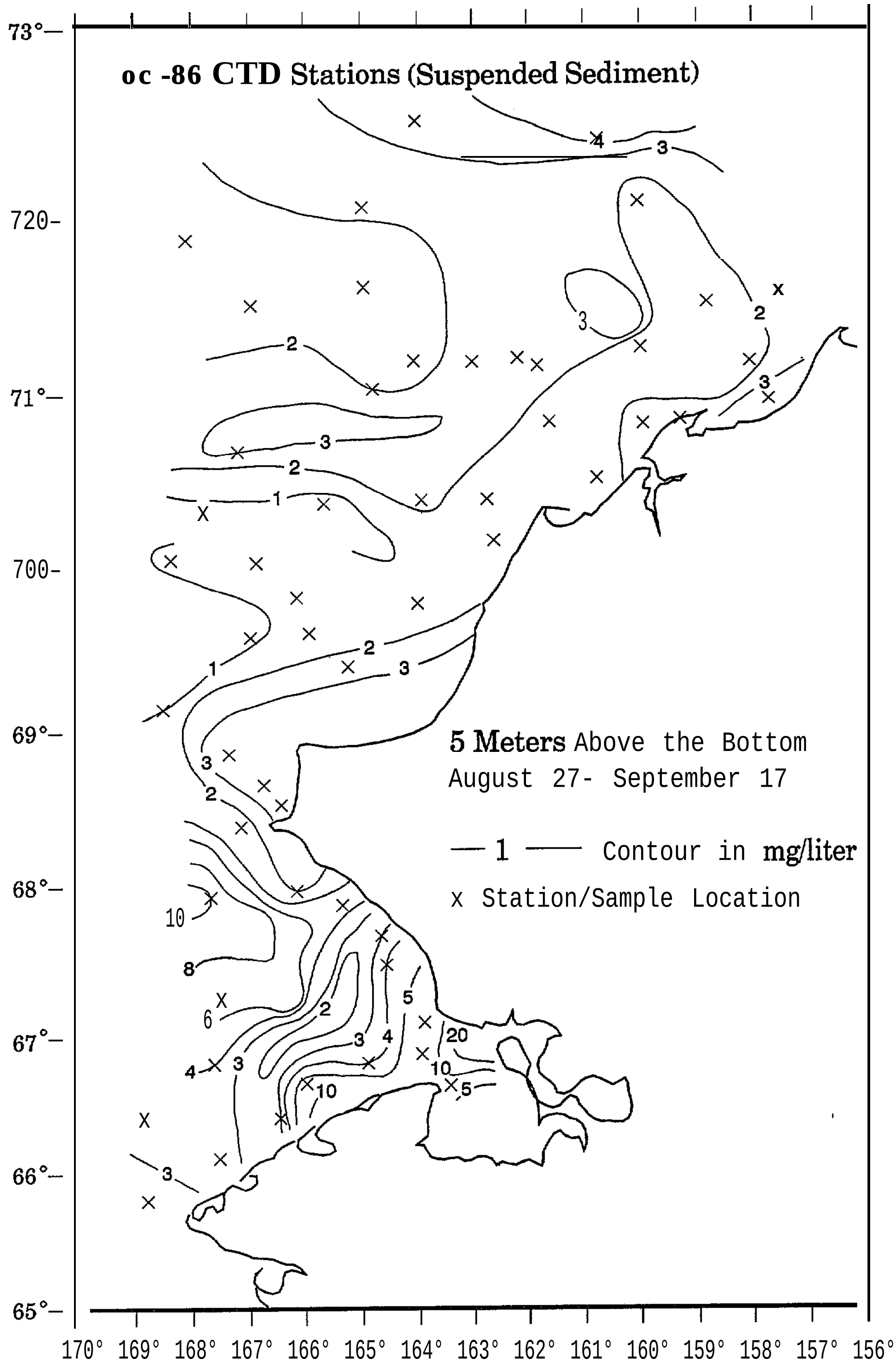

Figure 47. Suspended sediment concentration 5 m above the sea floor.

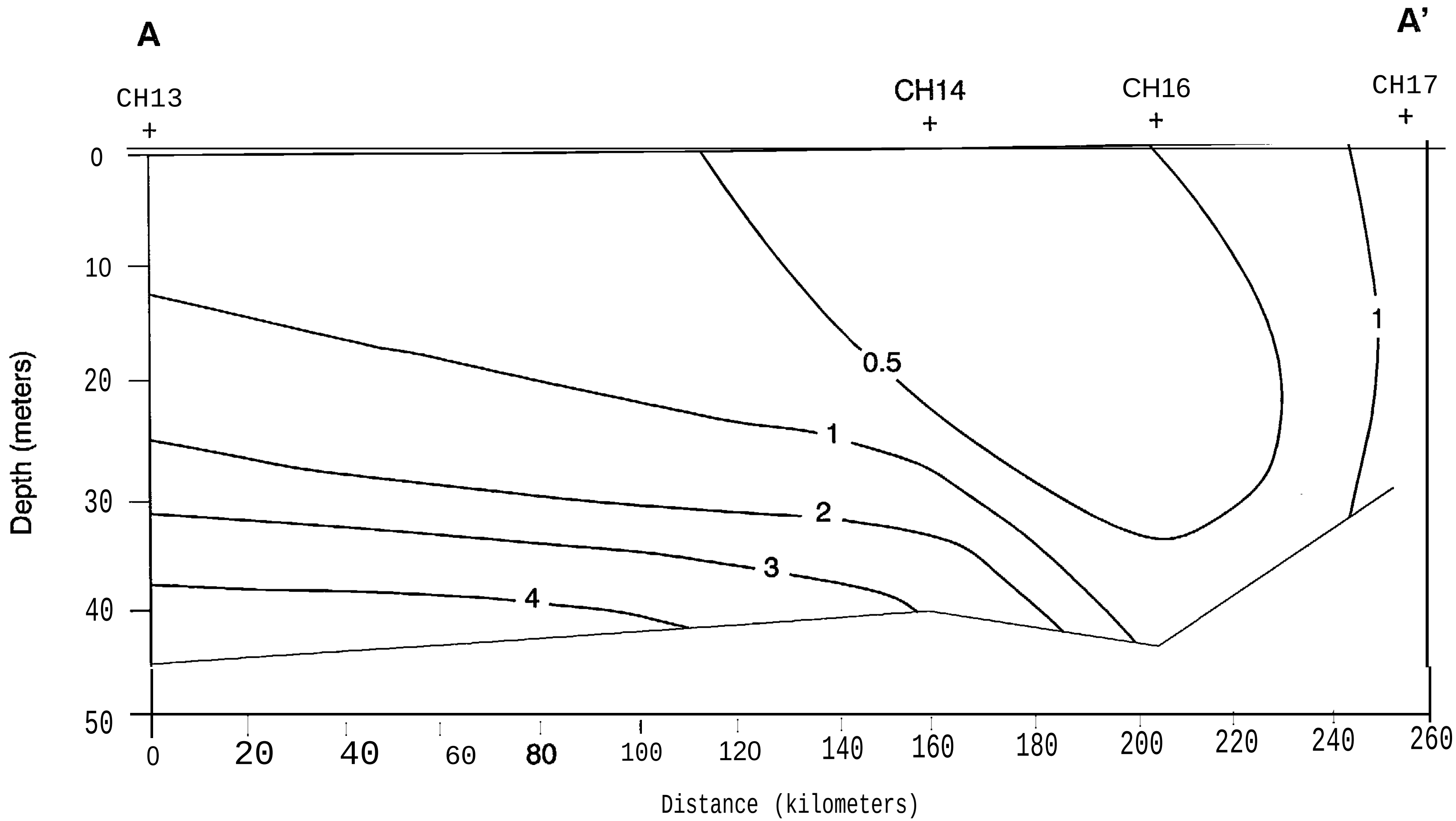

Figure 48. Chukchi Sea vertical profile of suspended sediment concentration. Contours are in mg/liter. For transect location, see Figure 11.

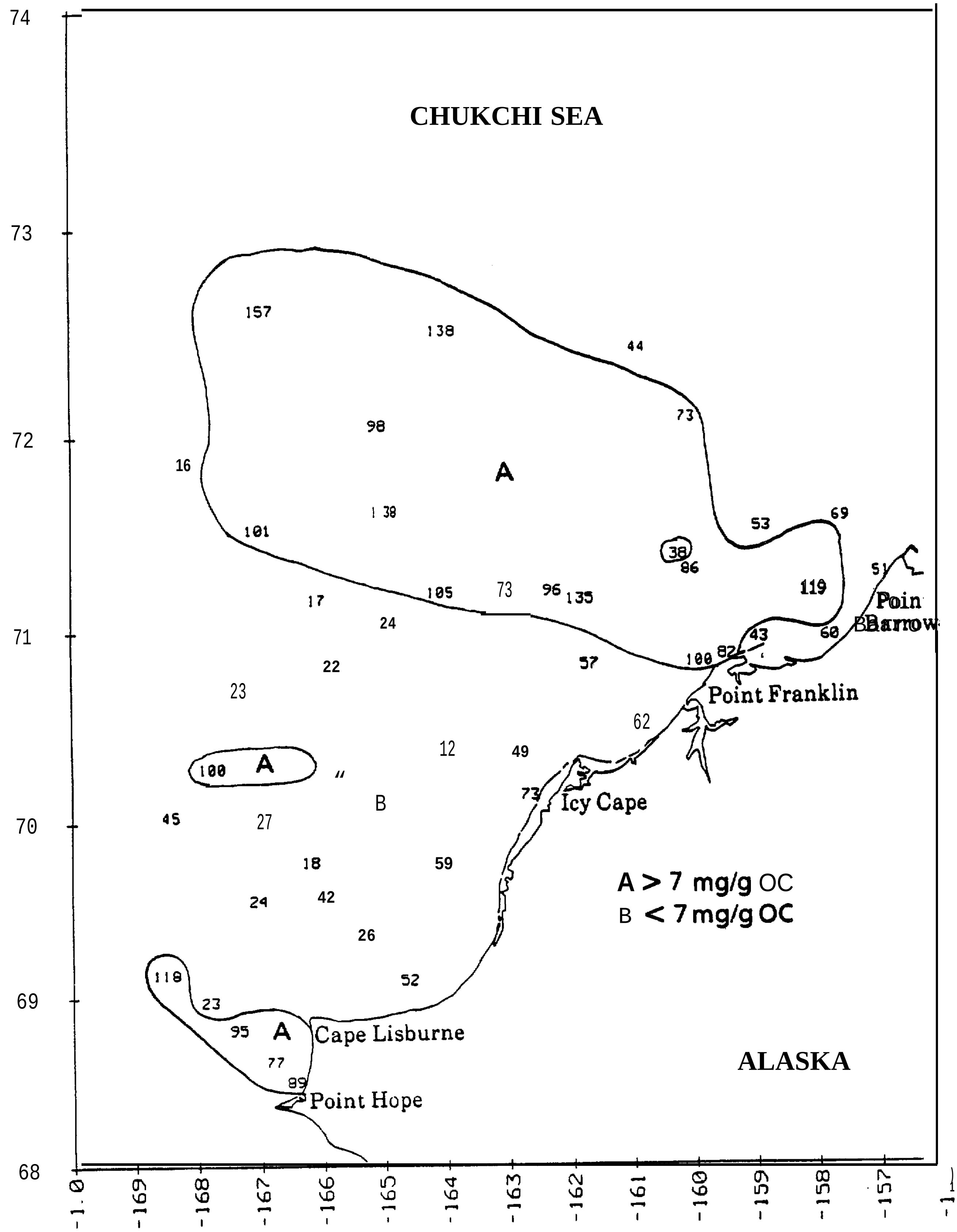

Figure 49. Organic carbon (mg/g x 10^{-1}) in bottom surficial sediments in the northeastern Chukchi Sea.

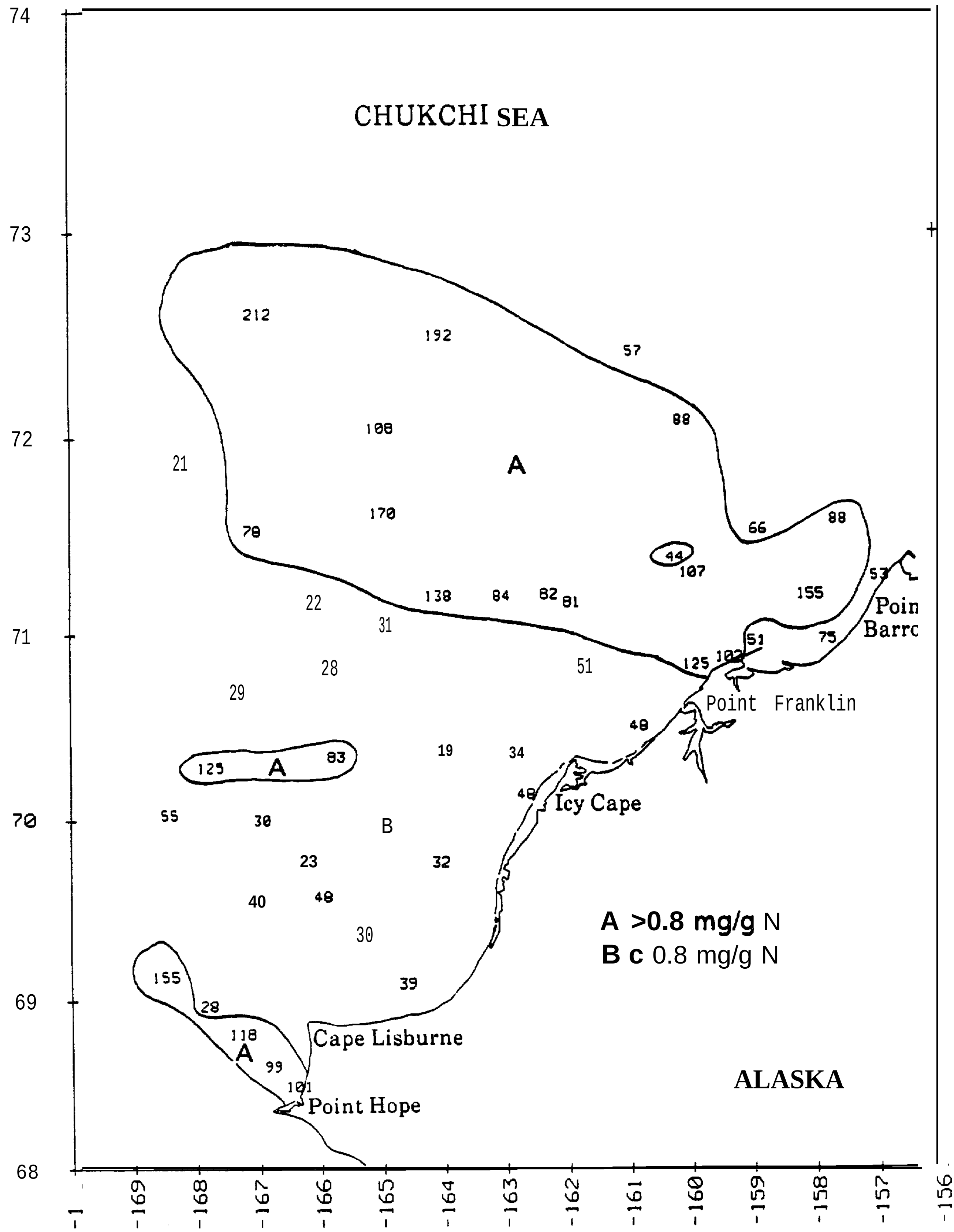

Figure 50. Nitrogen (mg/g x 10 '2) in bottom surficial sediments in the northeastern Chukchi Sea.

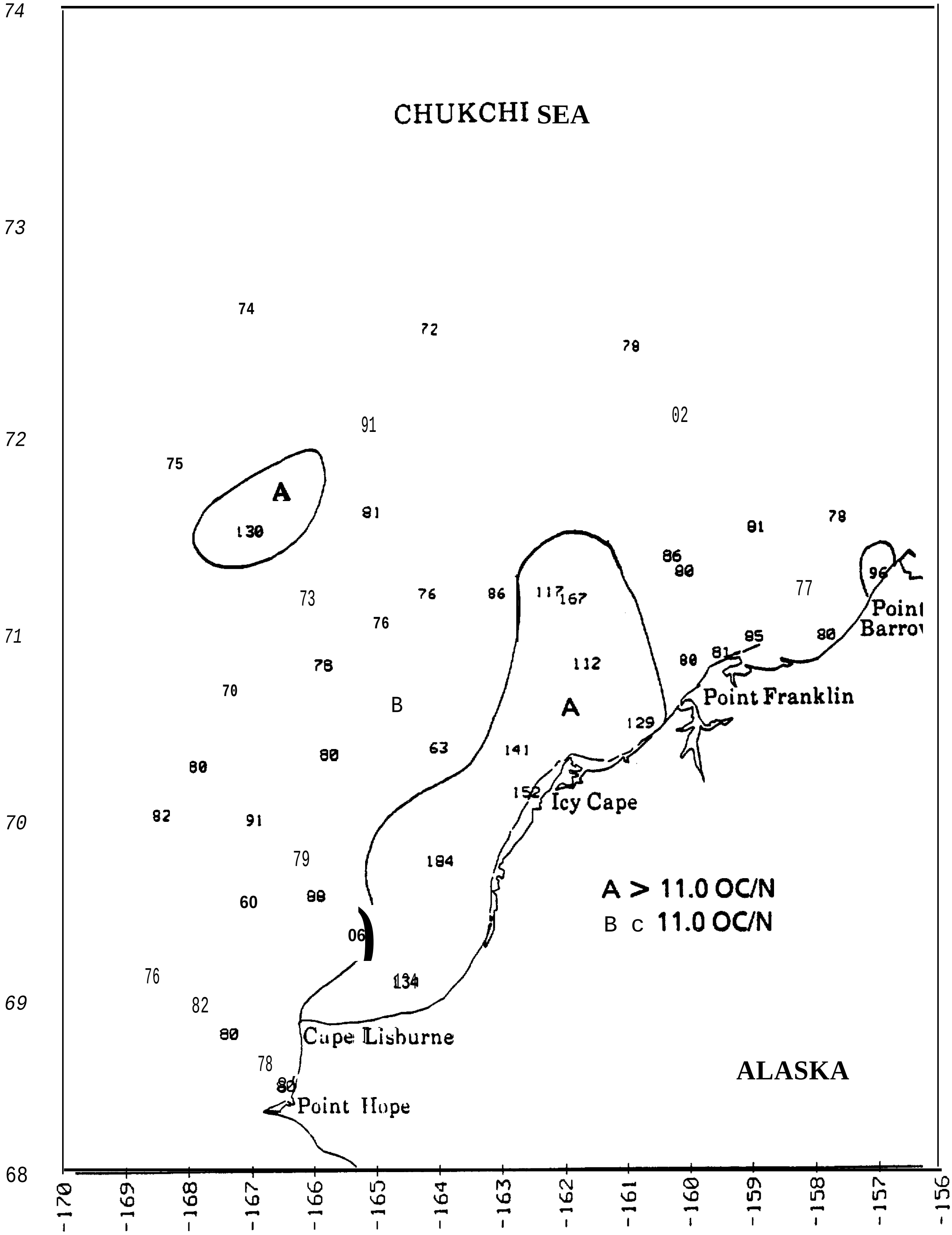

Figure 51. OC/N values (x 10^{-1}) of bottom surficial sediments in the northeastern Chukchi Sea.

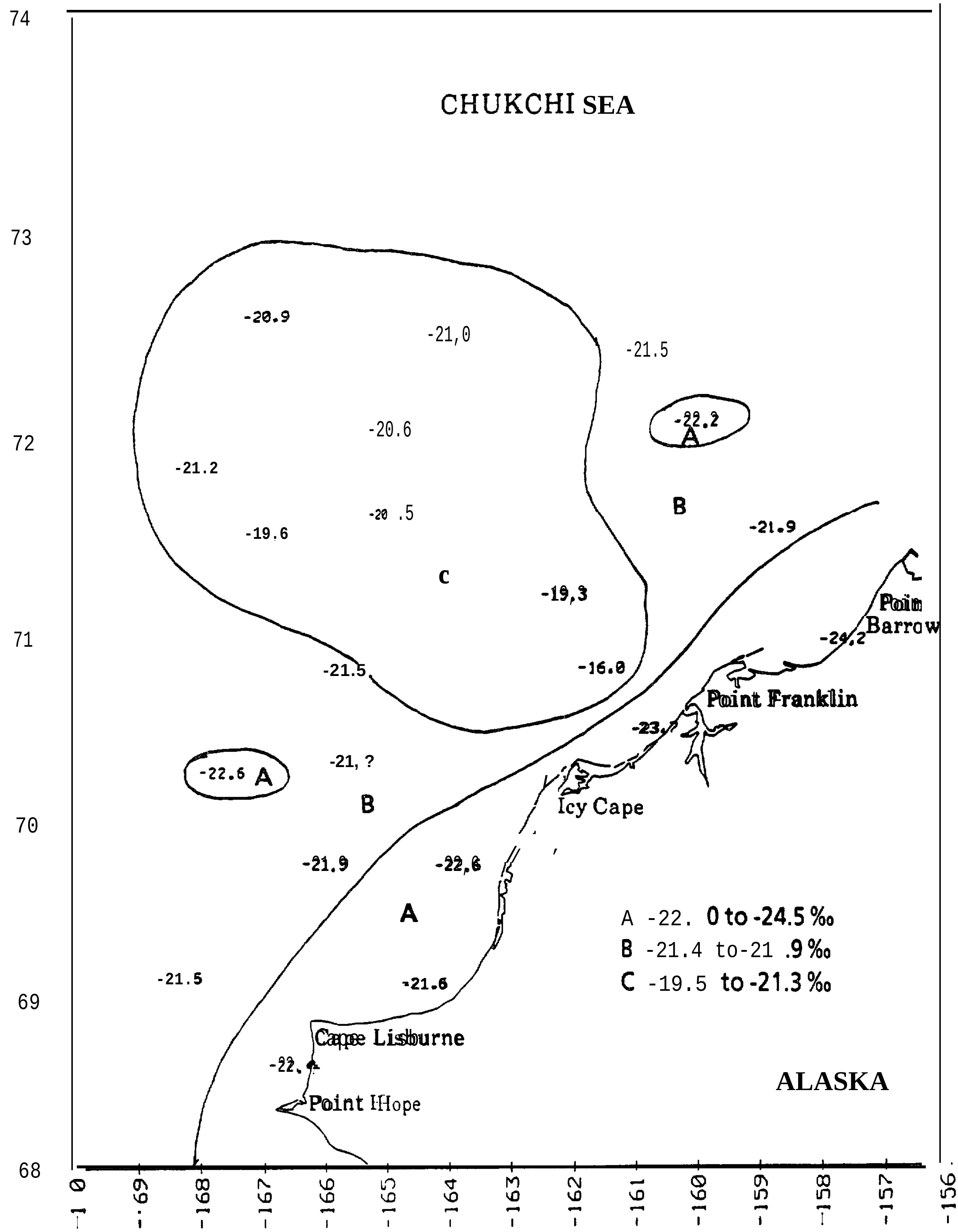

Figure 52. Stable organic carbon isotopic ratios ($\delta^{13}C^{o}/oo$) of bottom surficial sediments.

Table 6. Concentrations of suspended particulate and organic carbon (OC), nitrogen (N), OC/N ratios in the suspended particulate of surface (SWSP) and near bottom (BWSP) waters of the northeastern Chukchi Sea.

Station Name	SWSP (mg/l)	BWSP (mg/l)	OCSWSP (μg/l)	OCBWSP (μg/l)	NSWSP (μg/l)	NBWSP (μg/l)	OC/N SWSP	OC/N BWSP
CH1								
CH2	0.61	2.37						
CH3	0.34	0.95						
CH4	2.52	1.06						
CH5	3.21	3.63						
CH6	4.60	1.83	147.6	86.3	26.3	20.9	5.6	4.1
CH7	3.84	2.03	154.5	102.8	26.5	15.2	5.8	6.8
CH8	3.36	1.91	148.6	98.4	24.2	14.1	6.1	7*0
CH9	0.43	1.46	57.1	83.7	8,9	14.1	6.4	5,9
CH10	0.77	3.37	51.5	128.3	7.4	18.1	7.0	7*1
CH11	0.34	1.57	88.8	93.1	13.0	14.8	6.8	6.3
CH12	0.96	4.42	134.4	145.0	14.7	15.8	9.1	9,2
CH13	0.03	3.17	111.3	191.1	12.5	27.7	8.9	6.9
CH14	0.37	2.57	119.8	211.5	15.4	38.5	7.8	5.5
CH15	2.22	0.62	144.5	106.1	26.1	16.4	5.5	6.5
CH16	0.50	0.58	135.2	88.0	22.5	15.6	6.0	5.6
CH17	1.16	1.05	120.6	95.0	22.9	16.3	5.3	5.8
CH18	1.80	1.75		146.6		25.7		5.7
CH19	1.33	1.60		80.1		13.8		5.8
CH20		2.53						
CH21	0.96	1.76	163.7	132.6	30.1	23.1	5.4	5.7
CH22	0.85	1.40	151.2	133.6	21.5	21.3	7.0	6.3
CH23	0.71	1.21	119.1		18.6		6.4	
CH24	0.45	2.11	108.4	149.2	16.9	25.1	6.4	5.9
CH25	0.93	2.58	102.8	105.7	14.8	14.4	7.0	7.3
CH26	0.47	0.61						
CH27	0.69	2.26	843.2		137.3		6.1	
CH28	0.65	3.82						
CH29	1.13	0.78		78.5		15.4		10.2
CH30	0.85	2.35	170.6		32.6		5.2	
CH31	0.87	1.26	118.7	130.0	20.9	23.9	5.7	5.4
CH32	4.45		197.1		30.9		6.4	
CH33	3.08		196.5		36.0		5.5	
CH34	1.55	2.14	127.3	111.5	28.0	20.3	4.6	5.5
CH35	0.81	1.35	135.2	58.8	33.4	14.9	4.1	4.0
CH36	1.22	1.36						
CH37	0.80	1.26		72.9		13.3		5.5
CH38	0.35	3.52						
CH39		1.30						
CH40	0.44	0.72						
CH41	0.28	0.94						
CH42	0.03	0.72	96.0	135.5	21.9	19.9	4.4	6.8
CH43	3.72	2.47	197.4		40.1		4.9	
CH44	4.18	3.94						
CH45	4.31	3.82	106.4	185.1	16".5	26.2	6.5	7.1
CH46	0.29	0.51		220.5		32.5		6.8
CH47	1.25	0.78	248.7		28.4		8.8	

Table 7. Organic carbon (OC), nitrogen (N), OC/N ratios and stable organic carbon isotopic ratios ($\delta^{13}C$ ‰) of bottom surficial sediments, northeastern Chukchi Sea.

Station Name	OC (mg/g)	N (mg/g)	OC/N	δ13C 0/00
CH1	5.11	0.53	9.60	
CH2	6.90	0.88	7.80	
CH3	5.32	0.66	8.10	-21.9
CH4	11.86	1.55	7.70	-22.5
CH5	5.98	0.75	8.00	-24.2
CH6	4.31	0.51	8.50	
CH7	8.24	1.02	8.08	-24.9
CH8	10.02	1.25	8.00	
CH9	8.60	1.07	8.00	
CH10	3.76	0.44	8.60	
CH11	7.25	0.88	8.20	-22.2
CH12	4.43	0.57	7.80	-21.5
CH13	13.76	1.92	7.20	-21.0
CH14	9.62	0.82	11.70	-19.3
CH15	13.54	0.81	16.70	
CH16	5.71	0.51	11.20	-18.0
CH17	6.21	0.48	12.90	-23.7
CH18	7.30	0.48	15*20	-24.8
CH19	4.86	0.34	14.10	
CH20	7.25	0.84	8.60	
CH21	10.46	1.38	7.60	
CH22	2.36	0.31	7.60	
CH23	13.79	1.70	8.10	-20.5
CH24	9.79	1.08	9.10	-20.6
CH25	15.74	2.12	7.40	-20.9
CH26	10.11	0.78	13.00	-19.6
CH27	1.65	0.22	7.50	-22.6
CH28	2.19	0.28	7.80	-21.5
CH29	6.63	0.83	8.00	-21.7
CH30	1.21	0.19	6.30	-22.6
CH31	5.88	0.32	18.40	-22.6
CH32	----	----	----	
CH33	5.23	0.39	13.40	-21.6
CH34	2.59	0.30	8.60	-22.4
CH35	4.20	0.48	8.80	-23.2
CH36	1.82	0.23	7*90	-21.9
CH37	2.73	0.30	9.10	-23.4
CH38	2.25	0.29	7.80	
CH39	1.58	0.21	7.50	-21.2
CH40	10.04	1.25	8.00	-22.6
CH41	4.48	0.55	8.20	
CH42	2.40	0.40	6.00	
CH43	8.89	1.01	8.00	-23.6
CH44	7.73	0.99	7.80	-22.4
CH45	9.46	1.18	8.00	-22.4
CH46	2.29	0.28	8.20	
CH47	11.79	1.55	7.60	-21.5

one due northwest of Point Franklin and the other northwest of Point Hope (Figs. 49 and 50). The OC/N plots of bottom sediments in Figure 51 show a region of relatively high OC/N (>11.0) in the inshore area extending from Cape Lisburne to Wainwright. The carbon isotopic ratios ($\delta^{13}C$) of bottom surficial sediments are included in Table 7 and their distributional pattern in the northeastern Chukchi Sea is shown in Figure 52. The nearshore region adjacent to land has significantly lower ratios (>-22.0; -22.4 to -24.5 $^{o}/oo$) than the offshore area. A significant increase in the ratios (i.e., with less negative $\delta^{13}C$ values) with increasing distance from the coast is detected (Naidu, unpub.). A large area with relatively high ratios (-19.5 to -21.3 $^{o}/oo$) is delineated locally in the outer shelf northwest of Point Franklin and Wainwright (Fig. 52).

The OC, N and OC/N values of suspended particles of surface and near bottom waters at selected stations are shown in Table 8 and their distributions in the northeastern Chukchi Sea are plotted in Figures 53 through 58. It is notable that OC is consistently higher in the nearshore suspended particulate in surface and bottom waters and N in bottom waters in the southern region of the study area. Additionally, there is a disjointed area further north where the OC concentrations are also relatively higher in the suspended particulate in both surface and bottom waters (Figs. 53 and 55). It would seem that within and in the vicinity of this northern area the N values in the surface water suspended particles are relatively lower and the OC/N values corresponding to stations in the area are slightly higher (>7.0).

In Table 9 are shown the gross fluxes of suspended particles and particulate organic carbon and nitrogen from suspensions to the sea bottom. The fluxes are represented on a per day basis ($mg/cm^2/dy$) and were

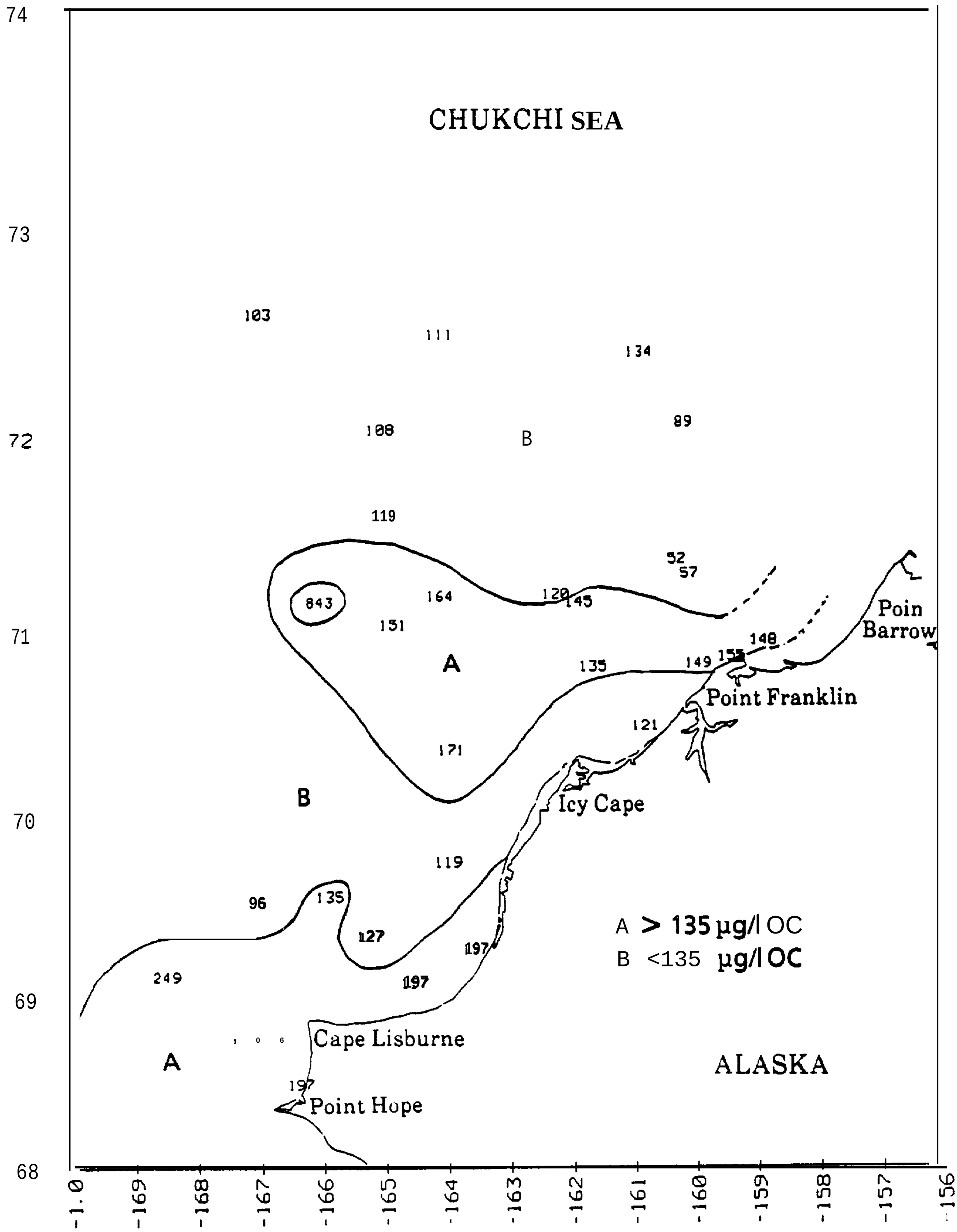

Figure 53. Organic carbon (µg/L) in suspended particles of surface waters in the northeastern Chukchi Sea.

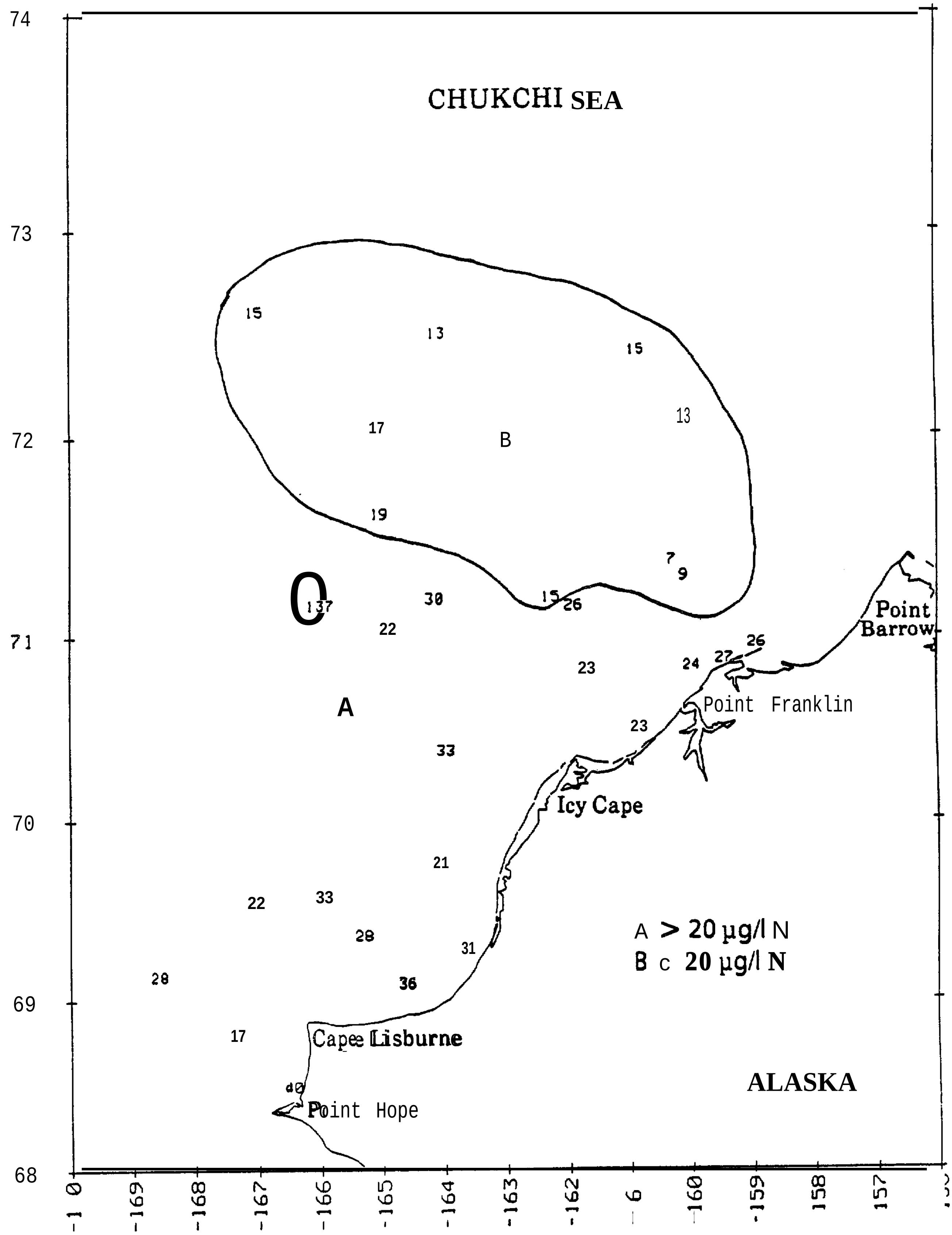

Figure 54. Nitrogen (µg/L) in suspended particles of surface waters in the northeastern Chukchi Sea.

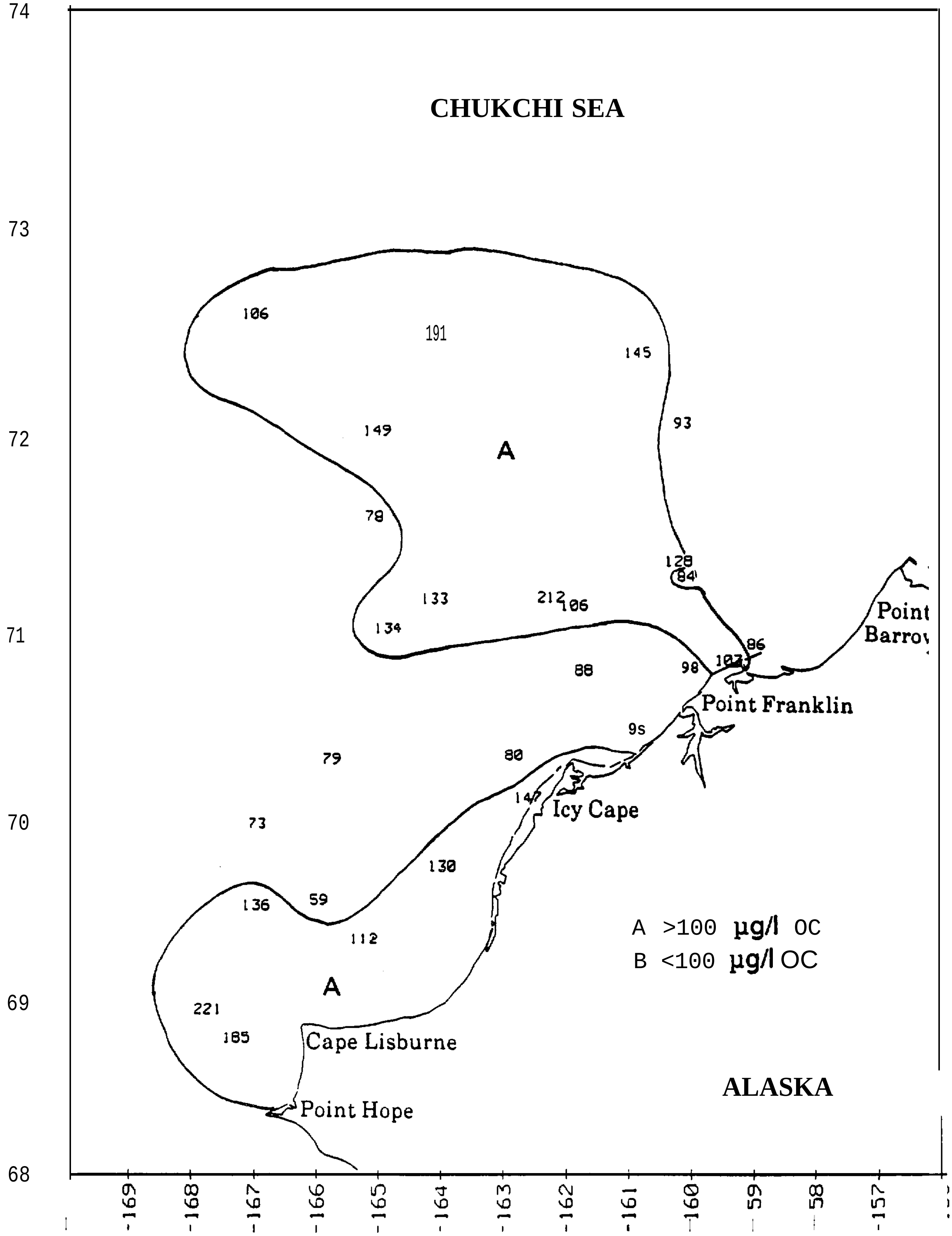

Figure 55. Organic carbon ($\mu g/L$) in suspended particles of near bottom waters in the northerneastern **Chukchi** Sea.

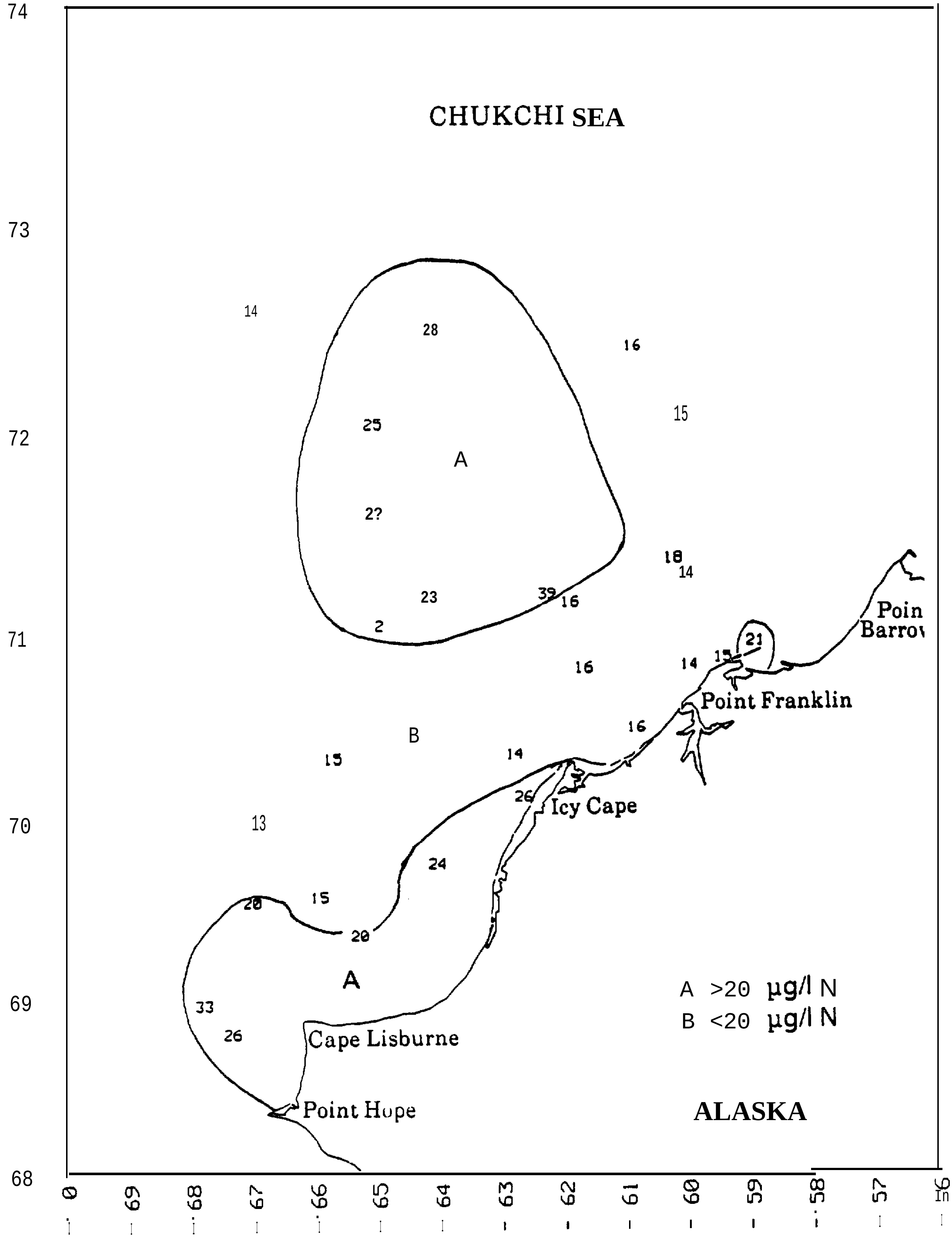

Figure 56. Nitrogen (µg/L) in suspended particles of near bottom waters in the northeastern Chukchi Sea.

Table 8. The gross flux of suspended particles (mg/L), contents of organic carbon (OC) and nitrogen (N), and OC/N ratios in carbonate-free suspended particles in the surface waters (O m) and at selected depths from the surface in east and southeast Chukchi Sea.

Station	Depth (M)	Suspended Particle (mg/L)	OC (µg/L)	N (µg/L)	OC/N
CH 05	14	3.63	109.91	15.33	7.17
CH 07	0	3.84	154.454	26.518	5.82
	12	3.11	124.071	20.679	6.00
	26	2.03	102.83	15.20	6.76
CH 08	0	3.36	148.555	24.183	6.14
	30	2.20	88.67	14.11	6.28
	41	1.91	98.43	14.068	7.00
CH 09	0	0.43	57.11	8.85	6.45
	25	0.37	45.900	8.343	5.50
	42	1.46	83.658	14.110	5.93
CH 10	0	0.77	51.50	7.39	6.97
	20	0.54	62.419	9.803	6.37
	37	3.37	128.32	18.1-29	7.08
CH 11	0	0.34	88.77	12.954	6.85
	15	0.81	247.080	57.102	4.33
	30	1.57	93.10	14.84	6.27
CH 12	0	0.96	134*40	14.69	9.15
		1.13	120.236	19.219	6.26
		4.42	145.02	15.79	9.18
CH 13A	0	0.03	111.305	12.530	8.88
	20	0.16	92.075	11.015	8.39
	45	3.17	191.142	27.682	6.90
CH 13B	0	0.86	112.471	18.538	6.07
	20	1.22	106.352	16.265	6.54
	40	4.18	229.604	103.386	2.22*
CH 14	0	0.37	119,755	15.432	7.76
	20	0.34	108.974	16.265	6.70
	34	2.57	211.538	38.462	5.50
CH 15	0	2.22	144.522	26.114	5.53
	20	0.73	92.075	18.765	4,91
	40	0.62	106.061	16.417	6.46
Ch 16	0	0.50	135.198	22.477	6.01
	19	0.31	108.100	17,780	6.08
	38	0.58	87.995	15.583	5.65
CH 17	0	1.16	120.629	22.932	5.26
	19	1.05	94.988	16.341	5.81
CH 18	13	1.75	146.55	25.65	5.71

Table 8. (continued)

Station	Depth (M)	Suspended Particle (mg/L)	OC (μg/L)	N (μg/L)	OC/N
CH 19	25	1.60	80.05	13.75	5.82
CH 21	39	1.76	132.57	23.05	5.75
CH 22	0	0.85	151.21	21.48	7.09
	17	0.62	157.97	27.52	5.74
	35	1.40	133.62	21.26	6.29
CH 23	0	0.71	119.056	18,562	6.41
	20	0.45	92.39	149.419	0.62*
	40	1.21	78.348	26.74	2.93*
CH 24	0	0.45	108.39	16.935	6.40
	20	0.54	100.54	14.865	6.76
	36	2.11	149 .15	25.06	5.95
CH 2s	0	0.93	102.83	14.84	6.93
	25	0.59	199.59	43.16	4.62
	46	2.58	105.68	14.387	7.3s
CH 27	0	0.62	843.240	137.326	6.14
CH 30	0	0.85	170.61	32.58	5.24
CH 31	0	0.87	118,73	20 .88	5.69
	21	1.26	129.97	23.90	5.44
CH 32	0	4.45	197.12	30,90	6.38
	0	7.56	211.53	41.29	5.12
CH 33	0	3.08	196.54	36.02	5.46
CH 34	0	1,55	127.34	28*01	4.54
	26	2,14	111.53	20.33	5.48
CH 35	0	0.81	135.16	33.43	4.04
	20	0.21	58.79	14*9L	3 .94*
CH 37	42	1.26	72.91	13.28	5.49
CH 42	21	0.03	96.01	21.871	4.39
	38	1.15	98.88	15.37	6.43
	38	0.72	135.457	19.898	6.81
CH 43	0	3.72	197.39	40.12	4.92
CH 45	0	4.31	106.372	16.518	6.44
	20	1.76	213.45	32.21	6.63
	39	3.82	185.08	26.170	7.07
CH 46	20	0.51	220.53	32.50	6.78
CH 47	0	1.25	24a. 70	28.40	8.76

Table 9. Gross fluxes ($mg/cm^2/dy$) of sediments, organic carbon, and nitrogen to the sea bottom from the water column in the northeastern Chukchi Sea (see Table 2 and Fig. 13 for station locations) during .4ugust-September 1986.

Station	Sediment	Oc	N	OC/N
CH17	1.180	0.00929	0.00103	'3.0
CH16	0.146	0.00129	0.00016	8.1
CH14	0.353	0.00070	0.00911	6.4
CH13	3.526	0.01282	0.00196	6.5

calculated by taking into account the amount of particulate intercepted in traps during August-September 1986 and corresponding to the four locations shown in Figure 13 (also see Table 2). By comparison to most nearshore areas, the sediment fluxes in the northeastern Chukchi Sea are generally very low. It would seem that the gross flux of suspended particulate increases seaward across the shelf from Station CH16 to CH13 through CH14, and that the gross flux is markedly higher at the northern margin of the study area (CH13, CH25). At Station CH17, which is shallow and nearer the coast, the gross sediment flux is relatively higher than at the two stations farther seaward (CH16 and CH14). The gross fluxes of OC and N are also highest at Station CH13 and both these values successively decrease from Stations CH17 to CH14 to CH16 (Table 9). The OC/N values of the trapped particulate samples are also provided in Table 9. It is shown that the OC/N values in the sediment trap samples decrease significantly from the inner shelf to the outer shelf.

The ^{210}Pb-based linear (cm/yr) and mass ($g/m^2/yr$) accumulation rates of sediments at selected offshore stations in the northeastern Chukchi Sea are shown in Table 10[1]. The linear rates vary from 0.16 cm/yr to 0.26 cm/yr whereas the mass accumulation rates range between 1,487 and 2,505 $g/m^2/yr$. Based on the mass sedimentation rates and the concentrations of organic carbon and nitrogen in surficial sediments (Table 7), the accumulation rates of organic carbon and nitrogen at the selected offshore stations were computed. These rates, corresponding to the various stations, are shown in Table 10. A lack of a net linear exponential decay in excess ^{210}Pb activity

Table 10. ^{210}Pb-based linear (cm/yr) and mass ($g/m^2/yr$) sediment accumulation rates ($g/m^2/yr$) of particulate organic carbon (OC) and nitrogen at selected stations, northeast Chukchi Sea.

