BENTHIC INVERTEBRATE MACROFAUNA OF THE EASTERN CONTINENTAL SHELF OF THE BERING AND CHUKCHI SEAS

A

THESIS

Presented to the Faculty of the
University of Alaska in partial fulfillment
of the Requirements
for the Degree of

DOCTOR OF PHILOSOPHY

By
Samuel Whiteford Stoker, B.A., M.S.
Fairbanks, Alaska

December 1978

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Date

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ABSTRACT

The overall view presented by this study is of closely interrelated Bering/Chukchi benthic community system that extends unbroken over the entire continental shelf, with the Chukchi Sea benthos probably relying heavily on the Bering Sea for both food supply and possibly recruitment. Indications are that this is a highly productive and relatively stable benthic system comprised of at least eight major faunal zones of considerable complexity. The environmental factor correlating most strongly with the distribution of these faunal zones and with distribution of individual major species appears to be sediment type, though summer bottom temperature may also be critical.

The distribution of standing stock biomass in relation to diversity suggests predation pressure on the southern and northern extremes of the study area, presumably the result of benthic-feeding marine mammal populations and possibly, in the case of the southern region, demersal fish.

In general terms it appears to be a strongly detrital-based trophic system, with an elevated standing stock biomass observed in the Bering Strait and southern Chukchi Sea region, probably the combined result of high near-surface primary productivity distributions and current structure.

The benthic fauna over this region appears to be dominated by boreal Pacific forms, probably also a result of the current structure, with high Arctic forms frequent only in the northern waters.

ACKNOWLEDGEMENTS

First, I would like to express special gratitude to Dr. C. Peter McRoy, who initiated this whole course of events, who kept the faith in times of doubt, and who offered help and advice when it was needed and refrained from doing so when it was not, and to the other members of my committee: Dr. Frances Fay, Dr. John Goering, Dr. Howard Feder, Dr. Ted Cooney, and Dr. Richard Nevé.

I would also like to express my appreciation and gratitude to the captain, officers, and crews of the various ships which were employed in the acquisition of the sample data: the U.S. Coast Guard Icebreakers CGC *Northwind*, CGC *Glacier*, and CGC *Burton Island*, and the research vessels R/V *Alpha Helix* and, especially, R/V *Acona*.

In addition there is George Mueller of the Marine Sorting Center, University of Alaska, whose infinite patience, fortitude, and generosity of time and wisdom made possible the identifications related to this project.

As regards taxonomy and identification, I would likewise like to express my thanks to Ken Coyle, also of the Marine Sorting Center, University of Alaska, for his invaluable assistance with the amphipods of this collection, to Ray Baxter of the Alaska State Department of Fish and Game, Bethel, for his expert advice on the mollusks collected during this study, and to numerous other personnel of the Marine Sorting Center for their advice and assistance. Especially, I would like to express my appreciation to Carol Robinson, formerly of the

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I would like to express gratitude also to those whose aid in the area of statistical application and computer programming was invaluable, particularly to Ivan Frome, James Dryden, Dr. Charles Geist, Sydnie Hanson, Grant Metheke, and Rosmarie Hobson, all of or formerly of the University of Alaska.

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To. A. J. Paul and Judy MacDonald I would like to extend very special gratitude, appreciation, and admiration for the very considerable expertise they provided and time that they expended in the analysis of molluscan age and growth patterns.

There are numerous others whose aid was enlisted, in one form or another, in the completion of this study. Space does not permit the naming of all of them, but to all of them I would extend my great appreciation and the hope that I may someday be able to reciprocate.

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INTRODUCTION

The sublittoral benthos of the continental shelf of the Bering and Chukchi seas has been the subject of numerous investigations in the past (Neyman, 1960; Filatova and Barsanova, 1964; Kuznetsov, 1964; Vinogradova and Neyman, 1964; Ushakov, 1952; Rowland, 1973; Stoker, 1973). All of these studies have been descriptive in terms of qualitative and quantitative distribution, and have in some cases investigated trophic structure (Kuznetsov, 1964), controlling physical parameters (Neyman, 1960), faunal origin (Ushakov, 1952), or seasonal effects (Stoker, 1973). Previously, however, there has been no attempt to assess the benthic fauna of this combined Bering/Chukchi shelf in terms of distribution, controlling ecological parameters, areal interrelationships, seasonal and annual fluctuations, trophic structure, and growth and productivity rates. This study will attempt to shed light on some of these questions in order to enlarge our understanding of the benthic distributions and processes of the Bering and Chukchi seas. This is a first and rather crude step in this direction but one which hopefully will suffice to encourage and lend support to more sophisticated future investigations.

OBJECTIVES

The objectives of this study were:

(1) To define the qualitative and quantitative distributions of benthic invertebrate macrofauna over the eastern continental shelf of the Bering and Chukchi seas in terms of density, wet weight biomass, organic carbon and organic nitrogen biomass, caloric values and faunal diversity,

and to correlate such distributions with environmental factors such as depth, sediment type, latitude and longitude.

(2) To evaluate, insofar as possible, seasonal and annual fluctuations of the benthic standing stock.

(3) To assess the growth, age structure, and productivity rates of selected key species and to extrapolate such assessments to overall benthic resources of the area.

(4) To define faunal associations (communities) and to correlate the distribution of such associations with environmental factors.

DESCRIPTION OF STUDY AREA

The region sampled quantitatively under this study comprises most of the continental shelf of the Bering and Chukchi seas east of the Convention Line of 1867 and from about 56°N latitude to 73°N latitude, a total area of roughly 1,000,000 km^2 (Fig. 1).

The continental shelf of the Bering and Chukchi seas totals about 1,595,438 km^2. Almost two-thirds of this area (1,015,438 km^2) lies in the Bering Sea (Lisitsyn, 1969), with 580,000 km^2 comprising the Chukchi (Ingham and Rutland, 1970). About 45% of the Bering Sea, and all of the Chukchi Sea, lies on this continental shelf. The physical descriptions of these two seas are reviewed separately, although, as will be pointed out later on, the physical and biological processes of the two are closely interrelated.

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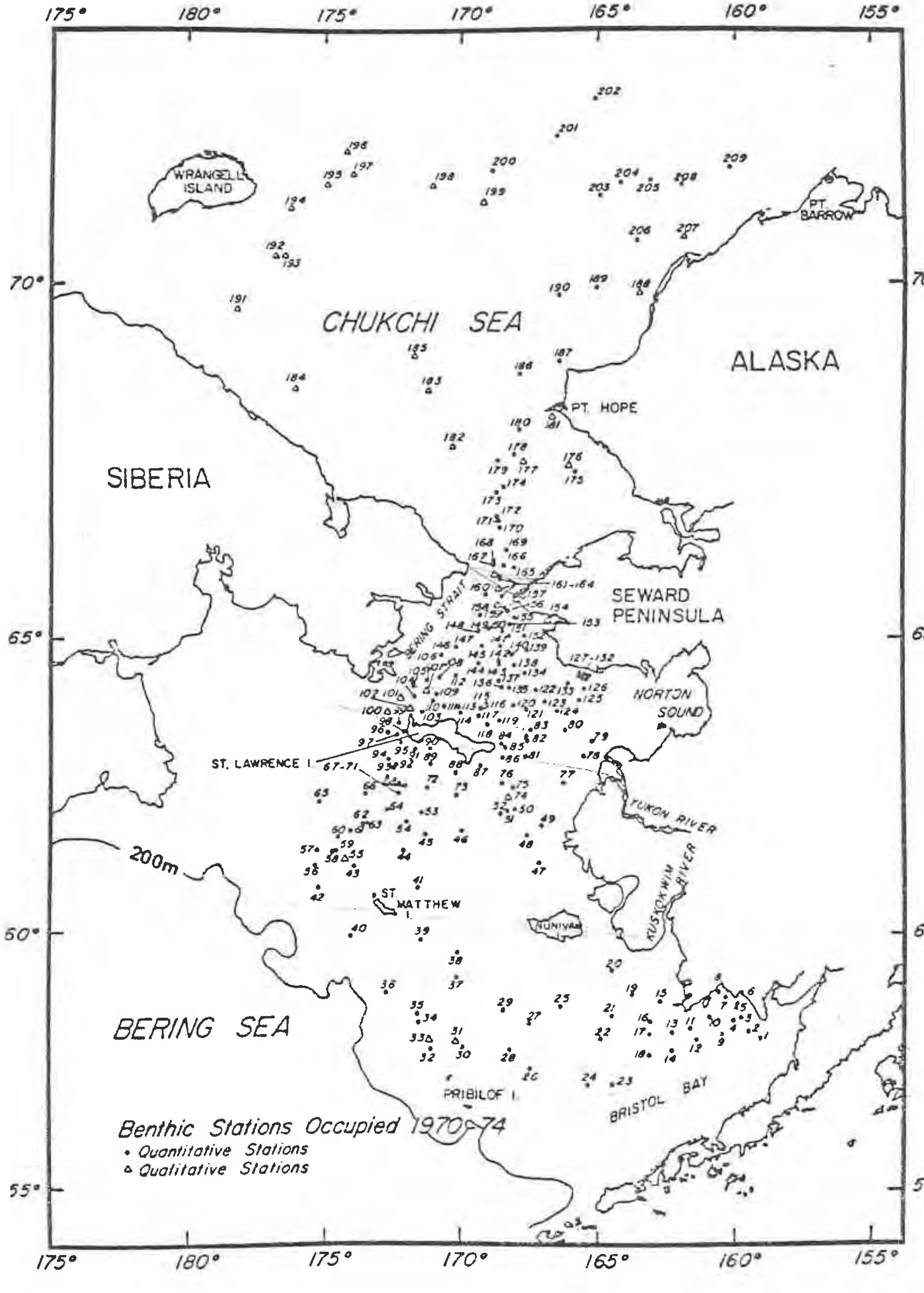

Figure 1. Benthic stations occupied on the Bering/Chukchi continental shelf.

Bering Sea

The Bering Sea is essentially an embayment of the North Pacific Ocean, separated from it only by the Aleutian-Komandorsky Island systems and the Alaska Peninsula. The sills between the islands are often of great depth, sometimes exceeding 4,000 m (Filatova and Barsanova, 1964), permitting virtually unrestricted exchange between the Bering Sea and the Pacific Ocean. By contrast, exchange with the Chukchi Sea and Arctic Ocean is limited to Bering Strait, 92 km wide and less than 50 m deep, and is virtually one-way (from south to north), though reversals have been observed (Coachman *et al.*, 1975).

The circulation of the Bering Sea south of St. Lawrence Island forms, in simplified terms, a huge counter-clockwise gyre (Fig. 2) with Pacific water entering through the Aleutian passes and moving generally north along the eastern side, thus endowing the eastern shelf with warmer bottom temperatures (Filatova and Barsanova, 1964). This main flow splits below St. Lawrence Island, part of it swinging westwardly and thence back south along the western margin, the other portion continuing north past St. Lawrence and through Bering Strait (Takenouti and Ohtani, 1974).

There are three major rivers emptying into the Bering - the Anadyr on the western side and the Yukon and Kuskokwim on the eastern. These three rivers account for 67% of the total runoff of 403.4 km^3/yr received by the Bering, with the Yukon providing 46% of this total (Lisitsyn, 1969). Surface sediments from Norton Sound, in the path of the Yukon plume, indicate that the bulk of the Yukon fine sediments are not being deposited upon entering the Bering but are probably being carried north

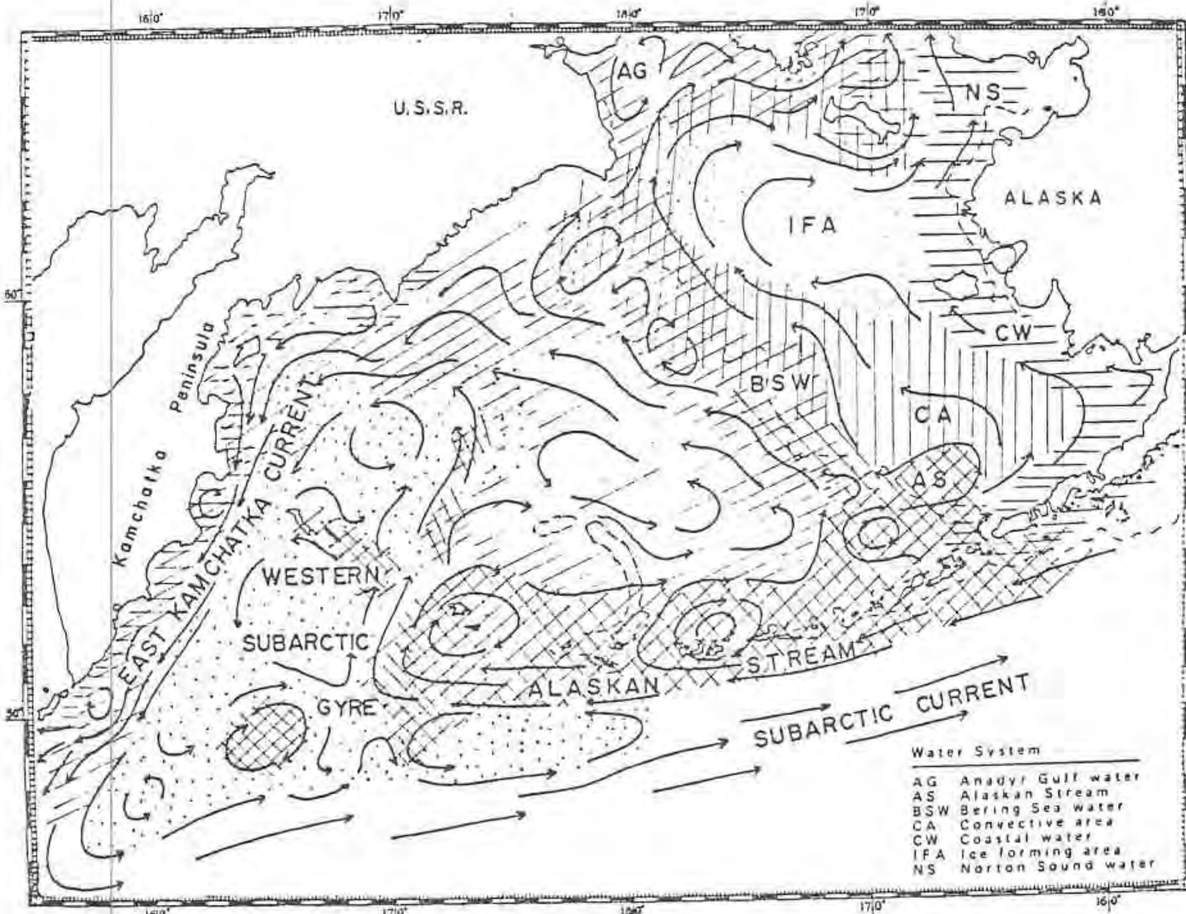

Figure 2. General patterns of surface circulation and extent of water masses over the Bering Sea continental shelf. From Takenouti and Ohtani (1974).

into the Chukchi (D. M. Hopkins, U.S.G.S., Menlo Park, personal communication). The Anadyr, on the western side, appears to plume south and out over the abyssal Commander Basin (Filatova and Barsanova, 1964). These observations have been limited to summer, and may not reflect winter conditions when the Bering Sea continental shelf waters are largely ice-bound. During a winter submarine survey beneath the ice pack south of St. Lawrence Island, a turbid layer was observed extending from about 35 m to the bottom, indicating a heavy suspended sediment load and possible winter deposition, of unknown type or origin (personal observation).

The Bering Sea shelf is extremely flat, averaging 4 to 6 cm/km in slope and exhibiting only scattered minor relief in the form of gently sloping depressions and low mounds and ridges, thought to be sediment-buried relics of sub-aerial erosion created during periods of Pleistocene emergence (Scholl *et al.*, 1968). The sediments of the shelf are generally terrigenous, steadily decreasing in particle size with depth from medium sand in the shallow zones to silt-clay at 100 m. Sorting seems to be somewhat correlated to latitude in that those sediments north of St. Lawrence appear to be more homogenous than do those to the south, possibly as a result of both current intensity and distance from the major sediment sources (Stoker, unpublished data).

The primary productivity of the Bering Sea is quite high, averaging 1.46 mgC/m^3-hr for Bristol Bay and 1.71 mgC/m^3-hr over the major part of the northeast shelf in summer (Taniguchi, 1969). Summer productivity in the Chirikof Basin, north of St. Lawrence Island, can be even higher, with 18.2 mgC/m^3-hr recorded at one station sampled (McRoy *et al.*, 1972). This productivity compares favorably with the highest values encountered in the world ocean. Recent investigations also indicate that productivity may be maintained at fairly high rates during the ice-covered months, at least during late winter and early spring, by diatoms utilizing the under surface of the pack ice as a substrate (McRoy and Goering, 1974), though the productivity of the water column beneath the ice is negligible during this period.

Available information regarding bottom temperature, salinity, and dissolved oxygen values is insufficient to present a detailed picture at this time, though some general conclusions may be drawn. Dissolved oxygen values seem to be near saturation during winter (Stoker, 1973) probably as a result of complete vertical mixing. During the summer, when some stratification does occur, these values probably decline somewhat, though no situations were encountered during the course of sampling for this study which would indicate oxygen depletion.

Salinities on the Bering shelf run somewhat lower than oceanic values, generally between 31°/₀₀ and 33°/₀₀ (Stoker, 1973; Takenouti and Ohtani, 1974).

Temperatures at or near bottom decline from east to west and from south to north, ranging, during summer, from 3°C or higher on the southeast shelf to near 0°C on the northern shelf (Takenouti and Ohtani, 1974; Neyman, 1960). During winter, the bottom water over the entire shelf is probably near the freezing point and may in some instances be supercooled (Stoker, 1973). Virtually all of the continental shelf region of the Bering is subject to seasonal sea ice, most of which forms *in situ* in the fall and winter and melts in place or is carried north in the spring. Far from being biologically detrimental, this seasonal ice is probably the key to much of the biological activity of the Bering, providing physical habitat for ice-dependent marine mammal species and for marine birds, and providing substrate and stratification conditions necessary to support late winter and early spring primary productivity of algae. This enhanced productivity and subsequent faunal activity at higher trophic levels is particularly apparent at the ice edge, resulting in a mobile zone of increased energetics which sweeps across the Bering shelf with the advance and retreat of the ice.

Chukchi Sea

The Chukchi Sea has received less research attention in all respects than has the Bering, and is consequently much less well described. Sufficient is known, however, to permit some comparisons.

While the Bering is essentially part of the North Pacific, the Chukchi is considered an embayment of the Arctic Ocean and thus, oceanographically, a part of the North Atlantic (Fleming and Heggarty, 1966). In terms of hydrographic conditions, sediment sources, and nutrient sources, however, the Chukchi seems in large part to be dependent on the inflow of Bering Sea water through Bering Strait (Fleming and Heggarty, 1966).

The current flow over the Chukchi shelf is generally from south to north, with Bering Sea water entering through Bering Strait and fanning out over the shelf to the Arctic Ocean. Current velocities diminish from values of about 30-35 cm/sec in the Strait region to 5 cm/sec in the central Chukchi (Creager and McManus, 1966). Warmer, less saline water holds to the eastern side of the shelf due to the coriolis effect (Fleming and Heggarty, 1966), as is the case in the Bering. As will be expanded upon later, this current structure and velocity gradient may be important to the benthic populations of the Chukchi shelf.

The terrigenous sediment sources for the Chukchi are primarily the rivers of the Bering Sea, namely the Yukon and Kuskokwim, whose fine sediments are swept north through the Strait. As might be predicted from the velocity gradient, sediment particle size decreases from south to north, from sand to silt, with a corresponding increase in homogenity (Creager and McManus, 1966). The only major river entering the Chukchi, the Kobuk, is probably insignificant as a sediment source compared to input from the Bering Sea.

The northern limit of the Chukchi is generally defined as the 200 m contour, where the continental shelf slopes off into the Arctic Ocean basin. As is the case with the Bering, the Chukchi shelf is by and large a flat plain, disturbed only by a few relict features of Pleistocene subaerial erosion such as the Hope Sea Valley.

Available data indicate that the temperature, salinity, and oxygen values for bottom water in the Chukchi are not greatly different from those for the Bering, with oxygen content near saturation, salinity ranging from 31°/₀₀ to 33°/₀₀, and temperatures ranging from 3°C or better to -1.0°C or below (Ingham and Rutland, 1970). As with the Bering, the Chukchi is seasonally ice-covered, generally from October through June.

The principal differences, in terms of physical conditions, between the shelves of the two seas is probably one of stress gradient. While there are no apparent abrupt changes in the environmental regimes, the Chukchi is, in general, subject to lower mean temperatures and to ice cover of greater extent and longer annual duration than is the Bering. Conversely, the Chukchi current system is, in general, less intense and complex than that of the Bering, with correspondingly greater homogeneity of sediment distributions.

There is little information available concerning the primary productivity of the Chukchi. Nutrient availability, light, and hydrographic conditions suggest that productivity should be high in the vicinity north of the Strait, as is the case south of the Strait in the Bering Sea. It may also be presumed that the mobile ice edge zone of enhanced productivity is likewise present in the Chukchi Sea. In addition to productivity generated in the Chukchi Sea itself, the current structure and velocity gradient suggest that the Chukchi may be the recipient of a significant portion of the particulate organics generated by or fed into the Bering Sea.

PREVIOUS INVESTIGATIONS OF THE BENTHOS ON THE BERING/CHUKCHI SHELF

Much more information is also available concerning the benthos of the Bering Sea than for the Chukchi Sea, though even for the Bering Sea large gaps in knowledge are apparent. Past benthic investigations of the Bering shelf benthos have been primarily Soviet, with major emphasis on the western shelf and the Gulf of Anadyr during summer. Only one study (Stoker,

1973) has assessed winter distributions and standing stock, and none have assessed seasonal and annual fluctuations.

Soviet studies of the western Bering shelf have described the faunal assemblages in two ways, by feeding (trophic) type (Kusnetsov, 1964), and by dominant species (Filatova and Barsanova, 1964; Neyman, 1960). In all descriptions of faunal assemblages by dominant species (Filatova and Barsanova, 1964; Neyman, 1960; Stoker, 1973), major elements of more than one trophic type are found, though generally one trophic type does exhibit numerical dominance within these assemblages.

From a review of available literature it appears that at least seven physical factors may influence the qualitative and quantitative distribution of Bering Sea benthic fauna. These factors are sediment particle size, bottom temperature, salinity, depth, sedimentation rates, circulation intensity, and suspended particulate content of the near-bottom water. Several of these conditions are interdependent. There seems, for instance, to be a close correlation between sediment particle size, depth, and circulation intensity, with particle size decreasing with depth and increasing with circulation intensity. Though it is difficult or impossible, given the data available, to define how these controlling factors influence distributions, it does appear possible to predict in a general sense the faunal composition and abundance of an area from descriptions of sediment particle size, bottom temperature, and depth (Neyman, 1960; Vinogradova and Neyman, 1964). Thus for the eastern Bering shelf in summer, with an average overall mean biomass of 74 g/m^2 wet weight, a mean biomass of 211 g/m^2 is attained on mud, muddy sand, and sandy mud at depths of 50-

150 m. At less than 50 m the bottom is sand, with a mean biomass of 8-50 g/m^2, and at depths greater than 150 m, where fine, soft mud prevails, the biomass decreases to 20-30 g/m^2. The highest local biomass occurs just south of St. Lawrence Island on muddy sand, reaching 500 g/m^2 (Neyman, 1960). Neyman (1960) conjectures that this higher biomass in the northern region is an indirect reflection of the low summer bottom temperatures of this region, which exclude most benthic feeding fishes. Vinogradova and Neyman (1964) further suggest that summer bottom temperature is the main determinant as to zoogeographical complex in this and related regions.

The maximum bivalve mollusk biomass on the Bering shelf, attaining, locally, 300 g/m^2, occurs on the northwestern shelf on muddy sand bottom, dominated by the species *Macoma calcarea, Leda (Nuculana) pernula, Nucula tenuis,* and *Serripes groenlandicus* (Neyman, 1960). In deeper water, on muddy bottom, *Yoldia hyperborea* and *Yoldia thraciaeformis* seem to predominate, while on the shallower southeastern shelf, with fine sand bottom, *Cyclocardia crebricostata* and *Clinocardium ciliatum*, with maximum species biomass of 90 and 160 g/m^2, respectively, are the leading bivalves. These distributions likely reflect both sediment type and bottom temperature as well as circulation patterns and suspended particulates (Neyman, 1960). The main concentrations of *Macoma calcarea, Nucula tenuis, Leda pernula,* and *Yoldia hyperborea* occur at bottom temperatures below 3°C, with *Macoma calcarea* seeming to prefer the -1°C to +1°C range and *Yoldia hyperborea* the 2-3°C range. *Yoldia thraciaeformis* is described as preferring temperatures around 2°C, while *Cyclocardia crebricostata* is found at temperatures exceeding 3°C (Neyman, 1960). These descriptions were all based on summer studies.

The maximum local biomass, in the Bering Sea, of the echinoid *Echinarachnius parma*, 494 g/m^2, is found south of St. Lawrence Island on muddy sand with bottom temperature between 2°C and 11°C. The asteroid *Ctenodiscus crispatus* is found at depths exceeding 100 m on mud bottom with temperatures in the 2-5°C range, where it reaches 200 g/m^2, while the holothurian *Chiridota* sp., attaining a biomass of 70 g/m^2, is found at 100-200 m on sand-gravel bottom just north of the Pribilofs. The most common echinoderm seems to be the ophiuroid *Ophiura sarsi*, which occurs on muddy sand south of St. Lawrence. At temperatures under 2°C this species attains a biomass of 140 g/m^2, falling to 82 g/m^2 at temperatures between 2°C and 3°C, and decreasing further, to 42 g/m^2, in the 3-4°C range, indicating a strong temperature preference by this species (Neyman, 1960).

The maximum polychaete biomass on the Bering shelf, between 50 and 100 g/m^2, occurs on muddy sand at temperatures greater than 2°C, while maximum amphipod biomass, 30 g/m^2, was encountered on muddy sand in the 0-1°C range (Neyman, 1960). All of these Soviet investigations use wet weight for standing stock measurements.

These Soviet results seem to be in general agreement with winter studies undertaken in the same area of the eastern Bering shelf. Though winter biomass figures from this area seem to be somewhat higher, the value of 127 g/m^2 (Stoker, 1973) is not significantly different in statistical terms from the 74 g/m^2 reported by Neyman (1960). During this winter study, a total of 129 species were identified, 8 of which constituted over 50% of the total numbers, wet weight biomass, and carbon biomass. Forty percent of the variability in density distribution of these 8 major species, as determined by stepwise multiple regression analysis, could be accounted for by sediment particle size, depth, temperature, salinity, and dissolved oxygen.

Unfortunately, no such detailed information is currently available regarding the benthic fauna of the Chukchi shelf. Such qualitative and semi-quantitative studies as have been undertaken in the southeastern Chukchi (Sparks and Pereyra, 1966) indicate that though more Arctic species are represented here than in the Bering Sea, the benthic fauna is primarily boreal Pacific in origin. It is conjectured (Sparks and Pereyra, 1966) that low bottom temperatures in this area may preclude *in situ* reproduction by many of the major species and that these species are dependent for recruitment on larvae swept north from the Bering Sea.

Ushakov (1952) also considers the Chukchi fauna to be a mixture of boreal Pacific and high Arctic forms, with the boreal Pacific forms tending to dominance on the eastern shelf within the regime of the warmer Bering Sea water. In general the Chukchi fauna is described as quantitatively depauperate compared to the Bering and Barents seas (Ushakov, 1952), though with locally high standing stock biomass evident in the southern Chukchi north of Bering Strait and along the eastern margin.

METHODS

Field Collection

The field sampling for this study spanned a four year period, from 1970 through 1974, and included both summer and winter collections. Sixteen quantitative stations were taken during January and February of 1970 from the icebreaker *Northwind;* 27 quantitative stations were taken from the icebreaker *Glacier* during March and April of 1971; 17 quantitative stations were taken during February and March of 1972 from the icebreaker *Burton Island;* 52 quantitative stations were taken during July, August and September of 1973 from the R/V *Acona* and R/V *Alpha Helix*; 69 quantitative stations were taken during June and July of 1974 from the R/V *Alpha Helix*. Stations were taken, during each cruise, at intervals of about 30 miles, weather and other factors permitting. Station patterns were concentrated in the north Bering Sea and Bering Strait region, an area considered critical to benthic-feeding marine mammal populations (Fig. 1).

At each quantitative station five samples were taken using a weighted 0.1 m^2 van Veen grab. It was determined from a previous assessment of results (Stoker, 1973) that five such replicate samples were sufficient to maintain statistically valid station descriptions. Non-quantitative samples of the infauna were taken with the van Veen where quantitative samples were not possible due to substrate type, and non-quantitative epifaunal samples were acquired by means of a 3 m otter trawl towed for durations of from 15 to 30 minutes depending on substrate type and faunal density. In all, a total of 176 quantitative and 33 non-quantitative stations were taken.

Once on board, each quantitative sample was washed and screened through 3 mm and 1 mm sieves and coarse and fine faunal fractions preserved separately in 10% buffered formalin for return to the laboratory. At stations where very coarse sediments were encountered, only the 3 mm faunal fraction was retained. At each station a sediment sample was obtained, also using the van Veen, and frozen for later analysis. Non-quantitative samples were sorted on board ship, the total numbers of each species or taxon recorded, and representative samples preserved in formalin for positive identification in the laboratory. Organisms of representative species were also collected from the non-quantitative samples and frozen so that comparative values could be obtained for frozen *versus* formalin-preserved samples in terms of organic carbon, nitrogen, and caloric content.

It must be pointed out that at none of the stations sampled was it feasible, given time limitations and/or ice conditions, to anchor the ship. While efforts were made to hold position as closely as possible, it is recognized that the 5 replicates comprizing a station may in fact be spread over a quite large area. This is particularly true of winter stations, where very rapid pack ice drifting was not infrequently encountered, resulting in the 5 samples comprising essentially a transect of a mile or more in length.

Laboratory Analysis

Upon return to the laboratory, the faunal samples were sorted and identified as to phylum, class, genus, and species, and the number of individuals and total wet weight of each species in each quantitative sample was recorded. Organisms not identifiable to species were identified to the closest possible taxonomic division and likewise counted and weighed. Due to time considerations and the apparently negligible biomass of the fine fractions, only one representative fine fraction sample of the five collected was processed, for comparative purposes, for most of the stations. All of the coarse fractions were processed. In the case of colonial organisms such as ectoprocts, sponges and some anthozoans, the number of individuals was listed as one per colony occurrence. Egg masses were identified to the closest taxon possible, included in the quantitative results, and assigned a density of one per occurrence. Fragments of animals, when no head or tail sections were present in the sample, were likewise identified to the closest taxon possible, assigned a total density of one per sample occurrence regardless of the number of such fragments, and included in the results.

Three common bivalve mollusk species (*Macoma calcarea, Serripes groenlandicus, Clinocardium ciliatum*) were saved from representative samples over the study area, sorted into 5 mm length increments, the shells removed, and shells and meat weighed separately to obtain shell/meat weight ratios for each size class. Shells were then analyzed (by A. J. Paul and J. McDonald, University of Alaska) to obtain age and growth rates.

The selection of these particular species for age and growth studies was made for reasons of: 1) practicality - established methods of age determination being available for these species; 2) areal distribution - these species occurring over most of the area in question; and 3) applicability - these species being of known importance in certain trophic pathways, particularly those of marine mammals. This latter factor applies especially to *Clinocardium* and to *Serripes* (Fay and Stoker, in preparation). *Macoma calcarea* was especially desirable as an indicator, in addition to the above, because of its dominate position in density, standing stock, and frequency of occurrence throughout much of the area, particularly on the northern Bering and southern Chukchi shelf.

All shells from these three species were examined under a 2X lens and shells with badly abraded surfaces were discarded (3% of the *M. calcarea* specimens collected). The screening process and subsequent formalin preservation destroyed the fragile shells of the majority of the very small specimens, and no quantitative data is available for the first 3 year classes. Age was determined for 2,463 remaining *M. calcarea*, and for 9 *C. ciliatum* and 399 *S. groenlandicus* by counting annuli - a series of closely spaced concentric growth lines which are the result of slow winter shell growth.

Since small numbers of *M. calcarea* were present at most sample stations, it was necessary to lump stations into 9 major groups, progressing from south to north. These groupings were determined, somewhat arbitrarily, by visual appraisal of the raw distributional data. It was hoped that this lumping of data into south to north groups would permit some assessment of latitudinal differences in growth rates.

Representative samples of each major species, including meat from mollusks analyzed for age and growth studies, were dried in a vacuum oven at 80°C for 12 hr, or until constant weight was obtained, and dry/wet weight ratios calculated. These dried samples were then pulverized and analyzed for organic carbon and nitrogen content using a Perkin-Elmer model 240 CHN Microanalyzer and for caloric content using a model 1221 Parr

Oxygen Bomb Calorimeter. For species suspected of high inorganic carbonate content (indifferentiable from organic carbon on the Perkin-Elmer), such as most echinoderms and some decapod crustaceans, alternate samples were acidified with 10% HCL solution to replace carbonates with chlorides (approximately equal molecular weight), re-dried, and analyzed for comparative organic carbon and nitrogen values. At least two replicates were processed for each sample for both CHN and caloric analysis. These values were then related to total wet weight for each species. For minor species not analyzed, values were extrapolated from the closest related taxon which was analyzed. Representative samples of frozen material was also analyzed for comparison with formalin-preserved results.

One sediment sample from each quantitative station was sieved through a series of standard sediment screens to obtain coarse fraction particle size percentages; remaining fine fractions were then subjected to standard pipette analysis to obtain fine fraction particle size percentages. Sediment mean and mode particle sizes are described by phi value (negative log to the base 2 of particle diameter in millimeters).

Data Processing

Upon completion of the laboratory analysis of samples, the resulting data were coded for incorporation in computer listing and analysis programs. Stations were coded sequentially from 001 to 209, with samples coded from 1 to 5 and appendixed onto the appropriate station code. Species were assigned an 8 digit code, the first 2 digits indicating phylum, the second 2 digits indicating class or other appropriate taxonomic division, the third 2 digits indicating genus, and the last 2 digits indicating species.

For each species, genus, class and phylum, appropriate values were entered on species information cards for conversion of wet weight to organic carbon and nitrogen biomass and caloric content. For each station, information cards were punched listing latitude and longitude, date sampled, water depth, sediment particle mean and mode size and, when available, bottom water temperature, dissolved oxygen content, and salinity. Cards were punched for each sample to indicate the species occurring at that sample, with the number of individuals and total wet weight listed for each species.

By means of a computer program (written by J. Dryden and C. Hanson, University of Alaska) this information was then utilized to provide a listing, by sample, station, and total area sampled, of (1) species present, (2) mean density and biomass in terms of wet weight, organic carbon and nitrogen, and caloric content by species, (3) mean totals for all species present, and (4) percentages of mean totals by species. All quantitative values were related to square meter area. For each station the Brillouin index of diversity was calculated and listed. The Brillouin index was judged preferable for this study in that it defines an index for each station independently, based only on information available for that station and not requiring knowledge of the population as a whole, according to the formula:

$$H = \frac{1}{N} \log \frac{N!}{N_1!N_2!\ldots.N_5!}$$

where:

H = index of diversity

N = total number of individuals of all species within the sample

$N_1 \ldots . N_5$ = number of individuals in species 1 through 5 within the sample.

Following completion of this main listing, all species were ranked according to their contributing percentage of total mean density and organic carbon biomass averaged over the total area. Those species comprizing, cumulatively, 95% of either density or organic carbon biomass were selected as indicator (dominant) species to be included in subsequent statistical analyses. Rare species (less than 4 station occurrences), organisms unidentifiable to species level, or species of questionable taxonomic certainty were excluded from this list. This ranking and listing was performed for both coarse and fine sieve fractions.

Using the quantitative results pertaining to these selected indicator species, a station cluster analysis was then performed in order to group stations according to faunal similarities. This program clustered stations on the basis of similarities in relative (percent) species composition, applying the formula

$$C = \Sigma_i^e \frac{2W}{A+B}$$

where:

C = affinity coefficient

A = percentage density comprized by species i-e at station A

B = percentage density comprized by species i-e at station B

W = the lesser percentage value comprized by species i-e at either station A or B

Species i-e = assessed species occurring at either station A or B. It was felt that the use of relative (percentage) density for this station cluster analysis would tend to mask out the apparently considerable density variations encountered and would thus be more applicable for defining faunal or ecological provinces irrespective of standing stock variations within provinces. This same cluster analysis program was then applied to quantitative data pertaining to species distributions in order to evaluate interspecific associations. Species clustering was performed both over the entire study area and within station cluster groups as determined from the first cluster analysis.

Stepwise multiple regression analyses (BMD-02R) were then employed in order to define correlations between major species distributions and environmental factors. For these results, the increase in R-squared was accepted as equivalent to a correlation percentage coefficient for the factor assessed.

Finally, a series of analyses of variance programs were run (Geist-Ullrich-Pitz, ANOVAR) in order to assess seasonal and annual fluctuations in density and standing stock of the major (indicator) species.

For estimation of natural mortality of *M. calcarea*, the technique developed by Gruffydd (1974) was applied. Gruffydd, working with the scallop *Pecten maximus* (L.), theorized that although recruitment varies from year to year in a given spot, overall recruitment in a large area is fairly constant. Accepting this assumption, he constructed a curve by plotting the total number of scallops from 30 areas against age on a semi-logarithmic scale. The curve thus created eliminated the effect of uneven recruitment apparent in individual samples. Utilizing the number of individuals estimated from the curve rather than from the actual catch, he was able to assess the total mortality (Z) from the expression $N_t + 1$ = the number of age t + 1. This method was applied to *M. calcarea* in the Bering and Chukchi seas.

Upon completion of the mortality and age structure estimates, an estimate of the net productivity (P_t) over the sample area in $mgC/m^2/yr$ was arrived at for *M. calcarea*, for age classes 4 through 10, using the equation:

$$P_t = Pm + Pg$$

$$P_m \text{ (mortality)} = D(Y_x M_x W_x + \text{---} \; Y_y M_y W_y)$$

$$P_g \text{ (growth)} = D(G_x Y_x + \text{---} \; G_y Y_y)$$

Y_{x-y} = percent of total population comprised by year class x-y

M_{x-y} = percent mortality expected at age x-y

W_{x-y} = mean weight/individual (mg organic carbon) at age x-y

G_{x-y} = mean growth (mg carbon/individual/yr) at age x-y

D = mean density (individual/m^2).

RESULTS

Physical Description of Stations

The 176 quantitative stations included in this study encompass approximately 14 degrees of latitude, from 57°05'N to 71°12'N, and 16 degrees of longitude, from 158°56.5'W to 175°12'W. Non-quantitative epifaunal stations extend as far west as 186°06' (Fig. 1) but are not included in environmental correlation analysis. Stations were obtained over a period of four years, and include observations from all seasons (Appendix 1).

The mean water depth at the 176 quantitative stations was 45 m, with a range of from 6 to 105 m. Sediment mean particle size over the 162 stations for which sediment analysis was run averaged 3.75 phi with a range of from -1.00 phi to 8.09 phi. Sediment mode particle size ranged from

-1.00 phi to 7.00 phi, with a station mean of 3.39 phi. Sediment mode phi size was the parameter used for correlation of sediment type to faunal distribution. As may be seen (Appendix 2) at any given station, sediment mode and mean size was, with a few exceptions, close to the same value.

Near-bottom temperature and salinity values were obtained, in conjunction with standard hydrographic sampling, at 55 of the 176 quantitative stations (Appendix 2). Salinity values averaged 32.19°/₀₀ with a range of from 30.23°/₀₀ to 34.02°/₀₀. Winter and early spring temperatures ranged from -1.87°C to 0.74°C, with mean value -1.25. Almost all winter and spring temperatures were below 0°C, with the lowest values occurring during March and April. In some instances, these extremely low temperatures indicate supercooling for water of corresponding depth and salinity (Stoker, 1973). Summer bottom temperatures ranged from -0.86°C at a station just north of the western end of St. Lawrence Island to 9.71°C in northern Bristol Bay, with a mean value of 3.47°C.

Near-bottom oxygen values were obtained for 47 of the 176 quantitative stations. The range of these values was from 6.35 ml/l to 8.68 ml/l, with a mean of 7.67 ml/l over the stations sampled (Appendix 2).

Temperature, salinity, and oxygen values were not utilized for faunal correlation analysis, for the following reasons. It is felt that winter temperatures do not greatly affect the distribution of faunal complexes in this region (Neyman, 1960; Vinogradova and Neyman, 1964), though summer temperatures probably do. Unfortunately, far too few summer temperatures are available at this time to permit a valid correlation analysis. Salinity values are generally fairly uniform over the study area and probably, with the possible exception of some nearshore regions near large fresh water sources such as the Yukon River, nowhere exhibit extremes likely to influence faunal distributions. Oxygen values are likewise fairly uniform, are always near saturation, and are nowhere considered to be biologically limiting.

As may be seen (Appendix 2), almost no temperature, salinity or oxygen data is available for stations north of Bering Strait.

Quantitative Biological Results

From the stations sampled, a total of 472 species were identified, encompassing 292 genera and 16 phyla (Appendix 3). The most ubiquitous major taxonomic group in terms of frequency of occurrence, and that comprising the most species, were the polychaetous annelids, occurring at 168 of the 176 quantitative stations and including 143 identified species and 93 genera. Bivalve mollusks were close behind in frequency, occurring at 167 stations, but comprising only 54 species and 29 genera. Gastropod mollusks occurred at 146 stations, with 76 species and 38 genera. Seventy-six amphipod species and 42 genera were identified, occurring at 158 stations. Other taxonomic divisions followed with fewer species, genera, and frequency of occurrence (Table 1).

Of the 176 quantitative stations, biological results of 50 are based on analysis of coarse sieve (3 mm) fraction only. For 18 of the earlier stations, the coarse and fine (1 mm) sieve fractions were lumped and analyzed as one total sample. These stations (Appendix 4) are indicated by an asterisk. For the remaining 108 stations, one fine fraction was selected at random and processed separately from the coarse fractions for comparison as to species present, density, and biomass (Appendices 5 and 6).

Table 1. Means and percentages of total means for major taxonomic groups encountered on the Bering/ Chukchi shelf (all others comprise less than 1% of any value).

Taxa	Density indiv/m^2	% Total	Wet Wt. g/m^2	% Total	Organic Carbon g/m^2	% Total	Organic Nitrogen g/m^2	% Total	cal/m^2	% Total
Crustacea	689.9	60.0	37.8	12.6	2.5	23.4	0.45	19.8	28651	22.9
Amphipoda	689.0	59.9	33.9	11.3	2.3	21.6	0.41	17.9	25954	20.7
Brachyura	0:9	0.1	3.9	1.3	0.2	1.8	0.04	1.9	2697	2.2
Polychaeta	190.0	16.5	28.8	9.6	1.9	17.7	0.50	21.6	20117	16.0
Molluska	166.6	14.5	126.4	42.0	4.1	38.0	0.81	35.1	48906	39.0
Bivalvia	151.5	13.2	114.9	38.2	3.4	31.7	0.65	28.3	41383	33.0
Gastropoda	15.1	1.3	11.5	3.8	0.7	6.3	0.16	6.8	7523	6.0
Echinodermata	54.8	4.7	81.1	27.0	1.0	9.5	0.21	8.8	12958	10.3
Ophiuroidea	31.9	2.8	9.8	3.3	0.2	2.3	0.05	2.0	2959	2.4
Echinoidea	19.6	1.7	56.2	18.7	0.5	4.5	0.07	2.9	6561	5.2
Holothuroidea	2.8	0.2	4.5	1.5	0.1	0.9	0.04	1.7	1149	0.9
Asteroidea	0.5	0.1	10.6	3.5	0.2	1.8	0.05	2.3	2289	1.8
Ascidiacea	18.0	1.7	7.0	2.3	0.3	2.6	0.07	3.0	3332	2.7
Anthozoa	8.0	0.7	7.0	2.3	0.4	3.7	0.10	4.5	4605	3.7
Sipunculida	2.4	0.2	5.9	2.0	0.3	2.6	0.09	3.8	3190	2.5
All Others	22.3	1.7	6.8	2.2	0.4	2.5	0.07	3.4	3678	2.9
Total	1152	100	300.8	100	10.8	100	2.3	100.0	125437	100.0

These comparisons will be discussed later. For the present it should be kept in mind that the following species occurrence, density, standing stock biomass, carbon/nitrogen ratio, and diversity index results are based only on the coarse sieve fractions with the exception of those 18 stations where coarse and fine fractions were lumped.

The number of species occurring at any one station over the study area varied greatly, ranging from a low of 3 at Station 117 to a high of 82 at Station 209 (Appendix 4), with a mean of 30 ± 2 (all data ± 95% confidence limits). Density (total number of individuals of all species per square meter) also varied greatly, as do all standing stock values. Density ranged from 38 indiv/m^2 at Station 116 to 8,760 indiv/m^2 at Station 144, with a mean of 1,152 ± 239. Total wet weight biomass averaged 300.8 ± 51.3 g/m^2, ranging from 6.8 g/m^2 at Station 69 to 2,230.8 g/m^2 at Station 158. Organic carbon biomass ranged from a low of 0.3 g/m^2 at Stations 10 and 11 to 56.5 g/m^2 at Station 172, with a mean value of 10.8 ± 1.6 g/m^2. Organic nitrogen biomass ranged from 0.1 g/m^2 at Stations 10, 11, 51 and 52 to 12.9 g/m^2 at Station 172, with a mean of 2.3 ± 0.3 g/m^2. Caloric values averaged 125,437 ± 18,865 cal/m^2, ranging from 3,678 cal/m^2 at Station 10 to 626,694 cal/m^2 at Station 172. It should be noted that the carbon, nitrogen, and caloric high values all occurred at the same station (172), but that the wet weight high value occurred at a different station (158), thus lending support to the use of measurements other than wet weight biomass. With the exception of one of the low organic nitrogen values, none of the extreme high or low values occurred at one of those 18 stations where fine and coarse fractions were lumped.

