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Marine Benthos in the Eastern Canadian High Arctic: Multivariate Analyses of Standing Crop and Community Structure

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ABSTRACT. Standing crop in 204 grab and diver-operated airlift samples taken in Lancaster Sound, Eclipse Sound, and northern and central Baffin Bay at depths of 5-1088 m was highest between 15 and 105 m. Standing crop was highest in Lancaster Sound and least in central Baffin Bay. Three species assemblages derived by factor analysis bore some similarities to communities described by other workers. Depth and location were better predictors of community composition and standing crop than were depth and substrate. The narrow range of grain size found in any one depth range probably accounts for the relative lack of substrate effect on standing crop and community composition. Differences among areas are probably related to food availability. High standing crop and communities including filter feeders may be maintained to considerable depths in Lancaster Sound by high current speeds and possible high primary productivity. Currents are weaker and biomass lower in northern Baffin Bay than in Lancaster Sound. The weakest currents were found in Eclipse Sound and central Baffin Bay; deposit feeders and low biomass characterized depths >25 m in both areas.

Key words: benthos, community structure, standing crop, multivariate analyses, Canada, High Arctic

RÉSUMÉ. Deux cent quatre échantillons ont été recueillis par "grab" ou par des plongeurs, à des profondeurs de 5-1088 m, dans les détroits de Lancaster et d'Eclipse et dans les parties nord et centre de la baie de Baffin. Le nombre total d'organismes le plus élevé se retrouvait dans les profondeurs entre 15 et 105 m. Le détroit de Lancaster enregistre le plus grand nombre total d'organismes et la baie de Baffin a le plus petit nombre total d'organismes. L'analyse factorielle a permis de distinguer trois assemblages d'espèces comportant certaines similitudes avec des communautés décrites par d'autres chercheurs. La profondeur et la position constituaient de meilleurs indices pour prédire la composition de communautés et le nombre total d'organismes que ne l'était la profondeur et le substrat. La faible variation dans la taille des grains trouvés à différentes profondeurs est probablement responsable de l'absence relative des effets du substrat sur le nombre total d'organismes et sur la composition des communautés. Les différences entre les régions dépendent probablement de la disponibilité de la nourriture. Les courants forts du détroit de Lancaster et possiblement la grande productivité primaire permettent à un grand nombre total d'organismes et à des communautés (incluant des organismes filtreurs) de se maintenir à des grandes profondeurs. Au nord de la Baie de Baffin, les courants sont plus faibles et la biomasse moins importante que dans la détroit de Lancaster. Les courants les plus faibles ont été identifiés dans le détroit d'Eclipse et au centre de la Baie de Baffin: les profondeurs de plus de 25 mètres pour chaque région sont caractérisées par la présence de détrivores et par une faible biomasse.

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INTRODUCTION

This study was designed to determine the species, numbers and species associations of infaunal animals present in the various types of benthic habitats in the Lancaster Sound-northwest Baffin Bay area. The ability to predict faunal characteristics from physical attributes would be useful in delineating areas that should receive attention when planning oil spill countermeasures, in determining the relative importances of various faunal assemblages in terms of areal coverage, and in selecting the most common and representative species and groups of species for monitoring and productivity studies. Intuitively, the long life cycles and low species diversity of the arctic marine fauna (Dunbar, 1968) would appear to enhance the chances of developing this capability.

The study area is wholly within the Arctic zoogeographic province (Dunbar, 1972). Sea ice is present for most of the year and pan ice, icebergs, and new ice are common throughout the open-water period. Two water masses are found within the depths considered. An arctic water mass with temperatures <−1.0°C and salinities <34‰ is found to a depth of ≃250 m (Bailey, 1957; Collin, 1962). During summer the upper 50 m may be warmer and fresher because of runoff and insolation. Below ≃250 m a relatively warm and saline water mass of Atlantic origin extends to ≃1000 m (Bailey, 1957).

General features of the arctic benthos and descriptions of communities are summarized by Thorson (1957) and Ellis (1960). The eastern high arctic shoreline is composed mainly of cobble, pebbles, or exposed bedrock with few sandy beaches. A barren zone primarily inhabited by amphipods and (in some areas) mysids extends to a variable depth of 3-10 m. The presence of fast ice during winter, and variations in temperature and salinity and ice scour during summer, are responsible for the impoverishment of this zone (Ellis, 1960; Lee, 1973). The typical shoreline substrates usually give way to sand or mud at some point in this zone.

The lower limit of the barren zone is usually marked by the appearance of the Laminariales and infaunal animals. Depths from there to 50 m have high standing crop and usually support variations of the arctic *Macoma* community (Thorson, 1957; Ockelmann, 1958: Ellis, 1960: Nesis, 1965). Biomass is generally low at depths >50 m and common communities are dominated by foraminifera or *Astarte crenata*.

METHODS

Field Methods

In August and September 1978 nearshore areas off Philpots Island, off the Phoenix Head Glacier (southern Devon Island), in Eclipse Sound, and in Scott Inlet were sampled from M/V *Gulf Star*, and 18 offshore stations were sampled

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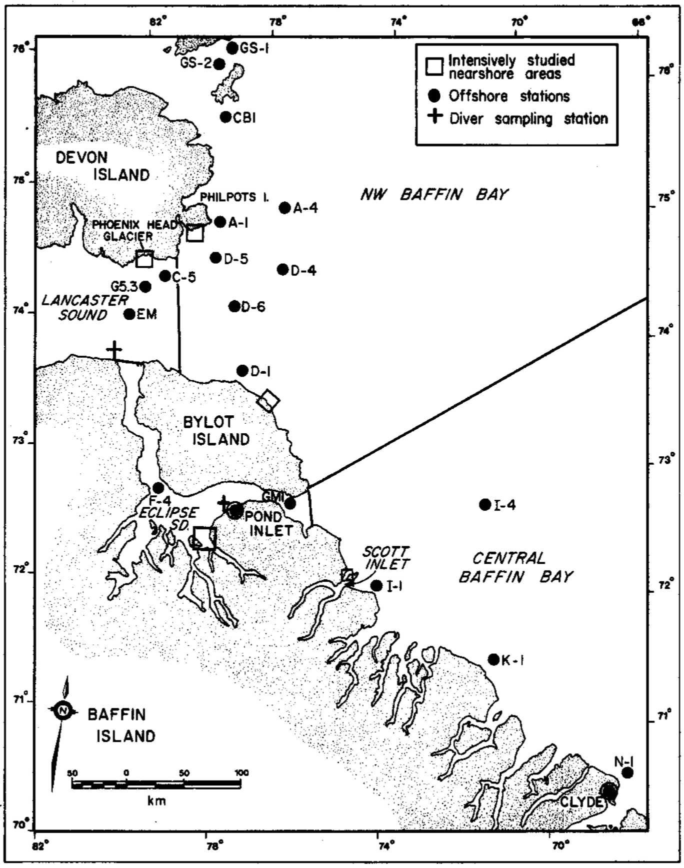

FIG. 1. Locations of nearshore sampling areas and offshore stations, and the four subdivisions of the study area used in multivariate analyses.

TABLE 1. Locations, depths and intensities of sampling

Location	Sampling depths (m)	Width of study site (km) /no. stations	No. samples
Nearshore			
Philpots Island	5-202	13 km	38
Phoenix Head Glacier	5-240	22 km	36
Bylot Island	5-50	2½-km sites	29
Eclipse Snd. & Pond Inlet	5-234	5 km	25
Scott Inlet	5-423	11 km	25
Offshore			
NW Baffin Bay	112-1060	9 stns	26
Lancaster Sound	290-750	3 stns	7
Eclipse Sound	401-413	2 stns	6
Central Baffin Bay	48-1088	4 stns	12

from M/V *Theron* (Fig. 1; Table 1). In August 1979 two sites along NE Bylot Island were sampled from a shore camp.

Ship-based grab sampling at nearshore sites was at depths of 20, 50, 100, and 200-250 m on transects perpendicular to shore. Along Bylot Island, grab samples were taken at 5, 10, 15, 30 and 50 m. Sampling at some depths and on some transects was impossible or unsuccessful because of ice, weather or substrate type. A 0.13 m^2 Van Veen grab was used from both ships in 1978 and a 0.05 m^2 Ponar grab was used along Bylot Island in 1979. Whenever possible triplicate samples were taken with the Van Veen grab and 5 replicates were taken with the Ponar grab. Sediment volume in the grab was measured in the field. Samples containing less than 1 L of substrate were not considered.

An airlift sampler was used by divers at depths of 5, 10 and 15 or 20 m. The sampler consisted of weighted PVC pipe (8 cm diameter) fitted with a 20 MPa air cylinder and the first stage of a diving regulator that maintained a constant pressure of 860 KPa above ambient. Quick release fittings on the 1-mm mesh collecting bag enabled it to be quickly removed and capped. Triplicate samples were taken using three 0.15 m^2 aluminum rings in a triangular array with centers 1 m apart. Animals were isolated in the collecting rings by 1 mm mesh nets that each contained a quick release fitting to receive the distal end of the airlift tube. The airlift normally sampled to a depth of 5 cm.

