Biological Productivity of the Southern Beaufort Sea: zoobenthic studies

J.W. WACASEY

Technical Report No. 12b

BIOLOGICAL PRODUCTIVITY OF THE SOUTHERN BEAUFORT SEA: ZOOBENTHIC STUDIES

J.W. Wacasey

Arctic Biological Station
Fisheries and Marine Service
Department of the Environment
P.O. Box 400
Ste. Anne de Bellevue, P.Q.

Beaufort Sea Technical Report #12b

Beaufort Sea Project
Dept. of the Environment
512 Federal Building
1230 Government St.
Victoria, B.C. V8W 1Y4

December, 1975

Reprinted September, 1976

Price $1.00

TABLE OF CONTENTS

1. SUMMARY

Baseline data obtained from a sampling program carried out from 1971 through 1975, primarily during the open water season, demonstrate the existence of zonation of zoobenthos across the shelf of the southern Beaufort Sea. These zones, which can be characterized physically and biologically, are designated: (1) Estuarine Zone, (2) Transitional Zone, (3) Marine Zone, and (4) Continental Slope Zone.

The Estuarine Zone, which exhibits salinities under 20‰, is located in waters of depths up to 15 m along the shore from Herschel Island to Cape Dalhousie at the tip of the Tuktoyaktuk Peninsula. Positive temperatures may occur seasonally. Diversity is less than 20 species per station and biomass averages 2g m^{-2}. Biomass is highest (average of 5g m^{-2})in Mason Bay. Most species in this zone are restricted to waters of low salinity. Echinoderms are conspicuously absent from this zone.

The Transitional Zone is located between the Estuarine Zone and the Marine Zone at water depths of 15-30 m, where salinities fluctuate between 20 and 30‰. Positive temperatures may occur seasonally. Diversity is over 20 species per station and biomass averages 5g m^{-2}. Species in this zone are largely a mixture of estuarine and marine species. Echinoderms are present in this zone, as in the succeeding zones.

The Marine Zone is located in water depths from 30 to 200 m, where salinities range from 30 to 33‰, and water temperatures are negative. Diversity is over 20 species with a maximum of 81 species at stationsin the eastern part. Biomass averages 34g m^{-2} with maximum values of 71g m^{-2} at stations in the eastern part. Very few of the many species in this zone are found in the Estuarine Zone.

The Continental Slope Zone is located at depths of 200 to 900 m. Salinities range from 34 to 35‰ and water temperatures are slightly higher than in the Marine Zone, reflecting characteristics of Atlantic Ocean water which covers the bottom of the continental slope in the arctic. Diversity is over 20 species per station and biomass averages 4g m^{-2}. Although Marine Zone species are represented, the characteristic species of this zone are those that are absent or rare in the Marine Zone.

Approximately 337 species have been identified from the study area. Average biomass is estimated to be 6g m^{-2}.

The factors that regulate distribution and abundance of zoobenthos are not definitely known. On the shelf of the southern Beaufort Sea some probable factors of significance, without specifying zonal applicability, are salinity, stability of environment, and nutrients.

Exploratory drilling on the continental shelf of the southern Beaufort Sea is regarded as having little impact on the zoobenthos. Damage can be assessed in terms of biomass per area and size of area jeopardized. Although the greatest biomass of zoobenthos would be damaged in the eastern sector of the Marine Zone, the most vulnerable areas are protected embayments because zoobenthos and substrate in these areas would be more disposed to contact with large quantities of oil in the event of a spill.

2. INTRODUCTION

2.1 Nature and Scope of Study

The potential for petroleum resources in the Beaufort Sea has been established. The activities of man in the exploration and development of petroleum resources impose a threat to the biota and environment of the area of intended operation. In order to measure the potential impact that industrial development will have upon an ecosystem, baseline information must be collected to establish reference points, which reflect the natural conditions. Baseline information on marine zoobenthos is scant, and quantitative values are lacking. This report is intended to correct this deficiency in part, and stems from studies carried out in the southern Beaufort Sea from 1971 to 1975.

2.2 Specific Objectives

2.2.1 To collect and assess data from previous studies.

2.2.2 To sample the zoobenthos in as many places as time and money allow.

2.2.3 To determine number of species, density, and biomass for each station.

2.2.4 To collect associated data such as depth, salinity, and temperature of water near the bottom.

2.2.5 To analyze and compare data in order to determine the existence and nature of a pattern of distribution of species and biomass, and to characterize the study area physically and biologically.

2.3 Relation to Offshore Drilling

In this report the term zoobenthos is applied to the marine invertebrates, exclusive of the protozoa, that live in and on the sea bottom or spend part of their time on the bottom.

Usually, zoobenthos is divided into two components, infauna and epifauna (Thorson, 1957). Infauna refers to the invertebrates living buried or digging in the upper surface layers of the bottom substrate. Epifauna consists of those invertebrates that sit or crawl on the substrate. Thorson also refers to a third group of motile invertebrates that are closely associated with the infauna and epifauna. In the arctic epifauna is relatively sparse, and is virtually nonexistent in intertidal areas where ice cover of 8 to 10 months duration promotes unfavorable conditions for a permanent habitat.

In the arctic most infaunal species and small epifaunal species can be adequately sampled by grab. The epifaunal, infaunal, and motile species, usually large organisms with sparse distribution, cannot be adequately sampled by grab, and larger collecting gear must be employed to obtain estimates of density and biomass. Epifauna in this report applies principally to those species with sparse distribution.

Zoobenthos is an interrelated component of the marine ecosystem. Abundance and diversity of zoobenthos may be sampled or may be inferred by abundance of other biological components (i.e. birds, mammals, fish, zooplankton). Natural changes in zoobenthos, which is a dynamic aggregation of animals, take place over long periods of time, years, rather than season to season. The degree of impact that man in his activities has on the zoobenthos is not readily evident, even when immediate damage can be assessed. Baseline information provides the capability for determining the biologically unique areas, the most productive areas, and the most vulnerable areas. Appropriate decisions can then be made for regulating exploration and development of resources with minimum impact on the environment and biota.

3. CURRENT STATE OF KNOWLEDGE

Quantitative zoobenthic studies of the Beaufort Sea are lacking. Previous studies have been largely of a taxonomic nature, and are of limited use in contributing to baseline information. Some qualitative information is available from the Canadian Arctic Expedition of 1913-1918, although little collecting was done in the area of present interest. Mac Ginitie (1955) published useful information on distribution and ecology of marine invertebrates, based on studies made at Point Barrow, Alaska from 1948 to 1950, but little is of quantitative significance; however, many of the reported species occur in the southern Beaufort Sea.

Fisheries studies were carried out in the area in 1960 and 1961 under the direction of J. G. Hunter of the Arctic Biological Station. In addition to fishes, collections of zoobenthic invertebrates, mostly epifauna collected by trawl, were made. Many of these specimens were dealt with in subsequent taxonomic works, as listed below:

Berkeley and Berkeley, 1962.....Polychaeta
Bray, 1962......................Isopoda
Hedgpeth, 1963..................Pycnogonida
Powell, 1968....................Bryozoa
Squires, 1969...................Decapoda
Calder, 1970, 1972..............Hydrozoa
Macpherson, 1971................Gastropoda
Lubinsky, 1972..................Pelecypoda

Berkeley and Berkeley (1956) also reported on some polychaetes from earlier collections made in the arctic. Wagner (1974) presented qualitative information on benthic foraminifera and molluscs of the Beaufort Sea.

Carey *et al.* (1974) presented quantitative data on the zoobenthos of marine areas off the North Slope of Alaska, and Wacasey (1974) reported quantitative values for zoobenthos of the inshore areas of the southern Beaufort Sea. Data used in the 1974 report by Wacasey are incorporated into the present report, which represents the most extensive survey of the southern Beaufort Sea to date.

4. STUDY AREA

4.1 Geographic Location

Zoobenthic studies were carried out from 1971 through 1975 within the area of the southern Beaufort Sea delineated by coordinates 69° to 71°22' North Latitude and 129° to 140° West Longitude.

4.2 Description

The area of study (Figs. 1, 10) is primarily the continental shelf which gradually slopes from an indented and irregular shoreline in the configuration of a V stretching from Herschel Island to Cape Dalhousie out for a distance of 130 km to a depth of about 200 m. The shelf narrows to about 50 km in the area north of Herschel Island. At the base of the V the Mackenzie Delta, consisting of many islands of which Richards Island is the most prominent, bulges out into the sea. Waters from the Mackenzie River drain into Mackenzie Bay to the west of the delta and into Kugmallit Bay to the east of the delta. Shallow depths may occur up to 24 km offshore.

The bottom topography exhibits several major features which have bearing upon the distribution and abundance of zoobenthos. A basin, Thetis Bay, with a depth of about 70 m occurs just south of Herschel Island, and is separated from Herschel Trench by a submarine ridge. Herschel Trench, located to the east of Herschel Island, extends from Mackenzie Bay, to the margin of the shelf. Another partially filled trench extends from Kugmallit Bay to the edge of the shelf and is most evident north of Tuktoyaktuk.

Scouring of the bottom by ice keels occurs in depths of water from 10 to 60 m, but appears to be more intense in depths from 20 to 40 m.

5. METHODS AND SOURCES OF DATA

Data are based on samples collected at 82 selected stations (Figs. 1, 4, 7) each of which was occupied within the period from May to September, 1971- 1975 (Table 1).

5.1 Sampling Times and Means of Collection

5.1.1 1971

Six stations were occupied by M. V. *Salvelinus* (Arctic Biological Station).

5.1.2 1973

Seventeen stations were occupied by *North Star of Herschel Island* (chartered by Arctic Biological Station).

5.1.3 1974: Beaufort Sea Project

a. Sixteen stations were occupied by M. V. *Theta* (under charter to Beaufort Sea Project).
b. One station was occupied by *Pisces IV / Pandora II* (under charter to Beaufort Sea Project).

5.1.4 1975: Beaufort Sea Project

a. Ten stations were occupied by *Pandora II*. Three of these stations involved dives by the submersible *Pisces IV*.
b. Ten stations in Mason Bay were occupied by M. V. *Salvelinus*.
c. Three stations were occupied by helicopter.
d. Nineteen samples, collected along the Yukon coast, were provided by Ray Kendel of Northern Operations, Fisheries and Marine Service, DOE.

5.2 Sampling Methods

5.2.1 Collection of samples

Previous zoobenthic sampling by grab has demonstrated that a sample encompassing a surface area of 0.25 to 0.33 m^2 of substrate is adequate for determining density and biomass of the infauna and some epifauna.

With the exception of 7 samples taken in 1975 by the Northern Operations group, all grab samples covered a surface area of bottom from 0.23 to 0.39 m^2. Collected samples were washed through a 0.5 mm screen and the retained invertebrates were placed in containers of formalin (1:9 ratio of formaldehyde to water) for transportation to the Arctic Biological Station at Ste. Anne de Bellevue, P.Q. where they were processed.

5.2.2 Processing samples

Each sample was sorted by hand using a Wild M 5 dissecting microscope. Specimens in most cases were identified to species, counted, dried, and weighed on a gravimetric balance to the nearest tenth of a milligram. With the exception of the calcareous parts of echinoderms, the dry weight refers to the organic weight, excluding tubes and calcareous shells.

Specimens from the samples collected by Northern Operations were weighed wet from alcohol, and dry weights were derived by using conversion factors which have been previously determined from other specimens.

5.2.3 Collection of epifauna

In order to assess the contribution of epifauna (species with sparse distribution) to the biomass of a station, dives were made in the submersible, *Pisces IV*, and dredges were taken at three of the stations where grab collections were made.

a. *Pisces IV*

One dive was made in 1974, northeast of Herschel Island in 135 m of water. Three dives were made in 1975 in Thetis Bay south of Herschel Island in 20 to 55 m of water. Estimates of the density of epifauna were obtained from two of these dives (75-337 and 75-339). These estimates were based on the number of individuals observed within a metal frame (1 m^2) held near the bottom by the mechanical arm of the submersible. A mean value was obtained by averaging the number of individuals seen over a number of observations. Dry weight values were derived from specimens kept at the Arctic Biological Station.

b. Dredges

Dredges were taken at three stations (75-570, 75-572, 75-574). Specimens larger than 5 mm were retained for determining density and biomass. Results were not altogether satisfactory, because distance covered by the dredge was difficult to estimate and separation of specimens into infaunal and epifaunal components was subjective. Samples were too few for results to have general application.