The ratio of organic carbon to organic nitrogen varied surprisingly, from a low C/N ratio of 1.8 at Station 22 to a high ratio of 8.0 at Station 82, with a mean ratio of 4.6 ± 0.1 (Appendix 4). This mean station ratio of 4.6 does not differ significantly from the species analysis mean ratio of 4.3 ± 0.3.

Considered by major taxonomic division, the amphipods lead in density with a mean value (3 mm sieve fraction) of 690 indiv/m^2 (Table 1), almost 60% of the total, though they constitute only 21.6% of the organic carbon biomass. Bivalve mollusks, on the other hand, constitute almost 32% (3.4 mg/m^2) of the carbon standing stock over the area sampled, but account for only 13% of the population density. Polychaetes comprise 16% of the overall population density and 18% of the carbon biomass. Other groups (Table 1) account for much lower percentages in any category.

The species index of diversity (Brillouin) of the 176 quantitative stations ranges from a low of 0.093 at Station 82 to a high of 1.414 at Station 208, with an overall mean value of 0.842 ± 0.040. The least diverse station lies off the east end of St. Lawrence Island, while the most diverse station is an offshore station in the northern extremes of the Chukchi (Appendix 4).

It should be kept in mind that these standing stock and diversity values, averaged as they are over all stations and over the total sample area, are of limited reliability and application. For one thing, the bulk of the stations are concentrated in the north Bering Sea region, which thus necessarily biases such mean values toward that area. Also, though the most exhaustive possible station coverage was obtained given the resources available, it is felt that even within areas where the station frequency is greatest, the patchiness of the fauna and large local standing stock variances make such mean values marginally acceptable, though they are of some value for purposes of comparison with other regions of the world.

Comparison of Sieve Fraction Results

In order to estimate the effect of utilizing only (with 18 exceptions) the coarse (3 mm) sieve fractions for density, standing stock, and species distribution analyses, one representative fine (1 mm) sieve fraction was processed from each of 108 of the 176 quantitative stations and results compared to coarse fraction results from the same station and sample (Table 2; Appendix 5 and 6). From these results, it is estimated that the number of species occurring in the fine fractions is considerably greater (224 ± 27% per sample) than in the coarse fractions. A mean number of 23 ± 1 species per sample were identified from the fine fraction samples as compared with 13 ± 1 species for the coarse fractions, averaged over all samples compared. The range of this fine/coarse species percentage is from 73% at Station 96, sample 2 to 1,000% at Station 82, sample 2. The species composition of the fine fractions is also significantly different from that of the coarse fractions, the two fractions having, on the average, only 19 ± 2% of their total combined species in common. This percentage ranges from 0% at Station 56, sample 5, Station 72, sample 2, and Station 82, sample 2, to a high of 46% at Station 49, sample 3 (Appendix 6).

The mean density (indiv/m^2) of the fine fractions averaged 633 ± 170% that of the coarse fractions for the same samples, ranging from 33% at Station 147, sample 1, to 5,765% at Station 28, sample 2. At only 6 of

Table 2. Comparison of fine to coarse sieve sample results (means) from benthic stations on the Bering/Chukchi shelf, with 95% confidence intervals.

	Coarse 3 mm fraction	Fine 1 mm fraction
No. species	13 ± 1	23 ± 1
Density (indiv/m^2)	1134 ± 313	3471 ± 792
Organic carbon (g/m^2)	10.74 ± 2.16	0.82 ± 0.15
Diversity index	0.834 ± 0.045	0.920 ± 0.040

Coarse to fine fraction species in common per station = 5.7 ± 0.7

Coarse to fine fraction species different per station = 24.2 ± 1.6

Total coarse and fine fraction species per station = 29.9 ± 1.9

Percent species in common per station = 19 ± 2%

the samples compared was the coarse fraction density greater than that of the fine fraction. Total mean density for the coarse fractions compared was 1,134 ± 313 indiv/m^2; total mean density for the fine fractions was 3,471 ± 792 indiv/m^2 averaged over all samples.

Conversely, the coarse fractions comprised much the bulk of the standing stock biomass. Comparing organic carbon biomass, the fine fractions yielded, by station average, only 23.8 ± 10.7% the biomass of the coarse fractions, with a range of from 0.31% at Station 96, sample 3, to 376% at Station 30, sample 1. Organic carbon biomass of the fine fraction exceeded that of the coarse fraction from the same sample at only 5 of the 108 stations and samples compared. Total mean carbon biomass for the coarse fractions was 10.74 ± 2.16 mg/m^2 as compared to 0.82 ± 0.15 mg/m^2 for the fine fractions (Appendix 5) averaged over all samples compared.

The diversity index (Brillouin) of the fine fraction samples ran somewhat higher than that of the compared coarse fractions, though not greatly so. The index of diversity for the fine fractions ranged from a low of 0.166 at Station 47, sample 3, to a high of 1.273 at Station 208, sample 1, with a mean value of 0.920 ± 0.040. The index of diversity for the compared coarse fractions ranged from a low of 0.093 at Station 82 to a high of 1.414 at Station 208, with a mean value of 0.834 ± 0.045. As may be noted (Appendix 5), the high values for both fine and coarse fractions fall on the same station, though the low values do not. It should also be pointed out that this diversity comparison is likely biased to some degree. The coarse fraction diversity index is calculated on

not surprising

station means (1 to 5 samples), while the fine fraction diversity is calculated on the basis of a single sample.

For purposes of general estimation over the area sampled, this comparison of fine to coarse sieve fraction results indicates that only about half of the species present are sampled using the coarse sieve approach, and only about one third of the population in terms of individual organisms per unit area, though roughly 90% of the biomass is retained, averaged over the total sample area. In any given sample, 76 ± 11% of the carbon biomass will be retained on the 3 mm mesh.

Dominant Species

For both coarse and fine fraction results, species were then ranked on the basis of percentage contribution to total mean density and total mean organic carbon biomass over the sample area, and cumulative percentages computed. From this ranking it was determined that 113 identified species and 25 additional taxa not identifiable to the species level comprised 95% of both density and carbon biomass of the coarse fractions. Thirty-five species and 2 additional taxa comprise 75% of both density and biomass, while only 10 identified species and one additional taxa account for 50% of both values.

For the fine fractions, 50 species and 23 unidentified taxa comprise 95% of density and biomass, 17 species and 6 unidentified taxa comprise 75% of density and biomass, and 6 identified species account for 50% of both values.

From the 113 species comprising the 95% values of the coarse fraction, 89 species (Table 3) were selected as indicator species for

Table 3. Coarse fraction species selected as dominant* (indicator) species from benthic stations on the Bering/Chukchi Shelf, with designation at Trophic Type**, reproductive type***, and zoogeographic region of origin or locus****.

Taxa	** Trophic Type	*** Larval Type	**** Origin
Molluska			
Bivalvia			
Astarte borealis	FF	DD	PA
Astarte montagui	FF	DD	PAB
Clinocardium ciliatum	FF	P	PA
Liocyma fluctuosa	FF	DD	PA
Macoma brota	SDF/FF	-	PAB
Macoma calcarea	SDF/FF	P	PA
Macoma lama	SDF/FF	-	ABP
Macoma loveni	SDF/FF	DD	PA
Musculus niger	FF	DD	PAB
Nucula tenuis	SDF	DD	PAB
Nuculana minuta	SDF	DD	LAB
Nuculana radiata	SDF	DD	PAB
Pseudopythina rugifera	FF	B	ABP
Serripes groenlandicus	FF	P	PA
Tellina lutea	SDF/FF	-	ABP
Thyasira flexuosa	FF	DD	PA
Cyclocardia crebricostata	FF	-	ABP
Yoldia hyperborea	SDF	DD	LAB
Yoldia scissurata	SDF	DD	ABP
Gastropoda			
Cylichna nucleola	CS	-	ABP
Tachyrhynchus erosus	CS	-	PAB
Annelida			
Polychaeta			
Ampharete acutifrons	SDF	P	LAB
Ampharete reducta	SDF	P	ABP
Anaitides groenlandica	CS	P	ABP
Antinoella sarsa	SDF	P	LAB
Arcteobea anticostiensis	CS	P	ABP
Artacama proboscidea	SDF	P	BP
Axiothella catenata	SSF	P	LAB
Brada ochotensis	SSF	P	ABP
Brada villosa	SSF	P	LAB
Capitella capitata	SDF	P	LAB
Chaetozone setosa	SSF	P	LAB
Chone duneri	FF	P	LAB

Table 3. Continued

Taxa	** Trophic Type	*** Larval Type	**** Origin
Chone infundibuliformis	FF	P	LAB
Cistenides granulata	SDF	P	LAB
Cistenides hyperborea	SDF	P	LAB
Flabelligera affinis	SDF	P	BP
Glycinde wireni	CS	P	BOP
Haploscoloplos elongatus	SSF	P	BOP
Harmothoe imbricata	CS	P	LAB
Lumbrinereis fragilis	SDF	P	LAB
Maldane sarsi	SSF	P	BP
Myriochele heeri	SDF	P	BP
Nephtys caeca	CS	P	LAB
Nephtys ciliata	CS	P	LAB
Nephtys longasetosa	CS	P	LAB
Nephtys rickettsi	CS	P	BOP
Nicomache lumbricalis	SDF	P	LAB
Nicolea venustula	SDF	P	LAB
Phloe minuta	CS	P	ABP
Polynoe canadensis	CS	P	LAB
Potamilla neglecta	FF	B	BP
Praxillella praetermissa	SSF	P	LAB
Proclea emmi	SDF	P	ABP
Scalibregma inflatum	SSF	P	BP
Spiophanes bombax	SDF	P	BP
Sternaspis scutata	SSF	P	BP
Terebellides stroemi	SDF	P	BP
Travisia forbesii	SSF	P	LAB
Arthropoda			
Amphipoda			
Ampelisca birulai	SDF/FF	B	ABP
Ampelisca macrocephala	SDF/FF	B	LAB
Anonyx nugax pacifica	SDF	B	LAB
Byblis gaimardi	SDF	B	LAB
Erichtonius tolli	SDF	B	ABP
Haploops laevis	SDF/FF	B	PAB
Lembos arcticus	SDF	B	PA
Melita dentata	SDF	B	PAB
Melita formosa	SDF	B	PA
Melita quadrispinosa	SDF	B	ABP
Paraphoxus milleri	SDF	B	BOP
Pontoporeia femorata	SDF	B	PAB
Protomedeia fascata	SDF	B	LAB
Protomedeia grandimana	SDF	B	PA

Table 3. Continued

Taxa	** Trophic Type	*** Larval Type	**** Origin
Cumacea			
Eudorella emarginata	SDF	B	PAB
Echinodermata			
Echinoidea			
Echinarachnius parma	SDF	P	PAB
Strongylocentrotus droebachiensis	SDF	P	ABP
Holothuroidea			
Cucumaria calcigera	SDF/FF	P	PAB
Ophiuroidea			
Diamphiodia craterodmeta	SDF/FF	P	LAB
Gorgonocephalus caryi	SDF/FF	P	ABP
Ophiura maculata	SDF/FF	P	PAB
Ophiura sarsi	CS/SDF	P	PAB
Ophiura flagellata	CS/SDF	P	LAB
Sipunculida			
Golfingia margaritaca	SDF	P	BP
Priapulida			
Priapulus caudatus	CS	P	ABP
Echiurida			
Echiurus echiurus	SDF	P	ABP
Chordata			
Ascidiacea			
Molgula siphonalis	FF	P	ABA
Pelonaia corrugata	FF	P	PAB
Styela rustica	FF	P	PAB
Chelyosoma inequale	FF	P	ABP

*Dominance determined on the basis at 95% cumulative contribution of either density, wet weight or organic carbon standing stock per unit area.

**Trophic Type - FF = Filter Feeder
SDF = Selective Detritus Feeder
SSF = Substrate Feeder
CS = Carnivore/Scavenger

***Reproductive Type - P = Pelagic Larvae
B = Brooding Behaviour
DD = Direct Development

****Zoogeographic Origin -

ABA = Arctic/Boreal Atlantic
ABP = Arctic/Boreal Pacific
LAB = Low Arctic/Boreal
PAB = Pan Arctic/Boreal
PA = Pan Arctic
BOP = Boreal Pacific
BP = Bipolar

correlation with environmental factors and for clustering station and species affinity groups. From the 50 species comprising 95% of the fine fraction values, 44 species (Table 4) were selected for the same purposes. Rare species (with less than 4 occurrences), and species presenting possible taxonomic problems were deleted in this selection process.

Station Cluster Analysis

Based on presence/absence and comparison of relative density of the 89 coarse fraction indicator species, a cluster analysis was performed on the 176 quantitative stations. This analysis resulted in 8 major station groups (Fig. 3, Appendices 7, 8, and 9). As may be seen (Fig. 4), several of these groups are not contiguous but are separated into areal subgroups. The largest group, referred to as the Central Bering Supergroup, itself comprises what might be classed as 4 separate groups and 8 subgroups, with major non-contiguous elements in both the Bering and Chukchi Seas.

Group I, the Chirikov Basin - Western St. Lawrence group, is comprised of 28 stations, 23 of which cover almost all of the offshore Chirikov Basin between St. Lawrence Island and Bering Strait. Four stations form a possible subgroup just west of St. Lawrence Island. A single station belonging to this group, considered an areal erratic (Station 86), lies just east of St. Lawrence Island, considerably to the south of the main group and separated from it by Group VII.

Group I shows the closest between-station affinity (0.42) of any of the cluster groups, and is almost totally discreet from the other groups.

Table 4. Dominant (95% cumulative density, wet weight, or organic carbon standing stock) species encountered within the 1mm sieve fraction at benthic stations on the Bering/Chukchi shelf.

Molluska
- Bivalvia
  - *Macoma calcarea*
  - *Nucula tenuis*
  - *Nuculana minuta*
  - *Pseudopythina rugifera*
  - *Thyasira flexuosa*
  - *Yoldia hyperborea*

Annelida
- Polychaeta
  - *Anaitides mucosa*
  - *Brada villosa*
  - *Capitella capitata*
  - *Chaetozone setosa*
  - *Eteone longa*
  - *Glycinde armigera*
  - *Haploscoloplos elongatus*
  - *Lumbrinereis fragilis*
  - *Myriochele heeri*
  - *Phloe minuta*
  - *Praxillella pratermissa*
  - *Prionospio malgreni*
  - *Scalibregma inflatum*
  - *Sternaspis scutata*
  - *Terebellides stroemi*
  - *Travisia forbesii*

Arthropoda
- Amphipoda
  - *Aceroides latipes*
  - *Ampelisca birulai*
  - *Ampelisca macrocephala*
  - *Anonyx nugax pacifica*
  - *Bathymedon nanseni*
  - *Byblis gaimardi*
  - *Corophium crassicorne*
  - *Haustorius eous*
  - *Harpinia gurjanovae*
  - *Orchemene lepidula*
  - *Paraphoxus milleri*
  - *Paraphoxus simplex*
  - *Photis spasskii*
- Amphipoda (cont'd)
  - *Pontoporeia femorata*
  - *Protomedeia fascata*
  - *Protomedeia grandimana*
- Cumacea
  - *Eudorella pacifica*
  - *Eudorellopsis deformis*
  - *Leucon nasica*
  - *Leucon #2*

Echinodermata
- Ophiuroidea
  - *Diamphiodia craterodmeta*

Pripulida
  - *Priapulus caudatus*

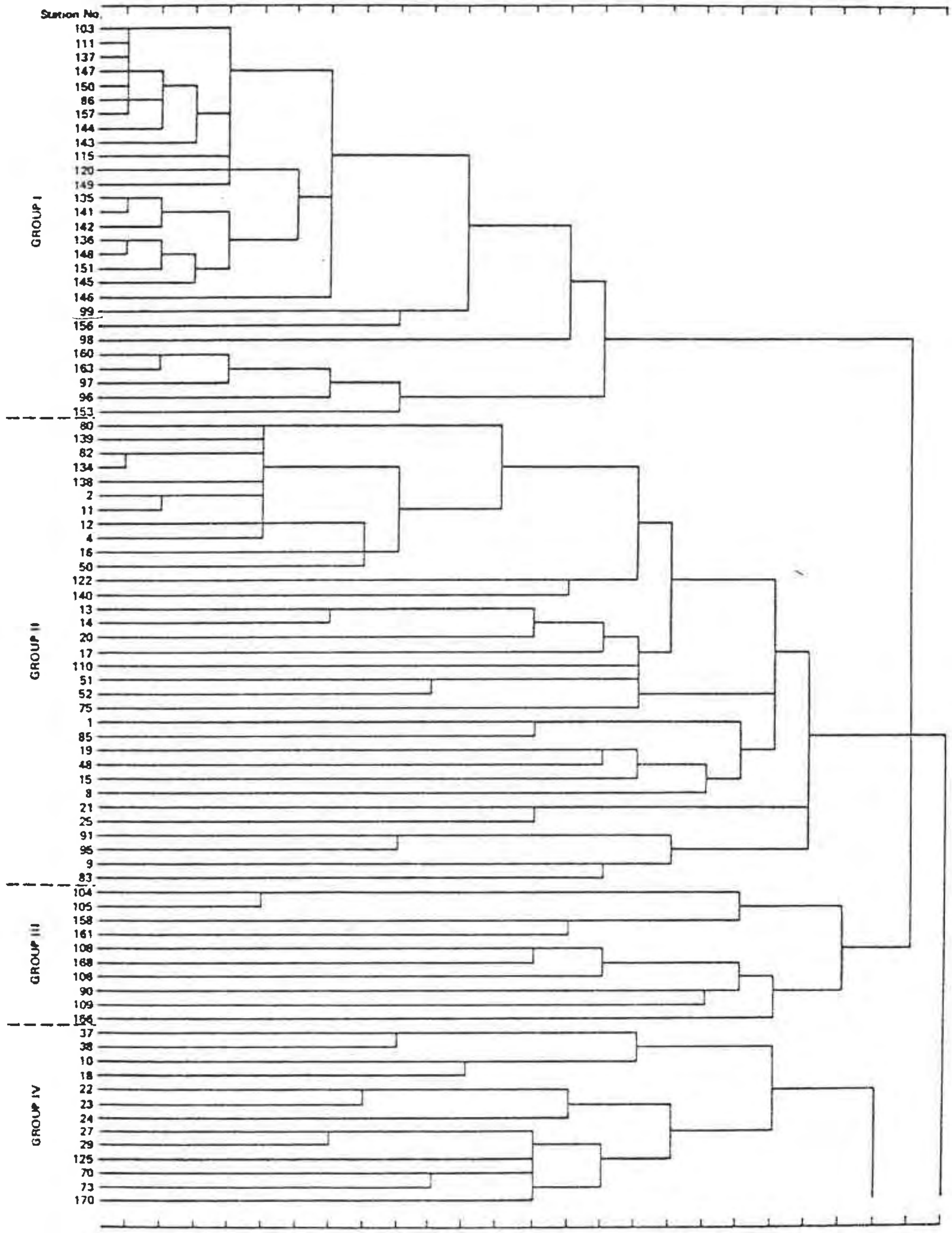

Figure 3. Dendogram generated by cluster analysis, based on faunal similarities, of benthic stations on the Bering/Chukchi Shelf.

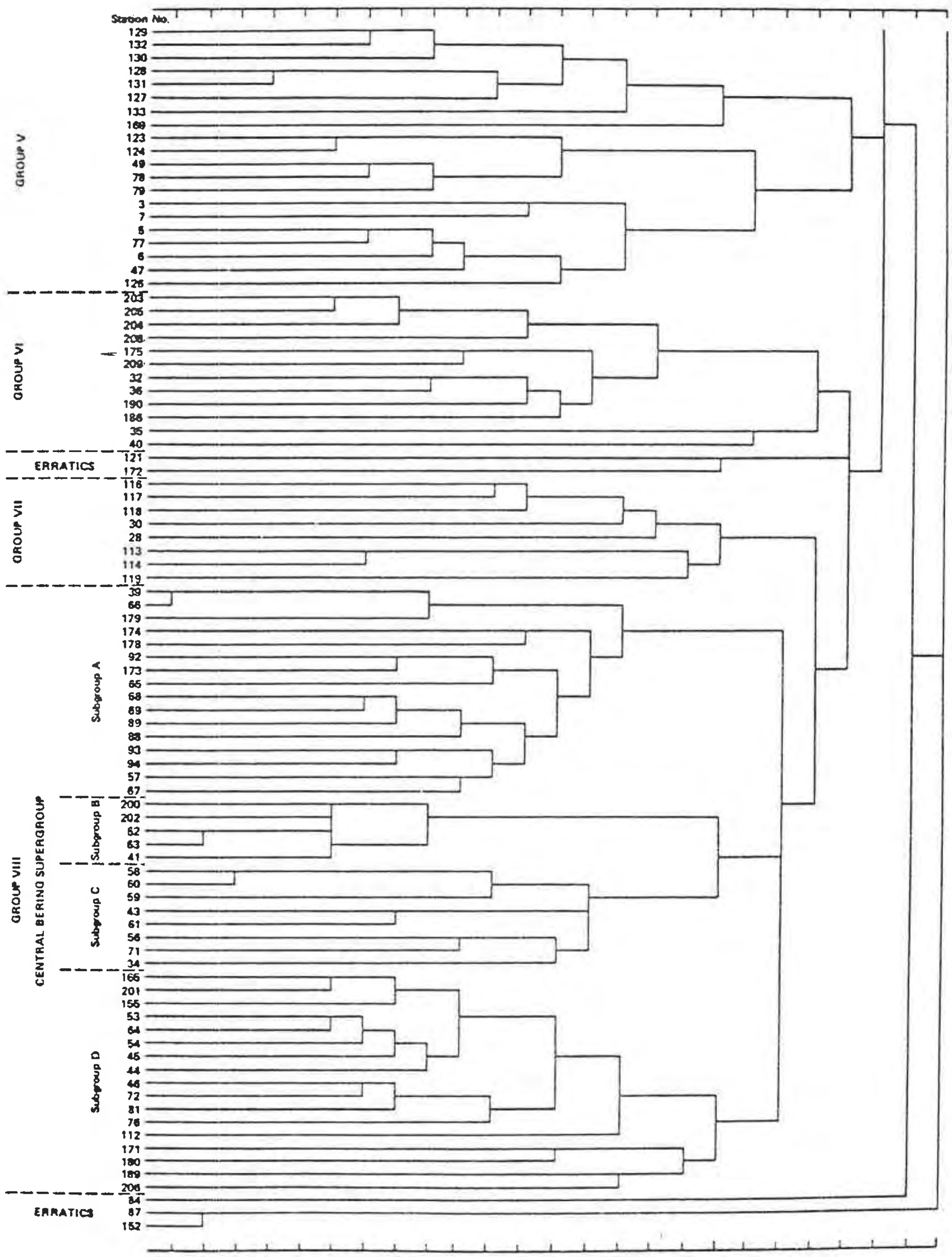

Figure 3. Continued

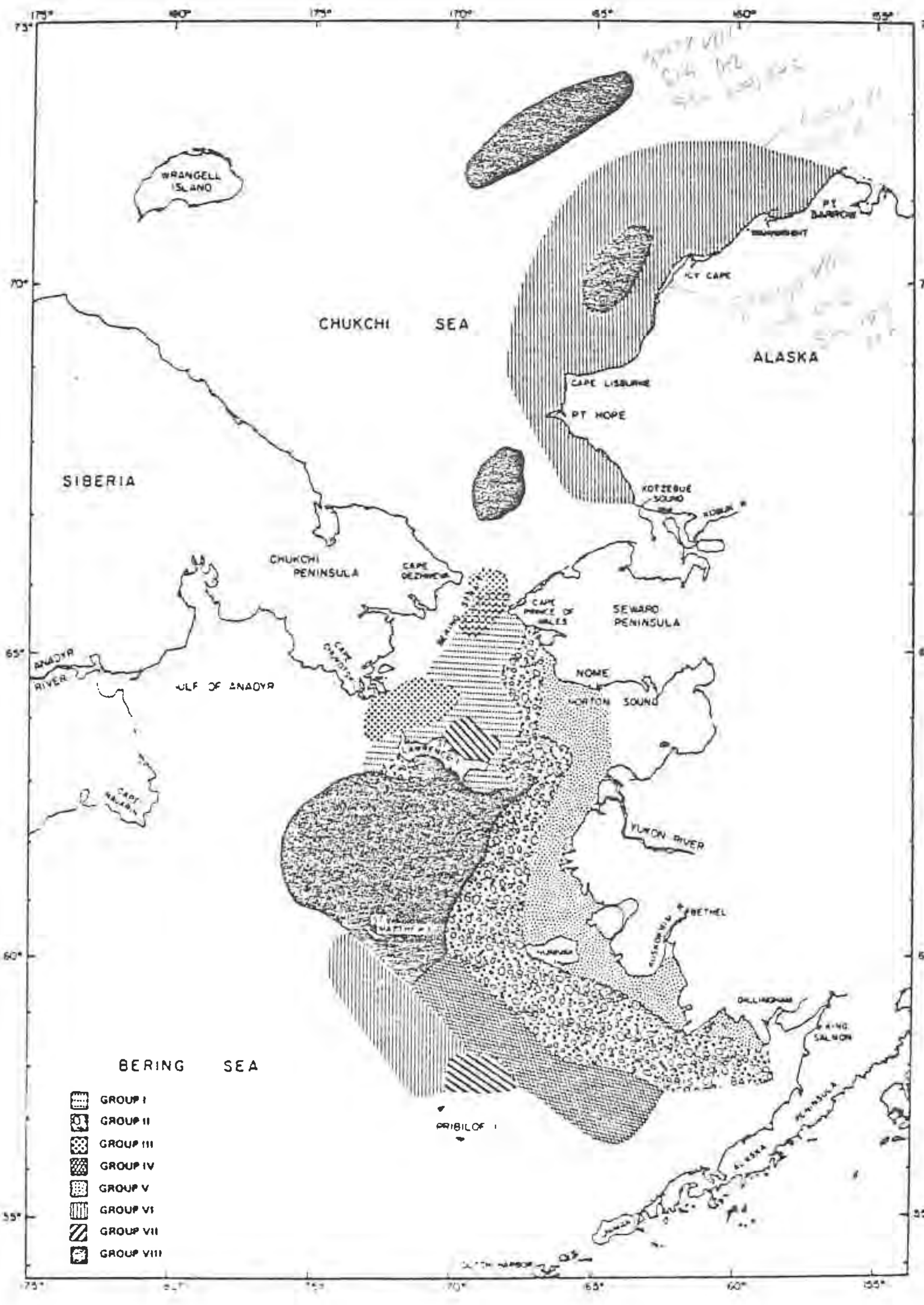

Figure 4. Station cluster groups as determined by benthic faunal similarities on the Bering/Chukchi Shelf.

The only other group showing any affinity with Group I is Group III, the Anadyr Strait-Bering Strait group, and this only at the 0.10 level.

Group I is characterized by the species *Ampelisca macrocephala*, *Byblis gaimardi*, and *Ampelisca birulai* (amphipods), and *Macoma calcarea* and *Astarte borealis* (bivalves). These 5 species, each of which, individually, comprises 10% or more of total group mean organic carbon biomass or population density, comprise jointly 72% of the total group mean biomass (organic carbon) and 90% of the total mean density. Each of these five species occurs at at least 15 of the 28 Group I stations. *Ampelisca macrocephala*, which is dominant in both density (60% of total) and organic carbon biomass (31% of total) occurs at all 28 stations. Four of these species are classified by Kuznetsov (1964) as selective detritus feeders, while the fifth (*A. borealis*) is considered a filter feeder, though these classifications are open to interpretation. Nine additional species occasionally attain local (station) dominance within this group (Table 5; Appendix 9).

Of the 89 indicator species selected for cluster and correlation analysis over the Bering/Chukchi shelf, 70 occur within Group I. The average total number of species per station within Group I is 42 ± 5. Wet weight biomass within Group I averages 482 ± 286 g/m^2. Mean organic carbon biomass is 23.1 ± 5.6 g/m^2, and mean density is 3,688 ± 823 $indiv/m^2$ (Table 6; Appendix 7). The mean diversity index for this group, averaged over all 28 stations, is 0.612 ± 0.084 (Table 6). The mean depth for the stations comprising Group I is 43 ± 3 m, ranging from 25 to 58 m. The mean sediment phi size is 3.00 ± 0.11, with a range of from 2.50 to 3.50 phi (Table 7; Appendix 8).

Table 5. Dominant species occurring within station cluster groups and subgroups on the Bering/Chukchi Shelf. Trophic, Zoogeographic, and Reproduction designations are as for Table 4.

Dominant Species	Trophic Type	Zoogeographic Origin	Reproductive Type
	Cluster Group I		
Ampelisca macrocephala	SDF	LAB	B
Byblis gaimardi	SDF	LAB	B
Ampelisca birulai	SDF	PAB	B
Macoma calcarea	SDF	PA	P
Astarte borealis	FF	PA	DD
Cluster Group I, Subgroup A			
Ampelisca macrocephala	SDF	LAB	B
Ampelisca birulai	SDF	PAB	B
Byblis gaimardi	SDF	LAB	B
Macoma calcarea	SDF	PA	P
Astarte borealis	FF	PA	DD
Serripes groenlandicus	FF	PA	P
Cyclocardia crebricostata	FF	ABP	U
Cluster Group I, Subgroup B			
Ampelisca macrocephala	SDF	LAB	B
Byblis gaimardi	SDF	LAB	B
Macoma calcarea	SDF	PA	P
Serripes groenlandicus	FF	PA	DD
Liocyma fluctuosa	FF	PA	DD
	Cluster Group II		
Tellina lutea	SDF	PA	P
Echinarachnius parma	SDF	PAB	P
Cluster Group II, Subgroup A			
Tellina lutea	SDF	ABP	U
Spiophanes bombax	SDF	BP	P
Echinarachnius parma	SDF	PAB	P
Travisia forbesii	SSF	LAB	P
Astarte montigui	FF	PAB	DD
Cyclocardia crebricostata	FF	APB	U
Tachyrhychus erosus	CS	PAB	U
Nephtys ciliata	CS	LAB	P

Table 5. Continued

Dominant Species	Trophic Type	Zoogeographic Origin	Reproductive Type
Serripes groenlandicus	FF	ABP	U
Haploscoloplos elongatus	SSF	POB	P
Ampelisca macrocephala	SDF	LAB	B
<u>Cluster Group II, Subgroup B</u>			
Echinarachnius parma	SDF	PAB	B
Cyclocardia crebricostata	FF	ABP	U
Nephtys ciliata	CS	LAB	P
Ampelisca macrocephala	SDF	LAB	B
Byblis gaimardi	SDF	LAB	B
Myriochele heeri	SDF	BP	P
Glycinde wireni	CS	BOP	P
Yoldia hyperborea	SDF	LAB	DD
Liocyma fluctuosa	FF	PA	DD
<u>Cluster Group II, Subgroup C</u>			
Cyclocardia crebricostata	FF	ABP	U
Macoma calcarea	SDF	PA	P
<u>Cluster Group III</u>			
Ophiura maculata	SDF	PAB	P
Strongylocentrotus droebachiensis	SDF	ABP	P
Cistenides granulata	SDF	LAB	P
<u>Cluster Group III, Subgroup A</u>			
Echinarachnius parma	SDF	PAB	P
Cistenides granulata	SDF	LAB	P
Ophiura maculata	SDF	PAB	P
<u>Cluster Group III, Subgroup B</u>			
Cistenides granulata	SDF	LAB	P
Ophiura maculata	SDF	PAB	P
Strongylocentrotus droebachiensis	SDF	ABP	P
Yoldia hyperborea	SDF	LAB	DD
<u>Cluster Group IV</u>			
Haploscoloplos elongatus	SDF	BOP	P
Protomedeia fascata	SDF	LAB	B
Yoldia hyperborea	SDF	LAB	DD

Table 5. Continued

Dominant Species	Trophic Type	Zoogeographic Origin	Reproductive Type
Cluster Group IV, Subgroup A			
Haploscoloplos elongatus	SDF	BOP	P
Protomedeia fascata	SDF	LAB	B
Eudorella emarginata	SDF	PAB	B
Nephtys ciliata	CS	LAB	P
Sternaspis scutata	SSF	BP	P
Yoldia hyperborea	SDF	LAB	DD
Tachyrhychus erosus	CS	PAB	U
Praxillella praetermissa	SSF	LAB	P
Artacama proboscidea	SDF	BP	P
Chaetozone setosa	SSF	LAB	P
Cluster Group V			
Serripes groenlandicus	FF	PA	P
Myriochele heeri	SDF	BP	P
Sternaspis scutata	SSF	BP	P
Diamphiodia craterodmeta	SDF	LAB	P
Gorgonocephalus caryi	SDF	ABP	P
Cluster Group V, Subgroup A			
Myriochele heeri	SDF	BP	P
Diamphiodia craterodmeta	SDF	LAB	P
Sternaspis scutata	SSF	BP	P
Lumbrinereis fragilis	SDF	LAB	P
Yoldia hyperborea	SDF	LAB	DD
Nephtys ciliata	CS	LAB	P
Nucula tenuis	SDF	PAB	DD
Serripes groenlandicus	FF	PA	P
Macoma brota	SDF	PA	P
Cluster Group V, Subgroup B			
Myriochele heeri	SDF	BP	P
Praxillella praetermissa	SSF	LAB	P
Sternaspis scutata	SSF	BP	P
Cluster Group VI			
Maldane sarsi	SSF	BP	P
Ophiura sarsi	CS	PAB	P
Golfingia margaritaca	SDF	BP	P
Astarte borealis	FF	PA	DD

Table 5. Continued

Dominant Species	Trophic Type	Zoogeographic Origin	Reproductive Type
Cluster Group VI, Subgroup A			
Maldane sarsi	SSF	BP	P
Nucula tenuis	SDF	PAB	DD
Sternaspis scutata	SSF	BP	P
Diamphiodia craterodmeta	SDF	LAB	P
Golfingia margaritaca	SDF	BP	P
Astarte borealis	FF	PA	DD
Macoma calcarea	SDF	PA	P
Ophiura sarsi	CS	PAB	P
Cluster Group VI, Subgroup B			
Maldane sarsi	SSF	BP	P
Sternaspis scutata	SSF	BP	P
Nephtys ciliata	CS	LAB	P
Ophiura sarsi	CS	PAB	P
Yoldia hyperborea	SDF	LAB	DD
Cluster Group VII			
Macoma calcarea	SDF	PA	P
Chone dunneri	FF	LAB	P
Cluster Group VII, Subgroup A			
Macoma calcarea	SDF	PA	P
Serripes groenlandicus	FF	PA	P
Nephtys ciliata	CS	LAB	P
Praxillella praetermissa	SSF	LAB	P
Cluster Group VII, Subgroup B			
Nephtys ciliata	CS	LAB	P
Cluster Group VIII			
Macoma calcarea	SDF	PA	P
Nucula tenuis	SDF	PAB	DD
Yoldia hyperborea	SDF	LAB	DD
Pontoporeia femorata	SDF	PAB	B
Cluster Group VIII, Subgroup A-1			
Macoma calcarea	SDF	PA	P
Nucula tenuis	SDF	PAB	DD
Pontoporeia femorata	SDF	PAB	B
Cistenides hyperborea	SDF	LAB	P

Table 5. Continued

Dominant Species	Trophic Type	Zoogeographic Origin	Reproductive Type
Haploscoloplos elongatus	SSF	BOP	P
Ophiura sarsi	CS	PAB	P
Yoldia hyperborea	SDF	LAB	DD
Pelonaia corrugata	FF	PAB	P
Ampelisca macrocephala	SDF	LAB	B
Cluster Group VIII, Subgroup A-2			
Macoma calcarea	SDF	PA	P
Nucula tenuis	SDF	PAB	DD
Pontoporeia femorata	SDF	PAB	B
Cistenides hyperborea	SDF	LAB	P
Polynoe canadensis	CS	LAB	P
Cluster Group VIII, Subgroup B-1			
Macoma calcarea	SDF	PA	P
Nucula tenuis	SDF	PAB	DD
Yoldia hyperborea	SDF	LAB	DD
Nuculana radiata	SDF	PAB	DD
Nephtys ciliata	CS	LAB	P
Ophiura sarsi	CS	PAB	P
Maldane sarsi	SSF	BP	P
Cluster Group VIII, Subgroup C-1			
Nucula tenuis	SDF	PAB	DD
Macoma calcarea	SDF	PA	P
Yoldia hyperborea	SDF	LAB	DD
Serripes groenlandicus	FF	PA	P
Pelonaia corrugata	FF	PAB	P
Nephtys rickettsi	CS	BOP	P
Cluster Group VIII, Subgroup C-2			
Nucula tenuis	SDF	PAB	DD
Nephtys ciliata	CS	LAB	P
Cluster Group VIII, Subgroup D-1			
Nucula tenuis	SDF	PAB	DD
Nuculana radiata	SDF	PAB	DD
Cluster Group VIII, Subgroup D-2			
Nuculana radiata	SDF	PAB	DD
Macoma calcarea	SDF	PA	P
Yoldia hyperborea	SDF	LAB	DD

Table 6. Observed biological characteristics of benthic station cluster groups and subgroups on the Bering/Chukchi shelf.

Group and Subgroup	Number of Species			Density (indiv/m²)			Wet Wt. Biomass (g/m²)			Carbon Biomass (g/m²)			Diversity Index		
	Mean	Standard Deviation	95% Confidence Limits (±)	Mean	Standard Deviation	95% Confidence Limits (±)	Mean	Standard Deviation	95% Confidence Limits (±)	Mean	Standard Deviation	95% Confidence Limits (±)	Mean	Standard Deviation	95% Confidence Limits (±)
Group I	42	12	5	3688	2123	823	482	286	111	23.1	14.3	5.6	0.612	0.216	0.084
Subgroup A	45	11	7	3989	2132	922	533	267	115	26.1	14.9	5.6	0.582	0.209	0.090
Subgroup B	30	10	15	2058	1675	2663	252	318	506	12.7	15.4	24.5	0.836	0.734	0.213
Group II	23	9	3	340	301	103	265	411	140	4.4	4.1	1.4	0.882	0.283	0.096
Subgroup A	23	7	3	302	219	149	113	128	68	3.6	3.3	1.8			
Subgroup B	21	10	6	387	356	205	395	565	326	4.4	4.6	2.6			
Subgroup C	38	10	89	341	164	1481	268	199	1785	7.8	4.3	38.6	1.248	0.021	0.188
Group III	37	17	12	481	200	143	673	744	532	14.1	11.3	8.1	1.105	0.510	0.222
Subgroup A	33	19	24	524	180	224	593	723	898	10.9	7.5	9.3	0.962	0.368	0.457
Subgroup B	44	14	25	352	149	237	903	890	1416	20.0	15.3	24.3	1.235	0.198	0.315
Group IV	27	10	6	634	328	198	102	207	125	3.3	4.2	2.5	0.901	0.205	0.124
Subgroup A	26	7	6	565	190	159	141	261	218	4.1	5.1	4.3	0.976	0.106	0.089
Group V	32	9	4	702	443	208	193	236	111	7.5	8.6	4.0	0.891	0.226	0.106
Subgroup A	31	9	5	639	414	230	191	216	120	7.5	8.5	4.7	0.869	0.183	0.101
Subgroup B	34	7	10	1072	372	592	56	14	22	3.0	1.0	1.5	0.967	0.285	0.454
Group VI	35	20	13	496	314	200	305	259	164	11.1	7.6	4.9	1.005	0.239	0.152
Subgroup A	43	20	17	596	330	276	416	250	209	14.6	7.0	5.8	1.098	0.195	0.163
Subgroup B	21	10	16	295	167	266	83	39	62	4.0	1.2	1.9	0.817	0.226	0.360
Group VII	17	10	8	427	495	414	219	149	125	9.5	6.2	5.2	0.738	0.165	0.138
Subgroup A	17	11	12	530	570	599	281	111	117	12.0	4.9	5.1	0.668	0.156	0.164
Subgroup B	16	1	13	67	1	13	31	13	114	2.0	0.7	6.4	0.948	0.014	0.126
Group VIII	26	9	3	934	1467	424	239	187	54	10.1	7.8	2.9	0.853	0.188	0.054
Subgroup A	32	10	5	1888	2203	1174	267	266	142	12.0	11.6	6.2	0.863	0.228	0.122
area A-1	29	8	5	1249	1454	977	179	105	70	7.7	4.6	3.1	0.902	0.218	0.146
area A-2	43	1	1	3943	3103	4936	568	386	614	26.6	14.8	23.5	0.866	0.168	0.267
Subgroup B	21	6	5	390	261	218	206	122	102	9.0	5.0	4.2	0.857	0.065	0.054
area B-1	23	5	6	443	274	287	222	116	122	9.6	4.5	4.7	0.857	0.073	0.077
Subgroup C	24	8	4	451	255	131	200	107	55	8.5	4.6	2.4	0.863	0.205	0.105
area C-1	21	7	5	468	298	229	197	81	62	8.3	3.5	2.7	0.842	0.106	0.081
area C-2	35	0	0	434	317	2849	156	134	1402	6.6	5.3	47.6	1.182	0.127	1.141
Subgroup D	22	3	4	393	167	207	338	176	219	10.7	4.0	5.0	0.785	0.134	0.166
area D-1	22	4	9	461	172	427	405	213	529	11.1	5.6	13.9	0.731	0.132	0.328
area D-2	24	2	19	292	136	1222	238	6	58	10.2	0.9	8.1	0.865	0.124	1.113

Table 7. Observed physical characteristics of benthic station cluster groups and subgroups on the Bering/Chukchi shelf.

Group and Subgroup	Depth (m)			Sediment Mode (phi size)		
	Mean	Standard Deviation	95% Confidence Limits (±)	Mean	Standard Deviation	95% Confidence Limits (±)
Group I	43	9	3	3.00	0.28	0.11
Subgroup A	43	8	4	3.00	0.28	0.12
Subgroup B	42	12	19	3.33	0.29	0.46
Group II	32	10	4	2.72	0.73	0.26
Subgroup A	33	10	6	2.62	0.34	0.19
Subgroup B	28	6	3	2.75	1.07	0.65
Subgroup C	55	5	44	2.88	0.18	1.62
Group III	48	17	12	0.25	2.75	4.38
Subgroup A	38	9	11	1.33	2.08	5.17
Subgroup B	50	7	11	-3.00	-	-
Group IV	49	16	10	3.11	1.44	0.97
Subgroup A	57	11	9	3.54	0.47	0.43
Group V	27	12	6	3.47	0.92	0.49
Subgroup A	24	5	3	3.71	0.89	0.57
Subgroup B	28	9	15	2.75	0.64	1.02
Group VI	63	26	17	5.15	1.51	0.96
Subgroup A	45	5	4	4.66	1.59	1.33
Subgroup B	98	6	10	6.13	0.75	1.19
Group VII	43	16	13	3.63	0.44	0.37
Subgroup A	35	3	4	3.80	0.26	0.27
Subgroup B	69	1	12	3.00	-	-
Group III	56	17	5	4.10	1.23	0.36
Subgroup A	57	15	8	4.25	1.14	0.61
area A-1	59	16	11	4.09	1.30	0.87
area A-2	46	5	7	4.50	0.71	1.12
Subgroup B	78	16	14	3.87	1.11	1.03
area B-1	80	11	12	3.92	1.27	1.33
Subgroup C	44	9	5	3.77	1.26	0.67
area C-1	46	10	8	4.00	1.27	0.98
area C-2	37	2	19	3.00	-	-
Subgroup D	56	6	7	5.05	1.44	1.79
area D-1	60	4	10	4.08	0.80	1.99
area D-2	51	0	0	6.50	-	-

Group II, the North Bristol Bay-West Norton Sound group shows a minimum between-station affinity value of 0.21. This group is totally discreet, showing no affinity with any other group. This group includes 33 stations, at least two areal subgroups, and one areal erratic (Station 110). The main distribution of stations comprising Group II appears to form a broad band offshore from the Alaska mainland in the eastern Bering Sea, with a minor areal subgroup lying south of the western end of St. Lawrence Island (Fig. 4). Though there are no stations available to supply supporting data, it is considered probable that Group II continues unbroken between Bristol Bay and Norton Sound, and that these two areas do not form distinct subgroups. As is the case with Group I, Group II is restricted solely to the Bering Sea.

The major species encountered within Group II (each comprising 10% or more of density and biomass) are *Tellina lutea* (bivalve) and *Echinarachnius parma* (echinoid). *Echinarachnius parma* occurs at 29 of the 33 total stations, with *T. lutea* occurring at 10. Together, these two species account for 36% of the total mean population density and 78% of the total mean organic carbon biomass. Both *T. lutea* and *E. parma* are considered to be a selective detritus feeders (Kuznetsov, 1964). Twenty-eight additional species are at times seen to share dominance on the local level (Table 5; Appendix 9).

Fifty-eight of the 89 indicator species are represented within Group II. The mean wet weight biomass, averaged over all 33 stations within the group, is 265 ± 140 g/m^2, the mean organic carbon biomass is 4.4 ± 1.4 g/m^2, the mean density is 340 ± 103 $indiv/m^2$, and the mean diversity is 0.882 ± 0.096. An average of 23 ± 3 total species are encountered per station within this group (Table 6; Appendix 7). The average depth at the stations within the group is 32 ± 4 m, ranging from 16 to 58 m. As may be seen (Table 7; Appendix 8), the mean depth of the St. Lawrence subgroup is considerably deeper (55 m) than that of the main group (32 m). The sediment particle size within Group II ranges from -0.31 to 4.00 phi, with a mean value of 2.72 ± 0.26 phi. Both the low phi value of -0.31 and the high value of 4.00 are considerable deviations from values derived from the other stations within this group.

Group III, the Anadyr Strait-Bering Strait group, is a fairly small assemblage of 10 stations split into two distinct areal subgroups. One subgroup, composed of 5 stations, lies west of St. Lawrence Island in Anadyr Strait, the other, with 4 stations, lies in Bering Strait. Group I overlaps Group III in areal distribution in Bering Strait, the only instance where such cluster group areal overlap is encountered (Fig. 4). The minimum between-station affinity value for Group III is 0.17. As might be expected from the overlap in distribution, Group III shows some affinity, at the 0.10 level, with Group I, and no affinity with any other group. One station clustered within Group III, Station 90, is an areal erratic lying just south of St. Lawrence Island.