Laboratory Methods

All samples were washed through nested seives with smallest aperture 1.0 mm. Animals were picked from the larger screens in the field, and all residue on the 1-mm screens was sorted in the laboratory under low power dissecting microscopes. With the exception of ostracods, tanaidaceans, nematodes and echiurans, animals were identified to the species level. Samples from 24 deep-water samples were identified to major taxon level only. Weights are formalin-preserved wet weights (molluscs in the shell and polychaetes without tubes). Animals were blotted dry before weighing. All weights were measured during a three week period, six to seven months after collection and after all identifications were completed.

A sediment subsample was retained from each triplicate set of samples or single sample. The sand fraction of sediment subsamples was separated by sieving and the fines by Day's (1965) hydrometer method (offshore samples and samples from Bylot Island) or a Micrometrics Instrument Corp. sedigraph (remaining samples). Mean grain size and sorting coefficient (standard deviation) were calculated from the grain size distribution. Classes used were sand ($\leq$3.9 Φ), coarse silt (4.0-4.9 Φ), and fine silt ($\geq$5.0 Φ; includes medium silt). Sorting coefficient classes were well sorted ($\leq$1.0) and poorly sorted ($\geq$1.01). Organic content of sediment subsamples that had been kept frozen was estimated from weight loss on ignition at 450°C after overnight dehydration at 98°C. Samples were raised to ignition temperature over 3-4 h and left for 10 h. A modified Walkley Black titration method (Gaudette and Flight, 1974) was used to check the ignition method. Organic content is expressed as % dry weight of total organic matter per unit dry sediment.

Analytical Approach

Three multivariate statistical techniques were used to determine relationships between physical attributes and standing crop of animals, to define relationships among species, and to classify and ordinate benthic samples.

Standing crop. Multiple regression analysis (BMDP2R, Dixon and Brown, 1977) was used to determine which physical variables could be used as predictors of total standing crop of benthic animals, and to define interrelationships among physical variables. The physical variables (predictors) used were mean grain size, sorting coefficient, depth, organic content of the mud, volume of sediment collected by the grab, and "dummy variables" representing the four geographic locations depicted in Figure 1. Preliminary analyses showed that the decrease in density and biomass of animals with depth was most closely approximated (considering percentage of variance explained and distribution of residuals) by a hyperbolic ($y=ax^{-b}$) expression. Thus, both standing crop and depth were logarithmically transformed. A "depth squared" term was also considered for inclusion in the equations to allow for possible deviations from the hyperbolic relationships.

When two or more intercorrelated predictor variables are considered in stepwise multiple regression analysis, the one most closely correlated with the dependent variable enters the equation first. In most cases, the other intercorrelated variables are of little additional value as predictors and do not enter the equation. It is usually impossible to determine which of the intercorrelated predictors are of direct importance to the animals. Stepwise multiple regression analysis develops an optimal subset of predictors without precisely defining their relative importance.

Analysis of covariance (BMDP2R, Dixon and Brown, 1977) was also used to assess the differences in standing crop among the four geographic locations. Depth was the covariate. Logarithmic transformations were also used in this analysis.

Relationships among species. Factor analysis (Dixon and Brown, 1977) was used to reduce the dimensionality of the species abundance data (and thereby present a relatively small number of independent variables to discriminant analysis) and to identify recurring assemblages of species. Densities of the 78 common species were log-transformed (log [no·m^{-2} + 1]) to reduce skewness inherent in such data. Principal components were extracted from the correlation matrix of transformed species densities and the factors were obtained by varimax rotation of the 24 principal components with eigenvalues 1. Although principal components analysis (on which factor analysis is based) has limitations as an ordination method due to distortion caused by non-linearity (Gauch and Whittaker, 1972), the primary purposes of this study were to characterize and compare faunal assemblages found in various circumstances rather than to relate assemblages to environmental gradients.

Comparison of benthos in various habitats. Various multivariate analysis techniques are available to classify and ordinate benthic samples (e.g., Hughes and Thomas, 1971; Stephenson *et al.*, 1972; Walker *et al.*, 1979). In this study, the objective was to compare and contrast animal communities found in various physically definable benthic habitats. For this purpose, discriminant function analysis (Dixon and Brown, 1977) was appropriate. The "predictor" variables used were the factor scores for each sample as generated by the factor analysis. Each factor score represents the "abundance" of the corresponding species assemblage in that sample.

One of the advantages of discriminant analysis is that a level of significance is placed on dissimilarities in the fauna of predefined groups of samples. Another advantage is that one can determine the accuracy of prediction of the group to which a sample belongs on the basis of the animals present. The "prediction" utilized the jackknife procedure, which reduces the bias that would otherwise result from the application of a model based on one set of data to the same data.

Discriminant analysis also derives canonical variables, which are linear additive functions of the variables on which the analysis is based (in this case factor scores). The coefficients provide information about the extent and nature of among-habitat differences in the benthic fauna. The analyses were structured such that only two canonical variables were derived, and such that the first of these emphasized species assemblages (factors) that differed among depths, while the second emphasized factors differing among substrates or areas.

RESULTS

Sediments

Sediments tended to be coarser in shallow than in deeper water and to vary considerably among areas (Table 2). Stepwise multiple regression analysis showed that depth alone accounted for 37% of the variance in mean grain size, and that substrates were relatively coarser (smaller values of Φ) in NW Baffin Bay and finer in Eclipse Sound (Table 3). The sorting coefficient was positively correlated with mean grain size ($r=0.74$, $P<0.001$), indicating that finer substrates tended to be poorly sorted and coarser substrates well sorted.

The combustion method appeared to yield an adequate measurement of total organic content of the sediments. Organic content determined by the combustion method was closely correlated with total organic carbon determined by the modified Walkley Black titration method in samples taken at depths of 48-836 m ($r=0.95$, $P<0.001$, $n=21$). Organic carbon was 26.6±SD 8.5% ($n=21$) of total organic matter.

Organic content (combustion method) was lowest in shallow water and highest in deep water:

Depth interval (m)	5-10	15-52	52-250	251-1088
No. samples	13	41	57	34
Mean % organic content ± SD	0.7±0.5	1.6±0.9	1.6±0.9	4.7±1.8

TABLE 2. Mean grain size (Φ) and mean sorting coefficient from nine depth intervals at four locations (Fig. 1) in the study area

Depth interval (m)	Lancaster Sound		NW Baffin Bay		Eclipse Sound		Central Baffin Bay		All Areas	
	n	Φ ±sorting	*n*	Φ ±sorting	*n*	Φ ±sorting	*n*	Φ ±sorting	*n*	Φ ±sorting
5	2	3.0±0.6	2	1.4±0.4	1	1.6±1.3	1	2.9±0.6	6	2.2±0.5
10	2	3.0±1.0	6	2.9±0.4	1	3.7±0.5	1	3.0±0.4	10	3.1±0.8
15-25	7	4.3±2.4	6	3.3±0.9	2	4.3±2.7	2	3.3±1.0	17	3.9±1.7
26-52	3	2.7±1.8	13	3.1±1.1	2	5.4±2.0	7	4.0±2.0	25	3.5±1.4
53-105	6	5.3±2.5	9	3.1±2.0	2	5.3±2.2	11	3.2±2.0	28	3.8±2.2
106-250	4	4.2±2.5	11	3.0±2.1	7	4.4±2.3	8	4.6±2.2	30	3.9±2.2
251-500	1	4.7±2.3	8	5.0±3.0	3	7.5±1.7	1	4.4±2.2	13	5.4±2.6
501-750	7	5.4±0.6	5	5.7±2.6					12	5.5±3.0
751-1100			7	5.0±3.1			3	7.7±2.9	10	5.8±3.1

TABLE 3. Multiple regression analysis of organic content and mean grain size of samples taken from depths of 5 to 1088 m in NW Baffin Bay and E Lancaster Sound[a]

	Mean grain size (Φ)	Log % organic matter
Depth (log m)	1.4223 ***	0.1586 ***
Mean grain size (Φ)	(not considered)	0.1228 ***
Sorting coefficient	(not considered)	0.984 ***
Area 1: Lancaster Sound[b]	—[c]	-0.1968 ***
Area 2: NW Baffin Bay	-0.0083 ***	—
Area 3: Eclipse Sound	0.0083 *	—
Area 4: Central Baffin Bay	—	-0.2884 ***
Constant (Y-intercept)	1.9711	-0.7154
Multiple *R*	0.69 ***	0.87 ***
% of variance explained	47.3	76.4
SE of estimate	1.09	0.20
No. of samples	170	170

[a]Regression coefficients of variables that entered the equation are shown, along with the constant (Y-intercept) and statistics describing the fit of the equation. Approximate significant levels are shown by asterisks; * means $0.05 \geq P > 0.01$, ** means $0.01 \geq P > 0.001$ and *** means $P \leq 0.001$.
[b]The four area variables represent areas demarked in Fig. 1. For a given sample, the appropriate area variable was coded as 1 and the other three variables were coded as 0.
[c]Variable excluded from equation because F-to-enter <3.8 ($P > 0.05$).

