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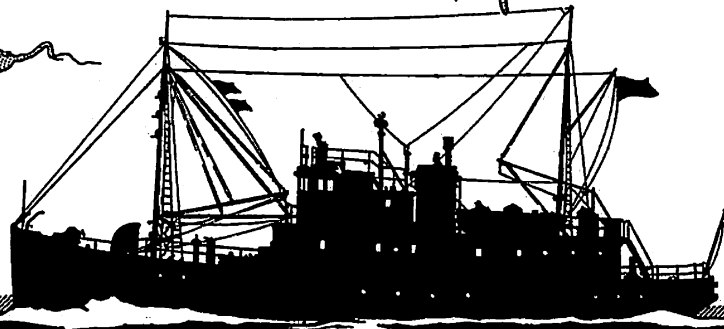
**Technical Report No. 68
PRELIMINARY INVESTIGATIONS OF THE
MARINE GEOLOGY
OF THE SOUTHEASTERN CHUKCHI SEA**

by

Joe S. Creager and Dean A. McManus

**Contract AT-45-1-540
U.S. Atomic Energy Commission
assisted by
Contract Nonr-477(10),
Project NR 083 012
Office of Naval Research**

**Reference 61-15
May 1961**



SEATTLE 5, WASHINGTON

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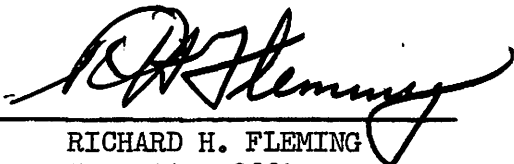
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Joe S. Creager and Dean A. McManus

Brown Bear Cruise No. 236
1 August to 2 September 1959

Contract AT-45-1-540
U. S. Atomic Energy Commission
assisted by
Contract Nonr-477(10)
Project NR 083 012
Office of Naval Research

Reference 61-15
May 1961


RICHARD H. FLEMING
Executive Officer

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PERSONNEL

N. K. Anderson bathymetry, calcium carbonate
analysis

W. L. Brundage, Jr. heavy mineral analysis

S. C. Cooper foraminiferal analysis

A. J. Eisenberg organic carbon analysis

R. W. Sternberg bathymetry

INTRODUCTION

As a part of Project Chariot of Operation Plowshare, the Department of Oceanography conducted an intensive oceanographic survey of the southeastern portion of the Chukchi Sea from 1 August to 2 September 1959 (Figure 1). This report is concerned with the marine geological phase of the survey; other aspects will be discussed in separate reports to be issued in the future. The oceanographic survey (Brown Bear Cruise 236) extended from Bering Strait northward to approximately 69° North and westward to about 169° West, encompassing an area of nearly 20,000 square miles. The area investigated is poorly charted and, except for pioneer studies of the physical, chemical, and geological oceanography (Barnes and Thompson, 1938; Goodman and others, 1942; Ratmanoff, 1937), was virtually unexplored until the start of recent investigations (Buffington, Carsola, and Dietz, 1950; and Saur, Tully, and LaFond, 1954).

The geological studies were confined to the offshore water because the U. S. Geological Survey is reporting on the bottom topography and marine geology of the nearshore areas.

The following discussion of the bathymetry and marine geology is based on 2,600 nautical miles of sounding data and on 120 surface grab samples and 11 short gravity cores (Figures 2 and 3). The soundings were made with EDO echo sounders Models AN/UQN 1B and 255C, operated throughout the survey on 1-foot interval scales. The cruise track was planned to provide sounding lines normal to the coastal configuration. In addition, numerous lines were run parallel to the general trend of the coast, as a control over the lines running offshore.

Bottom samples were collected with a modified van Veen grab sampler with a capacity of 4.3 liters. A 5.08 cm (2-inch) diameter gravity corer was used in an attempt to collect a vertical sediment sample at each station. Because of the very dense clayey silt encountered at most stations, this corer was successful at only 11 locations. The cores ranged in length from 48 to 132 cm.

BATHYMETRY

The general bathymetry of the area is shown in Figure 4. The location of the sounding tracks and stations may be in error by as much as 1 to 5 miles, particularly in the western portion of the survey area. A number of factors combined to preclude more accurate locations: (a) persistent overcast conditions that made astronomical sights impossible most of the time; (b) inadequate base charts of the area showing the coastal configuration; (c) lack of electronic navigational aids; and (d), strong winds and currents. Near shore, where visual sights or radar ranges could be made, the positions are probably accurate to within 1 to 3 miles, at least in regard to position relative to the coast as portrayed by the small-scale navigational charts.