The mean wet weight biomass of Group III is 673 ± 532 g/m^2, with the Bering Strait subgroup showing a higher mean value (903 g/m^2) than the Anadyr Strait subgroup (593 g/m^2) though the standard deviations and confidence intervals within these subgroups indicate that this difference may not be statistically valid (Table 6). The mean organic carbon biomass for the group is 14.1 ± 8.1 g/m^2, the mean density is 481 ± 143 indiv/m^2, and the mean index of diversity is 1.105 ± 0.222, the highest of any major group. Of the 89 indicator species, 59 are represented within Group III. An average number of 37 ± 12 species occurs per station.

The species characterizing Group III are *Ophiura maculata* (ophiuroid), *Strongylocentrotus drobachiensis* (echinoid) and *Cistenides granulata* (polychaete). These 3 species comprise 45% of the total density and 44% of the organic carbon biomass. All are considered selective detritus feeders (Kuznetsov, 1964). Eleven other species share dominance, locally, with these 3 species (Table 5; Appendix 9).

The mean depth of stations within Group III is 48 ± 12 m, ranging from 25 to 90 m. The only station deeper than 56 m is the areal erratic, Station 90. The sediment particle size at stations within this group varies widely from -3.00 to 3.00, with a mean value of 0.25 ± 4.38 phi (Table 7). At 6 of the 10 stations rocky substrate prohibited collection of valid sediment samples (Appendix 8). All of the stations are characterized by the presence of rocks, gravel and shell fragments.

Group IV, the western Bristol Bay group, is a rather untidy association cluster of 13 stations having a minimum affinity level of 0.24. Five of these 13 stations (Stations 10, 70, 73, 125, and 170) are areal erratics. The remaining 8 form a broad band seaward from Group III (Fig. 4) from about 55°N to 60°N. All but one station of the 13 (Station 170) lie on the shelf of the Bering Sea. Group IV shows affinity at the 0.14 level with Group V, though separated areally from it by Group III, and with Groups VI, VII, and VIII.

The dominant species within Group IV, accounting jointly for 61% of the mean density and 17% of the mean organic carbon biomass, are *Yoldia* *hyperborea* (bivalve), *Haploscoloplos elongatus* (polychaete), and *Protomedeia fascata* (amphipod). *Haploscoloplos elongatus* is one of the most ubiquitous species encountered, occurring at 126 stations within all 8 cluster groups. Only within Group IV, however, does it assume dominant proportions. The relatively low biomass percentage comprised within this group by its 3 dominant species is due to the very large biomass value of 14.7 g/m^2 (organic carbon) averaged at Station 24 by the cockle *Clinocardium ciliatum*. This one species accounted for 44% of the organic carbon biomass for the entire group. Since this was a single station occurrence, however, *C. ciliatum* was not included as a dominant species for Group IV. The 3 species selected as dominants occur at 7, 12, and 11, respectively, of the 13 total stations. Fifty-three of the 89 indicator species occur within Group IV. All 3 dominant species within this group are selective detritus feeders (Kuznetsov, 1964). In addition to these 3, 14 other species achieve a share in dominance on the local level (Table 5; Appendix 9).

The mean density (all species) for Group IV is 634 ± 198 $indiv/m^2$, the mean organic carbon biomass is 3.3 ± 2.5 g/m^2, the mean wet weight biomass is 102 ± 125 g/m^2, and the mean station diversity is 0.901 ± 0.124. On the average, 27 ± 6 species occur at each station within this group (Table 6).

The mean depth of stations within Group IV is 49 ± 10 m, ranging from 20 to 66 m. Within the major areal cluster of 8 stations, depth is less erratic, ranging from 52 to 66 m, with a mean of 57 ± 9 m. The mean sediment particle size is 3.11 ± 0.97 phi, ranging from -1.00 phi to 4.00 phi. As with depth, the particle size within the main distribution is more uniform, ranging from 2.75 to 4.00 phi with a mean of 3.54 ± 0.43 phi (Table 7). At one of the areal erratics (Station 170) rocky substrate prevented collection of a suitable sediment sample.

Group V, the Norton Sound-Walrus Island complex, possesses a minimum between-station affinity value of 0.17. This group is composed of 20 stations, including one areal erratic. The main distribution of stations forms a broad nearshore band stretching across western Norton Sound and south along the Alaska mainland to just north of Nunivak Island (Fig. 4). Fifteen stations lie within this band. Four other stations form a similar nearshore enclave in the Walrus Island region of northern Bristol Bay. No nearshore stations were taken from Nunivak south to Bristol Bay, but it is conjectured that the faunal complex characterizing Group V probably is continuous along the entire Bering Sea coast from the Seward Peninsula south to the Alaska Peninsula and that the Norton Sound and Walrus Island stations do not represent distinct subgroups in terms of areal distribution. The one areal erratic, Station 169, lies far north of the main body of stations, in the southern Chukchi Sea. Group V shows an affinity association of 0.14 with Groups IV, VI, VII, and VIII, none of which share with it a common border.

Of the 89 indicator species, 64 occur within Group V. Five of these 64 species, *Serripes groenlandicus* (bivalve), *Myrlocheli heeri* (polychaete), *Diamphiodia craterodmeta* (ophiuroid), and *Gorgonocephalus caryi* (ophiuroid), comprise 65% of the mean density and 48% of the organic carbon biomass for the group. One of these (*S. groenlandicus*) is an obvious filter feeder. Both polychaetes are classed as non-selective detritus (deposit) feeders, while both opiuroids are selective detritus feeders (Kuznetsov, 1964) making this a rather diverse group in terms of trophic forms and resource utilization. The mean density encountered at stations comprising Group V is 702 ± 208 indiv/m^2, the mean wet weight biomass is 193 ± 111 g/m^2, the mean organic carbon biomass is 7.5 ± 4.0 g/m^2, and the mean diversity index is 0.891 ± 0.106 (Appendix 7). It appears that there may be a trend toward increasing biomass from south to north within this group. The Walrus Island stations average only 3.0 ± 1.5 g/m^2 (organic carbon), while those in Norton Sound average 7.5 ± 4.7 g/m^2. This trend is, however, not strictly supportable on statistical grounds as the mean confidence intervals do overlap (Table 6). The one Chukchi Sea station (169) averages 25.4 g/m^2 (organic carbon) largely due to the considerable biomass of *G. caryi* encountered at this station. *Gorgonocephalus caryi* occurs at only 4 other stations, making it marginally acceptable as a dominant species. The other dominants occur at 8, 18, 13, and 18 of the 20 total stations, respective to the order in which they are named above. On the local level, 24 other species at times share this dominance (Table 5; Appendix 9).

The mean station depth encountered in Group V is 27 ± 6 m, ranging from 18 m (Station 6) to 73 m (Station 169). Excepting Station 169, the greatest depth encountered is 34 m. The sediment particle size ranges from 2.00 to 5.00 phi, with a mean value of 3.47 ± 0.49 phi. At 3 of the nearshore stations just south of the Seward Peninsula, rocky substrate prevented sediment collection. The erratic distribution of sediments encountered within this group is probably a result of its nearshore position. Such diversity of substrates may also account for the diversity of feeding types found within the major faunal elements of this group.

Group VI, the northern Pribilof-eastern Chukchi group, includes 12 stations split into 2 definite areal subgroups, with no areal erratics. Subgroup A, the eastern Chukchi subgroup, includes 8 stations forming a broad band along the Alaska mainland from Point Barrow south to Kotzebue Sound. Subgroup B, the northern Pribilof subgroup, forms an elongate band of 4 stations lying north and west of the Pribilofs (Fig. 4). The minimum station-station affinity within Group VI is 0.21. While there is clear areal distinction between Subgroups A and B, the distinction in terms of station-station affinity is less clean-cut, with one station (176) of Subgroup A having closer affinities with Subgroup B than with its own subgroup stations (Fig. 3). As a group, Group VI shows affinity at the 0.14 level with Groups IV, V, VII, and VIII, and shares a common boundary with all but Group V.

The species of major importance within Group VI, in terms of population density and standing stock biomass, are *Astarte borealis* (bivalve, also dominant in Group I), *Maldane sarsi* (polychaete), *Ophiuri sarsi* (ophiuroid), and *Golfingia margaritaca* (sipunculid). Fourteen additional species share this dominance at some stations. *Ophiuri sarsi* is considered a selective detritus feeder, *A. borealis* is a filter feeder, and *M. sarsi* and *G. margaritaca* are deposit feeders. One of each feeding type is locally dominant in each subgroup. Together, these 4 species account for 49% of the mean group density and 53% of the mean organic carbon biomass. They occur at 5, 8, 7, and 7, respectively, of the 12 total stations. Sixty-seven of the 89 indicator species occur within Group VI. The mean density within Group VI is 496 ± 200 indiv/m^2, the mean wet weight biomass is 305 ± 164 g/m^2, the mean organic carbon biomass is 11.1 ± 4.9 g/m^2, and the mean station diversity index is 1.005 ± 0.152. The mean organic carbon biomass of 14.6 ± 5.8 g/m^2 encountered within Subgroup A, as opposed to 4.0 ± 1.9 g/m^2 within Subgroup B, indicates a south to north trend of increased standing stock, as also appeared to be the case for Group V. In the case of Group VI this trend is supportable at the 95% confidence level (Table 6). On the average, 36 ± 13 species occur at each station within Group VI.

The mean depth for Group VI overall is 63 ± 17 m, with Subgroup A having a mean depth of 45 ± 4 m (ranging from 38 to 50) and Subgroup B having a mean depth of 98 ± 10 m (ranging from 90 to 105). The sediment particle size ranges from 2.50 to 6.50 phi within Subgroup A, with a mean of 4.66 ± 1.33, and from 5.00 to 6.50 phi, with a mean of 6.13 ± 1.19, within Subgroup B. The overall particle size mean for Group VI is 5.15 ± 0.96 phi (Table 7; Appendix 8).

Group VII, the Savoonga-Pribilof group, is a small cluster group composed of two distinct areal subgroups (Fig. 4), with 8 total stations. The minimum station-station affinity of Group VII is 0.31. There are no areal erratics, and no distinction in affinity, despite the areal separation, between subgroups. Subgroup A, the Savoonga subgroup, includes 6 stations forming a tight enclave just north of St. Lawrence Island. Far south of this lies Subgroup B, the Pribilof subgroup, which includes only two stations just north of St. Paul Island

(Fig. 4). Group VII shows affinity at the 0.17 level with Groups VI and VIII, and at the 0.14 level with Groups IV and V.

Group VII is characterized by the species *Macoma calcarea* (bivalve, also dominant in Groups I and VIII) and *Chone duneri* (polychaete), which together comprise 62% of the density and 60% of the mean organic carbon biomass of the group. *Macoma calcarea* is present at all 8 stations; *C. duneri* is present only at 2, both in Subgroup A. Both species are selective detritus feeders. Local dominance is shared between these and 11 other species (Table 5).

Only 39 of the 89 indicator species occur within Group VII. An average of only 17 ± 8 species occur at stations within this group. Mean wet weight biomass is 219 ± 125 g/m^2, mean organic carbon biomass is 9.5 ± 5.2 g/m^2, mean density is 414 ± 149 $indiv/m^2$, and mean diversity index is 0.738 ± 0.138. As with the previous groups where there are distinct areal separations by latitude, the more northerly stations possess much greater standing stock biomass than do the southerly ones. In this case, Subgroup A has a mean organic carbon standing stock biomass of 12.0 ± 5.1 g/m^2 as compared to 2.0 ± 6.4 g/m^2 for Subgroup B. Though not strictly supportable at the 95% confidence level, I consider that this difference is probably real, the large confidence interval for Subgroup B being a function of small sample size rather than within-group variance (Table 6).

The mean depth of stations within Group VII is 43 ± 13 m. Subgroup B, with a mean depth at 69 ± 12 m, is distinctly deeper than Subgroup A. Depth at Subgroup A averages 35 ± 4 m, ranging from 31 to 40. The sediment particle size within the group is more consistant, averaging

3.00 ± 0 phi for Subgroup B, 3.80 ± 0.27 for Subgroup A (ranging from 3.50 to 4.00), with an overall group mean of 3.57 ± 0.37 phi (Table 7).

Group VIII, known as the Central Bering Supergroup, is the least discreet and, conversely, the most complex of all the Bering/Chukchi cluster groups. It possesses a minimum station-station affinity of 0.31, and is composed of 4 distinct association subgroups on the basis of station-station affinity (Fig. 3). Three of these association subgroups are themselves composed of distinct areal subgroups (Fig. 4). All 4 of the major subgroups form, together, a large complex on the central Bering shelf from St. Lawrence Island to south of St. Matthew Island (Fig. 5). Three of these major association subgroups also possess areal subgroups in the Chukchi Sea. Overall, Group VIII shows affinity at the 0.17 level with Group VII, at the 0.14 level with Group VI, and at the 0.10 level with Groups IV and V. Association subgroups within Group VIII possess affinity with one another at the 0.24 level.

The Central Bering Supergroup is, overall, characterized by the species *M. calcarea* (bivalve, also dominant in Groups I and VII). *Nucula tenuis* (bivalve), *Yoldia hyperborea* (bivalve, also dominant in Group IV), and *Pontoporea femorata* (amphipod). All are classed as selective detritus feeders. Jointly, these 4 species account for 64% of mean Group VIII density and 49% of the organic carbon biomass. Seventy-three of the 89 indicator species occur within Group VIII, making it the most diverse of all the cluster groups in terms of major species included, which is not surprising given the group's complexity and areal distribution. Averaged over all stations within all 4 major affinity subgroups, the overall supergroup mean density is 934 ± 424

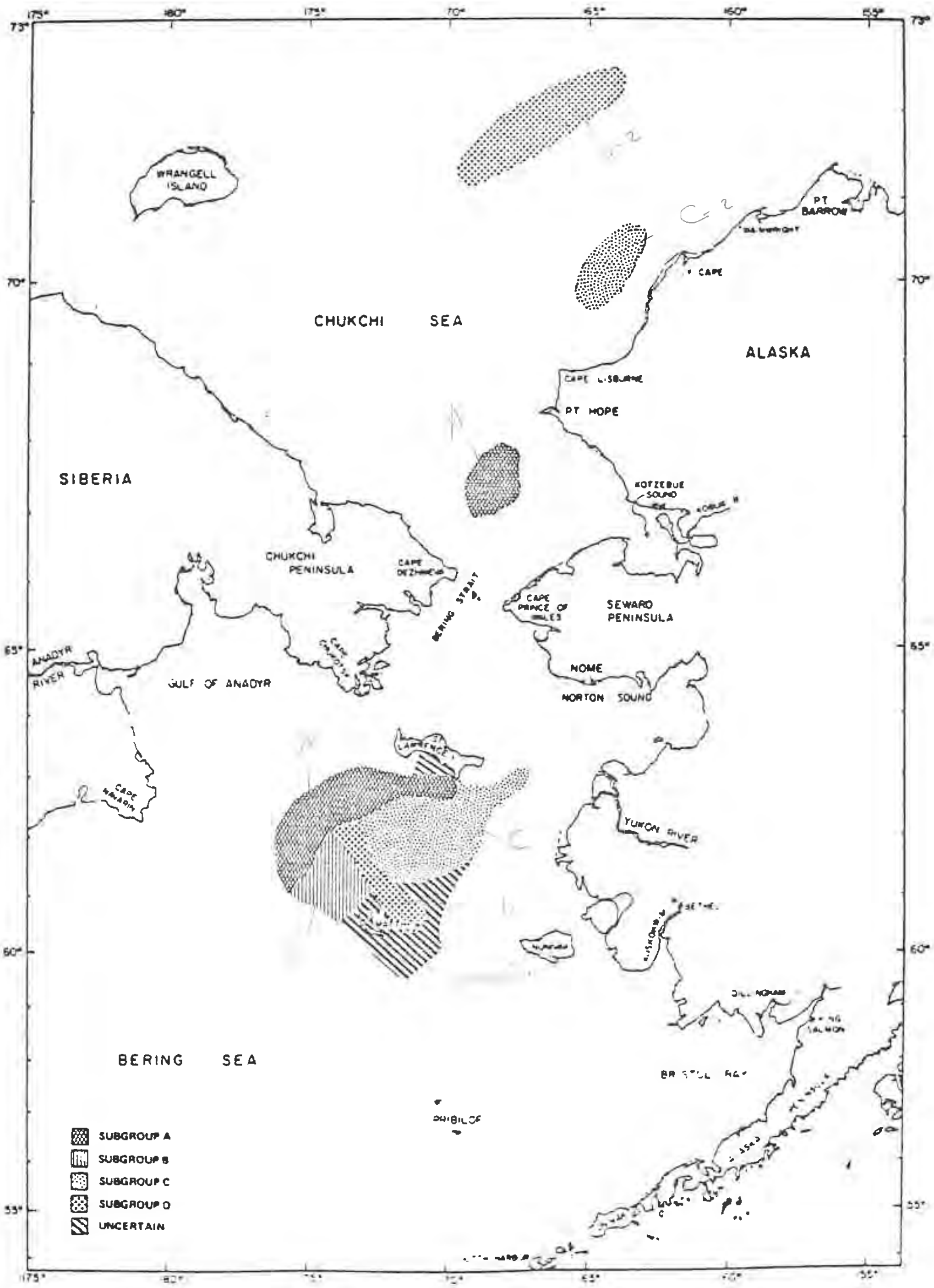

Figure 5. Major subgroups comprizing station cluster group VIII, the Central Bering Supergroup, on the Bering/ Chukchi Shelf.

indiv/m^2, mean wet weight biomass is 239 ± 54 g/m^2, mean organic carbon biomass is 10.1 ± 2.9 g/m^2, and mean station diversity is 0.853 ± 0.054 (Table 6). The overall mean station depth for the supergroup is 56 ± 5 m, and the mean sediment particle size is 4.10 ± 0.36 phi (Table 7).

Subgroup A of the Central Bering Supergroup, possessing an internal station-station minimum affinity of 0.42, is composed of 16 stations forming 2 distinct areal subgroups with one areal erratic. The major areal subgroup within Subgroup A is a cluster of 11 stations forming a broad crescent-shaped distribution just south of St. Lawrence Island (Fig. 5). The second areal subgroup, composed of 4 stations, is located north of Bering Strait in the southern Chukchi Sea. In addition to the 4 species characterizing the Supergroup as a whole, Subgroup A is characterized by strong complements of *Ophiura sarsi* (ophiuroid, also dominant in Group VI), *Pelonia corrugata* (tunicate), and *Cistenides hyperborea* (polychaete). This species characterization holds for both areal subgroups. The standing stock biomass of the southern (Bering Sea) areal subgroup averages 179 ± 70 g/m^2 wet weight and 7.7 ± 3.1 g/m^2 organic carbon as compared to 568 ± 614 g/m^2 wet weight and 26.6 ± 23.3 g/m^2 carbon for the northern (Chukchi) subgroup, again supporting, though not within rigorous statistical limits (Table 6), the trend of northerly increase in standing stock. The overall mean depth of stations within Subgroup A is 57 ± 8 m, averaging 59 ± 11 m for the Bering stations and 46 ± 7 for those in the Chukchi. The mean sediment particle size is 4.25 ± 0.61 phi; 4.09 ± 0.87 phi for the Bering Sea and 4.50 ± 1.12 phi for the Chukchi Sea (Table 7).

Subgroup B of the Central Bering Supergroup includes 8 stations and possesses a minimum station-station affinity of 0.46. The major distribution of this subgroup lies just northwest of St. Matthew Island and just south of Subgroup A (Fig. 5). There are two areal erratics - Station 34 to the southeast (within the bounds of Group VI) and Station 71 to the northeast. In addition to the dominant species for the Central Bering Supergroup as a whole, Subgroup B is characterized by the species *Nuculana radiata* (bivalve) and *Ophiura sarsi* (ophiuroid), with strong complements of *Maldane sarsi* (polychaete). *Pontoporea femorata* (amphipod) does not appear to exert dominance within this subgroup. The mean density for Subgroup B is 390 ± 218 indiv/m^2, the mean wet weight biomass is 206 ± 102 g/m^2, mean organic carbon biomass is 9.0 ± 4.2 g/m^2, and mean diversity index is 0.857 ± 0.054 (Table 6), with an average of 21 ± 5 species per station. The mean depth of Subgroup B is 78 ± 14 m, mean sediment particle size is 3.87 ± 1.03 phi (Table 7).

Subgroup C of Group VIII (Central Bering Supergroup) is a cluster of 17 stations having a minimum affinity of 0.31, the lowest of all the Central Bering subgroups. Correspondingly, the areal distribution of stations within this subgroup is indiscreet, forming at least two areal subgroups, one in the Bering and one in the Chukchi, with 6 areal erratics.

The main areal subgroup, consisting of 9 stations, lies just southeast of St. Lawrence Island (Fig. 5). A minor subgroup, of only 2 stations, lies in the northeastern Chukchi within the boundaries of Group VI. The areal erratics are scattered from Bering Strait almost to the northern limits of the Chukchi Sea, forming no distributional pattern that is readily discernable. The mean overall depth of stations within Subgroup C is 44 ± 5 m, ranging from 29 to 56 m. Mean depth for the Bering subgroup is 46 ± 8 m, that for the Chukchi is 37 ± 19 m. Sediment particle size averages 3.77 ± 0.67 phi over all Subgroup C stations, with a mean of 4.00 ± 0.98 phi for the Bering and 3.00 ± 0 phi for the Chukchi (Table 7).

While all 4 of the Central Bering Supergroup dominant species occur within this subgroup and exert dominance at at least some stations, the dominance of *M. calcarea* and, particularly, *N. tenuis* seems accentuated while that of *P. femorata* is much reduced. Corresponding to the generally unconsolidated nature of this subgroup, a total of 23 other species shares dominance with the 4 supergroup dominants in at least one station within the subgroup. It is of interest that at one station (112) *Macoma loveni* replaces *Macoma calcarea* as a dominant while at another (155) *Yoldia scissurata* replaces *Yoldia hyperborea*.

The mean density within Subgroup C is 451 ± 131 indiv/m^2, mean wet weight biomass is 200 ± 55 g/m^2, and mean organic carbon biomass is 8.5 ± 2.4 g/m^2. The standing stock mean for the areal erratics, 4 of which lie in the Chukchi Sea, is 9.4 g/m^2 carbon. The mean station diversity for Subgroup C is 0.863 ± 0.105 overall (Table 6).

Subgroup D, the last major subgroup encompassed by the Central Bering Supergroup, includes 5 stations forming 2 areal subgroups. Three of these stations lie in the Bering, forming an elongate distribution northeast of St. Matthew Island (Fig. 5), with the other two in the far northeastern Chukchi Sea. The mean depth of the Bering stations is

60 ± 10 m; that of the Chukchi stations is 51 ± 0 m. The mean sediment particle size is 4.08 ± 1.99 phi for the Bering and 6.50 ± 0 phi for the Chukchi (Table 7).

In addition to the 4 dominant supergroup species, *Nuculana radiata* (bivalve) appears to be strongly dominant within Subgroup D in both the Bering and Chukchi seas. *Pontoporea femorata*, conversely, is not a major element within this subgroup (Table 5). The sipunculid *Golfingia margaritaca* appears to be a major species for the Chukchi stations, though not for the Bering. The mean overall biomass for the subgroup is 338 ± 219 g/m^2 wet weight and 10.7 ± 5.0 g/m^2 carbon. The mean station diversity for Subgroup D is 0.785 ± 0.166 (Table 6).

More vague results were produced when a station-station cluster analysis was performed using the results from the 108 fine fraction samples analyzed. For this cluster analysis, the 44 species selected from the fine sieve fraction ranking program were implemented as indicator species. It appears, from the generated cluster dendogram, that all of the fine fraction stations fall into two major groups, each having a minimum station-station affinity of no better than 0.22. This affinity level is at least as good as that indicated for some of the coarse fraction cluster groups; however, when considering the areal distribution of these fine fraction cluster groups, the stations do not fall into discreet areal patterns as did, for the most part, the coarse fraction clusters, but appear to be distributed more or less at random over the study area. This result may be a reflection, or an indication, of the more ubiquitous nature of the fine fraction indicator species, or it may be a reflection of more pronounced clumping tendencies on the part of the fine-fraction species. It would be possible to break these two large cluster groups down into smaller station groups possessing some degree of areal integrity, but such effort would result in a large number of quite small cluster groups of low affinity and doubtful reliability. Consequently, analysis of the fine fraction results was suspended at this point and effort concentrated on the coarse sieve fractions, where the bulk of the biomass is contained and where further analysis seemed more feasible.

Species Cluster Analysis

For the 89 indicator species selected for the coarse sieve fraction station-station cluster analysis, species-species cluster analysis was also performed, with inconclusive results. Though a total of 8 major species clusters, corresponding vaguely to the 8 major station clusters, did appear to be discernable, the minimum species-species affinity level within these major groups was quite low (less than 0.10), so that confidence in their reliability is limited. The probable cause for this disappointing species cluster result is the large area included in the cluster analysis - in this case most of the continental shelf of the Bering and Chukchi seas.

In an attempt to circumvent this problem, cluster analysis was next performed on the 89 indicator species within station cluster groups, a separate species-species cluster being generated for each of the 8 major station groups. This analysis compared presence/absence and real (indiv/m^2) density by station rather than relative density. The results were somewhat more satisfactory than those produced when clustering species over the study area as a whole, though more questions seemed to be posed than solved by these results. At the 0.50 or higher affinity level, 83 species clusters or affinity groups were generated over all 8 station groups, ranging from 2 to 7 species per species cluster group and from 5 to 15 species cluster groups per station group (Appendix 10). The curious thing is, that while the same major species re-occur frequently within station groups, the same species clusters do not reappear within different station groups. Not only are discrete species clusters not repeated within different station groups, the same species appear to form different species-species affinities within different areas. The reasons for such shifting alliances are not apparent but would seem to indicate that distributions are generally not a result of interspecific biological interactions but are probably determined by the physical characteristics of the microhabitat. As each species probably reacts to not one but a suite of habitat determinants, these distributional relationships are apparently quite complex. One interesting observation is that while related species of the same genus frequently co-occur within the same station cluster group and even at the same station they do not, with one notable exception (*Yoldia hyperborea* and *Yoldia scissurata*, Species Group B, Station Cluster Group VII), form affinity clusters with one another. This result would seem to support a microhabitat theory of species distribution, assuming that related species of the same genus are adapted to and seek out slightly different ecological niches.

Environmental Correlations

The next approach, upon completion of the station and species cluster analysis, was to attempt stepwise multiple regression analysis (BMD02R), relating major species density distribution (indiv/m^2) to environmental factors (latitude, longitude, depth, sediment mode particle size). The 89 indicator species (coarse fraction) were used for this analysis. Temperature, salinity, and oxygen distributions were not utilized in this correlation, for reasons explained above. I recognized that the results of such a limited analysis would not necessarily define the causes of observed distributional patterns, but felt that such correlations would at least provide predictive capability and would permit speculation as to causes and reasons for distributional variability.

This correlation analysis provided rather gratifying, though not particularly startling, results. Of the 89 species assessed, 50% or better of the density distributional variability of 26 species could be accounted for (Table 8) by the 4 environmental factors utilized. Of these 26 species correlated at the greater than 0.50 (increase in R^2) level, 21 indicated a dominant distributional relationship with sediment particle size. Two of the remaining 5 correlate most strongly with longitude, 3 with latitude.

At the greater than 0.75 correlation level, 18 species indicate a dominant relationship with sediment type and 2 with latitude and longitude. At the 0.95 or better level, the distributional variability of all 12 species correlates most strongly with sediment type. Viewing the results from all 89 species, sediment particle size seemed to be the major correlating factor, of the 4 variables applied, for the distribution of 31

Table 8. Major species whose density distribution correlates at or above the 0.50 increase in R^2 level with distribution of environmental factors at stations on the Bering/Chukchi shelf.

Species	Major Environmental Correlation	Increase in R^2
M. dentata	sediment	0.97
S. droebachiensis	sediment	0.97
G. caryi	sediment	0.95
P. emmi	sediment	0.05
O. maculata	sediment	0.95
N. venustala	sediment	0.94
C. calcigera	sediment	0.94
E. emarginata	sediment	0.87
E. folli	sediment	0.87
E. echiuris	sediment	0.76
M. quadrispinosa	sediment	0.51
T. lutea	sediment	0.47
	latitude	0.23
N. minuta	sediment	0.47
	latitude	0.23
M. loveni	sediment	0.47
	latitude	0.23
C. infundibuliformis	sediment	0.46
	longitude	0.27
F. affinis	sediment	0.46
	longitude	0.27
M. niger	sediment	0.42
	latitude	0.27
N. radiata	sediment	0.37
	latitude	0.20
P. rugifera	sediment	0.37
	latitude	0.20
M. siphonalis	sediment	0.35
	depth	0.32

Table 8. Continued

Species	Major Environmental Correlation	Increase in R^2
N. lumbricalis	sediment	0.51
	depth	0.25
	latitude	0.24
A. borealis	longitude	0.33
	latitude	0.24
T. erosus	latitude	0.29
	longitude	0.26
B. ochotensis	latitude	0.32
	depth	0.30
C. crebricostata	longitude	0.30
	latitude	0.14
	sediment	0.11
Y. scissurata	latitude	0.24
	longitude	0.16
	depth	0.12

species, latitude for 25, longitude for 14, and depth for 11. Five exhibited uncertain correlation, relating equally to two or more of the 4 environmental factors (Table 9).

The results of this correlation analysis indicate that sediment type is the most strongly related of the 4 assessed environmental factors to variability in species density distributions. As stated above, however, and as will be discussed at greater length later on, this may be (and in some cases almost certainly is) an indirect rather than a direct correlation, reflecting conditions which determine both sediment type and species distribution rather than indicating a direct species/sediment relationship.

Seasonal and Annual Fluctuations

The final statistical approach applied to the quantitative distributional data was a series of 20 separate analysis of variance programs (Geist-Ullrich-Pitz, ANOVAR) intended to assess seasonal and annual variation in density and standing stock (carbon) biomass.

The first such analysis assessed possible variations in total standing stock carbon biomass between summer and winter over the 5 years during which sampling took place. The rather erratic areal and temporal distribution of samples made discrete seasonal evaluation of fluctuation within station cluster groups inadvisable, necessitating a 2x1 split plot factorial design with N=3, using pooled seasonal data over all stations, not the most desirable circumstance. With 3/1 degrees of freedom, this analysis yielded an F-ratio of 12.846, indicating no significant summer/winter variation in total standing stock over the study area.

Table 9. Correlation of major species density distribution with distribution of environmental factors at stations on the Bering/Chukchi shelf.

Species	Degree of Correlation (increase in R^2)				
	Sediment	Depth	Latitude	Longitude	Sum
Molluska					
Bivalvia					
A. borealis	0.16	0.09	0.24	0.33	0.82
A. montagui	0.00	0.03	0.05	0.03	0.11
C. ciliatum	0.02	0.02	0.00	0.25	0.29
L. fluctuosa	0.02	0.14	0.01	0.00	0.17
M. brota	0.47	0.05	0.23	0.05	0.80
M. calcarea	0.42	0.03	0.27	0.03	0.75
M. loveni	0.02	0.14	0.01	0.00	0.17
M. niger	0.47	0.05	0.23	0.05	0.80
N. tenuis	0.37	0.04	0.20	0.01	0.62
N. minuta	0.37	0.04	0.20	0.01	0.62
N. radiata	0.05	0.29	0.00	0.00	0.34
P. rugifera	0.47	0.05	0.23	0.05	0.80
S. groenlandicus	0.10	0.01	0.05	0.07	0.23
T. lutea	0.11	0.04	0.14	0.30	0.59
T. flexuosa	0.02	0.14	0.01	0.00	0.17
C. crebricostata	0.08	0.12	0.24	0.16	0.60
Y. hyperborea	0.10	0.01	0.05	0.07	0.23
Y. scissurata	0.14	0.10	0.29	0.26	0.79
Gastropoda					
C. nucleola	0.01	0.00	0.12	0.00	0.13
T. erosus	0.00	0.06	0.01	0.18	0.25
Annellida					
Polychaeta					
A. acutifrons	0.00	0.00	0.11	0.00	0.11
A. reducta	0.00	0.02	0.14	0.01	0.17
A. groenlandica	0.01	0.01	0.16	0.05	0.23

Table 9. Continued

Species	Degree of Correlation (increase in R^2)				
	Sediment	Depth	Latitude	Longitude	Sum
A. groenlandica	0.01	0.01	0.16	0.05	0.23
A. sarsi	0.03	0.15	0.05	0.01	0.24
A. anticostiensis	0.00	0.05	0.01	0.18	0.24
A. proboscidea	0.00	0.30	0.32	0.00	0.62
A. catenata	0.01	0.18	0.02	0.01	0.22
B. ochotensis	0.00	0.02	0.14	0.01	0.17
B. villosa	0.02	0.17	0.12	0.02	0.33
C. capitata	0.00	0.06	0.02	0.00	0.08
C. setosa	0.02	0.17	0.12	0.02	0.33
C. duneri	0.00	0.06	0.02	0.00	0.08
C. infundibuliformis	0.46	0.18	0.06	0.27	0.97
F. affinis	0.03	0.01	0.09	0.00	0.13
G. wireni	0.01	0.00	0.04	0.00	0.05
H. elongatus	0.00	0.03	0.02	0.15	0.20
H. imbricata	0.00	0.01	0.09	0.00	0.10
L. fragilis	0.00	0.00	0.10	0.00	0.10
M. sarsi	0.00	0.02	0.10	0.03	0.15
M. heeri	0.01	0.18	0.01	0.02	0.22
N. cacea	0.01	0.00	0.04	0.01	0.06
N. ciliata	0.01	0.01	0.16	0.05	0.23
N. longasetosa	0.01	0.01	0.16	0.04	0.22
N. rickettsi	0.51	0.25	0.24	0.00	1.00
N. lumbricalis	0.94	0.00	0.05	0.00	0.99
N. venustula	0.05	0.04	0.02	0.11	0.22
C. granulata	0.03	0.01	0.00	0.03	0.07
C. hyperborea	0.01	0.00	0.04	0.01	0.06
P. minuta	0.06	0.04	0.03	0.11	0.25
P. neglecta	0.00	0.00	0.02	0.00	0.02
P. praetermissa	0.95	0.00	0.00	0.04	0.99
P. emmi	0.10	0.01	0.02	0.07	0.20

Table 9. Continued

Species	Degree of Correlation (increase in R^2)				
	Sediment	Depth	Latitude	Longitude	Sum
S. inflatum	0.06	0.04	0.03	0.11	0.24
S. bombyx	0.03	0.00	0.00	0.03	0.06
S. scutata	0.01	0.00	0.03	0.01	0.05
T. stroemi	0.10	0.01	0.01	0.07	0.19
T. forbesii	0.06	0.03	0.05	0.12	0.26
P. canadensis	0.06	0.03	0.04	0.12	0.25
Crustacea					
Amphipoda					
A. birulai	0.00	0.00	0.02	0.00	0.02
A. macrocephala	0.01	0.04	0.01	0.04	0.10
A. nugax pacifica	0.00	0.00	0.02	0.00	0.02
B. gaimardi	0.00	0.00	0.02	0.00	0.02
E. folli	0.87	0.00	0.10	0.00	0.97
H. laevis	0.04	0.04	0.03	0.14	0.25
L. arcticus	0.05	0.00	0.06	0.11	0.22
M. dentata	0.97	0.00	0.02	0.00	0.99
M. formosa	0.04	0.02	0.07	0.11	0.24
M. quadrispinosa	0.51	0.04	0.00	0.12	0.67
P. milleri	0.02	0.04	0.07	0.12	0.25
P. femorata	0.00	0.00	0.03	0.00	0.03
P. fascata	0.03	0.00	0.00	0.02	0.05
P. grandimana	0.10	0.01	0.02	0.06	0.19
Cumacea					
E. emarginata	0.87	0.00	0.10	0.00	0.97
Echinodermata					
Echinoidea					
E. parma	0.01	0.04	0.01	0.04	0.10
S. droebachiensis	0.97	0.00	0.03	0.00	1.00

Table 9. Continued

Species	Degree of Correlation (increase in R^2)				
	Sediment	Depth	Latitude	Longitude	Sum
Holothurida					
C. calcigera	0.94	0.00	0.05	0.00	0.99
Ophiuroidea					
D. craterodmeta	0.03	0.01	0.00	0.03	0.07
G. caryi	0.95	0.00	0.00	0.04	0.99
O. maculata	0.95	0.00	0.00	0.04	0.99
O. sarsi	0.10	0.01	0.02	0.07	0.20
Sipunculida					
G. margaritaca	0.10	0.01	0.02	0.07	0.20
Priapulida					
P. caudatus	0.10	0.01	0.01	0.06	0.18
Echiurida					
E. echiuris	0.76	0.00	0.00	0.07	0.83
Chordata					
Tunicata					
M. siphonalis	0.35	0.32	0.07	0.16	0.90
P. corrugata	0.03	0.18	0.06	0.01	0.28
Mean	0.19	0.05	0.07	0.06	0.37

The second analysis assessed annual variation in total carbon standing stock over the entire area in which winter sampling took place, using station data from the years 1970, 1971, and 1972. With 2/41 degrees of freedom and a 3x1 split plot factorial design with N=181, this analysis resulted in an F-ratio of 0.617, insufficient to indicate any significant variation. A similar analysis of annual variation in summer standing stock over the study area for the years 1973 and 1974, using a 2x5 design with N=20, also indicated no significant variation.

Failing to discern any significant seasonal or annual variation in overall standing stock carbon biomass within the entire study area, analysis of variance was performed on density and standing stock of selected major species within selected cluster groups. The first run of this type evaluated annual density (indiv/m^2) variation between summer stations (1973, 1974) within station cluster Group I. No variation was discernable for *Ampelisca macrocephala* (23/1 degrees of freedom, F-ratio 0.007), *Ampelisca birulai* (1/23 degrees of freedom, F-ratio 0.869), *Byblis gaimardi* (1/23 degrees of freedom, F-ratio 0.532), or *Macoma calcarea* (1/23 degrees of freedom, F-ratio 0.001), thus indicating that there was no significant variation in density for these species, within cluster Group I, between the summers of 1973 and 1974. Similarly, no significant fluctuation in standing stock carbon biomass was discernable for *M. calcarea* or for *Astarte borealis* between the summers of 1973 and 1974 (1/23 and 1/23 degrees of freedom, F-ratio 0.588 and 0.914, respectively) within this cluster group.

The echinoid *Echinarachnius parma*, however, with 1/22 degrees of freedom and an F-ratio of 7.590, did appear to vary significantly in density within cluster Group II between the summers of 1973 and 1974 at the 95% confidence level. At the 99% confidence level, this variation is not significant. Analysis of seasonal variation (summer/winter) of *E. parma* density within this cluster group, however, did not indicate significant variation with 1/31 degrees of freedom and an F-ratio of 0.649.

Maldane sarsi, within cluster Group VI, exhibited no significant seasonal variation in density (1/9 degrees of freedom, F-ratio 1.985).

The bivalves *Nucula tenuis, Macoma calcarea,* and *Yoldia hyperborea* did not exhibit significant annual fluctuations in density between the winters of 1970, 1971, and 1972 within cluster Group VIII (1/18, 1/18, and 1/18 degrees of freedom and F-ratios of 0.236, 0.739, and 0.037, respectively), though within this same cluster group the Amphipod *Pontoporea femorata* did seem to fluctuate significantly in density between the winters of 1970, 1971, and 1972 at the 95% confidence level, though not at the 99% level, with 1/18 degrees of freedom and F-ratio 3.407. The density of *M. calcarea* did not vary significantly from summer to winter within this cluster group (1/24 degrees of freedom, F-ratio 2.660), nor did the standing stock carbon biomass (1/24 degrees of freedom, F-ratio 0.171). Annual winter variation in standing stock carbon for *M. calcarea* within this cluster group was also insignificant with 1/18 degrees of freedom and F-ratio 0.062.

Within cluster Group VII, *M. calcarea* did not exhibit significant variation, in either density or standing stock carbon biomass, between the summers of 1973 and 1974 (1/4 and 1/4 degrees of freedom and F-ratio 0.647 and 0.058, respectively).

All of the above species within-group analyses amployed a 2x1 split plot factorial design.

Viewing the study region as a whole then, and looking at selected species and cluster groups, there appears to be little discernable fluctuation, seasonally or annually, in either density or standing stock. The only statistically significant variations appear to be annual density fluctuations for the echinoid *Echinarachnius parma* within cluster Group II, and for the amphipod *Ponteporea femorata* within cluster Group VIII, between the summers of 1973 and 1974 and between the winters of 1970, 1971, and 1972, respectively. These results are statistically valid at the 95% but not at the 99% confidence level.

This apparent seasonal and annual population stability may be a real situation, or may be an artifact reflecting sampling technique. Resources and logistics were not such as to support a sampling program, in either areal or temporal terms, designed around the null hypothesis of such seasonal and annual stability. The sampling pattern, therefore, left much to be desired and these limitations may be reflected in the results regarding population fluctuations. Population distributions tend to be extremely patchy, (Rowland, 1972; Stoker, 1973) particularly in the central Bering Sea, further compromising this analysis.

On the positive side, however, stability in terms of both density and biomass seems to be supported by the productivity assessment for the bivalve *Macoma calcarea*, discussed later on, where mortality is seen to be almost perfectly balanced by growth and recruitment, indicating a steady-state system. In any event, this problem of annual and seasonal fluctuation (or lack of such) deserves further attention.

Nutrient Analysis

Dry/wet weight ratios, organic carbon, organic nitrogen and caloric analyses were obtained for 68 of the more common taxa encountered. These results (Table 10) yielded overall means of dry weight 16.3 ± 2.1% wet weight, organic carbon 5.8 ± 0.6% wet weight, and organic nitrogen 1.3 ± 0.1% wet weight averaged over all taxa considered. The overall carbon/nitrogen ratio was 4.5 ± 0.8, and the overall caloric content 714 ± 61 cal/g wet weight. Ash content for the taxa analysed averaged 19 ± 4%. Results by species, class and phylum are presented in Tables 10 and 11.

All echinoderm and decapod crustacean values were from acidified samples. Due to the extremely high inorganic content of echinoderm samples, caloric analysis proved generally unreliable and was disregarded except for a few species. All of the above values are based on analysis of formalin-preserved samples.

Organic carbon and nitrogen results from this analysis are slightly at variance with results of a preliminary study (Stoker, 1973). Organic carbon values per wet weight run 1.6% higher for polychaetes, 0.3% higher for bivalve mollusks, 1.1% higher for amphipods, and 0.7% higher overall than indicated by the previous study, while nitrogen values run 0.5% higher for polychaetes, the same for bivalve mollusks, 0.1% lower for amphipods, and 0.2% higher overall. Methods and equipment employed for both studies were identical but no caloric analysis was done for the previous study. A possible explanation for this difference might be seasonal variations in the condition of the organisms.

Analysis was also performed on frozen samples of 19 taxa and results compared with those for formalin-preserved samples (Tables 12, 13, 14).

Table 10. Organic carbon, nitrogen, and caloric content of formalin-preserved specimens from the Bering/Chukchi shelf.