Station	Linear Accum. Rate (cm/yr)	Mass Accum. Rate ($g/m^2/yr$)	OC Accum. Rate ($g/m^2/yr$)	N Accum. Rate ($g/m^2/yr$)
CH13	0.16	1660	22.8	3.2
CH21	0.23	2153	22.5	2.9
CH26	0.26	2142	21.6	1.7
CH38	0.26	2505	5.6	0.7
CH39	0.21	1487	2.3	0.3
CH40	0.16	2149	21.6	2.7

[1]The raw data on which these calculations are based, including the total and excess ^{210}Pb and ^{226}Ra activities (dpm/g) and water contents of l-cm sections of individual cores are included in the appendix section of this report (Appendix I).

in sediment cores collected (and analyzed by us) from the inshore areas indicate extremely low or no deposition of sediments.

Figure 59 shows binary plots between surficial sediment mean size and the sediment grain size sorting (expressed as standard deviation, Folk, 1980), whereas Figure 60 displays the plots between percentages of water and mud (silt + clay) in surficial sediments. The ternary plots in Figure 61 relate to percentages of water, clay and gravel + sand in the surficial sea floor sediments at stations where benthic samples were also taken and analyzed. The plots in Figures 60 and 61 are based on data shown in Table 11, which correspond to calculations of proportional contents of water, mud and gravel plus sand on a wet sediment basis (please note that the granulometric data in Table 5 and Figure 59 are based on a dry sediment basis). Figures 59, 60, and 61 show that there are four distinct station groupings and that these groupings generally match closely with the benthic macrofaunal station groups.

C. Benthic Biological Studies

1. General

Over 425 taxa were identified from 37 stations occupied in October 1986 (Table 12; Fig. 62), with polychaetes, crustaceans (barnacles and amphipods), and mollusks (bivalves) typically dominant in abundance. Sipunculids, clams, sea cucumbers, and sand dollars were generally dominant in biomass (Appendix III; a complete list of taxa are on file at the Institute of Marine Science, University of Alaska Fairbanks).

2. Abundance, Diversity, Biomass, Carbon Production of Individual Stations

Abundance values (Table 12) for macrofauna ranged from 454 (offshore northern Station CH13) to 31,576 (inshore northern Station CH16)

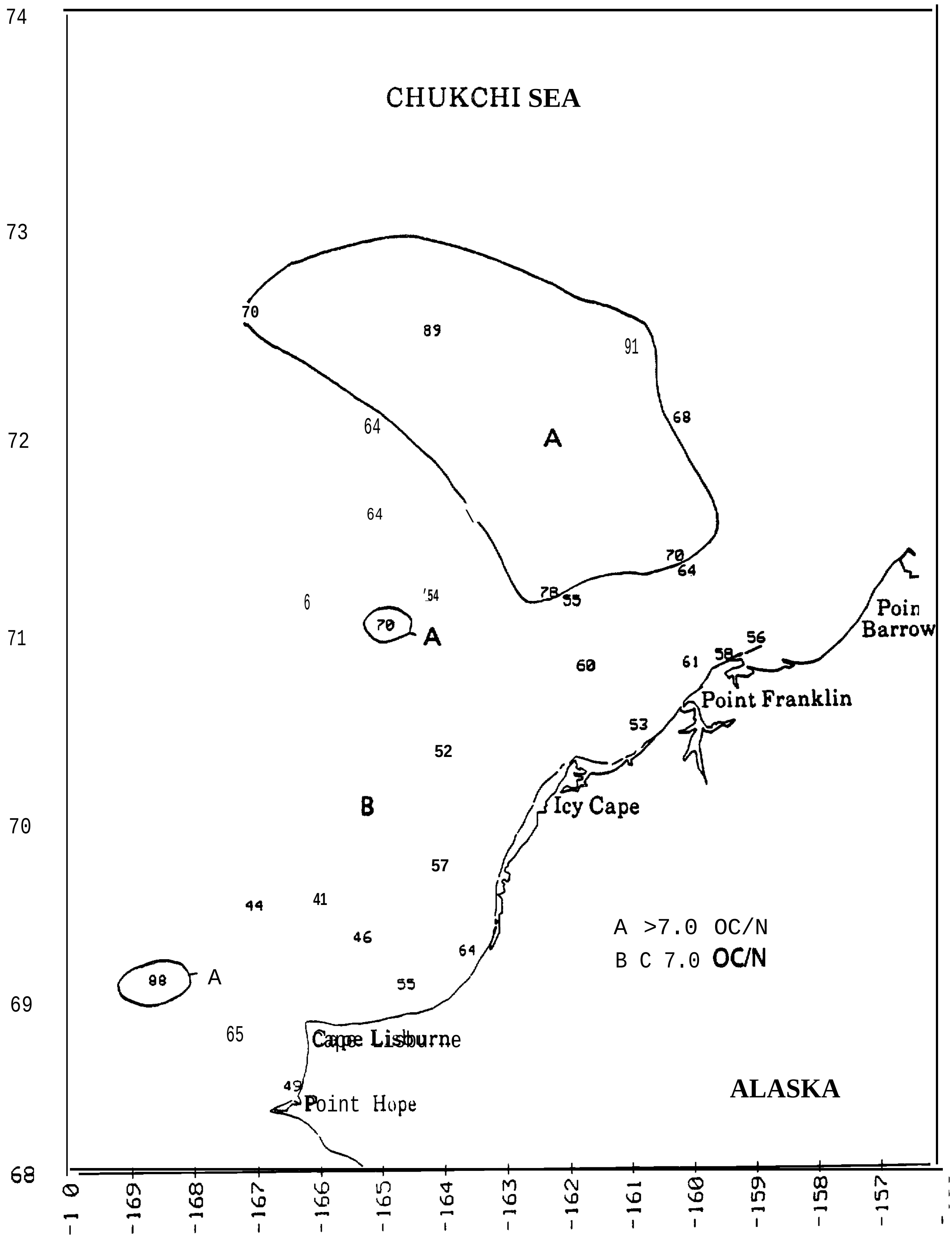

Figure 57. OC/N values (x LO-l) in suspended particles of surface waters in the northeastern Chukchi Sea.

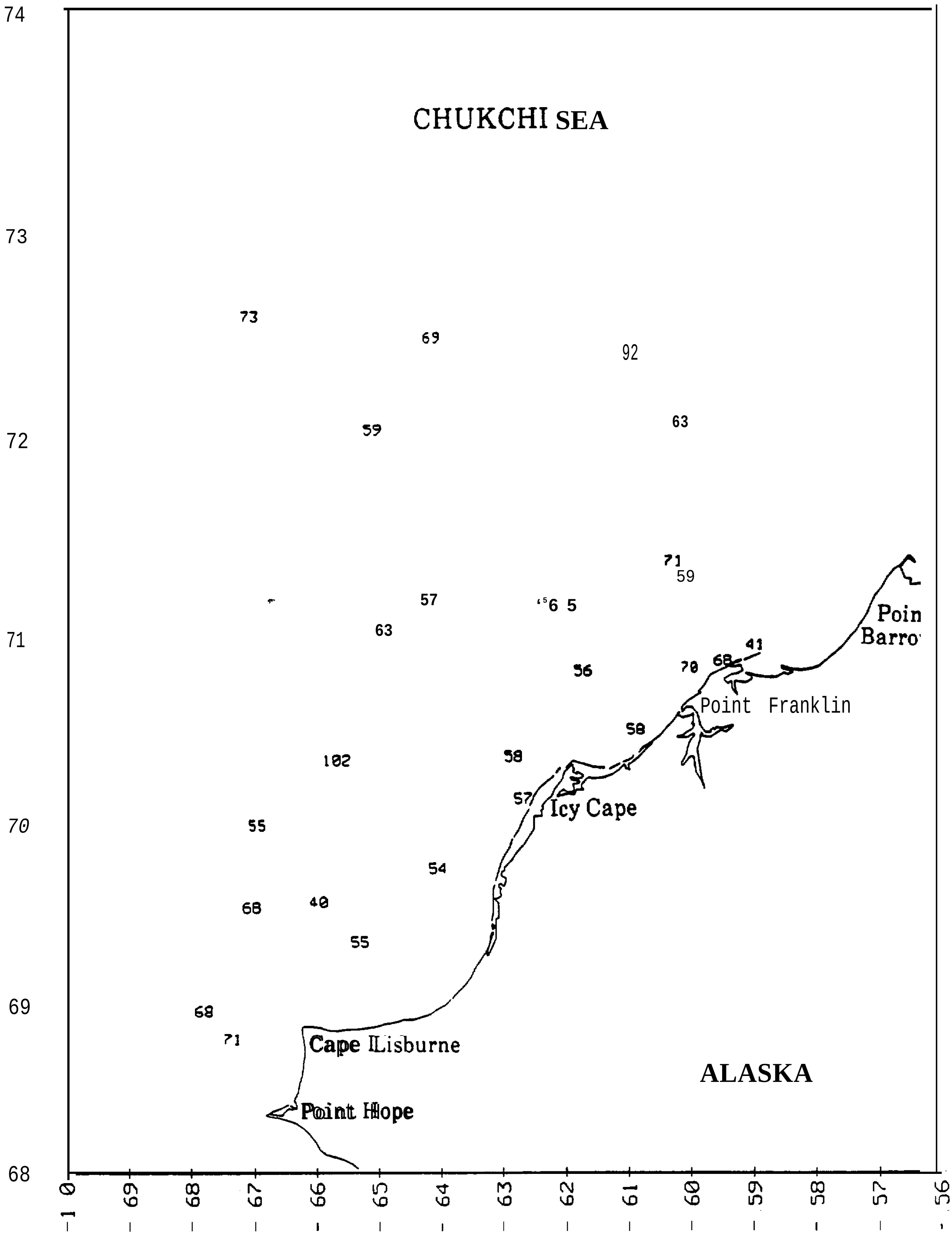

Figure 58. OC/N values (x 10-L) of suspended particles of near bottom waters in the northeastern Chukchi Sea.

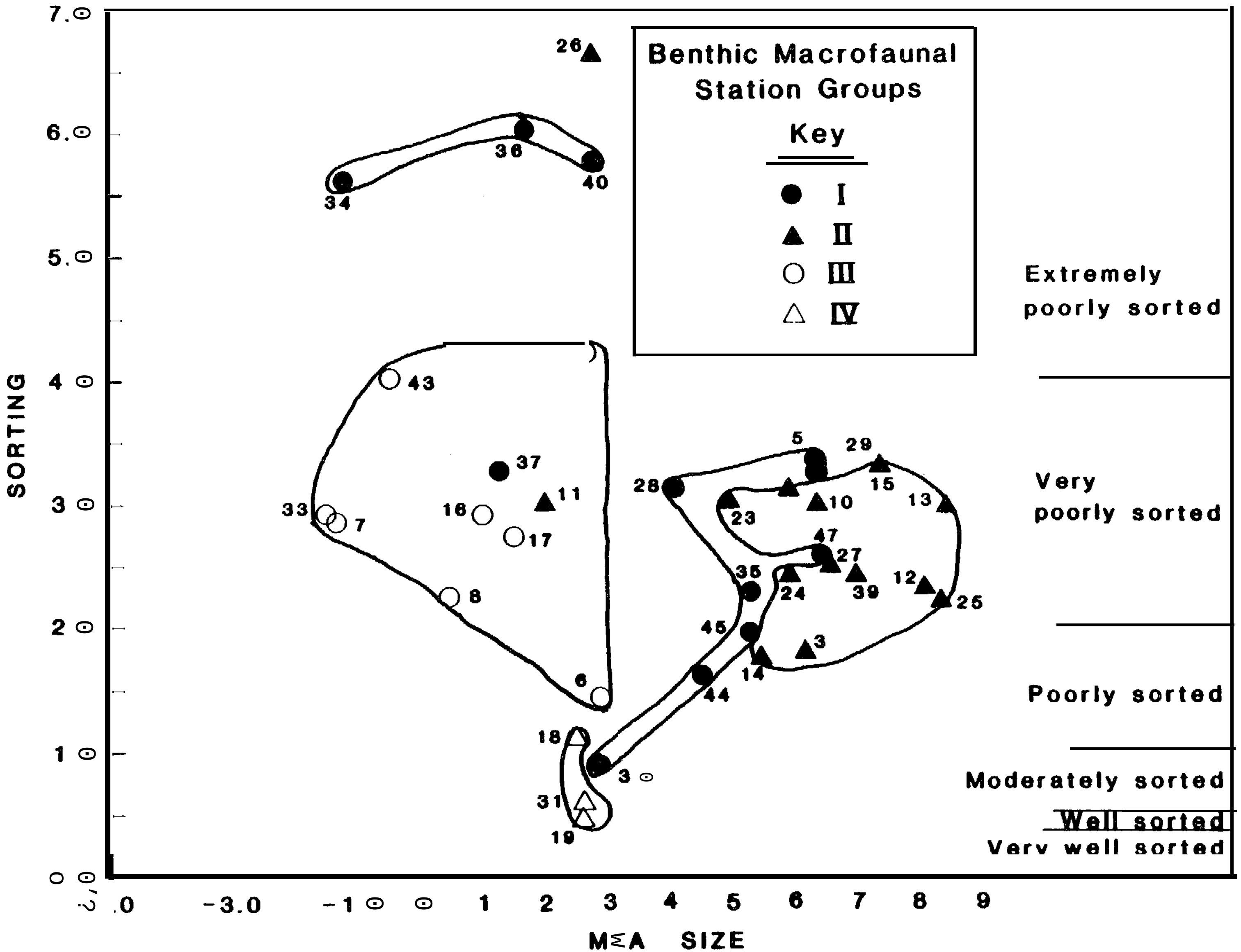

Figure 59. The relationship of the stations (CH) to station groups based on sorting and mean size of dry sediments for cluster groups (see Figs. 74 and 78).

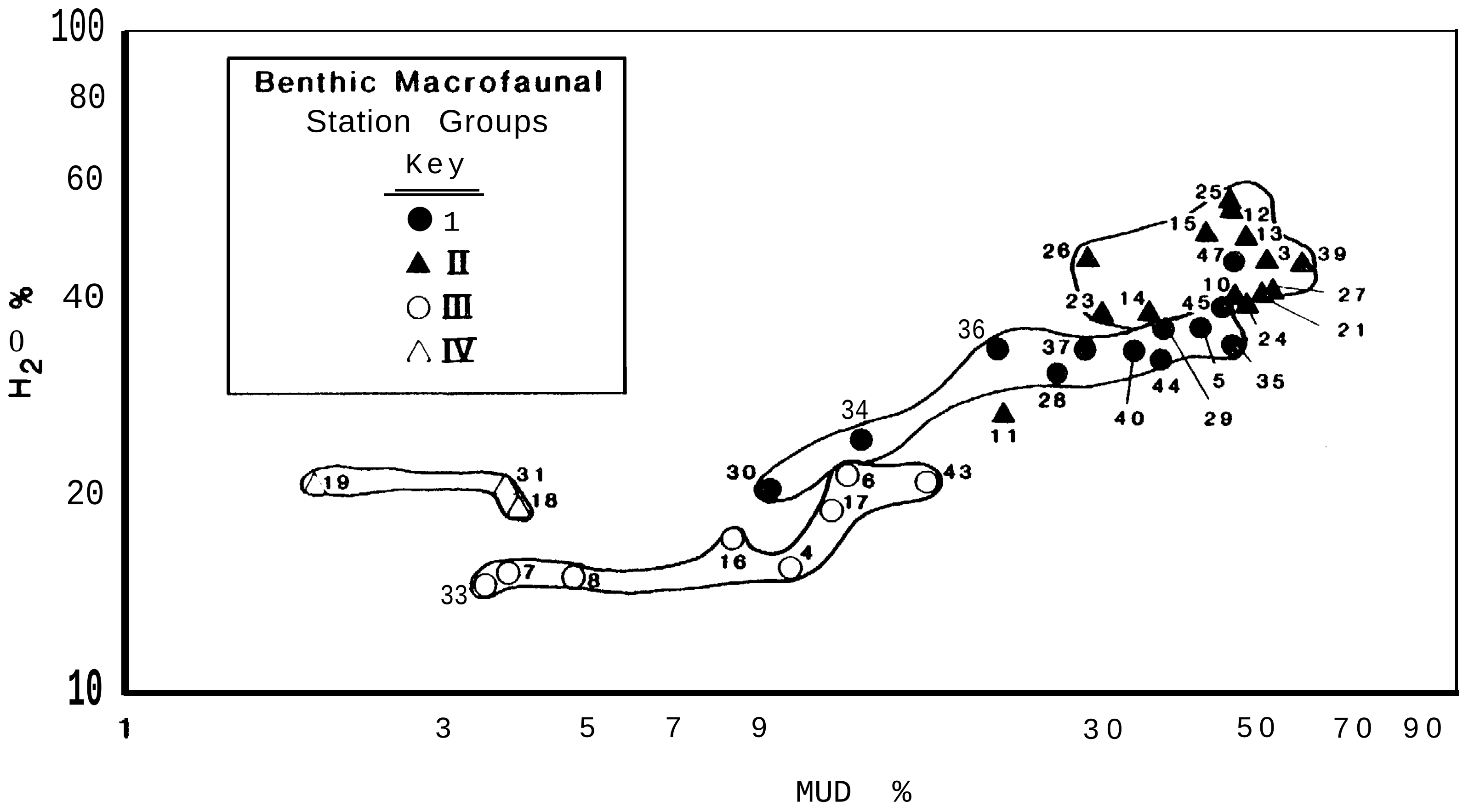

Figure 60. The relationship of the stations (CH) to station groups based on % water and % mud in sediment (see Figs. 74 and 78).

Table 11. Contents (by weight percent) of gravel and sand, mud and water in sea floor surficial wet sediments, northeast Chukchi Sea.

Sample No.	Gravel & Sand %	Mud %	Water %
CH1	11.48	73.48	15.04
CH2	6.45	47.91	45.64
CH3	1.74	5.16	45.10
CH4	73.99	9.78	16.23
CH5	22.25	42.14	35.61
CH6	67.55	11.71	20.73
CH7	81.03	3.73	15.23
CH8	80.35	4.77	14.89
CH9	6.02	46.26	47.76
CH10	13.50	47.05	39.44
CH11	52.67	21.37	25.96
CH12	0.10	46.69	53.20
CH13	1.75	49.34	48.91
CH14	28.75	33.97	37.28
CH15	8.25	42.50	49.25
CH16	74.43	8.35	17.21
CH17	69.51	11.69	18.79
CH18	77.02	3.85	19.14
CH19	77.87	1.92	20.21
CH20	22.35	37.99	39.64
CH21	10.34	50.38	39.28
CH22	66.36	10.60	23.04
CH23	33.40	29.61	36.99
CH24	14.28	47.26	38.46
CH25	0.20	45.51	54.27
CH26	26.65	28.30	45.05
CH27	5.86	53.77	40.36
CH28	44.60	25.48	29.92
CH29	28.76	35.84	35.40
CH30	70.18	9.50	20.32
CH31	76.25	3.70	20.03
CH32	99.61	0.39	0.00
CH33	81.99	3.51	14.49
CH34	63.17	12.74	24.14
CH35	19.92	46.85	33.22
CH36	46.38	20.37	33.25
CH37	40.96	25.81	33.23
CH38	25.81	39.30	34.88
CH39	2.39	52.94	44.69
CH40	35.28	31.49	33.21
CH41	61.95	8.84	29.18
CH42	20.07	43.11	36.81
CH43	63.69	15.94	20.37
CH44	32.84	35.69	31.47
CH45	16.49	45.19	38.32
CH46	8.21	49.65	42.14
CH47	6.93	47.26	45.81

Table 12. Abundance, biomass, and estimated carbon production and carbon requirements for benthic macrofauna collected by van Veen grab in the eastern Chukchi Sea aboard the NOAA R/V *Oceanographer,* August/September 1986, Cruise OC862. All taxa collected are included in the entries for this table. Fragments are not included in the abundance values, but are included in the other computations. TE = transfer efficiency.

Station Name	Abundance (indiv/m^2)	Wet Weight Biomass (g/m^{-2})	Carbon Biomass (gC/m^2)	Carbon Production (gC/m^2/yr)	Carbon Required (gC/m^2/yr) 10% TE	20% TE
CH3	838	177.24	7.53	2.8	28	14
CH4	1592	456.99	13.65	4.0	40	20
CH5	3656	138.01	6.63	3.4	34	17
CH6	8472	99.05	5.62	4.9	49	25
CH7	7482	387.33	19.64	15.6	156	78
CH8	2508	379.86	13.20	4.6	46	23
CH10	2912	306.71	13.00	7.0	70	35
CH11	1922	129.32	3.57	1.7	17	8
CH12	758	266.57	11.41	6.3	63	31
CH13	454	277.24	10.30	4.1	41	20
CH14	726	269.10	12.10	5.8	58	29
CH15	4392	272.86	11.17	9.4	94	47
CH16	31576	611.67	15.99	7.2	72	36
CH17	4998	125.50	5.64	5.4	54	27
CH18	462	136.66	3.21	2.3	23	11
CH19	1622	211.96	5.75	1.9	19	9
CH21	1146	296.60	11.79	11.5	115	58
CH23	616	246.69	9.60	5.9	59	29
CH24	1270	174.49	7.62	5.6	56	28
CH25	974	438.78	16.58	5.4	54	27
CH26	564	173.60	7.01	2.7	27	13
CH27	772	49.49	2.88	3.2	32	16
CH28	994	145.33	8.15	6.8	68	34
CH29	734	66.94	4.08	5.0	50	25
CH30	810	69.26	2.99	2.8	28	14
CH31	702	357.42	5.61	1.6	16	8
CH33	6988	168.07	3.21	1.4	14	7
CH34	2296	131.13	6.87	5.0	50	25
CH35	1328	202.87	9.67	8.0	80	40
CH36	1044	134.06	6.48	5.0	50	25
CH37	2566	140.21	7.16	5.6	56	28
CH39	1062	110.69	4.61	1.9	19	10
CH40	2014	265.34	11.50	9.9	99	50
CH43	3938	94.57	2.05	1.4	14	7
CH44	2320	141.93	6.77	2.8	28	14
CH45	828	17.96	0.96	0.7	7	3
CH47	632	87.10	4.34	1.8	18	9
Averages	2918	209.69	8.09	4.9	49	24
(±1 SD)	(5249)	(129.32)	(4.42)	(3.1)	(31)	(16)

individuals/m^2, wet weight ranged from 18 (inshore southern Station CH45) to 612 g/m^2 (inshore northern Station CH16), carbon biomass ranged from 0.96 (inshore southern Station CH45) to 19.64 gC/m^2 (northern Station CH7), and carbon production estimations varied from 0.7 (inshore southern Station CH45) to 15.6 gC/m^2/yr (inshore northern Station CH7). Mean ($\pm$ one standard deviation) values for these parameters for the 37 stations are 2,91855,249 indiv./m^2, 210$\pm$129 g wet weight/m^2, 8.09$\pm$4.42 gC/m^2, and 4.9$\pm$3.1 gC/m^2/yr. Shannon Diversity (Table 13) ranged from 1.07 (inshore Station CH8) to 3.72 (offshore Station CH40) and species richness ranged from 3.40 (Station CH31) to 13.76 (Station CH7). Simpson Diversity varied from 0.04 (offshore Stations CH11, 14 and 40) to 0.70 (Station CH16). Shannon Evenness varied from 0.22 (Station CH16) to 0.85 (Station CH14).

In general, highest abundance values occurred close to the coast north of Icy Cape (Table" 12; Figs. 62 and 63) with organisms dominated by polychaetes, barnacles and amphipods (Figs. 64-66). Benthic amphipods, a major food resource of gray whales, represented a dominant component of the fauna at coastal stations just north of Icy Cape, a region identified as a feeding area *for* populations of gray whales in the summer (Phillips *et al.*, 1985). Biomass, carbon production, and $\delta^{13}C$ values were significantly higher ($P<0.05$) to the north and west of a frontal zone (see Physical Oceanography section) (Table 14; Figs. 67-69). High biomass and production values were also obtained at Stations CH34, 35, 36, and 37 just north of Cape Lisburne.

3. Trophic Structure and Motility for Individual Stations

Data showing trophic structure, based on taxon abundance, at individual stations are included in Table 15 and Figures 70-73. As noted in this table and these figures the highest percentage values for suspension feeders were

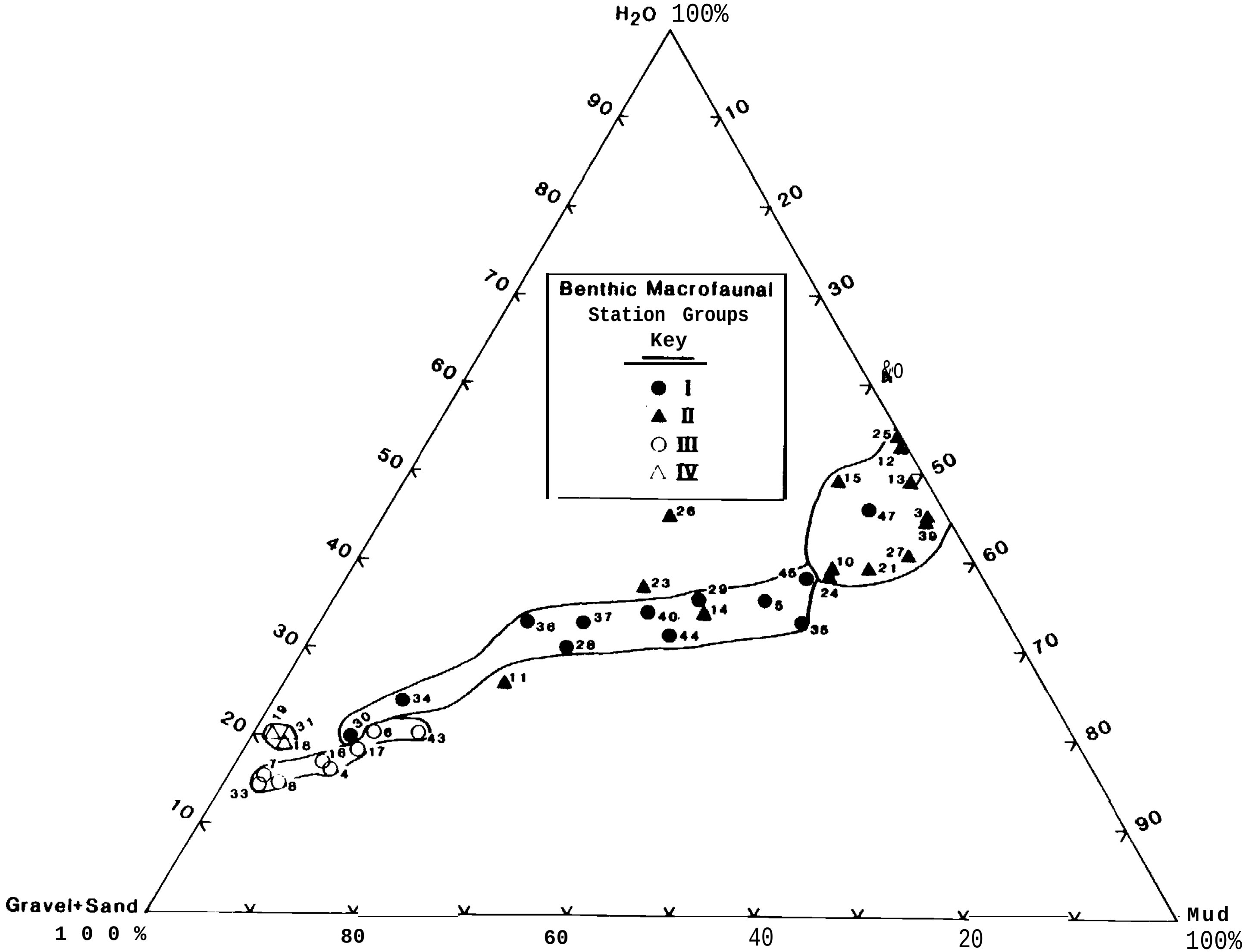

Figure 61. Ternary diagram relating stations (CH) to station groups based on% water, gravel, sand, silt, and clay (see Figs. 74 and 78) .

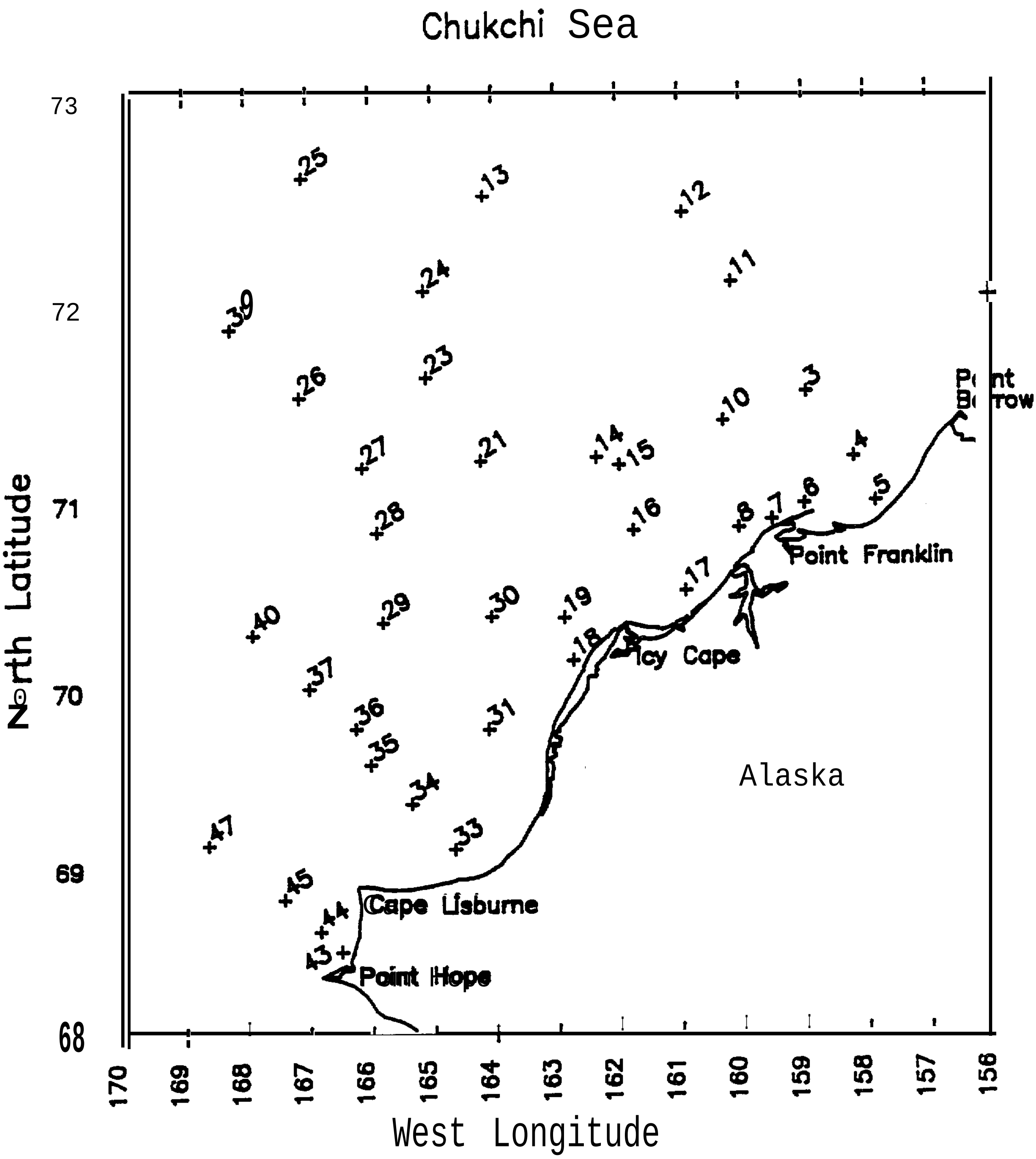

Figure 62. Stations (CH) where benthic biological (van Veen grab) samples were collected in the northeastern Chukchi Sea, August-September 1986. All station names are to be preceded by CH (e.g., CH3, CH4, CH5, etc.).

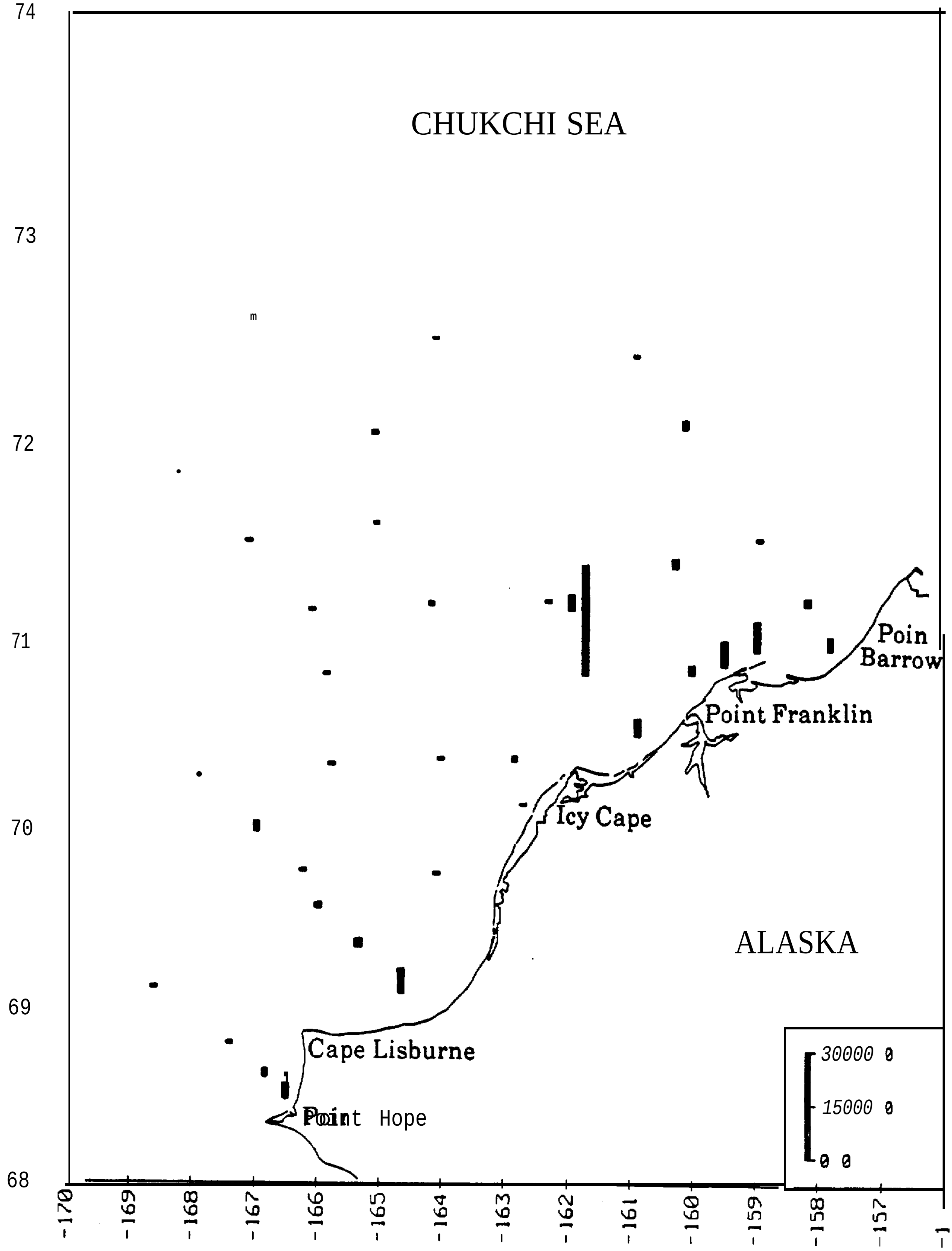

Figure 63. The abundance (indiv./m^2) of benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

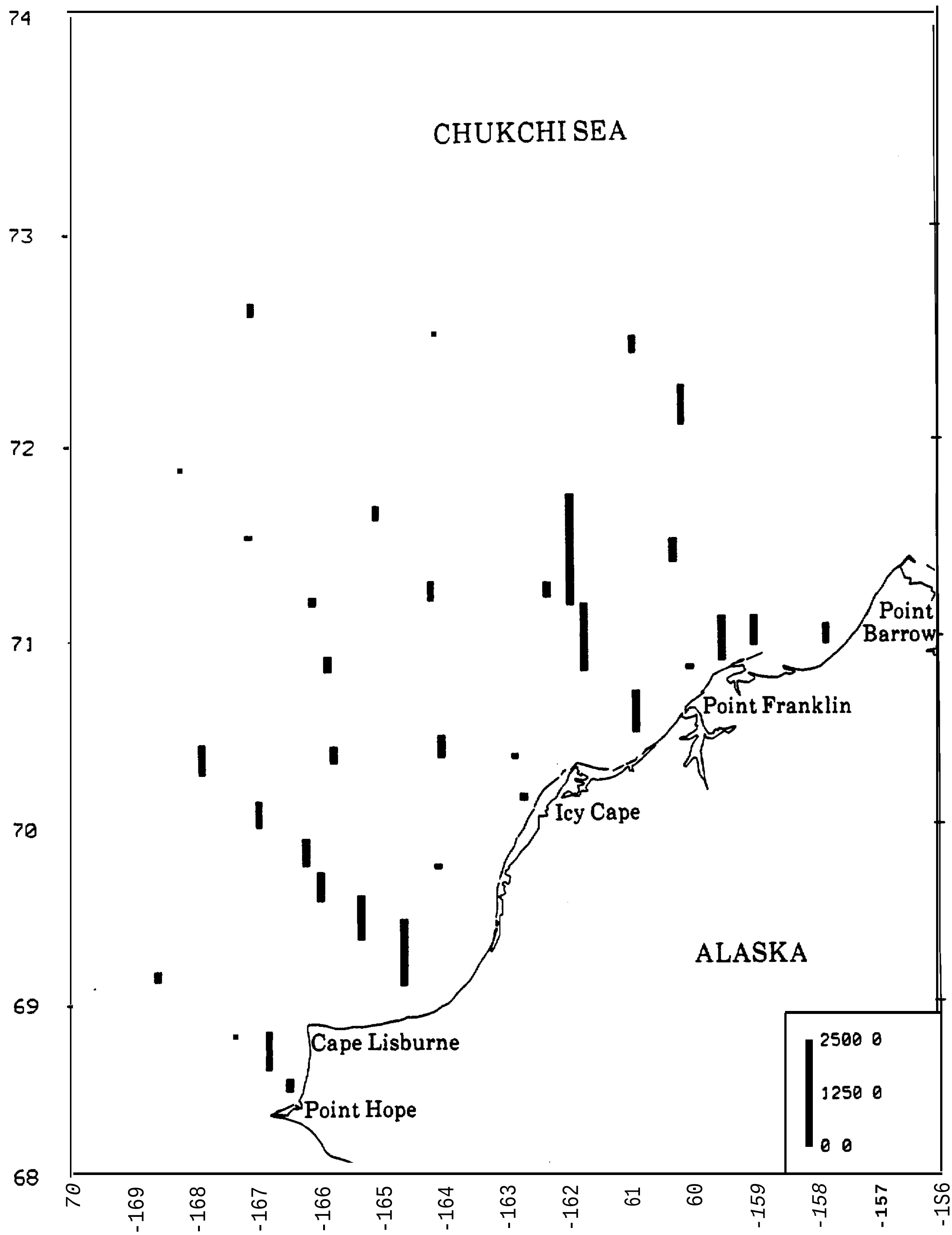

Figure 64. The abundance (indiv./m^2) of polychaetous annelids at stations occupied in the northeastern Chukchi Sea, August-September 1986.

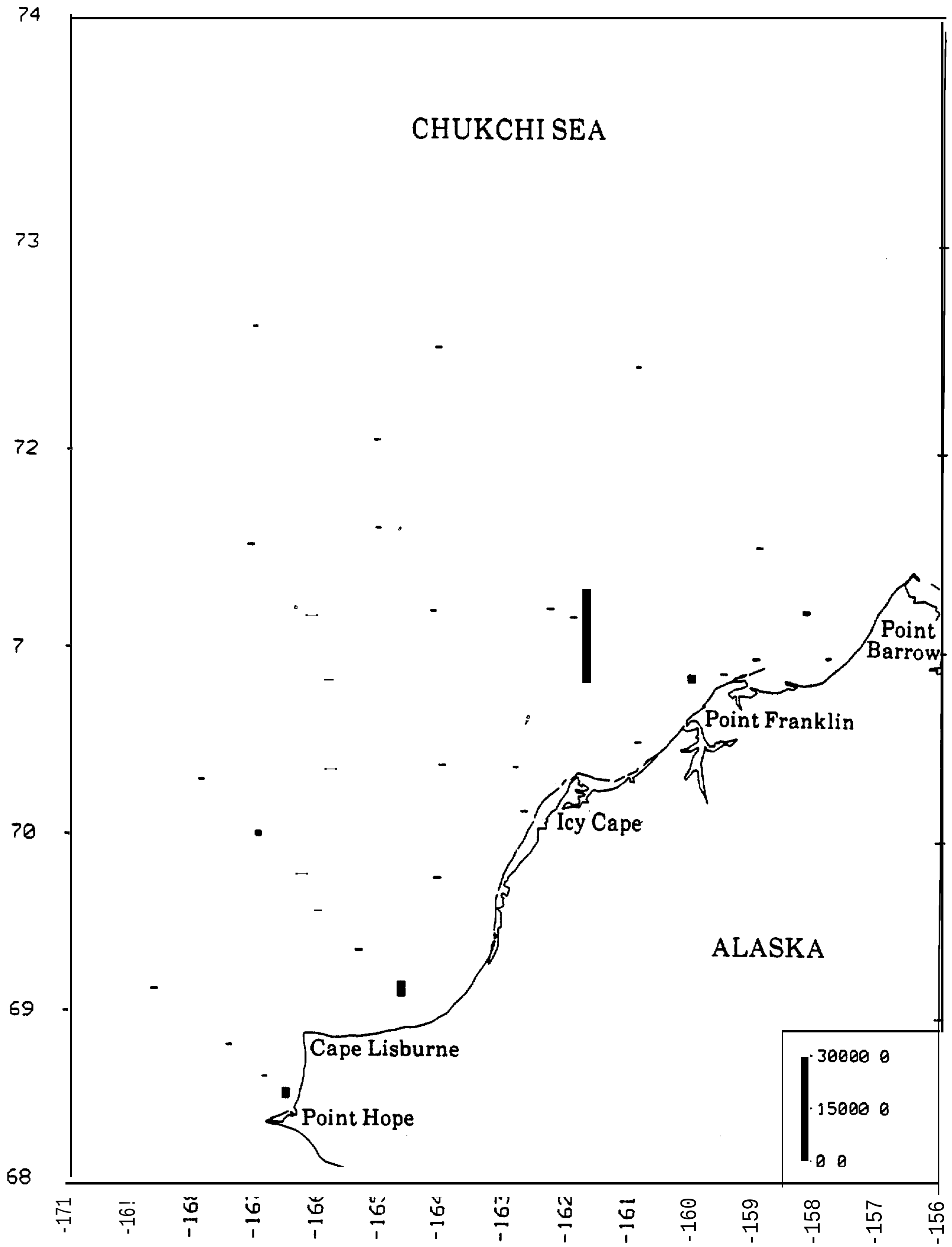

Figure 65. The abundance (indiv./m^2) of barnacles (*Balanus* sp.) at stations occupied in the northeastern Chukchi Sea, August-September 1986.

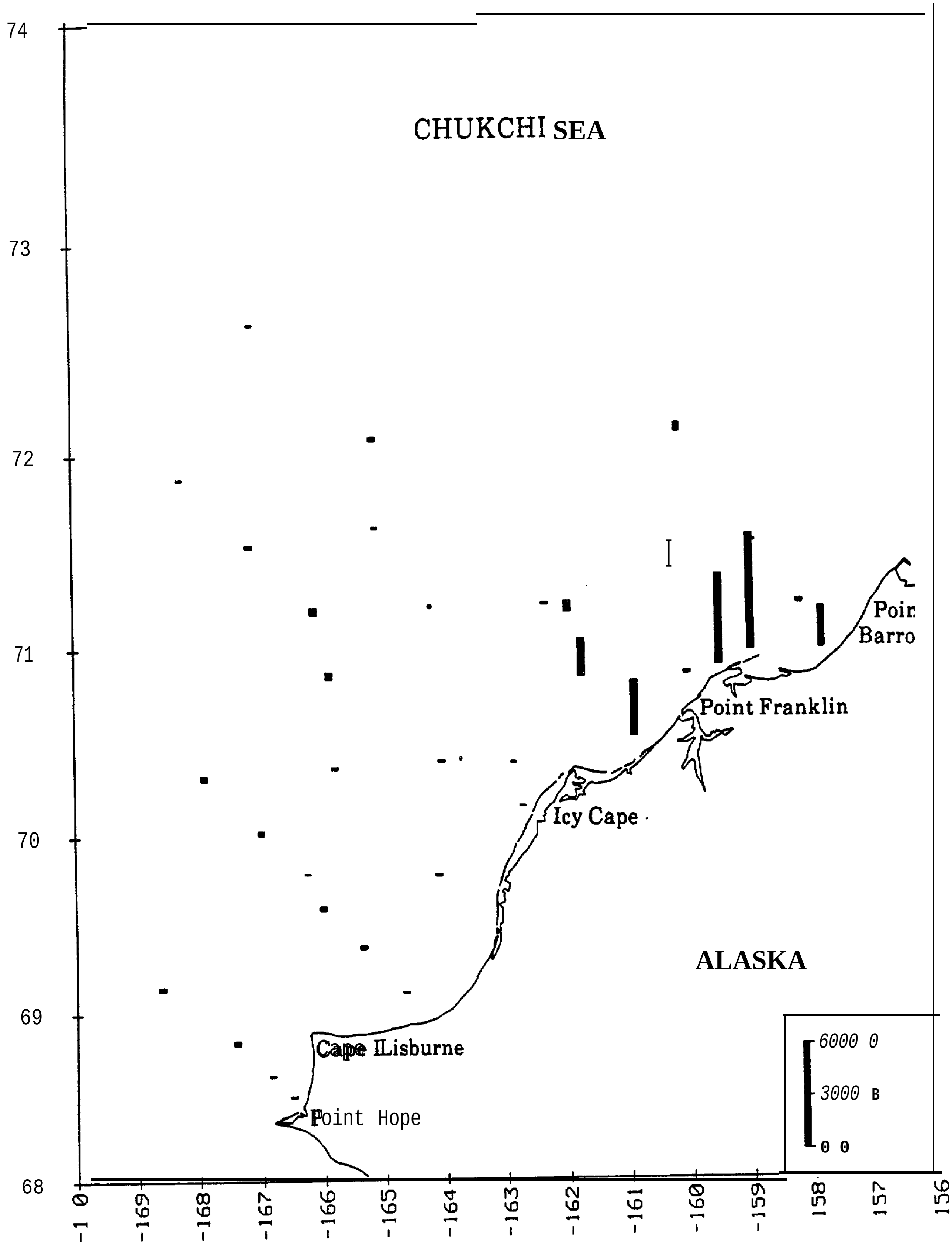

Figure 66. The number (indiv. $/m^2$) of amphipods at stations occupied in the northeastern Chukchi Sea, August-September 1986.

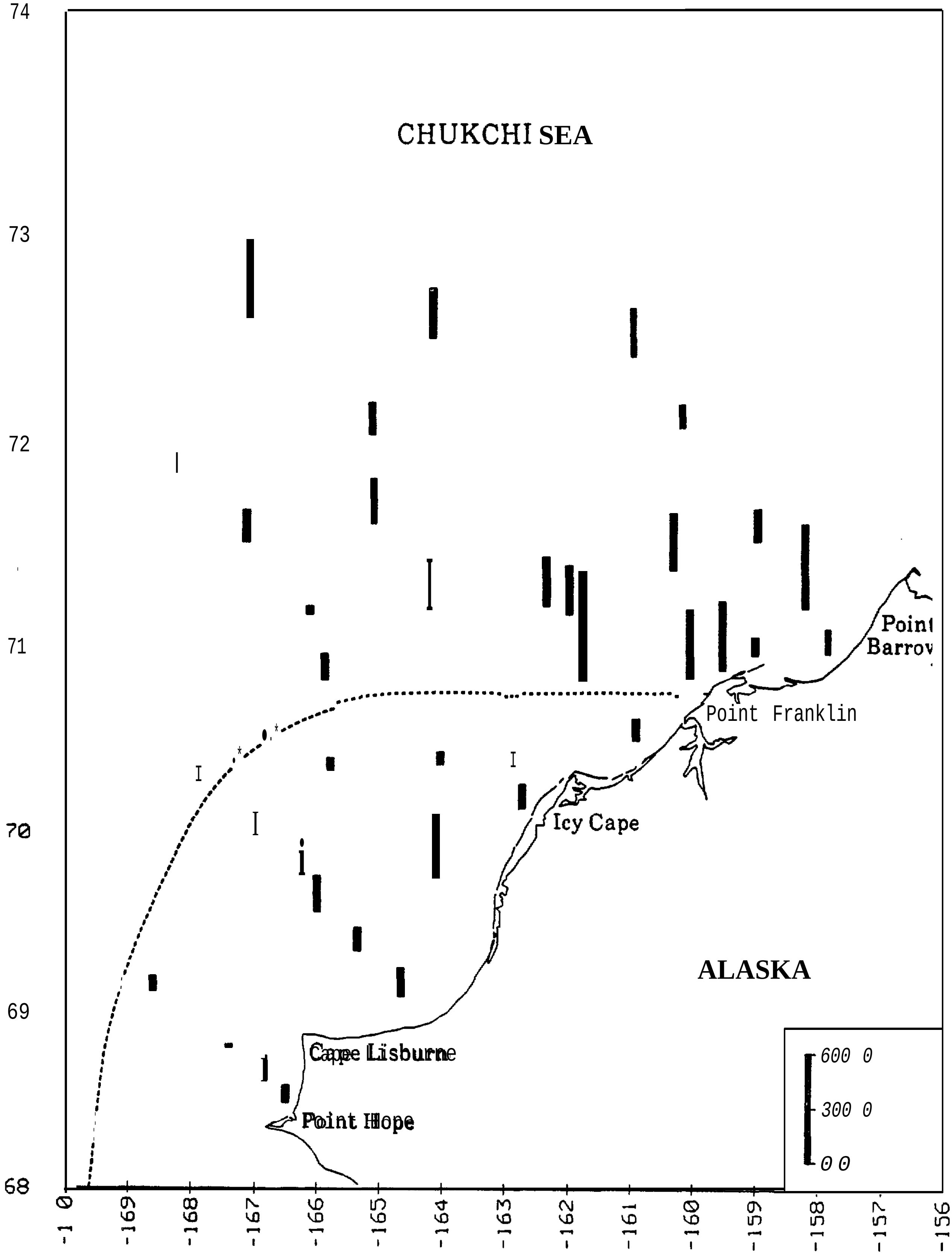

Figure 67. Distribution of wet weight biomass (g/m*) at stations occupied in the northeastern Chukchi Sea, August-September 1986. The frontal zone (shown by the dashed line) presumably separates the mixed Bering Shelf/Anadyr Water in the west and north from the Alaska Coastal Water.