With a few minor exceptions, the sounding track was continuous. A standard sounding velocity of 4800 feet per second was used for plotting depths. Variations in sound velocity from the nominal value of 4800 feet per

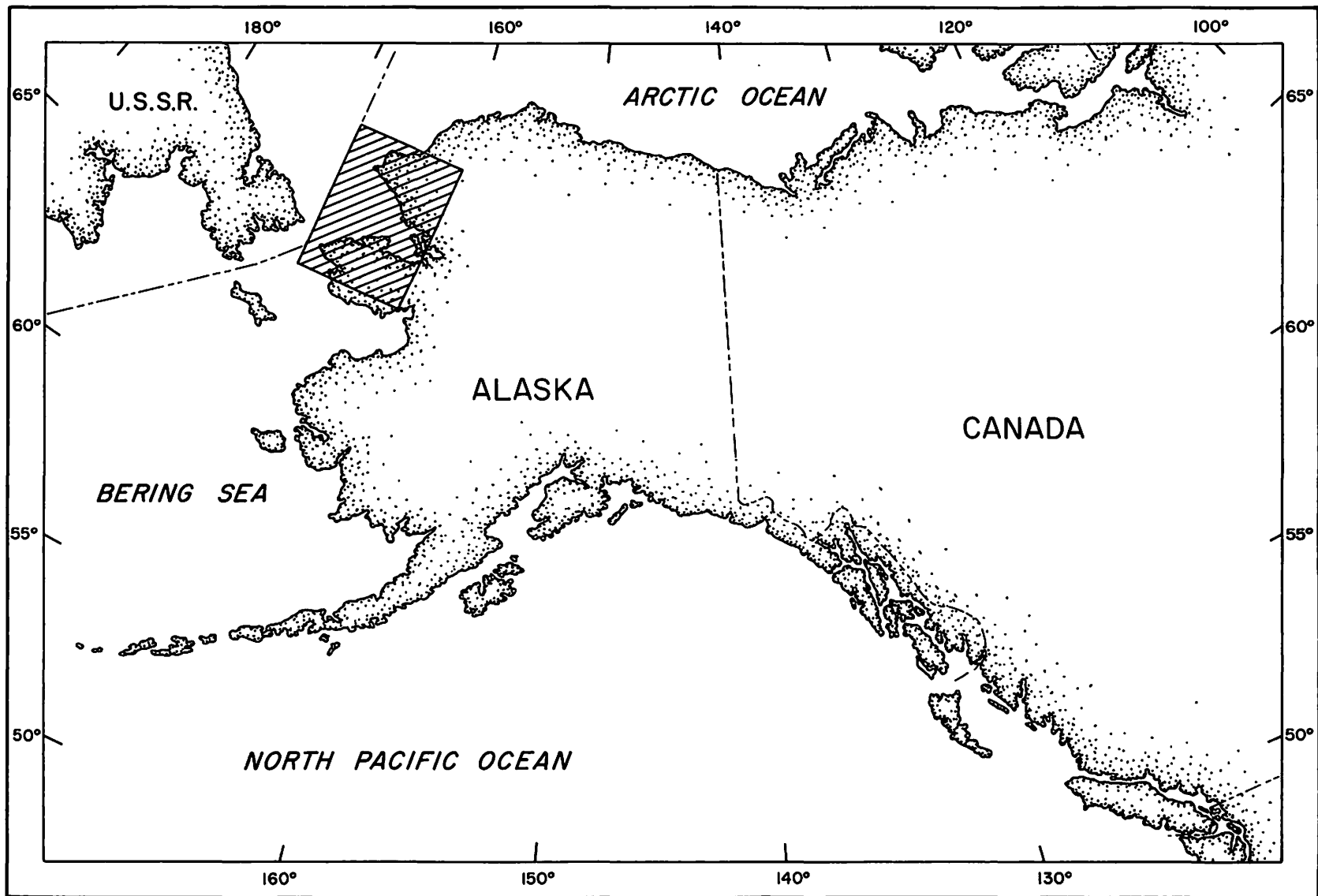


Fig. 1. Locations map of the study area.

