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Distribution, Abundance and Diversity of Benthic Macroinvertebrates on the Canadian Continental Shelf and Slope of Southern Davis Strait and Ungava Bay

PATRICK L. STEWART,[1,2] PATRICIA POCKLINGTON[1,3] and RICHARD A. CUNJAK[1,4]

ABSTRACT. Stations in a survey of benthic invertebrates on the Canadian continental shelf and slope of southeastern Baffin Island, in Ungava Bay, and on the northern Labrador Shelf, fell into definite groups as a result of an objective analysis of similarity in species composition. The groupings were shown to correspond to major water masses in the area. Groups corresponding to cold surface water masses, to the deep Irminger Atlantic water mass, and to mixtures of these with adjacent water masses were observed. The Irminger Atlantic group dominated on the Baffin Island continental shelf. Species diversity, also measured in the study, was high, with large numbers of species present in low abundance.

Key words: marine, benthos, invertebrates, distribution, shelf, slope, Davis Strait, Ungava Bay, subarctic

RÉSUMÉ. Des postes participant à une étude des invertébrés benthiques sur le plateau continental canadien et le versant sud-est de l'île de Baffin, dans la baie d'Ungava, et sur le plateau nord du Labrador, s'établirent en groupes définis à la suite d'une analyse objective des ressemblances dans la composition des espèces. Des groupes particuliers correspondaient aux masses d'eau prinicipales de la région, c'est-à-dire aux masses d'eau froide en surface, à la masse d'eau profonde atlantique Irminger et aux mélanges de ces masses aux eaux adjacentes. Le plateau continental de l'île de Baffin était dominé par le groupe atlantique Irminger. Il se présenta une grande diversité d'espèces, dont bon nombre étaient représentés par un nombre restreint d'invertébrés.

Mots clés: marin, benthos, invertébrés, distribution, plateau, versant, détroit de Davis, baie d'Ungava, subarctique

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INTRODUCTION

No major quantitative studies have been conducted on the distribution of benthic invertebrates on the Canadian continental shelf of southeastern Baffin Island and Ungava Bay. The *Calanus* expeditions (1947-52) made qualitative collections of the nearshore and shallow water fauna of the region. Studies of the *Calanus* collections and of collections from earlier expeditions advanced knowledge of the taxonomy and zoogeography of benthic invertebrates in the area. Notable recent studies include those of amphipods (Dunbar, 1954), polychaetes (Grainger, 1954), echinoderms (Grainger, 1955), decapods (Squires, 1962), bivalves (Lubinsky, 1980), prosobranch gastropods, chitons and scaphopods (Macpherson, 1971), bryozoans (Powell, 1968), hydroids (Calder, 1970, 1972), and ascidians (Trason, 1964).

Ecological studies of Canadian eastern arctic benthos include those by Ellis (1960), who examined quantitatively infaunal invertebrate abundance and standing crop in shallow-water coastal areas of northern Baffin Island and West Greenland and summarized communities down to 200 m; Grainger (1975), who reported benthic standing crop from several grabs from the "Calanus Shelf" in Frobisher Bay; Wacasey *et al.* (1980), who reported standing crop and species composition near Brevoort Island on the southeastern Baffin Island coast; and Thomson (1982), who studied standing crop and community structure of marine benthos in Lancaster Sound, Eclipse Sound and northern and central Baffin Bay.

The deeper subtidal invertebrate fauna of the Davis Strait (Canadian side) has been sampled occasionally. Several stations were occupied by the Godthaab Expedition of 1928, and benthic invertebrates were sampled by the R.V. *Hero* in western Davis Strait at depths from 132 to 192 m (Dearborn and Dean, 1969a,b; Blake and Dean, 1973).

The Greenland side of Davis Strait has received more study, as a result of research interest dating back to the turn of the century. The Ingolf Expedition (1895-96) sampled deep stations on the West Greenland side of Davis Strait, and the Godthaab Expedition sampled the shelf waters along the West Greenland coast and into Baffin Bay. More recently, quantitative studies have been conducted in shelf areas down to approximately 200 m in conjunction with exploratory petroleum drilling there (Marine Identification Agency, 1978), and biological observations from Godthaab have continued (Curtis, 1977, 1979; Petersen, 1977).

Beginning in 1976 and continuing through 1979 a consortium of oil exploration companies including Esso Resources Canada Limited, Aquitaine Company of Canada Limited and Canada Cities Service Limited, conducted an environmental baseline study of the continental shelf and slope of southeast Baffin Island and Ungava Bay under the Eastern Arctic Marine Environmental Studies (EAMES) program of the Canadian government, prior to receiving permission to drill exploratory wells in the area. The following presents the major findings of aspects of the baseline study dealing with marine macroinvertebrates. These aspects include distribution of the most abundant and widespread species, community diversity, and results of an analysis to determine the importance of water masses and water temperature in the distribution of species. As such it is the first quantitative study of macroinvertebrates in the area. The macroinvertebrates collected in the baseline

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[1] MacLaren Plansearch Limited, Suite 701, Purdy's Wharf Tower, 1959 Upper Water Street, Halifax, Nova Scotia, Canada B3J 3N2
[2] Present address: Box 109, Newport, Nova Scotia, Canada B0N 2A0
[3] Present address: Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6
[4] Present address: Department of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

study represent a significant addition to national holdings of Canadian marine invertebrate fauna. Information on standing crop of benthic macroinvertebrates gathered in the baseline study has been reported elsewhere (Stewart, 1983).

METHODS

Field Program

Sampling took place in August–September 1977 and April 1978 on cruises of the M.V. *Lady Johnson II*. Station locations are shown in Figure 1 and positions are listed in Table 1. Stations were chosen to give broad geographic coverage of the southeastern Baffin Island shelf and slope; three stations were selected in Ungava Bay and one on the northern Labrador Shelf.

Up to ten Van Veen grab samples (0.1m²) were taken per station. Volume of sediment in each sample was measured. Samples with volumes near the maximum obtained at a given station were used for quantitative analysis. Samples were agitated in buckets with running seawater, and overflow water containing animals was passed through an 0.42 mm sieve. Animals and sediment that did not pass through the sieve were stored in 10% formalin.