5.2.4 Associated data

Associated data, usually taken at the time of zoobenthic collections, include date, time, number of grabs, sampled area, depth, temperature and salinity (Table 2).

In 1971 and 1973 calibrated reversing thermometers were used for measuring water temperature, and salinity determinations were made with a laboratory salinometer. Temperature and salinity measurements from the 1974 and 1975 stations were made with *in situ* salinity-temperature-depth sensors. Data from the 1974 *Theta* stations and 1975 *Pandora* stations were obtained from the laboratory of Ocean and Aquatic Affairs, Pacific Region in Victoria, B. C. The Northern Operations group of DOE provided the temperature and salinity data for the 1975 stations along the Yukon Coast.

In most cases the temperature and salinity measurements were made from 1 to 10 m above the bottom, depending upon depth of water.

5.3 Data Analysis

Lack of time prohibits extensive analysis of all data. Estimates of biomass and diversity, based on grab samples, are used to denote abundance and distribution of zoobenthos. The number of species determined for each sample is used as a measure of diversity. The biomass value for each station is derived from the combined dry weights of all individuals in the sample. After the dry organic weight of the sample was determined, the value was multiplied by a factor (3-4) to convert to a square meter equivalent. Density values were determined in a similar way. The data from stations A-G and 200 may not be reliable, because of the small size of the samples.

6. RESULTS

Summarized data are presented in Tables 1-4. Table 1 lists the coordinates of the stations. Table 2 presents associated data. Table 3 consists of a list of species from the Beaufort Sea. Number of species, density, and biomass of each station are presented in Table 4.

Approximately 337 species of invertebrates are recognized from the combined 82 stations. Polychaetes with 101 species, amphipods with 67 species, gastropods with 33 species, and pelecypods with 36 species constitute 74% of the total number of species. A few species of echinoderms, gastropods, and crustacea are known only by observation from *Pisces IV* or from dredge hauls. These sparsely distributed species are regarded as epifauna and are inadequately sampled by grab.

The values derived from 78 stations sampled by grab are presented as estimates of diversity and biomass. The number of species per station ranges from 1 to 81. The density varies from 5 to 14175 individuals m^{-2}, and biomass ranges from 0.01 to 71.37 g m^{-2}. Only number of species and biomass values are plotted graphically, because it is thought these values best illustrate the pattern of diversity and productivity over the southern Beaufort Sea.

Results of two dives made in *Pisces IV* (Station 75-337 and 75-339) and the two dredge hauls from *Pandora II* (Stations 75-570 and 75-572) yielded estimates of biomass for the epifauna, but these data are of limited use because of their restricted geographical application. *Pisces IV* dive 337, which was made at a depth of 45 to 60 m in Thetis Bay, south of Herschel Island, resulted in an estimate of 14 *Ophiocten sericeum* (brittle star) m^{-2} (range of 7-19), which weighed 1.6 g. *Pisces IV* dive 339, was made at a depth of 20 to 30 m in Thetis Bay and resulted in an average of 1.6 *Mesidotea* (isopod) m^{-2} (range of 0-3) which weighed 1.9g m^{-2}.

The epifauna from two dredge hauls (Station 75-570 and 75-572) were sorted and identified, and total biomass was determined for each haul. The results are not itemized, but the fauna consisted of shrimp, isopods, brittle stars, sea stars and gastropods. In each case the biomass was less than 0.5g m^{-2}.

Epifaunal information is too limited for assessment of epifaunal contribution to biomass across the continental shelf. It is unlikely that it would exceed 2g m^{-2} in the best of areas. The values presented for biomass are derived from grabs and do not include the estimates for epifaunal species with sparse distribution.

7. DISCUSSION

The Mackenzie River, which is one of the major rivers of the North, releases large amounts of fresh water into the Beaufort Sea where mixing occurs with marine waters to produce an extensive estuarine region. Wacasey (1974) discussed the effects of fresh water from the Mackenzie River on the zoobenthos along the inshore areas. Diversity and biomass of the zoobenthos were reported as low compared to values derived from stations located in areas farther away from the influence of the Mackenzie River water. Results of additional sampling in the southern Beaufort Sea in 1974 and 1975 give a better perspective on the diversity and abundance of zoobenthos over the whole area.

The sea bottom of the southern Beaufort Sea can be divided into four principal zones which can be characterized by physical and biological parameters. These zones are designated: (1) Estuarine Zone, (2) Transitional Zone, (3) Marine Zone, and (4) Continental Slope Zone. The zones are discussed in sequence and data are summarized in a table at the end of the discussion.

7.1 Estuarine Zone

This zone (Fig. 10) encompasses sea bottoms from shore out to depths of 10 to 15 m extending along the coast from Herschel Island to Cape Dalhousie. Because of the influence of fresh water from the Mackenzie River, salinities are usually under 20‰ throughout the zone with values, which are initially low (0.1‰) in Mackenzie and Kugmallit Bays, gradually increasing with distance from the outlets of the river. During the open water season temperature of bottom waters may reach 16°C in the shallow depths.

Diversity in this zone is low, rarely exceeding 20 species at each station, and the stations with higher diversity border the Transitional Zone (Figs. 2, 5, 8). Low diversity in this zone can be largely attributed to the inability of many species, particularly echinoderms, to tolerate low salinities for extended periods of time. Low nutrients and unstable conditions may also be contributing factors.

Biomass, which is less than 1g m^{-2} in Mackenzie and Kugmallit Bays, near the outlets of the river, rarely exceed 10g m^{-2} in other parts of the zone (Figs. 3, 6, 9). The average value of biomass for the zone is about 2g m^{-2}. In Mason Bay, a protected embayment, biomass values were 8 to 20g m^{-2} at bottom depths of 4 to 6 m. The average for the bay is about 5g m^{-2}, higher than the average for the entire zone. Nutrient supply, high silt load of river water, and high rate of sedimentation, are factors that may affect biomass in the Estuarine Zone. The higher value of Mason Bay reflects the more stable conditions and nutrient enrichment that can occur in some protected embayments.

Some species characteristic of this zone are *Ampharete vega*, *Boeckosimus affinis*, *Onisimus glacialis*, *Pontoporeia affinis*, *Diastylis sulcata*, *Mesidotea entomon*, *Macoma balthica*, *Cyrtodaria kurriana*, *Yoldiella intermedia*, and *Halicryptus spinulosus*. *Mysis femorata* and *Mysis relicta* are also found in this zone, but these crustaceans usually occur in the water above the bottom. Echinoderms are conspicuously absent from this zone.

7.2 Transitional Zone

This zone (Fig.10), which is more difficult to delineate than the other zones, occurs between the Estuarine and Marine Zones in depths of water from 15-30 m. Temperature and salinity of the bottom waters may fluctuate over the year. The extent of the bottom area in which fluctuations occur depends upon the distance from the outlets of the Mackenzie River and the frequency and direction of storms. Salinities may range from 20 to 30‰ and temperatures may reach 7°C in the open water season.

Much of this zone is located in an area of intense scouring, where ice keels mechanically disturb the bottom. Although scouring occurs in depths of 10 to 60 m, it is more intense on bottoms of 20 to 40 m depth.

The bottom is a mosaic of unscoured areas, recently scoured areas, and scoured areas in various stages of recovery. Biomass (Fig. 3) which averages about 5g m^{-2}, is higher than that of the Estuarine Zone, but may be diminished in this zone by the removal of part of the substrate from productivity. Consequently, biomass as represented by fauna collected by grab may relate directly to the proportion of unscoured bottom in the zonal area. Motile species may invade the scoured areas, but their contribution to biomass may be no more than 1 or 2g m^{-2} as determined on unscoured bottoms at *Pisces IV* stations in Thetis Bay.

Diversity (Fig. 2) which varies from 20 to 40 species is greater than in the Estuarine Zone and this is easily explained by the presence of species from both Marine and Estuarine Zones. Some species may be well adapted to the fluctuating conditions that occur, and these species could be considered as representative, since they are most abundant in this zone. Examples of such species are: *Artacama proboscidea, Portlandia arctica,* and *Trochochaeta carica.* Echinoderms occur in this zone.

7.3 Marine Zone

This zone (Fig. 10) occupies over half of the shelf area in depths of water from 30 to 200 m. Salinities range from 30.1 to 32.8‰, and temperatures are negative from -0.1° to -1.58°C.

Stations located in the eastern part of the zone have the highest diversity (Fig. 2), with 81 species, and the greatest biomass (Fig. 3) with 71g m^{-2}. The average biomass for the eastern sector is 34g m^{-2}; for the central sector, 3g m^{-2}; and the the western sector, 6g m^{-2}. Average biomass for the entire zone is 14g m^{-2}. This zone is more representative of sea bottoms in the Canadian arctic, but diversity and biomass appear to be lower than at eastern arctic stations by at least a factor of 2 (Frobisher Bay, unpublished data). The reasons for the differences are not presently known, but nutrient supply may be one of the factors. Nutrient enrichment is a probable explanation for the higher diversity and biomass in the eastern and western sectors of the Beaufort Sea shelf.

Most stations have over 20 species and very few of the species of this zone are encountered in the Estuarine Zone with salinity the probable limiting factor. Some species that are typical of the Marine Zone are: *Maldane sarsi, Aricidea suecica, Paraonis gracilis, Onuphis conchylega, Haploops laevis, Pectinaria* *hyperborea*, *Mesidotea sabini*, *Astarte borealis*, *Astarte montagui*, *Macoma calcarea*, and the three species of *Musculus*. Echinoderms are well represented in this zone.

7.4 Continental Slope Zone

This zone is encountered at a water depth of about 200 m (Fig. 10). The range of station depths is 215 to 444 m. The depth of the lower limit was not determined from present sampling, but it is considered to be 900 m (Coachman, 1962). The layer of water between 200 to 900 m which covers the bottoms of the continental slope is regarded as Atlantic Ocean water sandwiched between the basin waters and surface waters of the Arctic Ocean.

Bottom salinities (34.31 to 34.81‰) and temperatures (-0.31° to 0.40°C) are slightly higher than those of the surface waters which cover the bottom of the Marine Zone.

Average biomass (Fig. 3) for the Continental Slope Zone is 4g m^{-2}, lower than the average for the Marine Zone. Diversity (Fig. 2) is over 20 species, as is the case in the Transitional and Marine Zones, but it is less than that in the eastern sector of the Marine Zone. Nutrients are again regarded as the major factor in regulating diversity and biomass in this zone.

The fauna of the slope is distinguished, not so much by the exclusion of species from the Marine Zone, but rather, by the presence of species that are absent or rare in the fauna of the shelf. Examples of species that fall into this category are: *Onuphis quadricuspis*, *Laonice cirrata*, *Haploops tubicola*, *Hippomedon abyssi*, *Gnathia stygia*, solenogasters, *Siphonodentalium lobatum*, *Priapulus bicaudatus*, and *Phascolion strombi*.

7.5 Summation of Data

Zone	Water depth (m)	Salinity (‰)	Temperature (°C)	No. of species per station	Biomass Range ($g\ m^{-2}$)	Biomass Average ($g\ m^{-2}$)
Estuarine	0-15	0.1-20	up to 16.6	1-32 usually <20	0.1-20	2
Transitional	15-30	20-30	7.0 to -1.58	20-40	1-20	5
Marine	30-200	30-33	-0.1 to -1.58	3-81	1-72	14
Continental Slope	200-900	34-35	-0.31 to 0.40	31-53	1-8	4

8. CONCLUSIONS

The zonation of the sea bottom of the Beaufort Sea shelf has resulted largely from the influence of large amounts of fresh water from the Mackenzie River, mixing with marine waters to produce an Estuarine Zone (about 25% of the shelf) with low salinities; a Transitional Zone (about 25% of the shelf) with fluctuating conditions and a scoured bottom; and a Marine Zone (about 50% of the shelf) with stable conditions that are representative of sea bottoms in most of the Canadian arctic. The presence of a Continental Slope Zone, while not a novelty, adds to the dimension of zonation of the Beaufort Sea shelf because of its proximity to an extensive estuarine area. The Estuarine Zone is displaced to the east along the Tuktoyaktuk Peninsula because of the effect of Coriolis Force and prevailing northwestern winds on the water from the Mackenzie River. The Transitional Zone is correspondingly displaced, but the zone is narrower along the peninsula than in the region north of Mackenzie Bay.