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Polychaeta								
Ampharete sp.	14.57	46.6	6.8	9.5	1.4	5230	762	10.9
Artacama sp.	20.18	30.0	6.1	7.2	1.5	3300	666	42.6
Brada sp.	20.84	21.0	4.4	5.8	1.2	2510	523	55.0
E. nodosa	15.46	47.0	7.3	13.6	2.1	5200	804	5.7
Gattyana sp.	15.04	46.1	6.9	12.7	1.9	5246	789	9.4
H. elongatus	16.69	36.1	6.1	9.0	1.5	3936	657	33.6
Lumbrinereis sp.	19.48	47.4	9.3	12.1	2.4	5323	1037	8.1
Maldanidae	20.49	34.0	7.0	9.2	1.9	3680	754	31.9
M. sarsi	24.00	28.6	6.9	7.2	1.7	3245	779	39.9
Nephtys sp.	20.07	35.7	7.2	9.9	2.0	3881	779	29.0
C. hyperborea	25.03	18.0	4.5	3.9	1.0	2066	517	64.0
Anaitides sp.	17.31	50.4	8.7	11.5	2.0	5604	970	6.1
P. praetermissa	18.23	40.8	7.4	10.6	1.9	4240	773	23.6
Sabellidae	14.95	50.1	7.5	11.0	1.6	5452	815	7.1
S. scutata	26.49	15.5	4.1	4.7	1.3	1547	410	70.0
Travisia sp.	28.74	33.0	9.5	10.6	3.0	1399	402	74.2
Mean	19.86	36.3	7.2	9.3	1.8	3600	715	31.9
95% C.L.	± 2.40	± 6.1	± 0.8	± 1.5	± 0.2	± 761	± 95	± 12.7

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Molluska								
Bivalvia								
A. borealis	3.52	43.2	1.5	10.1	0.4	4830	170	7.5
C. ciliatum	5.63	38.9	2.2	9.7	0.5	4759	268	10.4
L. fluctuosa	6.40	43.7	2.8	10.1	0.6	5141	329	7.0
L. norvegica	4.33	40.9	1.8	9.8	0.4	4596	199	15.5
M. calcarea	8.10	43.5	3.5	6.8	0.6	4802	389	13.5
M. niger	5.58	44.9	2.5	10.2	0.6	5054	282	7.2
N. tenuis	9.13	43.1	3.9	7.7	0.7	5049	461	16.4
N. radiata	4.78	39.8	1.9	8.6	0.4	4874	233	14.9
S. groenlandicus	8.70	40.5	3.3	9.7	0.8	5034	438	8.8
T. lutea	9.02	41.6	3.8	9.6	0.9	4800	433	7.7
C. crebricostata	3.90	36.6	1.4	8.2	0.3	4462	174	16.2
Y. hyperborea	11.60	40.6	4.7	8.9	1.0	4750	551	18.3
Mean	6.72	41.4	2.8	9.1	0.6	4846	327	12.0
95% C.L.	±1.59	± 1.5	± 0.6	± 0.6	± 0.1	± 127	± 80	± 2.7

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Molluska								
Gastropoda								
Buccinum sp.	18.77	45.5	8.5	11.4	2.1	4875	915	5.8
Colus sp.	12.31	45.9	5.7	10.6	1.3	4923	606	5.1
Margarites sp.	9.10	32.8	3.0	6.8	0.6	3703	337	28.7
N. clausa	16.98	42.7	7.3	9.9	1.7	4859	825	7.6
Neptunea sp.	10.93	44.3	4.8	9.9	1.1	4758	520	6.9
Polinices sp.	19.91	43.8	8.7	9.7	1.9	4771	950	6.8
Mean	14.67	42.5	6.2	9.7	1.4	4717	692	10.2
95% C.L.	±4.72	± 5.0	± 2.3	± 1.6	± 0.4	± 490	± 256	± 9.6

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Crustacea								
Amphipoda								
A. birulai	18.20	45.9	8.4	8.1	1.5	4994	909	14.1
A. macrocephala	14.77	45.0	6.7	8.2	1.2	5030	743	15.3
Anonyx sp.	17.70	45.9	8.1	7.5	1.3	4768	844	15.7
B. gaimardi	14.38	48.1	6.9	8.4	1.2	5292	761	11.9
E. folli	13.29	49.5	6.6	8.2	1.1	5403	718	9.8
H. laevis	15.46	51.2	7.9	8.5	1.3	5446	842	9.0
Hippomedon sp.	17.38	46.7	8.1	7.4	1.3	5063	880	15.0
L. arcticus	14.40	43.8	6.3	9.1	1.3	4708	678	17.0
M. formosa	12.70	44.4	5.6	7.2	0.9	4717	599	18.8
M. quadrispinosa	17.65	53.9	9.5	7.2	1.3	6040	1066	8.1
P. femorata	17.26	53.2	9.2	7.1	1.2	5794	1000	9.8
Protomedeia sp.	13.80	49.3	6.8	9.3	1.3	5181	715	12.0
R. aculeata	15.86	38.9	6.2	7.4	1.2	5189	823	21.5
Mean	15.60	47.4	7.4	8.0	1.2	5218	814	13.7
95% C.L.	± 1.33	± 2.4	± 0.7	± 0.4	± 0.8	± 241	± 79	± 2.4

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Crustacea								
Decapoda								
Crangonidae	18.60	29.3	5.5	7.5	1.4	4505	838	16.5
Chionoecetes sp.	20.12	25.8	5.2	5.2	1.0	3589	722	25.1
H. coarctatus	22.11	20.4	4.5	4.9	1.1	3008	665	31.6
Pagurus sp.	22.33	23.5	5.2	6.3	1.4	3672	820	24.0
Pandalus sp.	18.21	45.2	8.2	10.4	1.9	5058	921	11.9
Mean	20.27	28.8	5.7	6.9	1.4	3912	793	24.8
95% C.L.	± 2.50	± 12.0	± 1.7	± 2.8	± 0.4	± 1005	± 125	± 9.5

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Echinodermata								
C. calcigera	20.68	8.9	1.8	6.5	1.3	–	–	–
G. caryi	37.08	9.1	3.4	1.9	0.7	–	–	–
O. sarsi	47.88	2.9	1.4	0.5	0.2	–	–	–
Psolis sp.	27.24	8.9	2.4	1.8	0.5	–	–	–
S. droebachiensis	32.48	3.5	1.1	0.5	0.2	–	–	–
E. parma	51.48	1.5	0.8	0.1	0.1	–	–	–
Mean	36.14	5.8	1.8	1.9	0.5			
95% C.L.	±12.70	± 3.7	± 0.8	± 2.4	± 0.3			

Table 10. Continued

Taxa	Tissue Dry Wt % Total Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt
Miscellaneous Taxa								
B. ovifera	10.57	38.6	4.1	9.5	1.0	3567	377	18.7
Alcyonidium sp.	9.05	23.6	2.1	6.6	0.6	-	-	-
Nemertinea	17.86	52.3	9.3	11.6	2.1	5062	904	8.2
Sipunculidae	18.07	25.2	4.5	8.0	1.5	3010	544	43.2
Anthozoa	13.66	44.8	6.1	11.5	1.6	5029	687	9.3
Echiuridae	11.44	44.2	5.1	11.0	1.3	4921	563	15.2
Nudibranchiata	8.06	45.5	3.7	14.0	1.1	8040	648	10.5
P. corrugata	11.30	12.8	1.4	4.6	0.5	1946	220	59.5
Balanus sp.	2.46	44.5	1.1	10.6	0.3	4838	119	12.9
E. rubiformis	19.18	21.0	4.0	5.6	1.1	2899	556	34.1
Mean	12.10	35.2	4.1	9.3	1.1	4368	513	23.5
95% C.L.	± 3.80	± 9.5	± 1.7	± 2.2	± 0.3	± 1276	± 173	± 12.7

Table 11. Organic carbon, nitrogen, and caloric content of major taxonomic groups on the Bering/Chukchi shelf.

Taxa	Tissue Dry Wt % Wet Wt	C_{org} % Tissue Dry Wt	C_{org} % Total Wet Wt	N_{org} % Tissue Dry Wt	N_{org} % Total Wet Wt	Cal/g Tissue Dry Wt	Cal/g Total Wet Wt	Ash % Tissue Dry Wt	C_{org}/N_{org} Ratio
MAJOR TAXONOMIC GROUPS									
Polychaeta	19.86	36.3	7.2	9.3	1.8	3600	715	32	3.9
Molluska									
Bivalvia	6.72	41.4	2.8	9.1	0.6	4846	327	12	4.5
Gastropoda	14.67	42.5	6.2	9.7	1.4	4717	692	10	4.4
Crustacea									
Amphipoda	15.60	47.4	7.4	8.0	1.2	5218	814	14	5.9
Decapoda	20.27	28.8	5.7	6.9	1.4	3912	793	25	4.2
Echinodermata	36.14	5.8	1.8	1.9	0.5	-	216*	-	3.0
Overall Mean (all 68 species)	16.34	36.5	5.8	8.2	1.3	4369	714	19	4.5
95% C.L.	± 2.10	± 3.2	± 0.6	± 0.7	± 0.1	± 286	± 61	± 4	± 0.8

*extrapolated from cal/corg ratios

Table 12. Comparison of organic carbon content of frozen vs formalin-preserved (HCOH) specimens from the Bering/Chukchi shelf.

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Organic Carbon % Tissue Dry Wt (frozen)	Organic Carbon % Tissue Dry Wt (HCOH)	Organic Carbon % Total Wet Wt (frozen)	Organic Carbon % Total Wet Wt (HCOH)	Frozen/ HCOH Ratio (C_{org} % Total Wet Wt)
Molluska							
Bivalvia							
A. borealis	3.45	3.52	39.7	43.2	1.4	1.5	0.9
C. ciliatum	9.91	5.63	39.1	38.9	3.9	2.2	1.8
M. calcarea	11.10	8.10	36.9	43.5	4.1	3.5	1.2
M. niger	8.42	5.58	43.9	44.9	3.7	2.5	1.5
N. tenuis	11.03	9.13	41.3	43.1	4.6	3.9	1.2
N. radiata	6.47	4.78	37.3	39.8	2.4	1.9	1.3
S. groenlandicus	12.20	8.70	42.8	40.5	5.2	3.3	1.6
C. crebricostata	5.10	3.90	35.7	36.6	1.8	1.4	1.3
Y. hyperborea	13.90	11.60	41.2	40.6	5.7	4.7	1.2
Mean	9.06	6.77	39.8	41.2	3.6	2.8	1.3
95% C.L.	± 2.70	± 2.10	± 2.1	± 2.0	± 1.1	± 0.8	± 0.2

Table 12. Continued

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Organic Carbon % Tissue Dry Wt (frozen)	Organic Carbon % Tissue Dry Wt (HCOH)	Organic Carbon % Total Wet Wt (frozen)	Organic Carbon % Total Wet Wt (HCOH)	Frozen/ HCOH Ratio (C_{org} % Total Wet Wt)
Miscellaneous Taxa							
N. clausa	16.98	13.44	42.7	43.5	7.2	5.8	1.2
R. aculeata	23.75	15.86	41.6	38.9	9.9	6.1	1.6
Maldanidae	22.78	20.49	31.4	34.0	7.1	6.9	1.0
Nephtys sp.	23.35	20.07	36.5	35.7	8.5	7.1	1.2
Crangonidae	24.43	18.60	28.7	29.3	7.0	5.5	1.3
Pagurus sp.	28.08	22.33	20.0	23.5	5.6	5.2	1.1
Anthozoa	9.70	13.66	34.4	44.8	3.3	6.1	0.5
E. echiurus	10.95	11.44	36.1	44.2	3.9	5.0	0.8
Nudibranchiata	14.41	8.06	41.5	45.5	6.0	3.6	1.7
E. rubiformis	28.00	19.18	22.5	21.0	6.3	4.0	1.6
Mean	20.20	16.20	38.5	36.0	6.4	3.5	1.2
95% C.L.	± 4.90	± 3.40	± 5.6	± 6.4	± 1.4	± 0.7	± 0.3
Overall Species Mean	14.90	11.70	36.4	38.5	5.1	4.2	1.3
95% C.L.	± 3.80	± 3.00	± 3.2	± 3.4	± 1.1	± 0.8	± 0.2

Table 13. Comparison of organic nitrogen content of frozen vs formalin-preserved (HCOH) specimens from the Bering/Chukchi shelf.

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Organic Nitrogen % Tissue Dry Wt (frozen)	Organic Nitrogen % Tissue Dry Wt (HCOH)	Organic Nitrogen % Total Wet Wt (frozen)	Organic Nitrogen % Total Wet Wt (HCOH)	Frozen/ HCOH Ratio (Organic Nitrogen % Wet Wt)
Molluska							
Bivalvia							
A. borealis	3.45	3.52	10.0	10.1	0.3	0.4	.8
C. ciliatum	9.91	5.63	10.3	9.7	1.0	0.5	2.0
M. calcarea	11.10	8.10	7.3	6.8	0.8	0.6	1.3
M. niger	8.42	5.58	8.9	10.2	0.7	0.6	1.2
N. tenuis	11.03	9.13	9.1	7.7	1.0	0.7	1.4
N. radiata	6.47	4.78	7.9	8.6	0.5	0.4	1.3
S. groenlandicus	12.20	8.70	8.6	9.7	1.0	0.8	1.3
C. crebricostata	5.10	3.90	7.6	8.2	0.4	0.3	1.3
Y. hyperborea	13.90	11.60	9.1	8.9	1.3	1.0	1.3
Mean	9.06	6.77	8.8	8.9	0.8	0.6	1.3
95% C.L.	± 2.65	± 2.11	± 0.8	± 0.9	± 0.3	± 0.2	± 0.2

Table 13. Continued

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Organic Nitrogen % Tissue Dry Wt (frozen)	Organic Nitrogen % Tissue Dry Wt (HCOH)	Organic Nitrogen % Total Wet Wt (frozen)	Organic Nitrogen % Total Wet Wt (HCOH)	Frozen/ HCOH Ratio (Organic Nitrogen % Wet Wt)
Miscellaneous Taxa							
N. clausa	16.98	13.44	9.9	10.6	1.7	1.4	1.2
R. aculeata	23.75	15.86	7.3	7.4	1.7	1.2	1.4
Maldanidae	22.78	20.49	7.3	9.2	1.7	1.9	0.9
Nephtys sp.	23.35	20.07	10.2	9.9	2.4	2.0	1.2
Crangonidae	24.43	18.60	7.0	7.7	1.7	1.4	1.2
Pagurus sp.	28.08	22.33	5.0	6.3	1.4	1.4	1.0
Anthozoa	9.70	13.66	8.2	11.5	0.8	1.6	0.5
E. echiurus	10.95	11.44	9.5	11.0	1.0	1.3	0.8
Nudibranchiata	14.41	8.06	9.5	14.0	1.4	1.3	1.1
E. rubiformis	28.00	19.18	4.3	5.6	1.2	1.1	1.1
Mean	20.24	16.31	7.8	9.3	1.5	1.5	1.0
95% C.L.	± 4.83	± 3.28	± 1.4	± 1.9	± 0.3	± 0.2	± 0.2
Overall Species Mean	14.95	11.79	8.3	9.1	1.2	1.0	1.2
95% C.L.	± 3.76	± 2.96	± 0.8	± 1.0	± 0.3	± 0.2	± 0.2

Table 14. Comparison of caloric value of frozen vs formalin-preserved (HCOH) specimens, from the Bering/Chukchi shelf.

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Cal/g Tissue Dry Wt (frozen)	Cal/g Tissue Dry Wt (HCOH)	Cal/g Total Wet Wt (frozen)	Cal/g Total Wet Wt (HCOH)	Frozen/HCOH Ratio (Cal/g Total Wet Wt)
Molluska							
Bivalvia							
A. borealis	3.45	3.52	4223	4830	146	170	0.9
C. ciliatum	9.91	5.63	-	4759	-	268	-
M. calcarea	11.10	8.10	4366	4802	485	389	1.2
M. niger	8.42	5.58	4589	5054	386	282	1.3
N. tenuis	11.03	9.13	4599	5049	507	461	1.1
N. radiata	6.47	4.78	4234	4874	274	233	1.2
S. groenlandicus	12.20	8.70	4614	5034	563	438	1.3
C. crebricostata	5.10	3.90	3981	4462	203	174	1.2
Y. hyperborea	13.90	11.60	4762	4750	662	551	1.2
Mean	9.06	6.77	4422	4846	403	330	1.2
95% C.L.	± 2.67	± 2.11	± 219	± 141	± 153	± 104	± 1.1

Table 14. Continued

Taxa	Tissue Dry Wt % Total Wet Wt (frozen)	Tissue Dry Wt % Total Wet Wt (HCOH)	Cal/g Tissue Dry Wt (frozen)	Cal/g Tissue Dry Wt (HCOH)	Cal/g Total Wet Wt (frozen)	Cal/g Total Wet Wt (HCOH)	Frozen/ HCOH Ratio (Cal/g Total Wet Wt)
Miscellaneous Taxa							
R. aculeata	23.75	15.86	4286	3960	1016	625	1.6
Maldanidae	22.78	20.49	3297	3431	748	700	1.1
Nephtys sp.	23.35	20.07	3979	3881	927	776	1.2
Crangonidae	24.43	18.60	4302	4505	1050	838	1.3
Pagurus sp.	28.08	22.33	2910	3677	815	820	1.0
E. echiurus	10.95	11.44	3836	4921	418	561	0.7
Mean	22.22	18.13	3768	4063	822	720	1.2
95% C.L.	± 6.12	± 4.12	± 586	± 579	± 243	± 116	± 0.3
Overall Species Mean	14.33	11.32	4142	4533	586	486	1.2
95% C.L.	± 4.42	± 3.64	± 300	± 297	± 170	± 129	± 0.1

For bivalve mollusks (9 species compared), dry/wet weight values averaged 2.3% higher for frozen samples than for formalin samples, organic carbon values averaged 1.2% higher (per wet weight), organic nitrogen values averaged 0.2% higher (per wet weight), and caloric values averaged 66 cal/g higher (per wet weight). For all taxa compared, dry/wet weight values averaged 3.2% higher for frozen than for formalin samples, organic carbon values averaged 0.9% higher (per wet weight), organic nitrogen values 0.2% higher (per wet weight), and caloric values 100 cal/g higher (per wet weight). The analysis of dry tissue samples yielded very similar results for frozen and formalin-preserved samples, the primary difference lying in the dry/wet weight ratios, presumably as a result of water loss due to freezing or gain due to formalin preserving, probably the former (Tables 12, 13, 14). In any case, I decided that though these differences may be real and deserve further investigation, the present sample was too small in terms of species compared and the differences not significantly greater than those observed between formalin samples of this and previous analysis (Stoker, 1973). Accordingly, all carbon, nitrogen, and caloric values applied throughout this study are based on formalin preserved samples.

Analysis was also run on 8 taxa for comparison between acidified *versus* non-acidified samples. Overall, results indicate that the non-acidified samples contain 3.0% more carbon and 0.5% more nitrogen content (per wet weight) than do the acidified ones (Table 15). This follows expectations, the purpose of the acidification being to remove inorganic carbonates. Accordingly, for those species possessing large quantities of carbonate material, such as echinoderms and decapod crustaceans, acidified

Table 15. Comparison of organic carbon content of acidified (HCL) vs non-acidified (NA) specimens from the Bering/Chukchi shelf.

Taxa	Dry Wt % Wet Wt	Organic Carbon % Dry Wt (HCL)	Organic Carbon % Dry Wt (NA)	Organic Carbon % Wet Wt (HCL)	Organic Carbon % Wet Wt (NA)	HCL/NA Ratio (C_{org} % wet wt)
Crustacea						
Crangonidae	18.60	29.3	41.6	5.5	7.7	0.71
Chionoecetes sp.	20.12	25.8	36.2	5.2	7.3	0.71
H. coarctatus	22.11	20.4	32.2	4.5	7.1	0.63
Pagurus sp.	22.33	23.5	39.5	5.2	8.8	0.59
Mean	20.79	24.8	37.4	5.1	7.7	0.66
95% C.L.	± 3.00	± 5.9	± 6.4	± 0.5	± 1.1	± 0.10
Echinodermata						
C. calcigera	20.68	8.9	27.6	1.8	5.7	0.32
O. sarsi	47.88	2.9	16.4	1.4	7.8	0.18
Mean	34.28	5.9	22.0	1.6	6.8	0.25
95% C.L.	±59.51	±12.1	±24.1	± 2.5	± 4.6	± 0.92
Miscellaneous						
P. corrugata	11.33	12.8	19.2	1.4	2.2	0.64
E. rubiformis	28.00	22.5	31.1	6.3	8.7	0.72
Mean	20.00	17.7	25.2	3.9	5.5	0.68
95% C.L.	±36.00	±20.8	±25.6	±10.4	±13.7	± 0.92
Overall Species Mean	23.57	18.9	31.1	3.9	6.9	0.56
95% C.L.	± 9.00	± 7.6	± 7.5	± 1.7	± 1.8	± 0.17

sample results were used in the organic carbon, nitrogen, and caloric computations throughout the study.

For species with adequate data, comparisons were also made between organic carbon content and caloric value. These results indicate that organic carbon/caloric values are quite correlatable, there being only slight variance within taxonomic groups (Table 16). For polychaetes, the mean comparative value was 110 ± 3 calories per gram wet weight per organic carbon percent wet weight, with a range of from 100 to 125. Bivalve mollusks averaged 118 ± 4 calories per carbon percent, ranging from 111 to 133, with gastropods ranging from 108 to 113 and averaging 109 ± 3 cal/c%. Amphipods averaged 110 ± 4 cal/c%, with a range of from 104 to 133, and decapods averaged 142 ± 22 cal/c%, ranging from 112 to 158. Overall, the mean conversion value, for all species considered, was 117 ± 4 calories per carbon percent (wet weight). Due to the difficulty in obtaining caloric values for echinoderms as a result of the large percentage of non-combustible carbonates, no comparisons were possible for this phylum.

Caloric results seem compatible with those of at least one previously published study (Brawn, *et al.* 1968), which yielded mean values of 656 cal/g wet weight for polychaetes as opposed to the 715 cal/g mean of this study. By species, Brawn's estimate of 1059 cal/g for *Lumbrinereis fragilis* compares well with the 1037 cal/g value of this study, as do his estimates for *Nephtys ciliata* (747 as opposed to 779 cal/g), *Cistenides (Pectinaria) hyperborea* (554 as opposed to 517 cal/g), *Natica clausa* (791 as opposed to 825 cal/g). All of these values are calories per gram total wet (live) weight.

Table 16. Conversion factors for organic carbon and caloric content of selected species, from the Bering/Chukchi shelf.

Taxa	Organic Carbon % Wet Wt	Cal/g Wet Wt	Ratio % C/Cal
Polychaeta			
Ampharete sp.	6.8	762	112
Artacama sp.	6.1	666	109
Brada sp.	4.4	523	119
E. nodosa	7.3	804	110
Gattyana sp.	6.9	789	114
H. elongatus	6.1	657	108
Lumbrinereis sp.	9.3	1037	112
Maldanidae	7.0	754	108
M. sarsi	6.9	779	113
Nephtys sp.	7.2	779	108
C. hyperborea	4.5	517	115
Anaitides sp.	8.7	970	111
P. praetermissa	7.4	773	104
Sabellidae	7.5	815	109
S. scutata	4.1	410	100
Mean	6.7	736	110
95% C.L.	± 0.8	± 91	± 3

Table 16. Continued

Taxa	Organic Carbon % Wet Wt	Cal/g Wet Wt	Ratio % C/Cal
Molluska			
Bivalvia			
A. borealis	1.5	170	113
C. ciliatum	2.2	268	122
L. fluctuosa	2.8	329	118
L. norvegica	1.8	199	111
M. calcarea	3.5	389	111
M. niger	2.5	282	113
N. tenuis	3.9	461	118
N. radiata	1.9	233	123
S. groenlandicus	3.3	438	133
T. lutea	3.8	433	114
C. crebricostata	1.4	174	124
Y. hyperborea	4.7	551	117
Mean	2.8	327	118
95% C.L.	± 0.6	± 80	± 4
Gastropoda			
Buccinum sp.	8.5	915	108
Colus sp.	5.7	606	106
Margarites sp.	3.0	337	112
N. clausa	7.3	825	113
Neptunea sp.	4.8	520	108
Polinices sp.	8.7	950	109
Mean	6.3	692	109
95% C.L.	± 2.3	± 256	± 3

Table 16. Continued

Taxa	Organic Carbon % Wet Wt	Cal/g Wet Wt	Ratio % C/Cal
Miscellaneous			
B. ovifera	4.1	377	92
Nemertinea	9.3	904	97
Sipunculida	4.5	544	121
Anthozoa	6.1	687	113
Echiuridae	5.1	563	110
Nudibranchiata	3.7	648	175
P. corrugata	1.4	220	157
Balanus sp.	1.1	119	108
E. rubiformis	4.0	556	139
Mean	4.4	513	124
95% C.L.	± 1.8	± 185	± 22
Overall Species Mean	5.6	638	117
95% C.L.	± 0.6	± 62	± 4

While these carbon, nitrogen, and caloric results are employed in this study only for standing stock biomass and, in the case of *Macoma calcarea*, for growth and productivity estimates, it is hoped that continued application will be found as knowledge of food webs and trophic energetics increases in sophistication and detail.

Growth, Mortality, and Recruitment: *Macoma calcarea*

From the quantitative benthic samples, a total of 2,881 specimens of *Macoma calcarea* were analysed as described above for growth rates, shell/tissue ratios, and nutrient values. Unfortunately, data representing the younger year classes (below age 3) are missing or considered unreliable in this sample due to sampling technique and preserving methods. In general, specimens analysed rarely exceeded 30 mm in length and 9 years of age. Only 15 specimens older than 11 years were encountered in the samples. The largest individual had a shell length of 45.8 mm, with 18 annuli.

Applying the technique of Gruffydd (1974), mortality estimates were arrived at for age classes 5 through 10 (Table 17). As may be seen, these mortality estimates indicate that the older year classes (above 6) are increasingly subject to removal from the population by predation or other forms of mortality.

Only small numbers of *M. calcarea* were generally present from individual stations; as a result, little can be deduced about annual recruitment be station. Likewise, within the 9 station groups arbitrarily partitioned from south to north in order to estimate latitudinal effects, sufficient numbers for analysis of recruitment were not available for all groups. Only when totals from all stations and latitudinal groups were lumped were

Table 17. The actual and predicted age distribution of *Macoma calcarea* and estimated natural mortality on the Bering/Chukchi shelf.

Age (yrs)	Actual Number of Individuals at Each Age	Predicted Number of Individuals at Each Age	Estimated Natural Mortality (% age class/yr)
2	73	-	-
3	464	-	-
4	687	698	-
5	665	587	15.9
6	493	477	18.7
7	232	222	53.4
8	89	154	30.6
9	47	60	61.0
10	39	35	41.6

sufficient numbers available for estimation. Analysis of recruitment success was further impeded by inadequate data regarding the younger year classes and by the apparently heavy mortality suffered by age classes older than 6, leaving only animals in the year classes 3 through 6 representative of their original year class strength. Examination of the relative abundance of these year classes, however, indicated relatively stable annual recruitment over the sample area.

For the different age classes, mean values for shell length, total wet weight (g/indiv), shell weight (g/indiv), shell weight % total wet weight, tissue wet weight (g/indiv), tissue wet weight % total wet weight, organic carbon weight (mg/indiv), and growth rate (mm/year shell increase and mgC/indiv/yr increase) are listed in Tables 18 and 19. In terms of organic carbon, growth rates seem to decline gradually from a peak value of 70% annual increase at year 6 to 32%/yr at years 14-15. Somewhat surprisingly, growth rates do not appear to be greatly influenced by latitude, varying little over the sample area except perhaps within latitudinal Groups 2 and 9 (Table 19). The low values observed for these groups, however, are quite probably a sampling artifact since the older, faster growing age classes are absent from these areas. Within all 9 station groups, the majority of the mean shell lengths fall within the standard deviations calculated for that age class. Mean shell growth calculated over all ages and station groups was 3.0 mm/yr.

Distribution, Standing Stock, and Productivity: *M. calcarea*

From the results of the benthic sampling program, *M. calcarea* is one of the more ubiquitous species of the Bering/Chukchi shelf, occurring

Table 18. Shell length/biomass relationships and growth rates for *Macoma calcarea* on the Bering/ Chukchi shelf.

Age (yrs)	Shell Length (mm)	Mean Total Wet Wt (g/indiv)	Mean Shell Wt (g/indiv)	Shell Wt (% total wet wt)	Mean Tissue Wet Wt (g/indiv)	Tissue Wet Wt (% total wet wt)	Mean Corg (mg/indiv)	Mean Growth Corg (mg/ indiv/yr)	Organic Carbon Growth % Total Wt/yr
0-5	5-10	0.075	0.028	37	0.036	48	0.26	0.1	38
6	10-15	0.255	0.105	41	0.119	47	0.89	0.63	70
7	15-20	0.644	0.269	42	0.314	49	2.25	1.36	60
8	20-25	1.359	0.553	41	0.693	51	4.76	2.51	52
9-10	25-30	2.631	1.133	43	1.302	49	9.21	4.45	48
10-11	30-35	4.295	1.879	44	2.212	52	15.03	5.82	38
11-12	35-40	6.591	2.856	43	2.941	45	23.07	8.04	34
12-13	40-45	9.985	5.079	51	4.832	48	34.95	11.88	33
14-15	45-50	14.783	6.852	46	5.861	40	51.74	16.79	32
Mean				43		48		5.73	45

Table 19. The relationship of shell length to age class and growth rates for *Macoma calcarea* within areal groups on the Bering/Chukchi shelf. Numbers under each age class are shell lengths (mm).

Station Group	Age (yrs) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean Shell Growth (mm/yr)
1	-	-	9.0	10.5	13.7	16.4	20.7	24.1	27.4	35.2	37.9	42.8	-	-	3.4
2	-	-	7.1	8.9	12.5	-	-	-	-	-	-	-	-	-	1.8
3	3.9	5.4	7.4	9.5	12.7	16.0	21.1	24.4	30.0	33.0	-	40.4	44.6	-	3.1
4	3.4	5.0	6.7	10.6	15.9	19.9	22.9	26.6	30.4	33.0	37.1	40.5	-	48.0	3.1
5	4.2	5.6	7.3	10.1	12.3	17.6	23.7	26.1	30.7	34.7	34.7	42.0	-	-	3.2
6	4.3	5.4	7.2	10.1	12.9	16.0	20.5	29.1	27.0	31.3	34.3	40.2	41.5	44.1	2.8
7	-	5.2	6.8	9.1	12.4	16.0	20.8	21.7	-	34.3	-	40.0	42.5	-	3.1
8	-	-	-	-	12.7	17.2	20.8	27.7	-	-	-	-	-	-	3.8
9	3.6	5.0	6.5	8.6	11.5	-	-	-	-	-	-	-	-	-	1.6
Mean	3.9	5.3	7.3	9.7	13.1	17.0	21.5	25.7	29.1	33.6	36.0	41.0	42.9	46.1	3.0
Growth (mm/yr)	-	1.4	2.0	2.4	3.4	3.9	4.5	4.2	4.6	4.5	2.4	4.0	1.9	3.2	3.0

at 115 of the 176 quantitative stations and ranging from Bristol Bay in the southern Bering to the northern extremes of the Chukchi Sea. The mean density for *M. calcarea* over this area is 51 indiv/m^2, with a mean wet weight biomass of 34.12 g/m^2 and mean organic carbon biomass of 1.19 g/m^2. The highest standing stock estimates occur in station Cluster Group VII, the Savoonga Group, with mean values (within group) of 163 indiv/m^2, 138 g/m^2 wet weight, and 4.8 g/m^2 organic carbon biomass. Applying these estimates, along with the age composition, growth, and mortality figures described above, to the productivity equation $P_t = P_m + P_g$, a mean value over the total area sampled of 37.75 mgC/m^2/yr was obtained, indicating that the annual net productivity, for the age classes considered (5-10), is 32% of the mean standing stock. In terms of total species productivity, this 32% estimate is probably too low, perhaps to a considerable degree, due to the exclusion from the evaluation of the first four year classes. For station Group VII, the Savoonga group, this net productivity estimate reaches 1.5 gC/m^2/yr.

Growth Rates: *Clinocardium ciliatum*

The sample of *C. ciliatum* available for age/growth analysis was extremely small, consisting of only 9 animals. Therefore, no estimate could be made as to age composition of the population, mortality rates, recruitment, or productivity. An additional problem was the lack of reliable size/weight data, leaving mean growth in terms of shell length increase as the only permissable estimate. Animals were aged in the same manner as for *M. calcarea*, by counting growth annuli.

The results of this age/size analysis indicates that the sample, though small, does provide a valid growth curve (Fig. 6). As may be

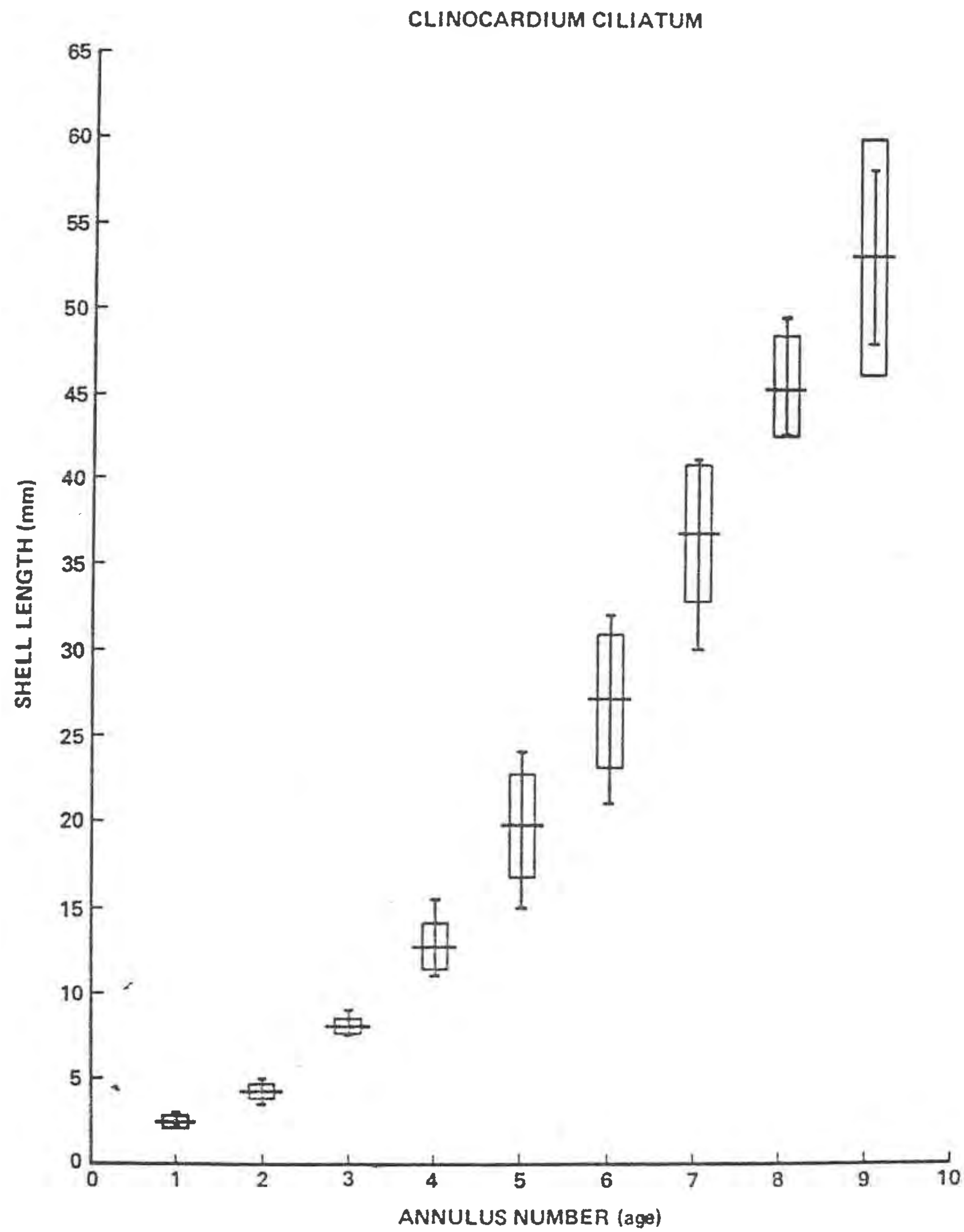

Figure 6. Relationship of shell length to age class for *Clinocardium ciliatum* on the Bering/Chukchi Shelf. Mean length is denoted by the horizontal line, standard deviation by the box, and range by the vertical line.

seen, standard deviations do not overlap except for ages 8 and 9. The mean growth rate is 6.77 mm/yr, more than double that for *M. calcarea*, ranging from 1.71 mm/yr at age 2 to 10.4 mm/yr at age 10. Viewing growth as percentage increase in shell length (Table 20), rates appear to decline from a high of 47% annually at age 3 to 14% at age 9. At age 10 the animals are still growing with no reduction in rate of actual shell increase (Fig. 6).

Growth Rates: *Serripes groenlandicus*

As for *C. ciliatum*, the sample size of *S. groenlandicus* and the size/age distribution of the samples obtained precluded estimates of age composition of the population, mortality rates, recruitment, and productivity rates. Part of the problem encountered with both this species and *C. ciliatum* is the segregated nature of age/size distributions whereby, as discussed previously, only one age/size class of the species is apt to be found in any given area. This probably results either due to interspecific predation (spat consumption by adults) or substrate conditioning which precludes spat settlement in an area already colonized. Unlike the case with *M. calcarea*, where mixed age classes occur, a very large number of samples would be required in order to present a satisfactory age composition estimate for the population as a whole when considering either of these other species.

The mean growth rate for *S. groenlandicus* in terms of shell length increase is estimated at 4.34 mm/yr, lower than for *C. ciliatum* but appreciably higher than for *M. calcarea*. The range of this shell growth rate for *S. groenlandicus* (Table 21), is from 2.56 to 6.35 mm/yr. This growth rate appears to decline after age 3, though the sample size,

Table 20. The relationship of shell length to age class and growth rates for *Clinocardium ciliatum* on the Bering/Chukchi shelf.

Age	Shell Length (mm)	Shell Growth (mm/yr)	Shell Growth (% total length/yr)
1	2.54	-	-
2	4.25	1.71	40
3	8.13	3.88	47
4	12.75	4.62	36
5	19.81	7.06	35
6	27.12	7.31	26
7	36.75	9.63	26
8	45.37	8.62	18
9	53.10	7.73	14
10	63.50	10.40	16
Mean		6.77	29

Table 21. The relationship of shell length to age class, and growth rates for *Serripes groenlandicus* on the Bering/Chukchi shelf.

Age	Shell Length (mm)	Shell Growth (mm/yr)	Shell Growth (% total)	Organic Carbon (g/indiv)	Growth (mgC/ indiv/yr)	Organic Carbon Growth (% total wt/yr)	Sample Size
1	3.40	-	-	-	-	-	85
2	5.96	2.56	43	-	-	-	83
3	10.72	4.76	44	2.07	-	-	85
4	17.07	6.35	37	3.43	1.36	39	83
5	21.88	4.81	22	9.22	5.79	62	52
6	26.03	4.15	16	13.57	4.35	32	11
Mean		4.34	32		3.83	44	

particularly in terms of the older age classes, is probably too small to be certain that this is a real circumstance.

The organic carbon growth estimate of 3.83 mgC/indiv/yr, considerably lower than the mean value of 5.73 mgC/indiv/yr for *M. calcarea* is probably much too low, compromised as it is by a distinct lack of data regarding the older age classes. As may be seen from the *Macoma* data (Table 18) elevated carbon growth rates are observed in these older age classes. The oldest specimen of *S. groenlandicus* recovered, a solitary individual captured in a bottom trawl, appeared to be in excess of 15 years of age.

DISCUSSION

Standing Stock

Quantitatively, the 300 ± 51 g/m^2 benthic standing stock (wet weight) averaged over the eastern continental shelf of the Bering and Chukchi seas from the results of this study seems to conform fairly well to quantitative assessments of other high latitude North American and Asian benthic faunas. The estimates of 20-400 g/m^2 wet weight for the East Greenland region (Thorson, 1934), 160-387 g/m^2 wet weight for Northwest Greenland (Vibe, 1939), 200-300 g/m^2 wet weight for the Baffin Island region (Ellis, 1960) and 200 g/m^2 wet weight for the Sea of Okhotsk (Zenkevitch, 1963) all fall within this range. Even the very high standing stock estimates of 1,481 g/m^2 wet weight and 3,500 g/m^2 wet weight for bivalve (*Serripes groenlandicus*) communities of the Northwestern and Eastern Greenland regions, respectively (Vibe, 1939), are not greatly in excess of the 1,000 to more than 2,000 g/m^2 values observed at several stations in the northern Bering Sea and Bering Strait region (Appendix 4). The estimates of 20 g/m^2 wet weight for the White Sea and 33 g/m^2 for the Baltic (Zenkevitch, 1963) indicate that these regions are, on the other hand, quantitatively depauperate as compared to the Bering/Chukchi shelf.

The mean value of 300 ± 51 g/m^2, while somewhat higher than previous estimates for the eastern Bering shelf (Neyman, 1960; Stoker, 1973) remains statistically within the bounds of those estimates. The higher mean value obtained by this study largely reflects the very high benthic standing stock values observed in the Bering Strait region, which was not included in the sampling schemes of previous studies.

The most apparent, or most readily recognizable, correlation of standing stock distribution over the study area is with latitude. When plotted out against degrees of latitude, the station means (organic carbon g/m^2) averaged over each degree of latitude would, if smoothed, come close to describing a normal, bellshaped curve (Fig. 7) with the mode in Bering Strait at 65°-68° N. latitude. As may be seen, however, the standard deviations and 95% confidence limits associated with these mean values are often quite large, mostly as a result of the small number of station available, particularly north of Bering Strait.

Based on information and observations available, it seems probable that this rapid rise in benthic standing stock in the Bering Strait region, and the relatively high maintenance of such standing stock levels considerably north of the strait, is the result of several augmenting conditions. One of these conditions is the quite high primary productivity rate observed in the Bering Strait region in early to late spring (McRoy *et al.*, 1972). While direct correlations between benthic biomass and the primary productivity of the overlying water have not been firmly

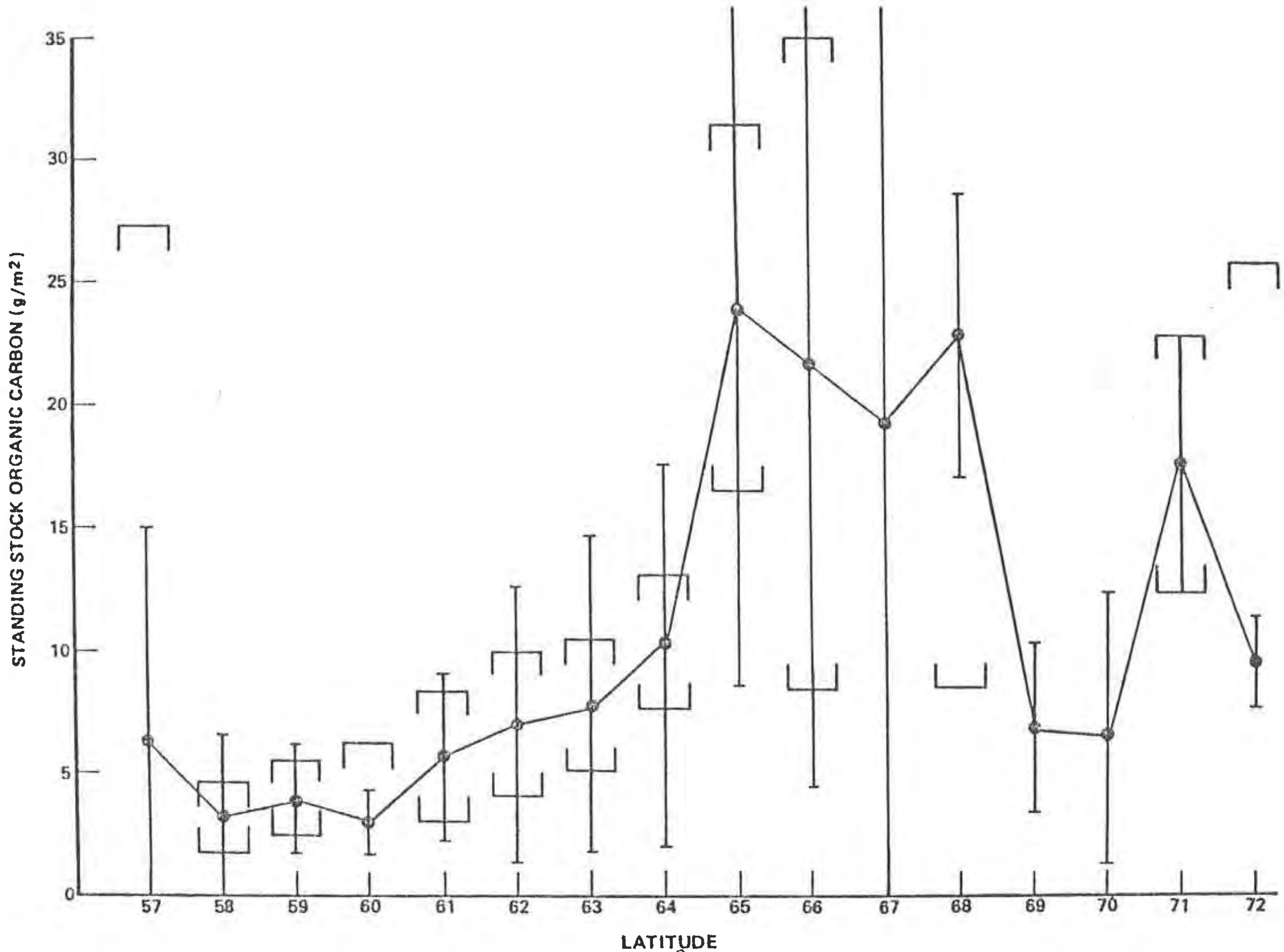

Figure 7. Relationship of standing stock biomass (gm/m^2 to latitude [°N]) at benthic stations on the Bering/Chukchi Shelf, with standard deviations (vertical line) and 95% confidence limits (bracket). Confidence limits are sometimes off scale due to small sample size.

established for this region, they have been for other areas (Rowe, 1969; McIntyre, 1961) and are assumed to apply here as well.

A second major factor which seems likely to be influential in this standing stock distribution is the terrestial detritus input of the Yukon and Kuskokwim rivers. While the actual contribution of these rivers, in terms of particulate detritus utilizable by benthic organisms, is open to question (McRoy and Goering, 1976), it is assumed to be substantial.

A third factor, or mechanism, which is probably decisive to this benthic standing stock distribution is the current structure of the Bering and Chukchi Seas. Near-surface currents, which likely extend to bottom over much of the shelf, move north along the eastern side of the shelf, often at a considerable rate. They are bottlenecked at Bering Strait where the velocity of this northward flow is increased greatly, and subsequently fan out over the Chukchi shelf at reduced velocities. Much of the near-surface primary productivity of the northern Bering may be swept north, concentrated in Bering Strait, and passed into the southern Chukchi where reduced current velocities permit settling to bottom. Likewise, the detrital input of the Yukon and Kuskokwim rivers may be entrained in this northward flow and held to the eastern side of the Bering by the coriolis effect. Near its source this riverine detrital input may be a deterrent to benthic fauna, consisting in large part of coarser and heavier inorganics which leave a smothering wake. The more readily suspended particulates, however, including fine organic detritus, may be maintained in the current stream until the constricture of Bering Strait is passed and the decreasing velocity allows settling. Some of this detritus of course, perhaps a great part of it, may settle out along the way to Bering Strait, notably in the central Chirikov Basin between St. Lawrence Island and the strait.

The trophic (feeder) types encountered over the study area seem to support this view of a detrital-based benthic food web. As may be seen (Appendix 9) the majority of species exhibiting dominance in any given area are detritus feeders, either selective detritophages or substrate feeders, with a complement of filter feeders, mostly bivalve mollusks. The distinction between selective detritus feeders, which in some cases, such as bivalve mollusks and tubiculous amphipods, may also act as facultative filter feeders, and primary filter feeders which are in fact probably filtering and feeding on detritus, seems more than somewhat vague and may in fact be meaningless in this instance. Also, the virtual exclusion from the benthic samples of the large bivalves of the genera *Mya* and *Spisula*, both filter feeders, may have compromised somewhat the present, as well as past, views as to the trophic structure of the Bering/Chukchi shelf.

A fourth consideration, possibly a major one, which should be taken into account when viewing the quantitative distribution of benthos over the Bering/Chukchi shelf is the distribution of predators. Benthic-feeding fish populations seem to be largely excluded from the entire region north of St. Lawrence Island by low bottom temperatures, which may help to account for the large benthic invertebrate standing stock observed in this area as opposed to the relatively low standing stock of northern Bristol Bay, which is heavily utilized by benthic-feeding fishes in the summer months (Neyman, 1960).