A multiple regression equation explained 76.4% of the variance in organic content of the sediment subsamples (Table 3). Grain size alone accounted for 52% of the variance and depth 12%. Organic content was highest in fine, poorly sorted substrates in deep water, and lower in Lancaster Sound and central Baffin Bay than in the other two areas.

Distribution of Standing Crop

A total of 62 892 animals was taken in the 144 grab and 60 airlift samples. Of the specimens, 51% were crustaceans, 20% polychaetes, and 16% bivalves. Bivalves accounted for 59% of the 5.7 kg of animals collected. About 343 taxa were identified, most to the specific level. This figure underestimated species richness because species in 24 offshore samples, plus ostracods, tanaidaceans, and some uncommon taxa were not identified to species. Overall, amphipods were the most important taxon in terms of biomass at 5 m depth, bivalves at 10 to 100 m, echinoderms at 100 to 500 m, and polychaetes at the greatest depths (Fig. 2).

Depth and geographic effects. The standing crop of infaunal animals showed considerable variation with depth and geographic location (Table 4). Biomass was generally low at depths of 5 and 10 m, reached a maximum between 15 and 105 m, and thereafter decreased with increasing depth. Density showed a similar but not identical trend. The low standing crop at depths of 5 and 10 m represents the barren zone (see Introduction) and these data were excluded from the following analyses. Below that zone, a high standing crop was found to depths of 50 to 100 m in Lancaster Sound but only to 25 m in Eclipse Sound (Table 4). In central Baffin Bay, standing crop was low at all depths (Table 4).

Multiple regression equations for depths 15-1088 m (Table 5) accounted for 60.5% and 49.8% of the variance in biomass and density of benthic animals. In each case depth alone accounted for over half of the variance explained. The log biomass-log depth relationship over the 15-1088 m depth range was well approximated by a hyperbolic curve. However, inclusion of the "depth squared" term in the equation for density indicated that the log density-log depth relationship was not precisely hyperbolic in form after allowance for other variables.

The geographic variables were also significant predictors of the standing crop of benthic animals after allowance for depth effects (Table 5). Biomass was lower in NW Baffin Bay, Eclipse Sound and especially central Baffin Bay than in Lancaster Sound, and density was lower in both NW and central Baffin Bay than in Eclipse Sound or Lancaster Sound.

The rate of decrease in biomass with depth was not significantly different among the four areas (analysis of covariance, $P=0.20$). Although maximum sampling depth was less in Eclipse Sound than in Lancaster Sound or Baffin Bay, regression equations were similar regardless whether the deeper stations (>413 m) were included or excluded.

After analysis of covariance had allowed for the effect of depth, biomass differed significantly among areas ($F=22.64, P<0.001, n=149$). The samples from Lancaster Sound contained a significantly higher biomass than those from NW Baffin Bay (t for adjusted group means $=3.1$, $P=0.002$), Eclipse Sound ($t=3.6$, $P=0.004$), and central Baffin Bay ($t=7.9$, $P<0.001$). Samples from NW Baffin Bay and Eclipse Sound contained similar biomasses ($t=1.5$, $P=0.13$) but biomasses in both these areas were significantly higher than those in central Baffin Bay ($t=6.3$, $P<0.001$ and $t=3.2$, $P=0.002$, respectively).

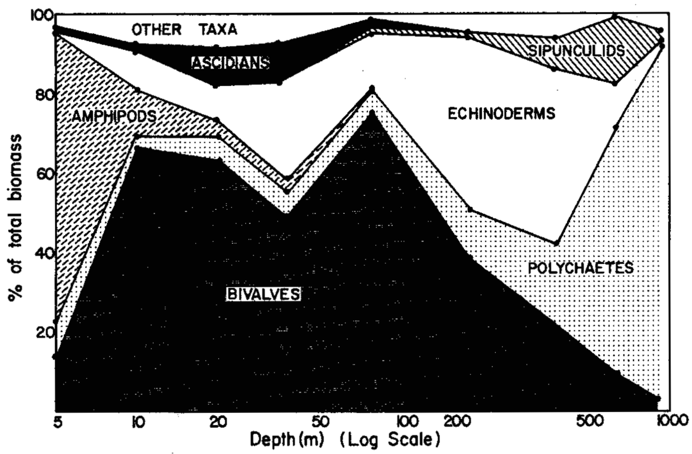

FIG. 2. Relative composition of the infaunal benthos as a function of depth. Mean % of total biomass for each of nine depth ranges is plotted.

TABLE 4. Standing crop of infaunal benthos in samples collected in NW Baffin Bay and adjacent areas. Mean, SD and *n* (in parentheses) are shown. Unless otherwise noted, samples were taken with a Van Veen grab.

Depth (m)	Lancaster Sound	NW Baffin Bay	Eclipse Sound	Central Baffin Bay
Density (no·m^{-2})				
5	1533 ± 871 (7A)[1]	1133 ± 1190 (8P, 6A)	1196 ± 442 (2A)	6193 ± 344 (2A)
10	2957 ± 1414 (6A)	3639 ± 3229 (4P, 6A)	1953 ± 1461 (11A)	4731 ± 780 (3A)
15-25	3560 ± 1596 (3A,6V)	3582 ± 3635 (6P, 3A, 1V)	5384 ± 1460 (3A, 1V)	1642 ± 156 (2)
26-52	3387 ± 137 (3)	5502 ± 4006 (15P, 3V)	2309 ± 679 (2)	1730 ± 1092 (7)
53-105	4564 ± 1709 (6)	2526 ± 1055 (9)	813 ± 619 (2)	1681 ± 1389 (11)
106-250	1797 ± 931 (4)	1983 ± 1141 (12)	2487 ± 1758 (7)	867 ± 572 (8)
251-500	1896 (1)	988 ± 509 (8)	936 ± 448 (3)	1482 (1)
501-750	857 ± 320 (7)	638 ± 266 (5)	—	—
751-1100		1222 ± 1910 (7)	—	231 ± 42 (3)
Biomass (g·m^{-2})				
5	55 ± 74 (7A)	19 ± 14 (8P, 6A)	68 ± 14 (2A)	25 ± 5 (2A)
10	94 ± 20 (6A)	55 ± 99 (4P, 6A)	492 ± 551 (11A)	58 ± 24 (3A)
15-25	787 ± 650 (3A,6V)	296 ± 253 (6P, 3A, 1V)	596 ± 144 (3A, 1V)	105 ± 31 (2)
26-52	519 ± 87 (3)	376 ± 297 (15P, 3V)	61 ± 45 (2)	92 ± 84 (7)
53-105	1094 ± 277 (6)	402 ± 221 (9)	53 ± 23 (2)	68 ± 126 (11)
106-250	180 ± 40 (4)	184 ± 138 (12)	134 ± 234 (7)	17 ± 12 (8)
251-500	153 (1)	49 ± 24 (8)	24 ± 12 (3)	104 (1)
501-750	33 ± 36 (7)	26 ± 26 (5)	—	—
751-1100	—	46 ± 22 (7)	—	4 ± 1 (3)

[1]A = airlift, P = Ponar grab, V = Van Veen grab

TABLE 5. Multiple regression analyses of total standing crop in relation to physical and location variables[a]

	Depths 15-1088 m		Depths 15-107 m	
	Total numbers	Total biomass	Total numbers	Total biomass
Constant (Y-intercept)	+3.5635	+3.9067	+3.2030	+2.4304
Depth (log m)	−0.2322N.S.	−0.7564 ***	—	—
Depth squared (log m)^2	−0.1327 ***	—	—	—
Organic content (arcsin %)	−4.8760 *	—	+22.5490 **	—
Mean grain size (Φ)	—	—	—	—
Sorting coefficient	—	—	—	—
Volume (L)	—	—	—	—
Lancaster Sound	—	—	—	+0.4117 **
NW Baffin Bay	−0.1240 *	−0.2066 *	—	—
Eclipse Sound	—	−0.4771 **	−0.3684 **	—
Central Baffin Bay	−0.3917 ***	−0.9066 ***	−0.2402 ***	−0.7431 ***
Multiple R	0.71 ***	0.78 ***	0.65 **	0.76 ***
% of variance explained	49.8	60.5	42.1	57.3
SE of estimate	0.29	0.42	0.26	0.40
No. of samples	127	127	65	65

[a]Presentation as in Table 3. Numbers and biomass were subjected to log (x + 1) transformation before analysis.

TABLE 6. Correlations of total standing crop (log transformed) and physical variables[a]. For depths 15 to 1088 m, n = 127; for depths 15 to 107 m, n = 65.

	Depths 15-1088 m		Depths 15-107 m	
	Total numbers	Total biomass	Total numbers	Total biomass
Depth (log m)	-0.58 ***	-0.59 ***	-0.19	-0.18
Depth squared (log m)^2	-0.59 ***	-0.59 ***	-0.18	-0.17
Organic content (arcsin %)	-0.47 ***	-0.40 ***	0.48 ***	0.37 **
Mean grain size (Φ)	-0.35 ***	-0.31 **	0.29 *	0.23
Sorting coefficient	-0.29 **	-0.20 *	0.15	0.23
Volume (L)	-0.40 ***	-0.38 ***	0.00	0.09
Lancaster Sound	0.25 **	0.36 ***	0.35 **	0.55 ***
NW Baffin Bay	-0.06	0.09	0.12	0.21
Eclipse Sound	0.11	-0.03	0.05	-0.05
Cent. Baffin Bay	-0.27 **	-0.43 ***	-0.50 ***	-0.70 ***

[a]Presentation as in Table 3. Pearson product-moment correlations and two-sided significance levels are shown.