Diversity of zoobenthos is somewhat variable from station to station, but there are in general less than 20 species per station in the Estuarine Zone and 20 or more species at stations in the other zones. Stations with the highest diversity (maximum of 81 species) are located in the eastern and western part of the Marine Zone. Low diversity can result from unstable conditions, low nutrients, and intolerance to waters of low salinity.

Biomass of zoobenthos exhibits a pattern of distribution similar to that for diversity. The average biomass is about 2g m^{-2} in the Estuarine Zone, 5g m^{-2} in the Transitional Zone, 14g m^{-2} in the Marine Zone, and 4g m^{-2} in the Continental Slope Zone. The most productive area is the eastern part of the Marine Zone with an average of 34g m^{-2}. The richest area of the Estuarine Zone is the protected embayment, Mason Bay, with an average biomass of 5g m^{-2}. Average biomass of 6g m^{-2} for the entire study area appears to be low by a factor of perhaps 5 to 10 when compared with localities in the eastern arctic. As in the case of diversity, low salinities, unstable conditions, and nutrient supply are possible limiting factors to production within and across the zones.

9. IMPLICATIONS AND RECOMMENDATIONS

9.1 Scientific

The continental shelf of the southern Beaufort Sea is unusual compared to other areas of the Canadian Arctic, because no other area, with the possible exception of James Bay, has as extensive an estuarine system. Although the number and kinds of zoobenthic zones which are demonstrated here could be encountered elsewhere in the Canadian Arctic, the scale of the Estuarine and Transitional Zones would be greatly reduced and the predominating zone would exhibit characteristics similar to the Marine Zone of the southern Beaufort Sea. This is due to the absence of large rivers in other regions of the Canadian Arctic.

It should be understood that zoobenthos serve as a vital link in many complex food chains involving other invertebrates, fish, birds and mammals. The relative abundance and welfare of zoobenthic invertebrates depend upon the condition of the substrate as well as numerous other factors interacting in ways not completely understood.

Zoobenthic communities in the arctic are systems which change slowly, and the dynamic balance between organisms and environment is most vulnerable when the substrate is fouled through mechanical or, more seriously, through chemical disturbances. Intensive human intervention can have cumulative effects, and by the time damage to zoobenthos is detected, the viability and recuperative powers of organisms can be serious impaired. Recovery will not occur until the stress factors are removed.

In general, arctic zoobenthos have slower growth, greater longevity, and a lower turnover rate than their counterparts in more temperate regions. Reestablishment of the mature community from a damaged state may take up to twelve years, based on the age of the estuarine bivalve, *Yoldiella intermedia* (unpublished data), and if the substrate has been poisoned chemically additional time would be needed for conditioning of substrate before reinvasion of zoobenthos occurs.

9.2 Offshore drilling

The extent of potential damage to zoobenthos depends upon the zone in which operations occur, the nature of the operations, and the combination of circumstances that result in the event of a spill or blowout.

An assessment of potential damage to zoobenthos can be made with reference to biomass per area and size of area that is jeopardized. The destruction of a few hundred square meters of substrate with its zoobenthos is insignificant, but destruction on a scale of several hundred square kilometers could be disruptive and if massive damage occurs in the relatively rich embayments, the consequences may extend beyond the destruction of only zoobenthos. At the present time information is not available to determine the critical size of an area or amount of zoobenthos that when damaged would be injurious in measurable ways to other components of the ecosystem as well as to the food chains within the zoobenthic system.

Exploratory drilling poses little threat to zoobenthos at the drilling site. Accumulation of toxic drilling muds may cause local damage to zoobenthos of 20 kg ha^{-1} (2g m^{-2}) of biomass in the Estuarine Zone and 340 kg ha^{-1} (34g m^{-2}) of biomass in the eastern sector of the Marine Zone. Using an average biomass value of 6g m^{-2} for the entire shelf, damage could be assessed at 60 kg ha^{-1}.

In the event of a blowout at the drill site, damage to zoobenthos would be no greater than that incurred from dumping of drilling muds, but in the event of a massive spill, oil, on the surface of the water and entrapped in or under the ice, may be transported to inshore areas of the Estuarine Zone where it would saturate the substrate of the shore and intertidal zone. Bottoms along shore in less that 2 m of water have an impoverished fauna because of an unstable habitat influenced by 8 to 10 months of ice cover. Damage to zoobenthos in this intertidal area would be minor or non-existent.

If, in some way, bottoms of embayments at depths greater than 2 m became saturated with oil, then biomass damage could be assessed at 50 kg ha^{-1}, based on an average of 5g m^{-2} for Mason Bay. Potential damage to zoobenthos would be greatest in embayments because these productive areas would be in closest proximity to large quantities of oil for the longest period of time.

9.3 Recommendations

Exploratory drilling in the southern Beaufort Sea would result in minor damage to zoobenthos. Dumping of drilling muds at a few drill sites and an occasional oil spill would not jeopardize the continued existence of zoobenthos in the area, but necessary precautions should be taken to minimize damage during operation, as a matter of principle.

10. NEED FOR FURTHER STUDIES

10.1 Identification of existing gaps of knowledge

The Arctic is one of the few remaining areas of the world where there is an opportunity to obtain baseline data before man through his intervention alters the environment before evaluating the possible consequences of his actions. Comprehensive data are not presently available, and efforts should be made to obtain adequate information before exploration and development progress too far.

Needed studies are listed below:

a. Comprehensive survey of Canadian Arctic to determine abundance and distribution of zoobenthos.

b. Assessment of factors that determine or regulate abundance and distribution of zoobenthos.

c. Investigation of the nature of the role of zoobenthos in the ecosystem.

d. Investigation of the energy relationship of zoobenthos in the ecosystem.

10.2 Proposal for Additional Studies

a. Collection of additional grab samples from the Transitional and Marine Zones would provide data for refining estimates of biomass in order to better delineate the more productive areas of these two zones.

b. Sampling of sparsely distributed species from all zones would provide information for determining if these species contribute significantly to biomass.

c. Further analysis of data may provide insight into the major factors that govern abundance and distribution of zoobenthos across the continental shelf.

11. REFERENCES

Berkeley, E. and C. Berkeley. 1956. On a collection of polychaetous annelids from Northern Banks Island, from the South Beaufort Sea, and from Northwest Alaska; together with some new records from the east coast of Canada. J. Fish. Res. Bd. Canada 13(2): 233-246.

Berkeley, E. and C. Berkeley. 1962. Polychaeta from British Columbia; with a note on some Western Canadian Arctic forms. Canadian J. Zool. 40: 571-577.

Bray, J. 1962. Zoogeograhpy and systematics of isopods of the Beaufort Sea. M.Sc. Thesis, McGill University, Montreal, P.Q. 138 p.

Calder, D. R. 1970. Thecate hydroids from the shelf water of northern Canada. J. Fish. Res. Bd. Canada 27(9): 1501-1547.

Calder, D. R. 1972. Some athecate hydroids from the shelf water of northern Canada. J. Fish. Res. Bd. Canada 29(3): 217-228.

Carey, A. G. Jr., R. E. Ruff, J. G. Castillo and J. J. Dickinson, 1974. Benthic ecology of the western Beaufort Sea continental margin: Preliminary results. *In*: John C. Reed and John E. Sater [Eds.]. The coast and shelf of the Beaufort Sea. Arctic Institute of North America, Arlington, Virginia. p. 665-680.

Coachman, L. K. 1962. Water masses of the Arctic. *In*: Proceedings of the Arctic Basin Symposium, October 1962. Arctic Institute of North America. p. 143-172.

Hedgpeth, J. W. 1963. Pycnogonida of the North American Arctic. J. Fish. Res. Bd. Canada 20(5): 1315-1348.

Lubinsky, Irene. 1972. Canadian Arctic marine bivalve molluscs. Ph.D. Thesis. McGill University, Montreal, P.Q. 345 pp. + illus.

Macpherson, Elizabeth. 1971. The marine molluscs of Arctic Canada. Nat. Mus. Canada, Publ. Biol. Ocean. No. 3: 1-149.

Mac Ginitie, G. E. 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithsonian Misc. Coll. 128(9): 1-201.

Powell, N. A. 1968. Bryozoa (Polyzoa) of Arctic Canada. J. Fish. Res. Bd. Canada 25(11): 2269-2320.

Squires, H. J. 1969. Decapod crustacea of the Beaufort Sea and arctic waters eastward to Cambridge Bay, 1960-65. J. Fish. Res. Bd. Canada 26(7): 1899-1918.

Thorson, G. 1957. Bottom communities. *In*: J. W. Hedgpeth [Ed.]. Treatise on marine ecology and paleoecology. Vol I, Ecology. Memoir 67, Geological Society of America, N. Y. p. 461-534.

Wacasey, J. W. 1974. Zoobenthos of the southern Beaufort Sea. *In*: John C. Reed and John E. Sater [Eds.] The coast and shelf of the Beaufort Sea. Arctic Institute of North America, Arlington, Virginia. p. 697-704.

Wagner, F. J. E. 1974. Benthonic foraminifera and mollusca in the Beaufort Sea. *In*: Report of activities Part B. November 1973 to March 1974. Geol. Survey Can., Paper 74-1, Part B, p. 130.

12. APPENDICES

Table 1. Coordinates of stations sampled in the Beaufort Sea, 1971-1975.

Station Number	North Latitude	West Longitude
71-501	69°24.4'	132°58.9'
71-502	69°49.3'	132°41.5'
71-503	69°58.4'	132°57'
71-504	70°16'	131°40'
71-505	70°13.2'	131°06'
71-506	69°59.4'	129°13.2'
73-526	69°23.7'	132°59.6'
73-527	69°30'	133°15'
73-528	69°50'	132°22'
73-529	70°01'	131°26'
73-530	70°11'	130°50'
73-531	70°23'	130°01'
73-532	70°43'	130°14'
73-533	70°56'	130°14'
73-534	69°43'	133°06'
73-535	69°40'	133°53'
73-536	69°50'	134°30'
73-537	69°48'	135°17'
73-538	69°33'	136°00'
73-539	69°17'	136°34'
73-540	69°02'	137°12'
73-541	69°14'	137°54'
73-542	69°32'	138°18'
74-544	70°33.4'	131°42.8'
74-545	70°23.2'	131°42.8'
74-546	69°56.6'	133°27.1'
74-547	70°18'	135°10.2'
74-548	70°08.1'	135°34.3'
74-549	69°56.2'	135°47.8'
74-550	70°21.1'	136°36.3'
74-551	70°06.9'	136°50.2'
74-552	69°56.2'	137°04.7'
74-553	70°05.4'	139°08.2'
74-554	69°47.4'	138°55.7'
74-555	69°44.9'	139°36.7'
74-556	69°27'	138°48.5'
74-557	69°36.3'	138°21'
74-558	69°32.8'	136°58.1'
74-559	69°59.7	135°21'
74-243	69°39.2'	138°18.4'

Table 1 (cont'd.)

Station Number	North Latitude	West Longitude
75-565	70°08'	132°37'
75-566	70°06'	138°56'
75-568	70°14'	139°04'
75-569	70°14'	139°04'
75-570	70°42'	134°45'
75-571	70°02'	135°34'
75-572	70°56'	132°33'
75-573	71°22'	130°24'
75-574	70°07'	132°17'
75-575	69°33'	138°56'
75-604	69°32.3'	133°52.5'
75-605	69°30.3'	133°55'
75-606	69°31.8'	133°57'
75-607	69°34.3'	134°09'
75-608	69°32.3'	134°09.4'
75-609	69°32.9'	134°07.5'
75-610	69°33.5'	134°05'
75-611	69°34.3'	134°03'
75-612	69°35.9'	133°58.5'
75-613	69°38.5'	133°55'
75-337	69°30.2'	138°52.3'
75-339	69°32.2'	138°53.4'
75-341	69°29'	138°30.9'
A	69°34.3'	138°56'
B	69°34'	138°57'
C	69°21'	138°43'
D	69°17'	138°32'
E	69°07'	137°57'
G	69°00.5'	137°13'
1	69°14.5'	138°29'
4	69°15.5'	138°28'
25	69°20.5'	138°42'
26	69°20.5'	138°44'
27	69°21'	138°40'
31	69°34.2'	138°56'
34	69°34'	138°53'
41	69°18'	138°24'
100	69°06.5'	137°57'
104	68°59	137°21'
107	68°58'	137°13'
114	69°06'	137°58.5'
200	69°04.8'	137°56'

Table 2. Associated data for stations sampled in the Beaufort Sea, 1971-1975.