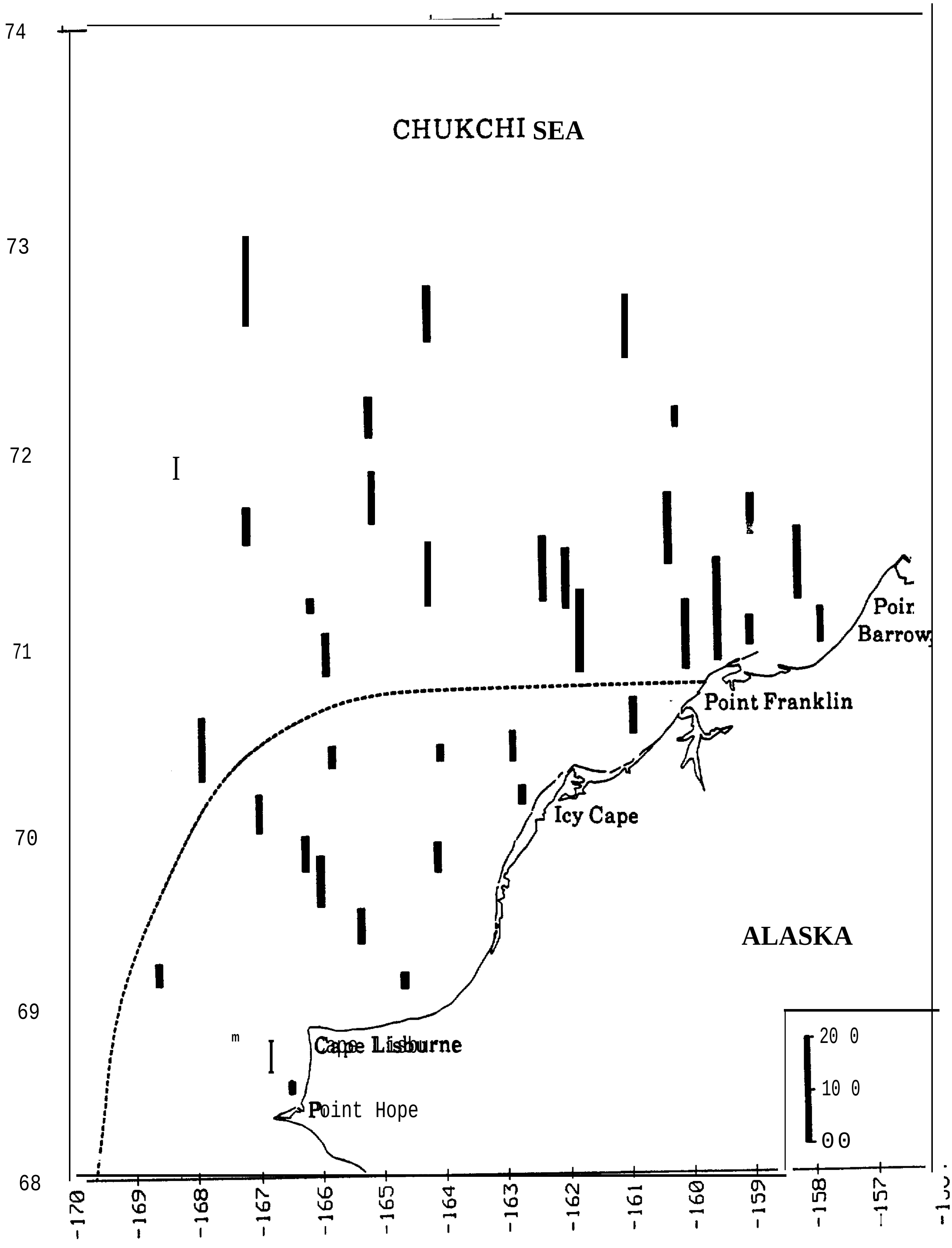

Figure 68. Distribution of biomass (gC/m*) in the northeastern Chukchi Sea, August-September 1986. The frontal zone (shown by the dashed line) presumably separates the mixed Bering Shelf/Anadyr Water in the west and north from the Alaska Coastal Water.

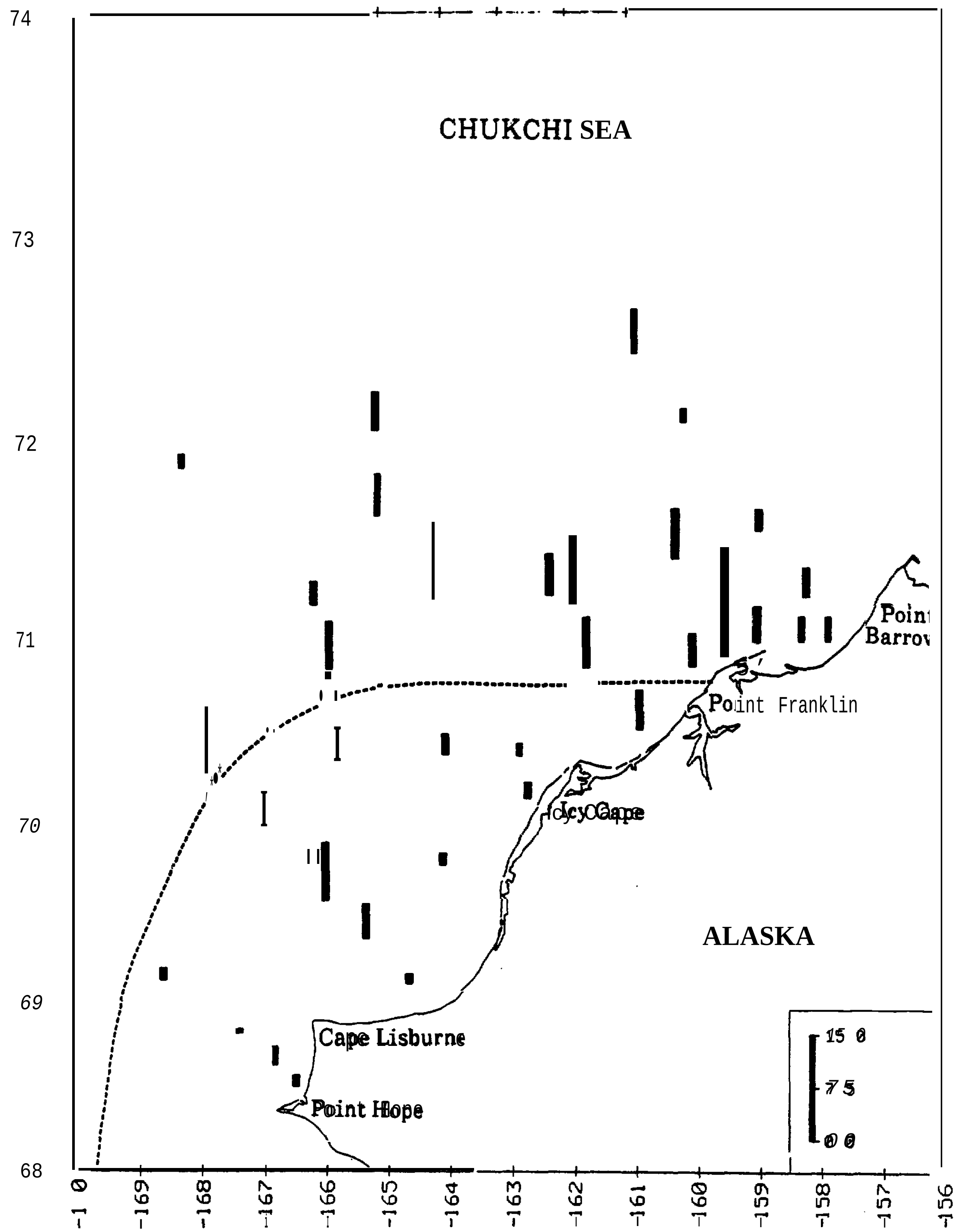

Figure 69. Carbon production estimates ($gC/m^2/yr$) for the 37 stations occupied in the northeastern **Chukchi** Sea, August-September 1986. The frontal zone (shown by the dashed line) presumably separates the mixed Bering **Shelf/Anadyr Water** in the vest and north from the **Alaska** Coastal Water.

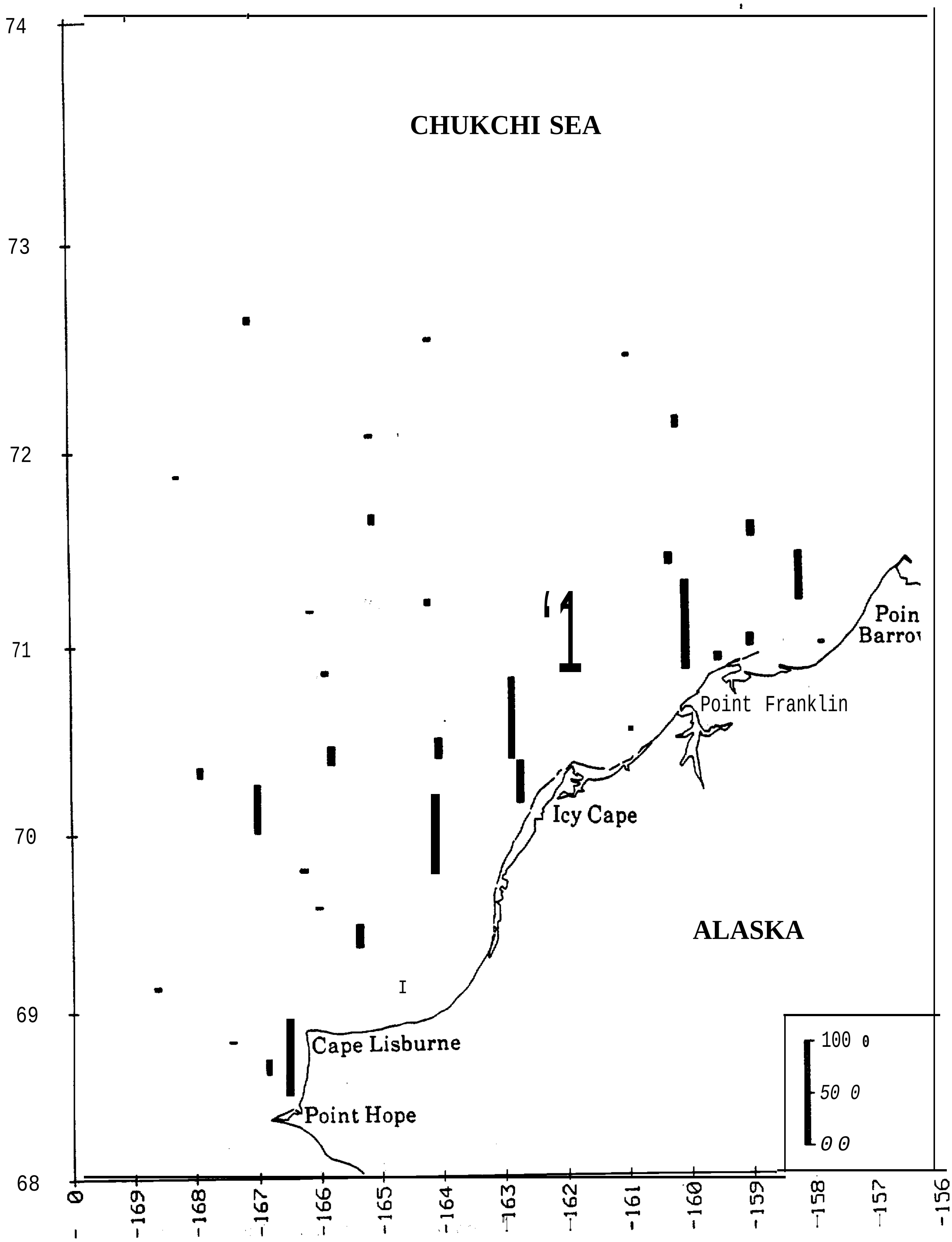

Figure 70. The percent abundance of suspension-feeding benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

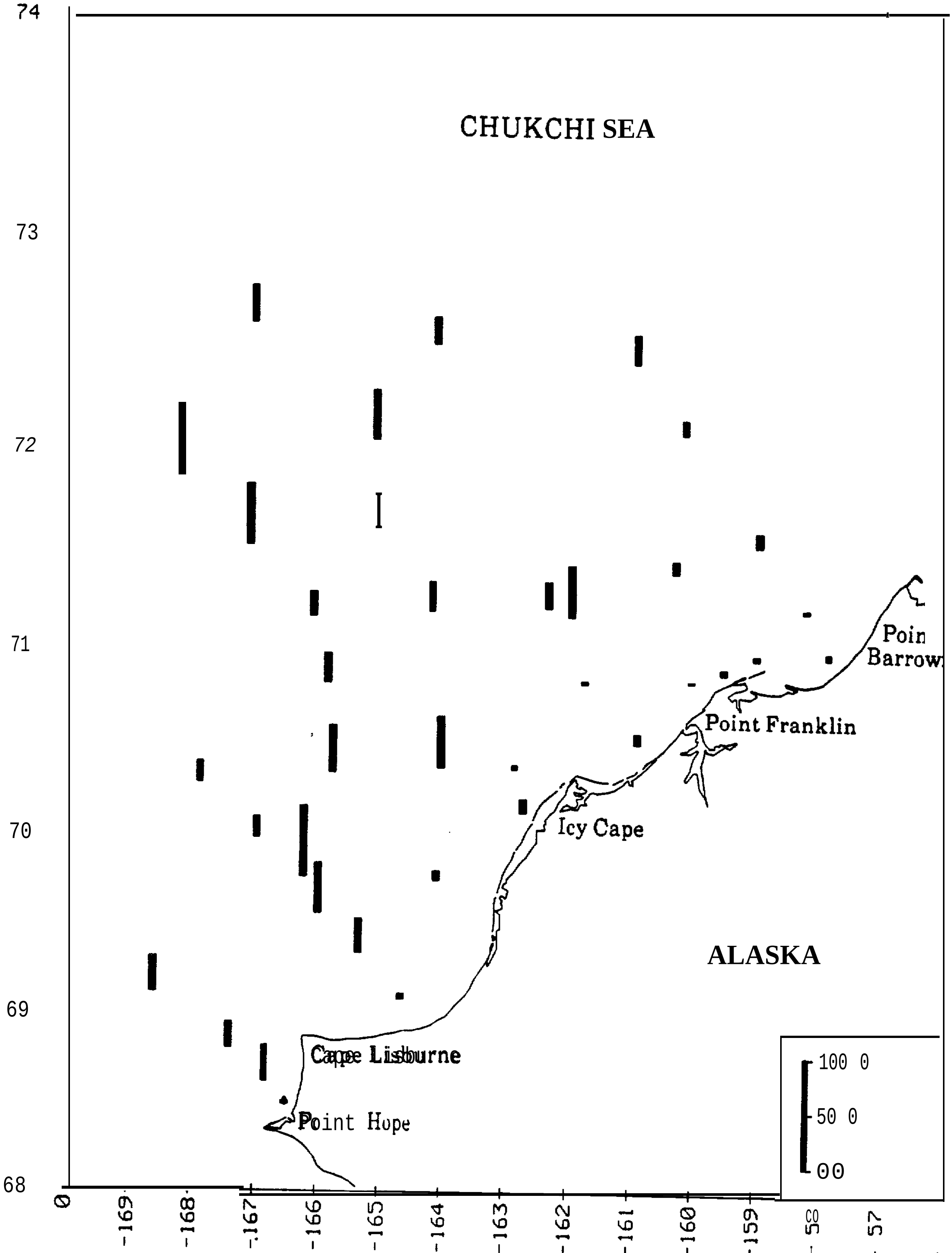

Figure 71. The percent abundance of subsurface deposit-feeding benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

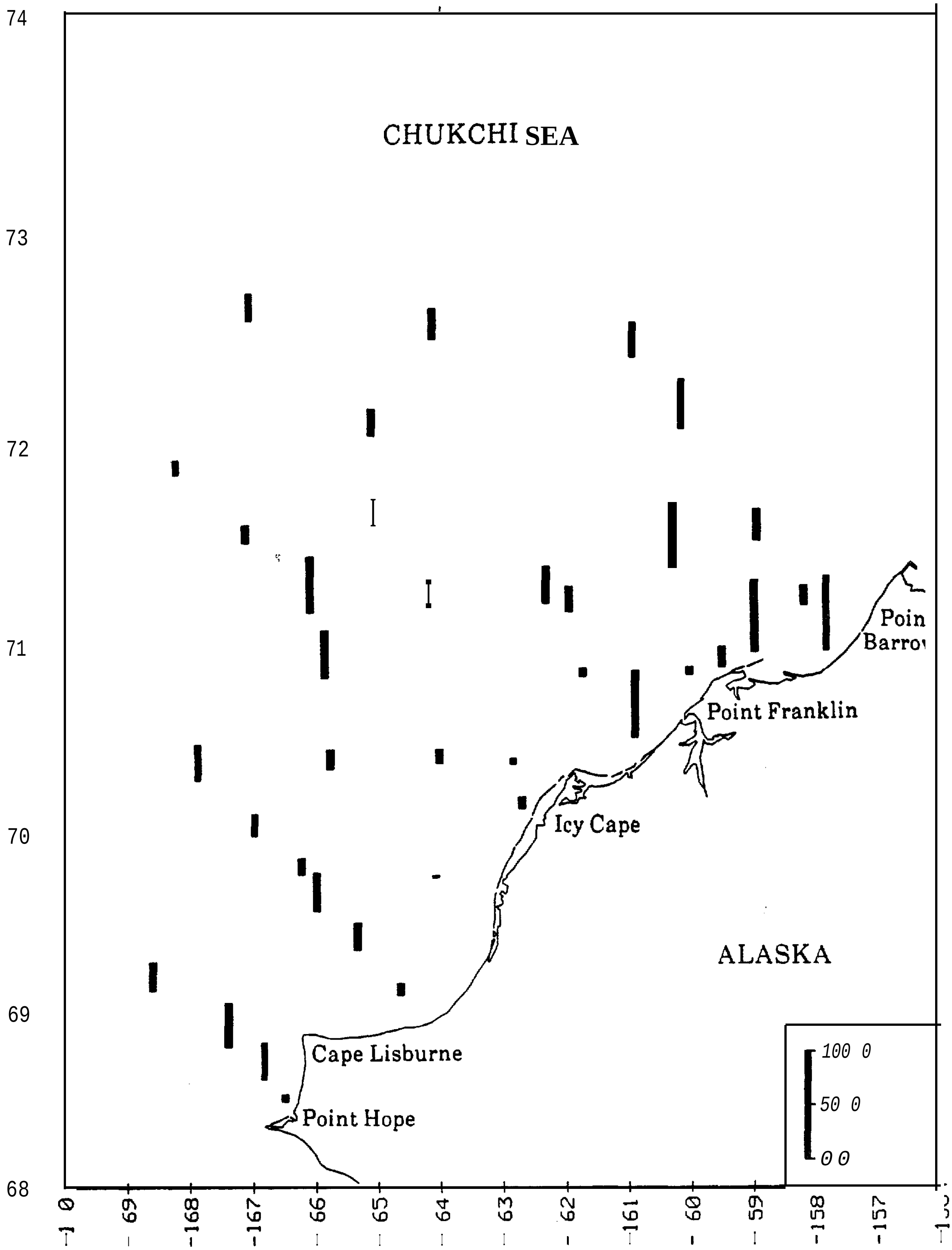

Figure 72. The *percent* abundance of surface deposit-feeding **benthic** fauna **at** stations occupied in the northeastern **Chukchi** Sea, **August-**September 1986.

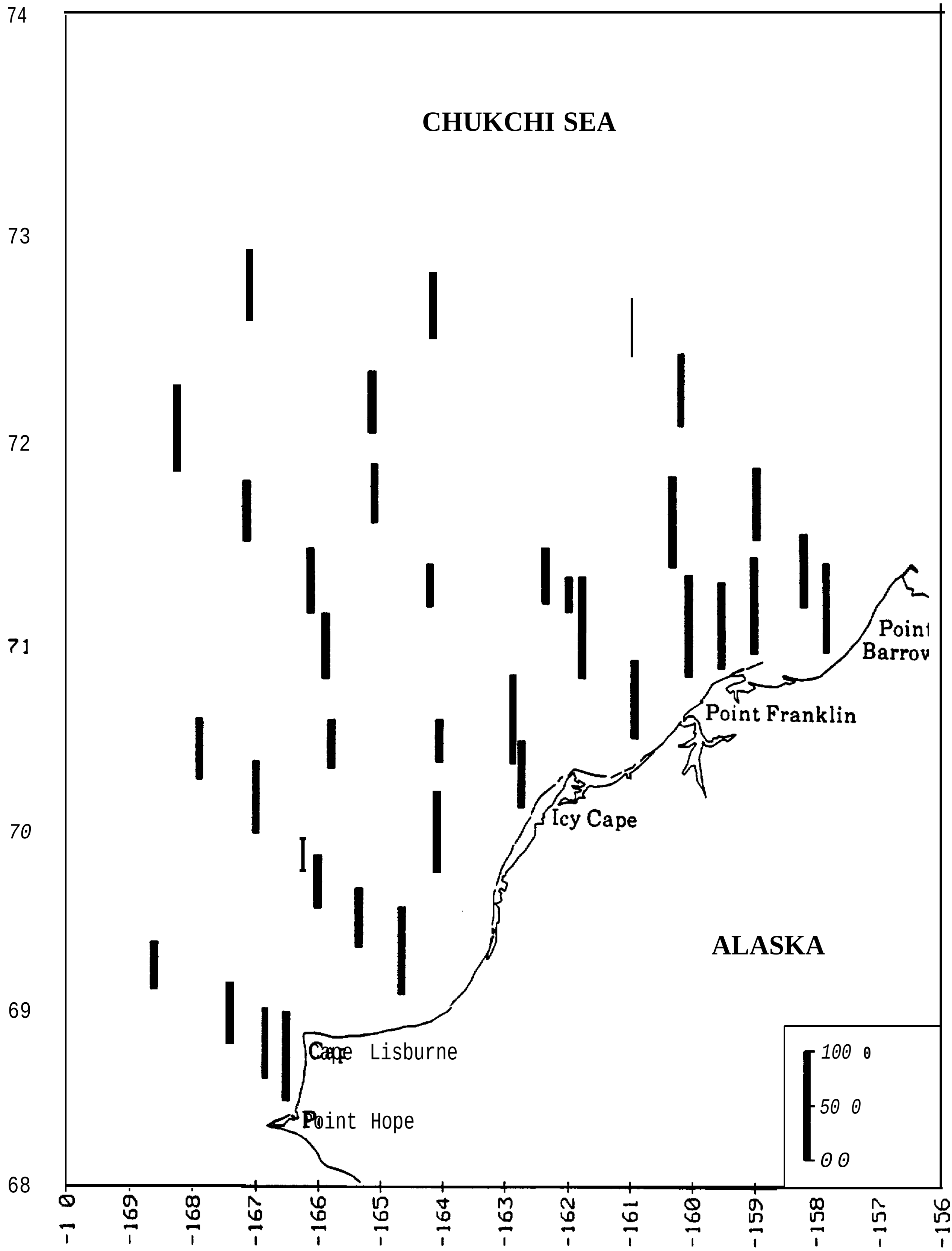

Figure 73. The percent abundance of interface-feeding (SDF+SF) benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

Table 13. Number of species (taxa), diversity indices, Shannon evenness, and species richness for benthic macrofauna collected at 37 benthic stations by van Veen grab in the eastern Chukchi Sea aboard the NOAA R/V *Oceanographer,* August/September 1986, Cruise OC862. Fragments and taxa excluded from cluster analysis (presented later) are not included in any computation.

Station Name	No. of Taxa	DIVERSITY Simpson	DIVERSITY Shannon	Shannon Evenness	Species Richness
CH3	61	0.07	3.27	0.80	8.98
CH4	68	0.19	2.57	0.61	9.21
CH5	74	0.18	2.40	0.56	9.09
CH6	101	0.22	2.52	0.55	11.42
CH7	123	0.26	2.50	0.52	13.76
CH8	40	0.65	1.07	0.29	4.99
CH10	79	0.11	2.88	0*66	9.97
CH11	87	0.04	3.71	0.83	11.47
CH12	46	0.09	2.90	0.76	6.81
CH13	35	0.14	2.52	0,71	5.57
CH14	61	0.04	3.49	0.85	9.19
CH15	107	0.19	2.73	0.58	12.68
CH16	143	0.70	1.10	0.22	13.72
CH17	91	0.22	2.61	0.58	10.63
CH18	29	0.19	2.35	0.70	4.61
CH19	43	0.29	1.94	0.52	5.70
CH21	60	0.09	2.98	0.73	8.52
CH23	52	0.06	3.30	0.84	8.04
CH24	54	0.09	3.03	0.76	7.48
CH25	45	0.12	2.64	0.69	6.40
CH26	37	0.21	2.38	0.66	5.86
CH27	48	0.09	2.99	0.77	7.14
CH28	55	0.08	3.12	0.78	7.93
CH29	52	0.06	3.25	0.82	7.82
CH30	40	0.13	2.70	0.73	5.86
CH31	23	0.28	1.73	0.55	3.40
CH33	72	0.44	1.65	0.39	8.08
CH34	53	0.11	2.73	0.69	6.79
CH35	45	0.08	2.89	0.76	6.14
CH36	45	0.14	2.65	0.70	6.37
CH37	70	0.19	2.58	0.61	8.87
CH39	31	0.44	1.62	0.47	4.36
CH40	94	0.04	3.72	0.82	12.44
CH43	37	0.39	1.52	0.42	4.40
CH44	39	0.13	2.56	0.70	4.98
CH45	35	0.12	2.69	0.76	5.21
CH47	28	0.11	2.54	0.76	4.31

Table 14. Mean (±one standard deviation) abundance, carbon biomass, carbon production, carbon requirements, $\delta^{13}C$, and OC/N of benthic organisms at station north and south of the postulated front in the eastern Chukchi Sea. Data collected by van Veen grab, August/September 1986. Fragments are not included in the abundance computations, but are included in all other computations.

	Abundance ($indiv/m^2$)	Wet Weight Biomass (g/m*)	Carbon Biomass (gC/m^2)	Carbon Production ($gC/m^2/yr$)	Carbon Required ($gC/m^2/yr$) 10% TE	20% TE	$\delta^{13}C$	OC/N
Northern CH Stations								
3,4,5,6, 7,8,10,11, 12,13,14,1.5, 16,21,23,24, 25,26,27,28, 39,40	3486 (6635) N=22	258 (136) N=22	10.16 (4.33) N=22	5.9 (3.3) N=22	59 (33) N=22	30 (16) N=22	-20.9 (1.89) N=14	8.9 (2.3) N=22
Southern CH Stations								
17,18,19,29, 30,31,33,34, 35,36,37,43, 44,45,47	1705 (1364) N=15	139 (79) N=15	5.05 (2.32) N=15	3.4 (2.1) N=15	34 (21) N=15	17 (11) N=15	-22.2 (0.78) N=7	10.3 (3.6) N=15

Table 15. Trophic structure, based on taxon abundance, for each station in the eastern Chukchi Sea, August-September 1986. SDF=surface deposit feeder, SSDF=subsurface deposit feeder, CARN=predator, SCAV=scavenger, HERB=herbivore, SF=suspension feeder.

BASED ON ABUNDANCE

STA #	SDF Number	SDF %	SSDF Number	SSDF %	CARN Number	CARN %	SCAV Number	SCAV %	HERB Number	HERB %	SO Number	SO %	UNKNOWN Number	UNKNOWN %	TOTAL # OF IND
CH3	253.3	30.23	108 7	12.97	141.4	16.88	48.8	5.59	S7.6	6.88	206.2	24.60	24.0	2.86	838.0
CH4	283.5	17.81	39 0	2,14	234.3	14.72	224.3	14.09	28.3	1.78	777.7	48.85	10.0	0.63	1592.0
CH5	2531.6	69.24	145.3	3.98	110.1	3.01	425.8	11.65	16.0	0.44	41'7.2	11.41	10.0	0.27	3856.0
CH6	S832 5	66.48	350 0	4 13	296 .4	3.50	879.8	10.38	464.1	5.48	805.2	9.50	44.0	0.62	8472.0
CH7	1471.7	19.67	370 0	4.95	541.4	7.24	2321.0	31.02	1877.7	25.10	704.2	9.41	196.0	2.62	'?482.0
CH8	193.3	7 71	28 0	1.12	8s.3	3.40	51.7	2.06	13.7	0.54	2114.0	84. 29	22.0	0.88	2508.0
CH10	1842.7	63 28	365 3	12 55	175.7	6.03	198.5	6.82	83.0	2.88	223.8	7.09	22.0	0.76	2912.0
CH11	857 5	44 62	263 3	13 70	251.9	13.11	185 3	9.84	31.0	1.61	299.0	15.56	34 0	1 '77	1922.0
CH12	255 8	33.74	210 0	27 70	112.6	14.86	27.3	3.61	. 45.8	6.04	94.5	12.47	12.0	1.58	758.0
CH13	130 6	28 76	114 0	25 11	75.5	16.62	24.2	S.32	' 31.3	6.89	72.5	15.97	6.0	1.32	454.0
CH14	264.6	36 45	187 3	25 80	.97.1	12.00	49.5	6.81	30.1	4.15	53.3	7 35	54.0	7.*4	726.0
CH15	1002.8	22.83	2101.3	47.84	422.6	9.62	403.3	9.18	142.6	3.25	231.5	5.27	88.0	2.00	4302.0
CH16	2700.6	8.55	1000 0	3.17	475.3	1.51	721.0	2.28	47.3	0.15	20589.8	84.15	62.0	0.20	31576.0
CH17	3184.8	63 .72	53'7.0	10.76	315.1	6.31	420.5	8.41	25.3	0.51	478.3	9.s7	36.0	0.72	4998.0
CH18	49.4	10.68	62 0	13.42	58.3	12.62	52.3	11.33	2.0	0.43	218.0	47.18	20.0	4.33	462.0
CH19	98.7	6 08	70 7	4 36	89.7	5.53	70.3	4.34	6.0	0.37	1272.7	78.46	14 0	0.88	1622 0
CH21	241.8	21.10	309 3	26.99	175.0	15.27	146.7	12.80	57.1	4.99	74.0	6.46	142.0	12.39	1146.0
CH23	154 4	25 07	221 3	35 93	72.0	11 68	30.6	6.44	23.8	3.87	74.8	12.15	30.0	4 87	616 0
CH24	314.2	24.74	588.0	46 30	103.1	8.12	50.8	4.00	17.3	1.30	108.5	8.54	88.0	6.93	1270 0
CH25	235.5	24 18	334.0	34 29	118.3	12.14	69.3	7.12	40.0	4.10	167.0	17.15	10.0	1.03	974.0
CH26	93.4	18 55	322 0	57 09	57.3	10.16	29.0	5.14	5.3	0.95	47.0	8.33	10.0	1.77	564.0
CH27	413.1	53.51	176 0	22 80	06.0	12.43	56.6	7.34	5.3	0.60	21.0	2.72	4.0	0 52	772 0
CH28	465.2	46.80	280 7	28 24	90.5	9.10	81.1	8.16	11.8	1.19	50.7	5.10	14.0	1.41	904.0
CH29	139.5	19 01	336 0	45 78	59.5	8.10	58.2	7.92	3.3	0.45	121.5	16.S5	18.0	2 18	734.0
CH30	106 4	13 13	405 3	50 04	74,0	9.13	S8.3	7.20	3.7	0.45	152.3	18.81	10.0	1.23	810 0

Table 15. (continued)

BASED ON ABUNDANCE

STA	SDF		SSDF		CARN		SCAB		HERB		SF		UNKNOWN		TOTAL #
#	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	OF IND.
CH31	8.3	1 19	61 3	8.74	44.0	6.27	32.3	4.61	1.7	0.24	518.3	73.84	36.0	6.13	702.0
CH33	S26 .5	11.83	437 3	6 26	397.6	S.69	343.6	4.92	53.8	0.77	4769 1	68.25	160.0	2.29	6988 0
CH34	586.9	2S.56	724 0	31.53	172.6	7.52	1s2.9	6.66	4.7	0.20	51s.0	22.43	140.0	6.10	2296.0
CH35	4S6.0	30.60	640 0	48.19	84.0	6.32	57.0	4.28	6.0	0.4s	33.0	2.48	22.0	1.66	1328.0
CH36	162 2	15.54	718 0	68.77	57.1	5.47	S0.8	4.87	3.3	0.32	32.5	3.11	20.0	1.92	1044 0
CH37	4s5 0	18 94	490 0	le. 10	196.3	7.65	210.0	8.1S	12.8	0.50	1127.0	43.0.2	44.0	1.71	2S86.0
CH39	139.0	13.00	720.0	67.80	63.7	5.99	21.3	2.01	8.0	0.7s	52.0	4.00	S8.0	5.46	1062.0
CH40	702.5	34.8S	300 0	19.3(3	193.9	9.63	301.9	14.99	17.7	0.88	3%2 .0	15.99	86.0	4.27	2014.0
CH43	245.8	6.24	78.7	2.00	333.0	8.45	323.3	8.21	6.7	0.17	2940 .7	74. 67	10.0	0.25	3938 .0
CH44	816.5	35.20	785 9	33.88	84.3	2.77	54.7	2.36	0.7	0.0s	4S3 . e	19.57	144.0	6.21	2320.0
CH45	352.4	42 56	206 7	24.96	76.7	9.26	57.7	6.96	23.0	2.78	39.7	4 79	72.0	8.70	828.0
CH47	180.2	28.51	218.0	34. 4's	4s.1	7.62	61.1	9.68	0.s	0.08	30.0	4.7s	94.0	14.87	S32 .0

at the nearshore stations (see Fig. 62), while the highest values for subsurface deposit feeders generally occurred offshore. Surface deposit feeders were variably common at inshore and offshore stations. A high percentage of interface feeders (surface deposit feeders + suspension feeders) occurred at all stations (Fig. 73). Generally, a high percentage, by abundance, of sessile organisms were found nearshore with more motile individuals generally occurring offshore (Table 16; Figure 62). Details of the fauna comprising the various feeding groups and motility types are considered by Station Group *in the* section below entitled "Dominant Taxa, Trophic Structure and Motility of Taxa within Cluster Groups" (page 157).

4. Numerical Analysis

A cluster analysis of the abundance data from 37 stations delineated four cluster (station) groups (Fig. 74). The dominant fauna characterizing each of the cluster groups, ranked by abundance within each cluster group, is presented in Table 17. The percent occurrence (Fidelity) of each of the dominant taxa at stations comprising the cluster groups is also included in this table.

The results of the principal coordinate analysis of abundance data are shown in Figures 75-77. The stations in Cluster Groups I and IV form relatively tight groupings on the plots of the first and second, and the first and third coordinate axes. Stations in Groups II and III are best separated on the plot of the first and third coordinate axes. Stations in Cluster Groups I and II are separated on the plot of the first and second coordinate axes. Although Station CH5 is located along the coast and north of all of the other stations in Group I, it joins this group *at* a relatively high level of similarity in the cluster analysis. Further, Station CH5 is closely associated with Group I on the plots of the first and second and the

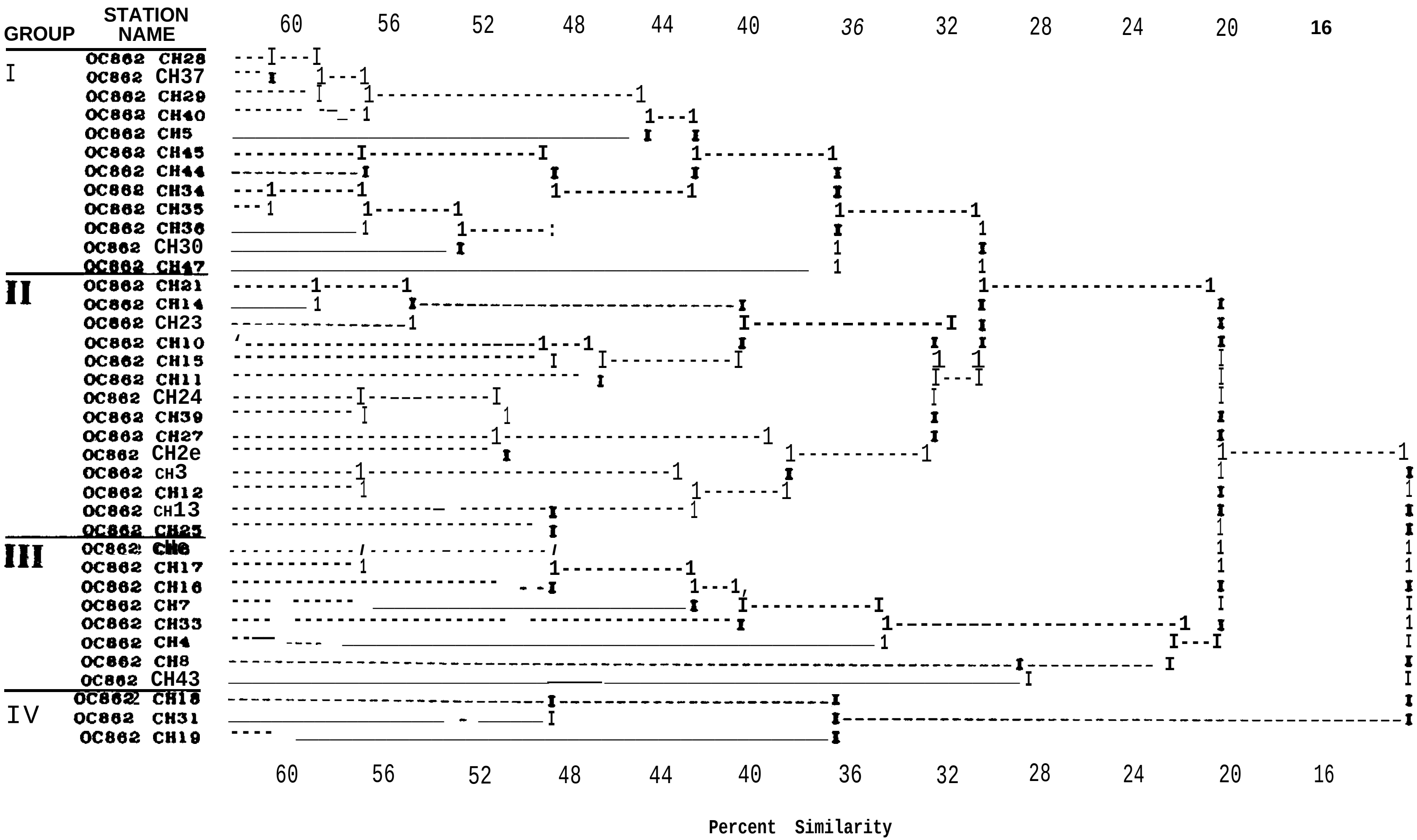

Figure 74. Dendrogram resulting from a hierarchical cluster analysis of benthic abundance data at 37 stations occupied in the northeastern Chukchi Sea, August-September 1986.

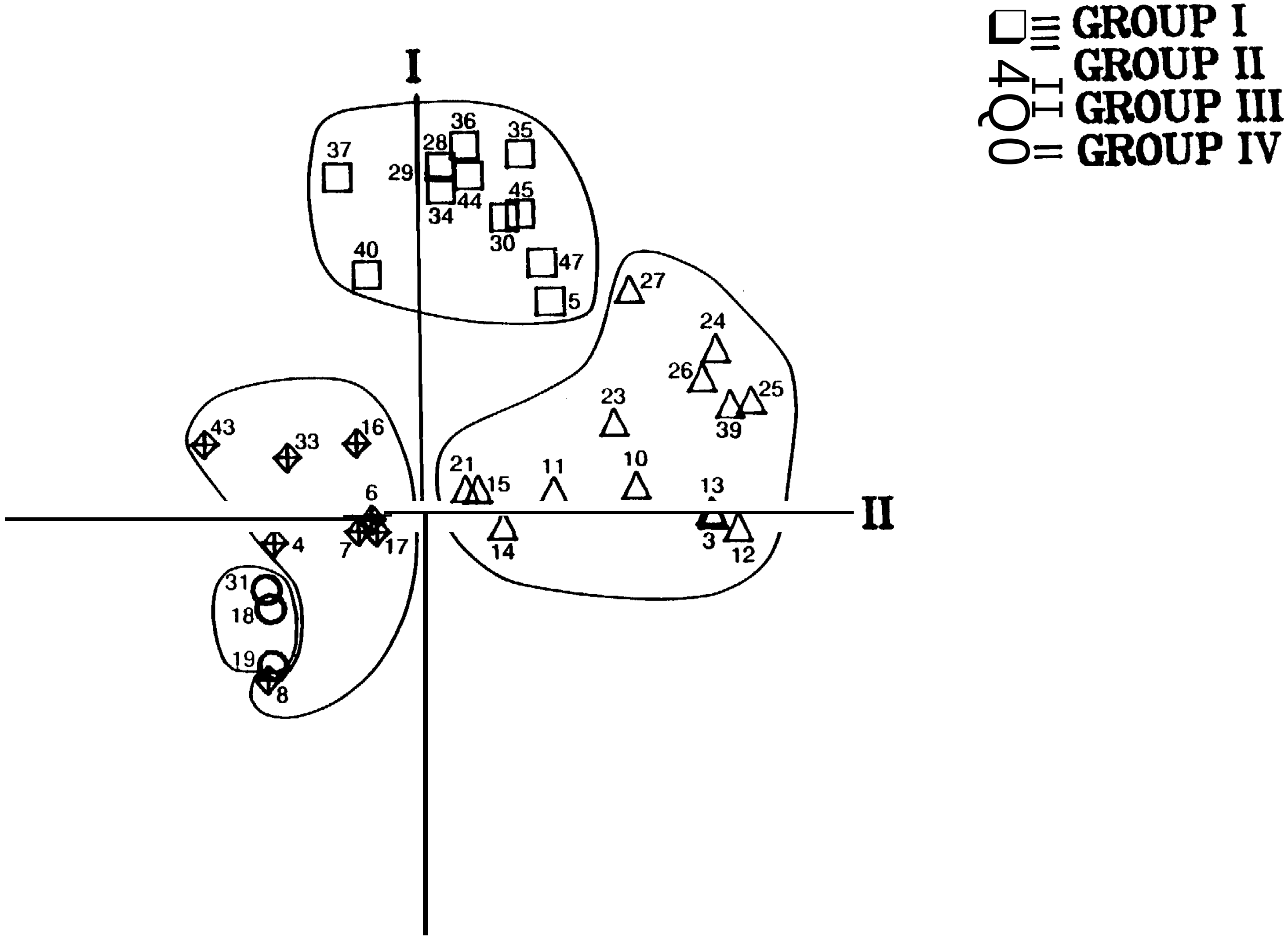

Figure 75 Plot of loadings on coordinate axes one and two of a Principal Coordinate Analysis of benthic data at stations occupied in the northeastern Chukchi Sea, August-September 1986. Station groups determined by multivariate analyses are differentiated by symbols and by lines circumscribing each group.

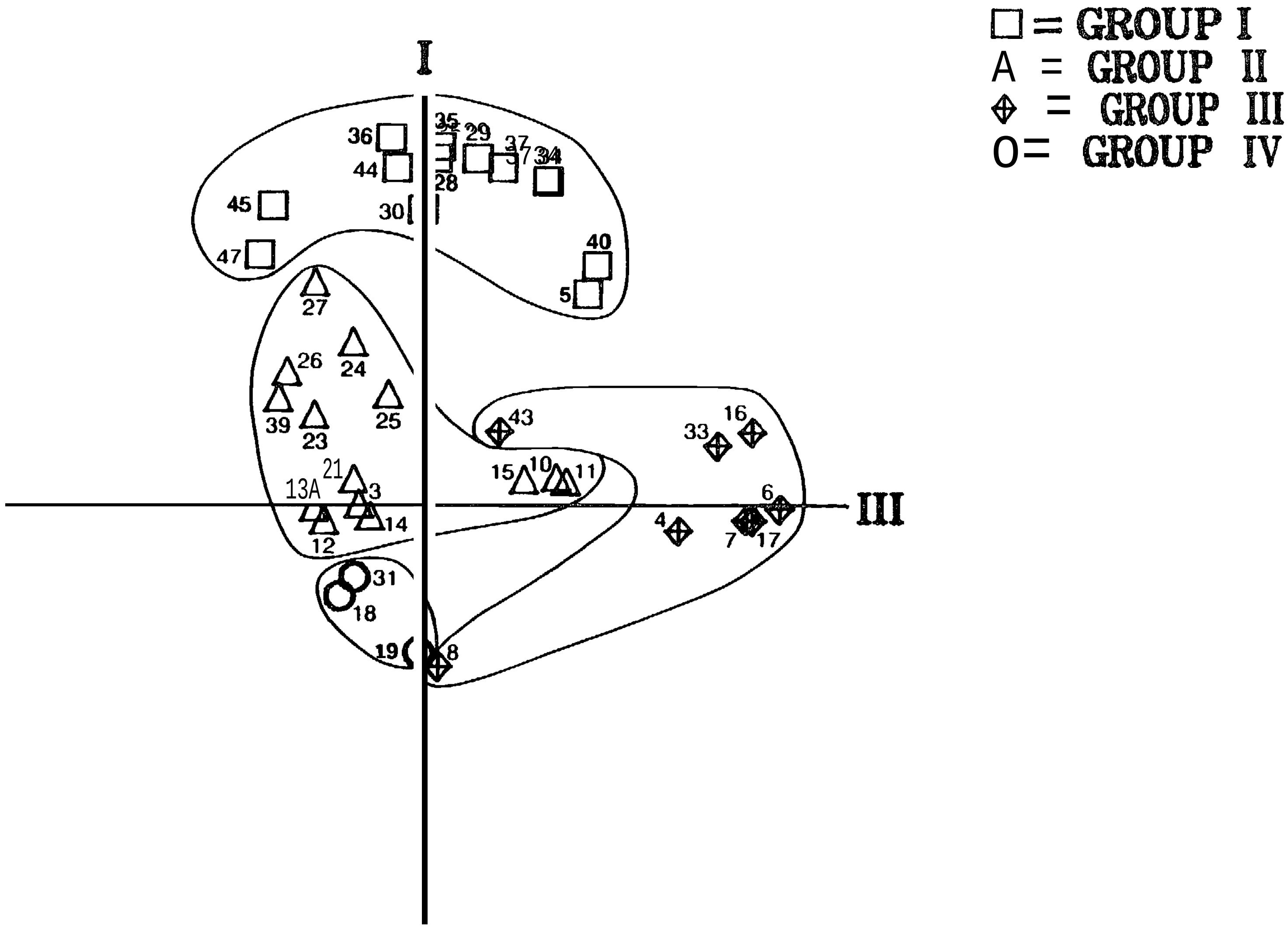

Figure 76. Plot of loadings on coordinate axes one and three of a Principal Coordinate Analysis of benthic data at stations occupied in the northeastern Chukchi Sea, August-September 1986. Station groups determined by multivariate analysis are differentiated by symbols and by lines around each group.

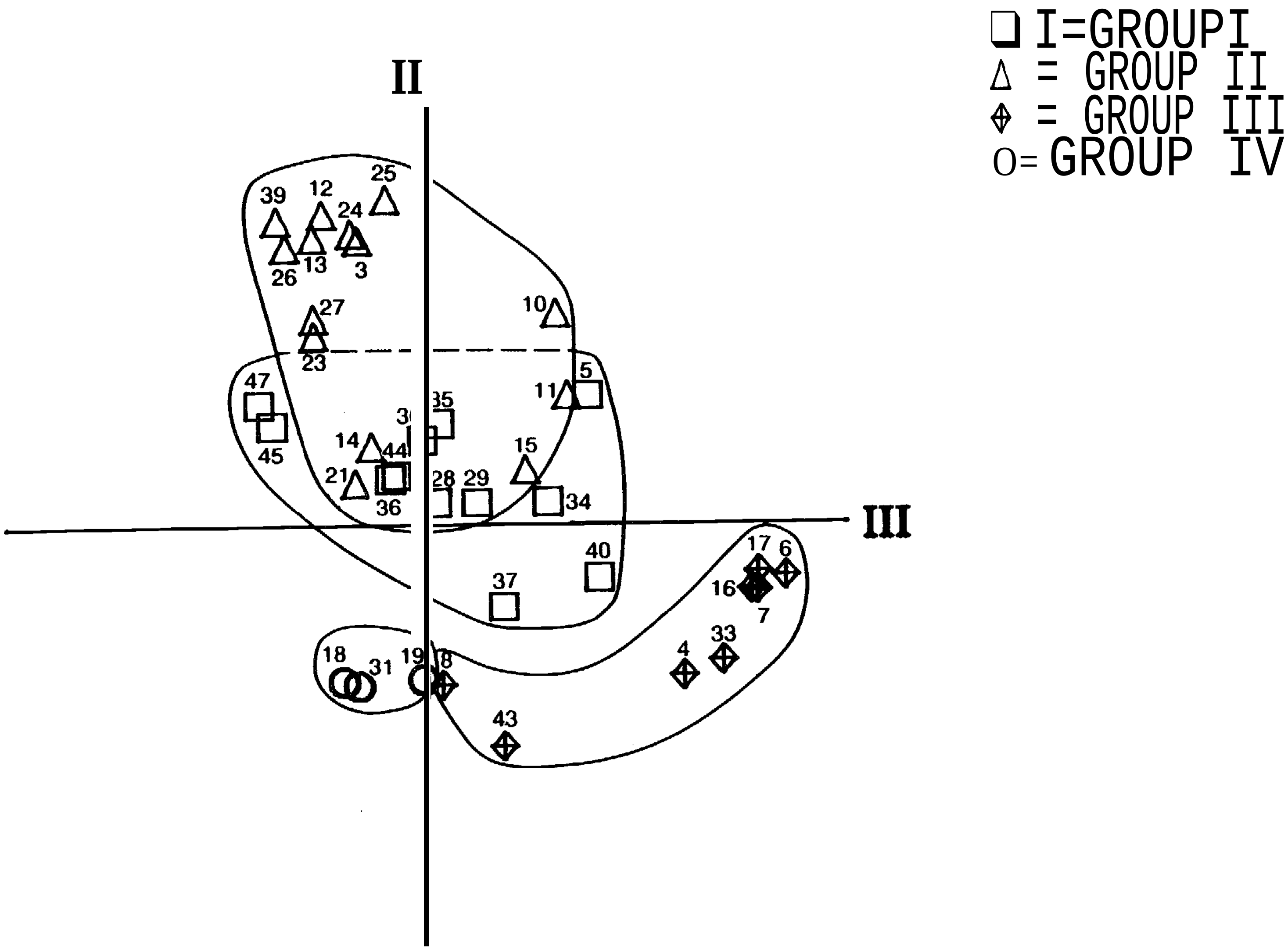

Figure 77. Plot of loadings on coordinate axes two and three of a Principal Coordinate Analysis of benthic data at stations occupied in the northeastern Chukchi Sea, August-September 1986. Station groups determined by multivariate analyses are differentiated by symbols and lines circumscribing each group.

Table 16. Motility types, based on taxon abundance for each station sampled in the eastern Chukchi Sea, August-September 1986. SESS=sessile, DM=discreetly motile, MOT=motile.