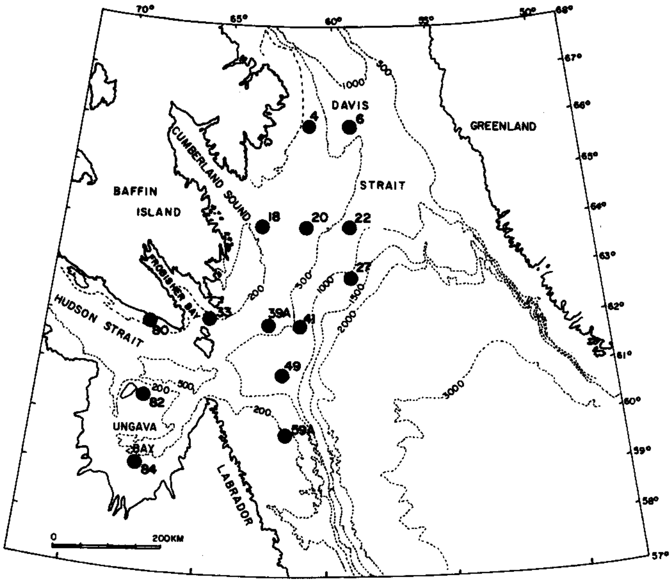

FIG. 1. Station locations, Davis Strait and Ungava Bay.

TABLE 1. Station data for Davis Strait benthic program

Benthic Station	Date (D/M/Y)	Position	Depth (m)	Bottom Temperature (°C)
4	16/08/77	66°01'N, 59°04'W	622	1.4
6	19/08/77	65°56'N, 56°59'W	658	1.4
18	22/09/77	64°00'N, 64°00'W	292	−0.2
20	22/09/77	64°00'N, 62°00'W	283	2.2
22	21/09/77	64°00'N, 60°00'W	920	2.9
27	13/08/77	62°59'N, 58°59'W	970	3.0
33	09/09/77	62°14'N, 65°01'W	177	0.4
39A	09/08/77	62°00'N, 62°38'W	507	4.3
41	01/08/77	62°02'N, 61°09'W	532	4.3
49	06/09/77	61°00'N, 61°50'W	621	4.0
59A	16/04/78	59°51'N, 61°39'W	180	3.0
80	03/08/77	61°55'N, 67°32'W	179	0.7
82	06/08/77	60°34'N, 67°35'W	106	0.0
84	05/08/77	59°11'N, 67°29'W	145	−0.7

A Hessler and Sanders epibenthic sled was towed at each station for 20 minutes at speeds of 1–4 knots to sample macroinvertebrates living in the vicinity of the sediment-water interface. Mesh size on the sled net was 1 mm. Sled contents were preserved in 10% formalin. Because of time constraints on project completion, the majority of sled samples could not be examined. These samples and all other invertebrate material collected in the benthic program are presently held by National Museums Canada, Museum of Natural Sciences, Ottawa.

Sediment samples were taken for grain-size analysis at most benthic stations, and from grabs taken opportunistically at a number of other locations, with the aim of obtaining a broad picture of the sediments in the study area.

Bottom water temperatures at benthic stations shallower than 200 m were measured by bathythermograph and at deeper stations were obtained from the results of physical oceanographic measurements made in the southern Davis Strait during the baseline environmental program (Osborn *et al.*, 1978) and from Fisheries and Oceans Canada, which conducted a shrimp survey that encompassed most stations in this study in August 1978 (H. Sandeman, pers. comm. 1980). In the absence of bottom water salinity information for many of the stations, bottom temperature was used in conjunction with information on distribution of water masses in the area at the time of the survey (Osborn *et al.*, 1978) and historically (Dunbar, 1951; Lee, 1968) to determine the identity of water masses likely to influence the benthos at a given station.

Laboratory Analysis

Polychaetes, molluscs, echinoderms, and crustaceans were identified to species; most other invertebrate taxa were identified to practical taxonomic levels. The results of all preliminary analyses are contained in MacLaren Marex Incorporated (1978, 1979).

Abundance information for polychaete, mollusc, echinoderm, and crustacean species from each grab at each station was used to calculate the average abundance of each species. The Shannon-Wiener diversity index (H') (Pielou, 1974) and Pielou's (1974) evenness index (J') were calculated from the pooled species abundance and total number of species at each station. To estimate the variation in the diversity measurements at a given station, the Shannon-Wiener index was calculated for each grab sample and averaged to give a station value and standard deviation. This average value will nearly always be smaller than the true diversity (Pielou, 1974).

Abundance information was used in a numerical clustering procedure to separate dominant groupings of stations and species. A matrix of similarity coefficients (Czekanowski Quantitative; Stephenson *et al.*, 1972) was computed from a data set consisting of the log transformed numerical abundance of each species present at a given station in greater than 0.5% of mean abundance and also present at two or more stations. The reduced species list thus consisted of 138 species. The log transformation (log (x + 1)) was used in this case because the Czekanowski index is sensitive to extremely large values in the data (Boesch, 1973), of which there were several. The clustering strategy used was hierarchical with flexible sorting since it clusters sharply (Stephenson *et al.*, 1972). In clustering stations, the flexible sorting strategy produced clusters identical to those obtained using an alternate strategy, group average sorting. Analyses were run on the "ORDANA" portion of a package of computer programs by Bloom *et al.* (1977).

Sediment grain size distribution from each station was determined by wet sieving and pipette analysis of the greater than 4 phi fraction of each sample. Sediment analyses are presented in detail in Stewart (1983) and only qualitatively here to support the data on species composition.

RESULTS

Sediment Type

Sediment types at benthic stations are illustrated in Figure 2. Most stations had substrate consisting of sand-silt-clay mixtures with two main groupings, sand and silt-clay. The field descriptions of sediments for stations 22 and 33, at which sediment samples were not taken, were "a silty clay" and "a coarse sand with rocks and gravel" respectively. No estimate of variability of sediment composition was available, as only a single sample was taken at most stations. However, station 41 sediments showed high variability as indicated by analysis of three separate samples taken there (Fig. 2).

Stations deeper than 600 m had fine sand-silt substrate; that at the deepest stations was predominantly silt and clay. Substrate at station 4 was a brown ooze containing large quantities of sponge spicules.