Substrate effects. Both biomass and density of benthic animals were negatively correlated with organic content, mean grain size and sorting coefficient (Table 6). However, depth, organic content, sorting coefficient and mean grain size were all intercorrelated. The finest substrates tended to occur at the deepest depths; also finer substrates tended to be more poorly sorted and to have a higher organic content than coarser substrates. As previously mentioned (see Methods) it is usually impossible to determine which of the intercorrelated predictors is (or are) of direct importance to the animals.

To reduce the confounding effect of depth, the multiple regression and correlation analyses were rerun using data from only the depths of maximum standing crop, 15-107 m (Tables 5, 6). Within this depth range geographic location was the major predictor of standing stock. Animal density was positively correlated with mean grain size at depths of 15 to 107 m (Table 6). However, once geographic location and organic content were taken into account by stepwise multiple regression analysis, grain size was not a significant predictor of density. This was a result of the previously discussed substrate differences among areas, and the relationship between grain size and organic content. Whether grain size itself influences density cannot be determined from these data.

In Lancaster Sound and NW Baffin Bay, there was a significant positive correlation between biomass and mean grain size at depths of 15-107 m (r=0.51, P<0.001, n=44). As discussed previously, substrates were significantly coarser and biomass significantly lower in NW Baffin Bay than in Lancaster Sound (Tables 3, 5). Substrate may be one factor responsible for biomass differences between these two areas. However, it is more likely that differences among these and the other areas are due to other factors. NW Baffin Bay (coarse substrates) and Eclipse Sound (fine substrates) were the most dissimilar in terms of grain size and sorting (Tables 2, 3) but analysis of covariance showed no significant difference in biomass between the two areas. Lancaster Sound (highest biomass) and central Baffin Bay (lowest biomass) were the most dissimilar areas in terms of biomass yet were the most similar in terms of substrate (Tables 2, 3). When the study area is considered as a whole, factors other than substrate apparently had the major influences on benthic biomass.

Organic content was a significant predictor of animal density over both depth ranges tested. Over the 15-1088 m depth range, high densities and biomasses tended to occur in samples with low organic content (Table 6). However, this may have been due to the confounding effect of depth. The lowest densities and highest organic content were found in the deepest water, but low densities are expected in deep water regardless of organic content. When only the samples from depths 15-107 m are considered, highest densities occurred in sediments with the highest organic content (Tables 5, 6). However, density was positively correlated with grain size as well as organic content, and these two measures of substrate were intercorrelated (r=0.43). Thus, it is not possible to determine which of the two variables, if either, was responsible for high densities of infauna.

Sampling efficiency. Some bias was undoubtedly introduced by the unavoidable use of three different sampling devices. In shallow water, the airlift as the most efficient device in that penetration depth (5 cm) could be controlled by the divers. Operation of the grab was hampered by the presence of rocks. The Van Veen grab penetrated to a sediment depth of 3.4±2.2 cm in water depths <105 m and 7.7±4.9 cm in the finer substrates found at depths >105 m. The Ponar grab, used only off Bylot Island in the NW

Baffin Bay area, was the least effective sampling device (penetration 1.6 ± 1.46 cm). However, depth of penetration was not significantly correlated with standing crop at depths 15-107 m (Tables 5, 6). There was, however, a significant negative correlation at depths of 15 to 1088 m. The finest substrates and lowest standing crops were found in the deepest water (Tables 2, 4) and grab penetration is best in finer substrates (Christie, 1975).

Community Structure

I assumed that certain species of animals would tend to occur in association with one another, and that these groups of species would be found under similar environmental conditions in different parts of the study area. Factor analysis was used to identify recurring groups ("assemblages") of species, and discriminant function analysis was used to compare the assemblages present in different areas, depths and substrates.

Species associations. Each species that was among the five most common species in one or more of the nine depth ranges and four areas sampled was considered in the analysis. These 78 species accounted for 74% of the individual animals found in the 179 usable samples from depths of 5-1088 m. The 24 factors derived in factor analysis of these 78 species accounted for 73.8% of the variance among the 78 species variables used in the analysis. Species whose densities were strongly and positively correlated with a factor (Table 7) tended to occur together and are referred to here as an assemblage. The measure of the abundance of each assemblage in samples ("factor scores") from various depth/area and depth/substrate combinations is shown in Fig. 3. A high factor score (>1.0) indicates that the group of species represented by the factor is common in the sample in question. Most of the species assemblages occurred predominantly in specific depth ranges, and some occurred mainly in only one or two geographical areas or

TABLE 7. Results of a factor analysis of the 78 most abundant benthic animals taken by grab and airlift in northern Baffin Bay and Lancaster Sound in 1978 and 1979. The values shown are the correlations between the log transformed abundances of various species (the original variables) and each of the 24 factors determined in the analysis. Species whose abundances were weakly correlated with a factor (-0.4 <*r* <0.4) are not shown. Each factor is assigned a name (beside number) indicating some or all of the main type(s) of animals represented.

1. *Macoma - Astarte*		2. *Astarte borealis*	
Ophiura robusta	0.853	*Astarte montagui*	0.432
Lepeta caeca	0.789	*Macoma moestra*	0.814
Macoma calcarea	0.758	*Guernea* sp.	0.773
Brachydiastylis resima	0.727	*Astarte borealis*	0.721
Strongylocentrotus droebachiensis	0.703	*Mya truncata*	0.567
Margarites spp.	0.694	*Pholoe minuta*	0.536
Astarte montagui	0.687	*Musculus niger*	0.520
Hiatella arctica	0.606	*Cistenides granulata*	0.441
Ophiocten sericeum	0.512	*Ophilina accuminata*	0.472
Glycera capitata	0.481	*Scoloplos armiger*	0.474
Ostracoda	0.495		

3. Owenids		4. *Praxillura - Golfingia*	
Ophiocten sericeum	0.424	*Paraxillura* sp.	0.812
Myriochele oculata	0.833	*Golfingia margaritacea*	0.699
Myriochele heeri	0.786	*Prionospio* spp.	0.610
Dacrydeum vitreum	0.737	*Glycera capitata*	0.572
Nephtys ciliata	0.560	*Onuphis conchylega*	0.525
Maldane sarsi	0.555	*Asychis biceps*	0.418
Foraminifera	0.548	*Ophiacantha bidentata*	0.418
Prionospio spp.	0.401		
Cistenides hyperborea	0.499		
Ophiura sarsi	0.412		
Ostracoda	0.488		

5. *Anonyx - Caprella*		6. *Travesia forbesi*	
Anonyx sarsi	0.768	*Anonyx laticoxae*	0.812
Caprella septentrionalis	0.659	*Travesia forbesi*	0.778
Anonyx nugax	0.622	*Monoculopsis longicornis*	0.737
Marenzelleria wireni	0.570	*Lamprops fuscata*	0.485
Paroediceros lynceus	0.568		
Atylus carinatus	0.508		

7. *Owenia - Diastylis*		8. *Protomedia fasciata*	
Owenia fusiformis	0.786	*Protomedia fasciata*	0.775
Diastylis rathkei	0.752	*Rhyzomolgula globularis*	0.730
Pelonaia corrugata	0.645	*Capitella capitata*	0.590
		Chaetozone setosa	0.523
		Lamprops fuscata	0.442

9. *Aglaophamus - Asychis*		10. *Cistenides*	
Aglaophamus malmgreni	0.821	*Cistenides granulata*	0.670
Asychis biceps	0.707	*Cistenides hyperborea*	0.538
Sipunculids	0.528	*Atylus carinatus*	0.523
Spiochaetopterus typicus	0.444		

11. Ampeliscids		12. *Pelonaia - Mesidotea*	
Ampelisca escherichti	0.835	*Pelonaia corrugata*	0.447
Byblis gaimardi	0.655	*Thracia* sp.	0.775
Scalibregma inflatum	0.413	*Mesidotea sabini*	0.752

13. *Lumbrineris - Ascidia*		14. *Apherusa*	
Lumbrineris fragilis	0.774	*Apherusa* sp.	0.783
Ascidia callosa	0.744	*Musculus discors*	0.510

15. *Samythella*		16. *Pontoporeia - Onisimus*	
Samythella sp. nr. *neglecta*	0.750	*Pontoporeia affinis*	0.901
Thelepus cincinnatus	0.651	*Onisimus litoralis*	0.682
Ophiacantha bidentata	0.428		

17. *Bathyarca - Praxillella*		18. *Ophiura sarsi*	
Bathyarca raridentata	0.781	*Ophiura sarsi*	0.652
Praxillella gracilis	0.771	*Terebellides stroemii*	-0.416

19. *Musculus*		20. *Brada inhabilis*	
Musculus discors	0.441	*Brada inhabilis*	0.691
Musculus niger	0.479		
Scalibregma inflatum	-0.558		

21. *Nereis zonata*		22. *Polyphysia crassa*	
Nereis zonata	0.862	*Polyphysia crassa*	0.907
		Spiochaetopterus typicus	0.568

23. *Ctenodiscus*		24. *Anonyx pacificus*	
Ctenodiscus crispatus	0.849	*Anonyx pacificus*	0.864

substrates. The depth ranges used in the following discussions are those of well defined environmental zones and roughly parallel those used by Wacasey (1975) in the Beaufort Sea.