BASED ON ABUNDANCE

STAT NO	SESS Number	SESS %	DM Number	DM %	MOT Number	MOT %	HIXED Number	HIXED %	UNKNOWN Number	UNKNOWN %	TOTAL # OF INDIVIDUALS
CH3	217.7	25 98	210.7	25.14	385.7	46.02	0.0	0.00	24.0	2.86	838.0
CH4	857.5	53 86	179.2	11.26	545.2	34.25	0.0	0.00	10.0	0.63	1592.0
CH5	169.4	4.63	1868.3	51.10	1608.3	43.99	0.0	0.00	10.0	0.27	3656.0
CH6	839.5	9.91	2060.3	24.32	5528.3	65.25	0.0	0.00	44.0	0.52	8472.0
CH7	435.8	5.82	4855.6	64.90	1994.6	26.66	0.0	0.00	196.0	2.62	748.2.0
CH8	2111 7	84.20	154 6	6.17	219.6	8.76	0.0	0.00	22.0	0.88	2508.0
CH10	174 1	5.98	2099.0	72.00	617.0	21.19	0.0	0.00	22.0	0.76	2912.0
CH11	499.5	25.99	485.3	25. 2S	903.3	47.00	0.0	0.00	34.0	1.77	1922.0
CH12	89.4	11.79	273.3	36.06	383.3	50.57	0.0	0.00	12 0	1.58	758.0
CH13	22.3	4.92	241.3	53.16	184.3	40.60	0.0	0.00	6.0	1.32	4S4.0
CH14	208.0	28 .65	168.0	23.14	296.0	40.77	0.0	0.00	54.0	7.44	726.0
CH15	2134.4	48 60	533.3	12.14	1636.3	37.26	0.0	0.00	88.0	2.00	4392.0
CH16	26789.2	84.84	1381.9	4.38	3342 .0	10.59	0.0	0.00	62.0	0.20	31576.0
CH17	524. 1	10.49	294S .0	S8.92	1493.0	29.87	0.0	0.00	36.0	0.72	4998.0
CH18	27.4	5 92	101.3	21.93	313.3	67.82	0.0	0.00	20.0	4.33	462.0
CH19	509 4	31 41	485.3	29.92	613.3	37.61	0.0	0.00	14,0	0.86	1622.0
CH21	262 7	22.92	169.7	14.80	571.7	49.88	0.0	0.00	142.0	12.39	1146.0
CH23	125.4	20. 35	202 3	32.84	256.3	41.94	0.0	0.00	30.0	4.87	616.0
CH24	72.3	5.70	495.3	39.00	614.3	48.37	0.0	0.00	88.0	6.93	1270.0
CH25	70.7	7,26	495.7	50.89	397.7	40.83	0.0	0.00	10.0	1.03	974.0
CH26	14.7	2.60	328.7	58.27	210.7	37.35	0.0	0.00	10.0	1.77	564.0
CH27	48.7	6.31	377.7	4$.92	341.7	44.26	0.0	0.00	4.0	0.52	772 0
CH28	133.7	13.45	406.6	40.91	430.6	44.23	0.0	0.00	14.0	1.41	994.0
CH29	230 7	31 43	167.7	22.84	319.7	43.55	0.0	0.00	16.0	2.18	734.0
CH30	178 4	22.02	193.3	23.87	428.3	52.88	0.0	0.00	10.0	1.23	810 0

Table 16. (Continued)

BASED ON ABUNDANCE

STAT NO	--SESS Number	%	DM------ Number	%	------HOT------ Number	%	---MIXED----- Number	%	--UNKNOWN---- Number	%	TOTAL 4 OF INDIVIDUALS
CH31	273.0	38.89	44.0	6.27	340.0	40.71	0.0	0.00	36.0	5.13	702.0
CH33	4733.5	67.74	664.3	9.51	1430.3	20.47	0.0	0.00	160.0	2.29	6988.0
CH34	617 8	26.91	424.6	18.49	1113.6	48. 50	0.0	0.00	140.0	6.10	2296.0
CH35	95 4	7.18	368.3	29.24	822.3	61.92	0.0	0.00	22.0	1.66	1328.0
CH36	371 3	3S .57	316.3	30.30	336.3	32. 22	0.0	0.00	20.0	1.92	1044.0
CH37	1327.2	51.72	557.9	21.74	636.9	24.82	0.0	0.00	44.0	1.71	2666.0
CH39	20 '7	1.95	769.7	72. 47	213.7	20.12	0.0	0.00	58.0	5.46	1062.0
CH40	357 4	17.75	487.3	24.20	1083.3	53.70	0.0	0.00	86.0	4.27	2014.0
CH43	3187.1	80.93	249.4	6.33	491.5	12.48	0.0	0.00	10.0	0.25	3038.0
CH44	422.0	18 19	1018 0	43.88	736.0	31.72	0.0	0.00	144.0	6.21	2320.0
CH45	53 0	6 40	392.0	47.34	311.0	37.56	0.0	0.00	72.0	8.70	828.0
CH47	122.7	19 41	160.7	25, 42	254.7	40.29	0.0	0.00	94.0	14.87	832.0

Table 17. Dominant (in terms of abundance) benthic fauna in four station cluster groups. Data collected by van Veen grab in the eastern Chukchi Sea aboard the NOAA R/V *Oceanographer*, Cruise OC862, August/September 1986.

Station Group	Stations in group	%[1] similarity	Dominant taxa	Abundance (indiv/m^2)	% Occurrence in group
I	28,37,29, 40,5,45, 44,34,35, 36,30,47	22	*Byblis gaimardi*	140	92
			Balanus crenatus (juv)	135	92
			Leitoscoloplos pugettensis	85	100
			Nucula bellotti	85	100
			Echiurus echiurus alaskensis	81	83
			Cirratulidae	73	100
			Brachydiastylis resima	72	50
			Barantolla americana	66	100
			Maldane glebifex	63	100
			Protomedeia spp.	56	83
			Byblis sp.	44	58
			Sternaspis scutata	42	75
			Thyasira gouldi	36	83
			Harpinia kobjakovae	23	67
			Leucon nasica	22	67
			Myriochele oculata	21	50
			Ampelisca macrocephala	21	67
II	21,14,23, 10,15,11, 24,39,27, 26,3,12, 13,25	32	*Nucula bellotti*	161	100
			Maldane glebifex	148	86
			Lumbrineris sp.	78	100
			Macoma calcarea	64	100
			Byblis breviramus	53	50
			Paraphoxus sp.	51	50
			Cirratulidae	33	93
			Ostracoda	33	57
			Barantolla americana	24	100
			Leitoscoloplos pugettensis	23	86
			Harpinia kobjakovae	21	64
			Haploops laevis	21	71
			Ophiura sarsi	19	50

(continued)

Table 17. (continued)

Station Group	Stations in group	%[1] similarity	Dominant taxa	Abundance (indiv/m^2)	% Occurrence[2] in group
III	6,17,16 7,33,4 8,43	22	*Balanus crenatus* (juv)	4159	88
			Atylus bruggeni	550	38
			Protomedeia spp.	437	88
			Balanus crenatus	345	50
			Ampelisca macrocephala	298	75
			Foraminifera	138	88
			Ischyrocerus sp.	106	75
			Leitoscoloplos pugettensis	77	88
			Cirratulidae	62	88
			Grandifoxus nasuta	59	50
			Ampelisca eschrichti	56	63
			Erichthonius tolli	56	25
			Urochordata	56	63
			Polydora quadrilobata	50	13
			Pholoe minuta	41	88
			Scoloplos armiger	40	75
IV	18,31,19	36	*Echinarachnius parma*	276	100
			Cyclocardia rjabininae	242	33
			Balanus crenatus (juv)	75	33
			Foraminifera	58	100
			Scoloplos armiger	37	100
			Spiophanes bombyx	21	67
			Mysella sp.	17	33
			Glycinde wireni	11	100
			Liocyma viridis	11	67
			Amphiophiura sp.	11	67

[1]Similarity level at which groups were selected.
[2]The value for each of the dominant taxa included in this column for multi-station groups is based on the number of stations at which the particular taxon occurs.

first and third coordinate coordinate axes. Nevertheless, the similarity of Station CH5 to northern Station Group II is indicated on the plot of the first and second coordinate axes. Stations CH8 and CH43 are included in coastal Station Group III, but join the other stations of this group at a low level of similarity. Both of these stations are also only marginally associated with other stations of Group III on the plots of principal coordinate axes. Stations in Group II separate, in the cluster analysis, into two subgroups at a higher level of similarity; these subgroups mainly comprise the northern offshore groups of stations (Stations CH3, 12, 13, 24, 25, 26, 27, and 39) and stations adjacent to Group III (Stations CH10, 11, 14, 15, 21, and 23). The separation of Group 11 into two subgroups is also apparent in the principal coordinate plots. The distribution of infaunal station groups based on cluster and principal coordinate analyses are shown in Figure 78. Also shown on this figure are stations making up five transects (A-E) that lie across the cluster groups. A characterization of these transects is included in Appendix IV.

A general description of the fauna comprising the four cluster (station) groups is included below (also see Tables 17-20).

Cluster Group I, the most southerly of the offshore groups identified, is composed of 12 stations. Crustaceans (primarily barnacles and amphipods) dominated in abundance (38% of the total abundance) but not carbon biomass (4% of the total carbon biomass). Annelids ranked next in abundance (34%) but highest in carbon biomass (43%). The most abundant organisms present were sessile, suspension-feeding, juvenile barnacles (*Balanus crenatus*) which occurred at 92% of the stations in the cluster group and the tube-dwelling, surface-deposit-feeding, ampeliscid amphipod *Byblis gaimardi* which also occurred at 92% of the stations. No adult *B. crenatus* occurred within this station group. This group is also characterized by the deposit-feeding polychaetes *Leitoscoloplos pugettensis* (Orbiniidae), *Barantolla americana* (Capitellidae), *Maldane glebifex* (Maldanidae), and Cirratulidae, and the deposit-feeding bivalve *Nucula bellotti*, all of which occurred at 100% of the stations. The deposit-feeding cumacean *Brachydiastylis resima*, the polychaete *Sternaspis scutata* (Sternaspidae), the echiuroid worm *Echiurus*

NORTHERN CHUKCHI SEA STATIONS

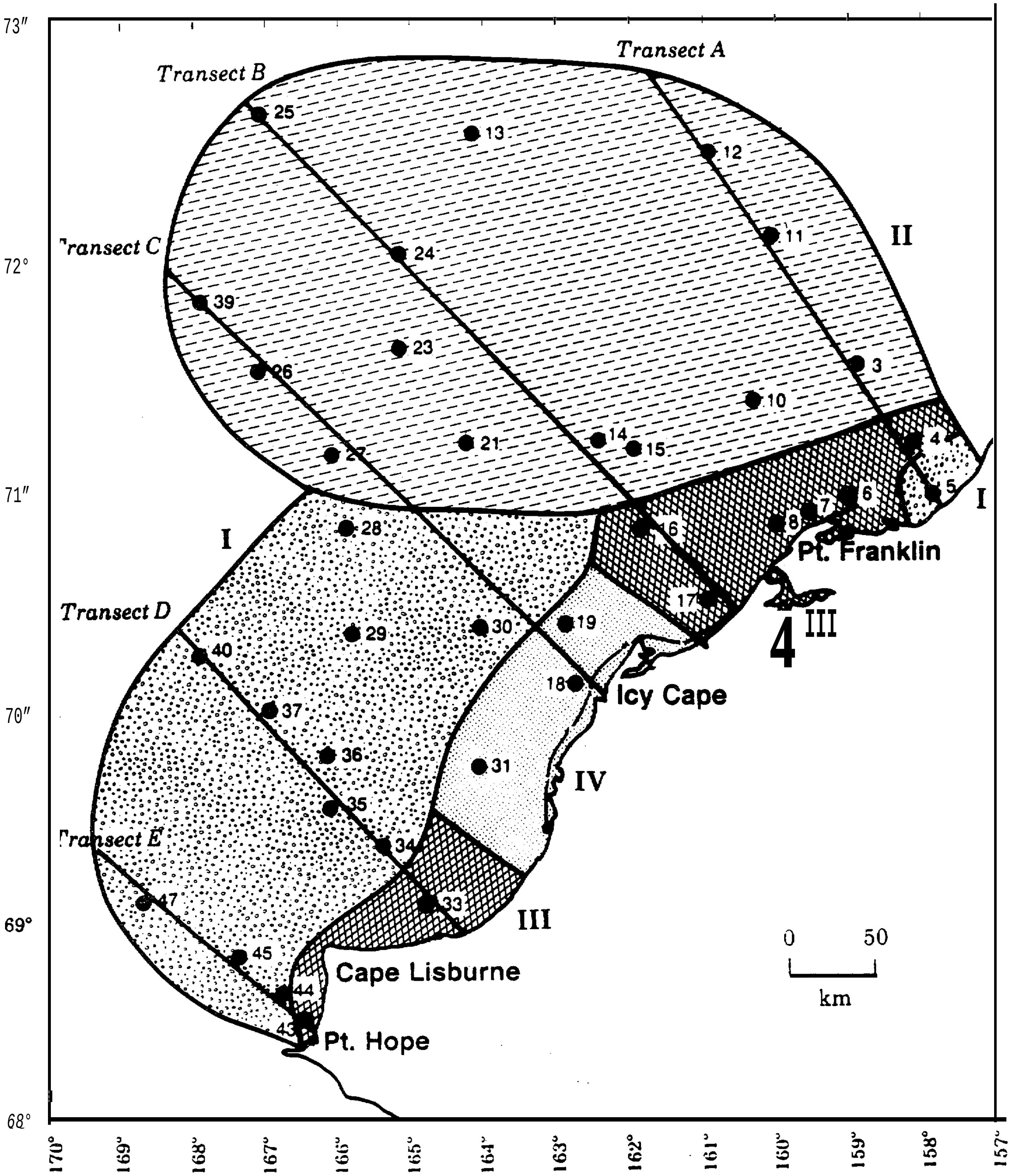

Figure 78. Distribution of macrofaunal communities in the northeastern Chukchi Sea based on cluster and principal coordinate analyses of abundance data collected August-September 1986. Transects shown on the figure are for station data included in Appendix IV.

Table 18. Dominant (in terms of carbon biomass) benthic fauna in four station cluster groups. Data collected by van Veen grab in the eastern Chukchi Sea aboard the NOAA R/V *Oceanographer,* Cruise OC862, August/September 1986.

Station Group	Stations in group	%[1] similarity	Dominant taxa	Biomass (gC/m*)	% Occurrence* in group
I	28,37,29, 40,5,45, 44,34,35, 36,30,47	22	*Golfingia margaritacea*	0.93	67
			Maldane glebifex	0.75	100
			Nephtys ciliata	0.43	100
			Nucula bellotti	0.42	100
			Echiurus echiurus alaskensis	0.33	83
			Macoma calcarea	0.30	42
			Nicomache lumbricalis	0.28	50
			Nephtys paradoxa	0.24	8
			Praxillella praetermissa	0.21	83
			Psolus peroni	0.20	8
II	21,14,23, 10,15,11, 24,39,27, 26,3,12, 13,25	32	*Macoma calcarea*	2.28	100
			Golfingia margaritacea	1.75	71
			Nucula bellotti	0.67	100
			Maldane glebifex	0.67	86
			Lumbrineris fragilis	0.37	57
			Astarte borealis	0.37	57
			Nuculana radiata	0.36	36
			Nephtys paradoxa	0.25	29
			Natica clausa	0.20	36
			Yoldia hyperborea	0.17	64
III	6,17,16, 7,33,4, 8,43	22	*Atylus bruggeni*	1.82	38
			Psolus peroni	1.72	50
			Golfingia margaritacea	0.45	75
			Liocyma viridis	0.43	50
			Astarte borealis	0.39	25
			Yoldia myalis	0.34	50
			Nephtys caeca	0.28	25
			Natica clausa	0.26	63
			Polinices pallida	0.23	75
			Chelyosoma sp.	0.23	50

(continued)

Table 18. (continued)

Station Group	Stations in group	%[1] similarity	Dominant taxa	Biomass (gC/m²)	% Occurrence[2] in group
IV	18,31,19	36	*Echinarachnius parma*	1.22	100
			Cyclocardia rjabininae	1.01	33
			Natica clausa	0.43	67
			Travesia forbesi	0.34	100
			Tellina lutes	0.33	33
			Yoldia scissurata	0.32	67
			Musculus niger	0.23	33
			Travesia pupa	0.10	33
			Liocyma viridis	0.07	67
			Macoma calcarea	0.07	67

[1]Similarity level at which groups were selected.

[2]The value for each of the dominant taxa included in this column for multi-station groups is based on the number of stations at which the particular taxon occurs.

echiurus alaskensis, and the amphipod *Protomedeia*, as well as the suspension-feeding bivalve *Thyasira gouldi*, were also common. In terms of carbon biomass, this group was dominated by the surface deposit-feeding sipunculid worm *Golfingia margaritacea* and *M. glebifex* which occurred at 67 and 100% of the stations, respectively.

Cluster Group 11, north of Group I, consists of 14 stations. The top-ranked phyla, in terms of abundance, in this group were Annelida (38%), Crustacea (primarily amphipods; 26%), and bivalve mollusks (24%). Bivalves dominated the carbon biomass (47%) followed by annelids (25%) and sipunculids (13%). This group is dominated by two subsurface deposit-feeding species, the polychaete *M. glebifex* and the bivalve *N. bellotti*. Also characterizing this group were the mixed-feeding polychaete *Lumbrineris* sp. (Lumbrineridae), the deposit/suspension-feeding clam *Macoma calcarea*, the tube-dwelling amphipod *B. breviramus*, and the amphipod *Paraphoxus* sp. Also

Table 19. The percentage by abundance, biomass, carbon, and carbon production of phyla at station groups. Data collected by van Veen grab in the eastern Chukchi Sea, August-September 1986. Fragments are not included in the abundance computations.

GROUP	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2/yr	CARBON PROD %
I	PROTOZOA	19.7	1.23	0.001	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.001	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	1.8	0.11	0.233	0.18	0.002	0.03	0.000	0.00
	RHYNCHOCOELA	1.0	0.06	1.612	1.26	0.150	2.38	0.015	0.32
	NEMATODA	47.0	2.03	0.005	0.00	0.000	0.00	0.000	0.00
	ANNELIDA *	539.5	33.66	40.025	31.89	2.739	43.48	3.834	81.01
	GASTROPODA	31.8	1.99	6.007	5.45	0.423	6.71	0.127	2.88
	CHITON	0.2	0.01	0.001	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	217.5	13.58	34.568	26.03	1.217	10.32	0.365	7.71
	PYCNOGONIDA	0.2	0.01	0.001	0.00	0.000	0.00	0.000	0.00
	BALANUS	135.5	6.46	0.267	0.21	0.003	0.05	0.000	0.01
	AMPHIPODA	365.3	22.81	3.326	2.50	0.221	3.51	0.221	4.07
	OTHER CRUSTACEA	115.0	7.18	0.251	0.20	0.018	0.29	0.018	0.38
	SIPUNCULA	11.5	0.72	20.798	16.20	0.936	14.86	0.094	1.98
	ECHIURA	81.3	5.08	6.452	5.03	0.320	5.22	0.033	0.70
	PRIAPULIDA	6.0	0.37	0.078	0.06	0.003	0.06	0.000	0.01
	BRYOZOA	0.3	0.02	1.146	0.80	0.012	0.19	0.001	0.03
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	16.3	1.02	9.805	7.64	0.220	3.49	0.022	0.46
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	11.8	0.74	1.878	1.46	0.026	0.42	0.003	0.06
		1601.6		128.345		6.299		4.733	
II	PROTOZOA	3.4	0.26	0.006	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.002	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	8.9	0.07	3.085	1.35	0.154	1.07	0.015	0.29
	RHYNCHOCOELA	1.4	0.11	1.420	0.62	0.132	1.43	0.013	0.25
	NEMATODA	11.0	0.84	0.003	0.00	0.000	0.00	0.000	0.00
	ANNELIDA *	494.4	37.61	33.023	14.80	2.334	25.30	3.267	62.38
	GASTROPODA	34.7	2.64	4.654	2.04	0.343	3.72	0.103	1.97
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	320.1	24.35	130.825	57.43	4.307	46.68	1.292	24.67
	PYCNOGONIDA	0.1	0.01	0.000	0.00	0.000	0.00	0.000	0.00
	BALANUS	0.9	0.07	0.000	0.00	0.000	0.00	0.000	0.00
	AMPHIPODA	274.6	20.88	5.696	2.50	0.383	4.15	0.383	7.32
	OTHER CRUSTACEA	78.7	5.84	0.182	0.06	0.011	0.12	0.011	0.21
	SIPUNCULA	21.3	1.62	27.527	12.08	1.230	13.43	0.124	2.36
	ECHIURA	2.0	0.15	0.012	0.01	0.001	0.01	0.000	0.00
	PRIAPULIDA	7.7	0.59	0.417	0.18	0.019	0.20	0.002	0.04
	BRYOZOA	2.3	0.17	0.152	0.07	0.002	0.02	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	50.6	3.85	13.370	5.67	0.165	1.79	0.013	0.26
	HEMICHORDATA	0.3	0.02	0.816	0.36	0.056	0.01	0.006	0.11
	UROCHORDATA	4.3	0.33	5.711	2.51	0.080	0.87	0.008	0.15
		1314.7		227.810		9.227		5.238	

*All annelids were in the class Polychaeta.

Table 19. (continued)

GROUP	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2/yr	CARBON PROD %
III	PROTOZOA	139.8	1.65	0.020	0.01	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	6.948	2.39	0.069	0.69	0.007	0.13
	COELENTERATE	13.0	0.15	7.260	2.50	0.339	3.39	0.034	0.61
	RHYNCHOCOELA	3.3	0.04	0.359	0.12	0.033	0.33	0.003	0.00
	NEMATODA	200.0	2.37	0.016	0.01	0.000	0.00	0.000	0.00
	ANNELIDA *	792.3	9.38	19.774	6.81	1.387	13.87	1.942	34.94
	GASTROPODA	55.0	0.65	12.706	4.38	0.895	8.95	0.260	4.s3
	CHITON	4.0	0.05	0.33'7	0.12	0.021	0.21	0.006	0.11
	BIVALVIA	157.0	1.86	64.500	22.21	1.662	16.82	0.499	8.97
	PYCNOGONIDA	10.3	0.12	0.013	0.00	0.001	0.01	0.001	0.02
	BALANUS	4505.0	53.35	9.454	3.26	0.104	1.04	0.010	0.19
	AMPHIPODA	2210.3	26.17	33.031	11.37	2.404	24.04	2.404	43.25
	OTHER CRUSTACEA	191.5	2.27	1.183	0.40	0.083	0.83	0.083	1.50
	SIPUNCULA	20.3	0.24	9.905	3.43	0.448	4.48	0.045	0.81
	ECHIURA	5.3	0.08	0.013	0.00	0.001	0.01	0.000	0.00
	PRIAPULIDA	0.3	0.00	0.001	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	12.3	0.15	3.740	1.29	0.052	0.52	0.005	0.09
	BRACHIOPODA	1.0	0.01	0.005	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	44.3	0.52	83.984	28.92	1.981	19.80	0.198	3 56
	HEMICHORDATA	0.0	0 00	0.000	0.00	0.000	0.00	0.000	0 00
	UROCHORDATA	79.8	0.04	37.087	12.77	0.519	5.19	0.052	0.93
		8444.3		290.385		10.002		5.559	

GROUP	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2/yr	CARBON PROD %
IV	PROTOZOA	58.0	6.25	0.301	0.13	0.003	0.06	0.000	0.02
	PORIFERA	0 0	0.00	0 000	0.00	0.000	0.00	0 000	0.00
	COELENTERATE	0.7	0.07	0 155	0.07	0.000	0.20	0.001	005
	RHYNCHOCOELA	0.0	0.00	0.096	0.04	0.009	0.18	0.001	0 05
	NEMATODA	3.3	0.36	0.001	0.00	0.000	0.00	0.000	0.00
	ANNELIDA *	113.3	12.20	8.018	3.41	0.666	13.71	0 032	48 56
	GASTROPODA	22.0	2.37	9.001	3.62	0.646	13.30	0.104	10 09
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	304 7	32 81	50.7'75	21.57	2 152	44.34	0 645	33 64
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BALANUS	75 3	8.11	0 018	0.01	0.000	0.00	0 000	0 00
	AMPHIPODA	34.0	3.66	0.081	0.03	0. 005	0.10	0.005	0 28
	OTHER CRUSTACEA	6.7	0.72	0.065	0.03	0.005	0.10	0 005	0 25
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	0 0	0.00	0.000	0.00	0.000	0.00	0 000	0 00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	BRACHIOPODA	0 0	0.00	0.000	0.00	0.000	0 00	0.000	0.00
	ECHINODERMATA	302 0	32 52	159.679	67.93	1.261	25.99	0.126	6 57
	HEMICHORDATA	0.0	0.00	0 000	0.00	0.000	0.00	0 000	0 00
	UROCHORDATA	8 7	0 93	6 055	2.96	0.007	2.01	0 010	0 51
		928.7		235.395		4. 8S3		1,919	

*All annelids were in the class Polychaeta.

Table 20. Benthic station groups and their associated dominant taxa together with feeding types, motility, and general remarks. Taxa are ranked by abundance. SF=Suspension Feeder, IF=Interface Feeder, SSDF=Subsurface Deposit Feeder, SDF=Surface Deposit Feeder, Pred=Predator, Sc=Scavenger, S=Sessile, DM=Discretely Motile (rarely moves), M = Motile.

Grp.	Dominant Taxon	Feeding Type	Motility	Remarks
I	*Byblis* (amphipod)	SDF (IF)	DM	Sandy Mud; in tubes
	Balanus (barnacle)	SF (IF)	S	Needs gravel/shell
	Leitoscoloplos (annelid)	SSDF	M	Needs mud
	Nucula (protobranch clam)	SSDF	DM	Needs mud
	Echiurus (echiuroid)	SDF (IF)	DM	Needs mud
	Cirratulidae (annelid)	SDF (IF)	M/DM	Needs mud
	Brachydiastylis (cumacean)	SDF (IF)	M	Needs mud
	Barantolla (annelid)	SSDF	M	Needs mud
	Maldane (annelid)	SSDF	s	Needs mud; in tubes
	Protomedeia (amphipod)	SDF (IF)	M	Needs mud, gravel
	Sternaspis (annelid)	SSDF	M	Mud
	Thyasira (bivalve)	SF (IF)	S	Mud
	Harpinia (amphipod)	SDF, P, Sc	M	Mud
	Leucon (cumacean)	SDF (IF)	M	Mud
	Myriochele (annelid)	SSDF	S or DM	Mud
	Ampelisca (annelid)	SDF (IF)	DM	Sandy mud
II.	*Nucula* (protobranch clam)	SSDF	DM	Mud
	Maldane (annelid)	SSDF	S	Mud; tubes
	Lumbrineris(annel id)	Pred./SDF (IF)	M	Mud
	Macoma {bivalve)	SDF/SF (IF)	DM	Mud
	Byblis (amphipod)	SDF (IF)	DM	Muddy sand; in tubes
	Paraphoxus (amphipod)	Pred	M	Muddy sand
	Cirratulidae (annelid)	SDF (IF)	M/DM	Mud
	Ostracoda (crustacean)	SF/SDF (IF)	M	Mud
	Barantolla (annelid)	SSDF	M	Mud
	Leitoscoloplos (annelid)	SSDF	M	Mud
	Harpinia (amphipod)	Pred	M	Muddy sand
	Haploops (amphipod)	SDF (IF)	DM	Muddy sand, gravel
	Ophiura (brittle star)	SDF/Pred/SC	M	Mud
III .	*Balanus* (juv. barnacle)	SF	S	Needs gravel/shell
	Atylus (amphipod)	SDF (IF)	M	Sandy mud
	Protomedeia (amphipod)	SDF (IF)	M	Needs mud, gravel
	Balanus (adult barnacle)	SF (IF)	Sessile	Needs gravel/shell
	Ampelisca (amphipod)	SDF (IF)	DM	Sandy mud; tubes
	Foraminifera	P/se	DM/M	Sandy mud
	Ischyrocerus (amphipod)	Sc	M	Sandy mud
	Leitoscoloplos (annelid)	SSDF	M	Mud

Table 20. (continued)

Grp.	Dominant Taxon	Feeding Type	Motility	Remarks
	Cirratulidae (annelid)	SDF (IF)	M/DM	Sandy mud
	Grandifoxus (amphipod	SDF	M	Sand
	Ampelisca (amphipod)	SDF (IF)	DM	Sandy mud
	Erichthonius (amphipod)	SDF/SF	DM	Sandy mud
	Urochordata (tunicate)	SF (IF)	S	Sandy gravel
	Polydora (annelid)	SDF/SF (IF)	DM	Sandy gravel/shell
	Pholoe (annelid)	P/s	M	Sandy mud
	Scoloplos (annelid)	SSDF	M	Sandy to Sandy Mud
IV.	*Echinarachnius*(sand dollar)	SF (IF)	M	Sandy to Sandy Mud
	Cyclocardia (cockle)	SF (IF)	DM	Sandy to Sandy Mud
	Balanus (juv. barnacle)	SF (IF)	S	Needs gravel/shell
	Foraminifera	P/se	M/DM	Mud, Sand
	Scoloplos (annelid)	SSDF	M	Sandy to Sandy Mud
	Spiophanes (annelid)	SDF/SF (IF)	S	Sandy to Sandy Mud
	Mysella (bivalve)	SF (IF)	DM/M	Sandy to Sandy Mud
	(members of the general group of *Mysella* tend to be commensals with sand-dwelling echinoderms like *Echinarachnius*)			
	Glycinde (annelid)	C/S	M	Sandy to Sandy Mud
	Liocyma (bivalve)	SF (IF)	DM/S	Sandy to Sandy Mud
	Amphiophiura (brittle star)	SDF/P/SC	M	Sandy to Sandy Mud
	Golfingia (sipunculid)	SDF (IF)	DM	Sandy Mud/Gravel
	Melita (amphipod)	SDF (IF)	M	Sandy Mud
	Astarte (bivalve)	SF (IF)	DM	Sandy Mud
	Chelysoma (tunicate)	SF (IF)	Sessile	Sandy Gravel
	Tharyx (annelid)	SDF (IF)	M/DM	Sandy Gravel

included among the dominant benthic fauna present in this group are deposit-feeding cirratulid polychaetes, the polychaetes *B. americana* and *L. pugettensis*, and ostracods. In terms of carbon biomass, this group was dominated by the surface deposit/suspension feeding bivalve *Macoma calcarea* and G. *margaritacea* at 100 and 71% of the stations, respectively.

Cluster Group III, occurring along the coast, consists of eight stations, separated into a northern and southern component. This group was completely dominated in abundance by crustaceans (juvenile and adult barnacles, and amphipods) that accounted for 82% of the abundance. Juvenile *B. crenatus*, occurred at 88% of the stations. Also common within this cluster group were adult *B. crenatus*, and the amphipods *Atylus bruggeni*, *Protomedeia* spp., and *Ampelisca macrocephala*. Amphipod crustaceans dominated the carbon biomass, and comprised 24% of that biomass. Bivalve mollusks comprised 17% and annelids 14% of the carbon biomass, respectively. The suspension-feeding sea cucumber, *Psolus peroni*, made up 17%[2]. The surface deposit feeding amphipod *Atylus bruggeni* and the *P. peroni* occurred at 38 and 50% of the stations, respectively.

Cluster Group IV, adjacent to the coast but between Point Lay and Icy Cape, consists of three stations. The two abundance co-dominants in this group were Echinodermata (primarily the sand dollar *Echinarachnius parma*) and bivalve mollusks (primarily the cockle *Cyclocardia rjabininae*) each making up 33% of the total abundance within the group. Annelids and crustaceans (primarily juvenile *B. crenatus*) each comprised 12% of the total abundance. No adult *B. crenatus* were found at stations within this group. Bivalves dominated the carbon biomass, comprising 44% of the total, followed by echinoderms (primarily sand dollars) at 26%, and annelids and gastropod, with 14 and 13% of the abundance, respectively. The dominant taxa were the two suspension-feeding species *E. parma* (at 100% of the stations in the group) and *C. rjabininae* (at 33% of the stations). Also important at this station were Foraminifera, juvenile *B. crenatus*, the subsurface deposit-feeding polychaete *Scoloplos armiger* (Orbiniidae), the small deposit/suspension-feeding polychaete *Spiophanes bombyx* (Spionidae), and the clam *Mysella* sp. Most of the preceding taxa are interface feeders.

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[2] computed as $\frac{1.7\ gC/m^2\ (Psolus\ \text{biomass})}{10.0\ gC/m^2\ (\bar{X}\ \text{biomass})} \times 100$.
See Results, Section H, page 209, for data table.

5. Abundance, Biomass, Production, and Diversity of Taxa within Cluster Groups

The mean abundance among cluster groups was lowest in Group IV with a value of 929 indiv./m^2 and highest in Group III with a value of 8444 indiv./m^2 (Table 21a). The mean wet weight biomass was lowest in Group I with a value of 128 g/m^2 and highest in Group III with a value "of 290 g/m^2. The mean carbon biomass among cluster groups was lowest in Group IV with a value of 4.9 gC/m^2 and highest in Group III with a value of 10.0 gC/m^2. Carbon production estimates were highest within Groups II (5.3 gC/m^2/yr) and III (5.6 gC/m^2/yr) and lowest at Group IV (1.9 gC/m^2) (Table 21a). The low production value for the latter group is a reflection of the dominance by two species with low P/B values, the cockle *Cyclocardia rjabininae* (P/B = 0.1) and the sand dollar *Echinarachnius parma* (P/B = 0.1). Mean number of taxa, Shannon and Simpson Diversity indices, and Shannon Evenness for each cluster group are included in Table 21b. High Shannon and low Simpson (a dominance index) values generally occurred within Cluster Groups I and II. Evenness values were generally high within the latter groups as well. Relatively low Shannon and high Simpson values occurred at Cluster Groups III and IV where specific taxa dominated (for example, juvenile barnacles dominated within Cluster Group III, while cockles and sand dollars dominated Cluster Group IV; Table 17).

6. Dominant Taxa, Trophic Structure and Motility of Taxa within Cluster Groups

The dominant taxa present (abundance and biomass), and the feeding and motility types identified within the station groups varied according to coastal location and substrate type (Figs. 64-66; 70-73; 79-82 and Tables 17, 22-23).

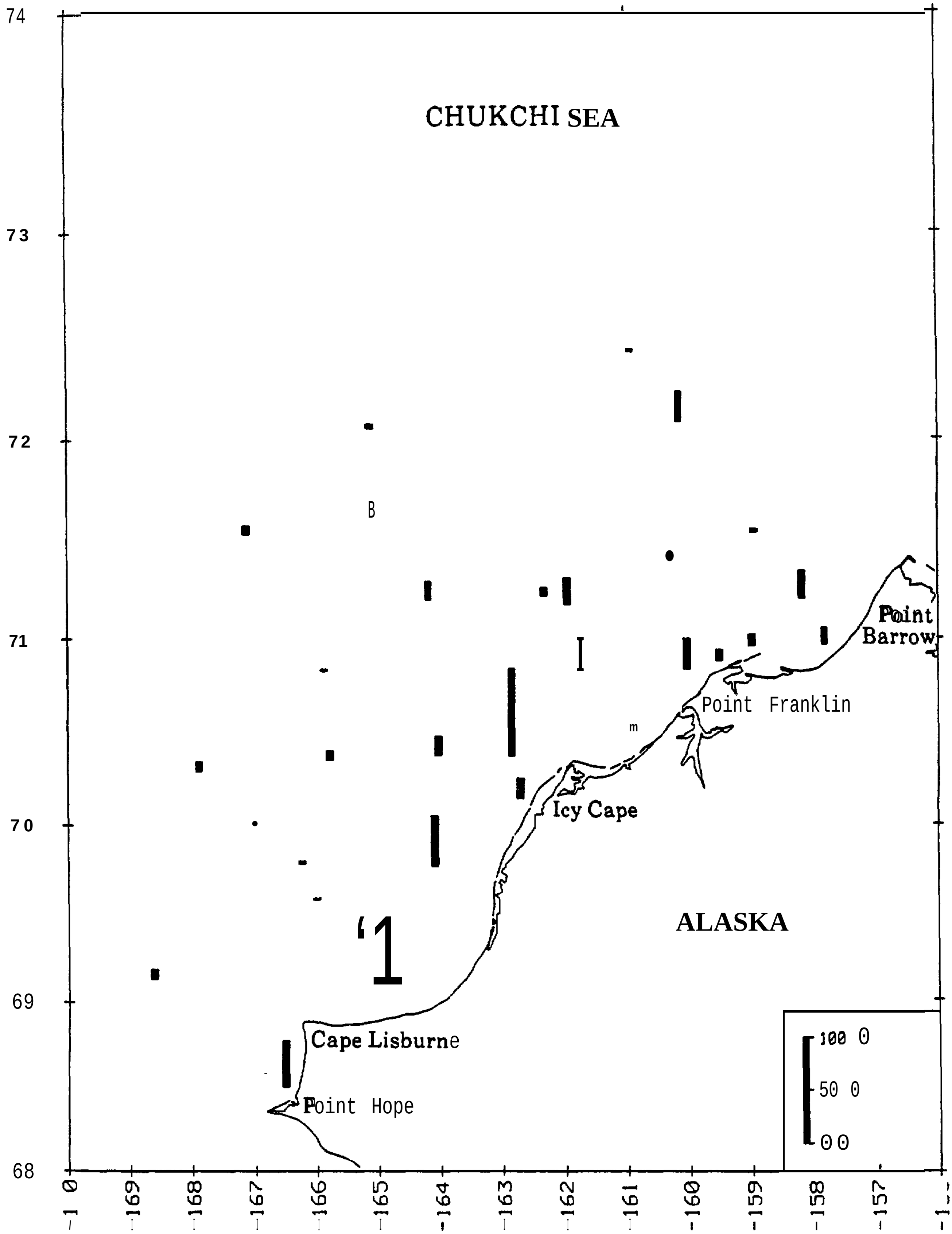

Figure 79. The percent carbon biomass of suspension-feeding benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

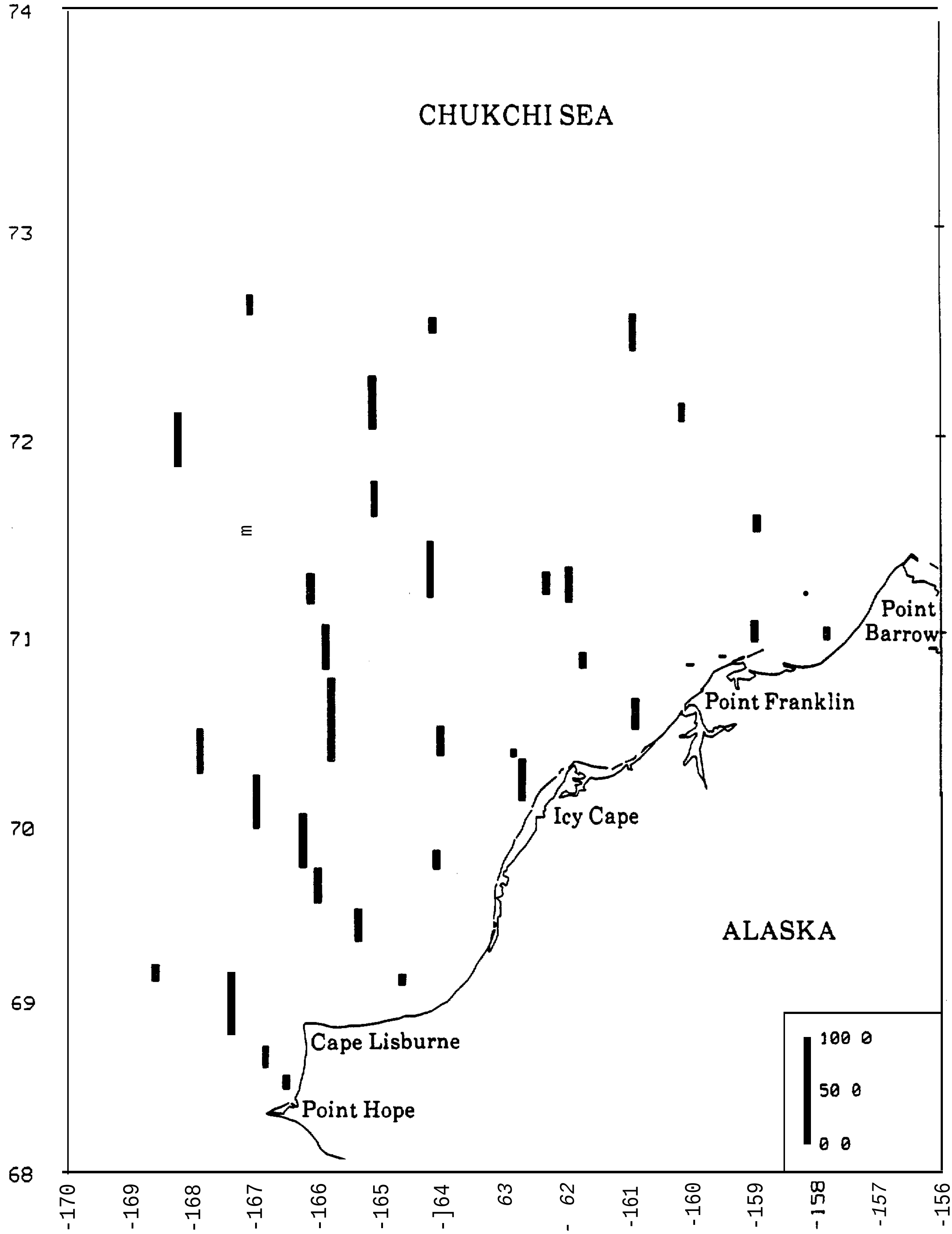

Figure 8o. The percent carbon biomass of subsurface deposit-feeding benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

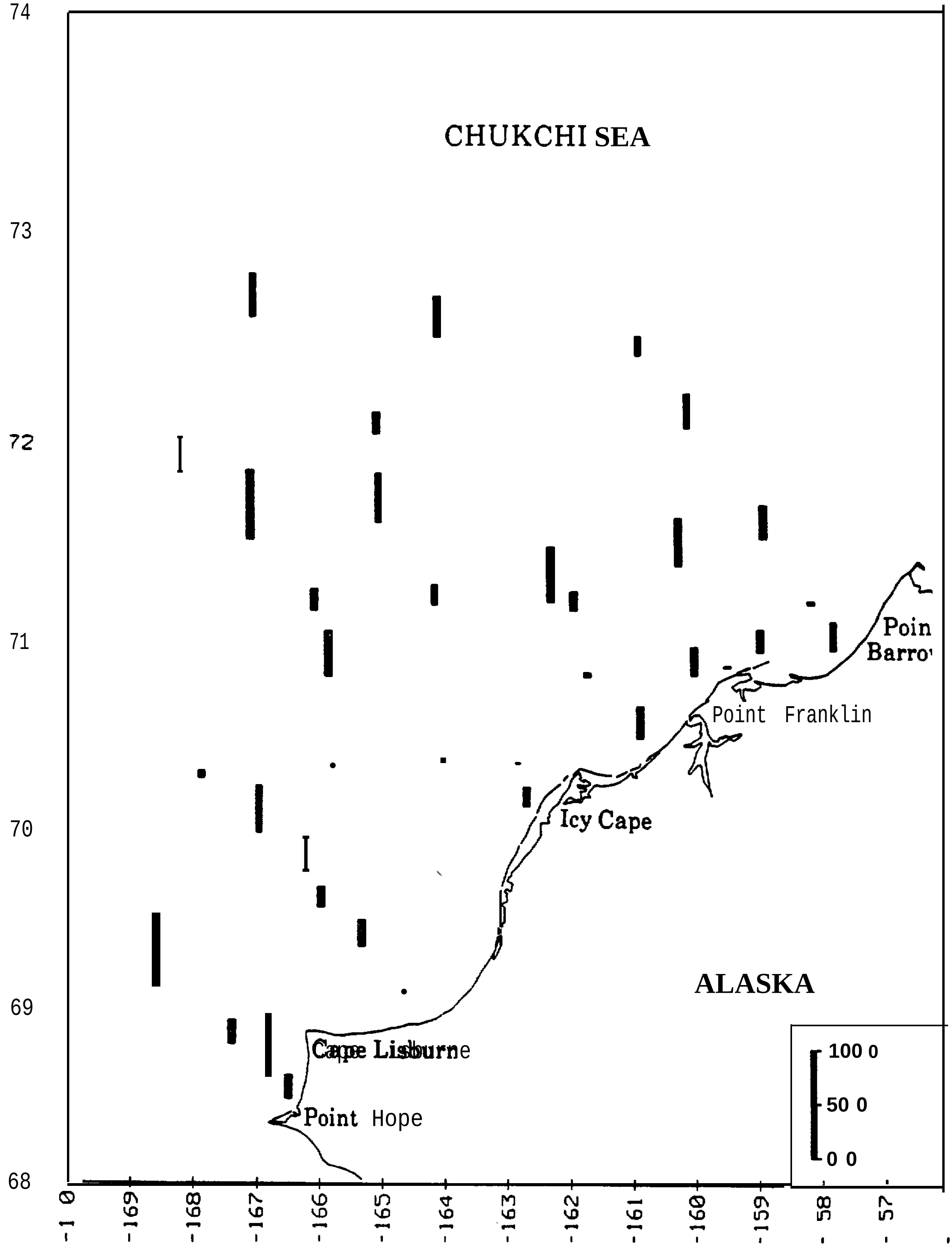

Figure 81. The percent carbon biomass of surface deposit-feeding benthic fauna at stations occupied in the northeastern Chukchi Sea, August-September 1986.

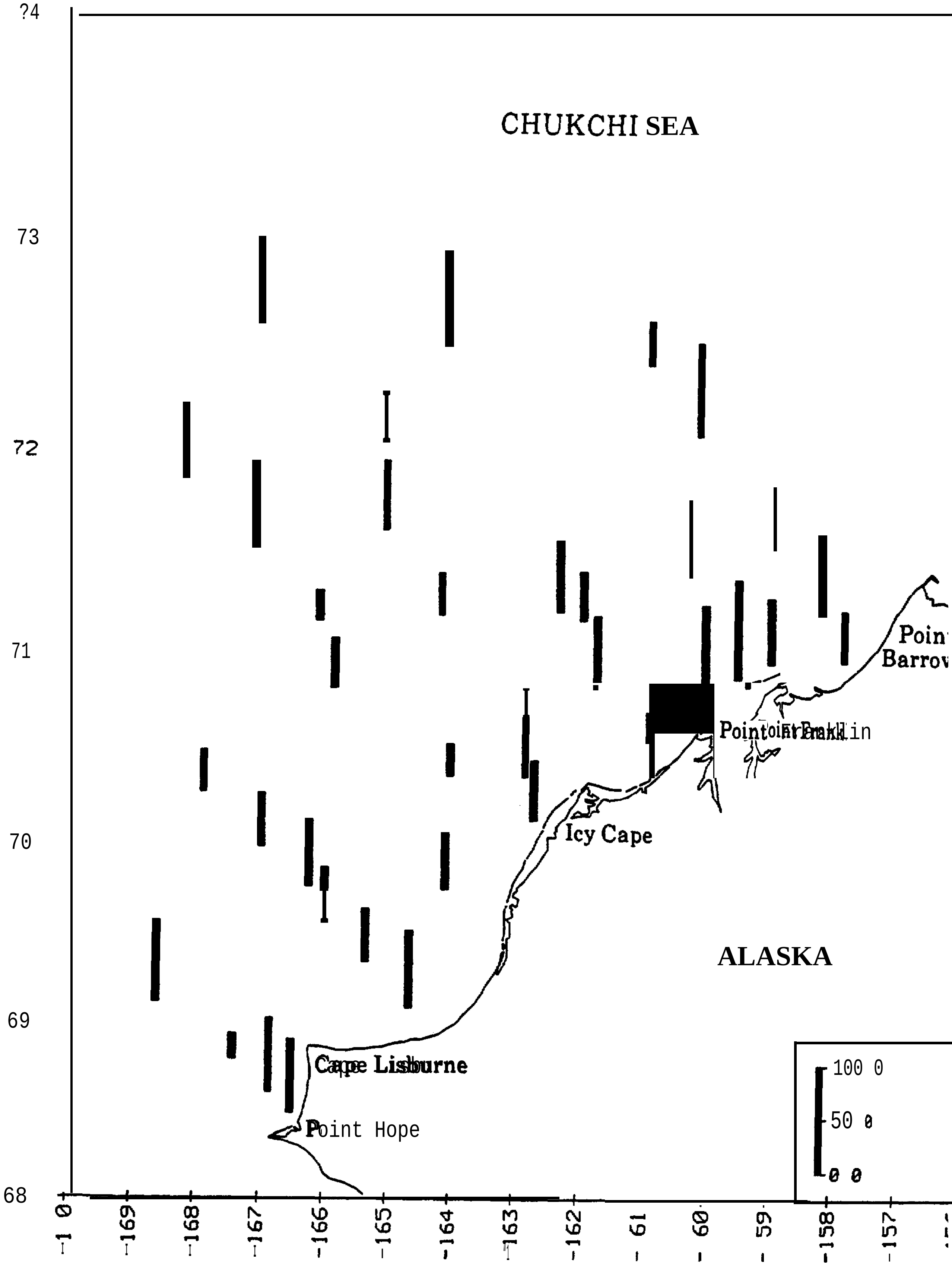

Figure 82. The percent carbon of interface-feeding **benthic** fauna at stations occupied in the northeastern **Chukchi** Sea, August-September 1986.

Table 21a. Mean abundance, wet weight biomass, carbon biomass, carbon production, and carbon requirements of benthic organisms at station groups. Data collected by van Veen grab in the eastern Chukchi Sea, August/September 1986. Fragments are not included in the abundance computations, but are included in the biomass computations. TE = transfer efficiency.

Station Group	Abundance (indiv/m²)	Wet Weight Biomass (g/m*)	Carbon Biomass (gC/m')	Carbon Production (gC/m²/yr)	Carbon Required (gC/m²/yr) 10%TE	20% TE
I	1602	128	6.3	4.7	47	24
II	1315	228	9.2	5.2	52	26
III	8444	290	10.0	5.6	56	28
Iv	929	235	4.9	1.9	19	9

Table 21b. Number of species (taxa), diversity indices, Shannon evenness, and species richness at station groups. Fragments and taxa excluded from cluster analysis are not included in these computations.

Station Group	No. of Taxa	DIVERSITY Simpson	Shannon	Shannon Evenness	Species Richness
I	172	0.04	3.65	0.71	23.51
II	204	0.05	3.84	0.72	28.55
III	248	0.29	2.47	0.45	27.51
IV	64	0.18	2.39	0.57	9.28

Table 22a. The percentage by abundance ($indiv/m^2$) of benthic feeding types at station groups. Data collected by van Veen grab in the eastern Chukchi Sea, August/September 1986. SDF = surface deposit feeder, SF = suspension feeder, IF = interface feeder (SDF + SF), SSDF = subsurface deposit feeder, CARN = carnivore, SCAV = scavenger. Fragments are not included in the abundance computations, but are included in the carbon and production computations. A small percentage of unknown feeding types were present, but omitted from the table.

Station Group	SDF %	SF %	IF Z	SSDF Z	CARN %	SCAV %	HERB Z	ABUNDANCE ($indiv/m^2$)
I	36.50	17.14	53.64	27.78	6.38	8.17	0.54	1602
II	33.68	9.37	43.05	32.71	10.61	7.33	3.15	1315
III	21.52	57.97	79.49	4.20	3.96	7.82	3.73	8444
IV	5.61	72.11	77.72	6.96	6.89	5.56	0.35	929

Table 22b. The percentage by carbon biomass (gC/m*) of benthic feeding types at station groups.

Station Group	SDF %	SF %	IF %	SSDF %	CARN %	SCAV %	HERB %	CARBON (gC/m′)
I	29.73	12,73	42.47	36.30	17.88	1.89	1.47	6.3
II	34.65	22.31	56.95	26.87	12.77	1.70	1.70	9.2
III	10.83	42.76	53.60	8.87	16.04	10.72	10.78	10.0
IV	5.03	60.17	65.20	18.33	14.51	1.40	0<55	4.9

Table 22c. The percentage by carbon production ($gC/m^2/yr$) of benthic feeding types *at* station groups.

Station Group	SDF %	SF %	IF %	SSDF %	CARN %	SCAV %	HERB %	PRODUCTION ($gC/m^2/yr$)
I	13.81	4.51	18.32	53.72	24.28	1.52	2.16	4.7
II	24.96	11.28	36.24	38.77	18.65	2.26	4.08	5.2
III	12.81	13.87	26.68	12.49	22.61	19.39	18.82	5.6
IV	5.16	32.76	37.94	43.50	15.92	1.40	1.26	1.9

Table 23a. The percentage by abundance ($indiv/m^2$) of benthic motility types at station groups. Data collected by van Veen grab in the eastern Chukchi Sea, August/September 1986. Fragments are not included in the abundance computations, but are included in the carbon and production computations. A small percentage of the unknown motility types were present, but omitted from the table.

Station Group	SESSILE %	DISCRETELY MOTILE %	MOTILE %	ABUNDANCE ($indiv/m^2$)
I	21.22	33.20	42.09	1602
II	21.52	37.21	38.11	1315
III	58.44	18.49	22.27	8444
IV	29.07	22.63	45.79	929

Table 23b. The percentage by biomass (gC/m^2) of benthic motility types at station groups.

Station Group	SESSILE %	DISCRETELY MOTILE %	MOTILE %	CARBON (gC/m')
I	31.03	41.23	27.74	6.3
II	18.95	57.90	23.15	9.2
III	41.53	35.05	23.41	10.0
IV	20.05	23.62	56.33	4*9

Table 23c. The percentage by carbon production ($gC/m^2/yr$) of benthic motility types at station groups.

Station Group	SESSILE %	DISCRETELY MOTILE %	MOTILE %	PRODUCTION ($gC/m^2/yr$)
I	48.19	14.24	37.58	4.7
II	32.96	31.08	35.96	5.2
III	17.96	45.67	36.38	5.6
IV	14.87	19.47	65.67	1.9

In terms of abundance and carbon biomass, the inshore fauna at Station Group III consisted primarily of suspension feeding (58% of the total abundance; 43% of the total carbon biomass; 14% of the total carbon production), sessile (58% of the total abundance; 42% of the total carbon biomass; 18% of the total carbon production) taxa living on a sandy-gravel substrate. Surface deposit feeding taxa (primarily amphipods but also polychaetes) are also common within Group III (22% of the total abundance but only 11% of the total carbon biomass).