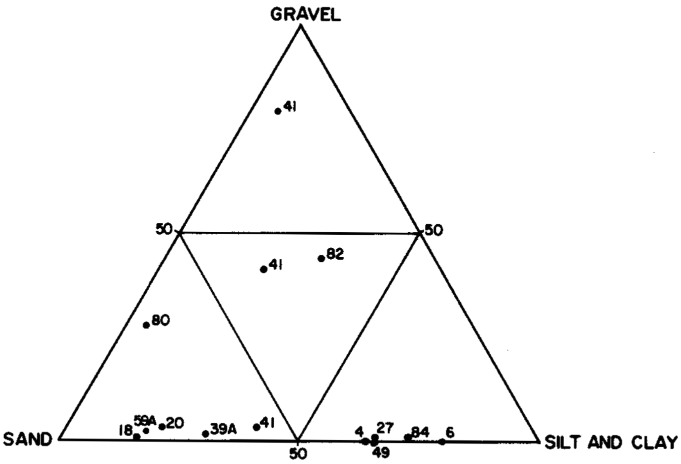

FIG. 2. Ternary diagram for sediment composition for Davis Strait benthic stations. Three samples were taken for station 41.

Water Masses

Several major water masses occur on the southeastern Baffin Island shelf and slope. A shallow (50–100 m), seasonally variable water mass lies over the entire area. Below it, the cold Baffin Island Current flows southward from its origin in Baffin Bay at depths to 300 m. A branch of this current flows through the mouth of Frobisher Bay and Gabriel Strait into the northern Hudson Strait, where it affects the southern Baffin Island Shelf (Leblond, 1980). A seaward branch of the Baffin Island Current mixes with water flowing out of Hudson Strait and reaches the Labrador Shelf, forming the Labrador Current. Hudson Strait outflow consists chiefly of cold, low-salinity water (−1.8–2.0°C; 32.0–33.5‰; Dunbar, 1951) leaving the Canadian Arctic Archipelago.

Below the Baffin Island Current the warm (4.0°C, 34.9‰; Osborn *et al.*, 1978) Irminger Atlantic water mass blankets the region at depths of 200–700 m. Below 700 m the slightly colder (3.4°C, 34.9‰; Osborn *et al.*, 1978) Atlantic Intermediate water mass occurs (Osborn *et al.*, 1978). South of Hudson Strait this water mass replaces the Irminger Atlantic water at depths below 200 m (Osborn *et al.*, 1978).

In the present study, some stations occurred in each of the major water masses. Five stations were directly or indirectly influenced by the Baffin Island Current. Stations 18, 33 and 80, at temperatures near 0°C (Table 1) occurred under Baffin Island Current water, while stations 20 and 59A occurred in mixed waters of which this water mass was a major component. Station 20 lay on 64°N latitude within 25 km of the zone of rapid temperature change that indicates the mixing zone between the Baffin Island Current and the Irminger Atlantic water mass lying below it (Osborn *et al.*, 1978) and had intermediate bottom water temperatures. Station 59A, the most southerly station in the study (Fig. 1), was evidently in a mixing zone between Labrador Current water and deeper, warmer Atlantic Intermediate water.

Stations 39A, 41 and 49 occurred under the Irminger Atlantic water mass, stations 22 and 27 lay in the Atlantic Intermediate water mass, and stations 82 and 84 in Ungava Bay were exposed to cold water flowing out of Hudson Strait. Stations 4 and 6, at the northern limit of the study area and marginally on the Baffin Bay side of the Baffin-Greenland sill in the Davis Strait, were probably exposed to mixtures of water of Baffin Bay and Irminger Atlantic origin, with the colder Baffin Bay water types predominating, as evidenced by the low bottom water temperatures observed (Table 1).

Species Distribution

Benthic macroinvertebrate species used in the cluster analysis and their abundance at each station are presented in Table 2. The analysis, with species as attributes, separated stations into two groups (Fig. 3). The first (Fig. 3,A) contained mainly stations having in common shallow depth (<300 m) and cold bottom water; two stations, 20 and 59A, were shallow but slightly warmer owing to their location near the boundary between a cold and a warm water mass. The second major group (Fig. 3,B) contained stations that were deep

TABLE 2. Mollusc, echinoderm, crustacean and polychaete species present at greater than 0.5% abundance and at two or more stations