Six factors assumed high values in the relatively impoverished subtidal barren zone at depths ≤10 m. In relatively well sorted sand, factor 16 representing mainly the amphipods *Pontoporeia affinis* and *Onisimus litoralis*

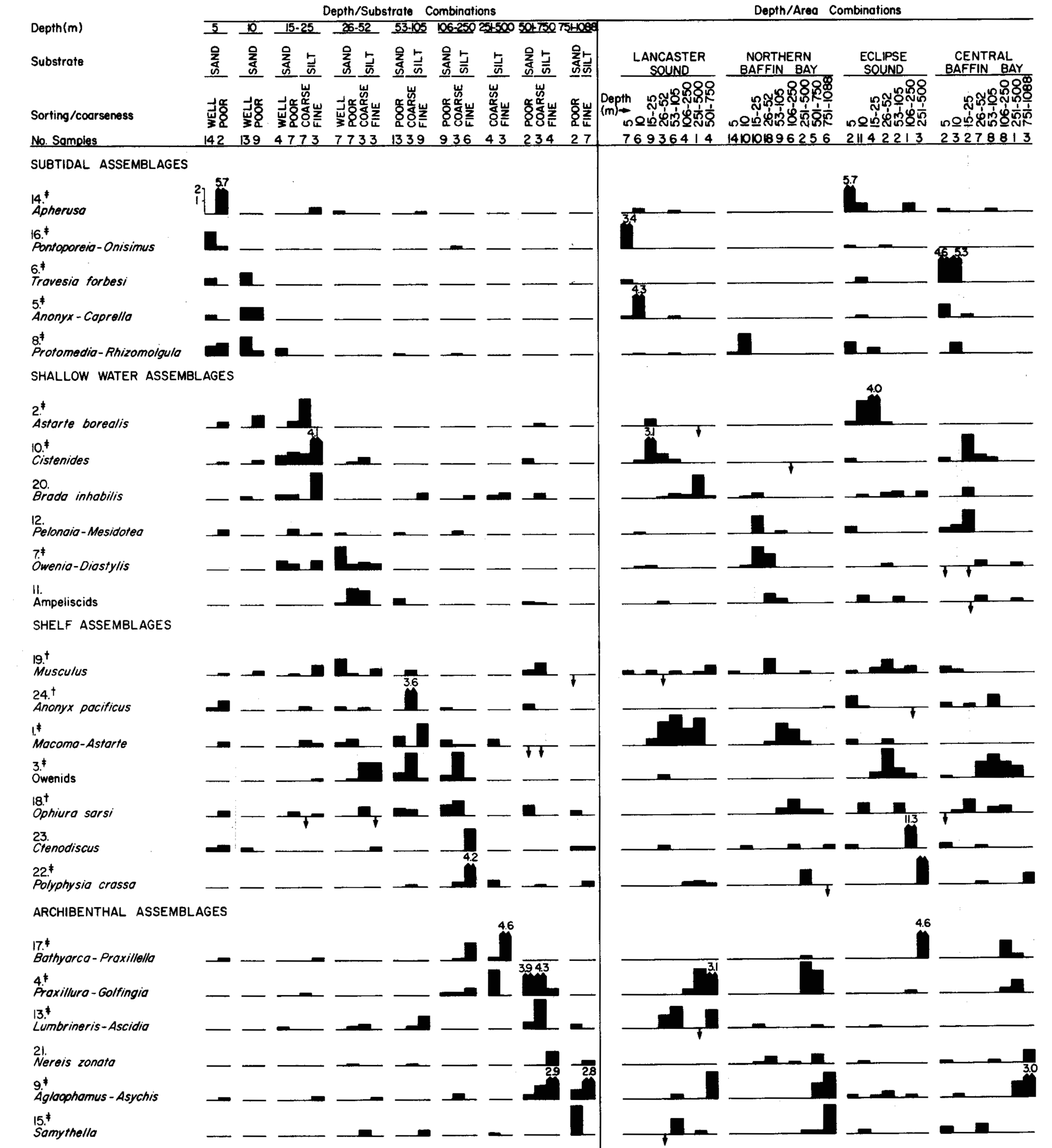

FIG. 3. Mean factor scores for various depth/substrate and depth/area combinations in the NW Baffin Bay and E Lancaster Sound region. Only values >0.1 (bar) and <-1.0 (↓) are shown. + and ‡ mean that the factor was useful in discriminating either depth/area combinations, or both depth/substrate and depth/area combinations, respectively.

assumed high values in Lancaster Sound, while factor 6 representing mainly the polychaete *Travesia forbesi* and three crustacean species was prominent in central Baffin Bay. In more poorly sorted sand, factor 14 representing the amphipod *Apherusa* sp. and the mussel *Musculus discors* was prominent at 5 m in Eclipse Sound. The other two factors prominent in shallow water were found in both well and poorly sorted sand and were less restricted in geographical distribution (Fig. 3).

Six factors had high scores at 15-50 m and relatively low scores at other depths (Fig. 3). Most primary productivity occurs at depths <50 m, and this depth is also near the lower limit of the water layer influenced by solar insolation and freshening in summer. Factor 2 representing the bivalves *Astarte borealis* and *Macoma moesta* and several bivalve and polychaete species (Table 7) was associated with coarse silt and poorly sorted sand in Eclipse Sound and, to a limited extent, in Lancaster Sound. Factor 10, which included the two pectinariid polychaetes, was associated with fine silt in Lancaster Sound and central Baffin Bay. Factors 7 and 12 both included the tunicate *Pelonaia corrugata* and were found on a variety of substrates. Factor 20, representing primarily the polychaete *Brada inhabilis*, was most prominent in fine silt at 15-25 m, but was evident at a wide range of depths and locations (Fig. 3).

Seven factors were characteristic of depths that, in more southerly latitudes, correspond to the continental shelf (50-250 m). The shelf itself does not exist in these regions but the transition between the surface Arctic water and deeper Atlantic water masses is near 250 m. Factor 1, representing *Macoma calcarea, Astarte montagui, Ophiura robusta* and other species was found over a wide depth range and a variety of sediments in Lancaster Sound and NW Baffin Bay. Factor 3, which included foraminifera and two species of owenid polychaetes, was more restricted in its depth distribution and appeared to be associated with intermediate substrates of intermediate grain size in Eclipse Sound and Scott Inlet (Fig. 3). Factors 22 and 23 were conspicuous mainly in Eclipse Sound and were associated with the finest substrates.

Depths of 250 to 1000 m, Ekman's (1967) archibenthal zone, are occupied by the Atlantic water layer in NW Baffin Bay and Lancaster Sound. Each "assemblage" that assumed high scores in this zone appeared to have discrete depth and substrate preferences. Factor 17, representing *Bathyarca raridentata* and *Praxillella gracilis*, was found in fine silt in Eclipse Sound and central Baffin Bay, while factor 4 was found mainly in coarser substrates in Lancaster Sound and NW Baffin Bay. Two factors were of primary importance at the deepest depth samples. Factor 9, representing three polychaete species and a sipunculid, was widely distributed in fine substrates. Factor 15, representing *Samythella* sp. nr. *neglecta, Thelepus cincinnatus* and an ophiuroid, was most important at the deepest station sampled in NW Baffin Bay.

Fauna of various depth/substrate combinations. Stepwise multiple discriminant analysis was used to assess the extent and significance of differences in the infaunal assemblages present in the various depth zones and substrates. Twelve combinations of sediment type and depth (corresponding to those used in the above discussion) defined the groups of samples to be discriminated. Poorly sorted sand substrates at depths of 251-1088 m were excluded from most of the analyses because too few samples were taken under these circumstances. For convenience, the 12 depth/substrate combinations are referred to as "habitats" in the following discussion. The variables on which the discrimination was based were the 24 factors (species assemblages) discussed above.

Fifty-one of 55 possible pairs of habitats supported significantly ($P < 0.05$) different, although not unique, combinations of benthic animals. At depths of 15-52 m animals found in poorly sorted sand were not significantly different from those in well sorted sand or those in coarse silt. At 53-250 m the fauna of poorly sorted sand was not significantly different from that of coarse or fine silt. All other pairs of habitats were statistically distinguishable on the basis of the animals present. Sixteen of the 24 factors (species assemblage) were useful in discriminating habitats (Fig. 3). All subtidal factors and four of five archibenthal factors were useful in discriminating habitats, while less than half of those characteristic of intermediate depths were useful discriminators.