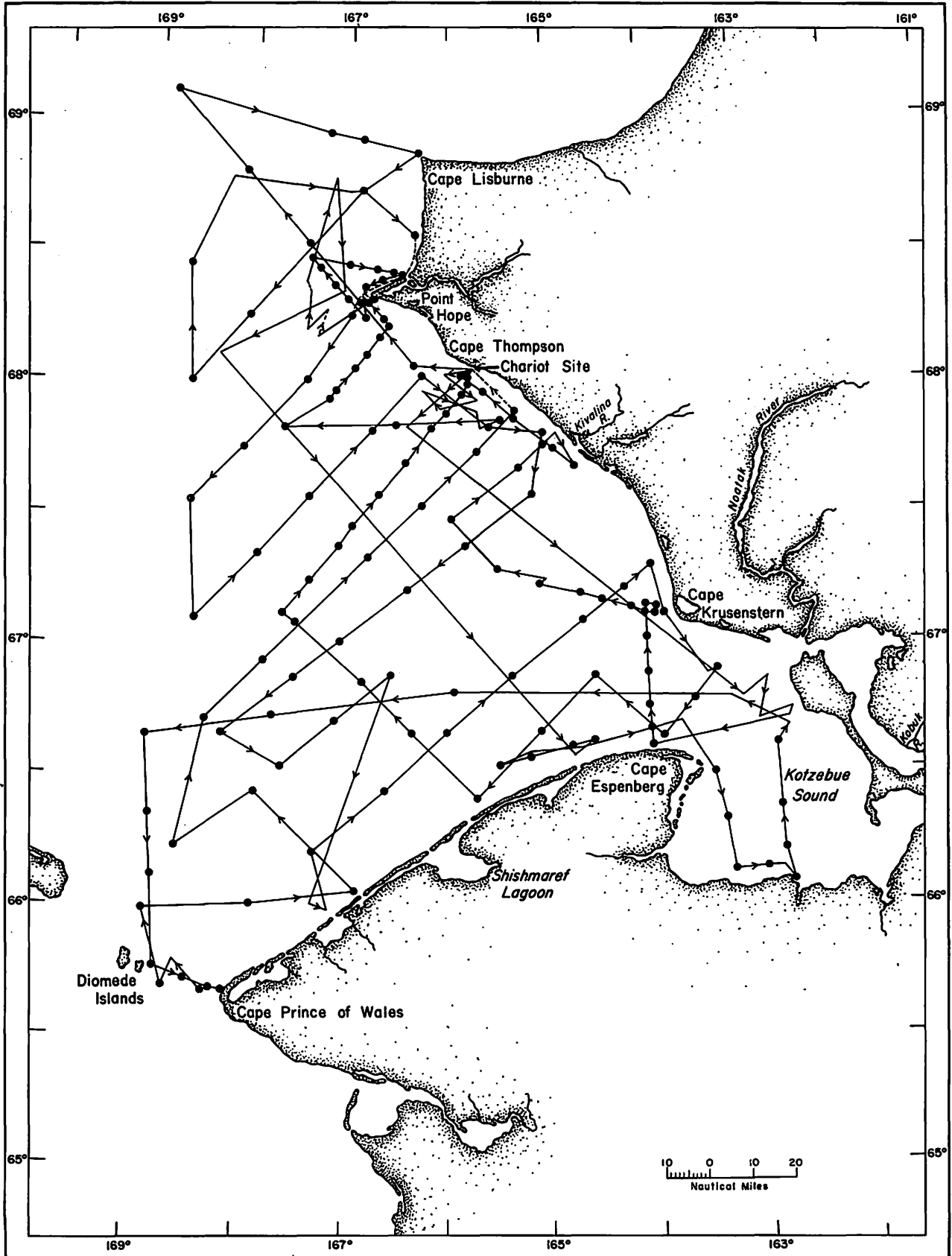


Fig. 2. Sounding track for Brown Bear Cruise 236 (polyconic projection).