Relative to abundance and carbon biomass, the fauna along the coast at Station Group IV consisted of an even higher percentage of suspension feeders (72% of the total abundance; 60% of the total carbon biomass; 33% of the total carbon production). All stations in this group were dominated by the suspension-feeding sand dollar *Echinarachnius parma* living in a sandy substrate. The number of surface deposit feeders were greatly reduced in Station Group IV (6% of the total abundance; 5% of the total carbon biomass; 5% of the total carbon production); amphipods were uncommon at the stations of this group. Primarily motile taxa occurred here (46% of the total abundance; 56% of the total biomass; 66% of the total production). Sessile taxa were common here (29% by abundance; 20% by biomass; 15% by total production), but reduced relative to Group III.

The offshore mud-dwelling fauna (Cluster Groups I and II) comprised a much higher percentage of subsurface deposit feeders (28-33% of the total abundance; 27-36% of the total carbon biomass; 39-54% of the total carbon production) than occurred in Groups III and IV. Surface deposit feeders were also common in these groups (34-37% by abundance; 30-35% by carbon biomass; 14-25% by carbon production). Discretely motile and motile taxa were more abundant in Groups I and II than at the inshore station groups. Sessile organisms were still common within the two offshore station groups, although only a few taxa mainly contributed to this category: Group 1 - primarily the tube-dwelling polychaete *Maldane glebifex* and the juvenile barnacle *Balanus crenatus*; Group 2 - mainly *M. glebifex (see* Table 23 for motility values).

7. Stepwise Multiple Discriminant Analysis

The results of stepwise multiple discriminant analysis of the environmental conditions recorded in the study on station groups (based on abundance data) are shown in Table 24 and Figs. 83-85. All of the sediment data used in the first two analyses (Tables 24a and b) are based on dry weight values.

The first analysis, summarized in Table 24a, excluded percent mud which had a high covariance with percent sand. Discriminant functions 1 and 2 contribute 97.8% of the total separation among station groups. Further, 62.2% of the stations were correctly grouped by the jacknife classification into station groups by the three variables that form the discriminant functions. These variables are arc sine transformed % gravel, % sand, and sediment OC/N. Station positions along the two function axes are plotted in Figure 83. An assessment of the coefficients of discriminant functions which produce the coordinates is presented in Table 24a. The lowest negative value along the discriminant function (DF) 1 (canonical variable 1) is due to % sand. The high positive value along DF 2 is the result of the percent gravel in the sediment. A negative value along DF 2 is the result of the OC/N value of the sediment. The centroid of Station Group IV is distinct from that of Groups I, II, and III along the axis of DF I. Centroids of Groups I and II are separated from Group III on DF axes I and II. Station Group II is distinct from Group I along the first and second discriminant functions. The separation of Group IV from Groups I, II, and III is mainly the result of

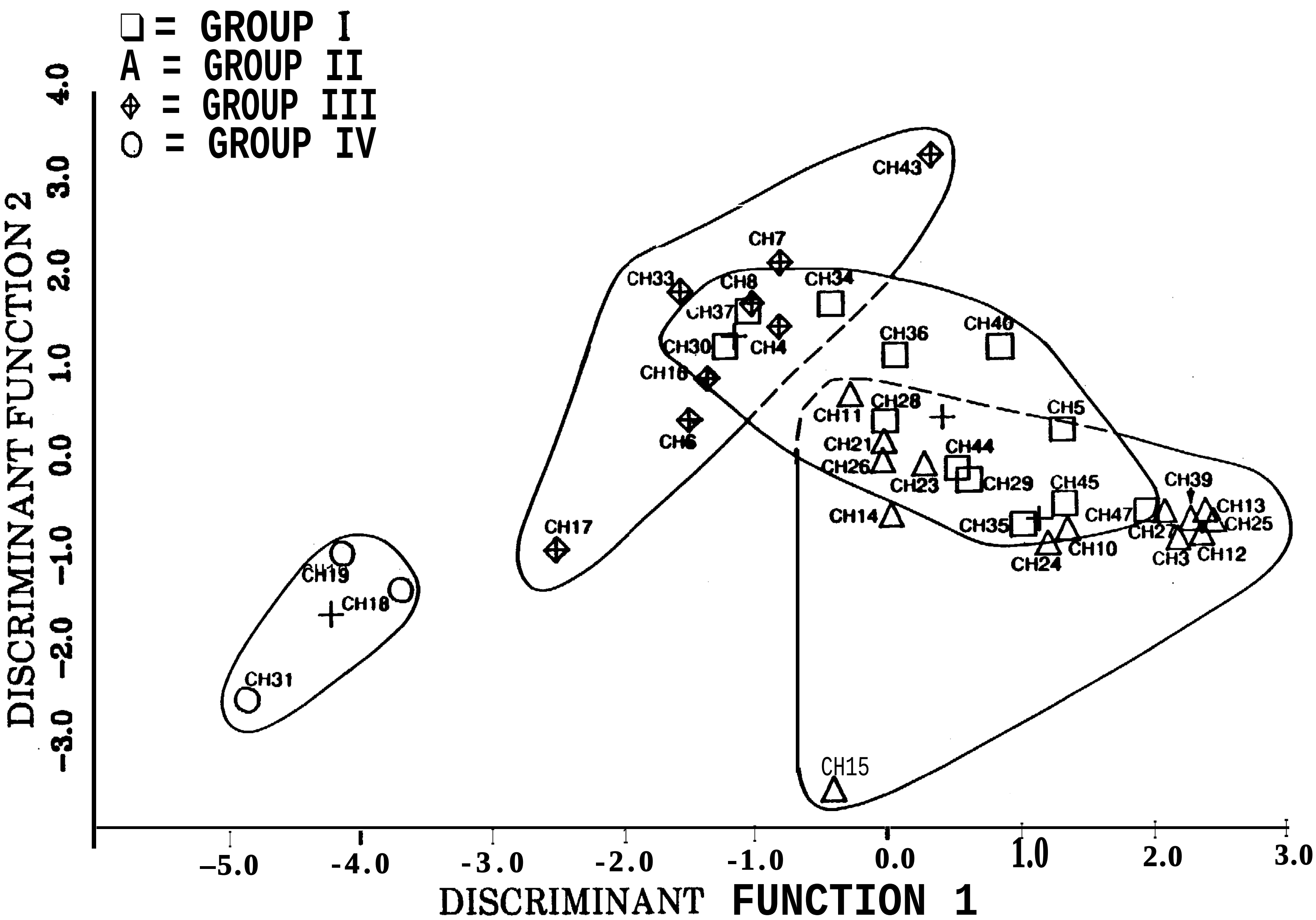

Figure 83. Station and station group plot of the results of the multiple discriminant analysis utilizing environmental conditions recorded in the study. The analysis is based on dry sediment weight values. The centroids of the four respective station groups are shown by +. Mud values are excluded (see Table 24a).

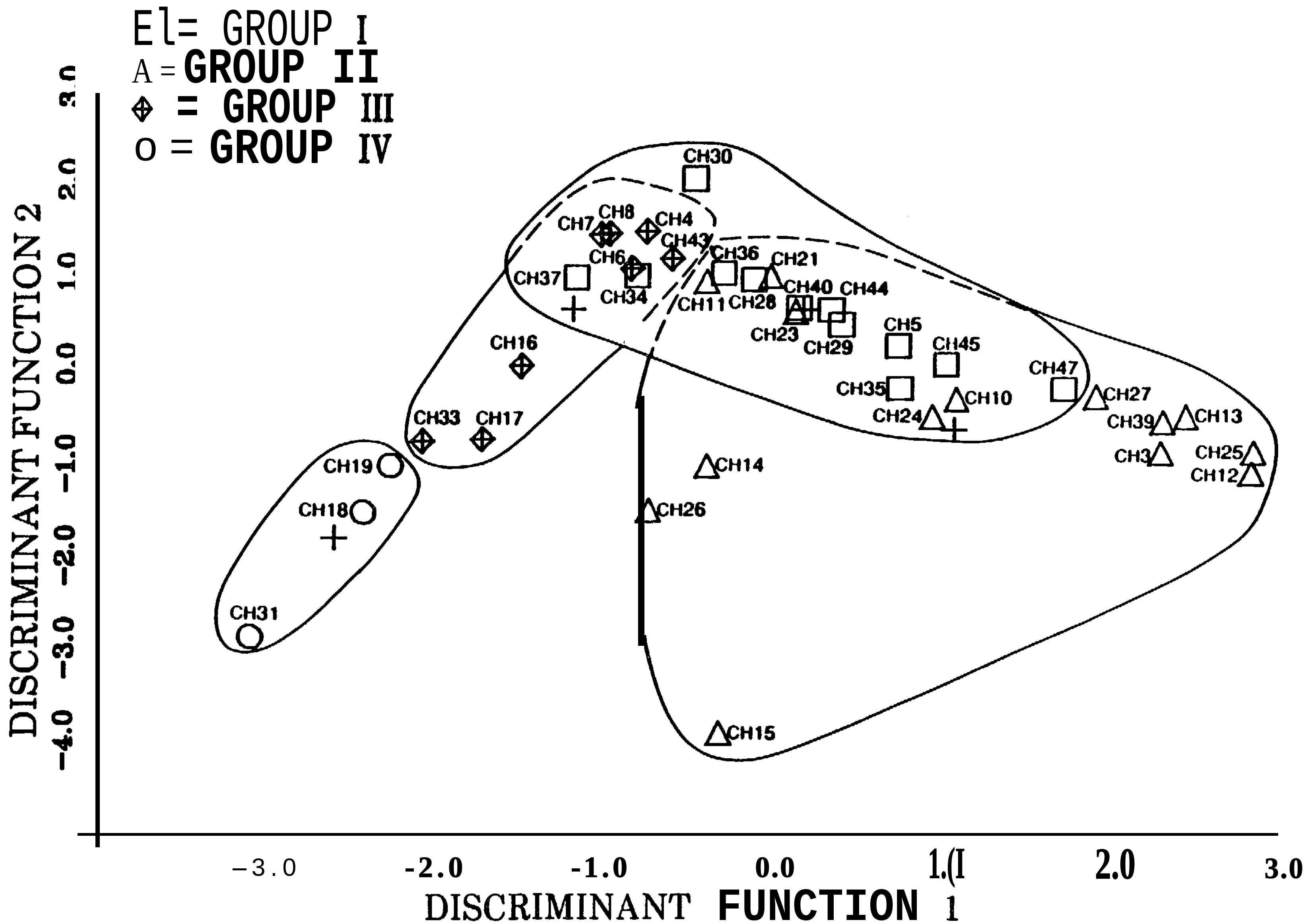

Figure 84. Station and station group plot of the results of the multiple discriminant analysis utilizing environmental conditions recorded in the study. The analysis is based on dry sediment weight values. The centroids of the four respective station groups are shown by +. Sand values are excluded (see Table 24b).

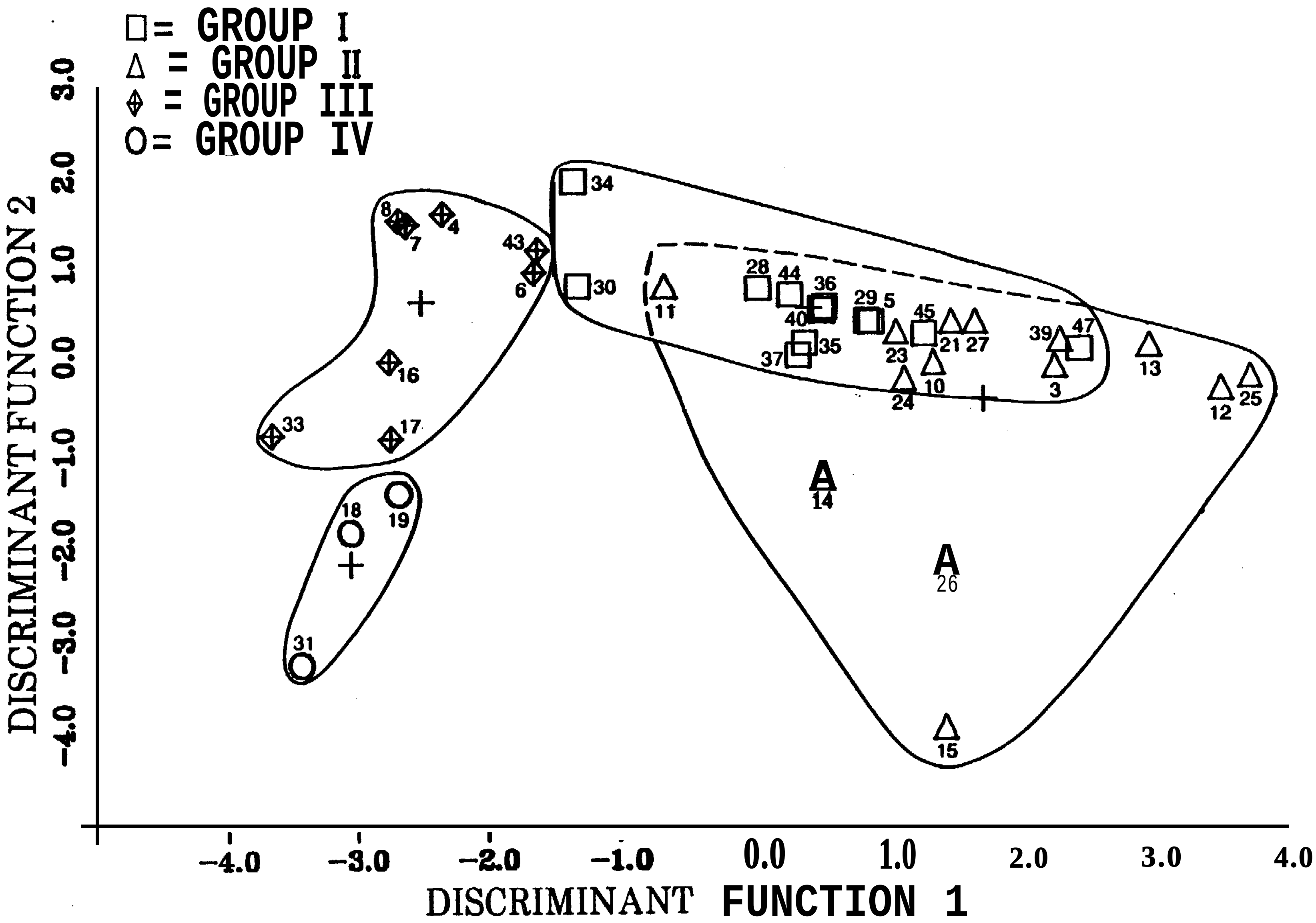

Figure 85. Station and station group plot of the results of the multiple discriminant analysis utilizing environmental conditions recorded in the study. The analysis is based on wet sediment weight values. The centroids of the four respective station groups are shown by +. All sediment data used in the analysis (see Table 24c).

Table 24a. Summary of the stepwise multiple discriminant analysis of the environmental conditions among the four station groups formed by cluster analysis of abundance data. Sediment data used in the analysis are based on dry weight values. Excludes percent mud which has a high covariance with percent sand (see Fig. 83).

Discriminant Function	1	2	3
Percent of Separation	71.61	26.19	2.20
Cumulative Percent of Separation	71.61	97.80	100.00

Variables and standardized discriminant function coefficients			
Percent Gravel	-0.30	0.95	--
Percent Sand	-0.91	0.36	--
Sediment OC/N	-0.53	-0.72	--

Table 24b. Summary of the stepwise multiple discriminant analysis of the environmental conditions among the four station groups. Sediment data used in the analysis are based on dry weight values. Excludes percent sand which has a high covariance with percent mud (see Fig. 84).

Discriminant Function	1	2
Percent of Separation	66.29	33.71
Cumulative Percent of Separation	66.29	100.80

Variables and standardized discriminant function coefficients		
Percent Mud	0.83	-0.59
Sediment OC/N	-0.44	-0.92

Table 24c. Summary of the stepwise multiple discriminant analysis of the environmental conditions among the four station groups. All sediment data used in the analysis are based on wet weight values (see Fig. 85).

Discriminant Function	1	2
Percent of Separation	83.65″	16.35
Cumulative Percent of Separation	83.65	100.00

Variables and standardized discriminant function coefficients		
Percent Water in Sediment	0.96	-0.29
Sediment OC/N	-0.17	-0.94

the higher percentage of sand in the sediment at Group IV. On the other hand, the difference in the percent gravel results in the differentiation between Groups I and II as well as the separation of both of these groups from Station Group III. Group IV has a higher OC/N value than Groups I, II and III.

The second analysis, summarized in Table 24b and plotted in Figure 84, excluded percent sand which had a high covariance with percent mud. Discriminant function 1 contributes 66.3% of the total separation among station groups while function 2 only contributes 33.7% to the total separation among station groups. Nearly 65% of the stations were correctly grouped by the jacknife classification into station groups by the two variable that form the discriminate functions. These variables are arc sine transformed percent mud and sediment OC/N values. The separation of the centroids of Groups I and II along DF 1 is based on the higher percentage of mud in Group II while both of these groups have a higher percentage of mud than Groups III and IV. The higher OC/N values at Station Groups III and IV along DF 1 separates these groups from I and II.

The results of another stepwise multiple discriminant analysis of environmental conditions recorded, using wet weight of sediment samples, on cluster groups are shown in Table 24c and Figure 85. Discriminant function 1 contributed 83.7% of the total separation among station groups. Further, 75.7% of the stations were correctly grouped by the jacknife classification into station groups by the two variables that form the discriminant functions. The variables are percentage of water within the sediment and the sediment OC/N value. A high positive value along the discriminant function 1 is due to the percentage of water in the sediment. The negative value along discriminant function 1 is due to the OC/N value of the sediment. The centroids of Station Groups I and II are distinct from those of Groups III and IV along the axis DF I. The separation of Groups I and II from III and IV on DF 2 is due to the higher percentage of water and the lower OC/N value in the sediments of Station Groups I and II. Separation of Station Group III from IV, and the separation of Group I from II is also apparent along the axis of DF 2, and is due primarily to the higher sediment OC/N values at Station Groups IV and II, respectively.

Since the mean carbon biomass at the stations to the north and west of a postulated frontal zone (10.3 gC/m^2) was significantly higher ($P<0.001$) than the mean value calculated for the southern stations (5.2 gC/m^2) (Table 14), stations were separated, by carbon biomass, into a northern and a southern group. Bottom temperature and bottom salinity were highly correlated variables; thus, two analyses were run, each with either bottom temperature or bottom salinity in addition to other physical oceanographic variables. Discriminant function 1 for each analysis contributed 100% of the total separation between the two station groups. Further, 91.9-97.3% (the former for bottom salinity; the latter for bottom temperature) of the stations were correctly grouped by the jacknife classification into the two groups by the variable (either bottom salinity or bottom temperatures) that formed a single discriminant function (Fig. 86). Thus, the contributing variables were either bottom temperature or bottom salinity, and the separation of the two groups, by carbon biomass, is due to lower bottom-water temperatures and higher bottom salinities in the northern region.

8. Production and Carbon Requirements of the Benthos

Overall, estimated annual benthic production was highest within Station Groups I-III (4.7-5.6 $gC/m^2/yr$) and lowest at Group IV (1.9 $gC/m^2/yr$) where

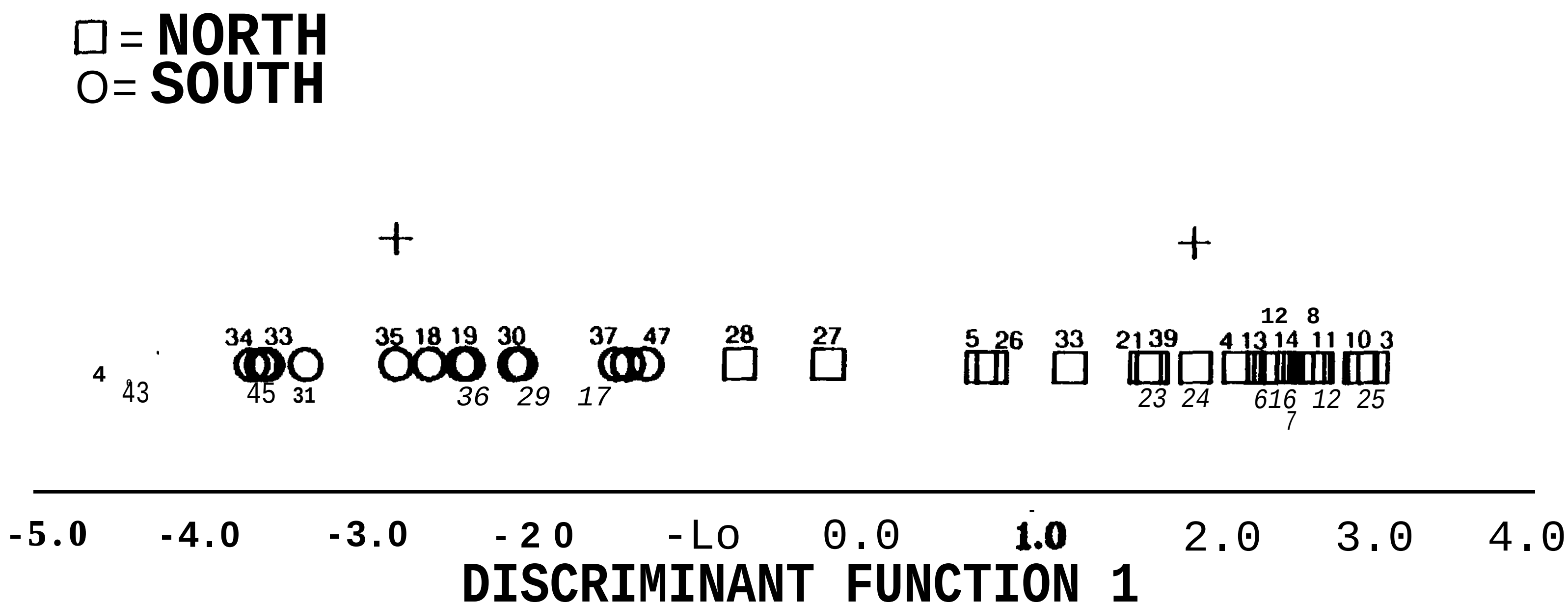

Figure 86. Station and station group plot of the results of the multiple discriminant analysis utilizing physical oceanographic conditions recorded in the study. The centroids of the two groups (north and south) separated by biomass values are shown by +.

the benthos was dominated by cockles and sand dollars (Table 21a; also see Table 12 for individual station data).

Annual production was dominated by the contribution from polychaetous annelids at Groups I (81% of the total production), II (62%), and IV (49%) (Table 19). No other groups were important at Group I. Bivalve mollusks were the next largest contribution to production within Group II (25%) and Group IV (34%). Annual production was dominated within Group III by amphipod crustaceans (43%), with polychaetes next in importance (35%).

Annual production by subsurface deposit-feeding taxa was highest at the two offshore groups (Group I: 54%; II: 39%) and at inshore Group IV (44%) (Table 22c). Production at inshore Group III was relatively evenly dispersed among all feeding groups. Assessment of interface feeders (surface deposit + suspension feeders) suggests that use of POC in the water column and on sediment surfaces was least important at offshore Group I (18%), but was important within the other three groups (11: 36%; III: 27%; IV: 38%).

Mean annual production of the northern high biomass stations (5.9 $gC/m^2/yr$; Table 14; Fig. 69) is significantly higher than that for the southern stations (3.4 $gC/m^2/yr$). Further, the annual production of interface feeders was highest at the northern stations, with suspension feeders dominating alongshore and surface-deposit feeders important offshore.

Four stations, south of the postulated front and just north of Cape Lisburne (Table 12; Figs. 62, 69: Stations CH34, 35, 36, 37), are located beneath a clockwise oceanic gyre (W. Stringer, pers. commun.), and have relatively high biomass values. Production at these stations is similar (i.e., a mean value of 5.9 $gC/m^2/yr$) to that of the stations north and west of the front. Alternatively, the other southern stations with low biomass values had a mean production value of only 2.5 $gC/m^2/yr$.

Estimates of carbon required by the benthos at Station Groups I-IV (groups delineated by cluster analysis of abundance data), and at the northern and southern station groups (the two latter groups separated according to biomass) are presented in Tables 21a and 14, respectively. Transfer efficiencies of 10 and 20% were utilized in the calculations. A transfer efficiency of carbon to the macrobenthos in northern Alaskan shelf of 20% is suggested by Walsh and McRoy (1986).

9. Demersal Fishes and Epibenthic Invertebrates

Demersal or benthic trawling was accomplished at ten stations in the northeastern Chukchi Sea between Point Hope and point Barrow (Table 2; Figs. 13 and 62). A small demersal otter trawl or try net (4 m net opening) was towed 10-15 minutes at 2-4 knots. Because the R/V *Oceanographer* did not have adequate trawling capabilities, all material obtained in the trawls was treated as non-quantitative. However, dominant taxa were ranked in decreasing order of importance based on relative abundance or biomass, whichever was applicable. A characterization of the trawl catches is included in Table 25. Few fishes were caught, although arctic cod (*Boreogadus saida*) and flathead sole (*Hippoglossoides elassodon*) were most numerous. The invertebrates that dominated in abundance were the brittle star *Ophiura sarsi*, the Tanner crab *Chionoecetes opilio*, and crangonid shrimps. Sea stars (*Asterias amurensis, Ctenodiscus crispatus,* and *Leptasterias* spp.) and tunicates (*Boltenia, Molgula, Styela,* and *Halocynthia*) dominated the biomass.

The brittle star *Ophiura sarsi* was most abundant at soft-bottomed Stations CH2, 23, 30, and 47 (Table 25). These were mainly large organisms

Table 25. Characterization of demersal trawl catches in the northeastern Chukchi Sea aboard the RV *Oceanographer,* August-September 1986. Dominant taxa (in terms of number and/or biomass) are ranked in order of decreasing dominance.

Station	Depth (m)	Bottom Type	Dominant 'Taxa[1]	Comments
CH1	48	hard	*Boltenia ovifera* - T	
			Molgula grifithsii - T	
			Sclerocrangon boreas - CS	
			Asterias amurensis - SS	
			Gorgonocephalus caryi - BAS	
			Cryptochiton stelleri - C	
			Bryozoa	
			Sponge	
CH2	66	soft	*Ctenodiscus crispatus* - SS	
			Ophiura sarsi - BS	
			Pectinariidae - P	
			Astarte spp. - CL	
			Cyclocardia sp. - CO	
			Eunephtya sp. - soft coral	
CH23	40	soft	*Ophiura sarsi* - BS	95% of biomass
			Chionoecetes opilio - SC	
			Hyas coarctatus - SPC	
CH26	46	soft	*Chionoecetes opilio* - SC	9-25 mm carapace width
			Leptasterias sp. - SS	
			Eualus sp. - HS	
			Boreogadus saida - AC	
			Argis lar - CS	
			Natica pallida - SN	
CH30	39	sand	*Ophiura sarsi* - BS	90% of biomass
			Chionoecetes opilio - SC	5% of biomass 10-30 mm carapace width
			Pagarus trigonocheirus - HC	
			Pandalus goniurus - PS	
			Pandalus tridens - PS	
			Argis lar - CS	
			Boreogadus saida - AC	
CH31	27	sand	*Echinarachnius parma* - SD	95% of biomass

Table 25. (cent'd)

Station	Depth (m)	Bottom Type	Dominant Taxa[1]	Ccmments
CH35	39	sand	*Leptasterias polaris acervata* - SS	
			Pandalus goniurus - PS	
			Chionoecetes opilio - SC	
			Pagurus trigonocheirus - HC	
			Ophiura sarsi - BS	
			Hippoglossoides elassodon - ??S	
CH36	44	soft	No organisms in two tows.	
CH37	47	hard	*Boltenia ovifera* - T	
			Boltenia echinata - T	
			Molgula retortiformis - T	
			Styela rustics - T	
			Halocynthia aurantium - T	
			Chionoecetes opilio - SC	
			Hyas coarctatus - SPC	
CH47	50	soft	*Chionoecetes opilio* - SC	10 adult females 11 subadult females
			Ophiura sarsi - BS	
			Leptasterias polaris acervata - SS	

[1]AC = Arctic cod
BAs = Basket star
BS = Brittle star
C = Chiton
CL = clam
CO = Cockle
CS = Crangonid shrimp
FS = Flathead sole
HC = Hermit crab
HS = Hippolytid shrimp
P = Polychaete
Ps = Pandalid shrimp
Sc = Snow crab
SD = Sand dollar
SN = Snail
SPC = Spider crab
Ss = Sea star
T = Tunicate

with disk diameters typically exceeding 20 mm. A subsample (N = 50) of *O. sarsi* from Station CH30 was examined for food items. The most frequently occurring food items were the remains of other brittle stars (100%), bivalves (92%), and gastropod (50%). All (.100%) brittle stars also contained sediment in their stomachs (Table 26).

Numerous Tanner crabs were collected at 7 of 10 trawl station locations. Most adults were caught at the southern sector; juveniles mainly came from the other regions. Station CH47 yielded ten adult females with eggs and 11 subadult females with internal developing ova. The size of the adults ranged between 45 and 58 mm carapace width, within the size range of adult females caught in the vicinity of Point Hope in 1976 (Jewett, 1981).

Two stations where several hundred juveniles were caught in a ten-minute tow were CH26 and CH30. The crabs at these stations were similar in size, i.e., 10-30 mm carapace width. The sex ratio was nearly one to one. One notable difference in the crabs from these two sites was the presence of juvenile barnacles on the exoskeleton of all crabs at inshore Station CH30 and absence of barnacles on crabs at offshore Station CH26. A subsample (N = 50) of crabs from each of these stations was examined for stomach analyses (Table 27). The most frequently occurring food groups in crabs from both stations, in order of percent frequency of occurrence, were clams and cockles (61%), crustaceans (53%), and polychaetes (22%). Prey in crabs at CH26, where mud dominated the substrate, were mainly unidentified polychaetes, *Yoldia* sp. clams, and amphipods., , The most frequently taken prey in crabs from Station CH30, a site where sand predominated the substrate, were foraminifera, unidentified clams, *Nucula bellotti* clams, amphipods, and barnacles. Sediment was present in all of the crabs at CH30, but absent from all crabs at CH26.

Table 26. Frequency of occurrence of items within stomachs of the brittle star, *Ophiura sarsi*, from Station CH30 in the eastern Chukchi Sea, September 1986, Cruise OC862.

Station:	CH30
Number Examined:	50
Average Disk Diameter:	22.1 mm (SD = 1.2)

Prey Group	Frequency of Occurrence Number	Percent
Foraminifera	7	14
Hydrozoa	2	4
Bivalvia	46	92
Gastropoda	25	50
Veliger larvae	1	2
Crustacea	9	18
Decapoda	1	2
Copepoda	1	2
Cyprid larvae	11	22
Ophiuroidea	50	100
Sediment	50	100

Table 27. Frequency of occurrence of items within the Tanner crab, *Chionoecetes opilio*, from Stations CH26 and CH30 in the eastern Chukchi Sea, September 1986, Cruise OC862.

Station:	CH26	CH30	CH26 + CH30
Number Examined:	50	50	100
Average Carapace width:	23.2 mm (SD = 1.3)	20.9 mm (SD = 2.1)	22.1 mm (SD = 2.1)

Prey Group	Frequency of Occurrence Number	(%)	Number	(%)	Number	(%)	
Protozoa	3	(6)	1	(2)	4	(4)	
Foraminifera	1	(2)	30	(60)	31	(31)	
Polychaeta (unidentified)	15	(30)	6	(12)	21	(21)	
Myriochele oculata	0	(0)	1	(2)	1	(1)	
Nereidae	1	(2)	0	(0)	1	(1)	22
Bivalvia (unidentified)	16	(32)	18	(36)	34	(34)	
Yoldia sp.	15	(30)	0	(0)	15	(15)	
Nucula bellotti	3	(6)	9	(18)	12	(12)	
Clinocardium sp.	1	(2)	0	(0)	1	(1)	61
Gastropoda	2	(4)	5	(10)	7	(7)	
Crustacea	14	(28)	10	(20)	24	(24	
Amphipoda	15	(30)	7	(14)	22	(22)	
Bathymedon sp.	3	(6)	0	(0)	3	(3)	
Copepoda	1	(2)	1	(2)	2	(2)	
Ostracoda	0	(0)	1	(2)	1	(1)	
Balanus sp.	0	(0)	6	(12)	6	(6)	53
Asteroidea	1	(2)	0	(0)	1	(1)	
Ophiuroidea	0	(0)	5	(10)	5	(5)	
Sediment	0	(0)	50	(100)	50	(50)	
Empty	2	(4)	3	(6)	5	(5)	

10. Gray Whale and Pacific Walrus Feeding Areas

Although no data were gathered in this study on gray whale (*Eschrichtius robustus*) and walrus (*Odobenus rosmarus divergens*) feeding nabits, some benthic biological data were obtained from areas where these marine mammals are known to feed. Macrofaunal sampling occurred at 12 stations, CH4-8, 17-19, 31, 33, 43, and 44 (Fig. 62), within the region where gray whales occur between Point Hope and Point Barrow mainly within *50 km* of shore (Clarke *et al.*, 1987). The average depth of these stations was 27.8±8.9 m. Only four of these stations had high concentrations of amphipods, the main prey of gray whales. Stations CH5, 6, 7, and 17 had an average amphipod abundance and carbon biomass of 4,319±1,987 individuals /m^2 and 4.7±5.9 gC/m^2, respectively (Table 28). The average amphipod abundance and carbon biomass at the other eight stations was only 87±63 amphipods/m^2 and 0.09±0.1 gC/m^2, respectively.

Three amphipod families dominated the abundance and carbon biomass at these four stations - Isaeidae, Ampeliscidae, and Atylidae ('Table 29). Isaeid amphipods were dominated by small *Protomedeia* Spp . and *Photis* spp.. Ampeliscids were dominated by the larger tube-dwellers *Ampelisca* spp. and *Byblis* spp.. The important atylid was *Atylus bruggeni*, a highly mobile species.

A group of stations sampled in the present study, i.e., Station Group II (14 stations) (Fig. 78), encompassed most of the summer and fall habitat of walruses (Fay, 1982; Frost *et al.*, 1983). The average organic carbon value within the sediment at Group II stations was highest (8.7 mgC/g) of the four station cluster groups. Also, the benthic macrofaunal carbon biomass at this group of stations was a high 9.2 gC/m^2. The fauna was dominated by the bivalves *Macoma* spp., *Nucula bellotti*

Table 28. Benthic stations in the northeastern Chukchi Sea between Point Hope and Point Barrow within 50 km of shore. These are within the area where gray whales occur during summer.

Station	Abundance (indiv/m²) All Infauna	Amphipods	% Amphipods	Biomass (gC/m²) All Infauna	Amphipods	% Amphipods
CH5	3656	2302	63.0	6.63	0.81	12.2
CH6	8472	6644	78.4	5.62	2.90	51.6
CH7	7482	5204	69.6	19.64	13.50	68.7
CH17	4998	3128	62.6	6.64	1.82	27.4
$\bar{X}$ (SD)	6152 (2215)	4319 (1987)	68.4 (7.4)	9.6 (6.7)	4.7 (5.9)	40.0 (25.1)
CH4	1592	204	12.8	13.65	0.40	2.9
CH8	2508	128	5.1	13.20	0.11	0.8
CH18	462	6	1.3	3.21	<0.01	0.3
CH19	1622	76	4,7	5.75	0.01	0.2
CH31	702	20	2.8	5.61	<0.01	0.2
CH33	6988	118	1.7	3.21	0.06	1.9
CH43	3938	68	1.7	2.05	0.10	4.9
CH44	2320	80	3.4	6.77	0.03	0.4
$\bar{X}$ (SD)	2516 (2112)	87 (63)	4.2 (3.7)	6.68 (4.4)	0.09 (0.1)	1.4 (1.7)

(tenuis), and *Astarte* spp., the sipunculid *Golfingia margaritacea*, and polychaete worms (Table 30).

Benthic samples were also taken in the present study in the area where extensive walrus feeding traces were observed offshore between Icy Cape and Point Franklin (Phillips and Colgan, 1987). Most stations within this area

Table 29. Dominant amphipod families at stations in the northeastern Chukchi Sea where gray whales occur.

Taxa	Dominant Amphipod Families in Individuals/m*					
	Stations					
	CH5	CH6	CH7	CH17	Average	%
Isaeidae	514	4564	136	98	1328	30.7
Ampeliscidae	1644	372	16	2530	1140	26.4
Atylidae	2	874	3506	0	1095	25.4
Corophiidae	44	160	848	60	278	6.4
Ischyroceridae	0	366	342	24	183	4.2
Phoxocephalidae	24	88	6	336	113	2.6
Lysianassidae	30	112	40	32	54	1.2

Taxa	Dominant Amphipod Families in gC/m^2					
	Stations					
	CH5	CH6	CH7	CH17	Average	%
Atylidae	0.001	1.687	12.836	0	3.631	75,3
Ampeliscidae	0.625	0.484	0.010	1.742	0.715	15.0
Isaeidae	0.055	0.501	0.014	0.004	0.144	3.0
Lysianassidae	0.112	0.033	0.302	0.009	0.114	2.4
Ischyroceridae	0	0.160	0.123	0.003	0.072	1.5
Corophiidae	0.003	0.016	0.158	0.018	0.049	1.0
Phoxocephalidae	0.001	0.003	0	0.041	0.011	0.2

grouped together (Group III) based on cluster analysis of the infaunal abundance data (Fig. 78). Few of the most abundant fauna were ones typically taken by walruses. However, bivalves and gastropod consisted of nearly 17% and 9% of the carbon biomass, respectively. Dominant bivalves were *Liocyma viridis, Astarte* borealis and *Yoldia myalis.* Dominant gastropod were *Natica clausa* and *Polinices pallida* (Table 31).

Table 30. Dominant infaunal invertebrates in Group 11 stations in the vicinity where Pacific walrus typically occur in the northeastern Chukchi Sea.

Number of stations: 14
Average indiv./m^2 1315 ±1094
Average gC/m^2 9.2 ± 3.9

Dominant Groups	Average Indiv./m^2	%	Dominant Groups	Average gC/m^2	%
Polychaeta	494	37.6	Bivalvia	4.3	46.7
Bivalvia	320	24.3	Polychaeta	2.3	25.0
Amphipoda	275	20.9	Sipuncula	1.2	13.0

Dominant Taxa	Average Indiv./m^2	Dominant Taxa	Average gC/m^2
Nucula bellotti	161	*Macoma* spp.	2.4
Maldane glebifex	148	*Golfingia margaritacea*	1.8
Lumbrineris sp.	78	*Nucula bellotti*	0.7
Macoma spp.	71	*Maldane glebifex*	0.7
Byblis brevirimus	53	*Lumbrineris fragilis*	0.4
Paraphoxus sp.	51	*Astarte* spp.	0.4
Cirratulidae	33	*Nuculana* radiata	0.4
Ostracoda	33	*Nephtys paradoxa*	0.3
Barantolla americana	24	*Natica clausa*	0.2
Leitoscoloplos pugettensis	23	*Yoldia hyperborea*	0.2

Table 31. Dominant infaunal invertebrates in Group III stations in the vicinity where Pacific walrus typically occur in the northeastern Chukchi Sea.

Number of stations:	8
Average indiv./m²	8444 ±9655
Average gC/m²	10.0 ± 6.5

Dominant Groups	Average Indiv./m²	%	Dominant Groups	Average gC/m²	%
Thoracea	4505	53.3	Amphipoda	2.4	24.0
Amphipoda	2210	26.2	Echinodermata	2.0	19.8
Annelida	792	9.4	Bivalvia	1.7	16.6

Dominant Taxa	Average Indiv./m²	Dominant Taxa	Average gC/m²
Balanus crenatus (juv.)	4159	*Atylus bruggeri*	1.82
Atylus bruggeni	550	*Psolus peroni*	1.72
Protomedeia spp.	437	*Golfingia margaritacea*	0.45
Balanus crenatus (adult)	345	*Liocyma viridis*	0.43
Ampelisca macrocephala	298	*Astarte borealis*	0.39
Foraminifera	139	*Yoldia myalis*	0.34
Ischyrocerus sp.	106	*Nephtys caeca*	0.28
Leitoscoloplos pugettensis	77	*Natica clausa*	0.26
Cirratulidae	62	*Polinices pallida*	0.23
Grandifoxus nasuta	59	*Chelyosoma* sp.	0.23

VI. DISCUSSION

A. Physical Oceanography

A salient feature of the physical oceanographic data presented in this report is that wind-driven coastal upwelling occurred. The measured currents from both the moorings near the coast (CH)17) and the shipboard ADCP system (near Barrow) indicated a reversal of the flow towards the southwest over a three day interval, followed by a return to the northeastward flow. There were significant correlations between Barrow winds and the currents at the three coastal moorings during this reversal. Based on the distance between the ship and the moorings, we can estimate that the reversal occurred from Point Barrow to Icy Cape and possibly to Cape Lisburne, implying a minimum alongshore length scale of 200 to 400 km. On the northern flank of Hanna Shoal (CH13), no reversal of the eastward flow along the shelf was observed. The temperature time series from the current meters supports the upwelling hypothesis, showing a decrease of 6°C over a three-day period, followed by a return to the original conditions. The upwelling resulted in lifting this isotherm at least 10 m to the 19 m depth of the CH17 current meter.

Alternative explanations for the observed temperature at CH17 include horizontal advection and in *situ* cooling and warming. The argument for *in* situ cooling is weak on the basis that the required cooling is more than could be produced by the measured air temperature over the short period of the event. In particular, the return of warm temperatures near the end of the time series could not have been produced by local warming of a water column 19 m thick when the air temperature did not exceed approximately 4°C. The contribution of horizontal advection to the upwelling hypothesis cannot be ruled out with the present data set. Cold water was available deeper in the Barrow Canyon which could move horizontally with the velocities measured by the current meters during the reversal event. The bottom temperature map (Fig. 38) shows that below 0°C temperatures were observed at CH8, approximately 50 km from the mooring location at the time of the minimum temperature at the mooring. The interpretation of the temperature map requires some caution, because it also represents both time and space variations. The most likely scenario is that both vertical and horizontal displacements of the water occurred as a result of the wind event. This signature was observed at CH17, even though the mooring station was more than two Rossby radii of deformation from the coast.

The temperature and salinity data from this cruise are similar to the summer conditions in the Chukchi Sea constructed by Coachman *et al.* (1975) as a composite of several cruises. The water mass analysis indicates that the warm coastal water had penetrated as far north as about 70°30'. Hydrographic data suggest that modified Bering Water (Chukchi Resident Water) approaches the Alaska coast north of Icy Cape. The Beaufort Sea water was found along the axis of the Barrow Canyon, producing a tongue of colder and higher salinity water near the bottom. For both of the traditional T-S technique and the cluster analyses, the front separating the water mass groupings follows the temperature contours (5°C at the surface, Fig. 35; 4°C at the bottom, Fig. 36) and the bottom salinity contours (32.5 ‰, Fig. 37). The temperatures and salinities of the water masses on both sides of the front vary interannually, as well as the intensity of the front itself (Coachman *et al.*, 1975). The front is essentially maintained by the alongshore flow of the Alaska Coastal Water.

B. The Relationship of Sediment Parameters to Taxon Assemblages

It is currently accepted that benthic communities and their component organisms are distributed in a continuum along environmental gradients (Hills, 1969). However, it is still possible to recognize faunal assemblages, realizing that their separation into groups are typically not as discrete as had been suggested previously (Thorson, 1957).

As presented in the Results section (Table 17), the assemblages identified in the northeastern Chukchi Sea included four cluster (station) groups: I - a muddy-sandy-gravel assemblage dominated in abundance by the tube-dwelling ampeliscid amphipod *Byblis gaimardi* and the juvenile barnacle *Balanus crenatus*, II - a muddy assemblage dominated by the tube-dwelling polychaete *Maldane glebifex* and the protobranch clam *Nucula bellotti*, III - a sand assemblage characterized by the juvenile and adult barnacle *B. crenatus* and amphipods (including the tube-dwelling ampeliscid *Ampelisca macrocephala*), and IV - a sandy-gravel assemblage dominated by the sand dollar *Echinarachnius parma* and the cockle *Cyclocardia rjabininae*. It would appear that mean grain size *per se* is rarely the factor to which organisms respond to exclusively; benthic assemblages are typically a reflection of sediment size as well as several other sediment properties. Thus, the separation of the four station groups identified in the northeastern Chukchi Sea is best explained by the relative presence of gravel, sand, and mud in conjunction with OC/N values and percent water in the sediment, as determined by stepwise multiple discriminant analysis (Figs. 83-85). The observed benthic groupings (as defined in the context of sediment granulometric composition and fluidity) in the northeastern Chukchi Sea are not surprising because benthic assemblages have been determined in other areas on the basis of substrate type and associated water content (e.g., Boswell, 1961; Day *et* al., 1971; Franz, 1976; McCave, 1976; Webb, 1976; Flint, 1981; Mann, 1982).

In our study area there is generally a covariance in the mud and water content in sediments (Fig. 60). The high water content in muddy sediments of our area is apparently related to the relatively higher porosity of the muds. Clayey particles which are enriched in muddy sediments, by virtue of their nonspherical shape, contribute to the higher porosity of the muds.

The presence of resident populations of the sand dollar *Echinarachnius parma* and the cockle *Cyclocardia rjabininae* (two shallow-dwelling suspension feeders) in inshore Group IV, in a low fluidity sandy-gravel deposit can simply be explained by the presence of a firm substrate with a high bearing strength in the area where these organisms occur. It is probable that the close association of these two species with a sand-gravel substrate is due to the prevalence of relatively intense currents (Alaska Coastal Water: ACW) over the above substrate type (Phillips, 1987) which would induce resuspension of sediments and associated Particulate Organic Carbon (POC) as a food source. Regional concentrations of suspended particles (Figs. 46 and 47; Table 6) indicate, as expected, that there is relatively more resuspension in the turbulent inshore region. As illustrated by the multivariate analyses of biological data (Figs. 74-77), there is a definite separation between inshore Station Groups 111 and IV which is presumably due to a generally higher content of gravel and lower content of sand in the substrate of Group III (Table 5; Figs. 39, 40, 61 and 83). As noted above, Group III is dominated by juvenile and adult barnacles associated with lag gravels under intense coastal currents. These coastal areas are also characterized by rocky outcrops (as shown by the high resolution seismic profiles recorded by Phillips *et* al., 1985, and by us) which reflect high energy hydrodynamic conditions. The predominance of amphipods, especially ampeliscids, in the northern portion of Group III is most likely not primarily controlled by the nature of the substrate. As discussed later, it appears that an unusual flux of POC to the bottom in the northern segment of Group III contributes to amphipod dominance there.

The dominance of two subsurface deposit-feeding species, the tube-dwelling polychaete *Maldane* and the protobranch clam *Nucula*, in offshore Station Group II is quite consistent with the muddy and fluid nature of the sediment in which these organisms dwell. It is to be expected that the higher water content in mud which results in a fluidized sediment, would also generally impart thixotrophic properties to the mud. Presumably this fluidized mud offers a suitable substrate for the building of subsurface tubes by *Maldane*, and provides easy access by the clam *Nucula* to the surrounding sediments with their contained POC. The close association of POC with muddy sediments has been repeatedly shown by numerous investigators (see Weston, 1988, for references). The importance of muddy fluidized and POC-enriched sediments (Figs. 49, 60, and 61) as an environment for deposit-feeding organisms within offshore Groups I and II, but particularly Group II, is further demonstrated by the variety of surface and subsurface deposit-feeding species present (Tables 15 and 20; Fig. 78).

The bottom on which organisms within Station Groups I and II reside consist predominantly of muddy substrates. However, there are some subtle differences in the sediment nature at the stations comprising these two groups, as illustrated by differences in the proportions of coarse grains (gravel+sand) and water (Fig. 61). These sediment differences are reflected by the differences and abundance of dominant species between the two groups (Table 17). Thus, Group I is dominated by the surface-deposit feeding ampeliscid amphipod *Byblis gaimardi* and the suspension-feeding juvenile barnacle *B. crenatus*, whereas Group II is dominated by two subsurface deposit-feeding species, the clam N. *bellotti* and the tube-dwelling *M. glebifex* (Table 17). The presence of juvenile, but not adult, barnacles, in Group I indicates that although larvae are transported to the area, insufficient POC must be present in the water column to sustain resident adult populations in the area. The relatively low concentrations of organic carbon in the bottom sediments of stations in Groups I, as compared to Group II, suggests a net lower flux of POC to the bottom in the region of the. Group I stations (Tables 7 and 8; Figs. 49, 55, and 78). In a latter section of this discussion, the relationship of the difference in flux of POC to the bottom in the above two regions is considered as it relates to regional variation in benthic biomass in our study area.

Our conclusions relative to substrate types and associated benthic macrofauna for the northeast Chukchi Sea are generally in agreement with the preliminary findings of Phillips et *al.* (1985) for selected sites extending from Icy Cape to Point Franklin. Differences, in the faunal components described by Phillips *et al.* (1985) and our work are probably related to differences in sampling gear utilized by the two projects.

C. Additional Factors Determining Taxonomic Composition of Benthic Groups

There are obviously a number of other factors, in addition to the sediment properties discussed above, that determine the taxonomic composition of benthic assemblages. Some of the factors that might be important in our study area are water" mass distributions, local eddies and gyres, intensified wave/current action during occasional storms, presence of and extent of polynyas, sediment accumulation rates, intensity of ice gouging on the bottom, the southern boundary of the pack ice in summer, disturbance of the sea bottom by the feeding activities of walruses and gray whales, and the *quantity as well as* nutritional quality of POC flux to the bottom.

At present, limited data makes it impossible to quantitativeiy assess the relationships between the above-cited factors and the distributional patterns, as well as biomass, of benthic species present in the northeast Chukchi Sea. Nevertheless, it is possible to speculate about the role of some of these factors on the benthos in our study area, based on a number of descriptive reports and papers (e.g., Barnes, 1972; Phillips *et* al., 1985; Arctic Ocean Science Board, 1988; and some of the data collected in our study). In this section we discuss water mass origins, the regional variations in sediment accumulation rates, intensity of ice-gouging, and presence of polynyas on the benthic community composition. The remaining factors will be considered in the section to follow.

The origin of water masses and their temperature/salinity regimes often explain the distribution of benthic invertebrates. The temperature and salinity values characterizing a particular water mass are often associated with identifiable assemblages (groups) of benthic species (e.g., see Stewart et *al.*, 1985; Grebmeier *et* al., 1988: also see Discussion, page 223, of this report relative to biomass distribution and its relationship to mixed Bering Sea water). The movement of water masses leads to dispersal of species by planktonic larval stages, which affects the distribution of such organisms (Thorson, 1957). The species found at our offshore Station Groups I and II are generally those characteristic of the cold, relatively high salinity, muddy bottom under the Chukchi Resident Water and the Bering Water north of Bering Strait. Alternatively, many of the benthic species of inshore Station Groups III (southern portion of the group) and IV are those generally characteristic of the somewhat warmer, lower salinity, sandy-gravel bottom under Alaska Coastal Water. Additionally, substrate typically affects small-scale distributions of species through choice of particular substrate types at the larval settlement stage (Wilson, 1953) and through adult substrate requirements. Thus, cyprid larvae of the barnacle *Balanus crenatus* were transported by ocean currents to inshore and offshore regions of our study area where they settled whenever a suitable substrate was available. However, only the inshore waters provided the requirements for adult survival and adult barnacles only occurred inshore. As another example, the tube-dwelling amphipods of the family Ampeliscidae occur in high abundance offshore on the sandy bottom of the northeastern Bering Sea under the cold, nutrient-rich Bering Shelf-Anadyr Water (Grebmeier, 1987). However, these amphipods only occur in abundance on the sandy substratum inshore in the northeastern Chukchi Sea north of 70030′, where mixed Bering Water (Bering Shelf-Anadyr Water) approaches the coast and presumably supplies POC to the crustaceans there as well (see Discussion, pages 223-224).