Likewise, predation pressure from the Pacific walrus population, some 150,000 animals, is concentrated on the southern and central Bering shelf. A large complement of this walrus population, some tens of thousands of animals, resides year-round and exerts year-round predation pressure in the northern Bristol Bay region. During the ice-bound winter months the bulk of the entire population resides along the ice edge on the southern shelf and in the area between St. Lawrence Island and St. Matthew Island, where ice conditions are favorable (F. H. Fay, University of Alaska, personal communication). Most of this walrus population does migrate back and forth across the northern Bering and southern and central Chukchi, though residence times on this part of the shelf are much less than on the more southern wintering grounds. During the summer months when the Bering and Chukchi are largely ice-free this population maintains itself along the edge of the permanent pack ice in the northern Chukchi Sea.

The California gray whale population, on the other hand, seeks out for their summer feeding grounds the rich amphipod populations of the Chirikov Basin, Bering Strait, and southern Chukchi Sea. No quantitative figures are available to indicate what this predation pressure from gray whales amounts to, but it must be considerable. It is of interest that each time feeding gray whales were observed in this northern Bering-southern Chukchi region, very large amphipod populations were evident in the grabs from that area.

The distribution of large invertebrate predators is probably more uniform over the study area than is the case for benthic-feeding fish and marine mammals. Tanner crabs (*Chionoecetes bairdi* and *C. opilia)*, spider crabs (*Hyas coartatus*), king crabs (*Paralithodes camtschatica*), and hermit crabs (*Pagurus* sp.) are found in considerable numbers over the entire study region at least as far north as the high standing stock area of the southern Chukchi.

In addition to natural predation, commercial fisheries utilizing the continental shelf, particularly of the Bering Sea south of St. Lawrence Island, are undoubtedly effecting the benthos of the region to some degree, though the extent and type of impact is uncertain. The extensive trawl fishery existant over the southern Bering shelf is bound to result in some degree of perturbation both through species removal and substrate disturbance. The disturbance effect could conceivably result in increased faunal diversity, and might result in increased water column and benthic productivity through accelerated recycling of benthic nutrients. The removal effect, directed primarily at benthic-feeding fish, might result in increased standing stock of benthic invertebrates through lowered predation pressure. In addition to the trawl fishery, a large pot fishery exists in the southern Bering directed at king crab (*Paralithodes*), snow crab (*Chionoecetes*) and neptunid gastropods (Nagai, 1974), all of which may be considered predator/scavengers. A subtidal clam-dredge fishery proposed for the southern Bering Sea-Bristol Bay region could result in greatly increased benthic disturbance and species removal in the future, and would probably come into direct resource competition with population of marine mammals, particularly walrus, which winter in that area (Stoker, 1977).

The curve generated by plotting station diversity against latitude seems to support the idea that the standing stock biomass of the Bristol Bay-southern shelf region may be depressed by predation. As may be seen (Fig. 8), diversity is highest in the southern Bering Sea region of low

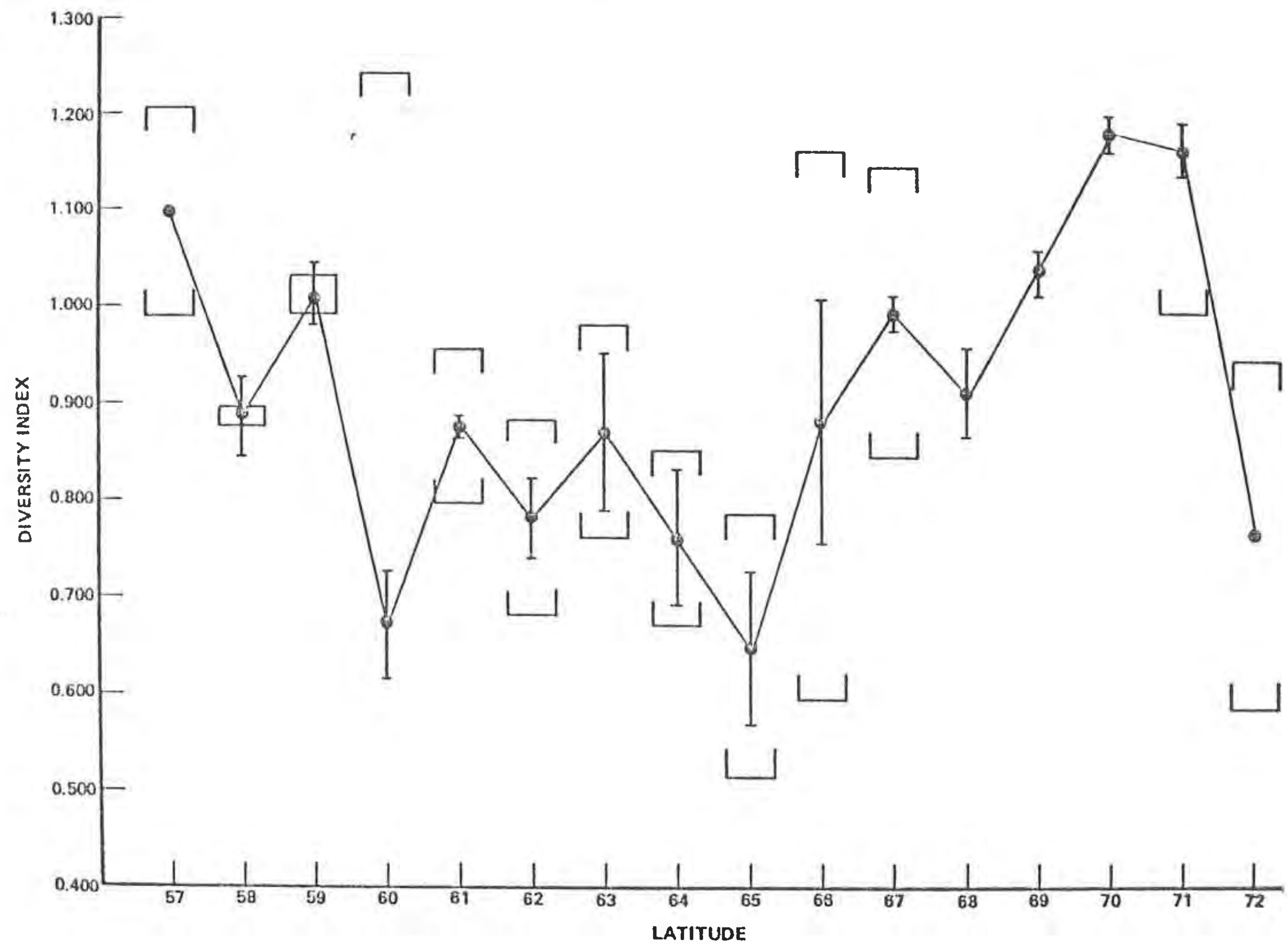

Figure 8. Relationship of diversity (Brillouin) vs latitude of benthic stations on the Bering/Chukchi Shelf, with standard deviation (vertical line) and 95% mean confidence limits (brackets). Confidence limits are sometimes off scale due to small sample size.

standing stock and in the northern Chukchi Sea, possibly indicating that, while the productivity may be high, in the southern Bering Sea at least, the standing stock remains reduced by predation (Pianka, 1966; Sanders, 1968). Diversity seems to decline in the Chirikov Basin region, where most of the large standing stock is composed of a few dominant amphipod and bivalve mollusk detritophages, then rises again in the southern and central Chukchi to about the same level as in the southern Bering. This northward increase in diversity beyond Bering Strait, somewhat at odds with most theories of high latitude faunas, is perhaps a reflection of the large input of food into this area. Apparently this input is reliable and constant enough to permit competition and diversification of feeding techniques, resulting in increased species diversity in a region where the physical stress of the environment would normally have the opposite effect. This increased diversity in the northern Chukchi may also be in part a result of predation, in this instance by marine mammals (walrus and bearded seals), which summer along the edge of the Arctic pack ice.

Plotting of mean standing stock (organic carbon) and diversity against depth (Figs. 9, 10) produced less definite correlation than appeared to be the case for latitude. Since depth is, over the sample area, quite strongly related to latitude, however, its influence is uncertain. The latitude-biomass curve certainly seems to indicate the stronger correlation, and is probably dominant. In neither case, of course, are the correlated factors themselves of primary influence. Latitude reflects, to a slight degree, temperature gradients, but more importantly it reflects primary productivity levels and food availability,

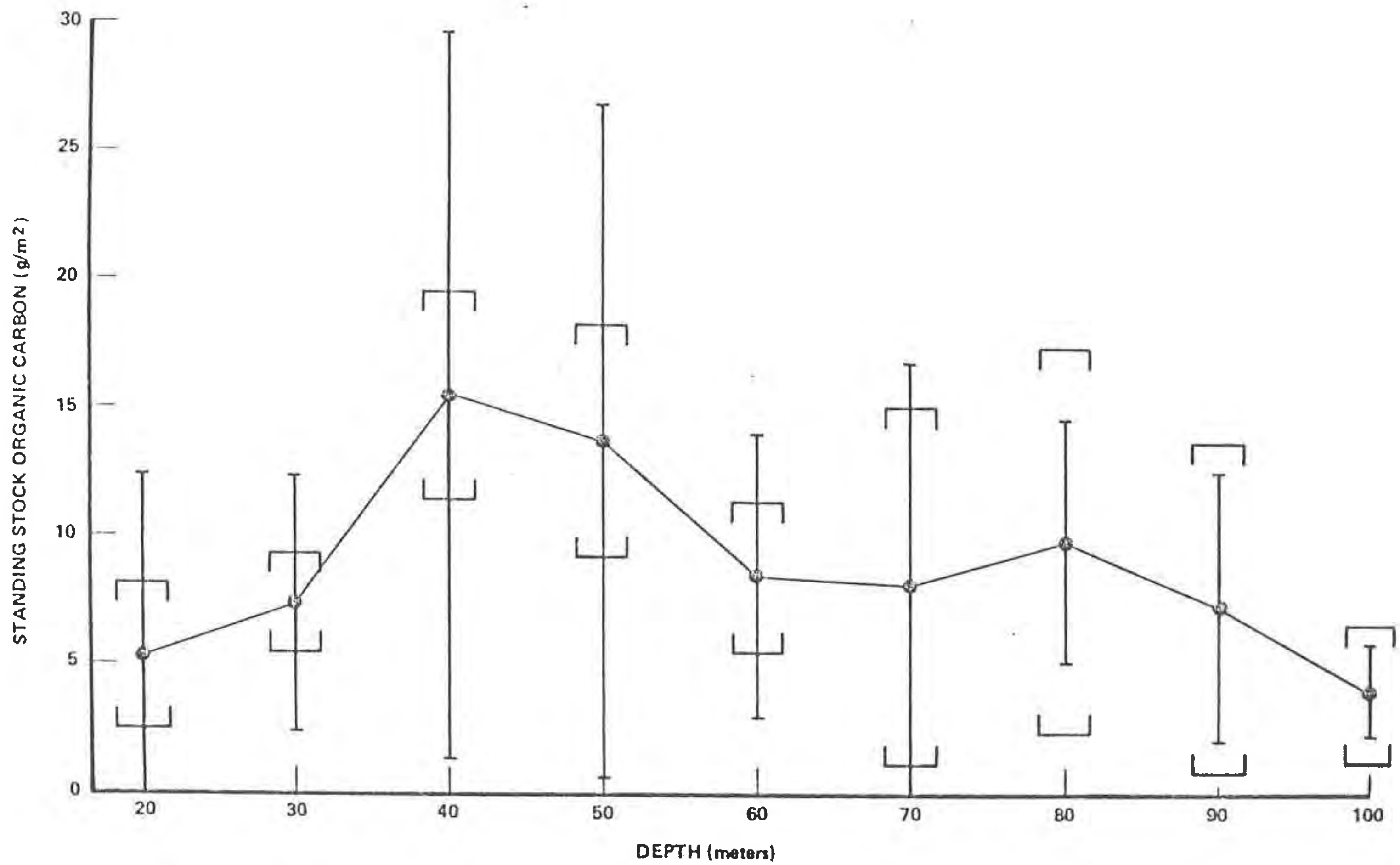

Figure 9. Relationship of standing stock biomass (g/m^2) to depth (m) at benthic stations on the Bering/Chukchi Shelf, with standard deviations (vertical line) and 95% mean confidence limits (brackets).

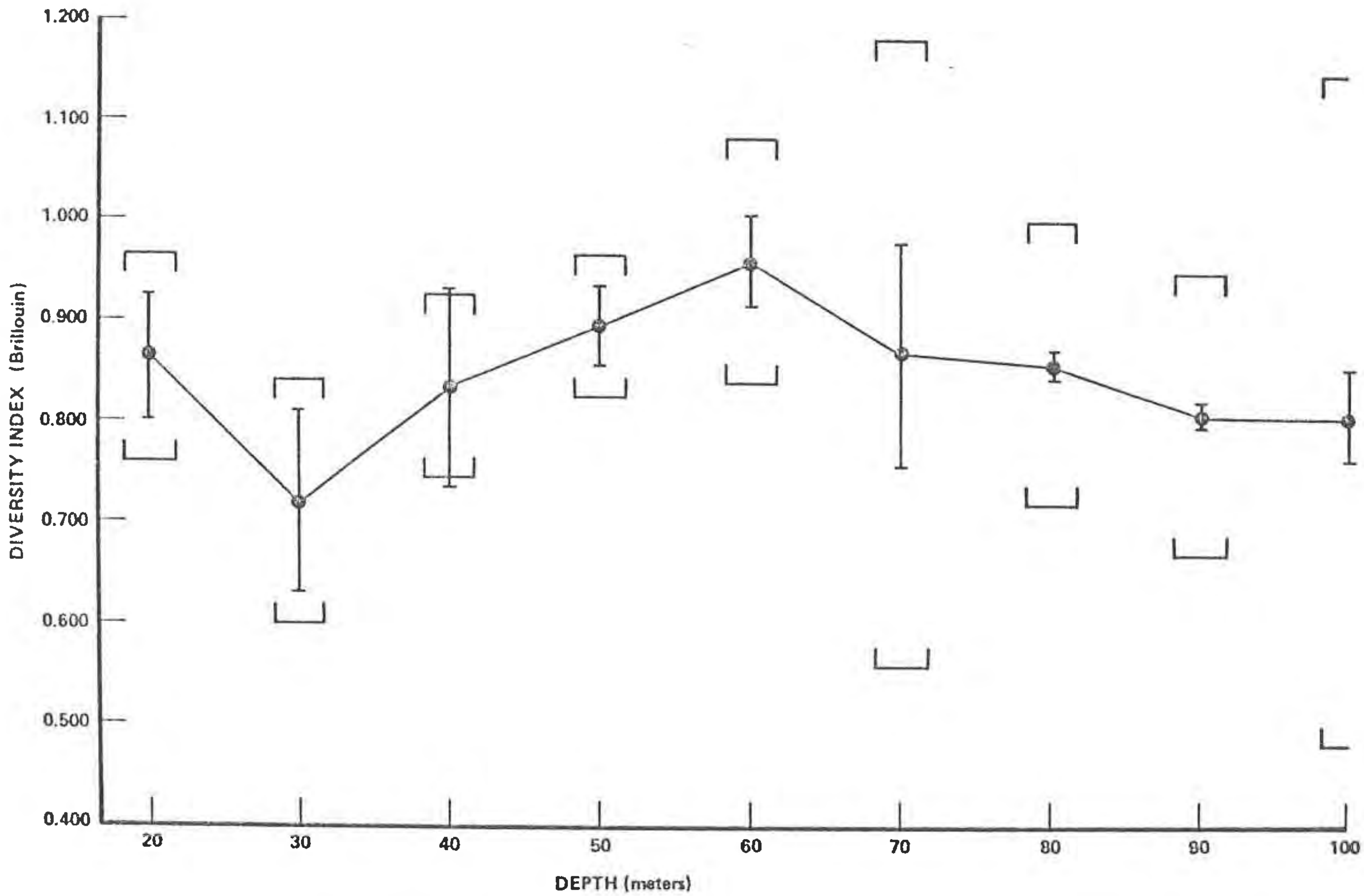

Figure 10. Relationship of diversity (Brillouin) to depth (m) at benthic stations on the Bering/Chukchi Shelf, with standard deviation (vertical line) and 95% mean confidence limits (brackets).

as discussed above. Depth reflects sediment type, current velocity to some degree and, coincidentally, latitude.

Likewise, the correlation of standing stock biomass with sediment type was felt to be of uncertain applicability. The high standing stock values occur for the most part on sand or muddy sand substrate (2.00-3.50 mean phi size), though so do some of the low standing stock values encountered in northern Bristol Bay. Substrate type does correlate strongly, however, with qualitative (species) distribution and with feeder type.

As an overview, the indication is that, quantitatively, benthic standing stock levels on the Bering/Chukchi shelf are determined by primary productivity levels, by current structure and velocity (both of these factors dictating food availability), by benthic-feeding fish and marine mammal predation, and only coincidentally by depth, sediment type, and latitude. Salinity, except perhaps near the output of the Yukon and Kuskokwim rivers, is probably never variable enough to be a major factor, nor is dissolved oxygen content, which everywhere seems near maximum. Winter temperatures near bottom are probably not important as a distributional influence, being always near minimum over the study area.

During the summer, however, these bottom temperatures may be important as a mechanism regulating the distribution of benthic-feeding fish and may effect the reproductive potential, though not the adult welfare, of at least some benthic bivalves (Hall, 1964).

Over most of the study region the distribution of benthos, both quantitative and qualitative, is observed from this and from past studies (Rowland, 1972; Stoker, 1973) to be extremely patchy. This is particularly true regarding the central Bering shelf from St. Matthew and Nunivak islands to just north of St. Lawrence Island. The reasons for such patchiness are uncertain but are thought to be largely the result, directly or indirectly, of variable substrate conditions. Such substrate conditions may themselves, of course, reflect other variables such as current velocity. Predation, particularly walrus predation, may also be a factor since this central Bering shelf area, where such patchiness is most profound, constitutes the main winter range for the bulk of the walrus population.

Other probable causes of patchiness are intraspecific in nature. The bulk of high latitude species rely on direct development of larvae rather than on pelagic dispersal (Thorson, 1950), which would seem to discourage uniformity in distribution. Many of the non-dominant species, for this or other reasons, do appear to be clumped rather than uniform in distribution, as has been observed elsewhere (Hairston, 1959). In the large filter-feeding bivalve mollusks (which do produce pelagic larvae), particularly *Clinocardium*, this clumping tendency is also striking, resulting not only in areal patchiness but also in quite distinct age/size class segregation. In no instance, in fact, were more than one age class of *Clinocardium* observed at the same sample location. This trend toward age/size segregation is also apparent for other filter-feeding bivalves such as *Cyclocardia crebricostata, Hiatella arctica*, and *Serripes groenlandicus*, though not so absolutely so. This phenomenon was also observed by Vibe (1939) in Greenland mollusk populations, and is probably the result of cannibalism, the adult filter-feeders indiscriminately consuming the larvae and settling spat, or of conditioning of the substrate by the adults so as to render it unfavorable for spat settlement.

Taxonomy

Over the sample area, a total of 472 species, 292 genera, and 16 phyla were identified. These results, in terms of numbers of taxa present over this area, are almost certainly too low. Several major taxa, notably the nemertinea, porifera, and most of the anthozoa, were found to be difficult if not impossible to identify in the preserved condition. The same was true for at least some of the tunicates and holothurians.

In addition to these outright gaps in taxonomy suffered by the present study, numerous other taxonomic problems were encountered, which will be summarized below.

In the early (Northwind-1970) collections, adequate literature and expertise was not available for the identification of the amphipods and cumaceans. Consequently, for this preliminary study (Stoker, 1973) these were separated into apparent taxonomic units upon the basis of gross morphology and assigned alphabetic designations. Representative samples were preserved for future identification, but by the time such identification was possible some of the smaller and more fragile specimens were beyond recognition, thus accounting for the sometimes large numbers of amphipods and cumaceans listed as unidentified.

Even after identification became feasible, numerous doubts and problems arose with several of the amphipod and cumacea genera. Within the amphipod genus *Ampelisca*, for instance, two very similar species, *A. macrocephala* and *A. eschrichti* are recognized. As is not uncommonly the case for Bering/Chukchi species, these seem to be distinct and recognizable at the ends of the morphological spectrum but over the large middle ground appear to blend together, lending doubt as to whether the two are in fact seperate species. This doubt is augmented, in this case, by the fact that the two seem to invariably occur together. Consequently, no attempt was made to separate the two, both being lumped together as *A. macrocephala*, which seemed the numerically dominant form.

Similar doubts were encountered within the amphipod genera *Anonyx*, *Erichtonius*, *Hippomedon*, *Monoculodes*, *Paraphoxus*, *Photis*, *Protomedeia*, and *Harpinia*. While serious and, it is felt, usually successful attempts were made to identify members of these genera to the species level, some confusion was apparent and the results are not above doubt.

The cumaceans seemed less of a problem except for one form, referred to as *Leucon* #2. This is a common form, obviously of the genus *Leucon* but conforming to none of the available species descriptions for that genus. The closest fit was *L. nasica*, but this seemed unsatisfactory.

Some troubles were also encountered among the polychaetous annelids. In the early collections (Northwind-1970) in particular, there may be some confusion among species within the genera *Anaitides*, *Brada*, *Eteone*, *Glycinde*, *Lumbrinereis*, and *Nephtys*. In all of the collections, *Brada sacchalina* may in fact be *Brada ochotensis*, *Capitella capitata* may include a second species or even a second genus (*Branchimaldane?*), *Haploscoloplos panamensis* are probably all *H. elongatus*, *Onuphis parva-striata* and *O. geophiliformis* are probably the same species, and *Lumbrinereis fragilis* may in fact be a species complex. The identification *Tharyx multifilis* is pretty much a guess, as are the distinctions between *Glycinde wireni* and *G. armigera*, which may be the same species. Doubt also applies to the identification *Aricidea uschakowi* and to the genus *Eteone*, which may be represented by several more species than are here included. Within the genus *Nephtys*, *N. ferruginea* and *N. paradoxa* may not be real species, *N. zonata* probably represents a species complex, and *N. ciliata* and *N. longasetosa* are probably synonymous. *Nephtys cornuta* is a new species record for this area, as are *Disoma multisetosa* and *Pionosyllis magnifica*.

Within the bivalve mollusks, there may exist some confusion within the genera *Macoma*, *Nuculana*, *Yoldia*, and *Pseudopythina*. All of the *Macoma* identified seem to be good species with the possible exception of *brota/calcarea*. As was the case with *Ampelisca macrocephala* and *eschrichti*, these two *Macoma* species seem distinct at ends of the spectrum but are frequently found to intergrade, casting doubts upon their validity. Of the two, *M. calcarea* seems clearly dominant. These two species were segregated whenever possible, though not without some skepticism. A similar case applies to *Nuculana radiata* and *N. minuta*. While relatively distinct in size and shell sculpture, the question arises as to whether *N. minuta* is not merely the immature form of *N. radiata*. These two forms are normally co-occurrent, and no immature forms identifiable as *N. radiata* are ever found, giving rise to such doubts. Within this genus, problems may also exist in the segregation of *N. radiata*, *N. fossa*, *N. buccata*, and *N. pernula*. Soviet investigations in the Bering (Neyman, 1960; Filatova and Barsanova, 1964) all list *Nuculana (Leda) pernula* as the dominant species of this genus, yet no specimen classifiable as *N. pernula* was discovered by this study. The identification *Yoldiella intermedia*, a single occurrence, is doubtful. Confusion may exist between *Pseudopythina rugifera* and *P. compressa* in some cases since these small and fragile bivalves were often badly eroded from the formalin preservative. Within the genus *Yoldia*, there may be some identification problems between *Y. hyperborea, Y. amygdalea,* and *Y. myalis*, particularly in the immature forms. It is felt that *Y. hyperborea* is much the most dominant despite possible confusion. *Asthenothaerus adamsi*, an uncommon species, was previously classified as *Thracia adamsi* (MacGinitie, 1959).

Within the gastropod mollusks, a state approaching general confusion seems to reign within the genera *Buccinum, Colus, Trophonopsis, Polinices, Natica, Margarites, Solariella,* and *Velutina*. In the case of *Natica*, all specimens were classified *N. clausa*, though multiple species may exist. The same is true for *Polinices*, most of which are referred to as *P. pallidus*. The best possible job was done to identify and segregate the various and often confusing species of *Buccinum, Colus, Trophonopsis, Margarites,* and *Solariella*, but few such identifications are absolutely above suspicion. The same is true, perhaps with an even greater degree of doubt, for *Velutina* and *Cylichna*. In the case of *Cylichna*, the question again arises as to whether *C. alba* may in fact be only the immature form of *C. nucleola*.

In most cases, no attempt was made to identify nudibranch mollusks, and those identifications that are made are subject to considerable question.

Among the mysids, the identification *Neomysis rayii* is questionable, as is the species distinction in the brachyurans between *Chionoecetes bairdi* and *opilio*, which frequently seem to intergrade.

Among the asteroids, *Pteraster obscura* may in fact consist of several species.

The holoturian identified as *Leptosynapta* sp. from an early sampling is probably *Chirodota* sp., possibly *C. discolor*.

As a general overview, it is felt that numerous problems and confusions exist relative to the species taxonomy of many such high-latitude forms. These difficulties may arise through the reproductive behavior of such forms, and through the patchy character of the faunal distribution. Many of these forms, particularly the genera within which confusion is most prevalent, exhibit brooding behavior. This, coupled with the observed patchy distribution (presumably reflecting variability in one or more environmental parameters) would seem to discourage genetic uniformity over the population as a whole and would tend to promote the generation of regional populations which may in some instances be mistakenly classified as separate species.

Since it was not the primary purpose of this study to become engaged in taxonomic exercises, the tendency, as is probably apparent, was to lump species when in doubt. A good splitter could almost certainly go through the same collection, as they are welcome to do, and come up with many more species in almost any category.

This total list of 472 species for the area is apt to be on the low side due to the sampling technique as well as to the taxonomic philosophy employed. At 50 of the quantitative stations only the coarse (3 mm) sieve fraction was retained for faunal analysis, and at 108 of the remaining 176 stations only one of the five fine samples was analyzed. For quantitative (biomass) estimation it is felt that this procedure is justified, something over 90% of the total mean areal biomass (76 ± 11% per station mean) being retained on the 3 mm mesh. Similar results from other investigations support this evaluation (Reish, 1959; Holme, 1953). This reliance on the 3 mm sieve, however, is certain to have resulted in the loss of many, perhaps the bulk, of individual organisms and perhaps as many as 50% of the species present. This loss is perhaps deplorable, but was considered a necessary sacrifice considering the time and effort which would have been required to process all of the fine fractions.

It should be pointed out that this relative neglect of the fine fraction fauna is based solely on standing stock biomass ratios, and does not imply that this fine fraction fauna is unimportant in the ecosystem. As information becomes available it may in fact prove to be the the case that this is where the base of the benthic food web lies and that within this small and presumably short-lived fauna the greater portion of benthic productivity takes place.

A more serious flaw in the sampling technique was the inability of the grabs, or trawl, to sample the deep-burrowing large bivalve populations of the genera *Mya* and *Spisula*. These bivalves are known to make up a very large part of the diet of the Pacific walrus in the northern Bering Sea and Bering Strait region (Fay and Stoker, in preparation), but are rarely obtained in samples from this area. When they are obtained by the grab, generally only part of the severed sipon is retained. This problem has plagued other investigators in the past (Lukshenas, 1968; Ellis, 1960), but could not be overcome at this time due to severe ship and gear limitations. It seems probable, from the evidence of the walrus stomachs, that these large bivalves may comprise a considerable part of the benthic standing stock over the study area, though what percentage is, at this time, impossible to estimate.

These large bivalves, as well as the other principal walrus prey genera (*Spisula, Hiatella,* and *Clinocardium*) are also somewhat unique in that they are all obvious filter-feeders in a trophic situation apparently dominated by detritus feeders. Also, such evidence as is available seems to indicate that the growth rates, and probably the net productivity rates, of these filter-feeding bivalves may be considerably higher than for the one detrital-feeding bivalve assessed (*Macoma calcarea*). Such apparently increased rates may be a result of the feeding behavior, perhaps due to shortening of the food chain. Whatever the reasons, such elevated rates are probably beneficial to both walrus and prey in this trophic relationship.

Feeding Type

As mentioned previously, and as may be seen from the table of dominant species (Table 5), the Bering/Chukchi benthic trophic system is heavily dominated by detritus feeders, though this view may be overemphasized due to the inadequate sampling of the large filter feeding bivalves. Most of the station cluster groups, as will be discussed later on, possess elements of all 4 trophic (feeder) types recognized for this study (filter-feeders, selective detritus feeders, substrate feeders, and carnivore/scavengers). As a general trend, the distribution and relative dominance of these trophic types is determined by, or is correlatable with, substrate conditions, as has been observed from previous investigations (Rhoads and Young, 1970; Neyman, 1970). Filter-feeders seem more inclined, for obvious reasons, toward areas of coarse substrate, relatively low sedimentation rates, and increased current intensity such as prevail in the northern

Bering Sea-Bering Strait region. Selective detritus feeders seem to prefer areas of sand or sandy mud at intermediate depths, while substrate feeders tend toward deeper areas of finer sediments rich in organics. The scavenger/carnivores are, of course, distributed independently of such considerations.

Dominant Species

Of the 472 total species identified, it was discovered that 113 species, along with 25 taxa not identifiable to the species level, accounted for 95% of both total standing stock (organic carbon) and total density of the coarse fraction samples, which accords well with Sanders (1960) study of Buzzards Bay in which very similar ratios were observed. Of these 113 species, 89 were then selected and utilized as indicator species for purposes of clustering stations and species and for correlation of species distribution with environmental factors. It is of interest that of these 89 indicator species (Table 3), 49 are considered selective detritus feeders, 9 are substrate feeders, 16 are filter feeders, and 14 are carnivore/scavengers (Kuznetsov, 1964). Of 83 of these same 89 species, 28 are considered to exhibit either brooding behavior or rapid, direct development of eggs and larvae while 55 rely on pelagic larval forms (Stanley, 1970; G. M. Mueller, *viva voce*). Furthermore, of these 89 species 27 are considered to be Pan Low Arctic Boreal in origin, 21 are considered Arctic Boreal Pacific, 17 are considered to be Pan High Arctic Boreal, 9 are considered Pan Arctic, 10 are considered Bipolar, 4 are considered Boreal Pacific, and only 1 is considered Arctic-Atlantic (Ushakov, 1955; Guryanova, 1951), lending a strongly Boreal-Pacific atmosphere to the overall fauna of the region as was previously postulated to be the case (Sparks and Pereyra, 1966). It is also possible, though unproven, that the cold summer bottom temperatures in the Chukchi Sea and perhaps over some of the northern Bering Sea may necessitate recruitment into these areas, for at least some of those species producing pelagic larvae, from warmer waters to the south (Sparks and Pereyra, 1966). If this is found to be the case, then the Chukchi Sea is dependent on the Bering not only as a major food source but as a spawning ground as well.

Cluster Groups

Using the quantitative data pertaining to the 89 indicator species, a station cluster dendogram was generated based on similarity of species composition and species relative density. This cluster analysis resulted in 8 major cluster groups, several of which are composed of at least two subgroups with discrete areal distribution. These cluster groups may be considered as faunal communities or assemblages, though caution should be exercised in this approach for, as will be discussed later on, the species themselves do not appear to exhibit strong association affinities with one another.

The first and most closely associated of these station cluster groups is referred to as Group I, the Chirikov Basin Group. This group occupies almost all of the central Chirikov basin (Fig. 3), extending into Bering Strait. A second-areal subgroup may be considered to exist off the western end of St. Lawrence Island, composed of 4 stations, though this is something of a moot point, the areal distribution being contiguous for all practical purposes. This is primarily a detritophagous community, four of the five group dominants (Table 5), three amphipod and one bivalve species, being considered selective detritus feeders. Considered by station, however (Appendix 9), a fairly strong complement of filter feeders appear as locally dominant species, as does one substrate feeder. It should be kept in mind also that filter feeders are in fact probably more dominant in this cluster group than appears to be the case since the large bivalves *Mya* and *Spisula*, which were virtually excluded from the samples as discussed above, appear to exist in large populations in this region from the evidence of walrus stomach analyses. Also, most or all of the species listed as selective detritus feeders may also be facultative filter feeders.

This trophic structure is what would be expected on the basis of substrate type, which consists of very uniform, hard-packed sand over the entire area, swept by relatively vigorous currents. It is of interest that the substrate, in terms of particle size (Table 7), is the most uniform within this of any of the cluster groups. Correspondingly, this group shows the highest affinity, in terms of faunal cohesiveness, of any of the cluster groups, lending strong support to the argument, discussed later on, that sediment particle size is the dominant environmental factor influencing, or correlating with, species distribution over the study area.

The mean carbon standing stock of this cluster group, 23.7 ± 5.6 g/m^2, is the highest of any observed, though the index of diversity, 0.612 ± 0.084, is by far the lowest. The inference from this evidence, supported by the physical data and by the station biological results, is that this region is one of very uniform habitat and high food input to the benthos, probably from both primary productivity and from terrestial (riverine) detritus.

The second major cluster group, Group II (Fig. 3), forms what appears to be a broad band offshore from the Alaska mainland in the Bering Sea stretching from northern Bristol Bay almost to Bering Strait. This group may consist of two areal subgroups, one in northern Bristol Bay and another to the north, along western Norton Sound, though this distribution is probably the result of inadequate station coverage and may not be a real condition. This is a much more heterogenous faunal assemblage in terms of trophic type (Table 5; Appendix 9). The group dominant species, the bivalve *Tellina lutea* and the echinoid *Echinarachnius parma*, are considered to be selective detritus feeders. The local, station dominants, however, represent all four trophic types in approximately equal proportion. This group is considerably more complex, in terms of both species distributions and trophic characteristics, than Group I, presumably as a result of less uniformity in the habitat, as evidenced in part at least by the more variable substrate characteristics (Appendix 8). The mean depth of this group, 32 ± 4 m, is significantly shallower than the mean of 43 ± 3 m for Group I, though the dominant influence is felt to be sediment type, which is both coarser and more variable within Group II (Table 7), rather than depth as such.

The mean standing stock of Group II is 4.4 ± 1.4 g/m^2 carbon or 265 ± 140 g/m^2 wet weight, slightly below the mean for the study area as a whole. Supportive of the previous opinion regarding south to north increase in benthic standing stock, the mean standing stock of the northern stations is considerable elevated over that of the southern ones. The diversity evidenced by this group is quite variable, averaging, over all stations, an index of 0.882 ± 0.096, near median for the study area as a whole.

One curious aberration of this cluster group is presented by a third small subgroup, consisting of only two stations, lying just off the southwest end of St. Lawrence Island far from the main distribution (Fig. 4). This subgroup lies at a somewhat greater depth (55 m) than the 32 m group average. The sediment mean particle size, 2.88 phi corresponds closely to the 2.61 mean phi value for the group as a whole, however, lending even more support to the argument that sediment type, not depth, is the primary correlative.

what aberration

Group III is characterized by two obviously distinct areal subgroups, one lying in Bering Strait and the other in Anadyr Strait (Fig. 4). Like Group I, which it overlaps in distribution in Bering Strait, this is a very strongly detritophagous assemblage. Almost all of the dominant species at stations within this group (Appendix 9) are selective detritus feeders, this homogeneity being disturbed only by the presence of two carnivore/ scavengers and two substrate feeders. For the group as a whole, the three dominant species, one ophiuroid, one echinoid, and one polychaetous annelid, are all considered selective detritus feeders, though the echinoid, *Strongylocentrotus droebachiensis*, may also be considered a grazer on live attached algae. As with Group I, however, this view of the prevailing trophic situation is probably misleading since the evidence produced from walrus stomach analysis is that large populations of *Mya* and *Spisula* occur in these regions.

The standing stock carbon biomass of this group is the second high-highest, though also one of the most variable (Table 6), of any encountered over the study area, averaging 673 ± 532 g/m^2 wet weight or 14.1 ± 8.1 g/m^2 carbon. Of the two subgroups, the Bering Strait distribution possesses both the highest mean standing stock value, 903 g/m^2 wet weight, and the highest index of diversity, 1.235. The mean index of diversity for the group as a whole, 1.105 ± 0.222, is the highest exhibited by any cluster group. This combination of very high standing stock coupled with very high diversity would seem to infer a habitat of considerable variability supplied by a large nutrient input. The extremely variable depth and substrate type exhibited within this group, ranging from 25 to 90 m and from medium sand to rock and gravel, certainly supports the inference of variable habitat, while other indications - primary productivity rates and current strength and direction - support the premise of a large nutrient input from primary productivity and riverine detritus.

Cluster Group IV is the most depauperate and most variable of any group in terms of standing stock, averaging only 102 ± 125 g/m^2 wet weight or 3.3 ± 2.5 g/m^2 carbon, with an approximately average diversity index of 0.901 ± 0.124. The main distribution of this group forms another broad band offshore from the distribution of Group II, stretching from northern Bristol Bay to southeast of St. Matthew Island in the Bering Sea (Fig. 4). Though no areal subgroups are apparent, this group does include five stations classed as areal erratics which are scattered from eastern Bristol Bay to the southern Chukchi Sea.

The species exhibiting overall dominance within this group, one amphipod, one polychaetous annelid, and one bivalve mollusk, are all selective detritus feeders, though the station results (Appendix 9) include dominant species from all four trophic types, filter feeders being the most poorly represented. The mean depth of stations within this group is 49 ± 10 m, considerably deeper than neighboring Group II, though these depths range from 20 to 66 m. The substrate type within this group is likewise variable, phi size ranging from -1.00 to 4.00. It is difficult, in fact, to ascribe any unifying characteristic to this group other than its faunal composition, which is itself rather complex.

Cluster Group V, forming a nearshore band from Bristol Bay to the southern Seward Peninsula, is similarly complex. This group may consist of two areal subgroups, one nearshore in northern Bristol Bay (Fig. 4), the other to the north, stretching from near Nunivak Island through Norton Sound. As for Group II, however, this distribution is felt to be the result of incomplete station distribution and not reflective of reality.

This is another relatively depauperate group, with a mean standing stock of only 193 ± 111 g/m^2 wet weight, 7.5 ± 4.0 g/m^2 carbon. This standing stock varies considerably within the group, as does the diversity index which averages 0.891 ± 0.106 for the group as a whole. The trophic status of this group is equally mixed, including all four trophic types, though filter feeders are again (apparently) poorly represented. The overall group dominants include two substrate feeders (polychaetous annelids), two selective detritus feeders (ophiuroids), and one filter feeder, (bivalve mollusk). In general, substrate feeders seem to be more strongly represented in this than in any other group, possibly reflecting its nearshore distribution which would make it the major recipient of coarse detritus dumped from the Yukon and

Kuskokwim rivers. Such rapid sedimentation rates could tend to discourage filter feeders and to encourage substrate feeders, as seems to be the case.

The habitat encompassed by this group seems as varied as its faunal and trophic composition, with sediment particle mode size ranging from 2.00 to 5.00 phi (Appendix 8). Three stations just offshore from Nome, on the Seward Peninsula, were found to have a mixed mud, rock, and gravel substrate. The mean depth of stations in this group is relatively shallow, 27 ± 6 m, ranging, with one exception, from 16 to 40 m. The one exception is Station 169, an areal erratic lying just north of Bering Strait, which has a depth of 73 m. With the exception of this one erratic, the factor unifying or characterizing this aggregation is probably its nearshore presence and the resultant sedimentation regime, and possibly summer bottom temperature.

Cluster Group VI represents the first distinct division of a group or assemblage into north and south components or areal subgroups. In this case one subgroup forms an elongate distribution in the south-central Bering Sea, between St. Matthew Island and the Pribilof Islands, while the second subgroup forms a nearshore band along the eastern Chukchi coast from Kotzebue Sound to Point Barrow. It is difficult to find a common element uniting these subgroups aside from their faunal similarities. Subgroup A, in the Chukchi, lies at an average depth of 45 ± 4 m, ranging from 38 to 50, while Subgroup B, the Bering subgroup, lies at an average depth of 98 ± 10 m, ranging from 90 to 105. The mean sediment mode size of the Chukchi subgroup is 4.66 ± 1.33 phi, ranging from 2.50 to 7.00

phi, while that of the Bering subgroup is 6.13 ± 1.19 phi, ranging from 5.00 to 6.50 phi.

In terms of standing stock the subgroups are equally dissimilar. The Chukchi subgroup possesses a mean biomass of 416 ± 209 g/m^2 wet weight, 14.6 ± 5.8 g/m^2 carbon, with a diversity index of 1.098 ± 0.163, one of the highest encountered for any subgroup or group, while the Bering subgroup displays a very low biomass, 83 ± 62 g/m^2 wet weight, 4.0 ± 1.9 g/m^2 carbon, and only an average diversity index, 0.817 ± 0.360.

Similarities are apparent, however, when reviewing the trophic structure of the two subgroups, both of which are composed almost equally of substrate feeders and selective detritus feeders, with a few filter feeders and carnivore/scavengers appearing as local, station, dominants. As a whole, the group is characterized by 4 dominant species, two of which, a polychaete and a sipunculid, are substrate feeders, a bivalve mollusk which is a filter feeder, and an ophiuroid which is a selective detritus feeder.

Despite some dissimilarities, it must be assumed, particularly with the evidence of the similar trophic structure in mind, that these two widely separated subgroups have sediment type, or sedimentation regime, as the common factor. Even though the mean particle sizes of the two subgroups are somewhat at odds, both fall within approximately the same size ranges. It is also entirely possible, of course, that the uniting denominator is something altogether unassessed, such as temperature or salinity. This puzzling lack of an obvious commonality is even more apparent for subgroup divisions of cluster Group VIII, as will be discussed later on. Whatever the reasons underlying this split distribution of Group VI, it does present a prime illustration of the tendency discussed previously of northerly increase in standing stock and, in this case, diversity as well. It seems probable in this instance that the increased diversity is the result of less uniform habitat in the northern group as evidenced from the sediment data (Table 7; Appendix 8), something which might be expected in such a nearshore environment.

Group VII is also composed of two distinct areal subgroups, though both lie within the Bering Sea. The first of these subgroups is a tight cluster of stations ajoining the northern coast of eastern St. Lawrence Island (Fig. 4), while the second subgroup consists of only two stations just north of the Pribilofs. Here again the mean depths of these two subgroups are quite different, 69 ± 12 m for the southern and 35 ± 4 m for the northern, though the sediment mean particle sizes are more similar, 3.00 ± 0 and 3.80 ± 0.27 phi, respectively (Table 7; Appendix 8). The trophic structures of the two subgroups is also similar, both being dominated by selective detritus feeders with a strong complement of substrate feeders and carnivore/scavengers. Only in the northern subgroup do filter feeders share local dominance in a couple of instances. The overall group dominants consist of a polychaetous annelid and a bivalve mollusk, both selective detritus feeders (Appendix 9).

In terms of standing stock, northerly increase is again apparent. The northern subgroup of Group VII has a mean standing stock of 281 ± 117 g/m^2 wet weight, 12.0 ± 5.1 g/m^2 carbon, while that of the southern subgroup averages only 31 ± 114 g/m^2 wet weight, 2.0 ± 6.4 g/m^2 carbon, the lowest of any subgroup or group. The diversity trend is here reversed, however, with the southern subgroup having a mean diversity index of 0.948 ± 0.126, quite high, as compared to 0.668 ± 0.164 for the northern subgroup. This might indicate that the depressed standing stock of the southern subgroup is the result of predation rather than decreased productivity. Again, it seems probable that substrate type is the common factor uniting the split distributions of this group.

Group VIII, referred to as the Central Bering Supergroup, presents a picture of considerable complexity. This supergroup is composed of 4 major subgroups loosely allied in faunal composition, three of which possess distinct areal distributions in the Chukchi Sea as well as in the central Bering Sea.

The first of these major subgroups, Subgroup A, possesses such a split distribution. The southern component of this subgroup forms an elongate distribution from southwest to northeast below St. Lawrence Island (Fig. 4), while the northern component forms a tight cluster of stations in the southern Chukchi Sea. Again, the trend toward northerly increase in standing stock is evidenced, the northern component possessing a much larger mean biomass, 568 g/m^2 wet weight, than the southern with 179 g/m^2 wet weight, though the confidence limits do overlap due to the small sample size of the northern group (Table 4). This result, as postulated earlier, may be due to the presumably vast benthic food supply dumped into the southern and central Chukchi Sea from the Bering as a result of the current structure.

Both components of this subgroup are dominated almost exclusively by selective detritus feeders, with one filter feeder, the tunicate *Pelonaia corrugata* sharing dominance with a host of selective detritus feeders within the southern component. The mean depths of these components may be somewhat at variance, 59 ± 11 m for the southern as opposed to 46 ± 7 m for the northern, though the sediment mean sizes are very similar, 4.09 ± 0.87 phi and 4.50 ± 1.12 phi, respectively.

The second subgroup, Subgroup B, is the only subgroup of the Central Bering Supergroup confined in distribution to the Bering Sea. This subgroup is composed primarily of a cluster of stations northwest of St. Matthew Island, with two areal erratics, one to the north and one to the south. The mean depth of this subgroup is 78 ± 14 m, the deepest of any within the supergroup, and the mean phi size is 3.87 ± 1.03, slightly coarser, which is surprising considering the greater depth, than for the components of Subgroup A.

The mean standing stock of this subgroup is 206 ± 102 g/m^2 wet weight, 9.0 ± 4.2 g/m^2 carbon, and the mean diversity index 0.857 ± 0.054, both of which are somewhat below average for the study region as a whole. The trophic structure, as for Subgroup A, is dominated almost exclusively by selective detritus feeders, most of which are bivalve mollusks (Table 5; Appendix 9).

Subgroup C of the Central Bering Supergroup again consists of two distinct areal components, one forming a large distribution southeast of St. Lawrence Island, the other composed of two isolated stations just offshore from Icy Cape in the northeast Chukchi Sea. The latter are completely surrounded to seaward by stations of cluster Group VI. In the case of these two areal components, both depth and sediment type appear to be quite similar. Both are dominated heavily by selective detritus feeders, though both include a fairly large proportion of substrate feeders, not in evidence in the previous subgroups, which share local dominance. In the case of the southern distribution, filter feeders are also prominent (Table 5; Appendix 9).