An "ordination" of habitats on the basis of the animals present was also produced by the analysis. This ordination is a visual portrayal of the degree of differences in the animals present in the various habitats (Fig. 4). Only the canonical variable that emphasised depth differences —

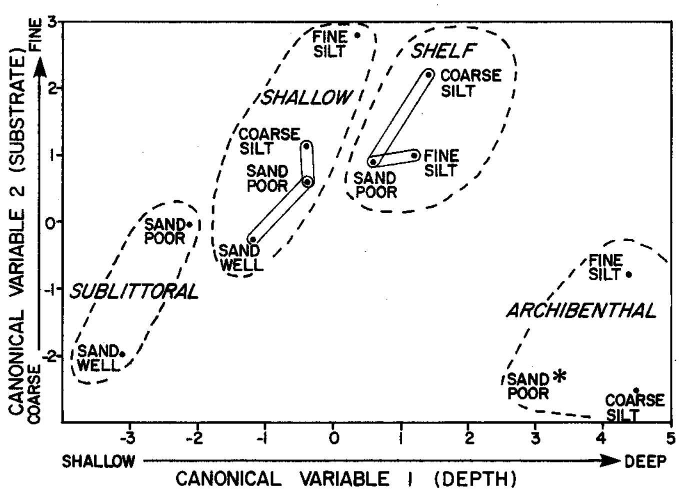

FIG. 4. Similarity of animals found in 12 depth/substrate combinations. The centroid of each combination is plotted against the two canonical variables (discriminant functions). Only two samples were obtained from poorly sorted sand in the archibenthal zone (251-1088 m), and this habitat was not considered while deriving canonical variates and is indicated by an asterisk. Depth/substrate combinations that could not be discriminated from one another ($P > 0.05$) on the basis of animals present are indicated.

not the one emphasising substrate differences — afforded significant ($P<0.05$) discrimination among habitats. Thus, faunal assemblages differed significantly among depths but not among substrates.

The results of the discriminant analysis were then used to assess the uniqueness of the assemblage of benthic animals in each habitat type. The approach used was to "predict" the habitat from which each sample was taken based on the animals contained in the sample. The habitat (one of 11 depth-substrate combinations) from which the sample had been taken was identified correctly for only 51% of the samples. However, the depth interval was identified correctly for 79% of the samples, indicating that the faunal communities found in the subtidal, shallow, shelf and archibenthal zones were quite different. Substrates were correctly identified less often — for 63% of the samples. Correct identification of substrate on the basis of animals present was more common for well sorted sand and fine silt (87% and 66% correct respectively) than for intermediate-sized substrates — poorly sorted sand (48% correct) and coarse silt (57%). The lack of discrimination of certain substrates indicates that, at depths of 25 to 250 m, substrate does not appear to limit the distributions of most faunal assemblages. It should be noted, however, that neither very coarse nor very fine substrates were found at these intermediate depths.

To determine whether the rather poor separation of substrate categories on the basis of the animals present was due to a poor substrate categorization procedure, discriminant analysis was run again using fewer categories. In their multiple discriminant analysis, Walker *et al.* (1979) used 0.0, 2.0 and 5.0 Φ as the class limits of the grain size distribution. A value of 5.0 Φ represents the upper limit of consolidated claylike sediments (Walker *et al.*, 1979). In this study too few samples (nine) were available in the range 0.0-2.0 Φ for these class limits to be used, so in our second analysis we used a class limit of 5.0 Φ. Sand was again classified as well or poorly sorted and the same four depth ranges were used. The results were slightly better than in the first analysis. Only one of 36 pairs of habitats did not support significantly ($P<0.05$) distinct faunal assemblages, and the jackknife procedure correctly identified the depth and substrate from which 55% of the samples had been taken.

Fauna of various depth/area combinations. Sample-by-sample analysis indicated that faunal assemblages of samples incorrectly classified in the above two discriminant analysis runs were often more similar to assemblages from different habitats found nearby than to assemblages from the same type of habitat in different areas. Thus geographical area may be at least as important a determinant of community composition as substrate. To test this, discriminant analysis was used to determine if geographic location, along with depth, could be used to classify benthic faunal assemblages. The 16 depth/area combinations considered were based on the usual four geographic areas (Fig. 1) and the four depth ranges used in previous analysis. However, archibenthal zones in Eclipse Sound and central Baffin Bay and the slope zone in Eclipse Sound were excluded from the analysis because $n < 5$.

All 91 possible pairs of habitats supported significantly different combinations of benthic animals ($P<0.001$ except for archibenthal zones in Lancaster Sound and NW Baffin Bay, for which $0.02 > P > 0.001$). The jackknife classification procedure correctly identified the area and depth from which 76% of the samples were taken. Depth of collection was correctly identified for 88% of the samples and area for 90% of the samples. In this case both canonical variables derived in the analyses (area and depth) provided significant ($P<0.01$) discrimination of faunal communities. The relative locations of area/depth centroids (Fig. 5) show a logical ordering of area/depth groups. This represents a corresponding ordering of the types and numbers of animals present.

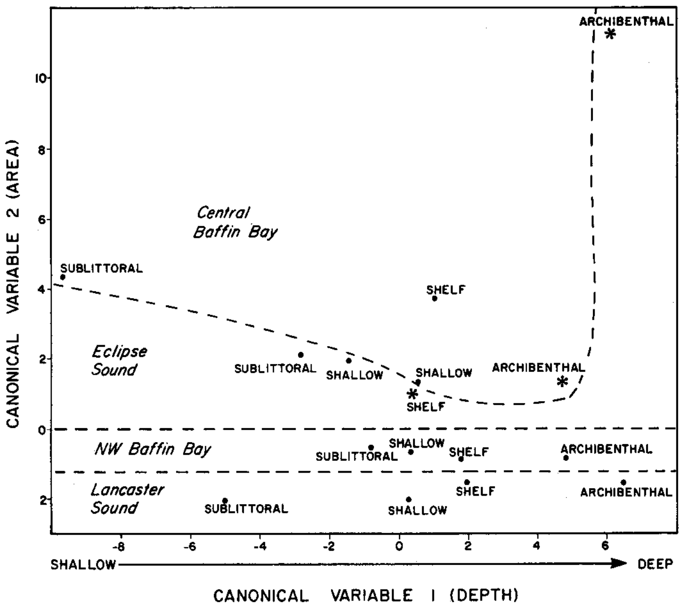

FIG. 5. Similarity of animals found in 16 depth/area combinations. The centroid of each combination is plotted against the two canonical variables (discriminant functions). The three depth/area combinations represented by less than five samples were not considered while deriving canonical variables by discriminant analysis; their centroids are shown by asterisks.

DISCUSSION

The biomass of animals collected in the study area is very high when compared to other marine areas in the High Arctic and elsewhere (Table 8). Especially rich in this respect were the areas sampled in Lancaster Sound, where the mean biomass was above 500 $g \cdot m^{-2}$ throughout the 15 to 50 m depth range. The mean biomass of 1094 ± 277 $g \cdot m^{-2}$ recorded at depths of 50 to 100 m in Lancaster Sound is rather unique for that depth range and among the highest recorded in the Arctic (*cf.* Vibe, 1939; Ellis, 1960; Alton, 1974; Curtis, 1975; Knox and Lowry, 1977). In contrast, biomass values from central Baffin Bay rank with the lowest. The biomass in Eclipse Sound was high in waters shallower than 25 m, but dropped off rapidly below that depth (Table 4).

Some of the species assemblages identified by our factor analysis are similar to communities that have been described from the Canadian High Arctic and Greenland (Thorson, 1957; Ockelmann, 1958; Ellis, 1960). The second factor includes strong loading from six of the nine species listed by Thorson (1957) as being characteristic of the arctic *Macoma calcarea* community: *Astarte borealis, A. montagui, Serripes groenlandicus, Mya truncata, Cistenides granulata* and (less strongly associated) *Macoma calcarea*. *Macoma moesta* was more strongly associated than *M. calcarea* with this factor. Similarly, Ockelmann (1958) suggested that the name arctic *Macoma* community be used since *M. moesta* is the dominant species of *Macoma* in East Greenland. The arctic *Macoma* community characteristic of water depths <50 m and marked by a high biomass has also been recorded in West Greenland and the Canadian Arctic (Ockelmann, 1958; Ellis, 1960). Our second factor assumed high scores in water depths <25 m and the mean biomass of the 14 samples with high (>1.0) scores for this factor was high: $516 \pm 370\ g \cdot m^{-2}$ (Table 9).

Two more of our assemblages bore resemblances to previously described communities. Our first factor also included strong representation from three species characteristic of Thorson's *Macoma* community (*M. calcarea, Astarte montagui* and *Ophiocten sericeum*). Three other species characterizing this community were less strongly associated with the factor (*Astarte borealis, Mya truncata, Cistenides granulata*). This assemblage assumed high factor scores at depths of 50-250 m and samples with high scores for this factor contained a large biomass ($529 \pm 350\ g \cdot m^{-2}$, $n = 30$). According to Thorson (1957) and Ellis (1960), these depths should be marked by *Astarte crenata* or foraminifera communities and a low biomass. Assemblage 1 may be analogous to the *Macoma calarea-Astarte montagui* biocoenosis recorded at depths of 100–235 m in the zone of

TABLE 8. Comparison of the mean integrated biomass ($g \cdot m^{-2}$) of benthic infaunal animals from arctic and subarctic areas. Only the depth range from 5 to 50 m is considered.