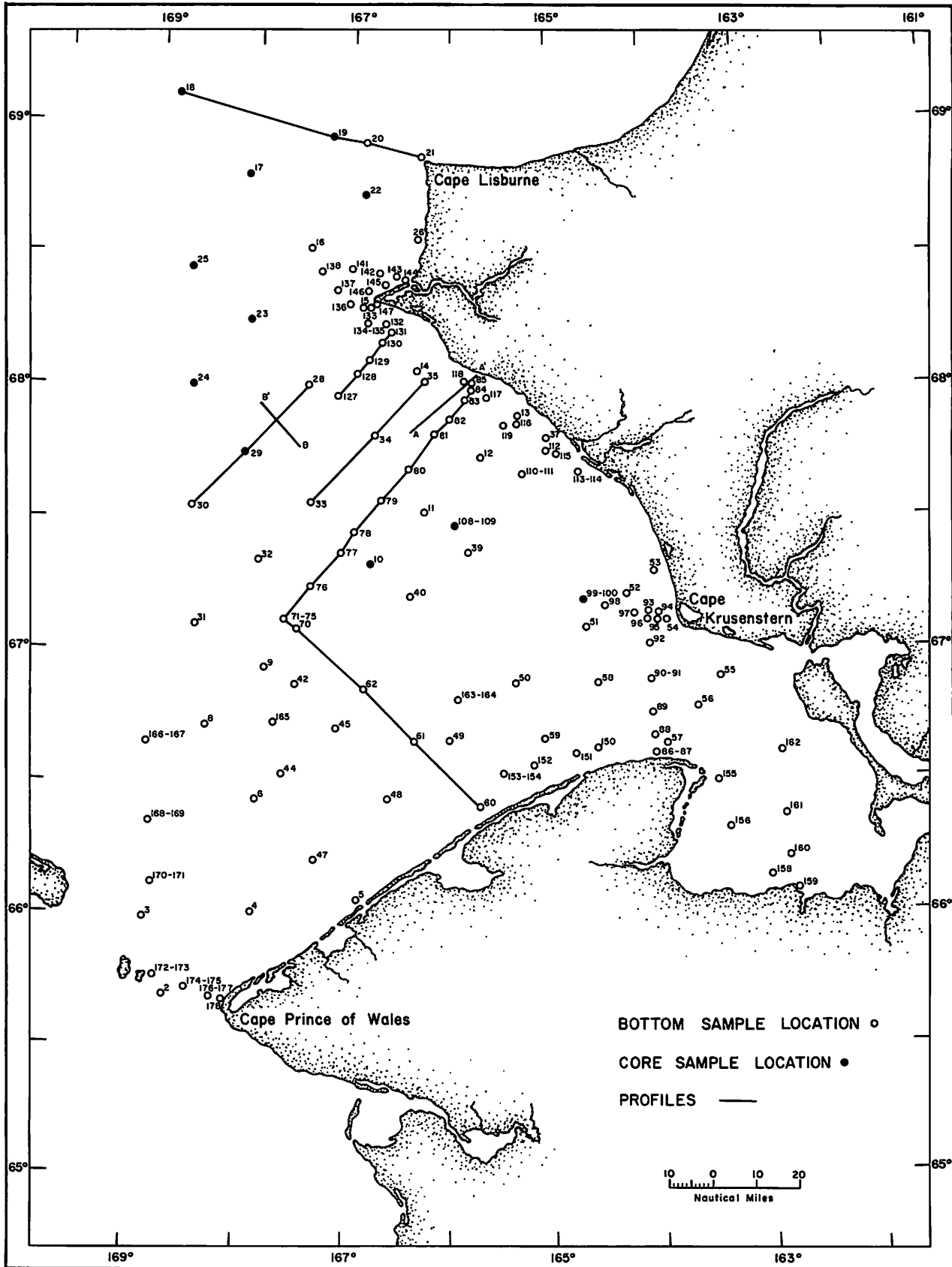


Fig. 3. Bottom sample locations, Brown Bear Cruise 236.