Station	Date	Time (PST)	Time (GMT)	No. of grabs	Sampled area (m^2)	Depth (m)	Temp. (°C)	Sal. (‰)
71-501	17 Jul 71	1945	0345	6	0.39	24	2.47	26.91
71-502	18 Jul 71	1810	0210	6	0.39	10	2.05	26.61
71-503	19 Jul 71	1114	1914	6	0.39	19	-1.10	30.70
71-504	19 Jul 71	0735	1535	6	0.39	38	-1.25	31.58
71-505	19 Jul 71	1315	2115	6	0.39	17	-0.95	31.34
71-506	20 Jul 71	1350	2150	6	0.39	13	3.1	26.69
73-526	20 Jul 73	0945	1745	5	0.25	8	4.6	16.5
73-527	20 Jul 73	1415	2215	5	0.25	5	10.0	5.0
73-528	22 Jul 73	1415	2215	5	0.25	7	8.0	6.9
73-529	22 Jul 73	1810	0210	5	0.25	12	7.0	9.6
73-530	23 Jul 73	0800	1600	5	0.25	9	6.6	12.7
73-531	23 Jul 73	1240	2040	5	0.25	15	6.3	15.5
73-532	23 Jul 73	1800	0200	5	0.25	36	-0.5	32.4
73-533	23 Jul 73	2130	0530	5	0.25	42	-0.8	32.8
73-534	24 Jul 73	1545	2345	5	0.25	7	5.4	9.3
73-535	25 Jul 73	1600	2400	5	0.25	6	6.3	7.8
73-536	25 Jul 73	1930	0330	5	0.25	9	2.8	13.0
73-537	25 Jul 73	2245	0645	5	0.25	9	0.6	24.4
73-538	26 Jul 73	1115	1915	5	0.25	5	8.5	4.6
73-539	26 Jul 73	1500	2300	5	0.25	3	16.6	0.1
73-540	26 Jul 73	1950	0350	5	0.25	4	8.7	10.5
73-541	27 Jul 73	1140	1940	5	0.25	34	-0.1	30.1
73-542	27 Jul 73	1730	0130	5	0.25	94	-1.3	32.3
74-544	27 Aug 74	0830	1630	4.5	0.29	41	-1.50	31.13
74-545	27 Aug 74	1140	1940	4	0.26	37	-1.51	30.99
74-546	27 Aug 74	1945	0345	4	0.26	21	-1.54	30.12
74-547	28 Aug 74	2245	0645	4	0.26	56	-1.44	31.96
74-548	29 Aug 74	2245	0645	4	0.26	44	-1.53	31.46
74-549	30 Aug 74	0715	1515	4	0.26	24	-1.58	30.42
74-550	30 Aug 74	1620	0020	4	0.26	58	-1.41	32.13
74-551	30 AUG 74	2220	0620	4	0.26	42	-1.53	31.66
74-552	31 Aug 74	0715	1515	4	0.26	40	-1.50	32.16
74-553	31 Aug 74	2230	0630	3.5	0.32	215	-0.31	34.31
74-554	1 Sep 74	0915	1715	3.5	0.32	106	-1.49	32.45
74-555	1 Sep 74	1230	2030	3.5	0.29	34	-1.54	32.00
74-556	1 Sep 74	1745	0145	4	0.26	54	-1.58	32.40
74-557	2 Sep 74	0915	1715	3	0.27	125	-1.49	32.50
74-558	2 Sep 74	1330	2130	4	0.26	23	-1.55	30.07
74-559	2 Sep 74	1930	0330	4	0.26	32	-1.57	30.94
74-243	5 Sep 74	0800	1600	-	-	135	-	-

Table 2 (cont'd.)

Station	Date	Time (PST)	Time (GMT)	No. of grabs	Sampled area (m^2)	Depth (m)	Temp. (°C)	Sal. (‰)
75-565	17 Jun 75	1600	2400	4	0.25	31	-1.56	31.60
75-566	5 Jul 75	1930	0330	4	0.25	318	0.00	34.61
75-568	18 Jul 75	1845	0245	4	0.25	408	0.40	34.55
75-569	5 Aug 75	0145	0945	3	0.25	441	0.37	34.81
75-570	5 Aug 75	1400	2200	3	0.25	55	-1.44	31.55
75-571	6 Aug 75	1410	2210	3	0.25	37	-1.54	31.68
75-572	7 Aug 75	1200	2000	3	0.25	65	-1.49	32.27
75-573	7 Aug 75	2130	0530	3	0.25	70	-1.47	32.38
75-574	8 Aug 75	1045	1845	3	0.25	32	-0.17	>29.15
75-575	9 Aug 75	1245	2045	3	0.25	10	3.67	21.82
75-604	13 Jul 75	0915	1715	4	0.25	4	7.50	4.09
75-605	13 Jul 75	1430	2230	4.5	0.30	15	-0.28	15.44
75-606	13 Jul 75	1815	0215	4.5	0.30	15	-0.29	11.60
75-607	14 Jul 75	1030	1830	4.5	0.30	26	1.53	18.41
75-608	14 Jul 75	1410	2210	4.5	0.30	4	8.50	10.61
75-609	14 Jul 75	1610	0010	4.5	0.30	11	1.32	18.08
75-610	14 Jul 75	1845	0245	4.5	0.30	18	1.50	18.37
75-611	15 Jul 75	1050	1850	4.5	0.30	3	10.02	3.94
75-612	17 Jul 75	1050	1850	4.5	0.30	7	12.20	<2.8
75-613	17 Jul 75	1225	2025	4.5	0.30	4	7.37	18.28
75-337	2 Sep 75	0800	1600	-	-	55	-	-
75-339	3 Sep 75	0900	1700	-	-	30	-	-
75-341	4 Sep 75	1030	1830	-	-	20	-	-
A	13 May 75	-	-	3	.07	6	-0.8	10.5
B	10 May 75	-	-	3	.07	9	-1.2	22.0
C	16 May 75	-	-	3	.07	7	-1.0	13.1
D	16 May 75	-	-	3	.07	7	-1.1	2.2
E	12 May 75	-	-	3	.07	16	-1.8	30.1
G	17 May 75	-	-	3	.07	4.5	-0.2	<1.0
1	24 Jul 75	-	-	10	.23	1.4	9.1	7.5
4	24 Jul 75	-	-	10	.23	1.3	9.1	8.1
25	23 Jul 75	-	-	10	.23	2.5	9.1	8.0
26	18 Jul 75	-	-	10	.23	2.5	2.5	>40.0
27	23 Jul 75	-	-	10	.23	12.5	1.0	26.2
31	20 Jul 75	-	-	10	.23	3.5	6.3	16.4
34	21 Jul 75	-	-	10	.23	3	6.5	18.8
41	24 Jul 75	-	-	10	.23	1.8	9.0	8.1
100	17 Jul 75	-	-	10	.23	13	1.0	28.3
104	16 Jul 75	-	-	10	.23	3	0.3	26.2
107	16 Jul 75	-	-	10	.23	2.8	1.6	27.5
114	29 Jul 75	-	-	10	.23	2.6	9.7	37.6
200	30 Jul 75	-	-	5	.12	3.0	9.8	3.5

Table 3. Species of invertebrates collected from all stations in the Beaufort Sea, 1971-1975.

Species	No.	Species	No.
ANNELIDA:Hirudinea	1	*Euchone papillosa*	
Leech		*Eucranta villosa*	
		Exogone naidina	
ANNELIDA:Oligochaeta	1	*Flabelligera mastigophora*	
Peloscolex sp.		*Gattyana cirrosa*	
		Glyphanostomum pallescens	
ANNELIDA:Polychaeta	101	*Harmothoe extenuata*	
Aglaophamus malmgreni		*Harmothoe imbricata*	
Ammotrypane breviata		*Harmothoe nodosa*	
Ammotrypane cylindricaudatus		*Hartmania moorei*	
Ampharete acutifrons		*Heteromastus filiformis*	
Ampharete arctica		*Lanassa nordenskioldi*	
Ampharete vega		*Laonice cirrata*	
Amphicteis sundevalli		*Leaena abranchiata*	
Amphitrite groenlandica		*Leiochone polaris*	
Antinoella sarsi		*Lumbriclymeme* sp.	
Apistobranchus tullbergi		*Lumbrineris fragilis*	
Aricidea suecica		*Lumbrineris minuta*	
Aricidea sp.		*Lumbrineris tenuis*	
Artacama proboscidea		*Lysippe labiata*	
Autolytus sp.		*Malacoceros fuliginosus*	
Brada villosa		*Maldane sarsi*	
Brada sp.		*Melinna cristata*	
Branchiomma infarcta		*Micronephthys minuta*	
Capitella capitata		*Myriochele heeri*	
Chaetozone setosa		*Nephtys ciliata*	
Chaetozone sp.		*Nephtys paradoxa*	
Chitinopoma fabricii		*Nephtys longosetosa*	
Chone duneri		*Nereimyra aphroditoides*	
Chone infundibuliformis		*Nereis zonata*	
Chone sp.		*Nicolea* sp.	
Cirratulid ?		*Onuphis conchylega*	
Cirratulus cirratus		*Onuphis quadricuspis*	
Cossura longocirrata		*Orbinia* sp.	
Diplocirrus glaucus		*Owenia fusiformis*	
Dysponetus pygmaeus		*Paraonis gracilis*	
Enipo torelli		*Paraonis* sp. b.	
Ephesiella biserialis		*Pectinaria hyperborea*	
Ephesiella minuta		*Petaloproctus tenuis*	
Eteone longa		*Pholoe minuta*	
Euchone analis			

Table 3 (cont'd.)

Species	No.	Species	No.
ANNELIDA:Polychaeta			
Phyllodoce groenlandica		*Arrhis phyllonyx*	
Phyllodoce mucosa		*Atylus carinatus*	
Pista maculata		*Bathymedon obtusifrons*	
Polydora caeca		*Boeckosimus affinis*	
Polydora caulleryi		*Boeckosimus plautus*	
Polydora quadrilobata		*Byblis gaimardi*	
Potamilla neglecta		*Centromedon calcaratus*	
Praxillella affinis		*Cercops holbolli*	
Praxillella praetermissa		*Corophium* sp.	
Praxillura sp.		*Dulichia porrecta*	
Prionospio cirrifera		*Ericthonius tolli*	
Prionospio steenstrupi		*Gammaracanthus loricatus*	
Pseudoscalibregma sp.		*Gammaropsis maculata*	
Rhodine loveni		*Gammarus oceanicus*	
Sabellides borealis		*Gammarus setosus*	
Sabellides octocirrata		*Guernea nordenskioldi*	
Scalibregma inflatum		*Haploops laevis*	
Scoloplos armiger		*Haploops tubicola*	
Scoloplos sp.		*Harpinia serrata*	
Sphaerodorum gracile		*Harpinia* sp.	
Spiochaetopterus typicus		*Hippomedon abyssi*	
Stauronereis caecus		*Hippomedon propinquus*	
Sternaspis scutata		*Hippomedon* sp.	
Syllis cornuta		*Ischyrocerus commensalis*	
Terebellides stroemi		*Ischyrocerus latipes*	
Tharyx acutus		*Ischyrocerus megalops*	
Trochochaeta carica		*Lembos arcticus*	
		Melita formosa	
ARTHROPODA:Amphipoda	67	*Melita* sp.	
Acanthostepheia behringiensis		*Metopa bruzelii*	
Acanthostepheia malmgreni		*Metopa* sp.	
Aceroides l. latipes		*Metopella nasuta*	
Aceroides sp.		*Monoculodes longirostris*	
Ampelisca eschrichti		*Monoculodes* sp.	
Ampelisca macrocephala		*Monoculopsis longicornis*	
Anonyx lilljeborgi		*Onisimus glacilis*	
Anonyx nugax		*Onisimus litoralis*	
Anonyx sarsi		*Orchomene pinguis*	
Anonyx sp.		*Paraphoxus oculatus*	
Argissa hamatipes		*Parathemisto abyssorum*	
Arrhinopsis longicornis		*Pardaliscella malygini*	
		Paroediceros lynceus	
		Paronesimus barentsi	

Table 3 (cont'd.)