	Cluster[a] Group	Abundance[b] by Station													
		4	6	18	20	22	27	33	39A	41	49	59A	80	82	84
MOLLUSCA															
Polyplacophora															
1. *Ischnochiton albus* (Linne)	1-2b							10.0	5.0					54.0	
Bivalvia															
2. *Astarte crenata* Gray	6-2		4.3	2.9	13.8	52.0	1.7		16.7	16.7		14.3	2.0	2.0	
3. *Astarte striata* Leach	1-2b							10.0				2.9		132.0	
4. *Bathyarca pectunculodes* Scacchi	6-2	3.3	1.4	2.9		34.0	1.7		23.3	13.3	5.7				
5. *Bathyarca sp. A*	7-2			1.4						3.3					
6. *Limatula subauriculata* (Smith)	4-1						1.7						6.0		
7. *Limatula hyperborea* (Jensen)	4-1									1.7			6.0		
8. *Macoma calcarea* (Gmelin)	2-2a											7.1			37.1
9. *Macoma moesta* (Deshayes)	2-1a							20.0						4.0	8.6
10. *Nucula delphinodonta* Mighels and Adams	6-2	3.3			3.8	14.0	28.3		18.3	16.7	2.9	18.6			
11. *Nuculana pernula* Link	2-1b			4.3											25.7
12. *Propeamussium imbriferum* (Loven)	7-2								1.7	3.3		2.9			
13. *Thyasira gouldi* (Philippi)	1-2a			7.1	1.3		1.7	10.0		8.3	8.6	15.7		14.0	
14. *Yoldia amygdalea* Valenciennes	2-2b				61.3		20.0				2.9				25.7
15. *Yoldia myalis* (Couthouy)	6-3			2.9	11.3		10.0				1.4				
16. *Yoldiella lucida* Loven	2-2b			1.4	11.3		11.7			3.3	15.7				8.6
Gastropoda															
17. *Cylichna alba* (Brown)	1-1d	3.3	4.3	2.9						1.7	1.4	1.4			1.4
18. *Lepeta caeca* (Muller)	1-2b		1.4					20.0	3.3	1.7		10.0	18.0	52.0	31.4
Scaphopoda															
19. *Dentalium entale* Linne	6-1					4.0	3.3		18.3	10.0	1.4				
20. *Dentalium occidentale* Stimpson	1-1a								18.3	11.7	8.6				
POLYCHAETA															
21. *Ophelina cylindrocaudata* A. Hansen	5-1		1.4	7.1	22.5		11.7		3.3		42.9		6.0		
22. *Ophelina aulogaster* Rathke	4-1				3.8								58.0		
23. *Amphicteis gunneri* McIntosh	4-2		5.7		1.3										
24. *Ancistrosyllis groenlandica* McIntosh	5-1	3.3	25.7	2.9	1.3	2.0	38.3			1.7	5.7				
25. *Aricidea catherinae* (McIntosh)	5-2						55.0			1.7					4.3
26. *Aricidea suecica* Eliason	2-2b		1.4		16.3		103.3			3.3		24.3	8.0	6.0	68.6
27. *Brada villosa* (Rathke)	1-2a			1.4				20.0		1.7	4.3				
28. *Ceratocephala loveni* Malmgren	4-2		65.7		5.0								4.0		
29. *Chaetozone setosa* Malmgren	2-2b			37.1	78.8		16.7	50.0	1.7	1.7	12.9	61.4		14.0	862.9
30. *Chone duneri* Malmgren	8	3.3	1.4										2.0		
31. *Eteone flava* (O. Fabricius)	2-1a													6.0	35.7
32. *Eteone longa* (O. Fabricius)	2-1a		1.4	2.9			1.7	10.0						8.0	31.4
33. *Euchone incolor* Hartman	1-2c	3.3	21.4		5.0	22.0		10.0		1.7			16.0		84.3
34. *Eunice pennata* (O.F. Muller)	6-1						3.3		11.7	1.7					
35. *Euphrosine borealis* Oersted	7-2									3.3				2.0	
36. *Eulalia bilineata* Johnston	7-2		1.4							5.0					
37. *Exogone brevipes* (Claparède)	1-1b								3.3		14.3				
38. *Glycera capitata* Oersted	5-1	3.3	101.4		3.8	2.0	51.7		31.7	75.0	48.6	10.0		22.0	
39. *Glyphanostomum pallescens* (Theel)	3			4.3		2.0									
40. *Laetmonice filicornis* Kinberg	1-1a								1.7	5.0	2.9				
41. *Laonice cirrata* (M. Sars)	7-2				2.5					3.3					
42. *Lumbrineris fragilis* (O.F. Muller)	5-1	10.0	38.5	2.9			81.7		3.3	5.0	8.6			30.0	55.7
43. *Lumbrineris impatiens* (Claparede)	5-1	10.0	72.9		6.3		21.7		1.7	8.3	40.0			6.0	15.7
44. *Lumbrineris latreilli* (Audouin & Milne-Edwards)	5-1		42.9		2.5	4.0	40.0		5.0	13.3	14.3				8.6
45. *Lumbrineris minuta* Theel	1-1d		4.3								17.1				8.6
46. *Lumbrineris* sp. A.	2-1b									1.7					38.6
47. *Maldane sarsi* Malmgren	2-2b		1.4	11.4	5.0		11.7					245.7			7.1
48. *Myriochele oculata* Zachs	3			65.7								17.1			1.4
49. *Nepthys ciliata* O.F. Muller	2-1a							10.0						2.0	37.1
50. *Aglaophamus malmgreni* Theel	2-1b										8.6				227.1
51. *Nichomache lumbricalis* (O. Fabricius)	2-2b				5.0		25.0		1.7		2.9	10.0			25.7
52. *Notalia sp. A*[c]	7-1						1.7			3.3					
53. *Notomastus latericeus* (M. Sars)	7-2			1.4	1.3					18.3					

(continued)

TABLE 2. (continued)