Location	Sample size	Mean biomass ($g \cdot m^{-2}$)	Source
Alaskan Beaufort Sea	131	41	Carey (1977)
Bridport Inlet, Melville I.	78	94	Buchanan *et al.* (1977)
Brentford Bay, Boothia Pen.	21	188	Thomson *et al.* (1978)
EAMES study area	110	319	present study
Lancaster Sound	25	520	this study
NW Baffin Bay	52	297	this study
Eclipse Sound	19	258	this study
Central Baffin Bay	14	88	this study
Northern Baffin I.	51	200-438	Ellis (1960)
Labrador coast (infauna only)	94	346	Barrie *et al.* (1980)
Newfoundland banks	6	1455	Nesis (1965)

TABLE 9. Mean biomass of samples with factor scores >1.0 for the indicated factors. Only factors with high scores at depths >15 m are considered. The locations from which most of these samples were taken and the feeding modes of the species most characteristic of each factor are also shown. SF = suspension feeder, DF = deposit feeder.

Factor	Name	No. of samples	Biomass mean ± SD	Feeding mode[a]	Location
<250 m					
10.	*Cistenides*	17	633 ± 542	DF	Lancaster Sound/Scott Inlet/Eclipse Sound (shallow)
1.	*Macoma - Astarte*	30	529 ± 350	DF/SF	Lancaster Sound/Philpots Island
2.	*Astarte borealis*	14	516 ± 370	DF/SF	Eclipse Sound (shallow)
19.	*Musculus*	18	502 ± 348	SF	Philpots Island/Lancaster Sound/Eclipse Sound (shallow)
11.	Ampeliscids	13	295 ± 230	SF/DF	Bylot Island/Philpots Island
12.	*Pelonaia - Mesidotea*	13	559 ± 660	SF/DF	Philpots Island
7.	*Owenia - Diastylis*	25	379 ± 415	SF/DF	Bylot Island
3.	Owenids	21	99 ± 139	DF	Scott Inlet/Eclipse Sound (deep)
13.	*Lumbrineris - Ascidia*	3	733 ± 778	DF/SF	Lancaster Sound
>250 m					
23.	*Ctenodiscus*	3	25 ± 5	DF	Eclipse Sound
9.	*Aglaophamus - Asychis*	16	61 ± 97	DF	All deep water except Eclipse Sound
4.	*Praxillura - Golfingia*	14	160 ± 216	DF	Lancaster Sound/NW Baffin Bay
15.	*Samythella*	7	27 ± 10	DF	Lancaster Sound/NW Baffin Bay
22.	*Polyphysia crassa*	5	26 ± 21	DF	Eclipse Sound/NW Baffin Bay
17.	*Bathyarca - Praxillella*	7	17 ± 13	SF/DF	Eclipse Sound/central Baffin Bay

[a]From Jumars and Fauchald (1977) and Feder (1979). Ranked in order of number of species of each type included in the factor.

influence of the Labrador current off Labrador and northern Newfoundland (Nesis, 1965). In other areas, the third factor was conspicuous. The 21 samples in which it was prominent generally contained low biomass (99 ± 139 $g \cdot m^{-2}$). These samples contained many foraminifera and oweniid polychaetes, species characteristic of Ellis's (1960) High Arctic deep-water impoverished communities.

Only in Eclipse Sound, with dominance of factor 2 plus high biomass in shallow water, and dominance of factor 3 plus low biomass in deeper water, did the vertical distribution of species assemblages and biomass resemble that "typical" of the Canadian High Arctic, described by Ellis (1960). Differences in community structure between exposed locations (such as the south coast of Devon Island) and enclosed bays and fiords (where most of the work on Canadian and Greenland benthic communities has been done) may explain discrepancies between my results and those of other arctic workers, especially in the vertical distribution of biomass.

Depth and geographic location were the most significant predictors of standing crop and were more effective than depth plus substrate as predictors of community composition. The narrow range of substrates generally encountered in any one depth range may be one of the reasons for the lack of a distinct substrate effect on standing crop. The negative relationship between depth and standing crop below the barren zone is well known (Rowe *et al.*, 1974; Curtis, 1975) and appears to be related to increasing distance from food supply. The importance of location as a determinant of faunal composition is indicative of the environmental heterogeneity of the study sites and implies that environmental parameters additional to depth and substrate influence faunal composition and standing crop. Among-area differences in hydrography, ice conditions, and primary productivity may affect the amount of food available to benthic animals.

Standing crops in eastern Lancaster Sound tended to be especially high, and those in central Baffin Bay tended to be especially low. The open-water period in eastern Lancaster Sound is generally longer than that along Baffin Island or in Eclipse Sound. Some open water normally appears in Lancaster Sound during spring, whereas fast ice persists in the latter two areas until well into the summer. However, it is uncertain whether a longer open-water season increases annual primary productivity and, indirectly, production of food usable by benthic animals. Primary productivity in the Arctic is limited by the supply of nutrients, which can be exhausted quickly even in a short open-water period (Dunbar, 1968).

The glaciers found on Devon Island may affect the nutrient supply in Lancaster Sound, especially near the Philpots Island and Phoenix Head Glacier sampling sites. Glacial enhancement of nutrients has been demonstrated in Jones Sound by Apollonio (1973), although the mechanism responsible for this is still in doubt (Dunbar, 1973). Glacier-related increases in nutrient levels may increase productivity of macrophytic algae and phytoplankton in Lancaster Sound.

The mean integrated biomass over the 5-50 m depth range generally decreases from the Grand Banks of Newfoundland through the Arctic Islands to the Beaufort Sea (Table 8). This trend appears to parallel a trend in decreasing primary productivity. Annual primary productivity of the Grand Banks areas is >180 g $C \cdot m^{-2} \cdot yr^{-1}$ (Koblentz-Mishke *et al.*, 1970 in Lorenzen, 1976). It is 40-70 g $C \cdot m^{-2} \cdot yr^{-1}$ in Frobisher Bay, SE Baffin Island (Grainger, 1975), about 20-35 g $C \cdot m^{-2} \cdot yr^{-1}$ in the Arctic Islands (Welch and Kalff, 1975), and 9-18 g $C \cdot m^{-2} \cdot yr^{-1}$ in the Beaufort Sea (Carey, 1978b). Benthic biomass at depths <50 m is >500 $g \cdot m^{-2}$ in the Bering Sea, an area with a primary productivity >100 g $C \cdot m^{-2} \cdot yr^{-1}$ (McRoy and Goering, 1976). Elsewhere, a positive relationship between benthic biomass and primary productivity has been established by Rowe (1971) and Rowe *et al.* (1974). On the whole, the EAMES study area — with the exception of Lancaster Sound — would appear to follow this pattern. The very high benthic biomass in Lancaster Sound may indicate that this is a region of relatively high (for the Arctic) primary productivity, while low biomass estimates from central Baffin Bay may indicate that this is a region of relatively low productivity.

Current strengths in various parts of the study area may also affect standing crop and species composition of benthic animals. A strong current generally enhances the food supply for filter feeders (Ölscher and Fedra, 1977). The strongest currents found in the study area were over sampling sites along southern Devon Island in Lancaster Sound, and the lowest were in Eclipse Sound (Fissel *et al.*, 1982). Current speeds over sampling sites off Philpots Island in NW Baffin Bay were weaker than in Lancaster Sound and stronger than in central Baffin Bay (Fissel *et al.*, 1982).

The probable importance of food availability as a primary determinant of community composition and standing crop becomes evident when modes of feeding of animals dominating the major assemblages are compared. Table 9 shows the mean biomass of samples with high scores for various factors, and the mode of feeding of the species most characteristic of each of these factors. All but one of the assemblages that included suspension feeders were most prominent at sites in northern Baffin Bay, Lancaster Sound, and shallow water in Eclipse Sound. Samples in which these assemblages were prominent tended to have high biomass. The only assemblage that included suspension feeders but was most prominent in samples with low biomass, factor 17, was most prominent in central Baffin Bay and deep water in Eclipse Sound. Assemblages that were characteristic of Scott Inlet and deeper areas in Eclipse Sound included only deposit feeding species and were, for the most part, most prominent in samples with low biomass.

The following relationships are postulated to explain areal differences in biomass and species composition in the study area. At depths of 15-250 m in Lancaster Sound, high biomass and communities including filter feeders may be maintained to considerable depths by high current speeds (Fissel *et al.*, 1982) and possibly by high primary productivity. Currents are somewhat less strong in NW Baffin Bay and biomass is lower there than in Lancaster Sound. Community composition is similar in Lancaster Sound and NW Baffin Bay and, as previously mentioned, the differences may be due to substrate. Weaker currents in Eclipse Sound and central Baffin Bay may lead to the observed low biomass and dominance by deposit feeders. High biomass and dominance of filter feeders in the shallow areas of Eclipse Sound indicate that productivity in this area may be high.