Species	No.
ARTHROPODA:Amphipoda	
Photis reinhardi	
Pontoporeia affinis	
Pontoporeia femorata	
Priscillina armata	
Protomedeia fasciata	
Protomedeia grandimana	
Rachotropis sp.	
Tryphosella schneideri	
Tryphosella sp.	
Westwoodilla brevicalar	
Westwoodilla caecula	
Westwoodilla megalops	
ARTHROPODA:Cumacea	16
Brachydiastylis resima	
Cumella sp.	
Diastylis echinata	
Diastylis edwardsi	
Diastylis goodsiri	
Diastylis oxyrhyncha	
Diastylis rathkei	
Diastylis scorpioides	
Diastylis sulcata	
Eudorella emarginata	
Eudorella truncatula	
Eudorellopsis deformis	
Leucon acutirostris	
Leucon fulvus	
Leucon nasica	
Leucon nasicoides	
ARTHROPODA:Decapoda	2
*Eualus gaimardi belcheri**	
Sabinea septemcarinata	
ARTHROPODA:Isopoda	13
Desmosoma lineare	
Eugerda tenuimana	
Eurycope pygmaea	
Gnathia elongata	
Gnathia stygia	
Ilyarachna sp.	
Macrostylis spinifera	
Mesidotea entomon	
Mesidotea sabini	
Mesidotea sibirica	
Mesidotea sp.	
*Munnopsis typica**	
Synidotea bicuspida	
ARTHROPODA:Mysidacea	3
Mysis litoralis	
Mysis relicta	
Pseudomma sp.	
ARTHROPODA:Ostracoda	8
Cyprideis sorbyana	
Cythereis dunelmensis	
Cythereis sp. a	
Cythereis sp. b	
Cythereis sp. c	
Chtheridea sp.	
Philomedes globosus	
Philomedes sp.	
ARTHROPODA:Pycnogonida	1
Nymphon grossipes	
ARTHROPODA:Tanaidacea	10
Leptognathia longiremis	
Leptognathia sp. a	
Leptognathia sp. b	
Leptognathia sp. c	
Leptognathia sp. d	
Leptognathia sp. e	
Leptognathia sp. f	
Pseudotanais macrocheles	
Sphyrapus anomalus	
Typhlotanais finmarchicus	
ASCHELMINTHES:Nematoda	1
Nematode	
BRACHIOPODA	2
Atretia gnomon	

Table 3 (cont'd.)

Species	No.	Species	No.
BRACHIOPODA		Bryozoan	
Hemithyris psittacea		Bryozoan	
CHORDATA:Ascidiacea	4	MOLLUSCA:Aplacophora	2
Chelyosoma sp.		_Chaetoderma_ sp.	
Pelonaia corrugata		Solenogaster	
Rhizomolgula globularis			
Ascidian		MOLLUSCA:Gastropoda	33
		Admete couthouyi	
COELENTERATA:Anthozoa	4	_Alvania cruenta_	
Gersemia rubiformis		_Boreotrophon clathratus_*	
Anemone		_Boreotrophon pacificus_*	
Anemone		_Buccinum angulosum_	
Anemone		_Buccinum tenue_*	
		Cingula castanea	
COELENTERATA:Hydrozoa	2	_Colus togatus_*	
Halecium sp.		_Cylichna alba_	
Hydrozoan		_Cylichna occulta_	
		Cylichna sp.	
ECHINODERMATA:Asteroidea	4	_Haminoea solitaria_	
Ctenodiscus crispatus		_Hydrobia minuta_	
_Icasterias panopla_*		_Lunatia pallida_	
_Solaster papposus_*		_Margarites costalis_	
Urasterias lincki		_Margarites olivaceus_	
		Natica clausa	
ECHINODERMATA:Holothuroidea	4	_Neptunea heros_*	
Myriotrochus rinki		_Oenopota arctica_	
Holothuroid		_Oenopeta decussata_	
Holothuroid		_Oenopota elegans_	
Holothuroid		_Oenopota incisula_	
		Oenopota novajasemliensis	
ECHINODERMATA:Ophiuroidea	7	_Oenopota reticulata_	
Amphiura sp.*		_Oenopota turricula_	
_Gorgonocephalus arcticus_*		_Philine finmarchia_	
_Gorgonocephalus c. caryi_*		_Philine lima_	
_Ophiacantha bidentata_*		_Retusa obtusa_	
Ophiocten sericeum		_Solariella obscura_	
_Ophiopleura borealis_*		_Tachyrhynchus erosus_	
Ophiura robusta		_Tachyrhynchus reticulatus_	
		_Trichotropis borealis_*	
ECTOPROCTA	3	_Volutopsius deformis_* (shell)	
Alcyonidium gelatinosum			

Table 3 (cont'd.)

Species	No.
MOLLUSCA:Pelecypoda	36
Astarte borealis	
Astarte crenata	
Astarte montagui	
Bathyarca glacialis	
Clinocardium ciliatum	
Cyrtodaria kurriana	
Dacrydium vitreum	
Hiatella arctica	
Liocyma fluctuosa	
Lyonsia arenosa	
Macoma balthica	
Macoma calcarea	
Macoma moesta	
Macoma torelli	
Montacuta maltzani	
Musculus corrugatus	
Musculus discors	
Musculus niger	
*Mya pseudoarenaria** (shell)	
Mysella tumida	
Mytilus edulis	
Nucula belloti	
Nuculana minuta	
Nuculana pernula	
Pandora glacialis	
Pecten groenlandicus	
Periploma abyssorum	
Portlandia arctica	
Thracia myopsis	
Thyasira gouldi	
Yoldia h. hyperborea	
Yoldiella fraterna	
Yoldiella frigida	
Yoldiella intermedia	
Yoldiella lenticula	
Yoldiella tamara	
MOLLUSCA:Scaphopoda	1
Siphonodentalium lobatum	
NEMERTINA	2
Nemertean	
Nemertean	
PLATYHELMINTHES:Turbellaria	1
Turbellarian	
POGONOPHORA	1
Pogonophoran	
PORIFERA	1
Sponge	
PRIAPULIDA	3
Halicryptus spinulosus	
Priapulus bicaudatus	
Priapulus caudatus	
SIPUNCULIDA	3
Golfingia margaritacea	
Phascolion strombi	
Sipunculid	
TOTAL	337

*Observed from *Pisces IV* or collected by dredge.

Table 4. Number of species, density, and biomass of invertebrates collected by grab from stations in the Beaufort Sea, 1971-1975.

Station	Date	No. of species	Density (no. m^{-2})	Biomass (g m^{-2})
71-501	17 Jul 71	6	2125	0.04
71-502	18 Jul 71	32	2270	1.89
71-503	19 Jul 71	31	1185	2.59
71-504	19 Jul 71	32	1088	13.57
71-505	19 Jul 71	27	1665	2.67
71-506	20 Jul 71	62	5095	15.89
73-526	20 Jul 73	16	4752	0.95
73-527	20 Jul 73	11	1360	1.77
73-528	22 Jul 73	17	1456	0.40
73-529	22 Jul 73	34	4916	7.28
73-530	23 Jul 73	33	5336	1.42
73-531	23 Jul 73	47	3064	3.90
73-532	23 Jul 73	48	12296	51.25
73-533	23 Jul 73	61	8724	71.37
73-534	24 Jul 73	29	4908	3.52
73-535	25 Jul 73	20	5944	6.39
73-536	25 Jul 73	29	4320	5.40
73-537	25 Jul 73	26	4344	0.88
73-538	26 Jul 73	12	432	1.35
73-539	26 Jul 73	6	88	0.02
73-540	26 Jul 73	4	1012	0.14
73-541	27 Jul 73	45	1756	5.44
73-542	27 Jul 73	57	5764	11.79
74-544	27 Aug 74	71	4963	31.20
74-545	27 Aug 74	27	2044	12.53
74-546	27 Aug 74	21	1828	4.30
74-547	28 Aug 74	30	1744	3.01
74-548	29 Aug 74	28	2008	1.32
74-549	30 Aug 74	27	1052	7.86
74-550	30 Aug 74	47	1372	1.66
74-551	30 Aug 74	34	1052	2.70
74-552	31 Aug 74	31	1256	1.86
74-553	31 Aug 74	53	1125	3.76
74-554	1 Sep 74	55	552	1.03
74-555	1 Sep 74	50	1218	5.50
74-556	1 Sep 74	14	904	1.87
74-557	2 Sep 74	63	3970	10.22

Table 4 (cont'd.)

Station	Date	No. of species	Density (no. m^{-2})	Biomass (g m^{-2})
74-558	2 Sep 74	20	1296	1.95
74-559	2 Sep 74	30	1304	2.32
75-565	17 Jun 75	21	312	7.96
75-566	5 Jul 75	36	1356	3.57
75-568	18 Jul 75	32	1293	7.68
75-569	5 Aug 75	31	1024	0.82
75-570	5 Aug 75	18	244	6.40
75-571	6 Aug 75	22	492	1.74
75-572	7 Aug 75	3	11	37.53
75-573	7 Aug 75	81	2944	18.68
75-574	8 Aug 75	19	168	0.78
75-575	9 Aug 75	45	1320	4.28
75-604	13 Jul 75	17	8964	8.31
75-605	13 Jul 75	4	2849	0.04
75-606	13 Jul 75	15	14175	1.26
75-607	14 Jul 75	6	770	0.06
75-608	14 Jul 75	20	4021	2.63
75-609	14 Jul 75	13	1229	0.90
75-610	14 Jul 75	9	7144	0.54
75-611	15 Jul 75	19	11441	20.73
75-612	17 Jul 75	16	1501	7.93
75-613	17 Jul 75	13	4434	1.77
A	13 May 75	14	952	5.70
B	10 May 75	18	1232	14.39
C	16 May 75	4	84	0.44
D	16 May 75	11	896	1.67
E	12 May 75	9	266	0.68
G	17 May 75	2	28	0.21
1	24 Jul 75	8	3367	0.36
4	24 Jul 75	5	1026	0.09
25	23 Jul 75	4	32	2.39
26	18 Jul 75	3	14	0.01
27	23 Jul 75	25	459	5.28
31	20 Jul 75	15	1220	5.31
34	21 Jul 75	13	621	0.62
41	24 Jul 75	1	5	0.01
100	17 Jul 75	9	176	0.29
104	15 Jul 75	8	576	1.13
107	16 Jul 75	4	86	0.05
114	29 Jul 75	9	180	1.08
200	30 Jul 75	4	297	1.85