	Cluster[a] Group	Abundance[b] by Station													
		4	6	18	20	22	27	33	39A	41	49	59A	80	82	84
54. *Onuphis conchylega* (M. Sars)	6-2	3.3		8.6	198.7	2.0			23.3	8.3		44.3	78.0	2.0	
55. *Onuphis holobranchiata* Marenzeller[c]	6-3				100.0					1.7					
56. *Owenia oculata* Zachs	2-1b										1.4				24.3
57. *Paramphinome pulchella* (M. Sars) G.O. Sars	5-2		2.9	1.4			31.7								
58. *Tauberia gracilis* Tauber	5-1		1.4	1.4			6.7				5.7	2.9	2.0		
59. *Pista cristata* (O.F. Muller)	6-1		1.4	1.4			1.7		15.0	13.3					
60. *Potamilla neglecta* (Sars)	6-2				12.5				18.3	3.3	1.4		2.0		
61. *Phyllodoce groenlandica* Oersted	3			2.9	2.5							10.0		4.0	1.4
62. *Praxillella praetermissa* (Malmgren)	1-2a			1.4	3.8	6.0	26.7	10.0		1.7	1.4	1.4		2.0	
63. *Prionospio steenstrupi* Malmgren	2-2b			2.9	43.8									4.0	15.7
64. *Prionospio cirrifera* Wiren	2-2b		8.6	54.3	122.5		16.7			1.7	7.1	7.1	18.0		32.9
65. *Prionospio* sp. A	6-3		2.9		10.0		3.3				2.9				
66. *Rhodine gracilior* (Tauber)	3				2.5							220.0		2.0	
67. *Samythella neglecta* Wolleback	7-2		1.4						3.3	1.7					
68. *Scalibregma inflatum* Rathke	3			2.9	1.3							18.6		4.0	2.9
69. *Scolelepides viridis* Verrill	6-3				10.0		1.7								
70. *Scoloplos armiger* (O.F. Muller)	1-2b		1.4				1.7	20.0			2.9	38.6	2.0	18.0	14.3
71. *Sphaerodorum gracilis* (Rathke)	2-1a		1.4		1.3			20.0		3.3				18.0	28.0
72. *Stauronereis caecus* (Webster and Benedict)	5-2		1.4				36.7								
73. *Syllis cornuta* Rathke	6-2		8.6		6.3	2.0	8.3	20.0	5.0	30.0	1.4	5.7	4.0	4.0	
74. *Syllis gracilis* Grube	5-2						6.7							2.0	1.4
75. *Syllis* sp. A	4-2		5.7						1.7						
76. *Terebellides stroemi* M. Sars	5-1		135.7	1.4		18.0	10.0		8.3	8.3	7.1	4.3	2.0	26.0	20.0
77. Polychaeta species A	5-1		182.9				55.0		3.3	38.6					
78. Polychaeta species B	3			2.9	1.3										
ECHINODERMATA															
Asteriodea															
79. *Crossaster papposus* Linne	8	3.3												4.0	
80. *Henricia sanguinolenta* (O.F. Muller)	1-2b							10.0						2.0	
Ophiuroidea															
81. *Amphipholis squamata* (Delle Chiaje)	1-1a								10.0	25.0	5.7		2.0		
82. *Amphiura fragilis* Verrill	1-1a								3.3	5.0	5.7				2.9
83. *Amphiura sundevalli* (Muller and Troschel)	1-1d		1.4						1.7	1.7	2.9	8.6		6.0	5.7
84. *Ophiacantha bidentata* (Retzius)	4-1				1.3					3.3			10.0		4.3
85. *Ophiocten sericeum* (Forbes)	3			17.1	1.3							1.4			
86. *Ophiopholis aculeata* (Linne)	1-2b							90.0	5.0	5.0		2.9	4.0	118.0	
87. *Ophiura robusta* (Ayres)	1-2b	13.3	5.7					460.0	31.7		4.3	20.0	250.0	3884.0	4.3
88. *Ophiura sarsi* Lutken	2-2a			1.4	7.5							11.4	10.0		5.7
89. *Stegophiura nodusa* Lutken	2-1b								1.7			1.4			154.3
Echinoidea															
90. *Strongylocentrotus droebachiensis* (Muller)	1-2b				2.5	2.0		30.0	1.7			2.9	4.0	46.0	
CRUSTACEA															
Amphipoda															
91. *Ampelisca amblyops* G.O. Sars	1-1a						1.7		1.7	6.7	90.0				
92. *Ampelisca declivitatis* Mills	1-1a						1.7		8.3	20.0	55.7				
93. *Ampelisca eschrichti* Kroyer	2-1a							10.0				4.3	2.0	146.0	128.6
94. *Ampelisca gibba* G.O. Sars	1-1a						6.7		3.3	3.3	77.1				
95. *Ampelisca latipes* Stephensen	4-1				3.8					1.7	1.4		14.0		
96. *Ampelisca macrocephala* Lilljeborg	4-1				2.5								10.0		
97. *Arrhis phyllonyx* (M. Sars)	1-1d		10.0												7.1
98. *Byblis crassicornis* Metzger	1-1b				1.3				3.3		87.1				
99. *Byblis gaimardi* (Kroyer)	2-2b			1.4	18.8						48.6	5.7	18.0	48.0	20.0
100. *Byblis minuticornis* G.O. Sars	5-2		4.3				8.3								
101. *Haploops tubicola* Lilljeborg[d]	1-2c	6.7	15.7	42.9	6.3	1292.0	1.7	10.0	3.3	8.3	1590.0	4.3			24.3
102. *Haploops setosa* Boeck	1-1c	6.7			1.3						10.0		2.0		1.4
103. *Harpinia mucronata* G.O. Sars	5-2		4.3				60.0		3.3						
104. *Harpinia bidentata* Stephensen	3			4.3	5.0						8.6	2.9			
105. *Harpinia propinqua* G.O. Sars	5-1	3.3	5.7		8.8		51.7			5.0	8.6	5.7			
106. *Ericthonius tolli* Bruggen	2-1a													22.0	68.6

(continued)

TABLE 2. (concluded)

	Cluster[a] Group	4	6	18	20	22	27	33	39A	41	49	59A	80	82	84
107. *Eriopisa elongata* (Bruzelius)	7-1						1.7			3.3	10.0				
108. *Eurystheus melanops* (G.O. Sars)	2-1a				1.3			90.0				1.4	4.0	32.0	52.9
109. *Eurystheus* sp. B	1-1b	3.3	2.9						3.3		10.0				
110. *Laetmatophilus armatus* (Norman)	7-2								3.3	3.3					1.4
111. *Lepechinella arctica* (Schellenberg)	1-1b								1.7		24.3				
112. *Liljeborgia fissicornis* (M. Sars)	1-1a								6.7	6.7	1.4				
113. *Ischyrocerus megacheir* (Roeck)	1-1a		4.3		2.5		6.7		21.7	6.7	145.7				2.9
114. *Ischyrocerus latipes* Kroyer	1-2b		4.3				3.3	190.0	1.7			8.6		26.0	97.1
115. *Ischyrocerus latipes var assimilis*	1-1a		5.7						5.0	3.3	57.1		2.0		10.0
116. *Melita dentata* (Kroyer)	1-1c							10.0			18.6		6.0		4.3
117. *Pardalisca cuspidata* Kroyer	1-2b							10.0						6.0	
118. *Photis tenuicornis* G.O. Sars	2-2a			1.4	1.3							8.6	2.0		28.6
119. *Phoxocephalus holbolli* (Kroyer)	1-2b							10.0					26.0	4.0	2.9
120. *Protomedia fasciata* Kroyer	4-1		2.9		2.5							1.4	16.0		1.4
121. *Siphonoecetes typicus* Kroyer	4-1									1.7		1.4	8.0		
122. *Tiron spiniferum* (Stimpson)	6-2		2.9		7.5				3.3	5.0	4.3	2.9	6.0	8.0	
123. *Tmetonyx gracilipes* Stephensen	7-1						8.3			1.7	4.3				
124. *Unciola leucopis* (Kroyer)	1-2b							60.0				25.7		22.0	
125. *Unciola laticornis* Hansen	1-1c										15.7	2.9	56.0		4.3
126. *Unciola crassipes* Hansen	7-1									3.3	1.4				
Cumacea															
127. *Cumella carinata* (Hansen)	1-2b						1.7	10.0					6.0	16.0	
128. *Diastylis echinata* Bate	1-1a								1.7	5.0	2.9				
129. *Diastylis scorpioides* (Lepechin)	2-2a				6.3							2.9	2.0		12.9
130. *Diastylis spinulosa* Heller	6-1				1.3				6.7						
131. *Diastylis rathkei* (Kroyer)	5-1	6.7	37.1		7.5		35.0		5.0	16.7	17.1				14.3
132. *Diastylis* sp. A	5-1	3.3	10.0				8.3				4.3				
133. *Hemilamprops uniplicata* (G.O. Sars)	4-1				1.3								12.0		
134. *Leucon nascicoides* (Lilljeborg)	2-1a							20.0				2.9	2.0	10.0	10.0
135. *Leucon pallidus* G.O. Sars	1-1a		2.9							3.3	28.6		12.0		
Isopoda															
136. *Ianira pulchra* Hansen	1-2a							10.0		1.7		1.4			
137. *Ilyarachna hirticeps* G.O. Sars	1-1a								3.3	1.7	10.0		2.0		
138. *Munna acanthifera* Hansen	1-1a		4.3						5.0	1.7	40.0				

[a] Refer to Figure 3.