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REFERENCES

ALTON, M.S. 1974. Bering Sea benthos as a food resource for demersal fish populations. In: Hood, D.W. and Kelley, E.J. [eds.]. Oceanography of the Bering Sea with Emphasis on Renewable Resources. University of Alaska, Institute of Marine Science, Occ. Pub. No. 2. 257-277.

APOLLONIO, S. 1973. Glaciers and nutrients in Arctic seas. Science 180:491-493.

BAILEY, W.B. 1957. Oceanographic features of the Canadian Archipelago. Journal of the Fisheries Research Board of Canada 14:731-769.

BARRIE, J.D., BENNETT, B.A., BROWNE, S.M. and MOIR, A.J. 1980. Offshore Labrador biological studies, 1979: Benthos. Nearshore studies in the Makkovik Bay and Cartwright region. Unpublished Report by Atlantic Biological Services Ltd., St. John's, Nfld. for Total Eastcan Explorations Ltd. 158 p. [Available in the Library, Dept. of Fisheries and Oceans. St. John's, Newfoundland.]

BUCHANAN, R.A., CROSS, W.E. and THOMSON, D.H. 1977. Survey of the marine environment of Bridport Inlet, Melville Island. Unpublished Report by LGL Ltd., Toronto, Ont., for Petro-Canada Explorations Inc. 265 p. [Available in Library, Arctic Institute of North America, University of Calgary, Calgary, Alberta T2N 1N4.]

CAREY, A.G., Jr. 1977. The distribution, abundance, diversity and productivity of the western Beaufort Sea benthos. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Report of the Principal Investigators, March 1977. Vol. 4. National Oceanic and Atmospheric Administation, Boulder, CO. 1-53.

———. 1978a. The distribution, abundance, diversity and productivity of the western Beaufort Sea benthos. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Report of the Principal Investigators, March 1978. Vol. 4. National Oceanic and Atmospheric Administration, Boulder, CO. 127-252.

———. [ed.]. 1978b. Marine biota. In: Interim synthesis: Beaufort/Chukchi. Environmental Assessment of the Alaskan Continental Shelf. National Oceanic and Atmospheric Administration, Boulder, CO. 174-237.

——— and RUFF, R.E. 1977. Ecological studies of the benthos in the western Beaufort Sea with special reference to bivalve molluscs. In: Dunbar, M.J. [ed.]. Polar Oceans. Calgary: Arctic Institute of North America, 505-530.

CHRISTIE, N.D. 1975. Relationship between sediment, texture, species richness and volume of sediment sampled by a grab. Marine Biology 30:89-96.

COLLIN, A.E. 1962. The oceanography of Lancaster Sound. Ph.D. thesis, McGill University, Montreal, Quebec. 204 p.

CURTIS, M.A. 1975. The marine benthos of arctic and subarctic continental shelves. Polar Record 17:595-626.

DAY, P.R. 1965. Particle fractionation and particle-size analysis. In: Black, C.A., *et al.* [eds.]. Methods of Soil Analysis. Part 1. American Society of Agronomy, Monograph No. 9. 562-566.

DIXON, W.J. and BROWN, M.B. 1977. Biomedical Computer Programs P-series. Berkeley: University of California Press. 880 p.

DUNBAR, M.J. 1968. Ecological Development in Polar Regions. Englewood Cliffs, NJ: Prentice-Hall. 119 p.

———. 1972. The nature and definition of the marine Subarctic, with a note on the sea-life area of the Atlantic salmon. Transactions of the Royal Society of Canada (IV) 10:250-257.

———. 1973. Glaciers and nutrients in arctic fiords. Science 182:398.

EKMAN, S. 1967. Zoogeography of the sea. London: Sidgwick and Jackson. 417 p.

ELLIS, D.V. 1960. Marine Infaunal Benthos in Arctic North America. Arctic Institute of North America Technical Paper No. 5. 53 p.

FEDER, M.M. 1979. Distribution, abundance, community structure, and trophic relationships of the benthic infauna of the northeast Gulf of Alaska. In: Environmental Assessment of the Alaskan Continental Shelf. Final Report of the Principal Investigators, Dec. 1979. Vol. 6. National Oceanic and Atmospheric Administration, Boulder, CO. 1-256.

FISSEL, D.B., LEMON, D.D. and BIRCH, J.R. 1982. Major features of the summer near-surface circulation of western Baffin Bay, 1978 and 1979. Arctic 35(this issue).

GAUCH, H.G., Jr. and WHITTAKER, R.H. 1972. Comparison of ordination techniques. Ecology 53:868-875.

GAUDETTE, H.E. and FLIGHT, W.R. 1974. An inexpensive titration method for the determination of organic carbon in recent sediments. Journal of Sedimentary Petrology 44:249-253.

GRAINGER, E.H. 1975. A marine ecology study in Frobisher Bay, Arctic Canada. In: Cameron, T.W.M. and Billingsley, L.W. [eds.]. Energy flow — Its Biological Dimensions. Canadian Committee for the IBP, Royal Society of Canada, Ottawa, Ont. 261-266.

HUGHES, R.N. and THOMAS, M.L.H. 1971. Classification and ordination of benthic samples from Bedeque Bay, an estuary in Prince Edward Island, Canada. Marine Biology 10:227-235.

JUMARS, P.A. and FAUCHALD, K. 1977. Between-community contrasts in successful polychaete feeding strategies. In: Coull, B.C. [ed.]. Ecology of Marine Benthos. Columbia: University of South Carolina Press. 1-20.

KNOX, G.A. and LOWRY, J.K. 1977. A comparison between the benthos of the southern ocean and the north polar ocean with special reference to the amphipoda and polychaeta. In: Dunbar, M.J. [ed.]. Polar Oceans. Calgary: Arctic Institute of North America. 423-462.

LEE, R.K.S. 1973. General ecology of the arctic benthic marine algae. Arctic 26:32-43.

LORENZEN, C.J. 1976. Primary production in the sea. In: Cushing, D.H. and Walsh, J.J. [eds.]. The Ecology of the Seas. Philadelphia: W.B. Saunders Co. 173-185.

McROY, C.P. and GOERING, J.J. 1976. Annual budget of primary production in the Bering Sea. Marine Science Communications 2:255-267.

NESIS, K.N. 1965. [Biocoenoses and biomass of benthos of the Newfoundland-Labrador region]. Trudy Vsesoyuznogo Nauchno-Issledovatel'skogo Instituta Morskogo Rybnogo Khozyaistva i Okeanograffii 57:453-489. (Canada Fisheries Marine Service Translations Series No. 1375).

OCKELMANN, W.K. 1958. The zoology of East Greenland; marine Lamellibranchiata. Meddelelser om Grønland 122(4):1-256.

OLSCHER, E.M. and FEDRA, K. 1977. On the ecology of a suspension feeding benthic community: filter efficiency and behavior. In: Keegan, B.F., Ceidigh, P.O. and Boaden, P.J.S. [eds.]. Biology of Benthic Organisms. Oxford: Pergamon Press. 483-492.

ROWE, G.T. 1971. Benthic biomass and surface produtivity. In: Costlow, J.D. [ed.]. Fertility of the Sea. New York: Gordon and Breach. 441-454.

———, POLLONI, P.T. and HORNER, S.G. 1974. Benthic biomass estimates from the northwestern Atlantic Ocean and the northern Gulf of Mexico. Deep-Sea Research 21:641-650.

STEPHENSON, W., WILLIAMS, W.T. and COOK, S.D. 1972. Computer analysis of Petersen's original data on bottom communities. Ecological Monographs 42:387-415.

THOMSON, D.H., CROSS, W.E., BAIN, H. and PATTERSON, L. 1978. Aspects of the spring and summer marine environment of Brentford Bay, Boothia Peninsula, N.W.T. Unpublished Report by LGL Ltd., Toronto, Ont., for Polar Gas Project. 203 p. [Available in Library, Arctic Institute of North America, Calgary, Alberta T2N 1N4.]

THORSON, G. 1957. Bottom communities. In: Hegpeth, J.W. [ed.]. Treatise on Marine Ecology and Paleoecology. Vol. I, Ecology. Geological Society of America, Memoir 67. 461-534.

VIBE, C. 1939. Preliminary investigations on shallow water animal communities in the Upernavik and Thule Districts (Northwest Greenland). Meddelelser om Grønland 124(2):1-42.

WACASEY, J.W. 1975. Biological productivity of the southern Beaufort Sea: zoobenthic studies. Department of the Environment, Victoria, B.C. Beaufort Sea Technical Report No. 12b. 39 p.

WALKER, H.A., SAILA, S.B. and ANDERSON, E.L. 1979. Exploring data structure of New York Bight benthic data using post-collection stratification of samples, and linear discriminant analysis for species composition comparisons. Estuarine and Coastal Marine Science 9:101-120.

WELCH, H.E. and KALFF, J. 1975. Marine metabolism at Resolute Bay, Northwest Territories. In: Proceedings of a Circumpolar Conference on Northern Ecology. Section 2. National Research Council of Canada, Ottawa, Ont. 67-75.