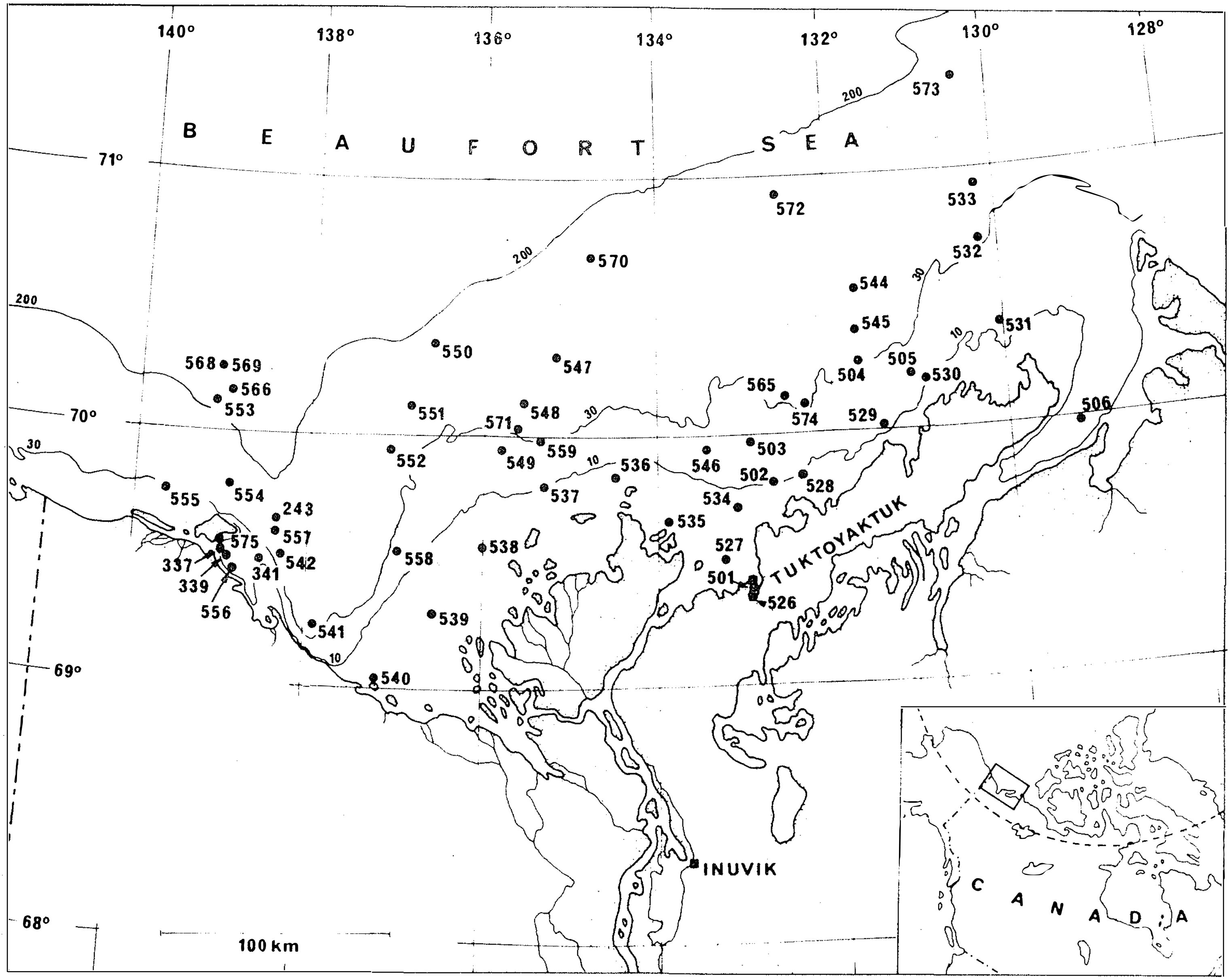

Fig. 1. Stations sampled in the Southern Beaufort Sea, 1971-1975 (annual prefix is omitted).

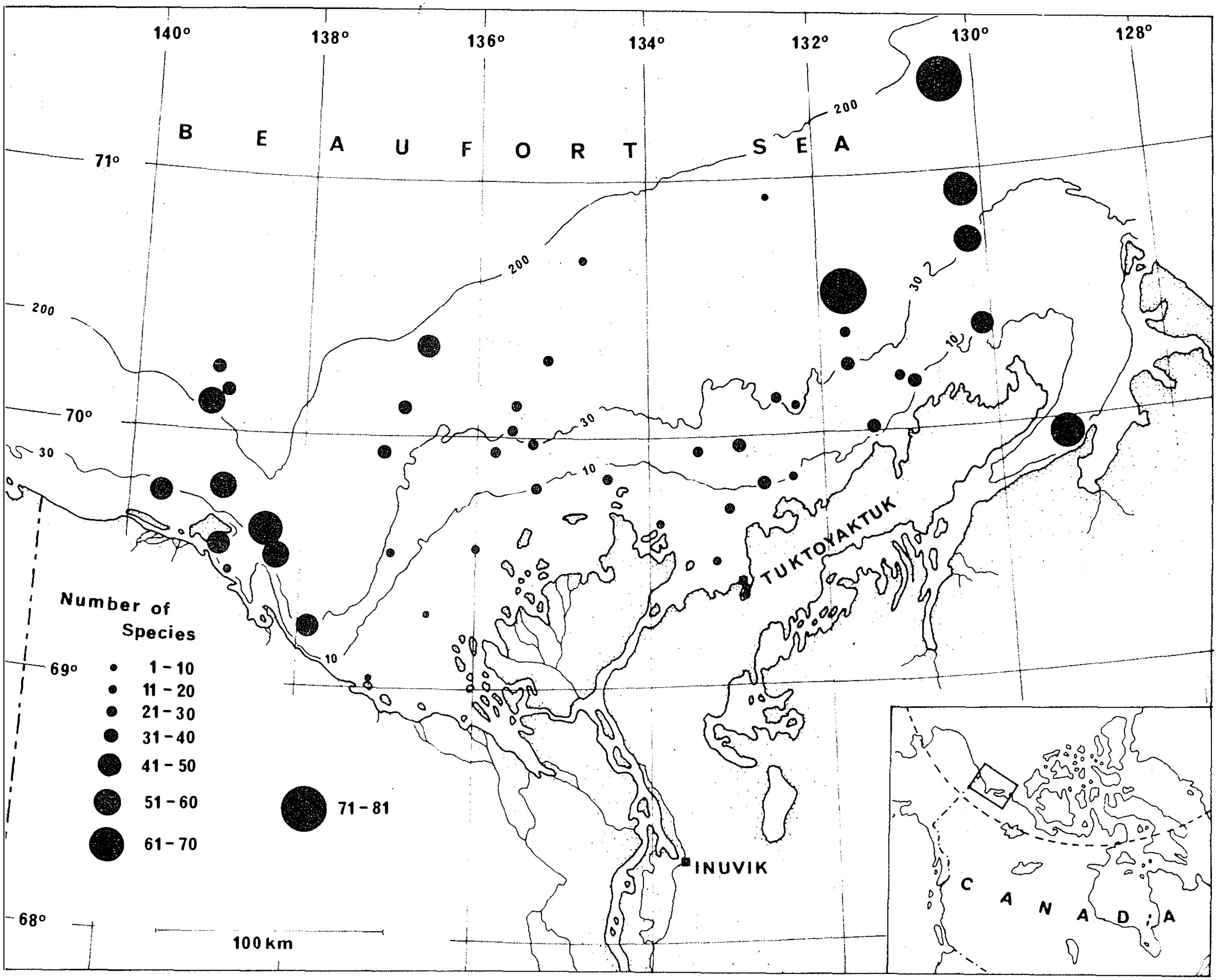

Fig. 2. Diversity of zoobenthos of the Southern Beaufort Sea.

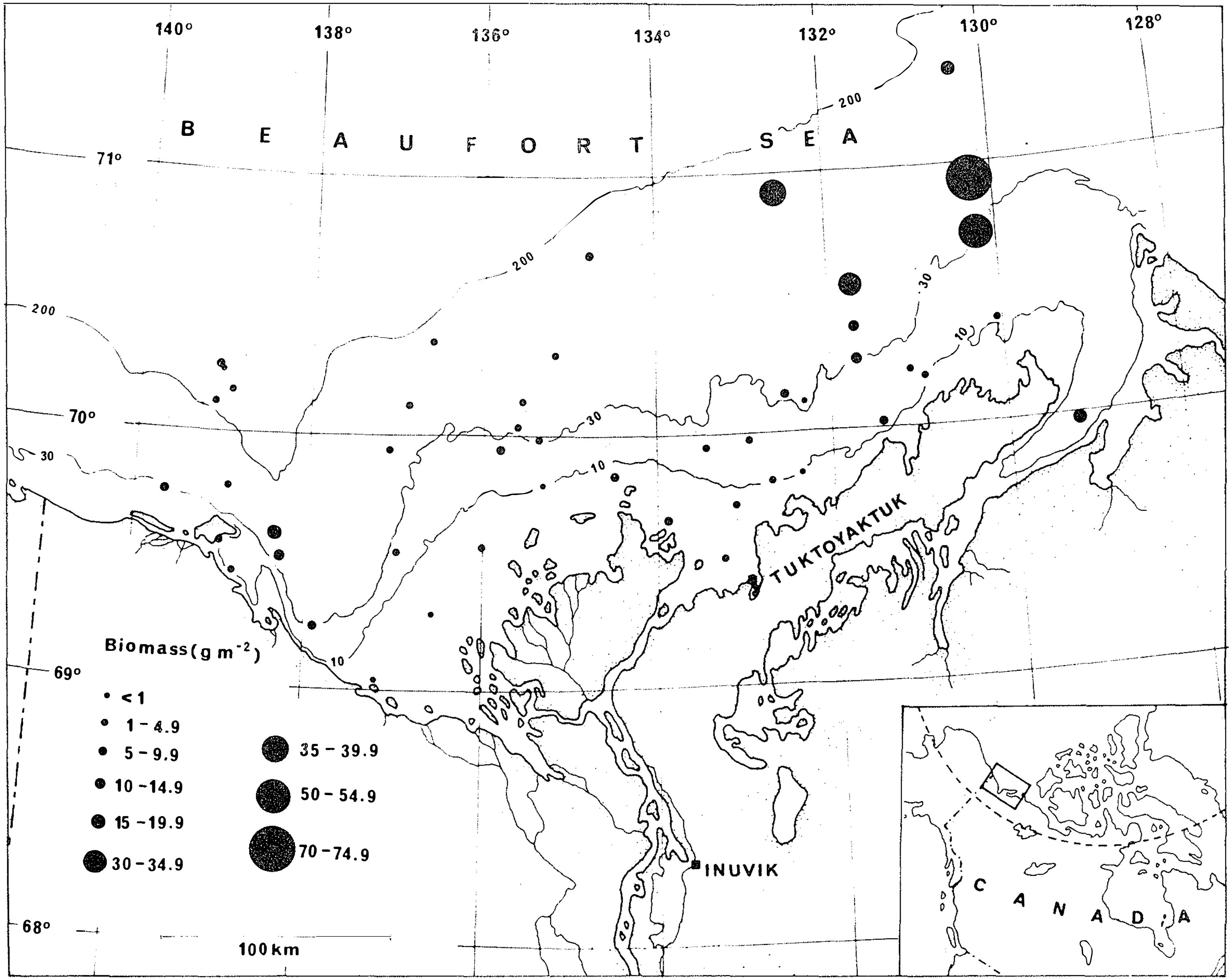

Fig. 3. Biomass of zoobenthos of the Southern Beaufort Sea.

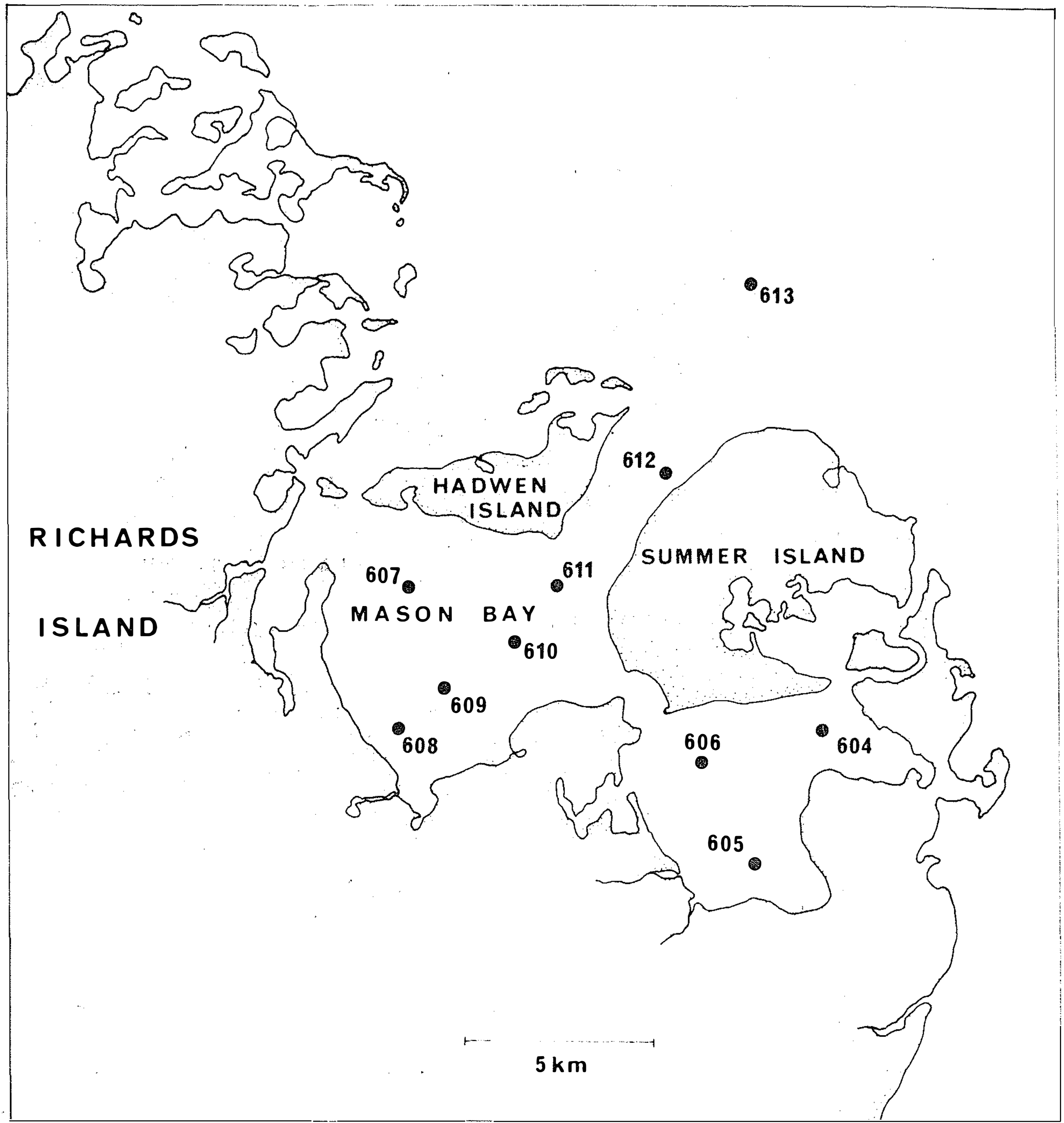

Fig. 4. Stations sampled in Mason Bay.