The influence of varying sediment accumulation rates on benthic community composition, feeding habits, and benthic motility has been widely demonstrated (refer to Feder and Jewett, 1987, 1988, for reviews emphasizing some Alaskan benthic biological systems). Based on high-resolution seismic profiles collected by Phillips et *al.* (1985) and by the present project (unpublished data), ^{210}Pb geochronology and the east-west lithological facies changes (Fig. 3; Phillips *et* al'., 1'985), it appears that the northeast Chukchi Sea can be divided into two broad areas with markedly different sedimentation rates. The inshore area up to 70 km offshore, and a few shallow-water offshore areas adjacent to Hanna Shoal (Fig, 6), are presumably regions of relatively low or no deposition. This is reflected inshore by presence of rock outcrops and a thin blanket of lag gravel and sandy deposits, as shown by the monographs, and in the lack of a net iinear exponential decay in excess ^{210}Pb activities of sediment cores. Such a substratum is consistent with the high energy hydrodynamic conditions prevailing there (Phillips *et al.*, 1985). In contrast, the far offshore area is a region with a net sediment accumulation, varying from 0.16 to 0.26 cm/yr (Table 10), suggesting sediment deposition under lower energy hydrodynamic environments than inshore. These broad regional variations in sediment accumulation rates complement our earlier conclusions relating to benthic biological distributional patterns based on sediment properties. The macrobenthic inshore Groups III and IV of our studies occur in regions characterized by very low sediment accumulation. These groups, unlike offshore Groups I and 11 that are dominated by deposit feeders, consist primarily of suspension feeders (Tables 20 and 22a).

Ice scouring of the sea floor disrupts and modifies the sea bed over much of the ice-stressed continental shelf of the Alaskan arctic, affecting the sediments and their associated fauna (Barnes and Reimnitz, 1974; Carey et al., 1974; Grantz *et al.,* 1982; Barnes *et al.*, 1984; Phillips *et al.*, 1985). In the Beaufort Sea, ice gouging results in lowered benthic abundance and biomass values in the inner to middle shelf and patchiness in benthic abundance along certain isobaths (Carey *et al.*, 1974; Feder and Schamel, 1976). A comparison of the benthic abundance and biomass values between the northeast Chukchi and Beaufort Sea shelf areas (Carey et *al.*, 1974, and data in this report) indicates regional differences. Generally speaking, in contrast to the shelf areas of the Beaufort Sea, the abundance and biomass values are higher on the northeastern Chukchi shelf, inclusive of the inner and midshelf areas (Appendix IV). Further, in the vicinity of Point Franklin in the northeastern Chukchi Sea (Figs. 63, 67, and, 68; Appendix Tables IV.1-IV.3), there are high abundance and biomass values inshore. We suggest that one of the reasons for the variations of the benthos between the Beaufort and northeast Chukchi Seas may be the decreased annual ice cover in the Chukchi region (Grantz et al., 1982). Consequently, it is expected that "the activity and the effects of sea ice on the Beaufort shelf to the northeast are more intense and pervasive in a general way than the Chukchi shelf" (Grantz *et al.*, 1982).

Polynyas are described for coastal shelf areas of the northeastern Chukchi Sea (Stringer, 1982), but not for the western Beaufort Sea. The local importance of the Chukchi polynyas to the marine ecosystem is not known (Arctic Ocean Science Board, 1988), but they do represent regions where ice is periodically excluded in winter. It is to be expected that ice gouging would be markedly reduced during such periods. This may explain, in part, the generally reduced affect of ice on the benthic fauna in the northeast Chukchi Sea in contrast to the marked reduction in this fauna inshore in the Beaufort Sea. As will be discussed below, increased benthic biomass values under some of the northern polynyas may also be a reflection of the increased input of POC generated locally within the polynyas (Arctic Ocean Science Board, 1988) to supplement advected sources of carbon.

D. Factors Affecting Benthic Abundance, Diversity, and Biomass

The dominant benthic organisms in the' northeastern Chukchi Sea were polychaetous annelids, bivalve mollusks, and amphipods (particularly tube-dwelling ampeliscid amphipods). Mean abundance values recorded in the present study for offshore station groups were generally lower than those reported by Grebmeier *et al.* (1989) for the southeastern Chukchi Sea.

Howevet-, the mean abundance value for the northeastern inshore stations of Group 111 delineated in our study (Figs. 63 and 78; Table 21a) was considerably higher than that for the inshore group described by Grebmeier *et al.* (1989) for the southeastern Chukchi Sea. Some of the high abundance and biomass values noted in our study occurred close to the coast north of Icy Cape to point Franklin, where the fauna was dominated by amphipods (inclusive of ampeliscids), a major food resource for gray whales (Nerini, 1984). Point Franklin has been identified as an area where these whales congregate and feed in summer ('Phillips *et al.*, 1985; Moore *et al.*, 1986 a,b). In contrast, stations in our inshore Group IV, adjacent to Icy Cape under Alaska Coastal Water (ACW), had low macrobenthic abundance values similar to those reported by Grebmeier *et al.* (1989) for coastal stations in the southeastern Chukchi Sea. Feeding aggregates of gray whales do not occur within our Group IV area.

High Shannon diversity and low Simpson (a dominance index) indices and high evemess values generally occurred within offshore Station Groups I and II, both primarily muddy areas. These latter two groups typically consisted of stations with a diverse fauna with no particular species dominating. On the other hand, specific taxa dominated inshore Groups III and IV, both sandy-gravel areas. In particular, juvenile barnacles and amphipods dominated Group III while cockles and sand dollars dominated Group IV. Dominance by a few taxa in the latter groups was reflected by relatively low Shannon, high Simpson, and low evenness values (Tables 13 and 21b).

In the context of sediment sorting, there was an important difference between the distributional patterns of the benthos in the southeastern and northeastern Chukchi Sea and the adjacent northeastern Bering Sea shelf. Grebmeier (1987) related diversity and evenness values in the northeastern

Bering Sea to sediment heterogeneity. She reported highest diversity values at nearshore stations where sediments were poorly sorted and lowest diversity values offshore where sediments were relatively well sorted. However, in the southeastern Chukchi Sea, she indicated that diversity increased offshore where more heterogeneous sediments, as reflected by poorer sorting, occurred. Our studies demonstrate that all sediments in the northeastern Chukchi Sea, both close to shore and further offshore, are very poorly to extremely poorly sorted. Consequently, differences in benthic faunal diversity between inshore and further offshore regions in the northeastern Chukchi are probably not solely related to differences in sediment sorting. Other environmental factors that could have influenced the benthic diversity in the northeastern Chukchi Sea are assessed below.

Some of the sea bed of the outer shelf of the northeastern Chukchi Sea consists of erosional lag gravels either of contemporary (Phillips, 1987) or relict origin (McManus *et al.*, 1969). These few offshore regions, consisting of poorly sorted gravely sediments, support abundant epifauna composed of anemones, soft corals, barnacles, bryozoans, basket stars and tunicates (also see Table 25). However, adjacent to these gravel fields, the sea floor contains a blanket of mud at least 60 cm thick (Phillips, 1987), reflecting sediment deposition under relatively low energy hydrodynamic conditions. Large numbers of motile infauna (up to 75% of the total abundance) are common at stations within this mud-rich area. Intense sediment reworking by bioturbation characterizes the shallow subsurface of these muddy regions, as reflected by the numerous biological tracks covering the sea floor surface and the mottling structure depicted in box-core samples (Phillips, 1987). Thus, benthic biological processes appear to dominate over the physical processes of waves, currents, and ice-gouging in the muddy offshore areas.

As mentioned above, some of the shelf gravels are contemporary lag deposits. The northward flowing ACW intensively reworks the sea floor sediments out to approximately 70 km from the eastern shore to water depths of about 30 m (Phillips, 1987), winnowing out fine particles. The inshore sediments, underlying the ACW north of Icy Cape, consist of lag gravels and sand that support benthic communities with high abundance values. The continuous disturbance of the bottom of these inshore waters by the combined action of local eddies and gyres, ice gouging, intensified wave/current action during occasional storms, and feeding activities of gray whales and walrus (Barnes, 1972; Phillips and Reiss, 1985a, b) results in a stressful environment with benthic populations of low Shannon diversity, low evenness, and high Simpson dominance values. Thus, opportunistic species characteristic of disturbed environments, e.g., ampeliscid amphipods (Oliver and Slattery, 1985), are dominant on the bottom inshore north of Icy Cape in the northeastern Chukchi Sea. Vertical sediment reworking by the bottom-feeding gray whales and walruses transfers particulate organic carbon (POC) derived from subsurface sediments onto the sea-floor surface. Such a process is described for the adjacent northeastern Bering Sea following gray whale bottom-feeding disturbance (Oliver and Slattery, 1985). The utilizable POC, derived from sediment reworking, would supplement the primary settling POC as a food source and would, therefore, enhance the success of fast-growing, opportunistic benthic species (see Boesch and Rosenberg, 1981; Jones and Candy, 1981; Poiner and Kennedy, 1984; Thistle, 1981, for reviews on this process).

In our studies, high biomass values were particularly obvious at most coastal and offshore stations north of 70°30′ latitude. as well as offshore Station 40 (Figs. 67 and 68). Previous work on the benthos in the adjacent northeastern Bering and southeastern Chukchi Seas (Grebmeier, 1987; Grebmeier *et al.*, 1988) demonstrated 'significantly higher benthic biomass (gC/m^2) values to the west of an oceanic front located between the nutrient-rich Bering Shelf-Anadyr Water (BSAW) and the relatively nutrient-poor Alaska Coastal Water (ACW). The BSAW has been demonstrated to be highly productive (Grebmeier et al., 1988; ISHTAR, unpubl. progress reports). Grebmeier *et al.* (1988) suggest that the high primary production of this water mass produces a persistent and nutritionally adequate food supply to the benthos. This frontal system (delineated by bottom salinity varying from 32.4-32.7 $^{o}/oo$) has not been identified within the northern Chukchi Sea, although the northward flow of the mixed BSAW after it passes through the Bering Strait (now called Bering Water by Coachman *et al.*, 1975) has been traced as it moves toward Point Barrow (Spaulding et *al.*, 1987). Analysis of hydrographic data collected by our project suggests that modified Bering Water approaches the Alaska coast north of Icy Cape. It is hypothesized that the carbon rich waters identified in the southeastern Chukchi Sea (i.e., the mixed BSAW or Bering Water, as modified by mixing in the central Chukchi; Grebmeier et *al.*, 1988) also extend into the northern Chukchi and the Alaska coast north of 70°30' latitude and supply a rich and persistent food source to the benthos that supplements resident POC. Net northward transport of water into the northeast Chukchi Sea is supported by the work of Naidu *et al.* (1981) and Naidu and Mowatt (1983) based on clay mineral distribution patterns. Their studies imply that the central and northeast Chukchi Seas are major depositional sites of the clays derived from the northeastern Bering Sea. St is assumed that all clay-sized particles, including associated bound organics and discrete POC, have similar transport pathways in the sea. The reasons for this are that both clay-sized inorganic and organic particles have similar hydraulic equivalents, and are therefore co-deposited (Trask, 1939) and that clays generally serve as a preferential binder for organics (Weston, 1988). In the present study, the highest biomass values occurred in the region approximately north and northwest of the 32.4 ‘/o. isohaline and the 0.0° isotherm ($\bar{X}$ = 10.2 gC/m^2 north of the front; $\bar{X}$ = 5.0 gC/m^2 south of the front) (Table 14; Figs. 67 and 68). Similarly, an examination of Stoker’s (1978) carbon values at stations in the northeastern Chukchi Sea revealed that carbon biomass was significantly greater (P=0.01) at northern stations (N=8) than at southern stations (N=4). Stepwise multiple discriminant analysis of our benthic biomass data demonstrates a separation of the north/northwestern region from the south/southeastern region by the higher bottom salinities and lower bottom-water temperatures present in the former region. Values for the latter two physical parameters in the northern region were similar to those identified offshore further south in the southeastern Chukchi Sea which suggests that modified Bering Water and the associated hydrographic front extends from south to north in the Alaskan Chukchi Sea.

Perhaps there are additional factors contributing to the high biomass north of 70030′ latitude in our study area. Periodic upwelling in the nearshore zone from Icy Cape to Point Barrow is reported (see Physical Oceanography section and Johnson, 1989). This process could locally enhance annual primary production, and increase the POC flux (as phytoplankton and zooplankton) to the bottom in this region. However, annual primary production north of 70°301 latitude, on-a regional scale, is reported as a modest 25-100 gC/m^2 (Parrish, 1987). It is possible that the annual water-column production is locally increased inshore within polynyas (Arctic Ocean Science Board, 1988). Further, the ice-edge region, which may extend as far south as Icy Cape in the summer, may also contribute considerably to total water-column productivity (Niebauer and Alexander, unpubl.). Additionally, carbon production by under-ice (epontic) algae in late spring is estimated as 13 $gC/m^2/yr$ (Parrish, 1987). Presumably flux of phytoplankton and epontic algal debris to the bottom is enhanced by reduced grazing pressures by zooplankton in these northern waters, similar to the situation described by Cooney and Coyle (1982) and Walsh and McRoy (1986) for the shallow inner and middle shelf of the southeastern Bering Sea. Additionally, the flux to the bottom of dead and dying zooplankters advected from more southerly waters might also be expected to enrich the benthic environment, resulting in enhanced benthic standing stocks. The increased plankton volumes from inshore to offshore and from south to north from Bering Strait to Icy Cape (English, 1966) seem to support the suggestion that zooplankters are advected northward by the water currents. Particulate organic matter enrichment of the bottom must, in fact, persist on a long-term basis in the northern margin of the northeastern Chukchi Sea, for the various reasons discussed above. This contention is supported by the local presence of a relatively higher content of organic carbon and nitrogen in the sediment and the continued return in summer of gray whales (Moore and Clarke, 1986; Clarke et *al.*, 1987) and walrus (Fay, 1982; person. commun.) to regions north of 70°30′ to feed.

The high benthic biomass that we observed for inshore waters north of Icy Cape is not typical of the inshore benthos under Alaska Coastal Water south of the Cape (this study; Grebmeier *et* al., 1988). The latter point to some extent supports our hypothesis that the advection of POC, presumably from the southeastern Chukchi Sea, via Bering Strait into these northern coastal regions, is important.

Throughout the entire study area, benthic interface feeders (surface deposit feeder + suspension feeders) generally dominate over subsurface deposit feeders (Figs. 71 and 73). This reflects the general importance of nutritionally adequate POC in the water column and its flux to the sediment surface where most of it is consumed by the interface feeders. Consequently, little POC apparently remains for incorporation into the bottom sediments for use by subsurface deposit feeders.

E. Biomass, Production, and Carbon Requirements of the Benthos

Thomson (1982) noted that the mean biomass (wet weight) generally decreased from Newfoundland (1455 g/m^2) through the Arctic Islands (200-438 g/m^2) to the Beaufort Sea (41 g/m^2: Carey, 1977), and he suggested that this trend appeared to parallel a trend in decreasing primary production. On the subarctic Alaska shelf, a relationship between biomass and primary productivity has also been documented. In the southeastern Bering Sea where primary productivity is 166 $gC/m^2/yr$ (Walsh and McRoy, 1986), benthic biomass in the mid-shelf region is 330 g/#. In the northeastern Bering Sea and Bering Strait, with primary production values of 250-300 $gC/m^2/yr$ (Sambrotto *et al.*, 1984; Springer, 1988; Walsh *et al.*, 1988), the benthic biomass offshore under Bering Shelf-Anadyr Water (BSAW) is reported as 482-1593 g/m^2 (Stoker, 1978; Feder et *al.*, 1985; Grebmeier, 1987). A wide, but lower, range of benthic biomass (55-482 g/m^2) occurs inshore under Alaska Coastal Water (ACW) in the northeastern Bering and southeastern Chukchi Seas where primary productivity is estimated at 50 $gC/m^2/yr$ (Sambrotto *et al.*, 1984; Springer, 1988; Walsh *et al.*, 1988. South of 70°30' north latitude, in the northeastern Chukchi Sea under ACW, a relatively low mean benthic biomass was determined (139 ± 79 g/m^2) (Table 14; Fig. 67). However, north of 70°30' latitude (for our offshore as well as inshore stations), relatively high values for benthic biomass were determined (258 ± 136 g/m^2), although primary productivity values for that area are only estimated to be 50-100 gC/m^2 (Parrish, 1987). Thus, the relatively high benthic biomass in the northeastern Chukchi Sea north of 70°30' appears to be an exception to the relationships referred to above, i.e., a direct relationship between benthic standing stock and primary production. Consequently, our biomass data reinforces the earlier conclusion that some source of POC, in addition to local primary production, is fluxing to the bottom in our study area. It is likely that this supplemental POC sustains the higher biomass in the northeastern Chukchi Sea in contrast to the lower values reported for the contiguous Beaufort Sea by Carey (1977).

The estimated mean benthic production value (5.9 gC/m^2/yr) for the region north of the oceanic front in the northeastern Chukchi Sea (Table 14; Fig. 69), as suggested above, is significantly greater ($P=0.009$) than that for the benthos south of this region (3.4 gC/m^2/yr). The higher benthic production in the northern region apparently sustains the seasonal predation by walruses and small populations of gray whales in parts of that area. Generally speaking, it would be expected that the numbers of walruses and gray whales present are related to the level of benthic production, providing of course that a large proportion of that production is utilizable as food by these marine mammals. In the case of the northeastern Chukchi Sea in the vicinity of Peard Bay, it appears that there is a disproportionate number of marine mammals present there, as compared to the northeastern Bering Sea, based on the differences in production in the two areas. Illustrating this point are the similar densities of gray whales in the central northeastern Bering Sea and coastal northeastern Chukchi Sea (Ljungblad, 1987), even though benthic production is different within the two regions. The estimated mean production value for the central northeastern Bering Sea is an estimated 13,7 $gC/m^2/yr$ <calculated from biomass data of Grebmeier, 1987), while that of the northeastern Chukchi is estimated at 5.9 $gC/m^2/yr$. The apparent discrepancy (i.e., similar gray whale densities in both areas but lower apparent production to the north) may be related to the reduced predation by bottom-feeding crabs and fishes in the northeastern Chukchi Sea (Naidu and Sharma, 1972} compared to the northeastern Bering Sea (Jewett and Feder, 1981) in conjunction with reduced feeding activities in late summer for these mammals in the northern waters (Clarke *et al.*, 1987).

Four stations (CH34-37) south of the front and just north of Cape Lisburne are located beneath a clockwise oceanic gyre (W. J. Stringer, person. commun.) and have relatively high benthic biomass values (Figs. 62, 67, and 68). Estimated production at these stations is similar (i.e., a mean value of 5.9 $gC/m^2/yr$) to that of the stations north of the front discussed above. Alternatively, all of the other stations north of Cape Lisburne and south of the front had relatively low benthic biomass values with a mean production of only 2.5 $gC/m^2/yr$. Presumably, a continued flux of carbon to the bottom under the gyre enriches the bottom and results in an enhanced carbon biomass and production at the four stations.

The short sampling time (i.e., a single cruise 22 August - 1 September 1986) makes it impossible to calculate a carbon budget for the study area. However, the multiple sources of autochthonous and allochthonous carbon available to the benthos in the northern portion of our study area and the presumed reduction in water-column grazing in this region (see comments on pages 38 and 40-41 of this report) 'suggests that the carbon requirements calculated for the benthos (Table 12) are reasonable. Additional sediment trap data and benthic respiration measurements are needed to substantiate our calculations and tentative conclusions.

F. The Relationship of Stable Carbon Isotopic Ratios, OC/N Values, and Macrobenthic Biomass

The distributional patterns of the stable carbon isotopic ratios ($\delta^{13}C$) clearly show that the nearshore areas, compared to offshore regions, are characterized by relatively lighter isotopic ratios (Fig. 52). This can be explained in the context of a model consisting of two-end-member sources of organic carbon to sediments, terrigenous and marine. This conclusion is substantiated by a general seaward decrease from the coast in OC/N values of bottom sediments (Fig. 51) and in the particulate collected in sediment traps (Table 8).

As discussed earlier, the abundance and biomass of macrobenthic animals in our study area can be related to a number of environmental factors. These factors include sediment characteristics, water mass origin, intensity of waves, currents, ice gouging, and feeding activities of marine mammals, as well as the amount and nutritional values of organic matter fluxing to and accumulating on the bottom. In attempting to assess the nutritional value of organic carbon in sediments, the $\delta^{13}C$ values were compared with benthic biomass and abundance values. It was assumed that carbon in sediments with relatively lighter isotopic ratios relate to terrigenous organic matter with large proportions of refractory organics, and thus, of low nutritional value. Likewise, it was assumed that carbon in sediments with heavier isotopic ratios reflect association with marine-derived organics which are generally more readily utilized by benthic organisms, and are, thus, of high nutritional value. Analyses of similar data from the southeastern Chukchi Sea nave shown that no significant correlations exist between $\delta^{13}C$ or OC/N and macrobenthic abundance or biomass (Research Unit 690 data not included in this report). The lack of correlations suggests that the nature of organic matter, as reflected by $\delta^{13}C$ and OC/N of the sediments) is not the sole factor controlling macrobenthic abundance and biomass in the northeastern Chukchi Sea. As discussed earlier, apparently sediment texture, water content of sediments, and the amount of organic matter fluxing to the bottom, some of which may be highly site-specific, are the predominant factors determining benthic abundance and biomass.

G. The Importance of Epibenthic Invertebrates and Demersal Fishes

Demersal trawling for invertebrates and fishes was conducted at ten stations in the Barrow Arch in August/September 1977 (Frost and Lowry, 1983). Ten fishes representing six families were caught. The most abundant and frequently caught fishes were the arctic cod (*Boreogadus saida*). The hamecon (Cottidae:*Artediellus scaber*) and the fish doctor (Zoarcidae: *Gymnelis viridis*) followed in abundance and frequency of occurrence. A total of 166 invertebrate species or species groups were found, including 38 gastropod, 26 amphipods, 20 bivalve molluscs, 14 shrimps, and 11 echinoderms. Echinoderms were the most abundant invertebrate group. These included six species of sea stars, three sea cucumbers, one sea urchin, and one brittle star. The brittle star, *Ophiura sarsi*, was the most abundant echinoderm. The most frequently caught gastropod were *Margaritas costalis, Natica clausa, Buccinum polare,* and *Polinices pallida*. These gastropod occurred in nine, eight, six and five of the ten stations, respectively.

Dominant species collected in the present study were somewhat similar to those collected by Frost and Lowry (1983). However, their collections included only a few Tanner crab (*Chionoecetes opilio*), an abundant epibenthic component of trawl catches at most of our stations. Generally, the dominant species collected in both studies reflected the type of bottom characterizing the trawled area. Further, knowing that the substrate consisted of mud, sand, or sand-gravel indicates the type of hydrodynamic conditions present on the bottom. Data available from the qualitative studies summarized above identify the need for an extensive, quantitative investigation of the epibenthos and demersal fishes of the northeastern Chukchi Sea.

The collections of brittle stars, *O. sarsi*, resulting from our trawl studies consisted primarily of large specimens (mean disc diameter = 22 mm), suggesting the presence of an abundant, nutritionally adequate source of food for these organisms. The brittle stars were feeding heavily on bivalve molluscs, gastropod, small crustaceans, and barnacle cyprid larvae. In a Danish fjord, a related species, *O. ophiura* (= *O. texturata*) fed mainly on juvenile bivalves and were more successful than members of the species living outside the fjord, where bivalves were rarely available as food (Feder, 1981; Feder and Pearson, 1988). *Ophiura sarsi* living in Cook Inlet, an embayment of the northern Gulf of Alaska, were smaller (mean disc diameter = 13 mm) than individuals living in the northeastern Chukchi Sea and were feeding primarily as scavengers (Feder et *al.*, 1981).

Although the northeastern Chukchi Sea approaches the northern limits of the range of the Tanner crab, *Chionoecetes opilio* (Jewett, 1981), the crab did occur at seven of the ten trawl stations occupied for our investigation. However, adult crabs were primarily found in the southern part of the study region while juveniles dominated catches in the more northern stations. Food appeared to be adequate to sustain these crabs to the adult stage in the northern portion of the study area (also see reviews on feeding habits for the Tanner crab in Alaskan waters in Feder and Jewett, 1981, 1987); thus, other factors must prevent survival of juveniles to adults. Possibly, low bottom temperatures decrease growth rates and make juveniles more vulnerable to predation. Relative to this point, the Tanner crab represents one of the most important forage species for bearded seal (*Erignathus barbatus*) in northern Alaskan waters, including the northeastern Chukchi Sea (Lowry *et al.*, 1980). Predation pressure by this mammal may be responsible for the low population levels of the Tanner crab. Consequently, as suggested previously, the Tanner crab does not appear to represent an important competitor for food used by walruses and gray whales in the northern sector of the northeastern Chukchi Sea.

H. Important Feeding Areas of Gray Whales and Pacific Walruses

1. Whales

A portion of the gray whale (*Eschrichtius robustus*) population annually migrates to the eastern Chukchi Sea in summer (Moore *et al.*, 1986a), passing through Bering Strait before mid-June (Braham, 1984). They are not typically associated with ice, and, in fact, the main movements into the Chukchi Sea occur after the pack ice has retreated northward. Approximately 1,650 gray whales were estimated to occur in the nearshore waters of the eastern Chukchi Sea in 1981 (Davis and Thomson, 1984). Few gray whales penetrate into the Beaufort Sea (Moore and Ljungblad, 1984).

The annual distribution, abundance, habitat preference and behavior of gray whales along the eastern Chukchi Sea were investigated via aerial surveys during July 1980-83 (Moore *et al.*, 1986a). Similar investigations were made in the northeastern Chukchi Sea during mid-July through late October 1982-86 (Clarke *et* al., 1987). Gray whales were distributed from south of Point Hope to north of Point Barrow, between 0.5 and 166 km offshore (Clarke *et al.*, 1987). Most sightings in 1982-84 were made between Icy Cape and Point Barrow at an average distance from shore and depth of 14.5±18.9 km and 20.5±9.9 m, respectively (Moore *et al.*, 1986b).

Monthly abundance estimates were highest in July and lowest in October, with the highest estimates calculated for the area north of 70°N from July through September, and for the Point Hope area in October (Clarke et *al.*, 1987). Annual variation of whale sightings has been high. The coastal Chukchi Sea south of Point Hope to Point Barrow supported relatively high whale densities (1.48 whales/km^2) in 1982, but relatively low densities were observed there in 1980, 1981 and 1983, i.e., 0.26, 0.28 and 0.37 whales/km^2, (Moore et *al.*, 1986a).

Annual differences in the gross annual recruitment rate of calves by region reflects a partial segregation of cow-calf groups in the northeastern Chukchi Sea (Moore *et al.*, 1986a). This northern range may be a possible weaning area for cow-calf pairs (Clarke *et al.*, 1987).

Monographs, television, and bottom photographs collected during reconnaissance surveys in the northeast Chukchi Sea in 1984 and 1985 identified scattered to dense benthic feeding traces on the sea floor from gray whales as well as walruses (Phillips and Colgan, 1987). The highest concentration of gray whale feeding traces were found at depths of 23 to 34 m on the inner shelf between Wainwright and Point Franklin where the Alaskan Coastal Current actively transports sediment and associated detrital particles.

Ljungblad (1987) noted that gray whale distribution and highest densities correspond to areas where dense prey assemblages have been documented. Both Chirikov Basin, in the north central Bering Sea, and coastal Saint Lawrence Island have been described as primary feeding areas for gray whales (Rice and Wolman, 1971; Zimushko and Ivashin, 1979; Bogoslovskaya *et al.*, 1981: all cited in Ljungblad, 1987). Dense assemblages of benthic amphipods dominate the benthic biota and the food of gray whales in these regions (Stoker, 1981; Nerini and Oliver, 1983; Thomson and Martin, 1984; Nerini, 1984; Oliver *et al.*, 1984). Analysis of stomach contents of gray whales taken by whalers along the northern Chukchi Peninsula revealed that three genera of amphipods, in particular *Ampelisca*, *Anonyx*, and *Pontoporeia*, were preferred prey, although there was usually a variety of prey species in the stomachs (Blokhin and Pavlyuchkov, 1983, as cited in Moore *et al.*, 1986b).

Thomson and Martin (1984) estimated that gray whales consume approximately 4% of the overall annual productivity of benthic amphipods, their principal prey in the Chirikov Basin. They further concluded that this level is sustainable by the prey populations there (Thomson and Martin, 1984). Recent investigations by Highsmith and Coyle (pers. commun.) have shown that gray whales within the Chirikov Basin are consuming amphipods at a rate approximating that of Thomson and Martin (1984).

Observations made in the northern Chukchi Sea between 1982 and 1986 revealed that most gray whale were feeding (59%), as indicated by mud plumes with whale sightings (Clarke *et al.*, 1987). Ljungblad (1987) noted that whales feeding on epibenthic animals probably do not create the mud plumes characteristic of whales foraging for infaunal species, thus their feeding may go unrecognized by aerial observers. As in other regions, benthic amphipods were assumed to be the principal prey group taken in the northern region, although Nerini (1984) also pointed out that gray whales exhibited a high degree of dietary flexibility and could be termed food “generalists.”

As suggested previously, the high benthic biomass and production values north of 70°30' in the northeastern Chukchi Sea, as determined by our studies, presumably sustain seasonal predation by the small inshore population of gray whales present.

An understanding of the extent and distribution of prime feeding habitat for gray whales in the northern Chukchi Sea is strengthened through macrofaunal sampling on whale feeding grounds. The infaunal sampling conducted by Stoker (1981) occurred seaward of the coastal regions typically used by gray whales. However, our study included 12 stations (CH4-8, 17-19, 31, 33, 43, and 44: Fig. 62) between Point Hope and Point Barrow within 50 km of the shore at an average depth of 27.3 ± 8.9 m where most sightings have occurred (Clarke *et al.*, 1987). Only four of these stations (CH5, 6, 7, and 17: Figs. 62 and 66) had high concentrations of amphipods ($\bar{X}=4,319 \pm 1,987$ amphipods/m^2), especially the families Isaeidae, Ampeliscidae, and Atylidae. Amphipod abundance values were also relatively high at stations CH10 and CH16, but both of these stations are located approximately 80 km offshore.

Amphipod abundance values at Stations CH5, 6, 7, and 17 (Table 28) were similar to those reported for the gray whale feeding grounds in the Chirikov Basin in the northern Bering Sea ($\bar{X}=5,086 \pm 5,907$ amphipods/m^2). However, the values at Stations CH5, 6, 7, and 17 were much lower than those reported for the gray whale feeding grounds off Southeast Cape, St. Lawrence Island in the northern Bering Sea ($\bar{X}=107,873+57,192/m^2$) (Thomson and Martin, 1984). Although the large ampeliscids are typically taken by gray whales, smaller amphipods (e.g., Isaeidae and Atylidae), as well as other benthic invertebrates, are also taken by these opportunistic feeders (Oliver *et al.*, 1983; Nerini, 1984). Presumably other epifaunal and infaunal prey are also taken to supplement their diet when they occur in the northern Chukchi Sea. The seemingly reduced quantity of benthic amphipods on the northern limit of the gray whales' range supports the observation made by Clarke *et al.* (1987), i.e., the northeastern Chukchi Sea is an important summering area for gray whales from July through October, principally as a peripheral feeding ground and possibly a weaning area for cow-calf pairs.

2. Walrus

Most of the Pacific walrus (*Odobenus rosmerus*) population, including adult females and calves and subadults of both sexes, summer in the Chukchi Sea mainly residing along the southern edge of the pack ice. The migrants move north with the receding ice typically reaching the Chukchi Sea by the end of June (Fay, 1982). The population mainly inhabits the northern Chukchi Sea north of Point Lay to east of Point Barrow to Wrangel Island. Their distribution is determined to a great extent by winds and ice conditions and varies from year to year. By using the moving ice, walruses are continually transported to new feeding grounds while they rest. By staying with the ice, they are able to exploit the benthic resources of nearly the entire shelf. As ice formation begins in the fall, walruses move southward, some swimming well ahead of the advancing ice. Solitary animals occasionally overwinter near Point Hope (Fay, 1982).

In September and October 1970, an area approximately 46 km northwest of Point Lay and another area north of Point Barrow had highest densities of walruses (Ingham *et al.*, 1972). A survey between Point Hope and the ice edge in September 1975 found walruses most abundant between 162° and 165°W longitude (Estes and Gol'tsev, 1984).

Reconnaissance surveys in the northeast Chukchi Sea in 1984 and 1985 identified scattered to dense benthic feeding traces on the sea floor from walruses in gravel and sand regions to depths of 53 m (Phillips and Colgan, 1987). Two areas of high concentrations of walrus feeding traces were identified as south of Hanna Shoal near the pack ice boundary and offshore between Icy Cape and Point Franklin.

The stomach contents of 44 walruses were examined in September 1987 from two areas approximately 50 km south of Hanna Shoal (Fig. 87; Area 1: 71°19′ to 71°38′ N lat., 163°20′ to 163°35′ W long.; Area 2: 71°12′ to 71°28′ N lat., 161°06′ to 161°44′ W long.) (F. Fay, pers. commun., 1988). These stomachs contained 36 prey taxa, with ten bivalve and nine gastropod taxa most numerous. Dominant prey, in order of decreasing biomass, were gastropod mollusks, the priapulid worm *Priapulus caudatus*, ampeliscid amphipods, the polychaete worm *Flabelligera* sp., bivalve mollusks, and the ascidian *Pelonaia corrugata* (Table 32). Stomachs of 11 males near Point Barrow in July and August 1952 and 1953 contained mainly siphons of the clam *Mya truncata* (Brooks, 1954, as cited in Fay, 1982). Also present were the holothurian *Molpadia arctica*, a priapulid worm, and three species of snails.

More than 60 genera of marine organisms, representing ten phyla, have been identified as prey of the Pacific walrus. Bivalve mollusks (clams, mussels, and cockles) have been found more often and in greater quantities than any other group of benthic invertebrates (Fay, 1982).

Information on the benthic invertebrate resources of the northeastern Chukchi Sea, in addition to what the walrus stomach analyses revealed, give insight into the relative productivity of this region. Stoker (1978, 1981) sampled the infaunal invertebrates with a van Veen grab at five stations south of Hanna Shoal during August and September 1973 and 1974 (Fig. 87). These stations were located in a region where walrus feeding is known to occur during open water in summer; the infaunal biomass at these stations

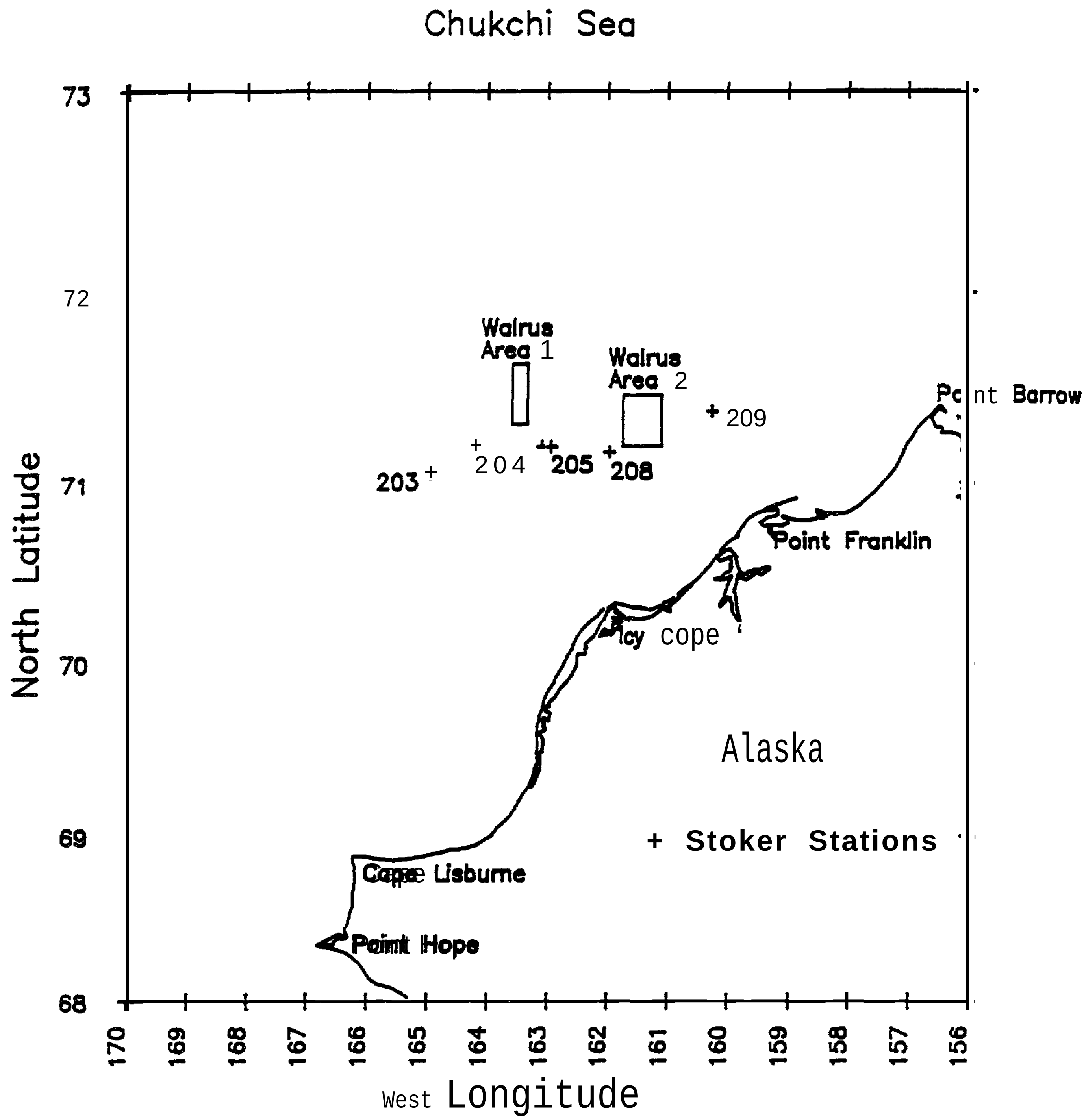

Figure 87. Locations where walruses were examined for stomach contents, September 1987 (Areas 1 and 2) (Fay, unpubl.) and where benthic sampling occurred in 1973-74 by Stoker (1978, 1981).

Table 32. Stomach contents from Pacific walrus collected in the northeastern Chukchi, September 1987 (F. Fay, pers. comm., 1988).

Area	1			2			Combined Areas		
Number of Stomachs	8			36			44		
	Percent								
	Number	Weight	Frequency	Number	Weight	Frequency	Number	Weight	Frequency
Polychaeta	12.7	16.7	63	3.2	1.6	44	5.1	3.8	48
Flabelligera sp.	12.4	16.6	50	3.2	1.6	36	5.0	3.7	39
Priapulus caudatus	6.5	7.7	100	7.1	8.9	78	8.1	8.7	82
Gastropoda	35.8	17.6	100	58.4	14.7	89	53.9	15.2	91
Naticidae	32.2	0	100	52.8	1.3	89	48.7	1.2	91
Pelecypoda	30.5	5.4	88	6.3	1.4	61	11.1	2.0	66
Tellinidae	24.0	3.0	75	4.4	0.3	42	8.3	0.7	48
Amphipoda	6.3	3.5	63	24.0	7.4	56	20.5	6.9	57
Pelonaia corrugata	7.1	6.7	50	0.1	0.1	22	1.5	1.0	27

averaged a relatively high value of 19.6 gC/m^2. 'The dominant macrofaunal groups in the five stations were bivalves, sipunculids, and polychaetes, making up 28, 25, and 24% of the carbon biomass, respectively (Table 33). The dominant bivalves were *Astarte* spp., *Macoma* spp., *Nucula* tenuis, and Mya *truncata*.

A group of stations sampled in the present study, i.e., the 14 stations in Station Group II (Fig. 78), encompassed most of the summer and fall habitat of walruses (Fay, 1982; Frost *et al.*, 1983). The average organic carbon value within the sediment at Group II stations was highest (8.7 mgC/g) of the four station cluster groups. Also, the benthic carbon biomass at this group of stations was a high 9.2 gC/m^2. The fauna was dominated by the bivalves *Macoma* Spp ., *Nucula bellotti (=tenuis)*, and *Astarte* spp., the sipunculid *Golfingia margaritacea*, and polychaete worms (Table 30).

Benthic samples were also taken in the present study in the area where extensive walrus feeding traces were observed offshore between Icy Cape and Point Franklin (Phillips and Colgan, 1987). Most stations within this area grouped together (Group 111) based on cluster analysis of the infaunal abundance data (Fig. 78). Few of the most abundant fauna were ones typically taken by walruses. However, bivalves and gastropod consisted of nearly 17% and 9% of the carbon biomass, respectively. Dominant bivalves were *Liocyma viridis*, *Astarte* borealis and *Yoldia myalis*. Dominant gastropods were *Natica clausa* and *Polinices pallida* (Table 31).

The feeding activity of gray whales and walruses may be a significant factor contributing to the high benthic productivity of the northeastern Chukchi Sea. Both excavate into the sediment suspending fines and recycling nutrients that would otherwise be trapped in the sediment. Furthermore,

Table 33. Dominant infaunal invertebrates from stations in the vicinity where Pacific walrus typically occur in the northeastern Chukchi Sea. Data from Stoker (1978, 1981).

Number of stations:	5
Average indiv./m^2	1127 ±535
Average gC/m^2	19.6 ±3.7

Dominant Groups	Average Indiv./m^2	%	Dominant Groups	Average gC/m^2	%
Polychaeta	553	49.1	Bivalvia	5.5	28.1
Bivalvia	210	18.6	Sipuncula	4.9	25.0
Ophiuroidae	177	15.7	Polychaeta	4.6	24.0

Dominant Taxa	Average Indiv./m^2	Dominant Taxa	Average gC/m^2
Maldane sarsi	322	*Golfingia margaritacea*	4.8
Ophiura sarsi	118	*Astarte* spp.	2.5
Nucula tenuis	67	*Psolus* Sp.	1.3
Macoma spp.	53	*Maldane sarsi*	1.1
Terebellides stroemi	45	*Macoma* spp.	1.0
Diamphiodia craterodmeta	42	*Nicomache lumbricalis*	0.5
Astarte spp.	38	*Flabelligera* sp.	0.4
Nicomache lumbricalis	20	*Terebellides* stroemi	0.4
Lumbrineris fragilis	18	*Nucula tenuis*	0.4
Golfingia margaritacea	17	Mya *truncata*	0.4
Yoldia hyperborea	13	*Pelonaia corrugata*	0.3

organic debris accumulates in the excavations, thereby attracting large numbers of animal colonizers (Oliver and Slattery, 1985).

Johnson and Nelson (1984) calculated that the volume of sediment injected into the water column by feeding gray whales in the northeastern Bering Sea is at least 1.2 x 10^9 m^3/yr, or over two times the yearly sediment load of the Yukon River. This figure may well approximate the volume of sediment liberated by both gray whales and walruses on their northern feeding grounds.

Additionally, the areas where gray whales and walruses feed in the northern Chukchi Sea are intensively gouged by ice (Grantz *et al.*, 1982). This mechanism, coupled with the the feeding activities of gray whales and walruses, which results in a tilling effect on the seabed, probably enhances benthic productivity of the region (Johnson and Nelson, 1984).

VII . CONCLUSIONS

Previous work in the northeastern Bering and southeastern Chukchi Seas identified an oceanic front between the relatively cold, nutrient-rich Bering Shelf-Anadyr Water (BSAW) or modified Bering Water and the relatively warm, nutrient-poor Alaska Coastal Water. The northward flow of the BSAW has been traced toward Point Barrow. Water mass analysis in our study indicates that generally the warm coastal water penetrates as far north as about 70°301 and that modified Bering Water approaches the coast north of Icy Cape. The Beaufort Sea water produces a tongue of colder and higher salinity water near the bottom of the Barrow Canyon. In the rest of the volume of the northeast Chukchi Sea, the Bering Sea-Anadyr water mass which flows northward through Bering Strait is the major water mass contribution. These water masses can be modified in their characteristics by winter ice formation, which tends to produce cold and salty deep and bottom waters and fresh near-surface layers. For both of the traditional T-S technique and the cluster analyses, the line separating the water mass groupings follows the temperature and bottom salinity contours. These water masses remain relatively distinct, with oceanic fronts between the masses. These fronts are maintained by the frontogenic forces of the mean currents, particularly the coastal current and the general northward flow resulting from the Bering Strait transport.

Temperature and salinity values characteristic of the water masses overlying the shelf of the northeastern Chukchi Sea were associated with identifiable assemblages of benthic species. The species collected at offshore Station Groups I and II (based on abundance values) were generally those characteristic of the cold, relatively high salinity bottom water under the modified BSAW which originates as a northward flow through Bering

Strait. Alternatively, many of the benthic species of inshore Groups III (primarily the southern portion of this region! and IV are those characteristic of the warmer, lower salinity bottom water of the Alaska Coastal Current. Previous work on the tube-dwelling amphipods of the family Ampeliscidae in the northeastern Bering Sea reported high abundance values for these crustaceans under the cold, nutrient-rich BSAW. However, in the northeastern Chukchi Sea these amphipods only occur in abundance inshore north of 70°30′ (within Station Group 111) where mixed Bering Water approaches the coast and apparently supplies a supplemental source of POC to the bottom where it is available to the crustaceans.

It is recognized that there are a number of other factors, in addition to water mass properties, that determine the taxonomic composition of benthic assemblages in the study area. However, because of the limited data available it is only possible at present to draw some tentative conclusions concerning the role of sedimentation rates, ice, and polynyas on benthic distribution patterns. It is suggested that the delineation (based on abundance values) of macrobenthic inshore Groups III and IV (consisting primarily of suspension feeders) from offshore Groups I and II (dominated by subsurface deposit feeders) is due to the relatively higher sediment accumulation rates in the offshore than in the inshore region. The broad regional variations in the sedimentation rates, as documented by us, are consistent with the net seaward decrease in wave energy conditions attended by greater sediment flux to the bottom during summer in the offshore region. The importance of fluidized muddy and POC-enriched sediments as an environment suitable for deposit-feeding organisms within offshore Groups I and II (but particularly Group 11) is indicated by the variety of subsurface deposit-feeding species present in these groups.

The distributional patterns of the stable carbon isotopic ratios ($\delta^{13}C$ ‰) of bottom sediments clearly show that the nearshore areas, compared to offshore regions, have relatively lighter isotopic ratios. This is explained in the context of a model consisting of two-end-member sources of organic carbon to sediments, terrigenous and marine, This conclusion is substantiated by a general seaward decrease from the coast in the OC/N values of bottom sediments and in the organic particulate collected in sediment traps. A lack of correlation between $\delta^{13}C$ or OC/N and macrobenthic abundance or biomass suggests that the nature of organic matter (e.g., relatively more labile or refractory), as reflected by $\delta^{13}C$ and OC/N of the sediments, is not the sole factor controlling macrobenthic abundance cr biomass in the study area. Apparently sediment texture and water content as well as the amount of organic matter fluxing to the bottom are the predominant factors determining benthic abundance and biomass.

The four macrobenthic station groups (based on abundance values) identified in the northeastern Chukchi Sea are best explained by discriminant analysis in terms of the percent gravel, sand, and mud in conjunction with OC/N values and percent water in the sediment. In general, Group I comprised a fauna associated with mud-sand-gravel with 20-40% water; dominant species consisted of the ampeliscid amphipod *Byblis gaimardi* and -juveniles of the barnacle *Balanus crenatus*. Group II consisted of fauna associated with a muddy substrate with 45-60% water content dominated by the tube-dwelling polychaete *Maldane glebifex* and the protobranch clam *Nucula bellotti*. Group III consisted of an assemblage associated with a sandy substrate containing 15-20% water, and characterized by juvenile and adult *B. crenatus* and amphipods (including the large *Ampelisca macrocephala*). Group IV consisted of an assemblage associated with a sandy-gravel substrate containing about 20% water, and dominated by the sand dollar *Echinarachnius parma*,

Previous work on the benthos in the southeastern Chukchi Sea demonstrated significantly higher biomass (gC/m^2) values to the west of an oceanic front located between the modified Bering Water and the ACW. High biomass values in our study were prevalent at most coastal and offshore stations north of 70°30′ latitude where modified Bering Water approaches the coast north of Icy Cape. We suggest that the carbon-rich waters identified in the southeastern Chukchi Sea (i.e., the mixed BSAW, as modified by mixing in the Chukchi Sea) also extend into the northern Chukchi and the coast north of 70°30′ and supply a rich and persistent food source to the benthos. The predominance (abundance and biomass) of surface deposit-feeding amphipods (including ampeliscids) in the northeastern section of Station Group III appears to reflect a region of unusual flux of POC to the bottom. Benthic amphipods are a major food resource for gray whales, and the presence of feeding populations of these whales in the vicinity of Point Franklin in the summer apparently represents a long-term response to an abundant and reliable food source.

In general, the dominant epibenthic invertebrates and fishes collected reflected the type of bottom characterizing the trawled area (data are only qualitative assessments obtained using a small otter trawl). The brittle star, *Ophiura sarsi*, was generally common and consisted primarily of large specimens which suggests the presence of an abundant, nutritionally adequate source of food. Adult Tanner crab, *Chionoecetes opilio*, occurred primarily in the southern part of the study region while juveniles dominated catches in the more northern stations. Food appeared to be adequate for these crabs in the northern portion of the study area, thus other factors must prevent survival of juvenile to adults. Possibly low bottom temperatures decrease growth rates and make juveniles more vulnerable to predation. Thus, the Tanner crab does not appear to be an important competitor for food used by walruses and gray whales in the northeastern Chukchi Sea.

A comparison of the benthic abundance and biomass values between the northeast Chukchi and adjacent Alaskan Beaufort Sea shelf areas indicates higher abundance and biomass in the Chukchi, inclusive of the inner and midshelf areas. We suggest that one of the reasons for the observed regional variations of the benthos is the decreased annual ice cover in the northeastern Chukchi Sea. Additionally, presence of polynyas are documented for the inner shelf of the northeastern Chukchi Sea but not for the western Beaufort Sea. It is, therefore, presumed that ice-scouring of the sea floor would be relatively more intense and, thus, more devastating to the benthos, in the Beaufort Sea than in the Chukchi Sea.

A review of the gray whale (*Eschrichtius robustus*) literature reveals that these whales inhabit the northeastern Chukchi Sea primarily nearshore between Icy Cape and Point Barrow during July through October. Macrofaunal sampling in our project revealed that the greatest concentrations of benthic invertebrates, including amphipods (a preferred gray whale prey), occurs within the area where gray whales concentrate. A group of stations sampled in the present study, i.e. , the 14 stations in Station Group II, encompassed most of the summer and fall habitat of Pacific walruses (*Odobenus rosmarus divergent*). Values of organic carbon within the sediment and benthic macrofaunal carbon biomass were highest within this region. The faunal biomass sampled was dominated by polychaete worms, sipunculid worms, and bivalves, all common prey groups of walruses. Stomach contents of walruses examined by Dr. F. Fay within the general area sampled in our project revealed that common infaunal organisms, as well as several epifaunal species not sampled by the van Veen grab used in our study, were important food items.

In summary, the abundance and biomass of macrobenthic animals in the northeastern Chukchi Sea are related to a number of environmental factors. The factors discussed in this report include water mass origin, storm effects, currents, local eddies and gyres, presence and extent of polynyas, southern boundary of the pack ice in summer, sediment characteristics and accumulation rates, nutritional quality of POC flux to the bottom, ice gouging, and disturbance of the sea bottom by the feeding activities of walruses and gray whales. It is suggested that the carbon rich waters identified in the southeastern Chukchi Sea (i.e., the mixed BSAW as modified by mixing in the central Chukchi Sea) extend into the northern Chukchi and the coast north of 70°30' latitude and supply a rich and persistent food to the offshore and inshore benthos. Benthic biological processes appeared to dominate ever physical processes in the establishment and maintenance of benthic communities in the muddy offshore areas, although the increased flux of POC to the bottom in these areas generally resulted in higher biomass values north of 70030'. The disturbance of the bottom of inshore waters by the combined action of local eddies and gyres, ice gouging, storm induced turbulence, and feeding activities of gray whales and walruses (inshore north of Icy Cape) has resulted in a stressed environment where opportunistic species have become established. The success of these species has apparently been enhanced by advection of POC by mixed Bering Water (as suggested above).