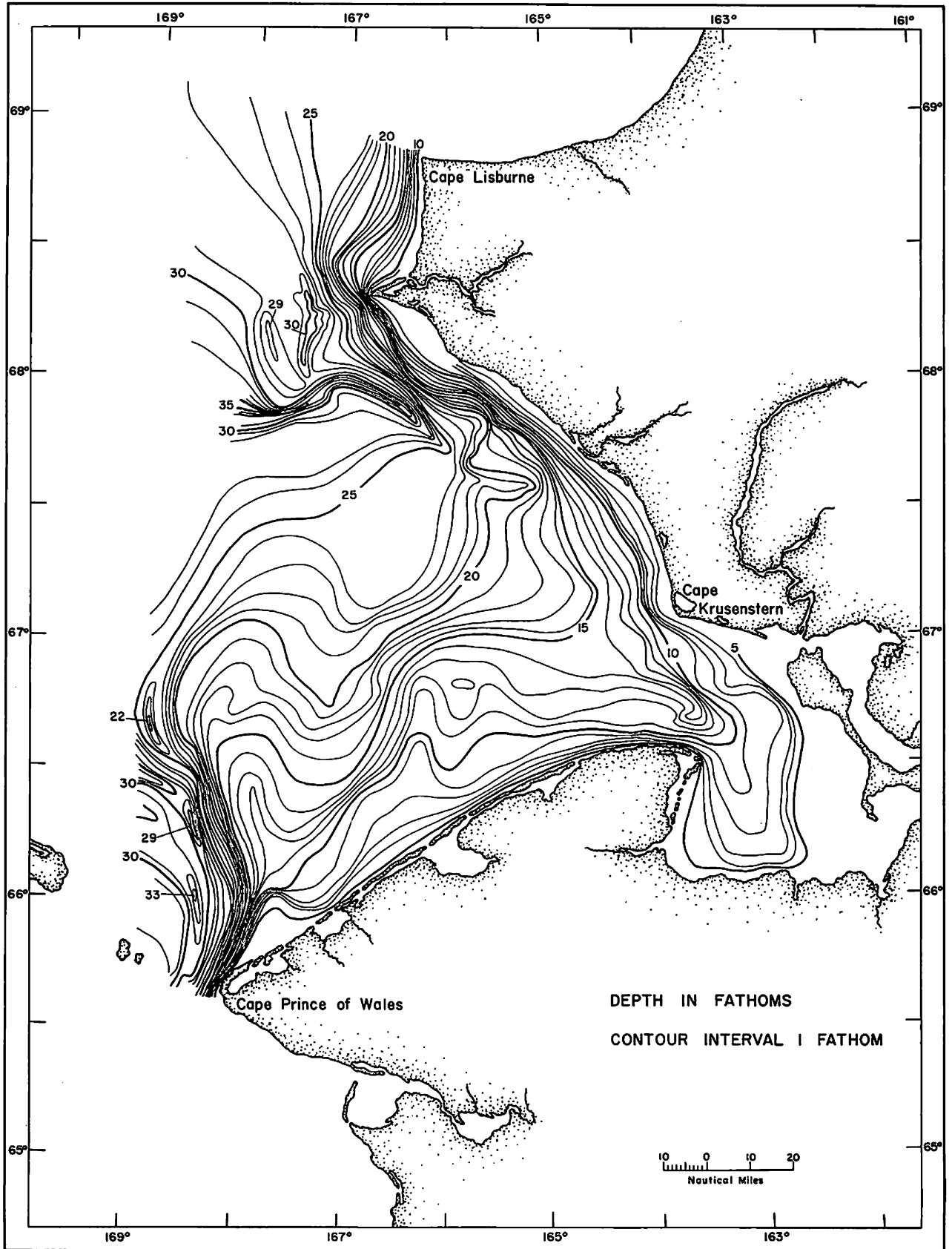


Fig. 4. Bathymetric chart of Southeastern Chukchi Sea.

second were found to be negligible when computed from temperature and salinity data. It was considered unnecessary to correct for tidal variations since the tidal range in the area is generally less than 1 foot. Recorded depths were transferred from the fathograms to a large-scale base chart and contoured at 1-fathom intervals*. At sounding-line crossings, differences of no greater than ± 1 fathom in recorded depth were accepted as indicating proper relative location of the two sounding lines. If the difference was greater, the sounding lines were adjusted to make the difference no greater than 1 fathom. In addition to relocation by depths, physical, chemical, and other geological data were used in relocating each sounding line. As many as 11 crossings on a single track were rectified by such relocations; in only one case did the necessary adjustment exceed 3 miles. The bathymetric chart (Figure 4) should be regarded only as a general indication of topographic trends.

This portion of the Chukchi Sea has been reported as being monotonously regular (Buffington *et al.*, 1950; Hopkins, 1959). Hopkins states that ". . . no features are recognized that can be interpreted as submerged valleys or submerged strand lines." However, gross delineation of a number of submarine features may be made from the results of the 1959 survey.

A large underwater salient, delimited by isobaths deeper than 20 fathoms, extends northward from Cape Prince of Wales for more than 70 miles and has an east-west width of over 20 miles. Other smaller salients may exist north of Shishmaref Lagoon. The remainder of the southern portion of the survey area appears to be featureless with very low gradients--apparent gradients of less than 1 to about $\frac{1}{4}$ feet per mile were noted between Stations 60 and 71 (Figure 5). Depths of 15 to 20 fathoms lie more than 30 miles offshore. The inner portion of Kotzebue Sound, as indicated by two sounding lines, is also flat and featureless.

The northern portion of the survey area is more rugged than the southern portion. Southwest of the Point Hope - Cape Thompson area there appears to be an extensive valley system ("shelf channel", Kuenen, 1950, p. 480). The main channel of this system is well-defined southwest of Point Hope, trending northeast-southwest. South of Point Hope it apparently turns toward the southeast, where it is much less well-defined. Good profiles across this system were obtained from a number of sounding tracks off Cape Thompson (Figure 6). The main channel of this valley system has been named Hope Submarine Valley. Relief of 18 to 24 feet was recorded for the head of the valley south of Cape Thompson, and relief of more than 30 feet was noted at the western extremity near 168° West. The gradients down the valley range from less than 1 foot per mile to a maximum of 6 feet per mile at the seaward extremity. The valley has an average width of $\frac{1}{4}$ to 5 miles. Profiles across the valley (Figure 6) indicate that gradients on the side walls are of similar (between Stations A and A') or that the wall on the northern side is steeper (between Stations B and B', 28 and 29, and 80 and 82). The steep side-walls exhibit gradients ranging from 20 to 54 feet per mile whereas the low-gradient side walls show apparent gradients of 2 to 3 feet per mile.

* This large-scale base chart (scale 1/463000) is not included in this report but is available on request.