In the case of this subgroup, the trend toward northerly increase in standing stock may be reversed, the southern component exhibiting a mean biomass of 197 g/m^2 wet weight, 8.3 g/m^2 carbon, as compared to 156 g/m^2 wet weight, 6.6 g/m^2 carbon for the northern (Appendix 7). This view is not strictly supportable on statistical grounds (Table 5), again due, in part at least, to the small sample size of the northern component. This is the first time this reversal has been seen, and is perhaps evidence of the decreasing food supply and increasing environmental stress in the far northern Chukchi Sea, though comparison of the mean diversity indices for the two components, 0.842 for the southern and 1.182 for the northern, tends to shed doubt on this approach since environmental stress should, theoretically, reduce diversity (Sanders, 1968, 1969). As mentioned earlier, this decreased standing stock in conjunction with increased diversity may also be the result of increased predation pressure as is hypothesized for the southern Bering shelf.

The last subgroup of the Central Bering Supergroup, Subgroup D, is also composed of a central Bering and a northern Chukchi component. The Bering component in this case consists of 3 stations lying along a southeast-northwest axis just northeast of St. Matthew Island. The mean standing stock of this component is 405 ± 529 g/m^2, and the mean diversity 0.731 ± 0.328. The Chukchi component is made up of only two stations in the far northern Chukchi with a mean biomass of 238 ± 58 g/m^2 wet weight. Oddly, as was the case for the components of the previous subgroup, the

Chukchi distribution has the higher index of diversity, 0.865 as compared to 0.731, though again this result is statistically open to question (Table 5). This is a puzzling circumstance, contrary to most views of high latitude faunal characteristics. It would seem to indicate, if current theories of diversity are correct, that either habitat conditions are more diverse and environmental stress less severe in the northern Chukchi than in the central Bering, 10 degrees of latitude to the south, or that predation pressure in this northern Chukchi region is increased, probably as a result of the walrus population which summers in this area.

A possible alternative to the theory that diversity is controlled in this region by habitat variability, environmental stress, or predation is that perhaps here, in the northern reaches of the Chukchi Sea, the boreal-Pacific fauna of the Bering and central Chukchi is at last being competed with and partially replaced by an Arctic-Atlantic fauna, resulting in diversification of species.

Another, though improbable, explanation for the increased diversity observed on the southern and northern extremes of the Bering/Chukchi shelf is that these regions are simply older and more mature marine environments. During the last Wisconsin glaciation virtually all of the Bering/Chukchi shelf was emergent as a terrestial environment due to lowered sea level. Toward the end of this last glacial age, subsequent to 25,000 years ago, this shelf was once more re-flooded by the sea, with the southern and northern extremes being the first regions to become again submergent and marine.

In this last subgroup of the Central Bering Supergroup more than in any other instance encountered, the common element uniting the two widely separated areal components is difficult to perceive. The average depths of the two components are not radically different, 60 ± 10 m for the southern and 51 ± 0 for the northern component, though the sediment means are quite variant, 4.08 ± 1.99 phi for the southern component and 6.50 ± 0 phi for the northern. For the first time, it appears that sediment type may not be the dominant correlating influence but that some unassessed factor may be ascendent.

Both of these areal components of Subgroup D are totally dominated by selective detritus feeders, largely bivalve mollusks, with no other trophic types sharing dominance even on the local level.

This observed tendency for station groups and faunal assemblages to be repeated in both the Bering and Chukchi Seas illustrates graphically the similarities and interdependent nature of the two regions. The original organization plan for this study was to consider the two regions, the continental shelf of the Bering Sea and that of the Chukchi Sea, as separate entities. As data and information became available, however, it became increasingly apparent that such a distinction was artificial and that this entire continental shelf should be considered as one integral biological system.

Environmental Correlations

In addition to the indications, discussed above, the results generated from correlation (BMD-02R) of species distributions with environmental variables strongly supports the view that sediment is in fact the variable most directly correlatable with the distribution of species over this continental shelf. As detailed in the results section, in 21 of the 26 species cases correlatable at the 0.50 (increase in R^2) level with environmental factors, sediment assumes dominance (Table 8). At the 0.75 level, sediment is dominant in 18 out of 20 cases, and at the 0.95 level sediment is dominant in all 12 cases.

As mentioned earlier, it should be kept in mind that this environment/species relationship is, within the context of this discussion, just what it is purported to be - a distributional correlation, nothing more and nothing less. For predictive purposes it is hopefully quite applicable. It does not necessarily, however, define a direct cause-and-effect relationship. In some instances organisms may seek out a distinct substrate type for its own peculiarities - for attachment, for burrowing or tube-building, or as a nutrient source in the case of substrate feeders - but more often it seems probable that these distributions, faunal and geological, are mutually dictated by some other agency or agencies such as current velocity and direction (also relatable to depth, latitude and longitude, etc.) and sedimentation rates and sources.

The second most strongly correlatable environmental factor apparent from this study is latitude, with longitude not far behind. In these cases, of course, this is certainly not a direct cause-and-effect relationship, but is reflective of other factors, paramount of which are probably bottom temperature, primary productivity distributions, distance from shore, and current regime. The same is probably true of depth, which does not appear, from either the species/environmental correlations or the cluster group distributions, to be a particularly influential factor in itself.

It is highly probable that the other environmental variable which would, were sufficient data available, prove to be strongly correlatable with faunal (species) distributions is summer bottom temperature (Neyman, 1960; Filatova and Barsanova, 1964). This temperature effect is probably a direct one, effecting the reproductive capacity of the species. In the case of those forms having pelagic larvae this temperature effect may not be so critical since recruitment is possible from other areas, as discussed previously regarding the fauna of the Chukchi and northern Bering. In the case of those forms exhibiting direct development or brooding behavior, however, this factor may be very critical in determining their distributions, as is postulated to be the case for the ophiuroid *Ophiura sarsi* (Neyman, 1960). As more data becomes available, the present prediction is that these two factors, sediment type and summer bottom temperature, will be found to be overridingly dominant in correlations, for predictive purposes, with faunal distributions.

Regarding faunal, inter-specific, associations, it must be reiterated that caution should be exercised in ascribing "community" characteristics to the dominant species assemblages apparent from the station cluster analysis results (Table 3; Appendix 9). In performing cluster analyses on indicator species, either within station cluster groups (Appendix 10) or over the area as a whole, no strong <u>and</u> repeated interspecies affinities were perceived though local interspecific affinities were sometimes quite strong. It seems not entirely clear what this indicates, though the inference is that biological interactions between species, with the exceptions of possible predator-prey relationships, are not particularly strong and that within-group distributional preferences are probably dictated by variations in the physical environment, by micro-habitats. As discussed above, species distributions may be, and probably are, controlled by not one but a suite of such environmental variables, which would account for the lack of constancy in species associations within the various groups or areas. For instance, the combination of sediment type, temperature, and current structure which might bring together mutual concentrations of two or more species in one area might prevent such mutual concentrations in another area where one or more environmental variables were altered slightly.

This view seems further supported by the curious and repeated co-occurrence within the same group, and often within the same station, of related species of the same genus. While such closely related species do not appear to be mutually exclusive through competition within cluster groups, stations, or faunal assemblages, the evidence of the within-group species cluster analysis is that in fact such related species seldom indicate any distributional affinity for one another, which again leads to the inference that, although concurrent, these closely related species are in fact seeking out slightly variant micro-habitats where slightly different life-styles enable them to co-exist without recourse to exclusive competition. Indirect support of this argument is also enlisted from previous observations as to the extremely patchy character of the benthic fauna of the central and northern Bering shelf (Rowland, 1972; Stoker, 1973) which would seem to indicate such variable micro-habitat.

Growth and Productivity

While the sample size for *C. ciliatum* and *S. groenlandicus* is too small to permit valid judgements regarding age composition and productivity rates for these species, certain trends do seem apparent when the three species, these two and *M. calcarea*, are compared.

For *M. calcarea*, primarily a selective detritus feeder, growth rates seem to be relatively slow, with a mean shell length increase of only 3.3 mm/yr, though overall net productivity is somewhat higher than might be expected, estimated at 32% standing stock per year for the population sampled, based on growth and mortality rates. This is somewhat higher than the 25% standing stock per year estimate arrived at by other authors for the benthos as a whole in this (Neyman, 1963) or other comparable areas (Zenkevich, 1963). This may be an indication of a true elevation in benthic productivity overall for this area, probably due to the magnitude and diversity of the food supply, or it may simply be a reflection of this particular species.

As seems apparent from the data (Table 20), the linear shell growth rates for both *C. ciliatum* and *S. groenlandicus* are considerably higher, perhaps as much as twice as high in the case of *C. ciliatum*, as for *M. calcarea*. Though such shell growth rates do not necessarily reflect increased net productivity, it seems likely that such is the case. Significantly, both these species are obvious filter feeders. The reasons why growth rates for such filter feeders should be elevated over those for a primarily selective detritus feeder are not entirely clear, though shortening of the food chain may be a contributory factor.

In addition to the increased growth rates estimated for the filter feeders *Serripes* and *Clinocardium*, a curious age segregation is observed in their distributions, no admixture of age/size classes occurring in the samples retrieved. Since the population distributions of these two species is extremely patchy over this study area, this age segregation lends considerable difficulty to any attempt at making a valid age structure or mortality estimate for these populations. The reasons for such age segregation are somewhat unclear but are thought to be the result of cannibalism, the adults indiscriminately filtering out and consuming their own larvae and spat along with other organisms from the water column, and perhaps substrate conditioning, probably through fecal production of the adults (Raymont, 1963), which precludes spat settlement.

Another somewhat surprising result of the growth analysis for all three species is that there do not appear to be significant latitudinal variations in these growth rates, as might be expected from the temperature regime. The indication from this result would seem to be that nutrient supply is the overriding factor determining growth. As postulated previously, this supply of nutrients is thought to increase and to be concentrated in the north Bering Sea-Bering Strait-south Chukchi Sea region, where standing stock also reaches its maximum.

Based on the limited data and conclusions available regarding benthic productivity over the study area, it would appear that net productivity rates are somewhat higher for the Bering/Chukchi than previously postulated by Neyman (1963) for the Bering or by Zenkevich (1963) for the Barents Sea. Annual productivity rates in both these cases were estimated at 25% standing stock, overall, as compared to the 32% estimate for *Macoma* *calcarea* populations over the Bering/Chukchi shelf arrived at by this study. While it is apparent that the extrapolation of productivity rates from a single species to the benthic population as a whole involves considerable risk, there are reasons for thinking that this estimate may not be excessive. In the first instance, *M. calcarea*, a bivalve mollusk, is recognized as a selective detritus feeder, though it may also act at times as a facultative filter feeder (Reid and Reid, 1968). The evidence so far available is that the growth rates at least for filter feeding bivalves in the same area may be considerably accelerated as compared to the primarily detritus feeding *M. calcarea*. If growth rates and net productivity are equatable, as they seem to be, then the productivity rates for the filter feeding bivalve complement of the fauna may in fact be in excess of 32%, tending to raise the average level. On the other hand, the possibility that *M. calcarea* may itself perform as a filter feeder in part could be an indication that its growth and productivity rates are likewise elevated somewhat in comparison with the bulk of the observed benthic species which are predominately detrital feeders. This 32% estimate for *M. calcarea* is itself felt to be almost certainly on the low side, however, due to inherent flaws in the sampling technique which virtually eliminated the first several year classes from such growth and productivity estimates. It is felt, in short, that all of these considerations tend to at least balance out, leaving the overall figure of 32% reasonably valid as a preliminary estimate.

Seasonal and Annual Stability

Somewhat more surprising than this net productivity estimate is the great degree of seasonal and annual stability evidenced by the benthic populations of the region, both on the overall standing stock level and on the regional species level. A total of 20 separate analyses of variance were performed in order to evaluate possible seasonal and annual fluctuations, and only in the case of two species, *Echinarachnius parma* and *Pontoporeia femorata*, were any significant statistical fluctuations indicated. These fluctuations were both density (indiv/m^2) variations rather than biomass changes, both were valid for only one area (station cluster group) and at the 95% confidence level but not at the 99% level. Admittedly, the sampling program as it was implemented was not designed around the null hypothesis of such variability and so necessitated severe statistical constraints. Even so, the obvious interpretation of these analyses is that the Bering/Chukchi benthic system, for all its distributional complexity and variability, does exhibit a population stability rather remarkable for such a high latitude fauna (Sanders, 1968; Holme, 1953). In a sense, however, this is not entirely surprising (MacArthur, 1955) given the rather high species diversity exhibited over much of this area, which in itself seems uncharacteristic for such latitudes. This elevated diversity and standing stock stability may also indicate a reliable and relatively uniform benthic food supply.

The results of the *M. calcarea* growth and productivity analysis are also supportive of this stability in that, over all available year classes lumped over the sample area, growth and mortality are seen to balance out almost perfectly, further indicating a steady-state system with little annual fluctuation.

Another possible reason for this population stability may lie in the reproductive nature of the fauna itself. Many of the species composing this fauna exhibit direct larval development or brooding behavior, and are thus less prone to annual recruitment failures than are those forms indicating pelagic larvae (Thorson, 1950; Feder and Paul, 1973).

CONCLUSION

The overall picture which emerges regarding the benthic fauna of the Bering/Chukchi shelf is one of a dynamically stable though distributionally complex system of considerable diversity. This diversity relates both to habitat and faunal assemblages, to species diversity within these assemblages, and perhaps to sources of food supplying these assemblages.

The faunal assemblages, of which there appear to be 8 major ones, each composed of several subgroups, forms a distributional mosaic within the study area. These patterns of distribution, at first glance disheartening in their complexity, appear upon inspection to correlate strongly with substrate type as the dominant factor determining most of the group distributions. This also seems to be the case regarding species distributions, though it is suspected that summer bottom temperatures also influence both species and assemblage distributions. The view of substrate type as determining faunal distributions is not to be taken literally as a cause-and-effect relationship. It is, in many cases at least, merely a reflection of other environmental conditions which dictate both faunal and sediment distributions. In this regard it serves a predictive, though not necessarily a determinant role.

The benthic fauna of this shelf in general appears to maintain a fairly high standing stock level, though not abnormally so when related to comparable areas in the high-latitude Atlantic and Asian Pacific. The features of this Bering/Chukchi fauna which do seem somewhat at variance with such comparable regions are its relatively high faunal diversity, productivity, dynamic stability, and latitudinal distribution of standing stock. Both diversity and standing stock tend to increase rather dramatically from south to north.

Clues to this situation are felt to be found in the physical/biological system which supplies food to this benthic fauna, and in the character of the fauna itself. The nutrient input to the benthic ecosystem is thought to consist of two main sources - primary productivity and riverine detritus. The dependability and diversity of the nutrient system probably accounts in large part for the dynamic stability of the benthic population and for the faunal diversity and elevated productivity of the system.

The physical transport system of oceanic currents associated with this nutrient system tends to sweep the bulk of this food supply across the shelf northward, where it is probably concentrated in the north Bering Sea and Bering Strait region and consequently dumped, by decreasing current velocity, into the southern and central Chukchi Sea, accounting for the remarkable increase in standing stock seen in this region.

The faunal system itself is largely dominated by detritus feeders, with a considerable complement of filter feeders, and so is geared to take advantage of this diversity in nutrient source. This fauna is also composed, to a large extent, of forms exhibiting direct larval development and so is less subject to the population (recruitment) fluctuations suffered by forms producing pelagic larvae.

In the southern Bering and in the Northern Chukchi, the latitudinal extremes of the system, a situation is exhibited of decreased standing stock and increased diversity, perhaps for similar reasons. In the southern Bering it is felt that standing stock is probably reduced through predation, though productivity and diversity are maintained at high levels as a result of food availability and decreased environmental (physical) stress. In the northern Chukchi, the situation seems possibly one of decreased food availability and increased environmental stress, accounting for the low standing stock (and probably low productivity) but with the diversity heightened either by competition/replacement of the boreal-Pacific forms which are seen to dominate the faunal composition over most of the region by Arctic-Atlantic forms, or by marine mammal predation.

In viewing the faunal assemblages and species associations of this Bering/Chukchi shelf, the evidence seems to indicate that faunal assemblages are dictated by physical, environmental, variables and are not strongly inter-related biologically. In this sense they are not true biological communities but consist rather of flexible confederations of species loosely allied by similar environmental requirements.

Based on the data available, *Macoma calcarea* is seen to be a relatively slow growing species which attains, despite this slow growth, a fairly substantial net productivity. This productivity estimate, 32%

standing stock carbon biomass per year, while probably in itself too low, is somewhat higher than previous estimates for the benthos as a whole.

It is conjectured that this elevated productivity may be a reflection of feeding methods. *Macoma calcarea*, while primarily a selective detritus feeder, may also perform at times and in part as a facultative filter feeder, which may serve to increase its growth and, presumably, productivity rates. This situation seems to be indicated at least from the other two species assessed, *Serripes groenlandicus* and *Clinocardium ciliatum*. Both of these species are obvious filter feeders and both appear to have growth rates considerably elevated over *M. calcarea*. Due to the small sample sizes available for these two species, and to their age segregated distribution, no estimates are available as to the age composition, mortality rates, or productivity rates for their populations.

In all three species, no certain latitudinal variability is observed in growth rates, indicating that food supply and not temperature may be the overriding concern.

Perhaps the most important conclusion developed from this study, in terms of possible perturbation effects, is the seemingly very strong dependence of the Chukchi system on the Bering Sea as a nutrient source or sources and, possibly, as a spawning ground providing recruitment. The Chukchi is, in this sense, somewhat of a saprophytic system and is apt to reflect strongly, even magnify, events which affect the Bering Sea itself.

APPENDICES

APPENDIX 1

Location and Collection Dates for Benthic Stations on the Bering/Chukchi Shelf

Station No.	Date	Position	
		Latitude	Longitude
1	05/08/73	57°59.4'N	158°56.5'W
2	13/07/74	58°09.5'N	159°26.5'W
3	04/08/73	58°28.0'N	159°39.0'W
4	13/07/74	58°22.5'N	159°56.5'W
5	13/07/74	58°35.0'N	159°49.0'W
6	04/08/74	58°41.3'N	159°44.0'W
7	04/08/73	58°46.5'N	160°12.5'W
8	04/08/73	58°57.0'N	160°25.8'W
9	13/07/74	58°05.0'N	160°21.0'W
10	12/07/74	58°25.0'N	160°46.5'W
11	12/07/74	58°13.0'N	161°26.0'W
12	12/07/74	57°57.0'N	161°18.0'W
13	12/07/74	58°08.0'N	162°06.0'W
14	12/07/74	57°45.0'N	162°06.0'W
15	02/08/73	58°41.4'N	162°31.0'W
16	02/02/70	58°19.5'N	162°57.0'W
17	11/07/74	58°02.0'N	162°55.0'W
18	01/02/70	57°39.0'N	162°58.0'W
19	02/08/73	58°48.3'N	163°38.0'W
20	01/08/73	59°13.0'N	164°17.0'W
21	11/07/74	58°26.0'N	164°22.0'W
22	31/01/70	57°58.0'N	164°45.0'W
23	03/02/70	57°05.0'N	164°77.0'W
24	03/02/70	57°07.0'N	165°15.0'W
25	11/07/74	58°34.0'N	166°12.0'W
26	26/03/72	57°21.0'N	167°23.0'W
27	04/02/70	58°14.0'N	167°26.0'W
28	17/04/71	57°41.0'N	168°03.0'W
29	04/02/70	58°30.0'N	168°16.0'W
30	16/04/71	57°46.3'N	169°45.0'W
31	15/04/71	57°48.0'N	169°56.0'W
32	14/04/71	57°46.0'N	170°58.0'W
33	14/04/71	57°53.0'N	170°55.0'W
34	12/04/71	58°13.0'N	171°23.0'W
35	11/04/71	58°22.0'N	171°27.0'W
36	10/04/71	58°44.0'N	172°31.0'W
37	05/02/70	59°05.0'N	169°58.5'W
38	05/02/70	59°31.0'N	169°53.0'W
39	06/02/70	59°45.0'N	171°22.0'W
40	08/04/71	59°56.0'N	173°51.0'W
41	08/07/74	60°41.5'N	171°25.0'W
42	09/02/70	60°42.5'N	175°00.0'W

APPENDIX 1. Continued

Station No.	Date	Position	
		Latitude	Longitude
43	06/04/71	61°10.5'N	173°47.4'W
44	08/07/74	61°22.0'N	171°53.0'W
45	02/04/74	61°40.0'N	171°10.0'W
46	02/04/74	61°45.4'N	169°44.0'W
47	31/07/73	61°11.5'N	166°59.5'W
48	31/07/73	61°40.0'N	167°26.0'W
49	14/08/73	61°52.0'N	166°58.0'W
50	31/07/73	62°08.0'N	167°53.0'W
51	01/04/71	62°09.0'N	168°08.0'W
52	31/03/71	62°06.0'N	168°23.0'W
53	08/07/74	62°05.0'N	171°20.0'W
54	03/04/71	61°57.0'N	171°45.0'W
55	06/04/71	61°15.0'N	174°02.0'W
56	29/02/72	61°09.0'N	175°12.0'W
57	01/03/72	61°22.0'N	175°03.0'W
58	21/03/72	61°26.5'N	174°27.0'W
59	20/03/72	61°26.0'N	174°24.0'W
60	06/04/71	61°37.0'N	174°24.0'W
61	01/03/72	61°44.0'N	173°50.0'W
62	04/04/71	61°54.0'N	173°25.0'W
63	02/03/72	61°56.0'N	173°21.0'W
64	02/03/72	62°13.5'N	172°39.0'W
65	12/02/70	62°19.0'N	175°04.0'W
66	12/02/70	62°27.0'N	173°27.0'W
67	18/03/72	62°41.0'N	172°36.0'W
68	03/03/72	62°39.0'N	172°20.0'W
69	12/03/72	62°37.0'N	172°06.0'W
70	13/02/70	62°35.0'N	171°53.0'W
71	11/03/72	62°29.0'N	172°10.0'W
72	08/07/74	62°30.5'N	171°06.0'W
73	13/02/70	62°25.0'N	170°00.0'W
74	31/03/71	62°26.0'N	168°05.0'W
75	31/03/71	62°36.0'N	167°59.0'W
76	31/07/73	62°35.5'N	168°19.5'W
77	14/08/73	62°35.5'N	166°04.0'W
78	14/08/73	63°03.0'N	165°24.0'W
79	15/08/73	63°38.0'N	165°01.6'W
80	07/07/74	63°26.0'N	166°04.0'W
81	30/03/71	63°04.0'N	167°31.0'W
82	29/03/71	63°19.0'N	167°28.0'W
83	29/03/71	63°28.5'N	167°20.0'W
84	31/07/73	63°14.9'N	168°27.0'W
85	31/07/73	63°14.9'N	168°11.0'W
86	07/07/74	63°04.0'N	168°19.0'W
87	07/07/74	62°51.5'N	169°10.0'W

APPENDIX 1. Continued

Station No.	Date	Position	
		Latitude	Longitude
88	07/07/74	62°45.0'N	170°03.0'W
89	08/07/74	62°54.0'N	170°59.0'W
90	08/07/74	63°11.0'N	171°00.0'W
91	16/03/72	63°10.4'N	171°33.0'W
92	05/03/72	62°57.0'N	172°12.0'W
93	08/03/72	62°55.0'N	172°11.0'W
94	06/03/72	62°59.0'N	172°36.0'W
95	01/07/74	63°15.5'N	172°03.0'W
96	30/06/74	63°27.0'N	172°36.0'W
97	04/03/72	63°29.0'N	171°54.0'W
98	04/03/72	63°26.0'N	172°09.0'W
99	01/07/74	63°36.0'N	172°08.5'W
100	30/06/74	63°47.0'N	172°35.0'W
101	30/06/74	64°01.0'N	172°03.0'W
102	28/07/74	63°52.0'N	171°45.0'W
103	01/07/74	63°45.0'N	171°21.0'W
104	01/07/74	64°01.5'N	171°41.0'W
105	30/06/74	64°12.0'N	171°41.5'W
106	28/07/74	64°18.5'N	171°08.0'W
107	30/06/74	64°09.5'N	171°15.0'W
108	30/06/74	64°21.0'N	170°42.0'W
109	30/06/74	63°03.5'N	170°46.0'W — not according to fig.
110	29/07/73	63°54.0'N	170°51.0'W
111	01/07/74	63°53.0'N	170°36.0'W
112	30/06/74	64°23.0'N	170°04.0'W
113	29/07/73	63°50.5'N	169°54.3'W
114	01/07/74	63°47.5'N	169°51.5'W
115	01/07/74	63°52.0'N	168°55.0'W
116	30/07/73	63°49.5'N	169°06.0'W
117	01/07/74	63°41.5'N	169°19.0'W
118	02/07/74	63°35.0'N	168°50.0'W
119	30/07/73	63°37.0'N	168°28.0'W
120	19/06/74	63°52.2'N	167°57.0'W
121	03/07/74	63°43.5'N	167°28.0'W
122	07/09/74	64°07.5'N	167°10.0'W
123	28/03/71	63°53.0'N	166°46.0'W
124	04/07/74	63°48.5'N	166°23.3'W
125	17/02/70	63°59.0'N	165°38.0'W
126	07/09/73	64°12.7'N	166°12.0'W
127	15/08/73	64°24.5'N	165°34.5'W
128	15/08/73	64°23.0'N	165°25.5'W
129	15/08/73	64°25.8'N	165°23.3'W
130	07/09/73	64°26.7'N	165°52.0'W
131	07/09/73	64°29.0'N	165°50.3'W
132	07/09/73	64°25.5'N	165°45.3'W

APPENDIX 1. Continued

Station No.	Date	Position: Latitude	Position: Longitude
133	27/03/71	64°14.0'N	166°00.0'W
134	29/06/74	64°25.0'N	167°34.0'W
135	07/09/73	64°11.0'N	168°06.5'W
136	19/06/74	64°16.0'N	168°18.0'W
137	29/06/74	64°18.0'N	168°36.0'W
138	19/06/74	64°35.0'N	167°55.0'W
139	19/06/74	64°46.0'N	167°36.0'W
140	29/06/74	64°41.5'N	168°03.0'W
141	29/06/74	64°49.5'N	168°27.0'W
142	29/06/74	64°37.0'N	168°30.0'W
143	07/09/73	64°34.0'N	168°30.0'W
144	29/06/74	64°35.5'N	169°19.0'W
145	29/06/74	64°49.0'N	169°12.0'W
146	28/07/73	64°42.2'N	170°40.0'W
147	29/06/74	64°49.0'N	170°04.0'W
148	28/06/74	65°02.0'N	169°20.0'W
149	28/06/74	65°08.0'N	168°53.0'W
150	28/06/74	65°01.0'N	168°25.3'W
151	07/09/73	64°58.0'N	168°11.0'W
152	19/06/74	65°59.0'N	167°36.0'W
153	19/06/74	65°12.2'N	168°06.0'W
154	15/08/73	65°17.0'N	166°30.0'W
155	18/08/73	65°19.1'N	167°50.9'W
156	18/10/73	65°21.8'N	168°18.5'W
157	19/06/74	65°22.0'N	168°22.0'W
158	28/06/74	65°17.5'N	169°15.5'W
159	06/09/73	65°28.0'N	168°30.0'W
160	28/06/74	65°33.0'N	168°54.0'W
161	18/08/73	65°32.5'N	168°26.4'W
162	18/08/73	65°47.0'N	168°30.0'W
163	28/06/74	65°49.5'N	168°35.0'W
164	18/08/73	65°52.0'N	168°32.2'W
165	28/06/74	66°02.8'N	167°57.0'W
166	28/06/74	66°02.8'N	168°24.5'W
167	18/08/73	66°05.8'N	168°42.0'W
168	28/06/74	66°06.5'N	168°47.0'W
169	28/06/74	66°16.7'N	168°22.5'W
170	20/06/74	66°34.2'N	168°32.0'W
171	27/07/73	66°47.5'N	168°30.0'W
172	06/09/73	66°42.5'N	168°34.0'W
173	06/09/73	66°10.0'N	168°35.0'W
174	20/06/74	67°13.3'N	168°25.0'W
175	22/06/74	67°27.5'N	165°46.0'W
176	22/06/74	67°33.0'N	165°56.0'W
177	21/06/74	67°35.0'N	167°40.6'W

APPENDIX 1. Continued

Station No.	Date	Position	
		Latitude	Longitude
178	21/06/74	67°41.0'N	168°00.0'W
179	06/09/73	67°36.0'N	168°40.0'W
180	06/09/73	68°02.0'N	167°52.0'W
181	06/09/73	68°16.0'N	166°30.0'W
182	19/08/73	67°50.0'N	170°22.0'W
183	19/08/73	68°36.0'N	171°11.0'W
184	24/08/73	68°38.0'N	176°00.0'W
185	19/08/73	69°03.0'N	171°38.0'W
186	05/09/73	68°48.0'N	167°46.0'W
187	05/09/73	68°58.0'N	166°20.0'W
188	05/09/73	69°51.0'N	163°25.0'W
189	05/09/73	69°53.0'N	164°58.0'W
190	05/09/73	69°29.0'N	166°24.0'W
191	23/08/73	69°38.5'N	178°08.0'W
192	22/08/73	70°19.0'N	176°45.0'W
193	22/08/73	70°19.0'N	176°30.0'W
194	21/08/73	70°56.0'N	176°18.0'W
195	21/08/73	71°13.5'N	174°56.0'W
196	20/08/73	71°36.0'N	174°20.0'W
197	20/08/73	71°19.0'N	174°00.0'W
198	25/06/73	71°10.0'N	171°00.0'W
199	25/08/73	71°00.0'N	171°10.0'W
200	26/08/73	71°20.0'N	168°55.0'W
201	26/08/73	71°47.0'N	166°35.0'W
202	27/08/73	72°17.8'N	165°10.0'W
203	28/08/73	71°03.0'N	164°57.0'W
204	28/08/73	71°12.0'N	164°12.0'W
205	29/08/73	71°12.0'N	163°05.0'W
206	05/09/73	70°29.0'N	163°35.0'W
207	04/09/73	70°32.0'N	161°47.0'W
208	29/08/74	71°10.0'N	161°57.0'W
209	31/08/73	71°23.0'N	160°15.0'W

Enter
Station No.
Depth

APPENDIX 2

Observed Physical Characteristics of Benthic Stations on the Bering/Chukchi Shelf

Station No.	Bottom Water: Temp. (°C)	Bottom Water: Sal. °/₀₀	Bottom Water: Oxygen ml/l	Depth (m)	Sediment: Mean Phi size	Sediment: Mode Phi size	Avg. Grab Penet. (cm)
1	8.19	31.09	6.99	38	1.66	2.00	3.5
2	-	-	-	31	2.06	2.50	2.4
3	8.98	30.30	6.35	27	3.00	3.00	5.5
4	-	-	-	20	1.99	2.50	3.2
5	-	-	-	40	3.38	3.50	3.1
6	-	-	-	18	2.50	2.50	5.3
7	-	-	-	25	2.22	2.00	3.8
8	-	-	-	6	2.89	3.00	3.7
9	-	-	-	43	2.48	3.00	2.4
10	-	-	-	20	-1.00	-1.00	8.8
11	-	-	-	38	-	-	2.4
12	-	-	-	42	2.38	2.50	2.4
13	-	-	-	40	2.38	2.50	2.9
14	-	-	-	43	2.49	2.50	3.0
15	9.71	30.68	6.78	42	-0.17	2.00	3.0
16	-1.72	31.60	7.74	24	2.75	2.75	3.6
17	-	-	-	37	2.52	3.00	3.7
18	-1.71	31.66	7.61	52	2.75	2.75	3.4
19	8.67	31.46	6.65	24	2.44	2.50	2.6
20	-	-	-	23	2.46	2.50	2.8
21	-	-	-	38	2.71	3.00	3.2
22	0.74	32.24	7.23	62	3.75	3.75	1.7
23	0.64	32.16	7.17	33	4.00	4.00	4.0
24	0.65	31.90	7.57	63	3.75	3.75	3.0
25	-	-	-	39	3.11	3.00	2.7
26	-	-	-	72	-	-	-
27	-0.08	32.03	7.34	63	3.75	3.75	3.8
28	-1.07	32.01	8.21	70	3.27	3.00	1.4

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Bottom Water Sal. °/oo	Bottom Water Oxygen ml/l	Depth (m)	Sediment Mean Phi size	Sediment Mode Phi size	Avg. Grab Penet. (cm)
29	-1.22	31.79	7.51	62	3.75	3.00	5.5
30	-1.69	31.76	8.10	68	3.47	3.00	3.8
31	-	-	-	80	-	-	-
32	-1.71	31.89	8.23	90	5.38	5.00	7.4
33	-	-	-	90	-	-	-
34	-1.70	31.81	8.06	92	5.87	4.25	7.5
35	-	-	-	105	6.14	6.50	5.6
36	0.36	32.26	7.54	100	6.47	6.50	6.4
37	0.18	32.02	7.30	63	3.75	3.75	5.1
38	-0.29	31.92	7.39	54	-	-	5.0
39	-0.23	32.29	7.46	75	5.00	5.00	4.4
40	-1.68	31.94	8.03	95	7.12	6.50	10.6
41	-	-	-	61	5.91	5.00	8.3
42	0.72	32.50	7.30	103	4.50	4.00	10.5
43	-1.74	32.11	8.08	75	5.42	3.25	8.6
44	-	-	-	56	5.47	7.00	9.6
45	-1.73	32.06	8.23	53	5.32	4.50	10.9
46	-1.75	32.34	8.28	48	5.08	4.25	7.1
47	8.49	30.23	6.60	19	3.59	3.50	2.8
48	4.07	30.10	-	22	3.12	3.25	2.2
49	-	-	-	22	3.76	3.75	3.3
50	2.07	31.02	8.33	25	3.30	3.50	1.8
51	-1.81	33.43	8.10	25	3.35	3.50	1.0
52	-1.80	33.14	8.06	34	3.54	3.50	1.2
53	-	-	-	48	4.25	3.50	11.2
54	-1.74	32.18	8.15	56	4.97	3.50	11.4
55	-	-	-	90	-	-	-
56	-	-	-	100	8.09	6.50	10.0
57	-1.74	31.85	-	86	7.58	7.00	9.4
58	-1.73	31.89	-	82	5.77	3.50	7.0

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Bottom Water Sal. °/oo	Bottom Water Oxygen ml/1	Depth (m)	Sediment Mean Phi size	Sediment Mode Phi size	Sediment Avg. Grab Penet. (cm)
59	-	-	-	78	5.47	3.25	7.5
60	-1.75	32.18	8.04	80	6.50	3.50	8.7
61	-	-	-	66	6.21	3.50	6.0
62	-1.73	32.02	-	63	5.79	3.50	13.1
63	-	-	-	55	5.43	3.75	8.8
64	-1.80	33.08	-	53	4.34	3.50	5.4
65	-0.71	32.27	7.30	90	5.50	6.00	7.8
66	-1.75	31.70	7.56	70	3.75	3.75	8.5
67	-	-	-	56	4.67	4.00	7.8
68	-1.77	32.55	-	48	4.02	3.50	3.6
69	-	-	-	52	2.52	2.75	1.7
70	-1.74	31.58	7.50	54	3.75	3.75	3.5
71	-1.77	32.52	-	49	3.23	3.25	1.5
72	-	-	-	38	3.12	3.00	2.4
73	-1.70	31.68	7.46	45	2.75	2.75	1.6
74	-	-	-	30	-	-	-
75	-1.82	33.34	8.08	23	1.01	-0.31	1.0
76	-	-	-	31	2.98	3.00	2.2
77	-	-	-	18	3.73	3.75	2.7
78	-	-	-	20	5.10	4.75	10.2
79	-	-	-	20	4.90	4.25	4.3
80	-	-	-	23	3.75	4.00	3.4
81	-1.83	33.63	7.97	33	3.35	3.00	3.6
82	-1.85	33.85	7.99	27	3.19	2.75	1.4
83	-1.85	34.02	8.06	28	3.21	3.25	1.5
84	-	-	-	38	-0.10	2.00	4.0
85	-	-	-	16	2.59	3.00	2.3
86	-	-	-	39	4.15	3.00	3.4
87	-	-	-	32	2.56	2.50	3.2
88	-	-	-	42	2.84	3.00	3.7

APPENDIX 2. Continued

Station No.	Bottom Water: Temp. (°C)	Bottom Water: Sal. °/°°	Bottom Water: Oxygen ml/l	Depth (m)	Sediment: Mean Phi size	Sediment: Mode Phi size	Avg. Grab Penet. (cm)
89	-	-	-	43	3.32	3.00	3.8
90	-	-	-	38	-	-	4.8
91	-	-	-	51	2.52	2.75	1.6
92	-	-	-	55	5.01	4.00	5.6
93	-	-	-	58	4.89	4.00	4.2
94	-	-	-	54	4.95	4.00	3.8
95	-	-	-	58	2.72	3.00	3.5
96	-	-	-	55	3.56	3.50	8.2
97	-	-	-	27	3.27	3.50	4.0
98	-	-	-	47	2.80	3.00	1.9
99	-	-	-	39	-	-	2.8
100	-	-	-	50	-	-	-
101	-	-	-	50	-	-	-
102	-	-	-	25	-0.41	-0.50	-
103	-	-	-	25	2.93	3.00	2.1
104	-0.86	32.59	-	39	-	-	-
105	-	-	-	49	-	-	2.4
106	-	-	-	41	1.27	2.00	3.7
107	-	-	-	36	-	-	-
108	-	-	-	36	3.45	3.00	3.0
√109	-	-	-	25√	-	<-1.00	4.6
110	-	-	-	30	2.71	3.00	2.3
111	-	-	-	29	3.38	3.50	2.4
112	-	-	-	43	3.00	3.00	1.4
√113	2.41	32.13	7.33	36√	3.39	3.50	3.5
114	-	-	-	40	3.72	3.50	6.2
115	-	-	-	31	3.40	3.50	2.9
116	-	-	-	36	3.97	4.00	7.2
117	-	-	-	35	4.13	4.00	3.4
118	-	-	-	31	4.34	4.00	10.1

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Sal. °/oo	Oxygen ml/1	Depth (m)	Sediment Mean Phi size	Mode Phi size	Avg. Grab Penet. (cm)
119	–	–	–	31	–	–	5.6
120	–	–	–	33	3.45	3.00	8.6
121	–	–	–	28	3.58	3.50	4.0
122	–	–	–	30	2.58	2.75	3.5
123	-1.84	33.77	8.10	30	4.58	4.25	7.9
124	–	–	–	24	4.48	5.00	8.5
125	-1.73	32.14	8.13	20	4.00	4.00	2.0
126	–	–	–	22	4.00	3.75	4.5
127	–	–	–	32	4.73	2.50	6.7
128	–	–	–	34	5.05	2.50	7.8
129	–	–	–	22	2.08	2.25	5.9
130	–	–	–	22	–	–	–
131	–	–	–	16	–	–	–
132	–	–	–	30	–	–	7.0
133	-1.87	34.00	8.23	27	4.31	4.25	5.0
134	–	–	–	30	2.23	2.50	2.9
135	–	–	–	40	3.24	3.00	8.3
136	–	–	–	38	2.95	3.00	6.1
137	–	–	–	38	3.10	3.00	5.3
138	–	–	–	35	2.23	2.50	3.2
139	–	–	–	35	1.99	2.00	2.9
140	–	–	–	35	–	–	3.5
141	–	–	–	42	2.90	3.00	6.4
142	–	–	–	39	2.52	3.00	7.2
143	–	–	–	44	2.83	3.00	7.0
144	–	–	–	43	3.01	3.00	6.9
145	–	–	–	43	3.11	3.00	7.4
146	0.43	32.92	6.77	44	3.40	3.50	5.1
147	–	–	–	47	3.56	3.50	7.4
148	–	–	–	47	3.26	3.00	9.6

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Bottom Water Sal. °/°°	Bottom Water Oxygen ml/l	Depth (m)	Sediment Mean Phi size	Sediment Mode Phi size	Avg. Grab Penet. (cm)
149	-	-	-	48	3.13	3.00	8.3
150	-	-	-	45	2.81	3.00	4.8
151	-	-	-	42	3.12	2.75	8.5
152	-	-	-	23	1.93	2.50	3.5
153	-	-	-	48	2.59	2.50	4.2
154	-	-	-	12	-	-	-
155	-	-	-	42	3.93	3.00	5.6
156	-	-	-	58	2.77	2.75	2.9
157	-	-	-	56	3.14	3.00	5.1
158	-	-	-	40	-	-	4.6
159	-	-	-	60	-	-	-
160	-	-	-	55	3.53	2.50	8.8
161	-	-	-	52	1.33	-3.00	5.0
162	-	-	-	56	-	-	-
163	-	-	-	52	-	-	2.4
164	-	-	-	58	-	-	-
165	-	-	-	29	3.50	3.50	4.2
166	-	-	-	56	-	-	2.7
167	-	-	-	60	-	-	-
168	-	-	-	53	-	-	2.8
169	-	-	-	73	-	-	2.9
170	0.57	32.63	-	42	-	-	2.4
171	1.89	32.24	8.68	40	-	-	2.1
172	-	-	-	42	3.24	2.75	6.4
173	-	-	-	45	3.89	3.50	7.4
174	-	-	-	41	5.03	5.00	8.8
175	0.00	32.30	-	38	6.44	7.00	12.0
176	0.18	32.45	-	39	-	-	-
177	0.31	32.70	-	44	-	-	-
178	0.37	32.69	-	45	5.86	5.00	13.1

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Bottom Water Sal. °/ₒₒ	Bottom Water Oxygen ml/1	Depth (m)	Sediment Mean Phi size	Sediment Mode Phi size	Avg. Grab Penet. (cm)
179	-	-	-	52	6.32	4.50	13.1
180	-	-	-	56	3.75	3.00	10.2
181	-	-	-	20	-	-	-
182	-	-	-	56	-	-	-
183	-	-	-	60	-	-	-
184	-	-	-	50	-	-	-
185	-	-	-	56	-	-	-
186	-	-	-	50	6.63	6.50	11.8
187	-	-	-	20	-	-	-
188	-	-	-	20	-	-	-
189	-	-	-	38	3.60	3.00	8.0
190	-	-	-	40	5.32	3.50	14.6
191	-	-	-	50	-	-	-
192	-	-	-	50	-	-	-
193	-	-	-	56	-	-	-
194	-	-	-	51	-	-	-
195	-	-	-	65	-	-	-
196	-	-	-	52	-	-	-
197	-	-	-	54	-	-	-
198	-	-	-	50	-	-	-
199	-	-	-	50	-	-	-
200	-	-	-	51	7.44	6.50	16.0
201	-	-	-	50	6.86	6.50	13.4
202	-	-	-	51	6.86	6.50	13.3
203	-	-	-	45	6.59	4.25	13.3
204	-	-	-	45	5.34	5.75	11.7
205	-	-	-	50	6.21	4.25	13.6
206	-	-	-	35	2.74	3.00	3.2
207	-	-	-	20	-	-	-

APPENDIX 2. Continued

Station No.	Bottom Water Temp. (°C)	Bottom Water Sal. °/₀₀	Bottom Water Oxygen ml/l	Depth (m)	Sediment Mean Phi size	Sediment Mode Phi size	Avg. Grab Penet. (cm)
208	-	-	-	45	4.08	3.50	8.8
209	-	-	-	50	3.02	2.50	13.1
Means		32.19	7.67	45	3.75	3.39	5.5
Summer	3.47						
Winter	-1.25						

APPENDIX 3

Taxa and Species of Invertebrates Identified from Benthic Stations on the Bering/Chukchi Shelf

MOLLUSCA

Bivalvia

Astarte borealis
Astarte montagui
Astarte rollandi
Asthenothaerus adamsi
Axinopsida sericata
Chlamys islandicus
Clinocardium ciliatum
Clinocardium nuttallii
Cyclocardia crebricostata
Cyclocardia crassidens
Diplodonta aleutica
Hiatella arctica
Liocyma fluctuosa
Lyonsia norvegica
Macoma brota
Macoma calcarea
Macoma crassula
Macoma elimata
Macoma lama
Macoma lipara
Macoma loveni
Macoma middendorfi
Macoma moesta
Macoma obliqua
Musculus niger
Mya priapus
Mya truncata
Mysella tumida
Mytilus edulis
Nucula tenuis
Nuculana minuta
Nuculana radiata
Nuculana fossa
Nuculana buccata
Panomya sp.
Periploma alaskana
Portlandia arctica
Pseudopythina compressa
Pseudopythina rugifera
Serripes groenlandicus
Serripes laperousii
Siliqua alta
Spisula polynyma

APPENDIX 3. Continued

Tellina lutea
Tellina modesta
Thracia myopsis
Thracia curta
Thyasira flexuosa
Yoldia amygdalea
Yoldia hyperborea
Yoldia myalis
Yoldia scissurata
Yoldia secunda
Yoldia thraciaeformis
Yoldiella intermedia

Gastropoda
Admete couthouyi
Admete c.f. Admete regina
Amicula pallasii
Amphissa sp.
Assiminea sp.
Beringius kennicotti
Buccinum angulosum
Buccinum ciliatum
Buccinum fringillum
Buccinum glaciale
Buccinum polare
Buccinum scalariforme
Colus aphelus
Colus dautzenbergii
Colus halli
Colus martensi
Colus ombronius
Colus roseus
Colus spitzbergensis
Crepidula grandis
Cryptobranchia alba
Cylichna alba
Cylichna nucleola
Cylichna occulta
Cylichnina sp.
Diaphana sp.
Epitomium groenlandicum
Lepata caeca
Leucosyrinx sp.
Lora albrechti
Lora elegans
Lora rugulata
Margarites costalis
Margarites helicinus
Margarites giganteus