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APPENDIX I

Table Ia. The weight percentages of water, and radioactivities (dpm g^{-1}) of ^{226}Ra, total ^{210}Pb ($^{210}Pb_T$) and excess ^{210}Pb ($^{210}Pb_{EX}$) in l-cm sections of sediment cores taken from selected stations in northeast Chukchi Sea.

Station	Core Section (cm)	$H_2O\%$	$^{210}Pb_T$	^{226}Ra	$^{210}Pb_{EX}$
CH-13	0-1	33.7	2.05 ± 0,05	0.82 ± 0.01	1.23 ± 0.05
	1-2	36.2	1.92 ± 0.07	1.05 ± 0.02	0.87 ± 0.07
	2-3	36.8	1.72 ± 0,05	1.06 ± 0.02	0.66 ± 0.05
	3-4	36.9	1.39 ± 0,04	0.75 ± 0.02	0.64 ± 0.04
	4-5	37.3	1.42 ± 0.04	1.34 ± 0.02	0.08 ± 0.04
	5-6	37.0	1.50 ± 0.05	0.98 ± 0.02	0.52 ± 0.05
	6-7	37,0	1.37 ± 0,03	0.95 ± 0.02	0.42 ± 0.04
	7-8	36.8	1,43 ± 0.05	1.16 ± 0.02	0.27 ± 0.05
	8-9	37.0	1.24 ± 0.04	1.24 ± 0.02	0.00 ± 0.04
		$\bar{x}$ = 36.52			
CH-21	0-1	45.3	1.99 ± 0.05	1.00 ± 0.01	0.99 ± 0.05
	1-2	44.0	2.05 ± 0.05	1.15 ± 0,02	0.90 ± 0.05
	2-3	40.6	1.91 ± 0.05	1.43 ± 0,02	0.48 ± 0.05
	3-4	39.1	1.67 ± 0005	1.10 ± 0.02	0.57 ± 0.05
	4-5	40.9	1.72 ± 0,05	1.17 ± 0.02	0.55 ± 0.05
	6-7	40.5	1.69 ± 0.05	1.19 ± 0,42	1.50 ± 0.42
	7-8	39.4	1.42 ± 0.04	1.14 ± 0.02	0.28 ± 0.05
		$\bar{x}$ = 40.39			
CH-26	0-1	59.9	2.05 ± 0.07	1.13 ± 0.02	0.92 ± 0.07
	1-2	46.9	1.87 ± 0.07	1.14 ± 0.02	0.73 ± 0.07
	2-3	36.0	1.66 ± 0.03	1,08 ± 0.02	0.58 ± 0.04
	3-4	39.8	1.48 ± 0.03	1.02 ± 0.02	0.46 ± 0.04
	4-5	41.7	1.62 ± 0.03	1.01 ± 0.02	0.61 ± 0.04
	5-6	39.8	1.57 ± 0.05	1.63 ± 0.03	-0.06 ± 0.06
	6-7	35,2	1.44 ± 0.03	1.14 ± 0,02	0.30 ± 0.04
	8-9	35.2	1.24 ± 0.03	0.84 ± 0.01	0.40 ± 0.03
		$\bar{x}$ = 40.59			

Appendix I. Continued.

Station	Core Section (cm)	$H_2O\%$	$^{210}Pb_T$	^{226}Ra	$^{210}Pb_{EX}$
CH-38	0-2	39.7	1.97 ± 0.05	1.09 ± 0.02	0.88 ± 0.05
	2-4	39.0	1.66 ± 0.05	1.06 ± 0.02	0.60 ± 0.05
	4-6	41.3	1.30 ± 0.04	1.31 ± 0.03	-0.01 ± 0.05
	6-8	42.9	1.51 ± 0.04	1.24 ± 0.03	0.27 ± 0.05
	8-10	33.5	1.27 ± 0.04	1.08 ± 0.02	0.19 ± 0.05
		$\bar{x}$ = 39.28			
CH-39	0-2	56.3	2.31 ± 0.05	1.28 ± 0.03	1.03 ± 0.06
	2-4	53.8	2.05 ± 0.05	1.29 ± 0.03	0.76 ± 0.06
	4-6	52.1	1.37 ± 0.05	0.95 ± 0.02	0.42 ± 0.05
	6-8	49,0	1.11 ± 0.05	1.07 ± 0.02	0,06 ± 0.05
	8-10	47.1	1.28 ± 0.03	1.13 ± 0.02	0.15 ± 0.04
	10-12	44,9	1.20 ± 0.03	0.74 ± 0.03	0.46 ± 0.04
		$\bar{x}$ = 50.53			
CH-40	0-1	34.4	1.47 * 0.05	0.94 ± 0.02	0.53 ± 0.05
	1-2	32.0	1.60 ± 0.05	0.86 ± 0.02	0,74 ± 0.05
	2-3	27.7	1.58 ± 0.04	0.99 ± 0.02	0.59 ± 0.05
	3-4	29.9	1.36 ± 0.04	1.40 ± 0.02	-0.04 ± 0.05
	4-5	32.1	1.33 * 0.04	0.91 ± 0.02	0.42 ± 0.05
	5-6	29.9	1.22 ± 0.03	1.05 ± 0.02	0.17 ± 0.04
	6-7	24.9	0.96 ± 0.03	0.98 ± 0.02	-0.02 ± 0.04
		$\bar{x}$ = 30.13			

Appendix 11. Conversion values[1], feeding and motility types[2] for macrofauna of the NE Bering and SE Chukchi Seas. P/B = Production/Biomass.

KEY : Feeding Type: H=herbivore, IF=Interface feeder, Mx=mixed, P=predator, S=scavenger, SDF=surface deposit feeder, SF=filter feeder, SSDF=subsurface deposit feeder, U=unknown

Motility Type: S=sessile, DM=discretely motile, M=motile, Mx=mixed

Taxon Code: P=phylum, Cl=Class, Subcl=Subclass, O=Order, F=Family

TAXON	TAXON CODE	CONV. C-ORG wet .wt,	P/B	FEEDING TYPE	MOTILITY TYPE
P. Protozoa					
(Foraminifera:*Pyrgo*)	345214	.010	0.l	P/S (Mx)	S/DM/M (Mx)
P. Porifera	36	.010	0.1	SF (IF)	S
P. Cnidaria					
Cl. Anthozoa	37	.061	0*1	SF(IF)/P	S
Cl. Hydrozoa	--	,061	0.1	P/SF(IF)	
F. Nephtheidae	374704	.040	0.1	SF	S
F. Cerianthidae	374301	.061	0.1	SF	S
F. Platyhelminthes	39	.093	0.1	P	M
P. Rhynchocoela	43	.093	0.1	P	M
F. Reineidae	430302	.093	0.1	P	M
P. Nematoda	47	.010	0.1	P/H/SDF (IF)(Mx)	M
P. Annelida	50		1.4	Mx	Mx
Cl. Polychaeta	5001	.069	1.4	Mx	Mx
F. Nereidae	500124	.069	1.4	(P/SDF/SF/IF) (Mx)	M
F. Ampharetidae	500167	.069	1.4	SDF(IF)	S
F. Chrysoptalidae	500108	.068	1.4	P	M
F. Flabelligeridae	500154	.044	1.4	SDF(IF)	M/DM
F. Magelonidae	500144	.069	1.4	SDF(IF)	DM
F. Maldanidae	500163	.070	1.4	SSDF	S
F. Nephtyidae	500125	.072	1.4	P	M

TAXON	TAXON CODE	CONV. C-ORG wet .wt.	P/B	FEEDING TYPE	MOTILITY TYPE
F. Ophelidae	500158	.095	1.4	SSDF	M
F. Orbiniidae	500140	.061	1.4	SSDF	M
F. Oweniidae	500164	.069	1.4	SF/SDF(IF) (Mx)	DM/M
F. Oweniidae		.069	1.4	SSDF	
F. Pectinariidae	500166	.045	1.4	SSDF	M
F. Phyllodocidae	500113	.087	1.4	P/S (Mx)	M
F. Polynoidae	500102	.073	1.4	P/S (Mx)	M
F. Sabellidae	500170	.075	1.4	SF	S
F. Spionidae	500143	.069	1.4	SF/SDF(IF) (Mx)	DM
F. Scalibregmidae	500157	.069	1.4	SSDF	M
F. Sternaspidae	500159	.041	1.4	SSDF	M
F. Syllidae	500123	.069	1.4	P/H/SDF(IF) (Mx)	M
F. Terebellida	500168	.061	1.4	SD	S
F. Capitellidae	500160	.069	1.4	SSDF	M
F. Glyceride	500127	.069	1.4	P	M/DM (Mx)
F. Eunicidae	500130	.069	1.4	P	M/DM (Mx)
F. Cirratulidae	500150	.069	1.4	SDF(IF)	M/DM/S (Mx)
F. Goniadidae	500128	.069	1.4	P/S (Mixed)	DM
F. Sphaerodoriidae	500126	.069	1.4	SSDF	M
F. Sigalionidae	500106	.069	1.4	P/S	M
F. Trichobranchidae	500169	.069	1.4	SDF(IF)	S
F. Lumbrineridae	500131	.093	1.4	P/H/SDF(IF) (Mx)	M
F. Onuphidae	500121	.069	1.4	P/SDF(IF)/S (Mx)	S/DM (Mx)
F. Chaetopteridae	500149	.069	1.4	SDF(IF)	S
F. Hesionidae	500121	.069	1.4	P	M
F. Paraonidae	500141	.069	1.4	SDF(IF)	M
F. Trochochaetidae	500145	.069	1.4	SDF (IF)	M
F. Dorvilleidae	500136	.069	1.4	P/S(Mx)	M
F. Cossuridae	500152	.069	1.4	SSDF	M
F. Apistobranchidae	500142	.069	1.4	SDF(IF)	DM
F. Arenicolidae	500162	.069	1.4	SSDF	DM
F. Sabellaridae	500162	.069	1.4	SF(IF)	S
F. Serpulidae	500173	.069	1.4	SF(IF)	S
Polychaete fragments	500100	.069	1.4		
C. Oligochaeta		.069	1.4	SSDF	
P. Sipunculida	72	.045	0.1	SDF(IF)	S
F. Golfingiidae	720002	.045	0.1	SDF(IF)	DM

TAXON	TAXON CODE	CONV. C-ORG wet.wt.	P/B	FEEDING TYPE	MOTILITY TYPE
P. Echiurida	73	.051	0.1	SDF(IF)	DM
F. Echiuridae	730102	.051	0.1	SDF(IF)	DM
P. Priapulida	74	.045	0.1	SDF(IF)/S/P (Mx)	DM
F. Priapulidae	740001	.045	0.1	SDF(IF)/P/S (Mx)	DM
P. Mollusca		.028	0,3	Mx	Mx
Cl. Aplacophora	54	.037	0.3	SSDF/P/S (Mx)	M
F. Chaetodermatidae	540201	.037	0.3	SSDF/P/S (Mx)	M
Cl. Polyplacophora	53	.063	0.3	S/H	M
F. Ischnochitonidae	530302	.063	0.3	S/H	M
Cl. Scaphopoda	56	.063	0.3	SSDF	M
Cl. Bivalvia	55	.028	0.3	SF/SDF/SSDF (IF)(Mx)	S/M/DM (Mx)
F. Pectinidae (*Delectopecten*)	550905	.028	0.3	SF(IF)	M
F. Astartidae	551519	.015	0.3	SF(IF)	S/DM?
F. Cardiidae	551512		0.3	SF/SDF(IF)	S/DM?
(*Serripes*)	55152202	.033	0.3	SF(IF)	DM
(*Clinocardium*)	55152201	.022	0.3	SF/SDF (Mx)	DM
F. Mytilidae	550701	.028	0.3	SF(IF)	S
F. Nuculanidae	550204	.047	0.3	SSDF	DM/M (Mx)
(*Yoldia*)	55020405	.047	0.3	SSDF	M
(*Nuculana*)	.55020402	.019	0.3	SSDF	DM
F. Nuculidae	550202	.039	0.3	SSDF	DM
F. Tellinidae	551531	.035	0.3	SDF/SF (IF)(Mx)	DM
(*Macoma*)	55153101	.03.5	0.3	SDF(IF)	DM
(*Tellina*)	55153102	.028	0.3	SF(IF)	DM
F. Veneridae	551547	.028	0.3	SF(IF)	S
F. Thyasiridae	551502	.028	0.3	SF(IF)	S
F. Montacutidae	551510	.028	0.3	SF(IF)	S
F. Myidae	551701	.028	0.3	SF(IF)	S/DM (Mx)
P. Bryozoa (encrusting)	78	.010	0.1	SF(IF)	S
F. Alcyonidiidae	780301	.021	0.1	SF(IF)	S
F. Flustridae	781506	.021	0.1	SF(IF)	S
P. Brachiopoda (*Terebratulina*)	80	.021	0.1	SF(IF)	S

Appendix II (continued)

TAXON	TAXON CODE	CONV. C-ORG wet. wt.	P/B	FEEDING TYPE	MOTILITY TYPE
F, Carditidae	551517	.062	0.3	SF(IF)	S/DM (Mx)
F. Cuspidaridae	552010	.028	0.3	P	DM
(*Cardiomya*)	55201001	.028	0.3	P	DM
F. Mactridae	551525	.028	0.3	SF(IF)	S
F. Pandoridae	552002	.028	0.3	SF(IF)	S
F. Kellidae	551508	.028	0.3	SF/SDF(IF) (Mx)	S/DM (MX)
F. Ungulinidae (*Diplodonta*)	551505	.028	0.3	SF/SDF(IF) (Mx)	S
F. Hiatellidae	551706	.028	0.3	SF(IF)	S
F. Lyonsiidae	552005	.018	0.3	SF(IF)	S
F. Periplomatidae	552007	.028	0.3	SF(IF)	S?
F. Thraciidae	552008	.028	0.3	SF(IF)	S
Cl. Gastropod	51	.062	0.3	P/S/H/SDF(IF) (Mx)	M
F. Cylichnidae	511004	.062	0.3	P/S (Mx)	M
F. Nassariidae	510508	.062	0.3	S/P/SDF(IF) (Mx)	M
F. Turridae	510602	.062	0.3	P	M
F. Olividae	510510	.062	0.3	P	M
F. Trochidae	510210	.062	0.3	H/P	M
F. Naticidae	510376	.080	0.3	P	M
F. Turitellidae	510333	.062	0.3	SF(IF)	DM
F. Muricidae	510501	.062	0.3	P	M
F. Lamellariidae	510366	,062	0.3	P	M
F. Pyramidellidae (*Odostomia*)	510801	.062	0.3	SDF(IF)	M
F. Rissoidae (*Alvinia*)	510320	.062	0.3	H	M
F. Acmaeidae	510205	.062	0.3	H	M
F. Epitoniidae	510351	,062	0.3	P	M
F. Trichotropidae	510362	.062	0.3	SF(IF)	DM
F. Calyptraeidae	510364	.062	0.3	SF(IF)	S/DM (Mx)
F. Buccinidae	510504	.057	0.3	P/S (Mixed)	M
F. Neptuneidae	510505	.048	0.3	P/S (Mixed)	M
F. Cancellariidae	510514	.062	0.3	H	M
F. Philinidae	511005	.062	0.3	P	M
F. Retusidae	511013	.062	0.3	P	M
Subcl. Opisthobranchia	5181	.037	0.3	P	M
Cl. Polyplacophora	53	.062	0.3	S/H (Mixed)	M
F. Ischnochitonidae	530302	.062	0.3	S/H (Mixed)	M
P. Arthropods		.074	1.0		
Cl. Crustacea	61	.074	1.0		

Appendix II (continued)

TAXON	TAXON CODE	CONV. C-ORG wet.wt.	P/B	FEEDING TYPE	MOTILITY TYPE
SubCl. Cirripedia					
F. Balanoidae	613402	.011	0.1	SF(IF)	S
SubCl. Malacostraca					
O. Cumacea	6154	.074	1.0	SDF(IF)	DM
F. Nannastacidae	615408	.074	1.0	SDF(IF)	DM
F. Leuconidae	615404	.074	1..0	SDF(IF)/S	M
F. Lampropidae	615401	.074	1.0	SDF(IF)/S (Mx)	DM
F. Diastylidae	615404	.074	1.0	SF(IF)/S(Mx)	M
F. Cumidae	615402	,074	1.0	SDF(IF)	M
F. Campylaspidae	615407	.074	1.0	SDF(IF)	M
O. Amphipoda	6169	.074	1.0	Mx	Mx
F. Ampeliscidae	616902	.068	1.0	SDF(IF)	DM
F. Aoridae	616906	.063	1.0	SDF(IF)	M
F. Corophidae	616915	.066	1.0	SF/SDF(IF) (Mx)	DM
F. Gammaridae	616921	.074	2.5	SDF(IF)	
F. Lysianassidae	616934	.081	1.0	S/SF/SDF(IF)/ P(Mx)	M
F. Isaeidae (prev.F. Photidae)	616926	.068	1.0	SDF(IF)	M
F. Oedocerotidae	616937	.074	1.0	SDF(IF)	M
Subcl. Ostracoda	6110	,974	1.0	SDF(IF)	M
O. Harpacticoida	6119	.074	1.0	SDF(IF)	M
O. Cyclopoida	6120	.074	1.0	SDF(IF)	M
O. Nebaliacea	6145	.074	1.0	SF/SDF(IF) (Mx)	M
F. Phoxocephalidae (*Paraphoxus, Harpinia*)	*616942*	.074	1.0	SDF(IF)	M
F. Pleustidae	616943	.074	1.0	SDF(IF)	M
F. Haustoriidae (*Pontoporeia*)	616922	.099	1.0	SDF(IF)	DM
F. Stenothoidae	616948	.074	1.0	SDF(IF)	M
F. Eusiridae	616920	.062	1.0	u	M
F. Dexaminidae	616917	.074	1.0	SF(IF)	DM
F. Acanthonotozomatidae	616901	.074	1.0	u	M
F. Caprellidae	617101	.074	1.0	S/P/SF(IF)/H (Mx)	M
F. Argissidae	616907	.074	1.0	u	M
F. Atylidae	616909	.074	1.0	S/H (Mx)	DM
F. Calliopiidae	616912	.074	1.0	S/H (Mx)	M
F. Ischyroceridae	616927	.074	1.0	S?	DM
F. Parampithoidae	616939	.074	1.0	u	M?
F. Podocereidae	616944	.074	1.0	P?/U (Mx)	M
F. Synopiidae	616950	.074	1.0	S	M

Appendix II (continued)

TAXON	TAXON CODE	CONV. C -ORG wet.wt.	P/B	FEEDING TYPE	MOTILITY TYPE
O. Isopoda	6158	.074	1.0	SDF(IF)/S (Mx)	M
F. Anthuridae	616001	.074	1.0	S/P (Mx)	DM
F. Amphithoidae	616904	.074	1.0	S/P (Mx)	M
Cl. Ostracoda	6110	.074	1.0	P/H/S/SF/SDF (IF)(Mx)	M
O. Decapoda	6175	.057	1.0	S/P (Mx)	M
F. Pinnotheridae	618906	.057	1.0	Mx	M
Cyclopoida	6120	.074	1.0	P	M
Thoracica	6134	.011	1.0	SF(IF)	S
Nebaliacea	6145	.074	1.0	SF/SDF(IF) (Mx)	M
Pseudocumidae	615406	.074	1.0	U	M?
Tanaidacea	6155	.074	1.0	P/SF/SDF(IF) (Mx)	DM/M
Idoteidae	616202	.074	1.0	H/S/P (Mx)	M
Munnidae	616312	.074	1.0	H/S/P (Mx)	M?
F. Ampeliscidae (for additional information on species)					
A. macrocephala	*6169020101*			SDF/SF(IF)	DM
A. eschrichti	*6169020105*			SDF/SF(IF)	DM
Byblis gaimardi	6169020202			SDF(IF)	DM
A. birulai	*6169020102*			SDF/SF(IF)	DM
Haploops	*61690203*			SF(IF)	DM
P. Echinodermata	81	.018	0.1	P/S/SDF(IF)/ SSDF(Mx)	M
Cl. Echinoidea	8136	.008	0.1	SDF(IF)/S/H/ SSDF(Mx)	M
F. Echinarachniidae	815502	.008	0.1	SF(IF)	M
F. Strongylocentrotidae	814903	.011	0.1	SDF(IF)/H (Mx)	M
Cl. Holothuroidea	8170	.018	0.1	SSDF/SF(IF) (Mx)	S
F. Psolidae	817203	.024	0.1	SDF/SF(IF) (Mx)	DM
F. Cucumariidae	817206	.018	0.1	SDF/SF(IF) (Mx)	DM
F. Synaptidae	817801	.018	0.1	SDF/SF(IF) (Mx)	DM

TAXON	TAXON CODE	CON-V. C - ORG wet. wt.	P/B	FEEDING TYPE	MOTILITY TYPE
Cl. Ophiuroidea	8120	.014	0.1	SDF(IF)/S/P (Mx)	M/DM (Mx)
F. Ophiactidae	812902	.014	0.1	SDF/SF(IF) (Mx)	DM
F. Ophiuridae	812701	.014	0.1	SDF(IF)/P/S (Mx)	M
F. Amphiuridae	812903	.014	0.1	SDF/SF(IF) (Mx)	M
Cl. Asteroidea					
F. Porcellanasteridae (*Ctenodiscus*)	810702	.018	0.01	SSDF	M

Dominant species in Families--For information only

F. Echnarachniidae - *E. parma*
F. Ophiactidae - O. *acuulata*
F. Ophiuridae - O. *maculata*

P. Enteropneusta	8201	.069	0.1	SDF/SF(IF) (Mx)	DM
P. Chordata					
Cl. Ascidiacea	8401	.014	0.1	SF(IF)	s
F. Styelidae (*Pelonaia corrugata*)	840601	.014	0.1	SF(IF)	s
F. Pyuridae	840602	.014	0.1	SF(IF)	s
F. Molgulidae	840603	.014	0.1	SF(IF)	s
F. Corellidae	840404	.014	0.1	SF(IF)	s

[1]Carbon conversion values from formalin wet weights are those included in Stoker (1978) or are calculated from values in Stoker (1978).

'Feeding and motility types are based on Abbott, 1974; Barnes, 1980; Bernard, 1979; Day, 1967; D'yakonov, 1950; Eltringham, 1971; Fauchald and Jumars, 1979; Feder *etal.*, 1973; Fretter and Graham, 1962; Hyman, 1967; Jorgensen, 1966; MacGinitie and MacGinitie, 1949; Mills, 1967; Morris, 1966; Morris *etal.*, 1980; Morton, 1958; Purchon, 1968; Schultz, 1969; Smith and Carlton, 1975; Stanley, 1970; Trueman, 1975; Yonge and Thompson, 1976.

STATION	PHYLUM	-----ABUNDANCE----- #/M2	%	------BIOMASS ----- g/M2	S	--CARBON BIOMASS--- gC/M2	S	----CARBON PROD---- gC/M2	%
CH3	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	42.0	5.01	24.262	13.89	1.480	19.65	0.148	5.22
	RHYNCHOCOELA	0.0	0.00	1.096	0.62	0.102	1.3s	0.010	0.36
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	312.0	37. 23	15.354	8.86	0.931	12.36	1.304	46.02
	GASTROPODA	36.0	4.30	7.013	3.96	0.s51	7.31	0.165	S.83
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	282.0	33. 65	86.813	48.08	3.199	42. 48	0.960	33.88
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	120.0	14.32	2.268	1.28	0.154	2.0s	0.1s4	5.44
	SIPUNCULA	10.0	1.19	16.416	9.26	0.739	9.81	0.074	2.61
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	PRIAPULIDA	2.0	0.24	0.004	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	30 0	3.58	21. 950	12.38	0.347	4 61	0.015	0.54
	HEMICHORDATA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	4.0	0.48	2.062	1.16	0. 029	0.38	0.003	0.10
		838.0		177.238		7.53a		a 833	
CH4	PROTOZOA	224.0	14.07	0. 00s	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	O 8S2	0.14	0.007	0.05	0.001	0.02
	COELENTERATE	16.0	1.01	31.413	6.87	1 .2s0	0.22	0.126	3.13
	RHYNCHOCOELA	0.0	0.00	0.198	0.04	0.018	0.13	0.002	0.0s
	NEMATODA	134.0	8.42	0-000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	220.0	13.82	1'7.920	3.92	1. 265	9.27	1.772	44.00
	GASTROPODA	32.0	2.01	21.239	4.6S	1.44$	10.62	0.43s	10.82
	CHITON	22.0	1.38	2.190	0.48	0.138	1.01	0.041	1.03
	BIVALVIA	20.0	1.26	36. SS3	8.00	1.427	10.46	0.428	10.66
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	808.0	so. 75	6.081	1.s3	0.4s4	3.33	0.451	11.22
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	4.0	0.25	2 .830	0.62	0.033	0.24	0.003	0.08
	BRACHIOPODA	8.0	0.90	0.044	0.01	0.001	0.01	0.000	0.00
	ECHINODERMATA	5s.0	3.64	287.354	62.88	e. 892	50.49	0.680	17.15
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	46.0	2.8$)	50.502	11.0s	0.707	5.18	0.071	1.76
		1502.0		456 .900		13.651		4.019	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	%	BIOMASS g/M2	%	CARBON BIOMASS gC / M2	S	CARBON PROD gC/M2	%
CH5	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0.0s	0.346	0.25	0.014	0.22	0.001	0.04
	RHYNCHOCOELA	2.0	0.0s	15.7%$2	11.39	1. 46a	22.08	0.146	4.31
	NEMATODA	28.0	0.77	0.005	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	416.0	11.38	16.293	11.81	1.132	17.08	1.584	46.7a
	GASTROPODA	30.0	0.82	8.630	0.25	0.458	6.91	0.137	4.0s
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	106.0	2.90	56.129	40.67	1.817	27.4$3	0.s4s	10.07
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	3046.0	83. 3a	13.869	10.05	0.892	13.48	0.891	26. 29
	SIPUNCULA	2.0	0.05	16.008	11.60	0. 7ao	10.87	0. 07a	a l a
	ECHIURA	4.0	0.11	0.268	0.19	0.014	0.21	0.001	0.04
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	2.0	0.05	9.010	6.53	0.005	1.43	0.000	0.28
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	18.0	0.49	1.730	1.25	0.023	0.35	0.002	0.07
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		36S6 .0		138.010		6.62'7		3.391	
CH6	PROTOZOA	128.0	1.51	0.015	0.02	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0 182	0.18	0. ooa	0.03	0.000	0.00
	COELENTERATE	0.0	0.00	0 688	0.69	o. 04a	0.75	0.004	0.09
	RHYNCHOCOELA	0.0	0.'00	0.068	0.07	0.006	0.11	0.001	0.01
	NEMATODA	100.0	1.18	0.000	0.01	0.000	0.00	0.000	0.00
	ANNELIDA	6s6 .0	?'.74	15.497	1S.6S	1.084	19.30	1.517	30.81
	GASTROPODA	56.0	0.66	2.s22	2.3.5	0.169	3.00	0.051	1.03
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	280.0	3.31	33 627	33.95	1.309	23.31	0.393	7.98
	PYCNOGONIDA	10.0	0.12	0. 04a	0.04	0.003	0.08	0.003	0.06
	CRUSTACEA	7146.0	84. 3S	41.640	4a. 04	2.952	52.57	2. 9s0	59.92
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	2.0	0.02	0.006	0.01	0.000	0.01	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	2.0	0.02	1.291	1.30	0.013	0.24	0.001	0 03
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	26.0	0.31	1.498	1.51	0.008	0.15	0.001	0.02
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	66.0	0.78	1.968	1.99	0.028	0.49	0.003	0.06
		8472.0		99.051		5.616		4. 923	

Appendix III (continued)

STATION	PHYLUM	--ABUNDANCE----- #/M2	%	------BIOMASS------ g/M2	%	--CARBON BIOMASS--- gC/M2	%	----CARBON PROD---- gC / M2	%
CH7	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	40.886	10.s6	0.409	2.08	0.041	0.26
	COELENTERATE	44.0	0.s9	24.029	6.20	1.296	6.00	0.130	0.83
	RHYNCHOCOELA	2.0	0.03	0.297	0.08	0.028	0.14	0.003	0.02
	NEMATODA	462.0	6.17	0.074	0.02	0.001	0.00	0.000	0.00
	ANNELIDA	1042.0	13.93	9.578	2.47	0.602	3.07	0.843	5.42
	GASTROPODA	112.0	1.s0	15.188	3.92	0.941	4.79	0.282	1.82
	CHITON	2.0	0.03	0.056	0.01	0-004	0.02	0.001	0.01
	BIVALVIA	64.0	0.86	6.649	1.72	0.236	1.20	0.071	0.45
	PYCNOGONIDA	72.0	0.96	0.0s8	0.01	0.004	0.02	0.004	0.03
	CRUSTACEA	5610.0	74.98	188.989	48.79	13.959	71.08	13.958	89.77
	SIPUNCULA	4.0	0.0s	0. 002	0.00	0.000	0.00	0.000	0.00
	ECHIURA	2.0	0.03	0. 002	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	2.0	0.03	0.006	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	6.0	0.08	14.460	3.73	0.181	0.82	0.016	0.10
	BRACHIOPODA	0.0	0.00	0 000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	52.0	0.70	78 928	20 .38	1.884	9.59	0.188	1.21
	HEMICHORDATA	0.0	0.00	0	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	6.0	0.08	8 1s4	2.11	0.114	0.S8	0.011	0.07
		7482.0		387 330		19.639		15.549	
CH8	PROTOZOA	50.0	2.23	0.003	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0. 028	0.01	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0.08	0.153	0.04	0.009	0.07	0.001	0.02
	RHYNCHOCOELA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	86.0	3.43	23. 404	6.16	1.619	12.26	2. 267	49 .06
	GASTROPODA	14.0	0.s6	22.852	6.02	1.824	13.81	0.s47	11.84
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	118 0	4.70	141.423	37.23	3.639	27.56	1.092	23.63
	PYCNOGONIDA	0 0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	CRUSTACEA	2110.0	84.13	12.022	3.16	0.229	1.73	0. 12s	2.70
	SIPUNCULA	86.0	3.43	76.006	20.01	3.420	2s .90	o. 34a	?.40
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.031	0.01	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	34.0	1.36	103.940	27 .36	2.463	16.65	0.246	5 33
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	2.0	0.08	0.001	0.00	0.000	0.00	0.000	0.00
		2508 0		379 .863		13.204		4.620	

Appendix III (continued)

STATION	PHYLUM	--ABUNDANCE----- #/M2	%	------BIOMASS------ g/M2	%	--CARBON BIOMASS--- gC/M2	%	----CARBON PROD---- gC/M2	%
CH10	PROTOZOA	2.0	0.07	0.004	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.113	0.04	0.007	0.0s	0.001	0.01
	RHYNCHOCOELA	0.0	0.00	0.350	0.11	0.033	0.25	0.003	0.05
	NEMATODA	14.0	0.48	0.00s	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	574.0	19.71	1s.184	4.9s	0.090	7.61	1.386	19.81
	GASTROPODA	52.0	1.79	20.430	6.66	1.596	12.27	0.470	6.84
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	608.0	20.88	188.187	61.36	6.307	48.5a	1.89a	27.04
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	1576.0	54.12	48.56S	15.83	3.144	24.18	3.144	44.93
	SIPUNCULA	54.0	1.85	15.932	5.19	0.717	5.51	0.07a	1.02
	ECHIURA	2.0	0.07	0.006	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	8.0	0.27	0.400	0.13	0.018	0.14	0.002	0.03
	BRYOZOA	0.0	0.00	0.07a	0.02	0.001	0.01	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	14.0	0.48	11.785	3.84	0.109	0.84	0.011	0.16
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	8.0	0.27	5.678	1.85	0.070	0.61	0.008	0.11
		2912.0		306.711		13.000		8.997	
CH11	PROTOZOA	6.0	0.31	0.003	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.001	0.00	0.000	0.00	0 000	0.00
	COELENTERATE	52.0	2.71	1.526	1.18	0.059	1.66	0.006	0.34
	RHYNCHOCOELA	0.0	0".00	0.321	0.2s	0.030	0.84	0.003	0.17
	NEMATODA	30 0	1.56	0.004	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	868.0	45.16	10.766	8.33	0.639	17.89	0.894	51.44
	GASTROPODA	64.0	3.33	0.915	0.71	0.0S8	1 64	0.018	1.01
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	220.0	11.45	51.511	30.83	1.681	47.09	0 504	29 01
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	600.0	31.22	3.346	2.59	0 226	8.32	0.226	12.99
	SIPUNCULA	8.0	0.42	0.070	0.0s	0.003	0.00	0.000	0.02
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0 000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	28.0	1.46	1.648	1.27	0.027	0.74	0.003	0.15
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	14.0	0.73	4.503	3.48	0.081	2.27	0.008	0.47
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	32 0	1.66	54.700	42.30	0.766	21.46	0.077	4.41
		1922.0		129.316		3.569		1.738	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH12	PROTOZOA	2.0	0.26	0.004	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	16.0	2.11	'7.118	2.67	0.434	3.81	0.043	0.69
	RHYNCHOCOELA	0.0	0.00	0. 252	0.09	0.023	0.21	0.002	0.04
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	360.0	47.40	41.631	15.62	2.721	23.86	3.810	60.86
	GASTROPODA	16.0	2.11	9 .223	3.46	0. 73s	6.44	0.220	3.52
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	274.0	38.15	179.372	67.29	7. 037	61.69	2.111	33. 7a
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	CRUSTACEA	02.0	8.18	0.564	0.21	0.040	0.35	0.040	0.6S
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECH I URA	O.O	0.00	" 0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.052	0.02	0.001	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	22.0	2.00	17.696	6.64	0. 265	2.33	0.017	0.27
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	6.0	0.79	10.654	4.00	0.149	1.31	0.015	0.24
		758.0		206.566		11.406		6.260	
CH13	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	16.0	3". 52	0.734	0.26	0.068	0.86	0.007	0.17
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	176.0	38.77	11.704	4.22	0.920	8.93	1.288	31.22
	GASTROPODA	12.0	2.64	2.112	0.?6	0.1s3	1.49	0.046	1.12
	CHITON	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	208 0	45.81	259.664	93.66	9.018	87.55	2.705	65.60
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	22.0	4.85	1.015	0.37	0.072	0.70	0.072	1.74
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	PRIAPULIDA	14.0	3.08	1.546	0.56	0.070	0.68	0.007	0.17
	BRYOZOA	0 0	0.00	0.000	0.00	0.000	0 00	0.000	0 00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	6.0	1.32	0.462	0.17	0.000	0.00	0.000	0.00
	HEMICHORDATA	0 0	0.00	0.000	0.00	0.000	0 00	0.000	0.00
	UROCHORDATA	0 0	0.00	0.000	0.00	0.000	0.00	0 000	0 0 0
		454.0		277.237		10.301		4.124	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	%	BIOMASS g/M2	%	CARBON BIOMASS gC/M2	%	CARBON PROD gC/M2	%
CH14	PROTOZOA	2.0	0.28	0.001	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	6.0	0.83	3.320	1.23	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	2.0	0.28	9.850	3.66	0.916	7.57	0.092	1.59
	NEMATODA	2.0	0.28	0.001	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	352.0	48.48	40.535	15.06	2.959	24.45	4.143	71.95
	GASTROPODA	16.0	2.20	9.412	3.S0	0.547	4.S2	0.164	2.85
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	100.0	13.77	55. 120	20.48	1.'773	14.65	0. 532	9.24
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	96.0	13.22	3. 865	1.44	0.203	2.17	0. 263	4.56
	SIPUNCULA	34 0	4.6a	116.132	43.16	5.226	43.18	0. 523	9.08
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	20.0	2.7S	0.63a	0.23	0.028	0.23	0.003	0.0s
	BRYOZOA	2.0	0.28	0.066	0.02	0.001	0 01	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	90.0	12.40	23.602	8.'77	0.209	2.47	0.030	0.52
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0 00	0 000	0 00
	UROCHORDATA	4.0	0.55	6.560	2.44	0.092	0.76	0.009	0 18
		'726.0		269.096		12.103		5 757	
CH15	PROTOZOA	22 0	0.50	0.056	0.02	0.001	0.01	0.000	0 00
	PORIFERA	0.0	0.00	0.026	0.01	0.000	0.00	0.000	0.00
	COELENTERATE	8.0	0.18	6.834	2.50	0.172	1.54	0.017	0.18
	RHYNCHOCOELA	0.0	0.00	0.413	0.15	0.038	0.34	0.004	0 04
	NEMATODA	16.0	0.36	0. 00s	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	2646.0	60.25	'77.029	28.23	s .660	50.66	7. 924	84 5a
	GASTROPODA	74.0	1.68	11.406	4.16	0.882	7.89	0. 265	2.82
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	196.0	4.46	122.668	44.96	2.969	26.58	0.891	9.50
	PYCNOGONIDA	2.0	0.0s	0.001	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	1058.0	24.09	2.069	0.76	0.144	1.29	0.144	1 54
	SIPUNCULA	156.0	3.5s	18.700	6.85	0.841	7.53	0.084	0.90
	ECHIURA	0 0	0.00	0.000	0.00	0.000	0 0 0	0.000	0.00
	PRIAPULIDA	40 0	0.91	1.588	0.58	0.071	0.64	0.007	0.08
	BRYOZOA	2.0	0.0s	0.180	0.07	0. 00a	0.02	0.000	0 00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	ECHINODERMATA	170.0	3.87	31.580	11.57	0.388	3.47	0.030	0 41
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	UROCHORDATA	2.0	0.0s	0.304	0.11	0.004	0.04	0.000	0.00
		4392.0		272, 859		11.173		9.375	

Appendix III (continued)

STATION	PHYLUM	-----ABUNDANCE----- #/M2	%	------BIOMASS------ g/M2	%	--CARBON BIOMASS--- gC/M2	%	----CARBON PROD---- gC/M2	%
CH16	PROTOZOA	58.0	0.18	0.002	0.00	0.000	0.00	0.000	0.00
	POR I FERA	0.0	0.00	13.702	2.24	0.137	0.86	0.014	0.19
	COELENTERATE	40.0	0.13	1.584	0.26	0.088	0.ss	0.009	0.12
	RHYNCHOCOELA	24.0	0.08	0.509	0.00	0.0s3	0.33	0. 00s	0.07
	NEMATODA	180.0	0.s7	0.009	0.00	0.0.00	0.00	0.000	0.00
	ANNELIDA	1554.0	4.92	42. 2S2	6.91	3.009	18.8a	4.212	58.88
	GASTROPODA	126.0	0.40	30.957	S.06	2.144	13.41	0.643	8.96
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	310.0	0.90	245.689	40.17	4.511	28.21	1.353	18.85
	PYCNOGON IDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	290s0.0	92.00	16.495	a.70	0.493	3.08	0.386	5.37
	SIPUNCULA	48.0	0.1s	1.626	0.27	0.073	0.46	0.007	0.10
	ECH I URA	38.0	0.12	0.094	0.02	0.005	0.03	0.000	0.01
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	86.0	0.27	9 .440	1.54	0.190	1.19	0.019	0.26
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	32.0	0.10	18S.147	30. 27	4.391	27.46	0.439	6.12
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	30.0	0.10	84.102	10.48	0.807	5.61	0.090	1 25
		31576.0		611.668		15.992		7.178	
CH17	PROTOZOA	34.0	0.68	0.104	0.08	0.001	0.02	0.000	0.00
	PORIFERA	0.0	0.00	0.130	0.10	0.001	0.02	0.000	0.00
	COELENTERATE	0.0	0.00	0.217	0.17	0.013	0.20	0.001	0.02
	RHYNCHOCOELA	0.0	0.00	1. 498	1.19	0.139	2.10	0.014	0.26
	NEMATODA	72.0	1.44	0. 00s	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	958.0	19.17	26.334	20 .98	1.916	28.84	2.683	50.17
	GASTROPODA	34.0	0.68	7. 544	6.01	0.s5s	8.36	0.167	3.12
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	308.0	6.16	44.786	35.69	1.900	28.60	0.570	10.66
	PYCNOGON IDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	CRUSTACEA	3444.0	68.91	27.080	aa. 30	1.880	28.43	1.889	3s .33
	SIPUNCULA	2.0	0.04	0.001	0.00	0.000	0.00	0.000	0.00
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	1.246	0.99	0.012	0.19	0.001	0.02
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	140.0	2.80	14.87a	11.85	0. 20s	3.00	0.021	0 38
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	6.0	0.12	0.780	0.6a	0.011	0.1s	0.001	0.02
		4998.0		125.497		6.844		s 347	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH18	PROTOZOA	50.0	10.82	0. 262	0.19	0.003	0.00	0.000	0.01
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0.43	0.466	0.34	0.028	0.89	0. 003	0.13
	RHYNCHOCOELA	0.0	0.00	0.219	0.16	0.020	0.64	0.002	0.00
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	152.0	32.00	15.574	11.40	1. 293	40.35	1.810	80.06
	GASTROPODA	8.0	1.73	0.838	0.46	0.046	1.45	0.014	0.62
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	28.0	0.06	35.620	26. 00	1.171	36.54	0.351	15.54
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	10.0	2.16	0. 245	0.18	0.018	0.s7	0.018	0.80
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	ECHINODERMATA	212.0	45.89	83.736	61.27	0. 625	19.49	0. 06a	2.76
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		462.0		138.660		3. 205		2.261	
CH19	PROTOZOA	88.0	5.43	0.528	0.25	0.005	0.00	0.001	0.03
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.030	0.02	0.003	0.06	0.000	0.02
	NEMATODA	2 0	0.12	0.001	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	112 0	6.91	3.828	1.71	0.308	5.36	0.431	22.06
	GASTROPODA	46.0	2.84	6.526	3.08	0.418	7.28	0.125	6.68
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	844.0	52.03	83. 172	39.24	4.041	70.34	1.212	64 59
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA '	90.0	5.5s	0.131	0.06	0.012	0.20	0.012	0.82
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	O.O	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	426.0	26.26	113.884	53.63	0.898	15.64	0.090	4.79
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 0 0
	UROCHORDATA	14.0	0.86	4.254	$$.01	0.060	1.04	0.006	0.32
		1622.0		211.960		5.745		1.877	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD. gC/M2	CARBON PROD. s
CH21	PROTOZOA	4.0	0.35	0.010	0.00	0.000	0.00	0.000	0.00
	POR I FERA	0.0	0.00	0-000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.009	0.00	0.001	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.262	0.09	0.024	0.21	0.002	0.02
	NEMATODA	2.0	0.17	0. ooa	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	400.0	34.90	104. 832	36.34	7.400	63. 52	10.486	90. 92
	GASTROPODA	42.0	3.66	0.387	0.13	0.017	0.14	0. 00s	0.04
	CHITON	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	BIVALVIA	154.0	13.44	130.988	44.16	a .623	22. 2s	0.767	6.82
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	410.0	35.78	1.622	0.55	0.099	0.04	0.099	0.86
	SIPUNCULA	12.0	1.0s	26.054	8.78	1.172	9.04	0.117	1.02
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.004	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.114	0.04	0.001	0.01	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	120.0	10.47	32.319	10.00	0.363	3.08	0.036	0.31
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	2.0	0.17	0.001	0.00	0.000	0.00	0.000	0.00
		1146.0		206.604		11.791		11.533	
CH23	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.008	0.00	0.000	0.01	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	1.094	0.44	0. 102	1.06	0.010	0.17
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	288.0	46.75	50.692	20.63	3.341	34.81	4.678	78.96
	GASTROPODA	22.0	3.s7	1.306	0.53	0.081	0.84	0.024	0.41
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	188.0	30.S2	91.616	37.14	2.152	22.42	0.646	10.QO
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	40.0	6.40	2.810	1.14	0.194	2.02	0.194	3.27
	SIPUNCULA	8.0	1.30	77.414	31.38	3.464	36.29	0.348	S.88
	ECHIURA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0 00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	ECHINODERMATA	70.0	11.36	21. 9s0	8.74	0. 24S	2.55	0 024	0 41
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		616.0		246.600		0.590		5.024	

Appendix III (continued)

STATION	PHYLUM	-----ABUNDANCE-----		------BIOMASS ------		--CARBON BIOMASS---		----CARBON PROD----	
		#/M2	%	g/M2	%	gC/M2	%	gC/M2	%
CH24	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	3.776	2.16	0.3s1	4.61	0. 03s	0.62
	NEMATODA	14.0	1.10	0.003	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	372.0	$39.20	43.9s1	25.19	2.837	37. 26	3.072	70.68
	GASTROPODA	52.0	4.09	0.430	0.25	0.027	0.3s	0.008	0.14
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	498.0	39.21	114.010	65. 34	3.080	52 .38	1.197	21. 30
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	238.0	18.74	5.806	3.33	0.407	5.35	0.407	7.25
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	8.0	0.63	0. 07a	0.04	0.004	0.05	0-000	0.01
	PRIAPULIDA	2.0	0.16	0.008	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	86.0	6.77	6.432	3.60	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		1270.0		174.487		7.81S		5.619	
CH25	PROTOZOA	2.0	0.21	0.004	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	2 0	0.21	0. 972	0.2a	0.090	0.55	0.000	0.17
	NEMATODA	70.0	7.19	0.016	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	258.0	26.49	6.834	1.58	0.510	3.08	0.714	13.2S
	GASTROPODA	20.0	2.05	0.162	0.04	0.011	0.07	0.003	0.06
	CHITON	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	528.0	54.21	413.475	94. 23	15.015	90.56	4.s0s	83.50
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	60.0	6.16	0.931	0.21	0.070	0.42	0.070	1.29
	SIPUNCULA	8.0	0.8a	0.760	0.17	0.034	0.21	0.003	0.08
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	PRIAPULIDA	2.0	0.21	0.210	0.09	0.009	0.08	0.001	0.02
	BRYOZOA	0.0	0.00	0.002	0.00	0.000	0.00	0.000	0 00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	20.0	2.05	3.988	0.01	0.052	0.32	0- 00s	0.10
	HEMICHORDATA	4.0	0.41	11.428	2.60	0.789	4.76	0.078	1.48
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		074.0		438.782		16.581		S.389	

Appendix III (continued)

STATION	PHYLUM	--ABUNDANCE----- #/M2	%	------BIOMASS------ g/M2	%	--CARBON BIOMASS--- gC/M2	%	----CARBON PROD---- gC/M2	%
CH26	PROTOZOA	0.0	0.00	0-000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.168	0.10	0.015	0.22	0-002	0.08
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	48.0	8.S1	14.947	8.61	1.019	14.54	1.427	53. 20
	GASTROPODA	18.0	3.19	0.068	0.04	0-004	0.06	0.001	0.06
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	366.0	64.89	67.877	39.10	1.761	2s.11	0.528	19.69
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	126.0	22. 34	4. 422	2.55	0.337	4.80	0.337	12.55
	SIPUNCULA	4.0	0.71	86. 120	49.61	3. 87s	55.27	0.388	14.45
	ECHIURA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	ECHINODERMATA	2.0	0.3s	0.002	0.00	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		564.0		173.602		7.012		2.682	
CH27	PROTOZOA	8.0	1.04	0.001	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.306	0.62	0. 028	0.09	0.003	0.00
	NEMATODA	2.0	0". 26	0.001	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	176.0	2a. 80	29.768	60.14	1.997	69. 32	2.796	87.80
	GASTROPODA	42.0	5.44	1.766	3.s7	0.109	3.78	0.033	1.03
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	92.0	11.92	13.423	27.12	0.483	16.78	0.14s	4 56
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	420.0	54.40	2.781	5.62	0.198	6.88	0.108	6.23
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	18.0	2.33	0.096	0.10	0. 00s	0.17	0.000	0.02
	PRIAPULIDA	10.0	1.30	1.336	2.70	0.080	2.09	0.006	0.19
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERM'IATA	2.0	0.26	0.014	0.03	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	2.0	0.26	0. 002	0.00	0.000	0.00	0.000	0.00
		772.0		49.494		2.881		3.181	

STATION	PHYLUM	ABUNDANCE #/M2	%	BIOMASS g/M2	%	CARBON BIOMASS gC/M2	%	CARBON PROD. gC/M2	%
CH28	PROTOZOA	14.0	1.41	0.002	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0.20	0.037	0.03	0.002	0.02	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	1. 678	1.15	0.156	1.92	0.016	0.23
	NEMATODA	12.0	1.21	0. 00s	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	348.0	34.81	64. 640	44. 48	4.442	54.52	6.219	91.14
	GASTROPODA	26.0	2.62	0.939	0.65	0.0S8	0.71	0.017	0.26
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	112.0	11.27	s .563	3.83	0.182	2.24	0. 0s5	0.80
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	446.0	44. 87	3. 022	2.08	0.$306	2.53	0.206	3.02
	SIPUNCULA	4.0	0.40	68.590	4'7.20	3.087	37.80	0.309	4.52
	ECHIURA	24.0	2.41	0.070	0.05	0.004	0.04	0.000	0.01
	PRIAPULIDA	2.0	0.20	0.018	0.01	0.001	0.01	0.000	0.00
	BRYOZOA	0.0	0.00	0.178	0.12	0.002	0.02	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	2.0	0.20	0.026	0.02	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	4.0	0.40	0.562	0.30	0.008	0.10	0.001	0.01
		904.0		145.332		8.147		6.823	
CH29	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.104	0.16	0.010	0.24	0.001	0.02
	NEMATODA	16.0	2.18	0.003	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	362.0	49.32	50.774	7s .85	3.386	83.03	4.740	94.60
	GASTROPODA	26.0	3.s4	4.911	7.34	0.303	7.43	0.091	1.82
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	88.0	11.99	6.516	9.73	0.229	5.62	0.069	1.37
	PYCNOGONIDA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	218 0	29.70	1.558	2.33	0.106	2.59	0.105	2.11
	SIPUNCULA	loo	1.36	0.064	0.10	0.003	0.07	0.000	0 01
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	2.0	0.27	0.438	0.85	0. 00s	0.13	0.001	0.01
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	6.0	0.8%	0.750	1.12	0.010	0.20	0.001	0.02
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	6.0	0.82	1.826	2.73	0.026	0.63	0.003	0.05
		734 0		06.944		4.078		5 011	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH30	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0.25	2.261	3.26	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	2.0	0.2s	0.863	1.25	0.080	2.68	0.008	0.29
	NEMATODA	18.0	2.22	0.003	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	492.0	60.'74	24.607	3s .62	1.7'70	59.44	2.491	88. SS
	GASTROPODA	22.0	2.72	5 .702	8.32	0.358	11.97	0.107	3.6a
	CHITON	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	BIVALVIA	230.0	28.40	2s .366	36.63	0.629	21.00	0.189	6.70
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	40.0	4.94	0. 064	0.09	0. 004	0.13	0.004	0.13
	SIPUNCULA	2.0	0.25	0.006	0.01	0.000	0.01	0.000	0.00
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.202	0.29	0.002	0.0'7	0.000	0.01
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	2.0	0.2s	10.064	14.s3	0.141	4.71	0.014	0.50
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		810.0		69.258		2.993		2.813	
CH31	PROTOZOA	36.0	5.13	0.114	0.03	0.001	0.02	0.000	0.01
	PORIFERA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0 . 0 0
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0. 03a	0.01	0.003	0.05	0.000	0.02
	NEMATODA	8.0	1.14	0. 002	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	76.0	10.83	4. 8s4	1.38	0.396	7.05	0.554	34.23
	GASTROPODA	12 0	1.71	19.844	5.5s	1.472	26. 2S	0.442	27.29
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	42.0	5.08	33 .626	9.41	1.243	22.16	0.373	23.04
	PYCNOGONIDA	0.0	0.00	0-000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	248 0	35.33	0.118	0.03	0.001	0.01	0.000	0.00
	SIPUNCULA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0".00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	268 0	38.18	282.21a	78.96	2.261	40.31	0.226	13.97
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	12.0	1.71	18.910	4.65	0.233	4.1s	0.023	1.44
		702 0		357.418		5.610		1.619	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH35	PROTOZOA	64.0	0.92	0.013	0.01	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.066	0.04	0.003	0.10	0.000	0.02
	RHYNCHOCOELA	0.0	0.00	0.106	0.06	0.010	0.31	0.001	0.07
	NEMATODA	542.0	7.76	0.017	0.01	0.000	0.01	0.000	0.00
	ANNELIDA	1570.0	22.47	11.879	7.07	0.766	23.79	1.070	74.87
	GASTROPODA	66.0	0.94	1.348	0.80	0.081	2.51	0.024	1.69
	CHITON	8.0	0.11	0.458	0.27	0.028	0.89	0.009	0.60
	BIVALVIA	138.0	1.97	4.434	2.64	0.179	5.58	0.054	3.78
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	4470.0	63.97	1.698	1.01	0.071	2.23	0.064	4.46
	SIPUNCULA	14.0	0.20	0.166	0.10	0.007	0.23	0.001	0.05
	ECHIURA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.585	0.35	0.006	0.18	0.001	0.04
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	116.0	1.66	147.316	87.65	2.062	64.18	0.206	14.43
		6988.0		168.066		3.213		1.430	
CH34	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.005	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	8.0	0.35	0.046	0.04	0.004	0.06	0.000	0.01
	NEMATODA	302.0	13.15	0.015	0.01	0.000	0.00	0.000	0.00
	ANNELIDA	1018.0	44.34	33.516	25.56	2.336	34.03	3.270	65.38
	GASTROPODA	20.0	0.87	11.314	8.63	0.874	12.74	0.262	5.24
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	324.0	14.11	63.109	48.13	2.380	34.66	0.714	14.27
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	554.0	24.13	10.481	7.99	0.700	10.19	0.6[illegible]2	13.96
	SIPUNCULA	2.0	0.09	11.848	9.03	0.533	7.76	0.053	1.07
	ECHIURA	48.0	2.09	0.456	0.35	0.023	0.34	0.002	0.05
	PRIAPULIDA	4.0	0.17	0.318	0.24	0.014	0.21	0.001	0.03
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	6.0	0.26	0.019	0.01	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	10.0	0.44	0.009	0.01	0.000	0.00	0.000	0.00
		2296.0		131.128		6.865		5.0[illegible]2	