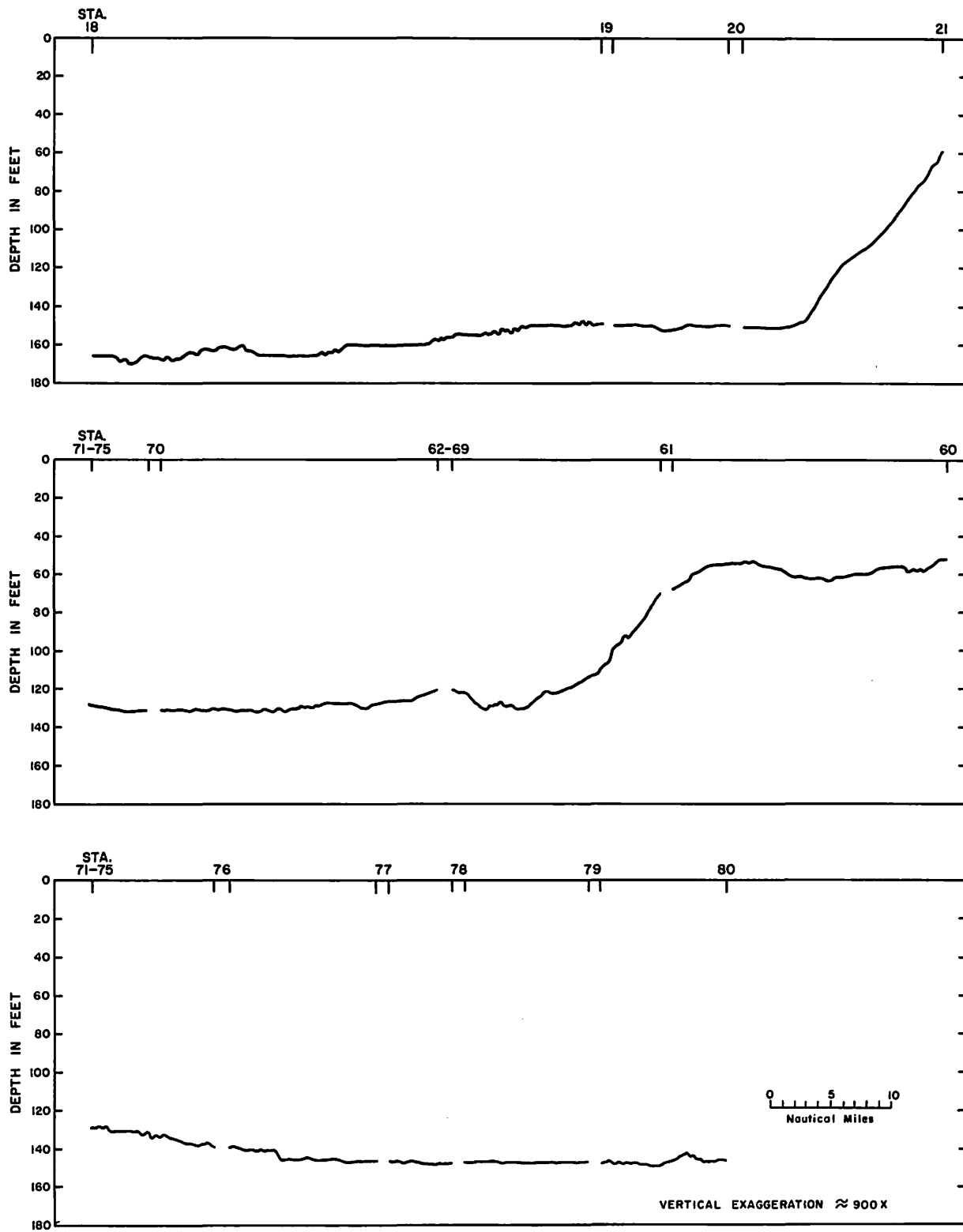


Fig. 5. Bottom profiles between Stations 18-21 and Stations 60-80.