[b] Species abundance is in number·m^{-2}

[c] Specimens lost and not verified.

[d] May include some *Haploops tenuis* known to occur near Station 22 (Kanneworf, 1966) but not recognized as a separate species in initial identifications. During subsequent verification the large number of *Haploops* sp prevented checking all samples for the possible presence of *H. tenuis*.

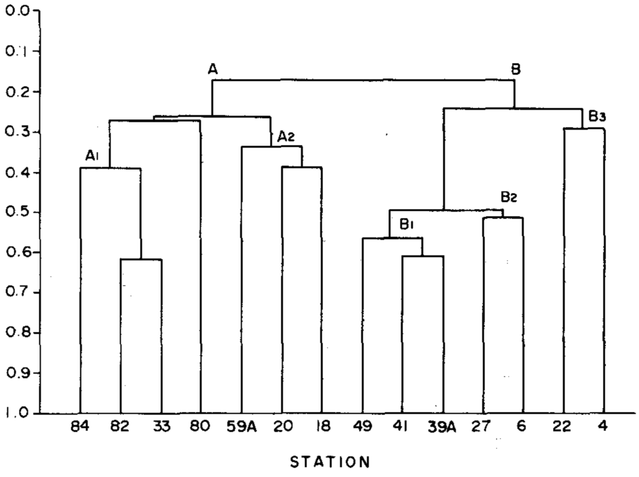

FIG. 3. Cluster groupings of Davis Strait benthic stations based on Czekanowski Quantitative index of similarity between stations.

(>300 m) and, with the exception of stations 4 and 6, were under warm bottom water.

Subgroups of both groups A and B were generally stations occurring under a particular water mass. Stations in group A_1, except station 33, occurred under Hudson Strait outflow from the Canadian Arctic Archipelago; those in group A_2 occurred under Baffin Island current or mixtures thereof; and station 80 was located in a region of possible mixing between the two. The anomalously large similarity of stations 33 and 82 (Table 3), in fact the largest of any in the study, conflicts with the above interpretation but it may be an artifact of the fact that only one grab sample from station 33 was analysed for species composition. The stations are alike in the dominant species present but are otherwise dissimilar in number of species present and total number of individuals.

Stations in group B_1 (39A, 41 and 49) were under Irminger Atlantic water and grouped closely, with stations 39A and 41

TABLE 3. Czekanowski Quantitative Similarity Indices for Davis Strait Benthic Stations

Station	4	6	18	20	22	27	33	39	41	49	59A	80	82
6	0.35												
18	0.20	0.23											
20	0.22	0.30	0.39										
22	0.29	0.25	0.25	0.23									
27	0.22	0.51	0.28	0.39	0.21								
33	0.10	0.15	0.15	0.15	0.14	0.13							
39A	0.25	0.38	0.16	0.27	0.31	0.34	0.16						
41	0.24	0.39	0.24	0.34	0.29	0.40	0.16	0.61					
49	0.26	0.42	0.24	0.33	0.20	0.45	0.13	0.45	0.49				
59A	0.13	0.15	0.33	0.34	0.16	0.22	0.29	0.22	0.17	0.13			
80	0.11	0.22	0.17	0.37	0.09	0.14	0.28	0.24	0.23	0.24	0.26		
82	0.15	0.24	0.19	0.24	0.13	0.22	0.62	0.25	0.24	0.20	0.34	0.32	
84	0.15	0.32	0.25	0.36	0.11	0.32	0.35	0.19	0.23	0.31	0.31	0.26	0.44

the most similar of any deep-water station pair. Stations 6 and 27 (group B_2) were located on the margin of the Irminger Atlantic water mass, and stations in group B_3 (4 and 22) did not appear to correspond to a definite water mass. These stations were the least similar of any station pair and were the last to group in the cluster analysis.

Clusters of species similar on the basis of common stations at which they are found showed a correspondence of species distribution with depth and water temperature (Fig. 4). Species in groups 1-1, 5 to 6-2, and 7 were distributed in greatest abundance at relatively deep, warm stations, those in groups 1-2 and 2 mainly at shallow, cold stations, and those in groups 3, 4-2, and 6-3 mainly near boundaries between warm and cold water masses. Species that clustered in groups 4-1 and 8 were found mainly at stations influenced by the Baffin Island Current. Some cosmopolitan species occurred in many of the above groupings (subgroups 1-2a,1-2c,2-2b,5-1b, and 5-1c).

Only a few of the species groupings appeared to result from substrate preference. Species in subgroups 2-1b and 2-2a were most abundant at station 84 in Ungava Bay (soft bottom), and species in subgroups 5-1a and 5-2 were most abundant at fine substrate stations on the continental slope. Species in groups 1-2c, 2-2b, 5-1b and 5-1c were largely cosmopolitan but had an apparent preference for fine substrate.

Two species that had an apparent substrate preference not indicated by the species grouping procedure were *Ischnochiton albus* and *Lepeta caeca,* which were associated with coarse or partially coarse bottom substrate (stations 39A and 41). Deposit feeders such as *Nuculana pernula, Yoldia* spp and *Nucula delphinodonta* occurred only in fine substrate.

Species Diversity

This study identified 492 species of molluscs, echinoderms, crustaceans, and polychaetes. Many species were present in low abundance at a small number of stations, mainly in only one grab at a station. A complete list of taxa and their abundance is found in MacLaren Marex (1978, 1979).

Most stations had a moderate Shannon-Wiener diversity of from 3.65 to 4.96 bits/individual (Table 4). The lowest were recorded at stations 22 and 82 (1.04 and 2.11 bits/individual respectively), and the highest at stations 27, 39A and 41. The highest diversity usually occurred at stations having high total number of species.