APPENDIX 3. Continued

Margarites vorticifera
Mohnia sp.
Natica clausa
Neptunea heros
Neptunea lyratus
Neptunea ventricosa
Obesitoma simplex
Odostomia cassandra
Oenopota bicarinata
Oenopota decussata
Oenopota harpa
Oenopota harpularia
Oenopota impressa
Oenopota nazanensis
Oenopota pyramidalis
Oenopota quadra
Oenopota turricula
Piliscus commodum
Plicifusus kroyeri
Plicifusus virens
Polinices nanus
Polinices pallidus
Propebela rosea
Propebela teniularata
Propebela viridula
Puncturella noachina
Pyrulofusus deformis
Retusa semem
Solariella micraulax
Solariella obscura
Solariella varicosa
Suavodrilla kennicotti
Tachyrhychus erosus
Tachyrhychus reticulatis
Trichotropis bicarinata
Trichotropis borealis
Trichotropis coronata
Trichotropis insignis
Trophonopsis beringi
Trophonopsis clathratus
Trophonopsis dalli
Trophonopsis pacificus
Trophonopsis stuarti
Trophonopsis truncatus
Turitella sp.
Turrit sp.
Velutina leavigata
Velutina plicatalis
Velutina undata

APPENDIX 3. Continued

Polyplacophora
Ishnochiton alba

Aplacaphora
Chaetoderma robusta

Nudibranchiata
Dendronotus frondosus
Tritonia c.f. Tritonia diomedia

Cephalopoda
Octopoda

ANNELIDA

Polychaeta
Acrocirrus heterochaetus
Amage sp.
Ammotrypane aulogaster
Ammotrypane multipapilla
Ampharete acutifrons
Ampharete arctica
Ampharete goesi
Ampharete lindstromi
Ampharete longopaleolata
Ampharete reducta
Amphitrite cirrata
Anaitides groenlandica
Anaitides maculata
Anaitides mucosa
Antinoella badia
Antinoella sarsi
Arctoebea anticostiensis
Arctonoe vittata
Aricidea uschakowi
Artacama proboscidea
Asabellides sibirica
Audounia tentaculata
Autolytus sp.
Axiothella catenata
Boccardia natrix
Brada granulata
Brada inhabilis
Brada nuda
Brada ochotensis
Brada sacchalina
Brada villosa
Capitella capitata
Ceratoneries paucidentata

APPENDIX 3. Continued

Chaetozone setosa
Chone cincta
Chone duneri
Chone infundibuliformis
Cistenides granulata
Cistenides hyperborea
Cossura setosa
Demonax sp.
Desoma multisetosum
Ephesia gracilis
Eteone barbata
Eteone flava
Eteone longa
Eteone spitsbergensis
Euchone analis
Eunoe depressa
Eunoe nodosa
Eusyllis blomstrandi
Exogone sp.
Flabelligera affinis
Flabelligera mastigophora
Gabricia pacifica
Gattyana amondseni
Gattyana ciliata
Gattyana cirrosa
Glycera capitata
Glycinde armigera
Glycinde wireni
Haploscoloplos elongatus
Haploscoloplos panamensis
Harmothoe extenuata
Harmothoe imbricata
Harmothoe multisetosa
Hesperone complanata
Heteromastus filiformis
Jasmineira pacifica
Lanassa nordenskioldi
Lanassa venusta
Laonome sp.
Lumbrinereis fragilis
Lumbrinereis heteropoda
Lumbrinereis L. japonica
Lysippe labiata
Magelona japonica
Magelona pacifica
Maldane sarsi
Melaenis loveni
Melinna cristata
Myriochele heeri

APPENDIX 3. Continued

Myxicola infundibulum
Neoamphitrite groenlandica
Nephtys caeca
Nephtys ciliata
Nephtys cornuta
Nephtys discors
Nephtys ferruginea
Nephtys longasetosa
Nephtys paradoxa
Nephtys punctata
Nephtys rickettsi
Nereis pelagica
Nereis zonata
Nicomache lumbricalis
Nicolea venustula
Nicolea zostericola
Onuphis geophiliformis
Onuphis parva-striata
Ophelia limacina
Opistobranchus sp.
Owenia fusiformis
Parahalosydna krassini
Paranois gracilis
Pherusii plumosa
Phloe minuta
Pionosyllis magnifica
Pista cristata
Pista elongata
Pista maculata
Polycirrus medusa
Polydora flava-flava
Polydora quadrilobata
Polynoe canadensis
Polynoe gracilis
Polynoe torrell
Potamilla neglecta
Praxillella gracilis
Praxillella praetermissa
Prionospio malmgreni
Proclea emmi
Proclea graffi
Pseudopotamilla reniformis
Pygospio sp.
Rhodine gracilior
Rhodine loveni
Sabella crassicornis
Sabella maculata
Scolelepis fuliginosa
Scoloplos armiger

APPENDIX 3. Continued

Spaerodoropsis minutum
Spaerodoropsis sphaerulifer
Spio filicornis
Spiophanes bombyx
Spiophanes kroyeri
Sternaspis scutata
Terebellides stroemii
Tharyx multifilis
Timarete japonica
Travisia forbesii
Travisia pupa
Trichobranchus glacialus
Typosyllis alternata
Typosyllis fasciata
Typosyllis harti
Typosyllis langerhansia

ARTHROPODA

Amphipoda
Acanthostepheia behringiensis
Acanthostepheia malmgreni
Aceroides latipes
Ampelisca birulai
Ampelisca derjugini
Ampelisca eschrichti
Ampelisca macrocephala
Anonyx nugax pacifica
Anonyx ochoticus
Anonyx schokalaskii
Arrhis luthkei
Atylus bruggeni
Atylus collingi
Bathymedon longimanus
Bathymedon nanseni
Boeckosimus krassini
Boeckosimus plautus
Byblis gaimardi
Ceradocus torelli
Corophium crassicorne
Dulichia arctica
Dulichia bispina
Dulichia unispina
Erichtonius grebnitzkii
Erichtonius hunteri
Erichtonius tolli
Eusirus cuspidatus
Gammarus setosa
Haliragesnilssoni
Haploops laevis
Harpinia gurjanovae
Harpinia kobjakovae

APPENDIX 3. Continued

Harpinia salabrosa
Harpinia tarasovi
Haustorius arenarius
Haustorius eous
Hippomedon abyssi
Hippomedon kurilicus
Hippomedon pacificus
Hippomedon propinquus
Hippomedon wirketis
Ischyroceros anguipes
Ischerodacus sp.
Ischyroceros commensalis
Ischyroceros latipes
Lembos arcticus
Maera loveni
Maera prionochira
Melita dentata
Melita formosa
Melita quadrispinosa
Monoculodes diamesus
Monoculodes hanseni
Monoculodes zernovi
Monoculopsis longicornis
Neopleustes pulchellus typicus
Orchemene lepidula
Paramithoe polyacanta bruggen
Paraphoxus alderi
Paraphoxus clypeata
Paraphoxus glacialis
Paraphoxus milleri
Paraphoxus oculatus
Paraphoxus simplex
Paroediceros lynceus
Photis fischmanni
Photis spasskii
Photis vinogradovi
Podoceropsis sp.
Pontoporeia femorata
Priscillina armata
Protomedeia fascata
Protomedeia grandimana
Rhachotropis aculeata
Rhachotropis oculata
Stegocephalus inflatus
Stenopleustes glaber
Tiron sp.
Weyprechtia pinguis

APPENDIX 3. Continued

Cumacea
Brachydiastylis resima
Campylaspis umbensis
Diastylis alaskensis
Diastylis aspera
Diastylis bidentata
Diastylis glabra
Diastylis goodsiri
Diastylis sulcata
Eudorella emarginata
Eudorella pacifica
Eudorellopsis biplicata
Eudorellopsis deformis
Eudorellopsis integra
Lamprops fuscata
Leucon nasica
Leucon nasicoides

Isopoda
Janira tricornis
Pleuroprion murdochi
Synidotea bicuspida
Synidotea laevis
Synodotea picta
Tecticeps sp.

Anomura
Labidochirus splendescens
Lopholithodes sp.
Pagurus camchatica
Pagurus capillatus
Pagurus ochotensis
Pagurus towsendi
Pagurus trigonocheirus
Pagurus undosus
Paralithodes camtschatica

Brachyura
Chionoecetes bairdi
Chionoecetes opilio
Hyas coarctatus
Oregonia gracilis
Telmessus cheiragonus

Caridea
Argis crassa

APPENDIX 3. Continued

Argis dentata
Argis lar
Crangon communis
Crangon dalli
Crangon intermedia
Eualus fabricii
Eualus gaimardi belcheri
Eualus macilenta
Eualus sukleyi
Lebbeus groenlandica
Pandalus borealis
Pandalus goniurus
Pandalus hypsinotus
Sabinea septemcarinata
Sclerocrangon alata
Sclerocrangon boreas
Spirontocaris spina

Cirripedia
Balanus balanus
Balanus crenatus
Balanus rostratus

Pycnogonidae
Ammothea borealis
Nymphon grossipes
Nymphon longitarse
Pycnogonum circularis

Mysidacea
Mysis oculata
Neomysis rayii

Nebalacea

Tanaidacea

Ostracoda
Philomedes globosus

ECHINODERMATA

Asteroidea
Asterias amurensis
Crossaster papposus
Ctenodiscus crispatus
Evasterias troschelli
Henricia tumida
Leptasterias arctica
Leptasterias groenlandica

APPENDIX 3. Continued

Leptasteris hylodes
Leptasterias polaris acervata
Lethasterias nanimensis
Pteraster obscurus
Solaster paxillatus
Urasterias linckii

Echinoidea
Echinarachnius parma
Strongylocentrotus droebachiensis

Holothuroidea
Caudina sp.
Chirodota discolor
Cucumaria calcigera
Leptosynapta sp.
Myriotrochus rinkii
Psolus fabricii

Ophiuroidea
Amphipholis squamata
Diamphiodia craterodmeta
Gorgonocephalus caryi
Monamphiura sundevalli
Nullamphiura psilopora
Ophiopholis aculeata
Ophiopus arcticus
Ophiura flagellata
Ophiura maculata
Ophiura sarsi
Stegaphiura nodosa

SIPUNCULIDA

Golfingia margaritaca
Golfingia vulgaris
Phascolion strombi

PRIAPULIDA

Priapulus caudatus

ECHIURIDA

Echiurus echiurus

COELENTERATA

Anthozoa
Eunephthya rubiformis
Myriothela phrygia

APPENDIX 3. Continued

Tubularia

Ectoprocta
Alcyonidium disciforme
Bidenkapia spitzbergensis
Carbasea carbasea
Eucratea loricata
Flustrella sp.
Hippothoa hyalina
Myriozoum subgracile

BRACHIOPODA

Hemithyris psittacea
Wildheimia cranium

NEMERTINEA

Cerebratulus sp.
Lineus torquatus

PORIFERA

Hexactinellida

NEMATODA

PLATYHELMINTHES

Polycladida

PLATYHELMINTHES

Cestodea

PROTOZOA

Foraminifera

CHORDATA

Ascidiacea
Ascidia callosa
Boltenia ovifera
Chelyosoma inequale
Chelysoma macloayanum
Halocynthia aurantium
Molgula griffithsii
Molgula retortiformis
Molgula siphonalis
Pelonaia corrugata
Styela rustica

ACANTHOCEPHALA

APPENDIX 4

Observed Biological Characteristics (means) of Coarse Sieve Fraction Benthic Stations on the Bering/Chukchi Shelf (*fine sieve fraction included)

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
001	18	412	308.0	12.0	133752	2.8	4.3	0.535
002	19	116	64.3	2.5	27961	0.6	4.2	0.771
003	33	582	65.1	3.8	41276	1.0	3.8	1.178
004	12	274	500.0	6.8	78772	1.3	5.2	0.637
005	26	1264	35.7	1.6	16662	0.5	3.2	0.548
006	33	1438	55.4	3.3	32168	0.9	3.7	1.038
007	42	1004	65.6	3.2	35595	0.7	4.3	1.105
008	29	984	40.2	2.2	21523	0.5	4.4	1.053
009	24	144	55.6	1.6	17600	0.4	4.0	1.024
010	5	80	9.3	0.3	3678	0.1	3.0	0.605
011	11	58	11.5	0.3	3719	0.1	3.0	0.684
012	19	116	73.7	1.6	18911	0.3	5.3	0.813
013	24	122	15.0	0.7	7795	0.2	3.5	1.038
014	20	122	85.2	1.5	20066	0.3	5.0	1.007
015	25	148	116.1	5.5	58396	1.3	4.2	1.134
*016	34	952	28.7	1.4	12493	0.4	3.5	0.887
017	32	258	129.2	5.4	61150	1.3	4.2	1.221
*018	29	824	49.9	2.7	26889	0.6	4.5	0.938
019	22	212	145.7	7.3	72605	1.9	3.8	1.059
020	26	374	169.5	7.1	75276	1.7	4.2	1.024
021	30	322	23.7	1.3	13938	0.3	4.3	1.145
*022	27	654	51.4	1.1	12957	0.6	1.8	0.845
*023	31	622	21.1	1.4	14939	0.4	3.5	1.029
*024	28	412	785.8	16.6	351832	4.1	4.0	1.168
025	25	214	32.4	1.1	12916	0.3	3.7	1.093
*027	30	460	35.2	1.7	18389	0.3	5.7	1.030

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
028	15	68	40.4	2.5	27077	0.6	4.2	0.937
*029	27	810	65.0	3.4	37115	0.8	4.3	0.929
030	16	66	22.4	1.5	16040	0.4	3.8	0.958
032	23	326	51.2	2.9	32186	0.8	3.6	0.945
034	19	368	282.9	13.1	152060	2.8	4.7	0.819
035	7	190	57.9	3.2	35221	0.8	4.0	0.537
036	20	146	136.6	5.6	68613	1.3	4.3	1.046
*037	22	410	53.1	2.8	30921	0.7	4.0	1.011
*038	10	330	65.6	3.3	36851	0.8	4.1	0.859
*039	15	698	28.9	1.6	18998	0.3	5.3	0.409
040	32	518	87.2	4.3	47566	1.0	4.3	0.740
041	21	266	160.4	4.6	53338	1.0	4.6	0.876
*042	23	1050	138.7	5.1	71917	1.2	4.3	0.771
043	27	238	144.4	7.3	81872	1.6	4.9	1.087
044	15	350	193.9	7.4	84850	1.5	4.9	0.806
045	19	234	139.7	5.0	60874	1.0	5.0	0.835
046	16	340	150.6	7.4	82134	1.6	4.9	0.707
047	16	250	10.0	0.8	8426	0.2	4.0	0.772
048	26	136	29.0	1.3	15017	0.3	4.3	1.200
049	31	438	35.0	1.7	17614	0.5	3.4	0.839
050	21	380	97.8	1.8	21451	0.5	3.6	0.675
051	36	1096	27.5	0.6	6251	0.1	6.0	1.040
*052	36	1234	12.4	0.5	5056	0.1	5.0	0.718
053	32	602	290.1	15.7	173238	3.5	4.5	0.914
054	23	182	279.0	9.2	102717	2.0	4.6	0.933
056	13	50	34.2	1.9	21722	0.5	3.8	0.877
057	16	116	77.1	3.5	40917	0.7	5.0	0.868
058	22	436	221.0	10.0	116241	2.2	4.5	0.892
059	22	580	276.7	10.9	126250	2.2	5.0	0.939

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
060	23	834	307.7	14.9	171311	3.3	4.5	0.736
061	28	520	347.3	12.3	142276	2.4	5.1	0.893
062	24	522	533.0	14.3	169065	2.8	5.1	0.700
063	17	594	523.1	14.3	169481	3.0	4.8	0.618
064	20	582	142.1	6.1	70992	1.2	5.1	0.864
*065	34	3706	280.7	13.0	148349	2.5	5.2	0.667
*066	34	4414	157.2	6.6	77831	1.3	5.1	0.407
067	29	764	107.4	4.8	55656	1.1	4.4	0.848
068	28	468	165.1	8.1	93847	1.9	4.3	1.033
069	14	156	6.8	0.5	5478	0.1	5.0	0.899
*070	30	874	39.4	2.0	23257	0.4	5.0	0.820
071	13	96	33.8	1.5	16982	0.3	5.0	0.896
072	24	856	238.1	9.5	110156	1.9	5.0	0.713
*073	29	1412	22.5	1.2	13689	0.3	4.0	0.405
*075	19	492	103.7	1.1	14993	0.2	5.5	0.728
076	31	954	284.1	10.6	131168	2.4	4.4	1.031
077	26	400	17.4	0.8	8239	0.2	4.0	0.907
078	28	664	63.9	3.2	34299	0.9	3.6	0.731
079	27	256	72.1	2.1	23735	0.5	4.2	0.958
080	13	112	17.6	0.9	10339	0.2	4.5	0.745
081	12	116	59.3	4.1	45568	0.9	4.6	0.779
082	4	170	1097.8	8.8	124256	1.1	8.0	0.093
083	15	146	73.9	1.6	19485	0.4	4.0	0.788
084	22	686	222.7	9.5	104514	1.9	5.3	0.560
085	26	396	161.0	3.7	47173	0.8	4.6	0.893
086	28	3204	229.3	14.0	157640	2.6	5.4	0.420
087	25	1416	230.0	9.5	108621	2.5	3.8	0.381
088	39	1558	362.0	15.8	184274	3.5	4.5	1.023
089	35	642	245.1	10.6	123853	2.4	4.1	1.148

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
090	31	780	154.0	9.3	101699	2.3	4.2	1.296
091	31	224	127.3	4.7	53701	1.1	4.3	1.233
092	26	968	290.1	11.5	133876	2.5	4.6	0.844
093	27	370	139.8	5.0	57996	1.0	5.0	1.097
094	35	580	137.1	5.0	57590	1.0	5.0	1.093
095	45	457	407.7	10.8	123649	2.4	4.5	1.263
096	44	2578	725.4	35.4	401185	7.2	4.9	0.924
097	27	4174	125.7	7.7	85276	1.4	5.5	0.633
098	24	430	32.9	1.6	18030	0.3	5.3	0.878
099	23	1050	124.1	6.0	66708	1.1	5.5	0.908
103	38	1244	216.0	10.6	106874	2.6	4.1	0.594
104	10	360	633.9	8.3	98429	1.6	5.2	0.606
105	16	700	117.1	4.9	63403	1.3	3.8	0.630
106	48	372	145.8	3.5	40106	0.8	4.4	1.293
108	37	454	1832.3	22.0	292440	3.8	5.1	0.885
109	53	734	235.5	13.5	150831	3.5	3.9	1.398
110	32	292	863.7	10.7	135961	2.0	5.4	1.226
111	43	1218	681.8	13.7	164951	2.8	4.9	0.604
112	19	398	120.1	4.8	54428	0.8	5.6	0.575
113	34	1136	427.6	17.4	199577	3.2	5.4	0.789
114	22	534	328.4	13.2	149404	2.5	5.3	0.592
115	27	3262	148.7	9.5	107094	1.9	5.0	0.184
116	9	38	124.2	5.3	58533	1.0	5.3	0.742
117	3	43	217.9	8.3	91576	1.4	5.9	0.384
118	11	116	226.9	10.6	120709	2.1	5.0	0.771
119	23	1310	361.1	17.2	186233	3.4	5.5	0.732
120	34	4066	340.1	19.6	221680	3.7	5.3	0.479
121	26	524	40.4	1.7	19442	0.5	3.4	0.853
122	34	236	741.3	9.8	124215	1.9	5.2	1.131

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
123	28	570	203.2	9.2	101804	2.4	3.8	0.860
124	20	844	664.8	29.9	333984	7.4	4.0	0.680
*125	43	796	33.2	1.6	17879	0.4	4.0	1.056
126	46	1844	726.1	24.5	316985	6.0	4.1	0.857
127	44	870	237.4	7.7	89636	1.8	4.3	0.985
128	26	770	176.4	7.2	81800	1.5	4.8	0.594
129	45	570	160.7	7.0	84329	1.7	4.1	1.224
130	24	228	150.7	5.2	60638	1.2	4.3	1.020
131	22	312	68.5	1.3	15899	0.3	4.3	0.403
132	39	526	138.0	5.5	65427	1.3	4.2	0.936
133	38	1040	146.3	6.1	71220	1.6	3.8	0.915
134	10	488	1826.2	15.3	213318	2.0	7.7	0.290
135	47	8312	705.4	30.9	351770	6.1	5.1	0.656
136	42	4078	340.3	18.4	205512	3.5	5.3	0.561
137	55	4070	657.4	29.2	323588	5.6	5.2	0.574
138	6	126	1076.3	9.3	128546	1.3	7.1	0.471
139	24	228	194.2	3.9	52653	0.8	4.9	0.629
140	21	178	76.9	2.4	30576	0.5	4.8	0.866
141	43	5980	486.2	27.0	302960	5.0	5.4	0.395
142	64	4542	553.0	28.7	323676	5.3	5.4	0.396
143	57	4044	311.4	18.8	209687	3.7	5.1	0.395
144	59	8760	998.0	53.1	589562	9.9	5.4	0.225
145	34	4650	727.1	32.5	367200	6.1	5.3	0.413
146	50	1940	990.8	40.7	452178	7.2	5.7	0.842
147	45	5506	977.9	47.3	537299	9.0	5.3	0.566
148	45	5206	633.6	33.7	378029	6.8	5.0	0.589
149	39	3852	537.6	25.2	282546	4.7	5.4	0.693
150	40	2970	651.3	21.3	244234	4.4	4.8	0.546
151	61	4926	532.8	28.5	315709	5.5	5.2	0.650

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
152	26	1476	84.6	3.2	37120	0.8	4.0	0.279
153	55	778	226.0	8.4	93892	1.9	4.4	1.134
155	27	742	197.3	6.9	78962	1.5	4.6	0.604
156	27	198	259.8	7.1	80589	1.7	4.2	0.886
157	41	2540	260.1	16.0	180270	3.0	5.3	0.507
158	58	476	2230.8	42.4	507142	11.2	3.8	1.410
160	60	4498	543.0	34.0	374236	6.7	5.1	0.790
161	52	478	561.5	14.9	179842	3.9	3.8	1.147
163	30	5190	936.2	47.4	536005	9.6	4.9	0.714
165	12	230	46.9	2.2	23212	0.6	3.7	0.551
166	45	180	469.6	14.2	179864	3.2	4.4	1.386
168	22	275	347.0	8.3	94766	1.8	4.6	0.997
169	41	160	770.1	25.4	328771	5.6	4.5	1.274
170	38	558	90.1	4.4	54186	1.0	4.4	1.022
171	33	316	449.5	18.0	206963	4.1	4.4	1.093
172	60	2793	1195.0	56.5	626696	12.9	4.4	1.037
173	43	8190	1084.6	45.3	532118	8.5	5.3	0.782
174	44	1440	153.4	9.3	104235	2.1	4.4	1.050
175	26	364	267.4	7.3	98661	2.9	2.5	0.778
178	43	1832	547.4	24.3	285156	4.9	5.0	0.956
179	42	4310	488.4	27.6	333504	6.1	4.5	0.677
180	24	250	330.1	16.4	181193	3.6	4.6	1.101
186	18	164	94.0	4.3	49994	1.2	3.6	0.918
189	35	658	249.8	10.3	114030	2.6	4.0	1.092
190	37	835	160.3	9.4	102064	2.6	3.6	1.055
200	22	196	242.3	9.5	111855	2.6	3.7	0.953
201	36	640	173.4	8.2	98822	2.0	4.1	0.803
202	25	388	233.2	10.8	124884	2.4	4.5	0.777
203	33	362	600.3	18.7	217703	5.1	3.7	1.127

Corrected from printout

APPENDIX 4. Continued

Standing Stock Biomass

Station No.	No. Species	Density (indiv./m^2)	Wet Wt. (g/m^2)	Organic Carbon (g/m^2)	Cal./m^2	Organic Nitrogen (g/m^2)	C/N Ratio	Diversity Index
204	39	532	355.0	14.6	166895	3.7	3.9	1.068
205	49	~~724~~ 718	~~421.1~~ 301.7	~~17.4~~ 14.7	201804	4.7	3.7	1.234
206	35	210	61.4	2.8	32572	0.7	4.0	1.272
208	58	570	838.0	23.0	263418	5.4	4.3	1.414
209	82	1218	588.5	22.1	250916	5.3	4.3	1.193
Total Mean	30	1152	300.8	10.8	125437	2.3	4.6	0.842
Standard Deviation	13	1620	347.0	11.1	127722	2.3	0.8	0.254
95% CL	± 2	± 239	± 51.3	± 1.6	± 18865	± 0.3	± 0.1	± 0.040

APPENDIX 5

Comparison of Fine to Coarse Sieve Sample Results from Benthic Stations on the Bering/Chukchi Shelf

a. <u>3 mm Fraction</u>

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Station Diversity
003-3	20	720	4.17	1.178
005-2	11	910	1.38	0.548
006-3	22	1830	2.26	1.038
009-2	11	170	1.00	1.024
012-2	5	90	0.35	0.813
014-2	5	90	0.71	1.007
017-2	13	260	14.18	1.221
019-1	10	150	10.96	1.059
020-1	10	300	5.49	1.024
021-1	16	320	1.14	1.145
025-2	12	400	1.84	1.093
028-2	15	68	2.53	0.937
030-1	4	60	0.41	0.958
032-2	9	220	0.84	0.945
034-4	10	511	11.67	0.819
035-1	7	190	3.18	0.537
036-3	8	110	5.06	1.046
040-4	15	500	6.88	0.740
041-2	10	220	3.05	0.876
043-3	10	210	6.06	1.087
044-2	11	370	6.44	0.806
045-3	6	210	6.89	0.835
046-1	5	350	6.10	0.707
047-3	5	230	0.45	0.772
049-3	16	500	2.24	0.839
053-3	15	530	7.39	0.914
054-3	7	170	2.98	0.933
056-5	3	40	1.25	0.877
057-5	6	130	3.11	0.868
058-5	10	440	15.22	0.892
059-2	11	530	8.43	0.939
060-1	11	990	16.31	0.736
061-4	8	330	6.87	0.893
062-4	10	411	2.90	0.700
063-5	8	650	14.82	0.618
064-1	17	750	8.71	0.864
067-4	16	1060	4.83	0.848
068-3	19	440	16.10	1.033
069-5	6	90	0.36	0.899
071-1	5	110	0.33	0.896

APPENDIX 5a. Continued

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Station Diversity
072-2	12	620	8.81	0.713
075-5	5	130	1.56	0.728
077-5	11	300	1.28	0.907
078-5	10	1010	4.65	0.731
079-2	5	150	0.60	0.958
080-2	4	40	1.71	0.745
081-5	5	100	6.52	0.779
082-2	1	190	11.37	0.093
083-3	8	160	0.88	0.788
086-3	11	3010	13.16	0.420
087-2	11	1700	6.23	0.381
088-2	20	2170	17.93	1.023
089-2	16	580	5.22	1.148
091-4	16	310	2.86	1.233
092-4	14	1010	18.47	0.844
093-3	12	320	0.70	1.097
094-2	15	390	2.19	1.093
095-3	16	360	12.28	1.263
096-3	22	2290	35.12	0.924
097-4	12	3660	9.14	0.633
098-4	13	390	2.08	0.878
103-2	15	940	6.44	0.594
111-3	17	1550	27.19	0.604
113-3	15	1630	30.50	0.789
114-2	6	610	13.86	0.592
115-2	10	2950	5.43	0.184
117-3	3	43	8.27	0.384
118-4	4	80	2.54	0.771
119-3	13	1430	16.42	0.732
120-1	19	4910	26.16	0.479
121-2	10	210	1.78	0.853
123-2	8	430	13.32	0.860
124-2	10	920	20.66	0.680
133-5	20	980	7.54	0.915
136-1	27	4310	21.76	0.561
137-4	26	4000	14.68	0.574
139-1	6	100	1.58	0.629
140-3	12	160	2.77	0.866
142-4	37	5720	32.47	0.396
144-2	25	6440	31.05	0.225
145-2	16	3710	22.16	0.413
146-1	19	2350	32.56	0.842
147-3	20	5430	42.42	0.566
148-3	26	6970	31.24	0.589
149-3	24	4570	33.89	0.693

APPENDIX 5a. Continued

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Station Diversity
150-3	17	1790	9.20	0.546
155-4	11	540	2.81	0.604
156-1	9	130	6.18	0.886
165-3	3	150	0.98	0.551
171-1	9	520	1.81	1.093
172-3	18	1530	30.37	1.037
173-3	31	8830	72.76	0.782
175-2	8	350	10.24	0.778
178-1	20	1810	18.26	0.956
179-4	23	4850	23.86	0.677
180-1	13	310	20.91	1.101
186-1	4	90	2.93	0.918
189-4	16	1180	16.27	1.092
190-1	12	540	8.85	1.055
200-1	7	190	3.98	0.953
201-1	10	560	3.07	0.803
202-5	10	460	13.56	0.777
203-1	13	180	14.92	1.127
204-5	12	360	8.84	1.068
205-1	21	1070	15.69	1.234
206-2	14	270	4.21	1.272
208-1	23	600	17.49	1.414
209-1	39	1160	28.83	1.193
Mean	13	1134	10.74	0.834
Standard Deviation	7	1660	11.44	0.242
95% CL	± 1	± 313	± 2.16	± 0.045

APPENDIX 5. Continued

b. 1 mm Fraction

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Sample Diversity
003-3	30	8180	1.59	0.926
005-2	18	2100	0.35	0.834
006-3	32	22240	3.38	0.620
009-2	14	620	0.12	0.985
012-2	10	220	0.07	0.794
014-2	14	510	0.11	0.956
017-2	18	1370	0.25	0.783
019-1	10	920	0.17	0.440
020-1	17	2730	0.58	0.525
021-1	25	1190	0.21	0.995
025-2	15	720	0.15	0.893
028-2	32	3920	0.63	1.118
030-1	35	8430	1.54	0.856
032-2	23	1920	0.65	1.167
034-4	21	1880	0.64	0.764
035-1	22	2840	0.49	0.666
036-3	23	1290	0.27	1.107
040-4	13	570	0.22	0.889
041-2	23	1850	0.60	0.823
043-3	27	980	0.51	1.025
044-2	29	2000	0.51	1.096
045-3	20	960	0.35	1.025
046-1	15	1020	0.38	0.645
047-3	14	10780	1.85	0.166
049-3	22	1810	0.48	0.915
053-3	31	3140	0.95	1.038
054-3	19	920	0.45	1.073
056-5	8	220	0.04	0.753
057-5	16	1160	0.23	0.952
058-5	15	510	0.31	0.950
059-2	16	950	0.48	0.937
060-1	17	1170	0.99	0.987
061-4	16	480	0.26	1.002
062-4	20	1340	0.54	1.012
063-5	23	2050	0.51	0.924
064-1	22	2570	0.73	0.895
067-4	24	3590	1.16	1.015
068-3	28	6740	1.02	1.090
069-5	22	3080	0.37	1.102
071-1	20	2720	0.34	1.122
072-2	12	460	0.09	0.934
075-5	8	630	0.12	0.341
077-5	23	5790	1.13	0.326

APPENDIX 5b. Continued

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Sample Diversity
078-5	24	6260	1.13	0.620
079-2	14	3260	0.54	0.201
080-2	15	1060	0.11	0.994
081-5	19	890	0.23	1.016
082-2	10	270	0.05	0.886
083-3	20	1450	0.13	0.987
086-3	18	1440	0.17	0.927
087-2	31	11170	1.95	0.786
088-2	22	7380	2.08	0.831
089-2	20	1420	0.41	1.033
091-4	13	260	0.05	0.964
092-4	23	1500	0.64	0.980
093-3	18	1070	0.37	1.030
094-2	24	2790	0.91	1.028
095-3	25	7750	1.91	0.623
096-3	16	330	0.11	0.915
097-4	23	9080	2.83	0.584
098-4	26	2550	0.47	1.064
103-2	26	3720	0.73	0.852
111-3	33	3860	1.10	1.034
113-3	19	24960	4.22	0.493
114-2	28	3860	0.80	0.954
115-2	28	11390	2.78	0.906
117-3	25	1480	0.28	0.971
118-4	16	340	0.11	1.026
119-3	24	6030	1.01	0.921
120-1	25	2100	0.37	1.151
121-2	24	8370	0.81	0.816
123-2	25	2140	0.82	1.131
124-2	20	930	0.20	1.036
133-5	39	13110	2.20	0.780
136-1	34	6840	1.41	1.122
137-4	33	8410	1.85	1.044
139-1	16	560	0.07	1.005
140-3	22	1560	0.18	0.710
142-4	32	4510	0.69	1.080
144-2	31	4180	0.89	1.116
145-2	24	3560	0.70	1.054
146-1	24	3950	0.74	0.740
147-3	25	1800	0.81	1.206
148-3	30	3490	0.83	1.143
149-3	31	6250	1.90	1.103
150-3	30	3450	1.06	1.050
155-4	18	2350	0.36	0.925

APPENDIX 5b. Continued

Station and Sample	No. Species	Density (indiv/m^2)	Organic Carbon (g/m^2)	Sample Diversity
156-1	16	660	0.10	1.067
165-3	13	870	0.19	0.938
171-1	20	9670	1.62	0.489
172-3	33	5770	1.55	0.973
173-3	35	16970	4.58	0.833
175-2	19	1030	0.15	0.979
178-1	27	2710	0.85	0.919
179-4	30	5950	3.75	0.876
180-1	30	1730	0.49	1.215
186-1	18	1050	0.38	0.858
189-4	28	4100	1.45	0.967
190-1	32	2335	1.50	1.131
200-1	12	650	0.28	0.714
201-1	20	950	0.41	0.964
202-5	18	800	0.36	1.077
203-1	28	970	0.41	1.260
204-5	20	680	0.52	1.135
205-1	20	1570	1.13	0.993
206-2	33	1560	0.44	1.169
208-1	42	1690	0.57	1.273
209-1	35	1420	1.11	1.219
Mean	23	3471	0.82	0.920
Standard Deviation	7.13	4203	0.86	0.212
95% CL	± 1	± 792	± 0.15	± 0.040

APPENDIX 5. Continued

c. 1 mm % 3 mm Fraction

Station and Sample	No. Species	Density	Organic Carbon
003-3	150	1136	38
005-2	164	231	25
006-3	145	1215	150
009-2	127	365	12
012-2	200	244	20
014-2	280	567	15
017-2	138	527	2
019-1	100	613	2
020-1	170	910	11
021-1	156	372	18
025-2	125	180	8
028-2	471	5765	25
030-1	875	1406	376
032-2	256	873	77
034-4	210	368	5
035-1	314	149	15
036-3	288	1173	5
040-4	87	114	3
041-2	230	841	20
043-3	270	467	8
044-2	264	541	8
045-3	333	457	5
046-1	300	291	6
047-3	280	4687	411
049-3	138	362	21
053-3	207	592	13
054-3	271	541	15
056-5	267	550	3
057-5	267	892	7
058-5	150	116	2
059-2	145	179	6
060-1	155	118	6
061-4	200	145	4
062-4	200	326	19
063-5	288	315	3
064-1	129	343	8
067-4	150	339	24
068-3	147	153	6
069-5	367	3422	103
071-1	400	247	103
072-2	100	74	<1
075-5	160	485	8
077-5	209	1930	88

APPENDIX 5c. Continued

Station and Sample	No. Species	Density	Organic Carbon
078-5	240	620	24
079-2	280	217	90
080-2	375	2650	6
081-5	380	890	4
082-2	1000	142	<1
083-3	250	906	15
086-3	164	48	1
087-2	282	657	31
088-2	110	340	12
089-2	125	245	8
091-4	81	84	2
092-4	164	149	3
093-3	150	334	53
094-2	160	715	42
095-3	156	2153	16
096-3	73	14	<1
097-4	192	248	31
098-4	200	654	23
103-2	173	396	11
111-3	194	249	4
113-3	127	1531	14
114-2	467	633	6
115-2	280	386	51
117-3	833	344	3
118-4	400	425	4
119-3	185	422	6
120-1	132	43	1
121-2	240	3986	46
123-2	313	498	6
124-2	200	101	1
133-5	195	1338	29
136-1	126	159	6
137-4	127	210	13
139-1	267	560	4
140-3	183	975	6
142-4	86	79	2
144-2	124	65	3
145-2	150	96	3
146-1	126	168	2
147-3	125	33	2
148-3	115	50	3
149-3	129	137	6
150-3	176	193	12
155-4	164	435	13
156-1	178	508	2

APPENDIX 5c. Continued

Station and Sample	No. Species	Density	Organic Darbon
165-3	433	580	19
171-1	222	1860	90
172-3	183	377	5
173-3	113	192	6
175-2	238	294	1
178-1	135	150	5
179-4	130	123	16
180-1	231	558	2
186-1	450	1167	13
189-4	175	347	9
190-1	267	432	17
200-1	171	342	7
201-1	200	170	13
202-5	180	174	3
203-1	215	539	3
204-5	167	189	6
205-1	95	148	7
206-2	236	578	10
208-1	183	282	3
209-1	90	122	4
Mean	224	633	23.8
Standard Deviation	145	901	56.9
95% CL	± 27	± 170	± 10.7

APPENDIX 6

Comparison of Fine to Coarse Sieve Sample Species Composition from Benthic Stations on the Bering/Chukchi Shelf

Station and Sample	Species in Common	Species Different	Total Species	% Species in Common
003-3	13	23	36	36
005-2	6	17	23	26
006-3	17	20	37	46
009-2	2	21	23	9
012-2	1	13	14	7
014-2	2	15	17	12
017-2	2	27	29	7
019-1	2	16	18	11
020-1	3	21	24	13
021-1	7	27	34	21
025-2	2	23	25	8
028-2	9	29	38	24
030-1	3	33	36	8
032-2	3	26	29	10
034-4	8	15	23	35
035-1	3	23	26	12
036-3	6	19	25	24
040-4	3	22	25	12
041-2	4	25	29	14
043-3	5	27	32	16
044-2	6	28	34	18
045-3	1	24	25	4
046-1	2	16	18	11
047-3	4	11	15	27
049-3	12	14	26	46
053-3	9	28	37	24
054-3	2	22	24	8
056-5	0	11	11	0
057-5	3	26	29	10
058-5	4	17	21	19
059-2	5	17	22	23
060-1	4	20	24	17
061-4	3	18	21	14
062-4	3	24	27	11
063-5	6	19	25	24
064-1	9	21	30	30
067-4	8	24	32	25
068-3	7	33	40	18
069-5	4	20	24	17
071-1	5	15	20	25
072-2	0	24	24	0
075-5	1	11	12	8

APPENDIX 6. Continued

Station and Sample	Species in Common	Species Different	Total Species	% Species in Common
077-5	6	22	28	21
078-5	9	16	25	36
079-2	4	11	15	27
080-2	1	17	18	6
081-5	2	20	22	9
082-2	0	11	11	0
083-3	3	22	25	12
086-3	3	23	26	12
087-2	5	32	37	14
088-2	7	28	35	20
089-2	7	22	29	24
091-4	6	17	23	26
092-4	7	23	30	23
093-3	6	18	24	25
094-2	7	25	32	22
095-3	6	29	35	17
096-3	6	26	32	19
097-4	8	19	27	30
098-4	11	17	28	39
103-2	5	31	36	14
111-3	10	30	40	25
113-3	6	22	28	21
114-2	4	26	30	13
115-2	7	24	31	23
117-3	1	26	27	4
118-4	2	16	18	11
119-3	9	19	28	32
120-1	8	28	36	22
121-2	5	24	29	17
123-2	5	23	28	18
124-2	4	22	26	15
133-5	10	39	49	20
136-1	13	35	48	27
137-4	14	31	45	31
139-1	3	26	29	10
140-3	5	24	29	17
142-4	11	47	58	19
144-2	15	36	41	37
145-2	4	32	36	11
146-1	8	27	35	23
147-3	7	31	38	18
148-3	8	42	48	17
149-3	13	29	42	31
150-3	6	35	41	15
155-4	6	17	23	26

APPENDIX 6. Continued

Station and Sample	Species in Common	Species Different	Total Species	% Species in Common
156-1	4	17	21	19
165-3	2	12	14	14
171-1	6	17	23	26
172-3	11	29	40	28
173-3	12	42	54	22
175-2	4	19	23	17
178-1	8	31	39	21
179-4	13	27	40	33
180-1	7	29	36	19
186-1	1	20	21	5
189-4	8	28	36	22
190-1	8	28	36	22
200-1	1	17	18	6
201-1	5	20	25	20
202-5	3	22	25	12
203-1	5	31	36	14
204-5	2	28	30	7
205-1	7	27	34	21
206-2	5	37	42	12
208-1	6	53	59	10
209-1	6	62	68	9
Mean	5.7	24.2	29.9	19
Standard Deviation	3.5	8.5	10.2	9
95% CL	± 0.7	± 1.6	± 1.9	± 2

APPENDIX 7

Observed Biological Characteristics of Benthic Station Cluster Groups on the Bering/Chukchi Shelf

Group I

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
086	28	3204	229	14.0	0.420
Subgroup A					
103	38	1244	216	10.6	0.594
111	43	1218	682	13.7	0.604
115	27	3262	149	9.5	0.184
120	34	4066	340	19.6	0.479
135	47	8312	705	30.9	0.656
136	42	4078	340	18.4	0.561
137	55	4070	657	29.2	0.574
141	43	5980	486	27.0	0.395
142	64	4542	553	28.7	0.396
143	57	4044	311	18.8	0.395
144	59	8760	998	53.1	0.225
145	34	4650	272	32.5	0.413
146	50	1940	991	40.7	0.842
147	45	5506	978	47.3	0.566
148	45	5206	634	33.7	0.589
149	39	3852	538	25.2	0.693
150	40	2970	651	21.3	0.546
151	61	4926	533	28.5	0.650
153	55	778	226	8.4	1.134
156	27	198	260	7.1	0.886
157	41	2540	260	16.0	0.507
160	60	4498	543	34.0	0.790
163	30	5190	936	47.4	0.714
Mean	45	3989	533	26.1	0.582
95% CL	±7	±922	±115	±5.6	±0.090
Subgroup B					
096	44	2578	725	35.4	0.924
097	27	4174	126	7.7	0.633
098	24	430	33	1.6	0.878
099	23	1050	124	6.0	0.908
Mean	30	2058	252	12.7	0.836
95% CL	±15	±2663	±506	±24.5	±0.213
Group Mean	42	3688	482	23.1	0.612
95% CL	±5	±823	±111	±5.6	±0.084

APPENDIX 7. Continued

Group II

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup A					
001	18	412	308	12.0	0.535
002	19	116	64	2.5	0.771
004	12	274	500	6.8	0.637
008	29	984	40	2.2	1.053
009	24	144	56	1.6	1.024
011	11	58	12	0.3	0.684
012	19	116	74	1.6	0.813
013	24	122	15	0.7	1.038
014	20	122	85	1.5	1.007
015	25	148	116	5.5	1.134
016	34	952	29	1.4	0.887
017	32	258	129	5.4	1.221
019	22	212	146	7.3	1.059
020	26	374	170	7.1	1.024
021	30	322	24	1.3	1.145
025	25	214	32	1.1	1.093
Mean	23	302	113	3.6	0.945
95% CL	±3	±149	±68	±1.8	±0.107
Subgroup B					
048	26	136	29	1.3	1.200
050	21	380	98	1.8	0.675
051	36	1096	28	0.6	1.040
052	36	1234	12	0.5	0.718
075	19	492	104	1.1	0.728
080	13	112	18	0.9	0.745
082	4	170	1098	8.8	0.093
083	15	146	74	1.6	0.788
085	26	396	161	3.7	0.893
122	34	236	741	9.8	1.131
134	10	488	1826	15.3	0.290
138	6	126	1076	9.3	0.471
139	24	228	194	3.9	0.629
140	21	178	77	2.4	0.866
Mean	21	387	395	4.4	0.733
95% CL	±6	±205	±326	±2.6	±0.176
Subgroup C					
091	31	224	127	4.7	1.233
095	45	457	408	10.8	1.263
Mean	38	341	268	7.8	1.248
95% CL	±89	±1481	±1785	±38.6	±0.188
110	32	292	864	10.7	1.226
Group Mean	23	340	265	4.4	0.882
95% CL	±3	±103	±140	±1.4	±0.096

APPENDIX 7. Continued

Group III

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
090	31	780	154	9.3	1.296
Subgroup A					
104	10	360	634	8.3	0.606
105	16	700	117	4.9	0.630
106	48	372	146	3.5	1.293
108	37	454	1832	22.0	0.885
109	53	734	236	13.5	1.398
Mean	33	524	593	10.4	0.962
95% CL	±24	±224	±898	±9.3	±0.457
Subgroup B					
158	58	476	2231	42.4	1.410
161	52	478	562	14.9	1.147
166	45	180	470	14.2	1.386
168	22	275	347	8.3	0.997
Mean	44	352	903	20.0	1.235
95% CL	±25	±237	±1416	±24.3	±0.315
Group Mean	37	481	673	14.1	1.105
95% CL	±12	±143	±532	±8.1	±0.222

APPENDIX 7. Continued

Group IV

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup A					
018	29	824	50	2.7	0.938
022	27	654	51	1.1	0.845
023	31	622	21	1.4	1.029
024	28	412	786	16.6	1.168
027	30	460	35	1.7	1.030
029	27	810	65	3.4	0.929
037	22	410	53	2.8	1.011
038	10	330	66	3.3	0.859
Mean	26	565	141	4.1	0.976
95% CL	±6	±159	±218	±4.3	±0.089
Erratics					
010	5	80	9	0.3	0.605
070	30	874	39	2.0	0.820
073	29	1412	23	1.2	0.405
125	43	796	33	1.6	1.056
170	38	558	90	4.4	1.022
Group Mean	27	634	102	3.3	0.901
95% CL	±6	±198	±125	±2.5	±0.124

APPENDIX 7. Continued

Group V

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup A					
047	16	250	10	0.8	0.772
049	31	438	35	1.7	0.839
077	26	400	17	0.8	0.907
078	28	664	64	3.2	0.731
079	27	256	72	2.1	0.958
123	28	570	203	9.2	0.860
124	20	844	665	29.9	0.680
126	46	1844	726	24.5	0.857
127	44	870	237	7.7	0.985
128	26	770	176	7.2	0.594
129	45	570	161	7.0	1.224
130	24	228	151	5.2	1.020
131	22	312	69	1.3	0.403
132	39	526	138	5.5	0.936
133	38	1040	146	6.1	0.915
Mean	31	639	191	7.5	0.869
95% CL	±5	±230	±120	±4.7	±0.101
Subgroup B					
003	33	582	65	3.8	1.178
005	26	1264	36	1.6	0.548
006	33	1438	55	3.3	1.038
007	42	1004	66	3.2	1.105
Mean	34	1072	56	3.0	0.967
95% CL	±10	±592	±22	±1.5	±0.454
169	41	160	770	25.4	1.274
Group Mean	32	702	193	7.5	0.891
95% CL	±4	±208	±111	±4.0	±0.106