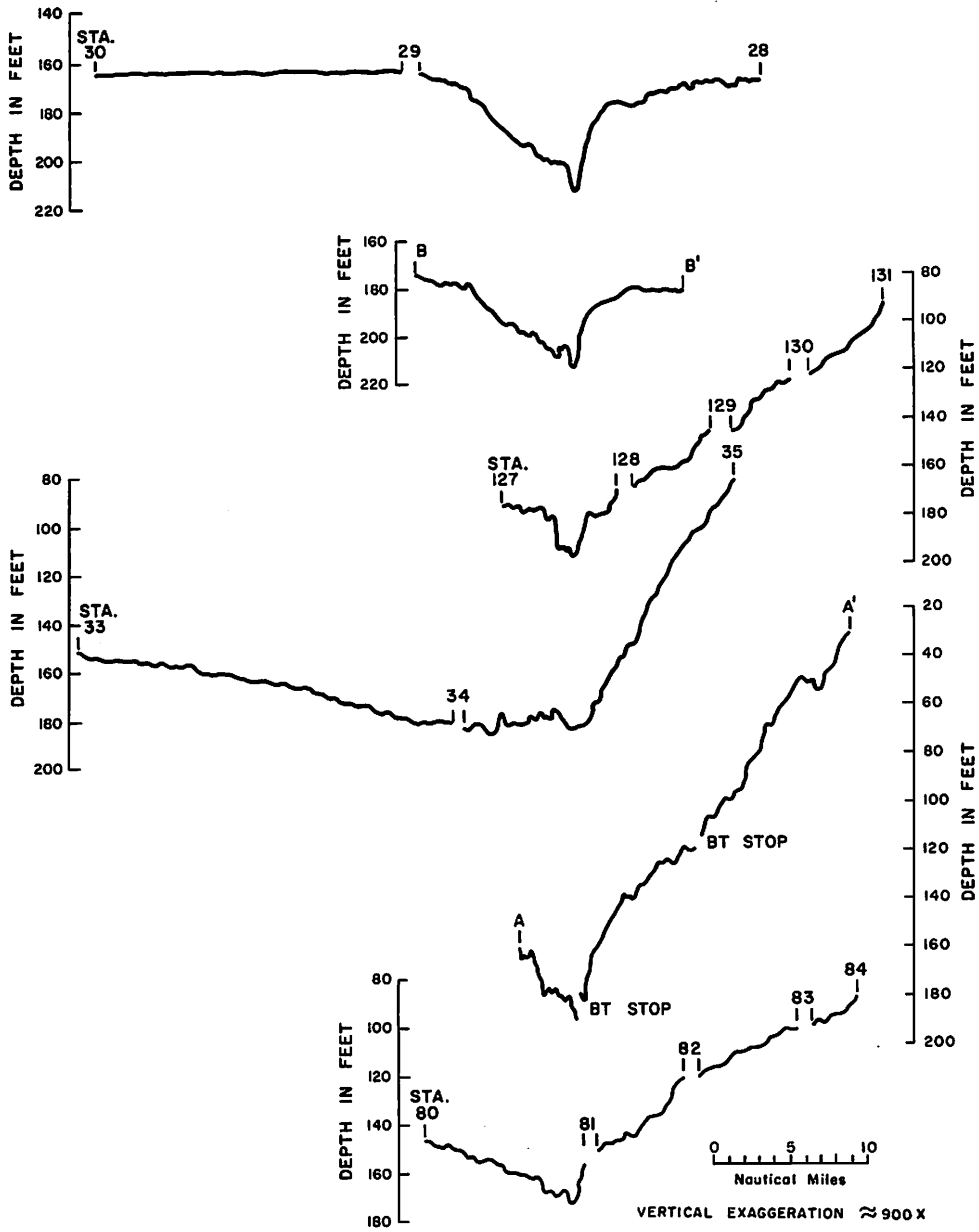


Fig. 6. Bottom profiles across Hope Submarine Valley.

A possible extension or tributary of the main channel of Hope Submarine Valley trends eastward from the head toward the coast south of Kivalina. Another possible tributary extends northward toward Cape Seppings. The relief in each of these tributaries is on the order of 12 feet. Ogotoruk Seavalley, delimited and named by Scholl and Sainsbury (1959), may be a tributary of this larger valley complex.

The central portion of the survey area is not only featureless but flat, with gradients so low as to be unmeasurable (profile between Stations 69 and 71, Figure 5). Landward of the valley area, the bottom shoals gradually to the 10-fathom isobath with average gradients of 3 to 6 feet per mile.

The area west of the Lisburne Peninsula is characterized by its featureless nature (profile between Stations 18 and 21, Figure 5). Between Stations 18 and 20 the bottom occurs at depths of 150 to 170 feet, and the slopes are less than 1 foot per mile. Landward of Station 20 the bottom rises smoothly and evenly to 10 fathoms, with an average gradient of 7 to 8 feet per mile. Two elongate depressions with only 1-fathom closures occur west of Point Hope; otherwise the bottom appears to be extremely flat offshore.

CHARACTER AND DISTRIBUTION OF SEDIMENTS

Locations of the bottom samples are shown in Figure 3. All surface grab samples were frozen immediately so that organic analyses could be made. Lack of suitable freezer space prevented freezing the cores.

Two splits were taken from each surface sample: (a) 10 grams for carbonate and organic carbon analyses; and (b) 25 to 30 grams for grain size, Foraminifera, and heavy mineral analyses. Similar splits were taken from the cores at the surface and at lithologic breaks; if no recognizable breaks occurred, the cores were sampled at top, middle, and bottom. A summary of analyses carried out on each sample is presented in Table 1.

Grain Size

The 25- to 30-gram split, after being dried to a constant weight, was centrifuged in distilled water to remove the sea salts. It was then mixed with dispersing agent (sodium lignosulfonate) and was wet-sieved to separate the coarse (>0.062 mm or $\frac{1}{4}$ ϕ) and fine fractions (<0.062 mm or $\frac{1}{4}$ ϕ). The coarse fraction was size-graded by sieving, and the fine fraction was graded by the pipette method described by Krumbein and Pettijohn (1938), which uses Wadell's correction of Stokes' Law for settling velocities. Statistics used in this study were determined by the method proposed by Folk and Ward (1957), as this method is well suited to the polymodal distributions of the Chukchi Sea sediments. The statistical analysis was programmed through the University's IBM 650 computer.