The variability of estimates of Shannon-Wiener diversity at each station was small (standard deviation of 7–25% of the mean at all stations except station 22) (Table 4). As expected, the average diversity calculated for each station was lower than that calculated from the pooled species information from each station (Pielou, 1974).

Many species occurred in small numbers, often singly, at a station. As a result Pielou's Evenness (J′) was high for most stations (only four measured below 0.70). Evenness is a measure of how the total number of individuals in a sample is distributed among species, with a value of 1.0 indicating the presence of the same number of individuals for each species present.

DISCUSSION

The faunal analysis conducted in this study quantitatively supports the contention that groups of marine benthic organisms in the waters off southeast Baffin Island can be associated with particular water masses and temperature regimes. The patterns observed appear to be more consistent with water mass and temperature distributions than with substrate distributions. However, too few stations were sampled, particularly in areas of high substrate variability such as Ungava Bay, to adequately assess the role of substrate.

The roles of temperature, water mass, and substrate in determining the distribution of benthic invertebrates in arctic and subarctic marine environments have been major topics of speculation among biologists for many years. Both bottom water temperature and water mass origin have been used as criteria for the establishment of zoogeographic and faunal boundaries, and water temperature accounts for the phenomenon of arctic submergence of cold water faunas at temperate latitudes (Ekman, 1953). The geographic overlap of species can be explained by the fact that a species can have different vegetative and reproductive temperature requirements and thus can exist under several regimes where it coexists with another species but only reproduces in one (Ekman, 1953). Water mass origin affects invertebrates both in terms of par-

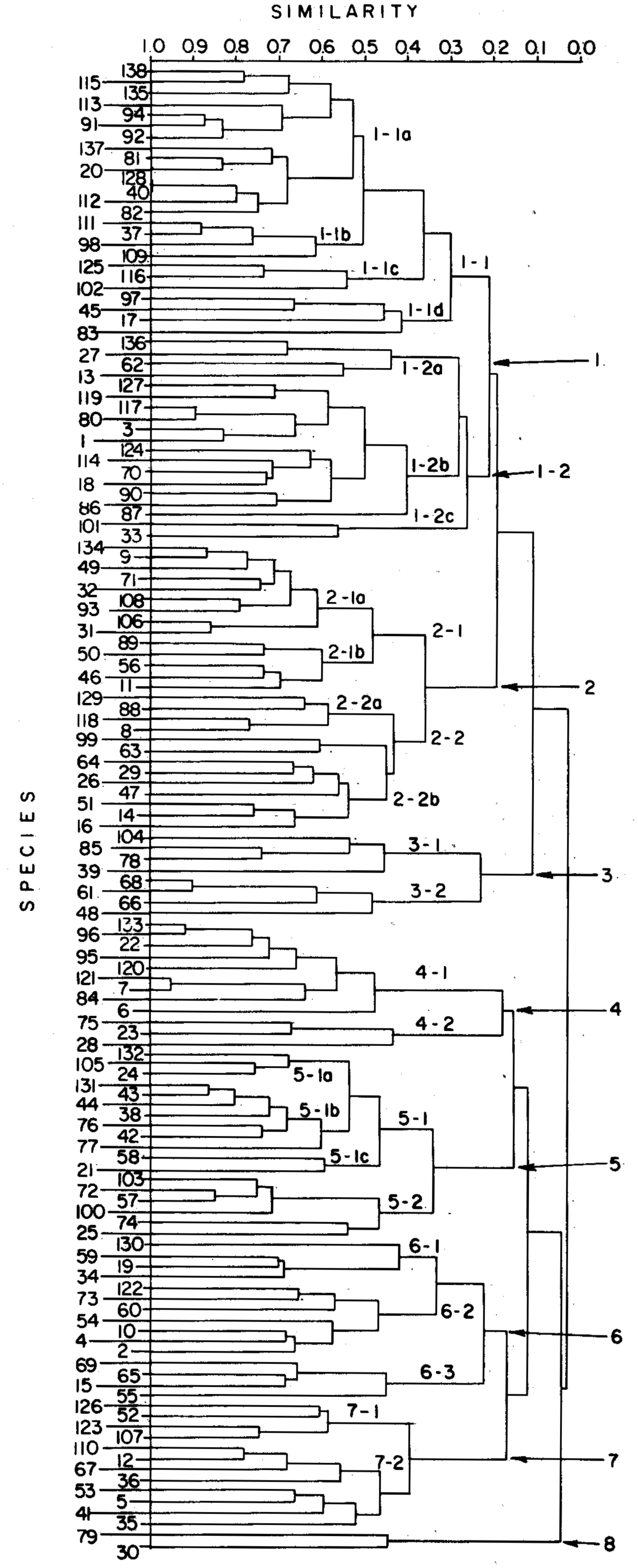

FIG. 4. Cluster groupings of Davis Strait species based on Czekanowski Quantitative index of similarity. Species numbers refer to Table 2.

TABLE 4. Species Diversity at Davis Strait Benthic Stations

Station	H'^a	$\bar{H}^b$	Standard Deviation	J'^c	N^d	S^e	No. of Replicates
4	4.35	2.89	0.49	0.96	32	23	3
6	4.62	3.69	0.26	0.71	683	93	7
18	4.20	2.46	0.62	0.74	236	50	7
20	4.80	3.49	0.71	0.73	736	95	8
22	1.04	0.99	0.63	0.22	744	28	5
27	5.30	4.22	0.29	0.83	643	82	6
33	3.66	3.66	—	0.73	130	33	1
39A	5.74	4.18	0.42	0.89	291	90	6
41	5.90	4.45	0.58	0.87	343	109	6
49	3.65	3.51	0.86	0.52	2096	126	7
59A	4.72	4.03	0.44	0.72	803	95	7
80	4.64	3.74	0.46	0.74	431	78	5
82	2.11	1.95	0.58	0.32	2581	95	5
84	4.96	4.00	0.89	0.67	2578	174	7

[a] Shannon-Wiener diversity.
[b] Average diversity.
[c] Pielou's Evenness.
[d] Total number of individuals.
[e] Total number of species.

ticular temperature and salinity regimes and because the movement of water masses often leads to dispersal of species, chiefly of those having planktonic larval stages (Thorson, 1957). Substrate generally affects small-scale distributions of species through adult substrate requirements and through choice of particular types of substrate even at the larval settlement stage (Wilson, 1953).