Appendix III (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH35	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.001	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.432	0.21	0.040	0.42	0.004	0.05
	NEMATODA	36.0	2.71	0.008	0.00	0-000	0.00	0.000	0.00
	ANNELIDA	682.0	51.36	69.893	34.45	4. 5?4	47.31	6.404	80.22
	GASTROPODA	22.0	1.66	2 .350	1.16	0.143	1.48	0.043	0.s4
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	208.0	15.66	121.541	59.91	4.432	4S .84	1.330	16.8S
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	248.0	18.67	2.620	1.29	0.172	1.78	0.172	2.16
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECH I URA	128.0	9.64	6.000	2,96	0.306	3.16	0.031	0.38
	PRIAPULIDA	4.0	0.30	0.028	0.01	0.001	0.01	0.000	0.00
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		1328.0		202. 873		9.669		7.983	
CH36	PROTOZOA	2.0	0.19	0.001	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0,004	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.140	0.10	0.013	0.20	0.001	0.03
	NEMATODA	10 0	0.86	0.002	0.00	0.000	0.00	0.000	0 0 0
	ANNELIDA	628.0	60.15	45.580	34.01	2.996	46.24	4.195	83.S5
	GASTROPODA	12.0	1.15	2 .006	1.50	0. 12s	1.94	0.038	0.7s
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	182.0	17.43	58.060	43.31	2.162	33.36	0.649	12.92
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	100 0	13.58	2.8S9	2.13	0. 0s0	0.77	0. 02s	0.50
	SIPUNCULA	2.0	0.19	23.942	17.86	1.077	16.63	0. 108	2.15
	ECH I URA	50 0	4.79	0.798	0.60	0.041	0.63	0.004	0.08
	PRIAPULIDA	42.0	4.02	0.336	0.25	0.015	0.23	0.002	0.03
	BRYOZOA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	16.0	1.53	0.324	0.24	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		1044.0		134.061		6.480		s .020	

STATION	PHYLUM	ABUNDANCE #/M2	%	BIOMASS g/M2	%	CARBON BIOMASS gC/M2	%	CARBON PROD gC/M2	%
CH37	PROTOZOA	218.0	8.S0	0.002	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.002	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.048	0.03	0.004	0.06	0.000	0.01
	NEMATODA	64.0	2.49	0.008	0.01	0.000	0.00	0.000	0.00
	ANNELIDA	572.0	22.29	5a. 188	37. 22	3. 584	49.79	4.980	89.95
	GASTROPODA	42.0	1.64	1. 920	1.37	0.119	1.66	0.038	0.04
	CH ITON	2.0	0.08	0.008	0.00	0-000	0.01	0.000	0.00
	BIVALVIA	168.0	8.59	5.085	3.83	0.186	2.60	0.056	1.01
	PYCNOGONIDA	2.0	0.08	0.012	0.01	0.001	0.01	0.001	0.0%
	CRUSTACEA	1310.0	51.0s	a. 723	1.04	0.157	2.19	0.152	2.74
	SIPUNCULA	74.0	2.88	65. 446	48.88	2.945	41.15	0. 29s	5.31
	ECH I URA	18.0	0.70	0.154	0.11	0.000	0.11	0.001	0.01
	PRIAPULIDA	4.0	0.16	0.0s4	0.04	0.002	0.03	0.000	0.00
	BRYOZOA	0.0	0.00	0.154	0.11	0.003	0.04	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	14.0	0.s5	0. 423	0.30	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	78.0	3.04	11.986	8.SS	0.168	2.34	0.017	0.30
		2566.0		140.211		7.1s7		S.S46	
CH39	PROTOZOA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.298	0.27	0.028	0.80	0.003	0.14
	NEMATODA	4.0	0.38	0.003	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	92.0	8.68	11.466	10.36	0.660	14.31	0.924	48.02
	GASTROPODA	20.0	1.88	0.546	0.49	0.034	0.73	0.010	0.53
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	768.0	72.32	56.830	51.34	a. 298	49.80	0.680	35.81
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	102.0	0.60	a .243	2.03	0.171	3.71	0.171	8.89
	SIPUNCULA	4 0	0.38	27.778	2s .00	1. a50	27.11	0 12s	6.50
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	10.0	0.04	0.110	0.10	0.005	0.11	0.000	0.03
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0 0 0	0.000	0.00	0.000	0 00
	ECHINODERMATA	62.0	5.84	11.422	10.32	0.168	3.83	0.002	0.09
	HEMICHORDATA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		1062.0		110.694		4.611		1.924	

STATION	PHYLUM	ABUNDANCE #/M2	%	BIOMASS g/M2	%	CARBON BIOMASS gC/M2	%	CARBON PROD gC/M2	%
CH40	PROTOZOA	2.0	0.10	0.004	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	COELENTERATE	16.0	0.79	0.136	0.0s	0.007	0.06	0.001	0.01
	RHYNCHOCOELA	0.0	0.00	0.282	0.11	0. 026	0.23	0.003	0.03
	NEMATODA	68.0	3.38	0.009	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	696.0	34.s6	90.293	34.03	e. 26a	54.47	8.767	88. 2s
	GASTROPODA	56.0	2.78	32.032	12.07	1.637	14.24	0.491	4.94
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	178.0	8.84	25.168	9.49	0. 7s0	6.s2	0. a2s	8.26
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	700.0	37.74	2.916	1.10	0.186	1.62	0.18S	1.87
	SIPUNCULA	38.0	1.89	0.535	0.20	0.024	0.21	o. ooa	0.02
	ECHIURA	134.0	6.6s	0.312	0.12	0.016	0.14	0.002	0.02
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	3. 772	1.42	0.036	0.33	0.004	0.04
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	22.0	1.00	101 .72a	38.34	2.436	21.19	0.244	2.4S
	HEMICHORDATA	0.0	0.00	0-000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	44.0	2.18	8.156	3.07	0.114	0.90	0.011	0.11
		2014.0		26S .337		11.496		Q . 03s	
CH43	PROTOZOA	554.0	14.07	0.018	0.02	0.000	0.01	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	2.0	0 .,0s	0.002	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.138	0.1s	0.013	0.63	0.001	0.09
	NEMATODA	110.0	2.79	0.006	0.01	0.000	0.00	0.000	0 00
	ANNELIDA	2s2.0	6.40	11.323	11.97	0.838	40.86	1.174	83.63
	GASTROPODA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CHITON	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	BIVALVIA	16.0	0.46	2.834	3.00	0.097	4.7s	0.029	2.08
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	CRUSTACEA	2616.0	66.43	S4 . 28a	57.40	0.681	33.20	0.157	11.19
	SIPUNCULA	8.0	0.20	1.926	2.04	0.087	4 22	0.009	0.62
	ECH I URA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PRIAPULIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRYOZOA	0.0	0.00	0.030	0.04	0.000	0.02	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	12.0	0.30	0.124	0.13	0.000	0.02	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	366.0	9.20	23.880	2s . 2s	0.334	16.29	0.033	2.38
		3938.0		94.569		2.052		1.404	

Appendix 111 (continued)

STATION	PHYLUM	ABUNDANCE #/M2	ABUNDANCE %	BIOMASS g/M2	BIOMASS %	CARBON BIOMASS gC/M2	CARBON BIOMASS %	CARBON PROD gC/M2	CARBON PROD %
CH44	PROTOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.001	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.002	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.036	0.03	0.003	0.0s	0.000	0.01
	NEMATODA	10.0	0.43	0.004	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	896.0	3$.82	25.669	18.23	1.349	19.91	1.88a	66.61
	GASTROPODA	8.0	0.34	6.130	4.32	0.400	7.24	0.147	5.19
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	674.0	29.0s	38.685	27.26	1.398	20.83	0.419	14.79
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	CRUSTACEA	94.0	4.0s	0.439	0.31	0.029	0.4s	0.029	1.0s
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	560.0	24.14	68.224	48.07	3.479	51 36	0.348	12.27
	PRIAPULIDA	8.0	0.34	0.04a	0.03	0.002	0.03	0.000	0.01
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	70.0	3.02	2.496	1.76	0.024	0.3s	0.002	0.08
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
		2320.0		141.928		6.774		2.835	
CH45	PROTOZOA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.006	0.03	0.000	0.01	0.000	0.00
	COELENTERATE	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	162.0	19.57	4.847	26.99	0.299	30.90	0.41s	59.88
	GASTROPODA	76.0	9.18	0.801	4.46	0.050	5.17	0.015	2.15
	CHITON	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	224.0	27.0S	9.002	50.13	0.419	43.68	0.126	18.14
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	CRUSTACEA	322.0	38.89	1.98S	11.05	0.131	13.67	0.131	18.92
	SIPUNCULA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHIURA	10 0	1.21	1.142	6.36	0.058	6.07	0.006	0.84
	PRIAPULIDA	6.0	0.72	0.110	0.61	0.005	0.s2	0.000	0 07
	BRYOZOA	0 0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0 0	0 00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	28 0	3 38	0.066	0.37	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	UROCHORDATA	0.0	000	0.000	0.00	0.000	0.00	0.000	0.00
		628.0		17.959		0.959		0.603	

Appendix III (continued)

STATION	PHYLUM	-ABUNDANCE----- #/M2	%	------BIOMASS------ g/M2	%	--CARBON BIOMASS--- gC/M2	%	----CARBON PROD---- gC/M2	%
CH47	PROTOZOA	0.0	0.00	0-000	0.00	0.000	0.00	0.000	0.00
	PORIFERA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	COELENTERATE	0.0	0.00	0.001	0.00	0.000	0.00	0.000	0.00
	RHYNCHOCOELA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	NEMATODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ANNELIDA	204.0	3a. 28	12.566	14.4s	0.749	17.26	1. 04e	60.04
	GASTROPODA	42.0	6.65	7.145	8.20	0. 4s7	10.53	0.137	7.8s
	CHITON	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BIVALVIA	116.0	18.3S	0.564	0.6S	0.019	0.44	0.006	0.3s
	PYCNOGONIDA	0.0	0.00	0.000	0.00	0.000	0.00	0-000	0.00
	CRUSTACEA	252.0	39.87	3.627	4.16	0.271	6.24	0.271	1s.50
	SIPUNCULA	4.0	0.63	63.148	72. 50	2. 84a	6S . SO	0.284	16..87
	ECH I URA	0.0	0.00	0.000	0.00	0-000	0.00	0.000	0.00
	PRIAPULIDA	2.0	0.32	0.024	0.03	0.001	0.02	0.000	0.01
	BRYOZOA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	BRACHIOPODA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	ECHINODERMATA	12.0	1.90	0.027	0.03	0.000	0.00	0.000	0.00
	HEMICHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0 00
	UROCHORDATA	0.0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
		632.0		87.102		4.338		1.746	

APPENDIX IV

Distribution of Fauna Along Transects

The fauna at benthic stations along five transects (Figure 78) were examined. A comparison of the stations were made according to dominant taxa, feeding method, motility, abundance, biomass, sediment type and organic content of sediment (Tables 1-6). A presentation of the five transects (A-E) is included below.

TRANSECT A

(Stations CH5, CH4, CH3, CH11, CH12)

Station CH5

The substrate at Station CH5 was mixed, with mud predominating (65%), followed by sand (19%) and gravel (15%). The benthic infaunal invertebrate abundance here was 3,656 individuals/m^2, the highest among stations along Transect A. Most benthic organisms residing here were either discretely motile (51%) or motile (44%) forms. The interface feeding organisms (surface deposit feeders and suspension feeders) that dominated in abundance reflected a surface-detritus based system where particulate organic carbon (POC) primarily accumulates on rather than within the sediment. The surface deposit feeding amphipods of the families Ampeliscidae and Isaeidae and cumaceans of the families Diastylidae and Leuconidae predominated. These groups accounted for nearly 80% of the station abundance. The predominant organisms, *Byblis* spp., belong to the amphipod family Ampeliscidae that may also suspension feed. *Byblis* is a genus that is characteristic of muddy sediment. This station is within an area where gray whales are known to feed in the summer on benthic amphipods.

Station CH4

At Station CH4, immediately offshore from Station CH5, approximately 70%! of the sediments here were sand; gravel accounted for 18%. The fauna were mainly sessile (54%) with 34% motile. The coarse substrates here was dominated by interface feeders, especially barnacles which utilize POC from the water column. Barnacles accounted for nearly 67% of the abundance. At this station the organic carbon values from the sediment, as well as the fauna, was highest among stations along the transect. Since the sediment carbon value was high and there were few subsurface deposit feeders it is implied that most of the sediment carbon was refractory. Although few in number, the sea cucumbers (Holothuroidea) dominated the carbon biomass.

Stations CH3 & CH12

The depth, substrate, and dominant benthic taxa at Stations CH3 and CH12 were similar. The sediment at these stations reflected a depositional environment with more than 97% of the substrate composed of mud. Organic carbon within the sediment and abundance values were similar. Station CH12 had a higher carbon biomass due mainly to the presence of protobranch clams of the family Nuculanidae. Polychaetes of the family Lumbrineridae (*Lumbrineris* sp.) and clams of the families Tellinidae (*Macoma calcarea*) were most numerous. Lumbrinerid worms obtain their food through a mixture of predatory and surface deposit feeding modes, while *Macoma* deposit feeds at the sediment surface. Other dominant surface deposit feeders common to Stations CH3 and CH12 were cumaceans of the family Leuconidae and polychaetes of the family Cirratulidae. Abundant subsurface deposit feeding groups common at both stations were the families Nuculanidae (clams) and Capitellidae (polychaetes). The organic carbon values in the sediment at these stations were also similar.

Station CH11

Station CH11, located between Stations CH3 and CH12, was mainly composed of the coarser fractions of sand (58%) and gravel (13%). The fauna here were primarily motile, although 26% of the abundance were sessile. Dominant organisms here mainly reflected a surface-detritus based system rather than a depositional and POC-accumulating environment. Surface deposit feeding polychaetes (Cirratulidae and Ampharetidae), amphipods (Ampeliscidae and Phoxocephalidae), and cumaceans (Diastylidae) dominated the abundance here. Since some subsurface deposit feeders were also fairly abundant (i.e., nuculid clams and maldanid polychaetes), some accumulation of POC also accumulates within the sediment.

Transect Summary

The substrate at stations along this transect passed alternately from mainly mud to sand. This patchiness of substrate types was also reflected in the fauna. In general, there was a trend of decreasing interface feeders from shore to sea and an increase of subsurface deposit feeders from shore to sea.

TRANSECT B

(Stations CH17, CH16, CH14, CH24, CH25)

Station CH17

Station CH17, located in the lee of Icy Cape in 23 m, was dominated by a sandy substrate (nearly 83%). Discretely motile and motile forms dominated the abundance with 59% and 30%, respectively. Here ampeliscid amphipods dominated the benthos in abundance and carbon biomass, therefore, the station indicated a surface-detritus based system. Ampeliscids, as well as two other numerically important amphipod families (Phoxocephalidae and Isaeidae) and a cumacean family (Diastylidae), utilize the POC deposited at the sediment surface, although the amphipods are also capable of suspension feeding. This station is within an area where gray whales are known to feed in the summer on benthic amphipods. Some accumulation of POC also occurs at this site since 11% of the abundance were subsurface deposit feeders, i.e., polychaetes (Maldanidae and Orbiniidae) and clams (Nuculanidae).

Station CH16

The next station offshore from Station CH17 was Station CH16 in 43 m. Here the benthic environment was mainly sand (58%) and gravel (32%); mud comprised only 10%. The fauna was extremely diverse with 143 taxa identified. Nearly 85% of the abundance were sessile organisms. Suspension feeders dominated with 84% of the abundance. More than 26,000 barnacles/m^2 were responsible for the high Simpson Diversity Index of 0.70. The high carbon biomass (16.2 gC/m^2) was due mainly to sea cucumbers (Holothuriodea) and astartid clams. Although this site is mainly characterized as a suspensory one, a reasonable amount of POC evidently reaches tha sediment surface as indicated by the numerous surface deposit feeders (9% of the abundance; e.g., isaeid, ampeliscid, phoxocephalid, and oedicerotid amphipods and cumaceans). Few subsurface deposit feeders were present (3% of the abundance).

Station CH14

Further offshore at Station CH14 the sediment had an increase in mud (S4%), but nearly 4S% was sand/gravel. Approximately 64% of the faunal abundance were motile and discretly motile; nearly 29% were sessile. The abundance of the fauna at this station (726 individuals/m^2) was less than 3% of that found at Station CH16, however, the carbon biomass was similar. The high carbon biomass was due mainly to sipunculid worms. The Simpson Diversity Index at Station CH14 was only 0.04. Because of the relatively high mud content deposit feeders dominated. Surface and subsurface deposit feeders accounted for 36 and 26% of the abundance, respectively. Only 7% of the abundance were suspension feeders. Therefore, since Station CH14 has a higher proportion of interface feeders it is characterized as mainly a surface-detritus based system. Some accumulation of POC also accumulates within the sediment as evidenced by the reasonably high abundance of subsurface deposit feeders. Although six groups were numerically important (the polychaetes - Lumbrineridae, Maldanidae and Ampharetidae; amphipods - Phoxocephalidae; brittle stars - Ophiuridae; and sipunculid worms - *Sipuncula*) at Station 14, no single group dominated.

Station CH24

Station CH24 was nearly 150 km offshore from Station CH14, but at a similar water depth. Here the substrate was predominately mud (77%) with moderate amount of sand (23%). No gravel was observed. The feeding modes of the fauna were mixed with organisms that feed at the sediment surface interface (33%) and ones that deposit feed within the substrate (46%).

Subsurface deposit feeding nuculid clams and surface deposit feeding gammarid amphipods dominated the abundance. Most of the abundance were discretely motile or motile.

Station CH25

The last station along Transect B, Station CH25, was about 380 km from shore in 51 m. Mud dominated the substrate here (99%). The organic carbon within the sediment (15.7 mg/g) and the carbon biomass (16.6 gC/m^2) here was the highest among stations along this transect. Interface feeders and subsurface deposit feeders accounted for 41 and 34% of the abundance, respectively. Tellinid clams (*Macoma* spp.) accounted for nearly 73% of the biomass. This group feeds at the sediment interface combining surface deposit feeding with suspenion feeding. Nuculid and tellinid clams accounted for nearly 44% of the abundance. As suggested by the extremely high carbon value at this station it is apparent that a high flux of POC to the bottom must occur here to sustain large numbers of both surface and subsurface deposit feeding organisms.

Transect Summary

The substrate along this transect became progressively muddier the farther from shore. As with Transect A, this transect displayed a general decrease of interface feeders and an increase of subsurface deposit feeders from shore to sea. Stations along this transect had the highest average values of sediment carbon, carbon biomass, and abundance among the five transects.

TRANSECT C

(Stations CH18, CH30, CH28, CH27, CH26, CH39)

Station CH18

Station CH18 consisted mainly of sand (90%) and organisms capable of utilizing mixed (mainly deposit and suspension feeders) feeding strategies. This station had the lowest abundance along Transect C, 462 individuals/m^2. Most of the faunal abundance were motile organisms; only about 6% were sessile. The sand dollar, *Echinarachnius parma*, dominated in abundance. This suspension-feeding echinoderm feeds at the sediment surface. Four of the numerically- important faunal groups feed at the sediment interface by suspension feeding and surface deposit feeding. These are the polychaetes Spionidae and Owenidae, sea cucumbers (Holothuroidea), and brittle stars of the family Ophiuridae. Based upon the physical composition of the sediment (i.e., 90% sand) this station represents a suspensory environment. Consequently, the POC present is available at the benthic boundary layer where it is used by the dominant suspension feeding sand dollar. The presence of subsurface deposit feeders (e.g., the polychaetes Pectinariidae, Opheliidae, and Orbiniidae) indicates that the relatively high organic content of the sediment is sufficiently nutritious to support these organisms as well.

Station CH30

Immediately offshore from Station CH18, in an area also dominated by sand (88%), was Station CH30. The fauna here did not typify that of a sand-dominated area because nearly 50% of the 10 dominant faunal groups were subsurface deposit feeders. Most were motile organisms. Sessile forms accounted for approximately 22% of the abundance. Surface deposit feeders were also present, but not as numerous as subsurface deposit feeders. Only one suspension feeding group was among the top ten abundant faunala groups, the clam family Thyasiridae (mainly *Axinopsida serricata*). Although the substrate at Stations CH18 and CH30 were similar, more resuspension of POC evidently occurs at Station CH18 than at Station CH30. Although the sediment carbon content was low (1.2 mg/g) as compared to Station CH13, the dominance of subsurface deposit feeders at Station CH30 indicates that the carbon present here is of high quality.

Station CH28

The substrate at Station CH28 was mainly sand (58%) and mud (36%). Approximately 85% of the organisms were motile or discretely motile. Nearly 52% were interface feeders and 23% were subsurface deposit feeders. Surface deposit feeding amphipods accounted for nearly 37% of the faunal abundance. The family Ampeliscidae, mainly *Byblis gaimardi*, accounted for 24% of the abundance. subsurface deposit feeders were also numerically important, in particular, polychaetes of the families Capitellidae, Maldanidae, and Orbiniidae. There were no suspension feeders among the 10 most abundant faunal groups (76% of the abundance). Abundant faunal groups present at both Stations CH28 and CH30 were Capitellidae, Maldanidae, Orbiniidae and Cirratulidae and clams of the family Nuculidae.

Station CH27

The sediment at Station CH27 consisted mainly of mud (90%). This station mainly resembles a surface-detritus based system, since the majority of the abundance were interface feeders. Approximately 51% of the faunal abundance consisted of four families of surface deposit feeding amphipods. *Haploops* and *Harpina* of the family Ampeliscidae dominated. Although surface deposit feeders were the most abundant forms, subsurface deposit feeders were also numerous, especially clams of the families Nuculanidae and Nuculidae and polychaetes of the families Sternaspidae and Orbiniidae. The presence of a high percentage of surface deposit feeders, as opposed to subsurface deposit feeders, suggest that a high flux of POC to the bottom occurs here, but that most of the carbon is utilized at the surface.

Station CH26

In contrast to Station CH27, where interface feeders dominated the muddy substrate, Station CH26 was dominated by subsurface deposit feeders in a substrate of less mud (51%) mud and more gravel (39%). Most (96%) were discretely motile and motile forms; few (3%) were sessile. Two subsurface deposit feeding clam families accounted for 55% of the faunal abundance. Nearly 20% of the abundance consisted of three families of surface deposit feeding amphipods. Abundant faunal groups in common at Stations CH26 and CH27 were the polychaetes Cirratulidae, the amphipods Ampeliscidae, Phoxocephalidae, and Lysianassidae, the clams Nuculanidae and Nuculidae, and the snails Retusidae.

Station CH39

Station CH39, the most distant from shore, had mostly a muddy substrate (96%), indicative of a depositional region. It had the highest abundance (1062 individuals/m^2) of all stations along this transect. There were few taxa here (31). Most (93%) of the faunal abundance were comprised of discretely motile and motile organisms. subsurface deposit feeders dominated, especially the nuculid clam *Nucula bellotti*, which accounted for more than 60% of the station abundance. This clam was responsible for the high Simpson Diversity Index of 0.44. Stations CH39 and CH26 were similar in that both were dominated by the clams Nuculidae, Nuculanidae, and

Tellinidae. Since most of the abundance at Station CH39 were subsurface deposit feeders one might conclude that the nutritional quality within the substrate was high, although the organic carbon value within the sediment was a low 1.6 mg/g. Furthermore, the abundant subsurface deposit feeding clams (Nuculidae and Nuculanidae) typically feed close to the sediment surface, adjacent to the newly deposit detrital zone.

Transect Summary

The substrate along this transect generally became progressively finer with increasing distance from shore. Interface feeders, as a percentage of the abundance, was generally lowest at the offshore end of the transect. Conversely, subsurface deposit feeders were most numerous farther from shore. The sediment carbon, carbon biomass, and abundance was generally low along this transect.

TRANSECT D

(Stations CH33, CH34, CH35, CH36, CH37, CH40)

Station CH33

Coarse substrate dominated Station CH33, 62% gravel and 34% sand, reflecting a suspensory environment. This station had the greatest abundance along the transect, 6,988 individuals/m^2. Approximately 67% of the faunal abundance were sessile organisms. Nearly 62% of the abundance were suspension feeding barnacles, 4,318/m^2. The preponderance of barnacles was responsible for the high Simpson Diversity Index, 0.44.

Station CH34

The sediment at Station CH34 had less gravel and more sand than at Station CH33. Here gravel, sand, and mud accounted for 33%, 50%, and 17%, respectively. Only 23% of the faunal abundance were sessile. Of the ten most abundant faunal groups surface and subsurface deposit feeders and suspension feeders were well represented. The carbon biomass at this station is primarily attributable to subsurface deposit feeding orbiniid polychaetes and nuculid clams, and surface deposit feeding/suspension feeding ampeliscid amphipods. Therefore, the environment at this station indicates that deposition of POC is sufficient to accumulate within and at the sediment surface, but not so much as to preclude the occurrence of suspension feeding organisms.

Station CH35

At Station CH35, where 70% of the sediment was mud, subsurface deposit feeders and interface feeders dominated the abundance. This reflected an environment of deposition where sufficient carbon appears to Be available to support both surface and subsurface deposit feeders. subsurface deposit feeding capitellid and sternaspid polychaetes and nuculid clams accounted for nearly 50% of the faunal abundance. Most (60%) of the abundance was comprised of motile forms .

Station cH36

Station CH36 had 49% sand, 30% mud, and 21% gravel. Approximately 35% of the faunal abundance were sessile organisms*, motile and discretely motile forms made up 33% and 29% of the abundance, respectively. subsurface deposit feeders dominated the faunal abundance, as well as the carbon biomass. Important subsurface deposit feeding families, in terms of abundance, were maldanid, capitellid and orbiniid polychaetes and nuculid clams. Common surface deposit feeders, in terms of abundance, presumably associated with the increased sand fraction at this station were echiurid worms, priapulid worms, and ampeliscid amphipods.

Station CH37

Coarse sediment was found at Station CH37; sand and gravel accounted for nearly 63% and 31%, respectively. This region can be characterized as a suspensory one. Sessile organisms amounted to more than 52% of the faunal abundance. Suspension feeders, in particular juvenile barnacles, dominated the abundance.

Station CH40

Station CH40, the outermost station along the transect, had mixed sediment. Mud , sand , and gravel accounted for 47%, 24% and 29%, respectively. A total of 94 taxa were identified, the most diverse station in the transect. Station CH40 had the highest biomass of all stations along this transect. More than 53% of the abundance were motile;about 15% were sessile. No single faunal group dominated as indicated by the low Simpson

Diversity Index of 0.04. Of the ten most abundant faunal groups, most were surface deposit feeders. Although surface deposit feeders dominate this station in terms of abundance, the subsurface-deposit feeding maldanid polychaete was a dominant in carbon biomass. Consequently, it is apparent that a high flux of POC to the bottom must occur to sustain surface and subsurface deposit feeders. That such a flux does occur is suggested by the high carbon value for this station, although the OC/N value and the δ^{13} values suggest that much of this carbon is refractory.

Transect Summary

The substrate along this transect displayed no obvious trend, rather it was relatively heterogeneous with high abundance and biomass values. Consequently, interface feeders generally were abundant throughout the transect.

TRANSECT E

(Stations CH43, CH44, CH45, CH47)

Station CH43

Gravel (60%) was the dominant sediment at Station CH43. In this suspensory environment, where 81% of the abundance were sessile organisms, suspension feeding barnacles dominated. This station had the highest transect abundance of 3,938 individuals/m^2. Nearly 65% of the abundance or 2,548 barnacles/m^2 were found here. This dominant group was responsible for the relatively high Simpson Diversity Index of 0.39.

Station CH44

Station CH44 was located immediately seaward of Station CH43. Gravel was absent here but sand and mud accounted for 48% and 52%, respectively indicative of a region of greater deposition. Motile and discretely motile forms accounted for about 76% of the abundance, both in similar proportions. Approximately 55% of the abundance was interface feeders. Surface and subsurface deposit feeders were also similar in abundance. The large surface deposit feeding echiurid worm, *Echiurus echiurus alaskensis*, dominated in abundance and carbon biomass.

Station CH45

The sediment at Station CH45 contained finer fractions than Station CH44. Mud predominated here with 73%; sand accounted for 27%. Most organisms were either motile or discretely motile forms. The abundance was dominated by Interface feeders. The surface deposit feeding amphipods from the family Ampeliscidae (mainly *Byblis gaimardi*) accounted for more than 23% of the faunal abundance. This genus typically resides in muddy sediments. The other important faunal groups were nearly equally divided between surface and subsurface deposit feeders. Only 6% of the abundance were suspension feeders. The carbon biomass here was the lowest of all stations (1 gC/m^2).

Station CH47

At Station CH47, the outermost station on the transect, the coarser fraction were reduced. In fact, the trend from shore to seaward along this transect was toward increasing muds or greater deposition. Station CH47 had the lowest transect abundance, 632 individuals/m^2. The motile, discretely motile, and sessile fauna accounted for 40%, 25%, and 19%, respectively. Deposit feeders dominated the abundance. The subsurface deposit-feeding polychaete family Maldanidae dominated the abundance and carbon biomass. Three amphipod families were the most abundant surface deposit feeders.

Transect Summary

The sediment at stations along this transect became progressively muddier the farther from shore. The sediment carbon values at the stations in this transect were all high with a trend of increasing values from onshore to offshore. However, the OC/N values and the $\delta^{13}C$ values suggest that the carbon, in general, is refractory at all stations, a circumstance to be expected in a shelf region underlying the Alaska Coastal Current (Grebmeier *et al.*, 1988).

Table IV.1 Summary of faunal and sediment parameters at five benthic station transects, southeastern Chukchi Sea, August-September 1985.

Transect	Sta Name	Depth m	Sediment G %	Sediment S %	Sediment M % 1/	Sediment Carbon mg/g	Abundance #/m²	Carbon Biomass gC/m²	Feeding Mode IF %	Feeding Mode SSDF %	Motility S %	Motility DM+M %
A	CH5	19	15	19	65	5.2	3656	6.6	81	4	5	95
	CH4	42	18	70	12	10.0	1592	13.7	67	2	54	45
	CH3	51	0	3	97	5.3	838	7.5	55	13	26	71
	CH11	32	13	58	29	6.4	1922	3.6	60	14	26	72
	CH12	44	0	0	100	4.4	758	11,4	46	28	12	87
B	CH17	23	3	83	14	6.1	4998	6.6	73	11	10	89
	CH16	43	32	58	10	4.3	31576	16.0	93	3	85	15
	CH14	47	18	27	54	8.1	726	12.1	44	26	29	64
	CH24	43	0	23	77	9.8	1270	7.6	32	46	6	87
	CH25	51	0	1	99	15.7	974	16.6	41	34	7	92
C	CH18	18	5	90	5	7.0	462	3.2	58	13	6	90
	CH30	39	0	88	12	1.2	810	3.0	32	50	22	77
	CH28	41	6	58	36	2.1	994	8.2	52	28	13	85
	CH27	42	0	10	90	1.6	772	2.9	56	23	6	93
	CH26	47	39	10	51	7.3	564	7,0	25	57	3	96
	CH39	48	0	4	96	1.6	1062	4.6	18	68	2	93
D	CH33	18	62	34	4	3.2	6988	3.2	80	6	68	30
	CH34	32	33	50	17	1.9	2296	6.9	48	32	27	67
	CH35	3’3	0	30	70	4.2	1328	'3.7	39	48	7	91
	CH36	44	21	49	30	1.5	1044	6,5	19	69	36	62
	CH37	47	31	63	6	2.1	2566	7.2	63	19	52	47
	CH40	45	29	24	47	7.8	2014	11 .5	51	19	18	78
E	CH43	23	60	20	20	5.5	3938	2.1	81	2	81	19
	CH44	31	0	48	52	7.7	2320	6.8	55	34	18	76
	CH45	45	0	27	73	9.5	828	1.0	47	25	6	85
	CH47	50	0	13	87	11.8	632	4.3	33	35	19	66

1/ Sediment: G = Gravel: S = Sand: M = Mud.
2/ Feeding Mode: IF = Interface Feeder: SSDF = Subsurface deposit feeder.
3/ Motility: S = Sessile:DM =Discretely Motile: M = Motile.
4/ Percent Feeding Mode and Motility is based on abundance,

Table IV.2 Station transects of dominant faunal groups as ranked by abundance--Transect A.

STATION	DOMINANT FAUNAL GROUP	ABUNDANCE #/M2	BIOMASS g/M2	CARBON gC/M2
CH5	AMPELISCIDAE	1644.0	9.186	0.625
	DIASTYLIDAE	632.0	1.002	0.074
	ISAEIDAE	514.0	0.808	0.055
	CIRRATULIDAE	160.0	0.398	0.027
	LEUCONIDAE	70.0	0.145	0.011
	SIGALIONIDAE	56.0	0.148	0.010
	MALDANIDAE	48.0	0.962	0.067
	COROPHIIDAE	44.0	0.052	0.003
	NUCULIDAE	32.0	5.454	0.213
	LYSIANASSIDAE	30.0	1.386	0.112
	OTHER	426.0	118.469	5.429
	TOTAL	3656.0	138.010	6.627
CH4	BALANIDAE	514.0	0.334	0.004
	FORAMINIFERA	224.0	0.005	0.000
	NEMATODA	134.0	0.009	0.000
	ISAEIDAE	74.0	0.106	0.007
	HOLOTHUROIDEA	54.0	287.298	6.892
	UROCHORDATA	46.0	50.502	0.707
	SYLLIDAE	38.0	0.083	0.006
	GAMMARIDAE	34.0	0.614	0.045
	LYSIANASSIDAE	32.0	3.692	0.299
	CIRRATULIDAE	32.0	0.524	0.036
	OTHER	350.0	113.823	5.655
	TOTAL	1592.0	456.990	13.651
CH3	LUMBRINERIDAE	142.0	0.470	0.044
	TELLINIDAE	86.0	61.802	2.163
	THYASIRIDAE	74.0	0.404	0.011
	NUCULIDAE	62.0	1.850	0.072
	LEUCONIDAE	44.0	0.190	0.014
	CNIDARIA	42.0	24.262	1.480
	MONTACUTIDAE	32.0	0.258	0.007
	CIRRATULIDAE	32.0	0.146	0.010
	NEPHTYIDAE	26.0	4.942	0.356
	CAPITELLIDAE	24.0	0.080	0.006
	OTHER	274.0	82.834	3.369
	TOTAL	838,0	177.238	7.532
CH11	CIRRATULIDAE	220,0	0.278	0.019
	AMPELISCIDAE	158.0	2.894	0.197
	DIASTYLIDAE	144.0	0.220	0.016
	PHOXOCEPHALIDAE	136.0	0.064	0.005
	AMPHARETIDAE	102.0	3.506	0.238
	NUCULIDAE	90.0	12.224	0.477
	LUMBRINERIDAE	84.0	0.438	0.041
	MALDANIDAE	72.0	0.789	0.055
	NEPHTYIDAE	72.0	1.870	0.135
	TRICHOBRANCHIDAE	62.0	0.990	0.06S
	OTHER	782.0	106.043	2.318
	TOTAL,	1922.0	129.316	3.569
CH12	LUMBRINERIDAE	124.0	0.8S0	0.0s2
	TELLINIDAE	110.0	103.532	3.624
	CIRRATULIDAE	104.0	0.480	0.033
	NUCULANIDAE	78.0	62.178	2.922
	NUCULIDAE	70.0	9.884	0.385
	NEPHTYIDAE	40.0	28.766	2.071
	LEUCONIDAE	28.0	0.125	0.009
	PECTINARIIDAE	26.0	9.854	0.443
	CAPITELLIDAE	22.0	0.138	0.010
	CNIDARIA	16.0	7.118	0.434
	OTHER	140.0	43.611	1.392
	TOTAL,	758.0	266.566	11.406

Table IV. 3 Station transects of dominant faunal groups as ranked by abundance--Transect B.

STATION	DOMINANT FAUNAL GROUP	ABUNDANCE #/M2	BIOMASS g/M2	CARBON gC/M2
CH17	AMPELISCIDAE	2530,0	25.612	1.742
	PHOXOCEPHAL IDAE	336,0	0.560	0.041
	DIASTYLIDAE	218.0	0.864	0.064
	MALDANIDAE	186.0	1.508	0.106
	ORBINIIDAE	178.0	0,496	0.030
	OWENIIDAE	156.0	0.482	0.033
	ASTARTIDAE	120.0	3.886	0.058
	OPHIURIDAE	108,0	14.632	0.205
	ISAEIDAE	98.0	0.063	0.004
	NUCULANIDAE	92.0	36.654	1.723
	OTHER	976.0	40.740	2.638
	TOTAL	4998.0	125.497	6.644
CH16	BALANIDAE	26134.0	10.794	0.119
	ISAEIDAE	654.0	0.691	0.047
	LEUCONIDAE	626.0	0.403	0.030
	AMPELISCIDAE	620.0	2.600	0.177
	OEDICEROTIDAE	330.0	0.316	0.023
	CAPITELLIDAE	326.0	0.150	0.010
	PHOXOCEPHALIDAE	298.0	0.318	0.024
	MALDANIDAE	280.0	17.872	1.251
	ORBINIIDAE	238.0	2.016	0.123
	NEMATODA	180.0	0.009	0.000
	OTHER	1890.0	576.499	14.188
	TOTAL	31576.0	611.668	15.992
CH14	LUMBRINERIDAE	86.0	8.436	0.785
	MALDANIDAE	72.0	24.560	1.719
	OPHIURIDAE	50.0	21.246	0.297
	NUCULIDAE	50.0	18.602	0.725
	AMPHARETIDAE	50.0	0.650	0.044
	PHOXOCEPHALIDAE	40.0	0.060	0.004
	AMPHIURIDAE	34.0	2.204	0.000
	SIPUNCULA	34.0	116.132	5,226
	CAPITELLIDAE	24.0	0.204	0.014
	MONTACUTIDAE	24.0	0.494	0.014
	OTHER	262.0	76.508	3.274
	TOTAL	726.0	269.096	12.103
CH24	NUCULIDAE	294.0	43.156	1.683
	GAMMARIDAE	118.0	0.604	0.045
	TELLINIDAE	108.0	31.010	1.085
	CAPITELLIDAE	84.0	0.672	0.046
	HOLOTHUROIDEA	82.0	5.670	0.000
	ORBINIIDAE	80.0	0.243	0.015
	STERNASPIDAE	58.0	18.308	0.751
	NUCULANIDAE	58.0	19.336	0.909
	LUMBRINERIDAE	46.0	14.726	1.370
	PHOXOCEPHALIDAE	36.0	0.027	0.002
	OTHER	306.0	40.735	1.710
	TOTAL	1270.0	174.487	7.615
CH25	NUCULIDAE	228.0	28.216	1.100
	TELLINIDAE	196.0	345.698	12.099
	LUMBRINERIDAE	120.0	1.450	0.135
	NEMATODA	70.0	0.016	0.000
	MONTACUTIDAE	56.0	0.530	0.015
	CAPITELLIDAE	42.0	0.102	0.007
	NUCULANIDAE	38.0	37.252	1.751
	LEUCONIDAE	26.0	0.140	0.010
	ORBINIIDAE	22.0	0.054	0.003
	GONIADIDAE	14.0	0.122	0.008
	OTHER	162.0	25.202	1.451
	TOTAL	974.0	438.702	16.581

Table IV.4 Station transects of dominant faunal groups as ranked by abundance--Transect C.

STATION	DOMINANT FAUNAL GROUP	ABUNDANCE #/M2	BIOMASS g/M2	CARBON gC/M2
CH18	ECHINOIDEA	174.0	74.740	0.598
	FORAMINIFERA	50.0	0.252	0.003
	SPIONIDAE	46.0	0.510	0.035
	SIGAL1ONIDAC	24.0	0.108	0.007
	HOLOTHUROIDEA	18.0	7.082	1.000
	OWENIIDAE	18.0	0.180	0.012
	OPHIURIDAE	10.0	1.910	0.027
	PECTINARIIDAE	16.0	2.460	0.111
	OPHELIIDAE	12.0	10.024	0.952
	ORBINIIDAE	12.0	0.442	0.027
	OTHER	74.0	38.942	1.432
	TOTAL	462.0	136.660	3.205
CH30	ORBINIIDAE	242.0	2.158	0.132
	THYASIRIDAE	132.0	0.576	0.016
	NUCULIDAE	68.0	3.042	0.119
	C. ON IADIDAE	52.0	0.080	0.006
	CAPITELLIDAE	50.0	0.032	0.002
	CIRRATULIDAE	34.0	0.050	0.003
	MALDANIDAE	30.0	4.689	0.328
	SIGALIONIDAE	26.0	0.050	0.003
	MAGELONIDAE	22.0	0.130	0.009
	NEMATODA	18.0	0.003	0.000
	OTHER	136.0	58.448	2.375
	TOTAL	810.0	69.258	2.993
CH28	AMPELISCIDAE	234.0	2.746	0.167
	CAPITELLIDAE	86.0	0.463	0.032
	PHOXOCEPHALIDAE	84.0	0.043	0.003
	MALDANIDAE	80.0	44,706	3.129
	NUCULIDAE	70.0	2.320	0.091
	CIRRATULIDAE	46.0	0.284	0.020
	OEDICEROTIDAE	46,0	0.035	0.003
	LEUCONIDAE	34.0	0.052	0.004
	ORBINIIDAE	28.0	0.206	0.013
	NEPHTYIDAE	28.0	10.636	0.766
	OTHER	2S6.0	83.833	3.901
	TOTAL	994.0	14 S.332	8.147
CH27	AMPELISCIDAE	258.0	1.644	0.112
	PHOXOCEPHALIDAE	68.0	0.050	0.004
	OEDICEROTIDAE	48.0	0.064	0.005
	NUCULANIDAE	46.0	0.964	0.04S
	STERNASPIDAE	42.0	6.762	0.277
	NUCULIDAE	32,0	0.514	0.020
	ORBINIIDAE	26.0	0.092	0.006
	RETUSIDAE	24.0	0.218	0.014
	CIRRATULIDAE	24.0	0.206	0.014
	LYSIANASSIDAE	20.0	0.774	0.063
	OTHER	184.0	36.206	2.322
	TOTAL	772.0	49.494	2.881
CH26	NUCULIDAE	200.0	8.420	0.32S
	NUCULANIDAE	112.0	8.636	0.406
	LYSIANASSIDAE	64.0	2.102	0.170
	TELLINIDAE	42.0	13.214	0.462
	PHOXOCEPHALIDAE	24.0	0.024	0.002
	AMPELISCIDAE	20.0	0.S06	0.034
	RETUSIDAE	12.0	0,012	0.001
	LUMBRINERIDAE	10.0	0.480	0.045
	NEPHTYIDAE	10.0	9.414	0.678
	CIRRATULIDAE	8.0	0.116	0.008
	OTHER	62.0	130.676	4.877
	TOTAL	564.0	173.602	7.012
CH39	NUCULIDAE	644.0	36.326	1.417
	TELLINIDAE	72.0	6.900	0.242
	HOLOTHUROIDEA	54.0	1.910	0.000
	NUCULANIDAE	38.0	13.518	0.635
	ISAEIDAE	20.0	0.240	0.016
	NEPHTYIDAE	26.0	4.916	0.354
	PHOXOCEPHALIDAE	24.0	0.021	0.002
	STERNASPIDAE	22.0	1.950	0.080
	LUMBRINERIDAE	16.0	0.080	0.007
	HAUSTORIIDAE	14.0	0.216	0.021
	OTHER	124.0	44.617	1.637
	TOTAL	1062.0	110.694	4.611

Table IV.5 Station transects of dominant faunal groups as ranked by abundance--Transect D.

STATION	DOMINANT FAUNAL GROUP	ABUNDANCE #/M2	BIOMASS g/M2	CARBON gC/M2
CH33	BALANIDAE	4318.0	0.762	0.008
	NEMATODA	S42.0	0.017	'3.000
	SPIONIDAE	662.0	0.708	0.049
	ORBINIIDAE	168.0	0.664	0.041
	SYLLIDAE	146.0	0.224	0.015
	CAPITELLIDAE	142.0	0.037	0.003
	UROCHORDATA	116.0	147.316	2.062
	CIRRATULIDAE	114.0	0.066	0.005
	SIGALIONIDAE	94.0	0.050	0,003
	AMPHARETIDAE	90.0	0.687	0.047
	OTHER	'96.0	17.535	0.980
	TOTAL	6988,0	16S.066	3,213
CH34	BALANIDAE	414,0	0.157	0.002
	ORBINIIDAE	384.0	4.494	0.274
	NEMATODA	302.0	0.015	0.000
	CIRRATULIDAE	272,0	0.206	0.014
	CAPITELLIDAE	182.0	0.115	0.008
	AMPELISCIDAE	118.0	10.208	0.694
	NUCULIDAE	100.0	28.202	1.100
	ECHIURIDA	48.0	0.456	0.023
	THYASIRIDAE	42.0	0.218	0.006
	PHYLLODOCIDAE	26.0	0.055	0.005
	OTHER	400.0	97.002	4.738
	TOTAL	2296.0	131.128	6.S65
CH35	CAPITELLIDAE	184.0	0.423	0.029
	STERNASPIDAE	178.0	11.998	0.492
	NUCULIDAE	154.0	47.0S2	1.836
	GAMMARIDAE	140.0	1.346	0.100
	ECHIURIDA	128.0	6.000	0.306
	CIRRATULIDAC	88.0	0.159	0.011
	ORBINIIDAE	68.0	0.250	0.015
	ISAEIDAE	60.0	0.108	0.007
	MALDANIDAE	48.0	9.098	0.637
	POLYNOIDAE	38.0	0.184	0.013
	OTHER	242.0	126.225	6.222
	TOTAL	1328.0	202.873	9.669
CH36	MALDANIDAE	338.0	24.762	1.733
	NUCULIDAE	162.0	34.250	1.336
	CAPITELLIDAE	118.0	0.203	0.014
	ORBINIIDAE	80.0	0.304	0.023
	ECHIURIDA	50.0	0.790	0.041
	PRIAPULIDA	42.0	0.336	0.015
	AMPELISCIDAE	26.0	0.182	0.012
	POLYNOIDAE	24.0	0.374	0.027
	LEUCONIDAE	18.0	0.034	0.003
	BALANIDAE	18.0	2.4S8	0.027
	OTHER	168.0	70.242	3.247
	TOTAL	1044.0	134.061	6.480
CH37	BALANIDAE	904.0	0.483	0.00S
	FORAMINIFERA	218.0	0.002	0.000
	AMPELISCIDAE	190.0	0.990	0.067
	CAPITELLIDAE	182.0	0.963	0.066
	MALDANIDAE	116.0	4S.66S	3.197
	NUCULIDAE	104.0	2.674	0.104
	CIRRATULIDAE	94.0	0.174	0.012
	UROCHORDATA	78.0	11.986	0.168
	SIPUNCULA	74.0	65.446	2.94S
	ORBINIIDAE	64.0	0.162	0.010
	OTHER	462.0	11.663	0.582
	TOTAL	2566.0	140.211	7.157
CH40	DIASTYLIDAE	190.0	0.130	0.010
	PHOXOCEPHALIDAE	158.0	0.108	0.008
	LEUCONIDAE	136.0	0.153	0.011
	CIRRATULIDAE	134.0	0.165	0.011
	ECHIURIDA	134.0	0.312	"0.016
	MALDANIDAE	120.0	65.870	4.611
	CAPITELLIDAE	110.0	0.346	0.024
	AMPELISCIDAE	92.0	1.594	0.108
	NEMATODA	68.0	0.009	0.000
	POLYNOIDAE	6S.0	2.118	0.155
	OTHER	804.0	194.532	6.S42
	TOTAL	2014.0	265.337	11.496

Table IV.6 Station transects of dominant faunal groups as ranked by abundance--Transect E.

STATION	DOMINANT FAUNAL GROUP	ABUNDANCE #/M2	BIOMASS g/M2	CARBON gC/M2
CH43	BALANIDAE	2548.0	52.946	0.582
	FORAMINIFERA	554.0	0.018	0.000
	UROCHORDATA	366.0	23.880	0.334
	NEMATODA	110.0	0.006	0.000
	CIRRATULIDAE	96.0	0.453	0.031
	GAMMARIDAE	66.0	1.336	0.099
	ORBINIIDAE	38.0	2.104	0.128
	AMPHARETIDAE	22.0	0.130	0.009
	GONIADIDAE	14.0	0.160	0.011
	CAPITELLIDAE	14.0	0.031	0.002
	OTHER	108.0	13.505	0.855
	TOTAL	3938.0	94.569	2.052
CH44	ECHIURIDA	560.0	68.224	3.479
	THYASIRIDAE	314.0	1.026	0.029
	OWENIIDAE	240.0	0.314	0.022
	STERNASPIDAE	218.0	13.584	0.557
	NUCULIDAE	120.0	0.638	0.025
	NUCULANIDAE	84.0	8.795	0.413
	MALDANIDAE	76.0	4.830	0.338
	ORBINIIDAE	74.0	0.442	0.027
	TELLINIDAE	74.0	0.190	0.007
	CAPITELLIDAE	70.0	0.247	0.017
	OTHER	490.0	43.638	1.861
	TOTAL	2320.0	141.928	6.774
CH45	AMPELISCIDAE	194.0	1.732	0.118
	NUCULANIDAE	82.0	8.742	0.411
	LEUCONIDAE	68.0	0.148	0.011
	TELLINIDAE	60.0	0.054	0.002
	PHOXOCEPHALIDAE	44.0	0.022	0.002
	NUCULIDAE	40.0	0.090	0.004
	MALDANIDAE	38.0	1.838	0.129
	TROCHIDAE	34.0	0.656	0.041
	CIRRATULIDAE	30.0	0.176	0.012
	STERNASPIDAE	28.0	0.850	0.035
	OTHER	210.0	3.651	0.196
	TOTAL	828.0	17.959	"0.959
CH47	MALDANIDAE	110.0	7.104	0.497
	AMPELISCIDAE	90.0	1.352	0.092
	LYSIANASSIDAE	56.0	2.094	0.170
	PHOXOCEPHALIDAE	54.0	0.040	0.003
	LEUCONIDAE	40.0	0.077	0.006
	NUCULIDAE	36.0	0.090	0.004
	CAPITELLIDAE	28.0	0.114	0.008
	CIRRATULIDAE	26.0	0,252	0.017
	STERNASPIDAE	18.0	3.448	0.141
	NUCULANIDAE	16.0	0.210	0.010
	OTHER	158.0	72.321	3.391
	TOTAL	632.0	87.102	4.338