APPENDIX 7. Continued

Group VI

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup A					
175	26	264	267	7.3	0.778
186	18	164	94	4.3	0.918
190	37	835	160	9.4	1.055
203	33	362	600	18.7	1.127
204	39	532	355	14.6	1.068
205	49	~~724~~ 718	~~421~~ 361.7	~~17.4~~ 14.7	1.234
208	58	570	838	23.0	1.414
209	82	1218	589	22.1	1.193
Mean	43	596	416	14.6	1.098
95% CL	±17	±276	±209	±5.8	±0.163
Subgroup B					
032	23	326	51	2.9	0.945
035	7	190	58	3.2	0.537
036	20	146	137	5.6	1.046
040	32	518	87	4.3	0.740
Mean	21	295	83	4.0	0.817
95% CL	±16	±266	±62	±1.9	±0.360
Group Mean	35	496	305	~~111.1~~ ?: 10.8	1.005
95% CL	±13	±200	±164	±4.9	±0.152

APPENDIX 7. Continued

Group VII

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup A					
113	34	1136	428	17.4	0.789
114	22	534	328	13.2	0.592
116	9	38	124	5.3	0.742
117	3	43	218	8.3	0.384
118	11	116	227	10.6	0.771
119	23	1310	361	17.2	0.732
Mean	17	530	281	12.0	0.668
95% CL	±12	±599	±117	±5.1	±0.164
Subgroup B					
028	15	68	40	2.5	0.937
030	16	66	22	1.5	0.958
Mean	16	67	31	2.0	0.948
95% CL	±6	±13	±114	±6.4	±0.126
Group Mean	17	427	219	9.5	0.738
95% CL	±8	±414	±125	±5.2	±0.138

APPENDIX 7. Continued

Group VIII

Central Bering Supergroup

Cluster Subgroup A

Subgroup & Station	Mean No. Species	Density (indiv./m²)	Wet Wt. Biomass (g/m²)	Carbon Biomass (g/m²)	Diversity Index
039	15	698	29	1.6	0.409
Subgroup A-1					
057	16	116	77	3.5	0.868
065	34	3706	281	13.0	0.667
066	34	4414	157	6.6	0.407
067	29	764	107	4.8	0.848
068	28	468	165	8.1	1.033
069	14	156	7	0.5	0.899
088	39	1558	362	15.8	1.023
089	35	642	245	10.6	1.148
092	26	968	290	11.5	0.844
093	27	370	140	5.0	1.097
094	35	580	137	5.0	1.093
Mean	29	1249	179	7.7	0.902
95% CL	±5	±977	±70	±3.1	±0.146
Subgroup A-2					
173	43	8190	1085	45.3	0.782
174	44	1440	153	9.3	1.050
178	43	1832	547	24.3	0.956
179	42	4310	488	27.6	0.677
Mean	43	3943	568	26.6	0.866
95% CL	±1	±4936	±614	±23.5	±0.267
Subgroup Mean	32	1888	267	12.0	0.863
95% CL	±5	±1174	±142	±6.2	±0.122

APPENDIX 7. Continued

Group VIII

Central Bering Supergroup

Cluster Subgroup B

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
034	19	368	283	13.1	0.819
Subgroup B-1					
043	27	238	144	7.3	0.806
056	13	50	34	1.9	0.877
058	22	436	221	10.0	0.892
059	22	580	277	10.9	0.939
060	23	834	308	14.9	0.736
061	28	520	347	12.3	0.893
Mean	23	443	222	9.6	0.857
95% CL	±6	±287	±122	±4.7	±0.077
071	13	96	34	1.5	0.896
Subgroup Mean	21	390	206	9.0	0.857
95% CL	±5	±218	±102	±4.2	±0.054

APPENDIX 7. Continued

Group VIII

Central Bering Supergroup

Subgroup C

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup C-1					
044	15	350	194	7.4	0.806
045	19	234	140	5.0	0.835
046	16	340	151	7.4	0.707
053	32	602	290	15.7	0.914
054	23	182	279	9.2	0.933
064	20	582	142	6.1	0.864
072	24	856	238	9.5	0.713
076	31	954	284	10.6	1.031
081	12	116	59	4.1	0.779
Mean	21	468	197	8.3	0.842
95% CL	±5	±229	±62	±2.7	±0.081
Subgroup C-2					
189	35	658	250	10.3	1.092
206	35	210	61	2.8	1.272
Mean	35	434	156	6.6	1.182
95% CL	±0	±2849	±1402	±47.6	±1.141
Erratics					
112	19	398	120	4.8	0.575
155	27	742	197	6.9	0.604
165	12	230	47	2.2	0.551
171	33	316	450	18.0	1.093
180	24	250	330	16.4	1.101
201	36	640	173	8.2	0.803
Subgroup Mean	24	451	200	8.5	0.863
95% CL	±4	±131	±55	±2.4	±0.105

APPENDIX 7. Continued

Group VIII

Central Bering Supergroup

Subgroup D

Subgroup & Station	Mean No. Species	Density (indiv./m^2)	Wet Wt. Biomass (g/m^2)	Carbon Biomass (g/m^2)	Diversity Index
Subgroup D-1					
041	21	266	160	4.6	0.876
062	24	522	533	14.3	0.700
063	17	594	523	14.3	0.618
Mean	21	461	405	11.1	0.731
95% CL	±9	±427	±529	±13.0	±0.328
Subgroup D-2					
200	22	196	242	9.5	0.953
202	25	388	233	10.8	0.777
Mean	24	292	238	10.2	0.865
95% CL	±19	±1222	±58	±8.1	±1.113
Subgroup Mean	22	393	338	10.7	0.785
95% CL	±4	±207	±219	±5.0	±0.166
Supergroup Mean	26	934	239	10.1	0.853
95% CL	±3	±424	±54	±2.9	±0.054

170 Total

APPENDIX 8

Observed Physical Characteristics of Benthic Station Cluster Groups on the Bering/Chukchi Shelf

Group I

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
086	63°04'	168°19'	39	3.00	Areal erratic
Subgroup A					
103	63°45'	171°21'	25	3.00	
111	63°53'	170°36'	29	3.50	
115	63°52'	168°55'	31	3.50	
120	63°52'	167°57'	33	3.00	
150	65°01'	168°25'	45	3.00	
135	64°11'	168°07'	40	3.00	
136	64°16'	168°18'	38	3.00	
137	64°18'	168°36'	38	3.00	
141	64°50'	168°27'	42	3.00	
142	64°37'	168°30'	39	3.00	
143	64°34'	168°30'	44	3.00	
144	64°36'	169°19'	43	3.00	
145	64°49'	169°12'	43	3.00	
146	64°42'	170°40'	44	3.50	
147	64°49'	170°04'	47	3.50	
148	65°02'	169°20'	47	3.00	
149	65°08'	168°53'	48	3.00	
151	64°58'	168°11'	42	2.75	
153	65°12'	168°06'	48	2.50	
156	65°22'	168°19'	58	2.75	
157	65°22'	168°22'	56	3.00	
160	65°33'	168°54'	55	2.50	
163	65°50'	168°35'	52	--	
Mean			43	3.00	
95% CL			±4	±0.12	
Subgroup B					
096	63°27'	172°36'	55	3.50	
097	63°29'	171°54'	27	3.50	
098	63°26'	172°09'	47	3.00	
099	63°36'	172°08'	39	--	
Mean			42	3.33	
95% CL			±19	±0.46	
Group Mean			43	3.00	
95% CL			±3	±0.11	

APPENDIX 8. Continued

Group II

Subgroup & Station	Position Lat.N.	Position Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup A					
001	57°59'	158°57'	38	2.00	
002	58°10'	159°27'	31	2.50	
004	58°23'	159°57'	20	2.50	
008	58°57'	160°26'	06	3.00	
009	58°05'	160°21'	43	3.00	
011	58°13'	161°26'	38	--	
012	57°57'	161°18'	42	2.50	
013	58°08'	162°06'	40	2.50	
014	57°45'	162°06'	43	2.50	
015	58°41'	162°31'	42	2.00	
016	58°20'	162°57'	24	2.75	
017	58°02'	162°55'	37	3.00	
019	58°43'	163°38'	24	2.50	
020	59°13'	164°17'	23	2.50	
021	58°26'	164°22'	38	3.00	
025	58°34'	166°12'	39	3.00	
Mean			33	2.62	
95% CL			±6	±0.19	
Subgroup B					
048	61°40'	167°26'	22	3.25	
050	62°08'	167°53'	25	3.50	
051	62°09'	168°08'	25	3.50	
052	62°06'	168°23'	34	3.50	
075	62°36'	167°59'	23	-0.31	
080	63°26'	166°04'	23	4.00	
082	63°19'	167°28'	27	2.75	
083	63°29'	167°20'	28	3.25	
085	63°15'	168°11'	16	3.00	
122	64°08'	167°10'	30	2.75	
134	64°25'	167°34'	30	2.50	
138	64°35'	167°55'	35	2.50	
139	64°46'	167°36'	35	2.00	
140	64°42'	168°03'	35	--	
Mean			28	2.75	
95% CL			±3	±0.65	
Subgroup C					
091	63°10'	171°33'	51	2.75	
095	62°57'	172°12'	58	3.00	
Mean			55	2.88	
95% CL			±44	±1.62	
110	63°54'	170°51'	30	3.00	Areal erratic
Group Mean			32	2.72	
95% CL			±4	±0.26	

APPENDIX 8. Continued

Group III

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
90	63°11'	171°00'	90	--	Areal erratic, rocky
Subgroup A					
104	64°02'	171°41'	39	--	Rock and gravel
105	64°12'	171°42'	49	--	Rock and gravel
106	64°19'	171°08'	41	2.00	
108	64°21'	170°42'	36	3.00	
109	63°04'	170°46'	25	-1.00	
Mean			38	1.33	
95% CL			±11	±5.17	
Subgroup B					
158	65°18'	169°16'	40	--	Rock and gravel
161	65°33'	168°26'	52	-3.00	
166	66°03'	168°25'	56	--	Rock and gravel
168	66°07'	168°47'	53	--	Rock and gravel
Mean			50	-3.00	
95% CL			±11		
Group Mean			48	0.25	
95% CL			±12	±4.38	

APPENDIX 8. Continued

Group IV

Subgroup & Station	Position Lat.N.	Position Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup A					
018	57°39'	162°58'	52	2.75	
022	57°58'	164°45'	66	3.75	
023	57°05'	164°77'	33	4.00	
024	57°07'	165°15'	63	3.75	
027	58°14'	167°26'	63	3.75	
029	58°30'	168°16'	62	3.00	
037	59°05'	169°15'	63	3.75	
038	59°31'	169°53'	54	--	
Mean			57	3.54	
95% CL			±9	±0.43	
010	58°25'	160°47'	20	-1.00	Areal erratic
070	62°35'	171°53'	54	3.75	Areal erratic
073	62°25'	170°00'	45	2.75	Areal erratic
125	63°59'	165°38'	20	4.00	Areal erratic
170	66°34'	168°32'	42	--	Areal erratic, rocky
Group Mean			49	3.11	
95% CL			±10	±0.97	

APPENDIX 8. Continued

Group V

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup A					
047	61°12'	167°00'	19	3.50	
049	61°52'	166°58'	22	3.75	
077	62°36'	166°04'	18	3.75	
078	63°03'	165°24'	20	4.75	
079	63°38'	165°02'	20	4.25	
123	63°53'	166°46'	30	4.25	
124	63°49'	166°23'	24	5.00	
126	64°13'	166°12'	22	3.75	
127	64°25'	165°35'	32	2.50	
128	64°23'	165°26'	34	2.50	
129	64°26'	165°23'	22	2.25	
130	64°27'	165°52'	22	--	Rock and gravel
131	64°29'	165°50'	16	--	Rock and gravel
132	64°26'	165°45'	30	--	Rock and gravel
133	64°14'	166°00'	27	4.25	
Mean			24	3.71	
95% CL			±3	±0.57	
Subgroup B					
003	58°28'	159°39'	27	3.00	
005	58°35'	159°49'	40	3.50	
006	58°41'	159°44'	18	2.50	
007	58°47'	160°13'	25	2.00	
Mean			28	2.75	
95% CL			±15	±1.02	
169	66°17'	168°23'	73	--	Areal erratic, rocky
Group Mean			27	3.47	
95% CL			±6	±0.49	

APPENDIX 8. Continued

Group VI

Subgroup & Station	Position Lat.N.	Position Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup A					
175	67°28'	165°46'	38	7.00	
186	68°48'	167°46'	50	6.50	
190	69°29'	166°24'	40	3.50	
203	71°03'	164°57'	45	4.25	
204	71°12'	164°12'	45	5.75	
205	71°12'	163°05'	50	4.25	
208	71°10'	161°57'	45	3.50	
209	71°23'	160°15'	50	2.50	
Mean			45	4.66	
95% CL			±4	±1.33	
Subgroup B					
032	57°46'	170°58'	90	5.00	
035	58°22'	171°27'	105	6.50	
036	58°44'	172°31'	100	6.50	
040	59°56'	173°51'	95	6.50	
Mean			98	6.13	
95% CL			±10	±1.19	
Group Mean			63	5.15	
95% CL			±17	±0.96	

APPENDIX 8. Continued

Group VII

Subgroup & Station	Position Lat.N.	Position Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup A					
113	63°51'	169°54'	36	3.50	
114	63°48'	169°52'	40	3.50	
116	63°50'	169°06'	36	4.00	
117	63°42'	169°19'	35	4.00	
118	63°35'	168°50'	31	4.00	
119	63°37'	168°28'	31	4.00	
Mean			35	3.80	
95% CL			±4	±0.27	
Subgroup B					
028	57°41'	168°03'	70	3.00	
030	57°46'	169°45'	68	3.00	
Mean			69	3.00	
95% CL			±12		
Group Mean			43	3.63	
95% CL			±13	±0.37	

APPENDIX 8. Continued

Group VIII

Central Bering Supergroup

Subgroup A

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
039	59°45'	171°22'	75	5.00	Areal erratic
Subgroup A-1					
057	61°22'	175°03'	86	7.00	
065	62°19'	175°04'	90	6.00	
066	62°27'	173°27'	70	3.75	
067	62°41'	172°36'	56	4.00	
068	62°39'	172°20'	48	3.50	
069	62°37'	172°06'	52	2.75	
088	62°45'	170°03'	42	3.00	
089	62°54'	170°59'	43	3.00	
092	62°57'	172°12'	55	4.00	
093	62°55'	172°11'	58	4.00	
094	62°59'	172°36'	54	4.00	
Mean			59	4.09	
95% CL			±11	±0.87	
Subgroup A-2					
173	66°10'	168°35'	45	3.50	
174	67°13'	168°25'	41	5.00	
178	67°41	168°00'	45	5.00	
179	67°36'	168°40'	52	4.50	
Mean			46	4.50	
95% CL			±7	±1.12	
Subgroup Mean			57	4.25	
95% CL			±8	±0.61	

APPENDIX 8. Continued

Group VIII

Central Bering Supergroup

Subgroup B

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
034	58°13'	171°23'	92	4.25	Areal erratic
Subgroup B-1					
043	61°11'	173°47'	75	3.25	
056	61°09'	175°12'	100	6.50	
058	61°27'	174°27'	82	3.50	
059	61°26'	174°24'	78	3.25	
060	61°37'	174°24'	80	3.50	
061	61°44'	173°50'	66	3.50	
Mean			80	3.92	
95% CL			±12	±1.33	
071	62°29'	172°10'	49	3.25	Areal erratic
Subgroup Mean			78	3.87	
95% CL			±14	±1.03	

APPENDIX 8. Continued

Group VIII

Central Bering Supergroup

Subgroup C

Subgroup & Station	Position Lat.N.	Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup C-1					
044	61°22'	171°53'	56	7.00	
045	61°40'	171°10'	53	4.50	
046	61°45'	169°44'	48	4.25	
053	62°05'	171°20'	48	3.50	
054	61°57'	171°45'	56	3.50	
064	62°14'	172°39'	53	3.50	
072	62°31'	171°06'	38	3.00	
076	62°36'	168°20'	31	3.00	
081	63°04'	167°31'	33	3.00	
Mean			46	4.00	
95% CL			±8	±0.98	
Subgroup C-2					
189	69°53'	164°58'	38	3.00	
206	70°29'	163°35'	35	3.00	
Mean			37	3.00	
95% CL			±19		
112	64°23'	170°04'	43	3.00	Areal erratic
155	65°19'	167°51'	42	3.00	Areal erratic
165	66°03'	167°57'	29	3.50	Areal erratic
171	66°48'	168°30'	40	--	Areal erratic
180	68°02'	167°52'	56	3.00	Areal erratic
201	71°47'	166°35'	50	6.50	Areal erratic
Subgroup Mean			44	3.77	
95% CL			±5	±0.67	

APPENDIX 8. Continued

Group VIII

Central Bering Supergroup

Subgroup D

Subgroup & Station	Position Lat.N.	Position Long.W.	Depth (m)	Sediment Mode (phi size)	Comments
Subgroup D-1					
041	60°42'	171°25'	61	5.00	
062	61°54'	173°25'	63	3.50	
063	61°56'	173°21'	55	3.75	
Mean			60	4.08	
95% CL			±10	±1.99	
Subgroup D-2					
200	71°20'	168°55'	51	6.50	
202	72°18'	165°10'	51	6.50	
Mean			51	6.50	
Subgroup Mean			56	5.05	
95% CL			±7	±1.79	
Supergroup Mean			56	4.10	
95% CL			±5	±0.36	

APPENDIX 9

Dominant Species (10% total density, organic carbon biomass, and frequency of occurrence) for Cluster Groups, Subgroups, and Stations on the Bering/Chukchi Shelf, with Apparent Trophic Type (FF-filter feeder, SDF-selective detritus feeder, SSF-substrate feeder, CS-carnivore/scavenger)

Station	Dominant Species	Trophic Type
	Cluster Group I, Subgroup A	
103	*Ampelisca macrocephala*	SDF
	Serripes groenlandicus	FF
	Cyclocardia crebricostata	FF
	Yoldia scissurata	SDF
	Travisia forbesii	SSF
111	*Ampelisca macrocephala*	SDF
	Cyclocardia crebricostata	FF
	Echinarachnius parma	SDF
115	*Ampelisca macrocephala*	SDF
120	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Macoma calcarea	SDF
	Serripes groenlandicus	FF
135	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Astarte borealis	FF
136	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Astarte borealis	FF
137	*Ampelisca macrocephala*	SDF
	Astarte borealis	FF
141	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Macoma calcarea	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group I, Subgroup A	
142	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Macoma calcarea	SDF
143	*Ampelisca macrocephala*	SDF
144	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF
145	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Astarte borealis	FF
	Macoma calcarea	SDF
146	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF
147	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF
	Serripes groenlandicus	FF
148	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Astarte borealis	FF
	Macoma calcarea	SDF
149	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Macoma calcarea	SDF
150	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Astarte borealis	FF
151	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Astarte borealis	FF
153	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Strongylocentrotus droebachiensis	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group I, Subgroup A	
156	*Ampelisca macrocephala*	SDF
	Astarte borealis	SDF
	Cyclocardia crebricostata	FF
157	*Ampelisca macrocephala*	SDF
	Serripes groenlandicus	FF
160	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Lembos arcticus	SDF
163	*Ampelisca macrocephala*	SDF
	Ampelisca birulai	SDF
	Byblis gaimardi	SDF
	Strongylocentrotus droebachiensis	SDF
	Cluster Group I, Subgroup B	
096	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Macoma calcarea	SDF
	Serripes groenlandicus	FF
097	*Ampelisca macrocephala*	SDF
	Byblis gaimardi	SDF
	Liocyma fluctuosa	FF
098	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF
	Protomedeia grandimana	SDF
099	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF
	Liocyma fluctuosa	FF
	Yoldia scissurata	SDF
	Cluster Group I, Areal Erratics	
086	*Ampelisca macrocephala*	SDF
	Macoma calcarea	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group II, Subgroup A	
001	*Tellina lutea*	SDF
	Spiophanes bombyx	SDF
002	*Tellina lutea*	SDF
	Echinarachnius parma	SDF
004	*Travisia forbesii*	SSF
	Echinarachnius parma	SDF
	Astarte borealis	FF
	Astarte montigui	FF
008	*Macoma lama*	SDF
	Glycinde wireni	CS
	Spiophanes bombyx	SDF
	Terribellides stroemi	SDF
009	*Cyclocardia crebricostata*	FF
	Tachyrhynchus erosus	CS
	Echinarachnius parma	SDF
011	*Tellina lutea*	SDF
	Echinarachnius parma	SDF
	Nephtys ciliata	CS
012	*Tellina lutea*	SDF
	Tachyrhychus erosus	CS
	Echinarachnius parma	SDF
013	*Tachyrhychus erosus*	CS
	Echinarachnius parma	SDF
	Erichtonius tolli	SDF
014	*Serripes groenlandicus*	FF
	Haploscoloplos elongatus	SSF
	Tachyrhychus erosus	CS
	Nephtys rickettsi	CS
	Echinarachnius parma	SDF
015	*Tellina lutea*	SDF
	Astarte montagui	FF
	Echinarachnius parma	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group II, Subgroup A	
016	*Spiophanes bombyx*	SDF
	Echinarachnius parma	SDF
	Cyclocardia crebricostata	FF
	Haploscoloplos elongatus	SSF
017	*Ampelisca macrocephala*	SDF
	Paraphoxus milleri	SDF
	Echinarachnius parma	SDF
	Tellina lutea	SDF
019	*Spiophanes bombyx*	SDF
	Travisia forbesii	SSF
	Nephtys ciliata	CS
020	*Tachyrhychus erosus*	CS
	Haploscoloplos elongatus	SDF
	Echinarachnius parma	SDF
	Cyclocardia crebricostata	FF
	Tellina lutea	SDF
021	*Tachyrhychus erosus*	CS
	Ampelisca macrocephala	SDF
	Byblis gaimardi	SDF
	Echinarachnius parma	SDF
025	*Cylichna nucleola*	CS
	Tachyrhychus erosus	CS
	Serripes groenlandicus	FF
	Cyclocardia crebricostata	FF
	Ampelisca macrocephala	SDF
	Myriochele heeri	SDF
	Phloe minuta	CS
	Cluster Group II, Subgroup B	
048	*Haploscoloplos elongatus*	SSF
	Byblis gaimardi	SDF
	Musculus niger	FF
	Cyclocardia crebricostata	FF
	Tachyrhychus erosus	CS
	Nephtys ciliata	CS

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group III, Subgroup A	
104	*Harmothoe imbricata*	CS
	Strongylocentrotus droebachiensis	SDF
	Ophiura maculata	SDF
105	*Ophiura maculata*	SDF
	Cistenides granulata	SDF
106	*Nicolea venustula*	SDF
	Cistenides granulata	SDF
	Echinarachnius parma	SDF
108	*Cistenides granulata*	SDF
	Lembos arcticus	SDF
	Echinarachnius parma	SDF
	Cluster Group III, Subgroup B	
158	*Cistenides granulata*	SDF
	Ophiura maculata	SDF
	strongylocentrotus droebachiensis	SDF
	Maldane sarsi	SDF
161	*Ophiura maculata*	SDF
	Strongylocentrotus droebachiensis	SDF
	Diamphiodia craterodmeta	SDF
	Golfingia margaritaca	SDF
166	*Strongylocentrotus droebachiensis*	SDF
	Yoldia hyperborea	SDF
168	*Cistenides granulata*	SDF
	Melita dentata	SDF
	Yoldia hyperborea	SDF
	Cluster Group III, Areal Erratics	
090	*Nicolea venustula*	SDF
	Nephtys caeca	CS
	Ampharete acutifrons	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group IV, Subgroup A	
018	*Haploscoloplos elongatus*	SSF
	Protomedeia fascata	SDF
	Echinarachnius parma	SDF
	Tachyrhychus erosus	CS
022	*Haploscoloplos elongatus*	SSF
	Protomedeia fascata	SDF
	Eudorella emarginata	SDF
	Cucumaria calcigera	SDF
023	*Haploscoloplos elongatus*	SSF
	Protomedeia fascata	SDF
	Eudorella emarginata	SDF
	Nephtys ciliata	CS
	Sternaspis scutata	SSF
024	*Protomedeia fascata*	SDF
	Eudorella emarginata	SDF
	Nephtys ciliata	CS
	Clinocardium ciliatum	FF
027	*Haploscoloplos elongatus*	SSF
	Protomedeia fascata	SDF
	Macoma calcarea	SDF
	Yoldia hyperborea	SDF
029	*Haploscoloplos elongatus*	SSF
	Protomedeia fascata	SDF
	Tachyrhychus erosus	CS
	Nephtys ciliata	CS
	Praxillella praetermissa	SSF
	Artacama proboscidea	SDF
037	*Haploscoloplos elongatus*	SSF
	Praxillella praetermissa	SSF
	Sternaspis scutata	SSF
	Chaetozone setosa	SSF
	Yoldia hyperborea	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group IV, Subgroup A	
038	*Haploscoloplos elongatus*	SSF
	Chaetozone setosa	SSF
	Sternaspis scutata	SSF
	Artacama proboscidea	SDF
	Yoldia hyperborea	SDF
	Nucula tenuis	SDF
	Cluster Group IV, Areal Erratics	
010	*Haploscoloplos elongatus*	SSF
070	*Protomedeia fascata*	SDF
	Pontoporeia femorata	SDF
	Pelonia corrugata	FF
073	*Protomedeia fascata*	SDF
125	*Protomedeia fascata*	SDF
	Sternaspis scutata	SDF
	Yoldia hyperborea	SDF
170	*Protomedeia fascata*	SDF
	Yoldia hyperborea	SDF
	Tahcyrhychus erosus	CS

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group V, Subgroup A	
047	*Myriochele heeri*	SDF
	Haploscoloplos elongatus	SSF
	Lumbrinereis fragilis	SDF
	Nephtys caeca	CS
049	*Sternaspis scutata*	SSF
	Yoldia hyperborea	SDF
077	*Myriochele heeri*	SDF
	Sternaspis scutata	SSF
078	*Myriochele heeri*	SDF
	Sternaspis scutata	SSF
	Diamphiodia craterodmeta	SDF
	Lumbrinereis fragilis	SDF
079	*Sternaspis scutata*	SSF
	Lumbrinereis fragilis	SDF
	Yoldia hyperborea	SDF
123	*Sternaspis scutata*	SSF
	Nephtys ciliata	CS
	Nucula tenuis	SDF
124	*Sternaspis scutata*	SSF
	Nucula tenuis	SDF
	Nephtys ciliata	CS
	Pelonaia corrugata	FF
126	*Myriochele heeri*	SDF
	Echinarachnius parma	SDF
	Serripes groenlandicus	FF
127	*Myriochele heeri*	SDF
	Diamphiodia craterodmeta	SDF
	Yoldia hyperborea	SDF
	Astarte borealis	FF
	Macoma calcarea	SDF
	Macoma brota	SDF
128	*Diamphiodia craterodmeta*	SDF
	Yoldia hyperborea	SDF
	Tachyrhychus erosus	CS
	Macoma brota	SDF

APPENDIX 9. Continued

Station	Dominant Speices	Trophic Type
	Cluster Group V, Subgroup A	
129	*Diamphiodia craterodmeta*	SDF
	Yoldia hyperborea	SDF
	Serripes groenlandicus	FF
130	*Diamphiodia craterodmeta*	SDF
	Yoldia hyperborea	SDF
131	*Diamphiodia craterodmeta*	SDF
	Chone infundibuliformis	FF
	Strongylocentrotus droebachiensis	SDF
132	*Diamphiodia craterodmeta*	SDF
	Yoldia hyperborea	SDF
133	*Diamphiodia craterodmeta*	SDF
	Myriochele heeri	SDF
	Sternaspis scutata	SSF
	Nephtys ciliata	CS
	Serripes groenlandicus	FF
	Cluster Group V, Subgroup B	
003	*Haploscoloplos elongatus*	SSF
	Myriochele heeri	SDF
	Proxillella praetermissa	SSF
	Yoldia scissurata	SDF
	Sternaspis scutata	SSF
005	*Myriochele heeri*	SDF
	Sternaspis scutata	SSF
006	*Myriochele heeri*	SDF
	Sternaspis scutata	SSF
	Phloe minuta	CS
	Nephtys ciliata	CS
	Terebellides stroemi	SDF
	Travisia forbesii	SSF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group V, Subgroup B	
007	*Myriochele heeri*	SDF
	Sternaspis scutata	SSF
	Diamphiodia craterodmeta	SDF
	Praxillella pratermissa	SSF
	Macoma calcarea	SDF
	Yoldia hyperborea	SDF
	Tachyrhychus erosus	CS
	Cluster Group V, Areal Erratics	
169	*Praxillella praetermissa*	SSF
	Diamphiodia craterodmeta	SDF
	Byblis gaimardi	SDF
	Clinocardium ciliatum	FF
	Nephtys rickettsi	CS
	Gorgonocephalus caryi	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VI, Subgroup A	
175	*Maldane sarsi*	SSF
	Clinocardium ciliatum	FF
	Cucumaria calcigera	SDF
186	*Maldane sarsi*	SSF
	Nucula tenuis	SDF
	Sternaspis scutata	SSF
	Diamphiodia craterodmeta	SDF
	Golfingia margaritaca	SDF
190	*Maldane sarsi*	SSF
	Sternsaspis scutata	SSF
	Melita quadrispinosa	SDF
	Nephtys ciliata	CS
	Golfingia margaritaca	SDF
203	*Maldane sarsi*	SSF
	Ophiura sarsi	CS
	Astarte borealis	FF
	Golfingia margaritaca	SDF
204	*Maldana sarsi*	SSF
	Ophiura sarsi	CS
	Macoma calcarea	SDF
	Golfingia margaritaca	SDF
205	*Mardane sarsi*	SSF
	Ophiura sarsi	CS
	Nucula tenuis	SDF
	Golfingia margaritaca	SDF
208	*Ophiura sarsi*	CS
	Diamphiodia craterodmeta	SDF
	Macoma calcarea	SDF
	Golfingia margaritaca	SDF
209	*Maldane sarsi*	SSF
	Astarte borealis	SDF
	Nicomache lumbricalis	SDF
	Chelyosoma inequale	FF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VI, Subgroup B	
032	*Maldane sarsi*	SSF
	Sternaspis scutata	SSF
	Nephtys ciliata	CS
035	*Ophiura sarsi*	CS
	Yoldia hyperborea	SDF
	Nuculana minuta	SDF
036	*Maldane sarsi*	SSF
	Sternaspis scutata	SSF
	Diamphiodia craterodmeta	SDF
	Serripes groenlandicus	FF
	Yoldia hyperborea	SDF
	Nephtys ciliata	CS
040	*Maldane sarsi*	SSF
	Ophiura sarsi	CS
	Macoma brota	SDF
	Nephtys ciliata	CS

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VII, Subgroup A	
113	*Macoma calcarea*	SDF
	Serripes groenlandicus	FF
	Protomedeia fascata	SDF
	Lumbrinereis fragilis	SDF
114	*Macoma calcarea*	SDF
	Serripes groenlandicus	FF
	Cistenides hyperborea	SDF
116	*Macoma calcarea*	SDF
	Serripes groenlandicus	FF
	Ampharete acutifrons	SDF
	Nephtys ciliata	CS
	Praxillella praetermissa	SSF
117	*Macoma calcarea*	SDF
	Nephtys ciliata	CS
118	*Macoma calcarea*	SDF
	Nephtys ciliata	CS
	Ampharete reducta	SDF
	Praxillella praetermissa	SSF
119	*Macoma calcarea*	SDF
	Nucula tenuis	SDF
	Chone dunneri	FF
	Cluster Group VII, Subgroup B	
028	*Yoldia hyperborea*	SDF
	Nephtys ciliata	CS
030	*Macoma calcarea*	SDF
	Nephtys longasetosa	CS
	Nephtys ciliata	CS
	Praxillella praetermissa	SSF
	Ampharete acutifrons	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VIII, Subgroup A, Areal Erratics	
039	*Yoldia hyperborea*	SDF
	Pontoporeia femorata	SDF
	Terribellides stroemi	SDF
	Cluster Group VIII, Subgroup B	
043	*Macoma calcarea*	SDF
	Nucula tenuis	SDF
	Yoldia hyperborea	SDF
	Nuculana radiata	SDF
	Scalibregma inflatum	SSF
	Terebellides stroemi	SDF
056	*Nucula tenuis*	SDF
	Yoldia hyperborea	SDF
	Artacama proboscidea	SDF
	Nephtys ciliata	CS
058	*Yoldia hyperborea*	SDF
	Maldane sarsi	SSF
	Ophiura sarsi	CS
059	*Macoma calcarea*	SDF
	Yoldia hyperborea	SDF
	Nuculana radiata	SDF
	Ophiura sarsi	CS
060	*Yoldia hyperborea*	SDF
	Ophiura sarsi	CS
	Maldane sarsi	SSF
061	*Macoma clacarea*	SDF
	Yoldia hyperborea	SDF
	Nucula tenuis	SDF
	Nuculana radiata	SDF
	Cluster Group VIII, Subgroup B, Areal Erratics	
034	*Nucula tenuis*	SDF
	Yoldia hyperborea	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VIII, Subgroup B, Areal Erratics	
071	*Macoma calcarea*	SDF
	Nucula tenuis	SDF
	Yoldia hyperborea	SDF
	Ophiura sarsi	CS
	Haploscoloplos elongatus	SSF
	Nephtys ciliata	CS
	Cluster Group VIII, Subgroup C-1	
044	*Nucula tenuis*	SDF
	Nuculana radiata	SDF
	Echiurus echiurus	SDF
045	*Nucula tenuis*	SDF
	Yoldia hyperborea	SDF
	Clinocardium ciliatum	FF
046	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Terebellides stroemi	SDF
053	*Nucula tenuis*	SDF
	Axiothella catenata	SSF
	Nephtys rickettsi	CS
054	*Nucula tenuis*	SDF
	Scalibregma inflatum	SSF
	Musculus niger	FF
064	*Nucula tenuis*	SDF
	Yoldia hyperborea	SDF
	Byblis gaimardi	SDF
072	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Serripes groenlandicus	FF
	Pelonaia corrugata	FF
076	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Serripes groenlandicus	FF
	Pelonaia corrugata	FF
	Echinarachnius parma	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VIII, Subgroup C-1	
081	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Praxillella praetermissa	SSF
	Nephtys rickettsi	CS
	Cluster Group VIII, Subgroup C-2	
189	*Nucula tenuis*	SDF
	Sternaspis scutata	SSF
	Melita quadrispinosa	SDF
	Nephtys ciliata	CS
	Golfingia margaritaca	SDF
	Proclea emmi	SDF
206	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Lumbrinereis fragilis	SDF
	Nephtys ciliata	CS
	Ophiura sarsi	CS
	Nephtys lumbricalis	CS
	Cluster Group VIII, Subgroup D-1	
041	*Nucula tenuis*	SDF
	Nuculana radiata	SDF
	Sternaspis scutata	SSF
062	*Nucula tenuis*	SDF
	Nuculana radiata	SDF
	Macoma calcarea	SDF
063	*Nucula tenuis*	SDF
	Nuculana radiata	SDF
	Cluster Group VIII, Subgroup D-2	
200	*Nuculana radiata*	SDF
	Macoma calcarea	SDF
	Yoldia hyperborea	SDF
	Pseudopythina rugifera	FF
	Golfingia margaritaca	SDF

APPENDIX 9. Continued

Station	Dominant Species	Trophic Type
	Cluster Group VIII, Subgroup D-2	
202	*Nuculana radiata*	SDF
	Macoma calcarea	SDF
	Yoldia hyperborea	SDF
	Lumbrinereis fragilis	SDF
	Cluster Group VIII, Areal Erratics	
112	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Macoma loveni	SDF
155	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Astarte borealis	FF
	Yoldia scissurata	SDF
	Nephtys ciliata	CS
165	*Nucula tenuis*	SDF
	Sternaspis scutata	SSF
	Nephtys ciliata	CS
	Nephtys rickettsi	CS
171	*Nucula tenuis*	SDF
	Macoma calcarea	SDF
	Melita dentata	SDF
	Protomedeia fascata	SDF
	Nephtys ciliata	CS
	Gorgonocephalus caryi	SDF
180	*Macoma calcarea*	SDF
	Melita dentata	SDF
	Protomedeia grandimana	SDF
	Pontoporeia femorata	SDF
	Praxillella praetermissa	SSF
	Pelonaia corrugata	FF
201	*Nucula tenuis*	SDF
	Sternaspis scutata	SSF
	Golfingia margaritaca	SDF

APPENDIX 10

Species Showing Association Affinity at or Exceeding the Motyka 0.50 Level Within Station Cluster Groups on the Bering/Chukchi Shelf. Species Affinity Groups are Listed in Descending Order of Confidence

Species Group	Species	Affinity Level
	Station Cluster Group I	
A	*Nuculana radiata* *Harmothoe imbricata*	0.96-1.00
B	*Clinocardium ciliatum* *Antinoelli sarsi*	0.56-0.60
C	*Ampelisca birulai* *Byblis gaimardi*	0.52-0.56
D	*Nephtys ciliata* *Terebellides stroemi* *Golfingia margaritaca*	0.52-0.56
E	*Astarte montigui* *Ampharete reducta* *Arcteobea anticostiensis*	0.52-0.56
F	*Ampharete acutifrons* *Anaitides groenlandica* *Axiothella catenata* *Lumbrinereis fragilis*	0.50-0.52
G	*Astarte borealis* *Glycinde wireni* *Phloe minuta*	0.50-0.52
H	*Thyasira flexuosa* *Haploscoloplos elongatus* *Praxillella praetermissa*	0.50-0.52
I	*Anonyx nugax pacifica* *Lembos articus*	0.50-0.52
J	*Cistenides granulata* *Diamphiodia craterodmeta*	0.50-0.52
K	*Cyclocardia crebricostata* *Yoldia scissurata*	0.50-0.52
L	*Nicomache lumbricalis* *Polynoe canadensis*	0.50-0.52

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group II	
A	*Antinoella sarsi* *Gorgonocephalus caryi*	0.96-1.00
B	*Pontoporeia femorata* *Ophiura sarsi*	0.76-0.80
C	*Ampharete acutifrons* *Lembos arcticus*	0.72-0.76
D	*Thyasira flexuosa* *Anaitides groenlandica*	0.52-0.56
E	*Cylichna nucleola* *Protomedeia fascata*	0.52-0.56
F	*Yoldia hyperborea* *Ampelisca birulai*	0.50-0.52
G	*Macoma calcarea* *Cyclocardia crebricostata*	0.50-0.52
H	*Myriochele heeri* *Phloe minuta*	0.50-0.52
I	*Tellina lutea* *Terebellides stroemi* *Travisia forbesii*	0.50-0.52
J	*Styela rustica* *Lumbrinereis fragilis* *Cistenides hyperborea*	0.50-0.52
K	*Nephtys longasetosa* *Praxillella praetermissa*	0.50-0.52

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group III	
A	*Myriochele heeri* *Cucumaria calcigera*	0.96-1.00
B	*Flabelligera affinis* *Cistenides hyperborea* *Gorgonocephalus caryi*	0.65-0.69
C	*Nucula tenuis* *Maldane sarsi* *Nephtys rickettsi* *Terebellides stroemii*	0.65-0.69
D	*Musculus niger* *Axiothella catenata* *Potamilla neglecta*	0.65-0.69
E	*Clinocardium ciliatum* *Tachyrynchus erosus* *Erichtonius tolli* *Pontoporeia femorata*	0.65-0.69
F	*Ampharete acutifrons* *Chone duneri* *Praxillella praetermissa* *Ampelisca macrocephala* *Anonyx nugax pacifica* *Lembos arcticus* *Golfingia margaritaca*	0.61-0.64
G	*Liocyma fluctuosa* *Nephtys caeca* *Byblis gaimardi* *Protomedeia grandimana*	0.61-0.64
H	*Astarte borealis* *Nuculana minuta* *Thyasira fluctuosa* *Chaetozone setosa* *Travisia forbesii*	0.58-0.61
I	*Astarte montigui* *Yoldia hyperborea*	0.58-0.61

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group III. Continued	
J	*Macoma calcarea*	0.50-0.54
	Ampharete reducta	
	Arcteobea anticostiensis	
	Phloe minuta	
K	*Capitella capitata*	0.50-0.54
	Haploscoloplos elongatus	
	Lumbrinereis fragilis	
	Scalibregma inflatum	

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group IV	
A	*Thyasira flexuosa*	0.96-1.00
	Nephtys caeca	
	Ampelisca macrocephala	
	Melita dentata	
	Melita quadrispinosa	
B	*Tachyrhychus erosus*	0.65-0.68
	Nephtys longasetosa	
	Byblis gaimardi	
C	*Pelonaia corrugata*	0.65-0.68
	Macoma brota	
D	*Brada inhabilis*	0.65-0.68
	Priapulus caudatus	
E	*Liocyma fluctuosa*	0.57-0.61
	Musculus niger	
F	*Chone duneri*	0.57-0.61
	Polynoe canadensis	
	Echiurus echiurus	
G	*Cyclocardia crebricostata*	0.53-0.57
	Yoldia scissurata	
	Arcteobea anticostiensis	
	Glycinde wireni	
	Anonyx nugax pacifica	
	Diamphiodia craterodmeta	
H	*Nephtys ciliata*	0.53-0.57
	Phloe minuta	
I	*Nucula tenuis*	0.53-0.57
	Chaetozone setosa	

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group V	
A	*Molgula siphonalis*	0.96-1.00
	Styela rustica	
	Liocyma fluctuosa	
	Echiurus echiurus	
B	*Yoldia scissurata*	0.88-0.92
	Spiophanes bombyx	
C	*Glycinde wireni*	0.73-0.77
	Phloe minuta	
D	*Chone duneri*	0.65-0.69
	Polynoe canadensis	
E	*Ampharete reducta*	0.65-0.69
	Chone infundibuliformis	
	Nicomache lumbricalis	
	Protomedeia grandimana	
	Strongylocentrotus droebachiensis	
F	*Astarte borealis*	0.61-0.65
	Lumbrinereis fragilis	
G	*Pelonaia corrugata*	0.53-0.57
	Nucula tenuis	
H	*Maldane sarsi*	0.53-0.57
	Nephtys ciliata	
	Melita formosa	
	Ophiura sarsi	
I	*Macoma loveni*	0.53-0.57
	Brada villosa	
	Travisia forbesii	
	Protomedeia fascata	
J	*Haploscoloplos elongatus*	0.53-0.57
	Praxillella praetermissa	
K	*Serripes groenlandicus*	0.53-0.57
	Echinarachnius parma	

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group V. Continued	
L	*Cylichna nucleola* *Ampelisca macrocephala* *Byblis gaimardi*	0.50-0.53
M	*Lembos arcticus* *Melita quadrispinosa*	0.50-0.53

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group VI	
A	*Antinoella sarsi* *Artacama proboscidea*	0.96-1.00
B	*Axiothella catenata* *Chone infundibuliformis*	0.96-1.00
C	*Capitella capitata* *Nicomache lumbricalis*	0.73-0.77
D	*Scalibregma inflatum* *Polynoe canadensis* *Melita formosa*	0.69-0.73
E	*Anonyx nugax pacifica* *Pontoporeia femorata*	0.65-0.69
F	*Brada villosa* *Haploops laevis*	0.65-0.69
G	*Ampharete acutifrons* *Phloe minuta*	0.65-0.69
H	*Sternaspis scutata* *Melita quadrispinosa*	0.62-0.65
I	*Cyclocardia crebricostata* *Lumbrinereis fragilis* *Cistenides hyperborea* *Praxillella praetermissa* *Travisia forbesii* *Golfingia margaritaca*	0.62-0.65
J	*Pelonaia corrugata* *Astarte montagui* *Thyasira flexuosa* *Flabelligera affinis* *Ophiura maculata*	0.58-0.62
K	*Clinocardium ciliatum* *Serripes groenlandicus*	0.58-0.62

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group VI. Continued	
L	*Anonyx nugax pacifica* *Tachyrhychus erosus* *Proclea emmi*	0.54-0.58
M	*Macoma loveni* *Priapulus caudatus*	0.54-0.58
N	*Astarte borealis* *Macoma calcarea* *Terebellides stroemii* *Diamphiodia craterodmeta*	0.54-0.58
O	*Nephtys ciliata* *Byblis gaimardi* *Protomedeia grandimana*	0.50-0.54

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group VII	
A	*Nephtys caeca* *Potamilla neglecta*	0.85–0.87
B	*Yoldia hyperborea* *Yoldia scissurata* *Pontoporeia femorata*	0.77–0.81
C	*Anaitides groenlandica* *Scalibregma inflatum* *Terebellides stroemii* *Melita formosa* *Protomedeia grandimana*	0.70–0.74
D	*Capitella capitata* *Harmothoe imbricata*	0.66–0.70
E	*Artacama proboscidea* *Polynoe canadensis* *Diamphiodia craterodmeta*	0.66–0.70
F	*Nephtys longasetosa* *Sternaspis scutata*	0.62–0.66
G	*Glycinde wireni* *Haploscoloplos elongatus* *Ampelisca macrocephala* *Paraphoxus milleri*	0.58–0.62

APPENDIX 10. Continued

Species Group	Species	Affinity Level
	Station Cluster Group VIII	
A	*Harmothoe imbricata* *Ophiura maculata*	0.96-1.00
B	*Astarte borealis* *Cucumaria calcigera*	0.76-0.80
C	*Cyclocardia crebricostata* *Paraphoxus milleri*	0.64-0.68
D	*Macoma calcarea* *Cistenides hyperborea*	0.52-0.56
E	*Nuculana minuta* *Brada ochotensis* *Phloe minuta*	0.52-0.56

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