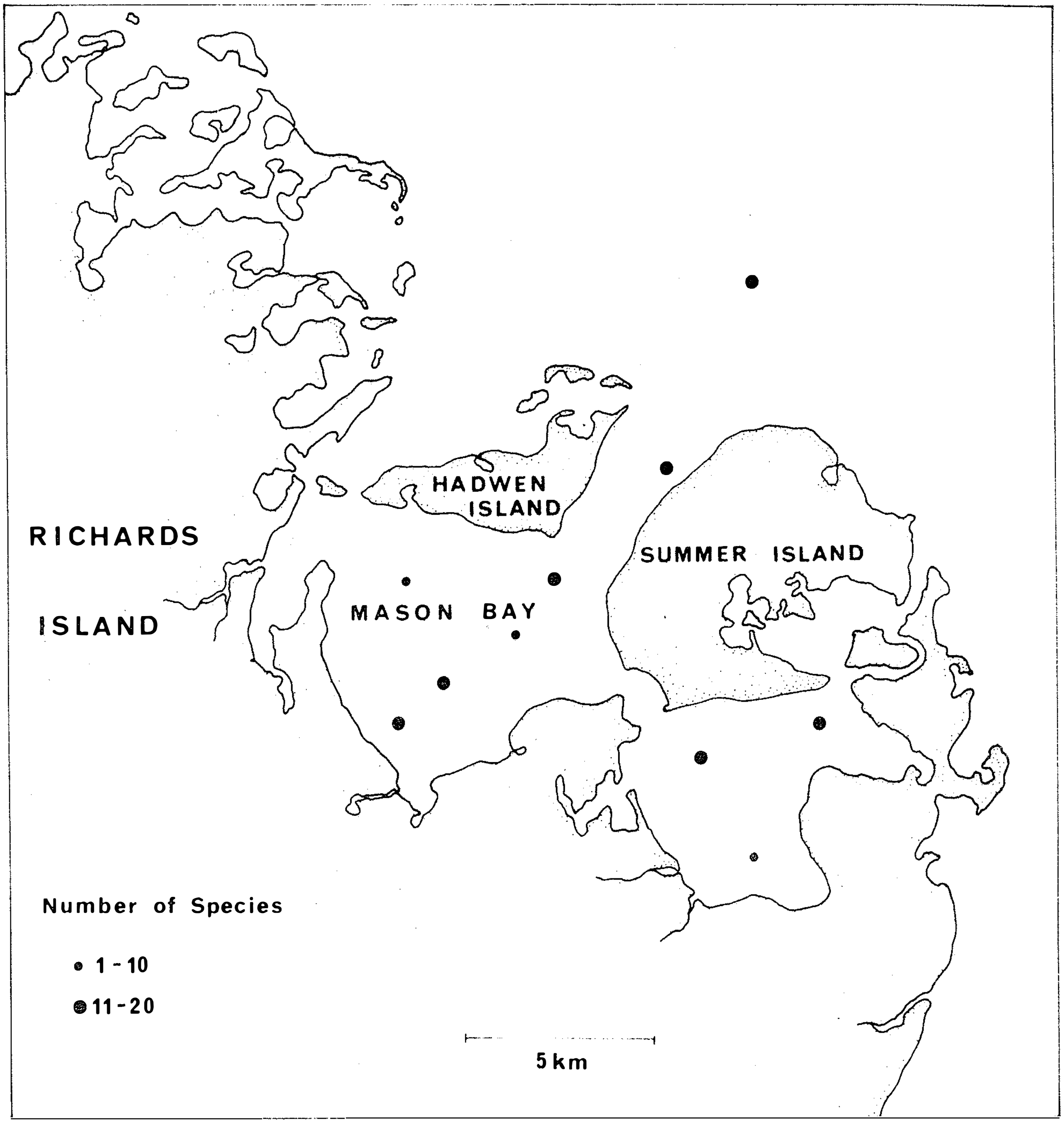

Fig. 5. Diversity of zoobenthos of Mason Bay.

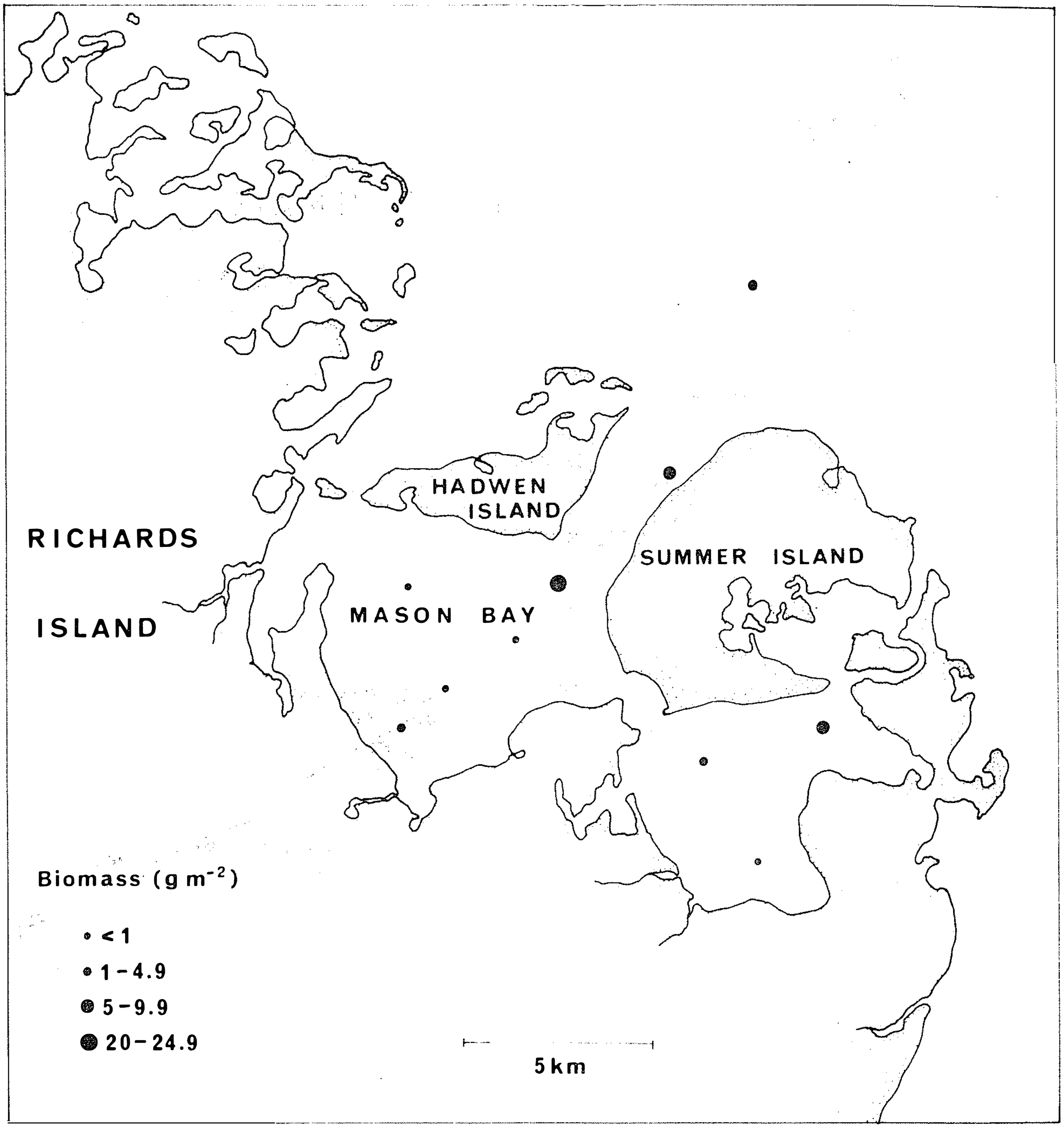

Fig. 6. Biomass of zoobenthos of Mason Bay.

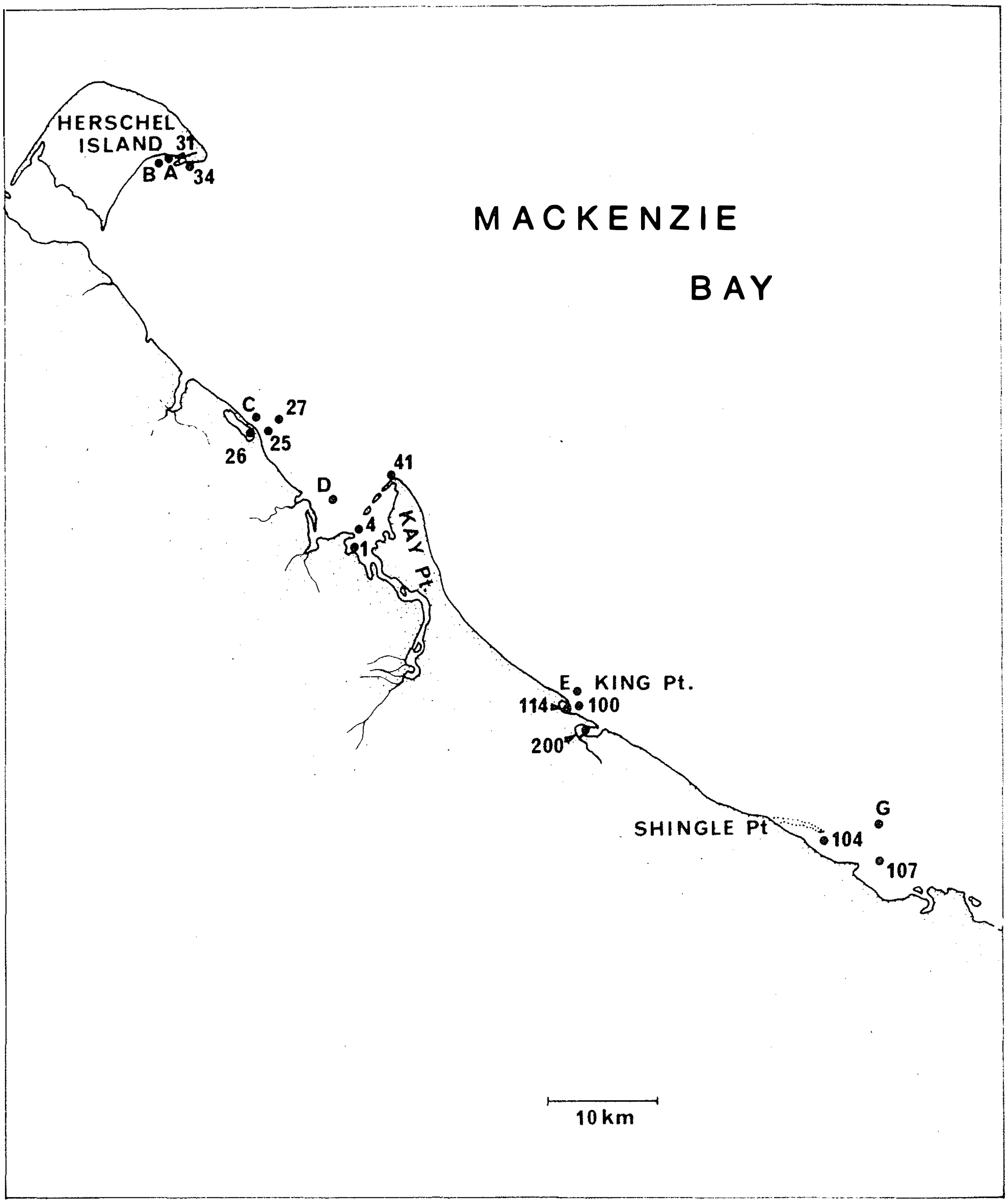

Fig. 7. Stations sampled along the Yukon Coast.