Many of the dominant species in the present study (Table 5) have been observed as community dominants elsewhere. The bivalve mollusc *Macoma calcarea* dominated in terms of standing crop at station 84 in Ungava Bay, as it does in widely distributed cold, shallow-water arctic and subarctic environments (Thorson, 1957) and also in waters off north Baffin Island (Ellis, 1960). The bivalves *Bathyarca pectunculodes* and *Astarte crenata* were important in both numbers and standing crop at most of the deep-water stations in the present study, as they were in an *Astarte-Bathyarca* community (*A. crenata* and *B. glacialis*) described by Thorson (1957) from shallow water off East Greenland.

Dense patches of the ampeliscid amphipod *Haploops tubicola* (stations 22 and 49, up to 1850 and 3680 individuals·m^{-2} respectively) have also been found in Danish waters (Thorson, 1957) and off Scotland (Allen, 1953), while *Haploops* and *Byblis* species have been observed to characterize slope areas, as is the case with stations 22 and 49 (Mills, 1971). In addition communities consisting of numerous *Ampelisca* species have been observed in the Sea of Japan (*A. macrocephala* densities up to 14 500·m^{-2}) and they occur in Danish waters as well (Thorson, 1957). At station 49 in the present study many of the amphipod species present in addition to *Haploops* were ampeliscids.

Foraminifera, chiefly *Rhabdammina* sp., were observed at all the deep Davis Strait stations (MacLaren Marex, 1978). Carpenter (1876) observed *Rhabdammina abyssorum* in benthic samples taken in the southern Davis Strait.

Shannon-Wiener diversity observed in this study exceeded that observed on other parts of the North American continental shelf (North Carolina — Boesch, 1972; Gulf of Maine —

TABLE 5. Dominant Species in Major Taxa at Davis Strait Benthic Stations

Station	Molluscs	Polychaetes	Echinoderms	Crustaceans
4	*Bathyarca pectunculodes* *Nucula delphinodonta* *Cylichna alba*	*Lumbrineris impatiens**	*Ophiura robusta**	*Haploops tubicola* *H. setosa* *Diastylis rathkei*
6	*Astarte crenata* *Cylichna alba*	*Terebellides stroemi** Polychaete sp. A* *Glycera capitata* *Lumbrineris impatiens* *Ceratocephala loveni*	*Ophiura robusta*	*Haploops tubicola* *Diastylis rathkei*
18	*Thyasira gouldi* *Nuculana pernula*	*Myriochele oculata** *Prionospio cirrifera** *Chaetozone setosa*	*Ophiocten sericeum*	*Haploops tubicola*
20	*Yoldia amygdalea* *Astarte crenata*	*Onuphis conchylega** *Chaetozone setosa* *Onuphis holobranchiata* *Prionospio cirrifera**	*Ophiura sarsi*	*Byblis gaimardi*
22	*Astarte crenata** *Bathyarca pectunculodes*	*Terebellides stroemi* *Euchone incolor*	*Strongylocentrotus droebachiensis*	*Haploops tubicola**
27	*Nucula delphinodonta* *Yoldia amygdalea*	*Glycera capitata* *Lumbrineris fragilis** *Aricidea suecica** *A. jeffreysii*	*Ophiomusium lymani*	*Harpinia mucronata* *H. propinqua* *Diastylis rathkei*
33	*Lepeta caeca* *Macoma moesta*	*Chaetozone setosa*	*Ophiura robusta** *Ophiopholis aculeata*	*Ischyrocerus latipes** *Unciola leucopis* *Eurystheus melanops*
39A	*Bathyarca pectunculodes* *Nucula delphinodonta* *Dentalium occidentale* *Dentalium entale*	*Onuphis conchylega* *Glycera capitata**	*Ophiura robusta**	*Ischyrocerus megacheir*
41	*Astarte crenata* *Bathyarca pectunculodes* *Nucula delphinodonta*	*Glycera capitata** *Syllis cornuta**	*Amphipholus squamata*	*Ampelisca declivitatis* *Diastylis rathkei*
49	*Yoldiella lucida* *Thyasira gouldi* *Dentalium occidentale*	Polychaete sp. A *Glycera capitata* *Ophelina cylindrocaudatus* *Lumbrineris impatiens*	*Amphipholis squamata* *Amphiura fragilis*	*Ischyrocerus megacheir** *Ampelisca gibba* *A. amblyops* *Haploops tubicola** *Byblis crassicornis*
59A	*Tachyrhynchus erosus* *Macoma loveni*	*Rhodine gracilior** *Maldane sarsi** *Chaetozone setosa*	*Ophiura robusta*	*Unciola leucopis*
80	*Lepeta caeca*	*Onuphis conchylega** *Ophelina aulogaster*	*Ophiura robusta**	*Phoxocephalus holbolli* *Unciola laticornis*
82	*Ischnochiton albus* *Lepeta caeca* *Astarte striata*	*Sphaerodorum gracilis* *Lumbrineris fragilis* *Terebellides stroemi*	*Ophiura robusta** *Ophiopholis aculeata*	*Ampelisca eschrichti** *Byblis gaimardi* *Syrrhoe crenulata*
84	*Lepeta caeca* *Nuculana pernula* *Yoldia amygdalea* *Macoma calcarea*	*Aglaophamus malmgreni** *Euchone analis* *Chaetozone setosa*	*Stegophiura nodusa* *Ophiopholis aculeata*	*Ischyrocerus latipes* *Ampelisca eschrichti* *Erichthonius tolli* *Aceroides latipes* *Eurystheus melanops* *Eudorellopsis integra**

*Indicates two most dominant species at each station. Several dominant species occurred at one station only and thus were not included in the cluster analysis and Table 2 (e.g., *Ophiomusium lymani*, *Eudorellopsis integra*).

Rowe *et al.*, 1975) and were of the same order as in the deep ocean (5 bits/individual for polychaetes and bivalves only — Sanders, 1968). The level of diversity may reflect the importance of subarctic and temperate influences on the fauna of the region, as opposed to a strictly arctic influence, which would result in low diversity (Margalef, 1977).

The small number of species and individuals observed at station 4 may be due to the peculiar substrate observed there, a fine brown ooze containing large amounts of sponge spicules. Fine brown oozes off arctic fjord mouths may foster low invertebrate standing crop (Curtis, 1975) and numbers of species and individuals may be reduced as well.

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