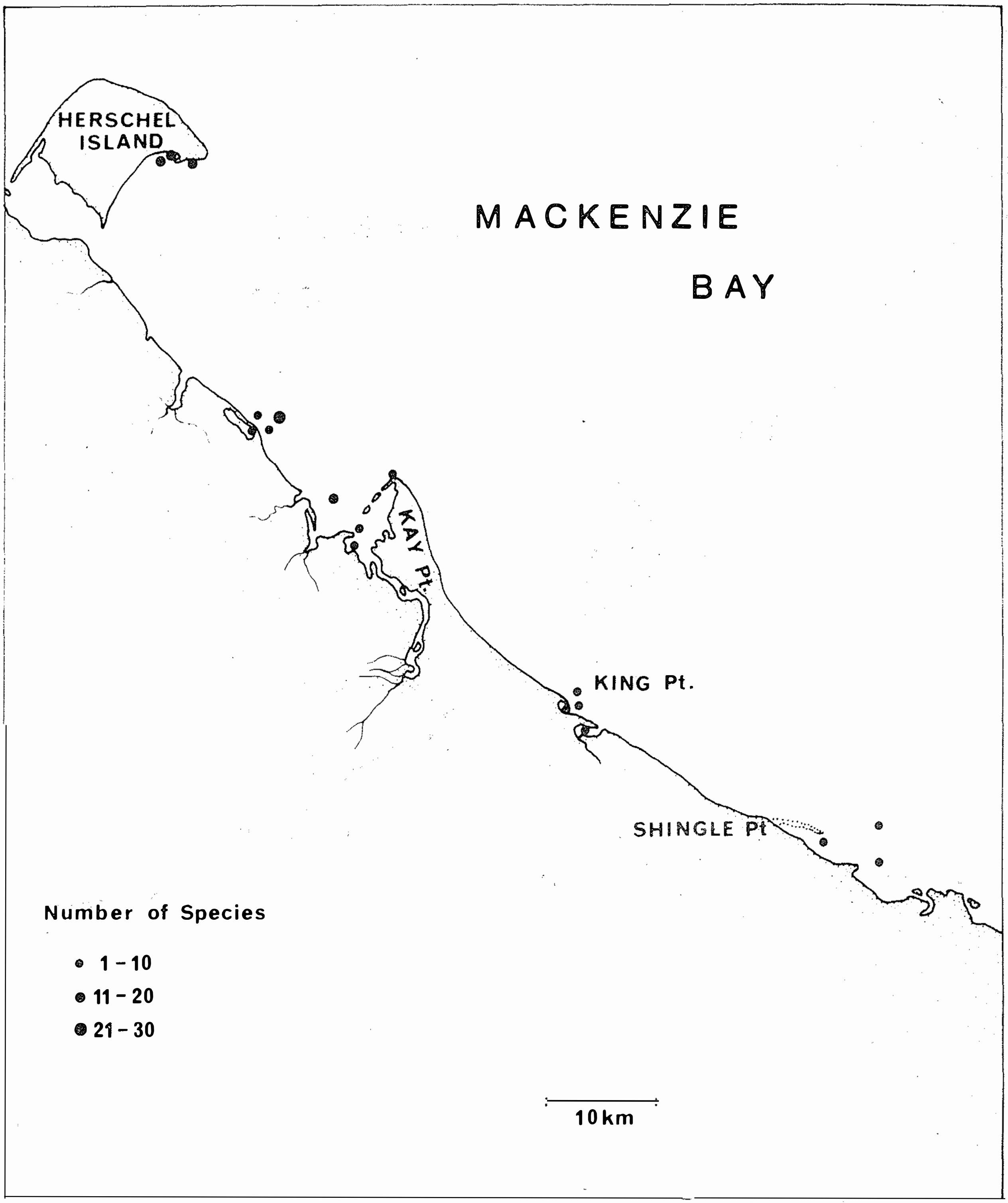

Fig. 8. Diversity of zoobenthos along the Yukon Coast.

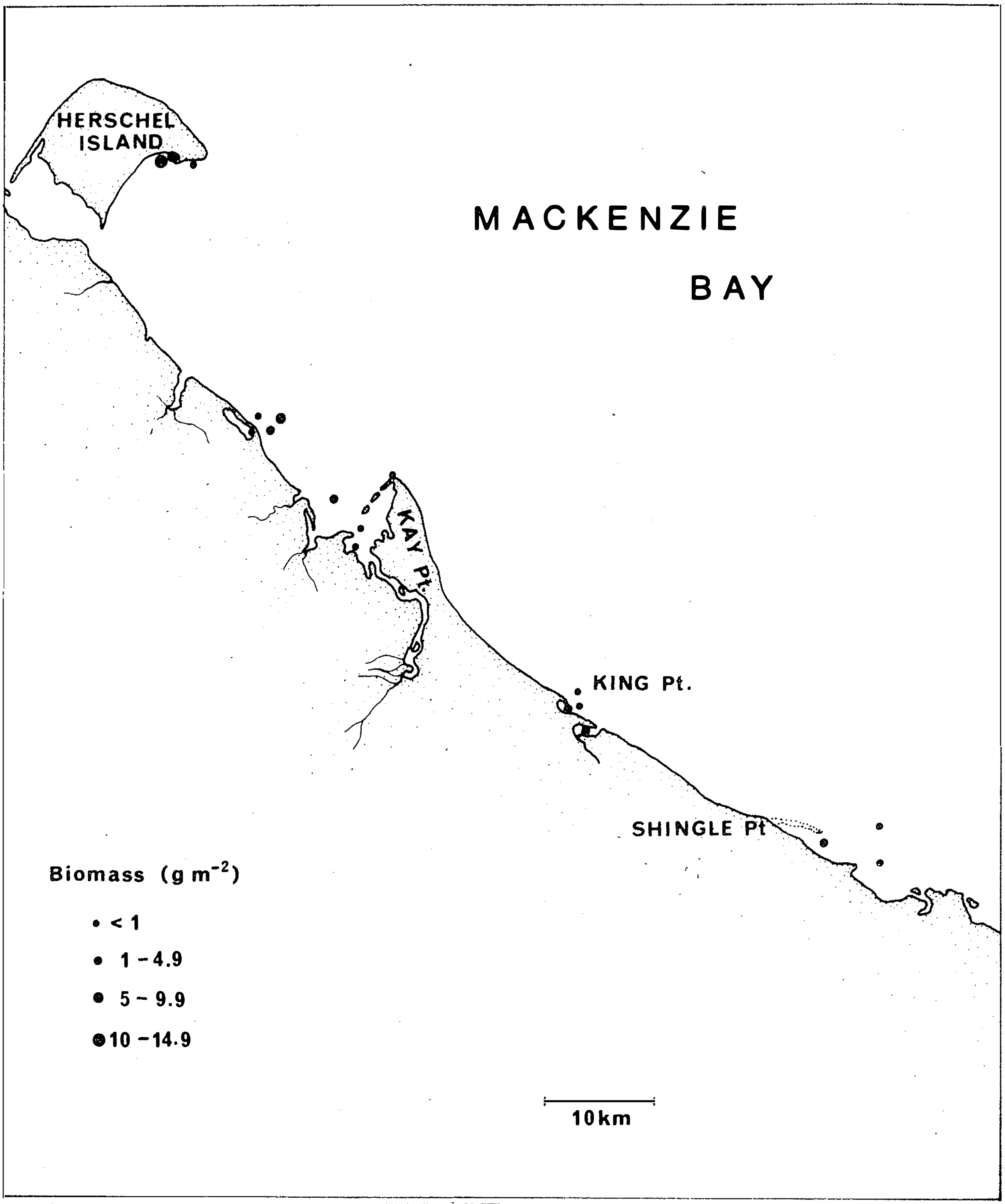

Fig. 9. Biomass of zoobenthos along the Yukon Coast.

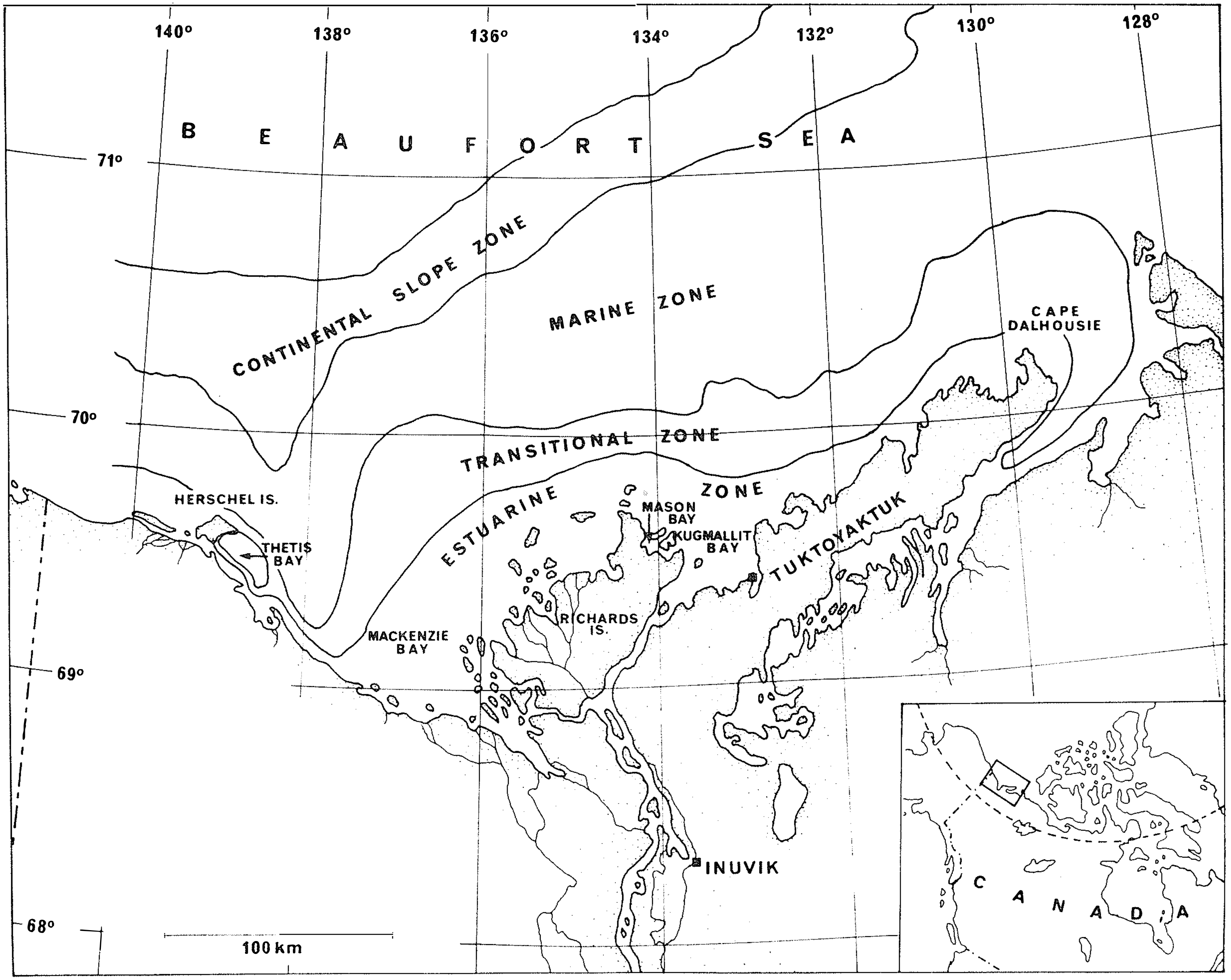

Fig. 10. Zoobenthic zones of the southern Beaufort Sea.