Results of the analyses show the distribution of grain size and sorting characteristics. Bottom sediments in the Chukchi Sea exhibit a wide range of size grades. According to the phi unit (ϕ) terminology of Krumbein (1934), the mean size of the samples includes pebbles, sand, and silt. Finer and coarser materials also occur, but not as a large part of any sample. For general discussion the sediment is referred to as silt, as sand, or, if the mean diameter is coarser than sand size, as gravel.

TABLE 1. Laboratory analyses of bottom samples.
 (Samples analyzed for size grades only are omitted.)

Sample No.	Size Analysis	Heavy Minerals	Carbonates	Organic Carbon	Foraminifera
2	x	x			x
3	x	x	x	x	x
5	x	x	x	x	x
6	x	x	x	x	x
8	x	x	x	x	x
9	x	x			x
13	x	x	x	x	x
17	x	x	x	x	x
18	x	x	x	x	x
19	x	x	x	x	x
21	x	x	x	x	x
22	x	x	x	x	x
24	x	x	x	x	x
25	x	x	x	x	x
26	x	x	x	x	x
28	x		x	x	
29	x		x	x	
30	x		x	x	
31	x		x	x	
32	x		x	x	
34	x	x	x	x	x
39	x	x	x	x	x
40	x	x	x	x	x
45	x		x	x	
47	x		x	x	
48	x		x	x	
49	x	x	x	x	x
53	x	x	x	x	x
56	x		x	x	x
57	x		x	x	
60	x	x	x	x	x
71	x		x	x	
79	x		x	x	
85	x	x	x	x	x
90	x	x	x	x	x
93	x		x	x	
99	x		x	x	
110	x	x	x	x	
113	x		x	x	x
128	x		x	x	
134	x		x	x	x
138	x		x	x	
151	x		x	x	
155	x		x	x	
158	x		x	x	
161	x		x	x	
162	x	x			x
163	x		x	x	
167	x		x	x	x
170	x		x	x	x
178	x		x	x	x

Although a variety of sizes is present, the area is characterized by a regional gradation and broad trends are the rule, rather than patchwork distributions.

Although gravel is an important part of the sediment, the region as a whole shows an interrelation of sand, silt, and clay. For this reason, a triangular end-point diagram based on percentages of these constituents has been constructed in the manner of Shepard (1954), thus providing a method of illustrating the distribution of sediment types (Figure 7). The general distribution shows a decrease in grain size outward from shore. The coarsest material, gravel, occurs in Bering Strait and along the coast between Cape Lisburne and Kivalina. The remainder of the coast and the nearshore areas are composed primarily of sand. The finest material, clayey silt, occurs along the northwestern margin, in the central part of the survey area, and in the innermost part of Kotzebue Sound, forming an east-west trend from Kotzebue Sound through the central part of the area to the deeper water on the west.

Silt and clay in the survey area tend to be influenced by the sedimentation processes in a similar way. Figure 8 shows the distribution of the ratio of sand to mud (silt and clay). A close relationship is apparent between this distribution and the bathymetry. In addition to the east-west trend of mud across the area, another trend of fine material extends northward from Cape Prince of Wales. Other salient features seen on this textural chart are: (a) sand and gravel in Bering Strait; (b) a somewhat isolated area of sand along the coast near Shishmaref Lagoon; (c) the muddy sand between Cape Espenberg and Cape Krusenstern, separating the mud of Kotzebue Sound from that of the open sea; and (d), the sand and gravel along the northeast coast.

Although an offshore decrease in grain size characterizes the entire area, the gradient is much more gentle off the Shishmaref coast, where there is also a lack of the sharp perturbations characterizing the northeast coast. Some of the narrow thumbs of fine material appear to be related to shallow valleys leading seaward from the shore. The coarse material along the northeast coast continues to the northwest past Point Hope.

A continuous gradation of sediment sizes (between the extremes of -3ϕ and 7ϕ) is lacking in the area. Figure 9, a scatter plot of mean size versus sorting, shows the sediment sizes that are missing. The lack of certain sizes permits delimiting the sediments into various groups. The individual statistics of the sediment samples (Table 2) show certain interrelationships which can perhaps best be shown by families of grain-size cumulative-frequency curves. The size distribution at any station can be placed in one of the families of curves (Figures 10 and 11). In turn, these families are represented by clusters of samples on the mean diameter and sorting diagram (the families are numbered to correspond to the clusters). Thus, certain related samples can be grouped into families, and the families into associations.

A distinction can be made between two broad depositional regimens in the Chukchi Sea, designated "I" and "II" (Figures 9, 10, and 11). Group I sediments are mainly coarse or, if of the same size as Group II, show a poorer degree of sorting. Group I represents the gravels and some of the sands, whereas Group II contains the silts and the rest of the sands.

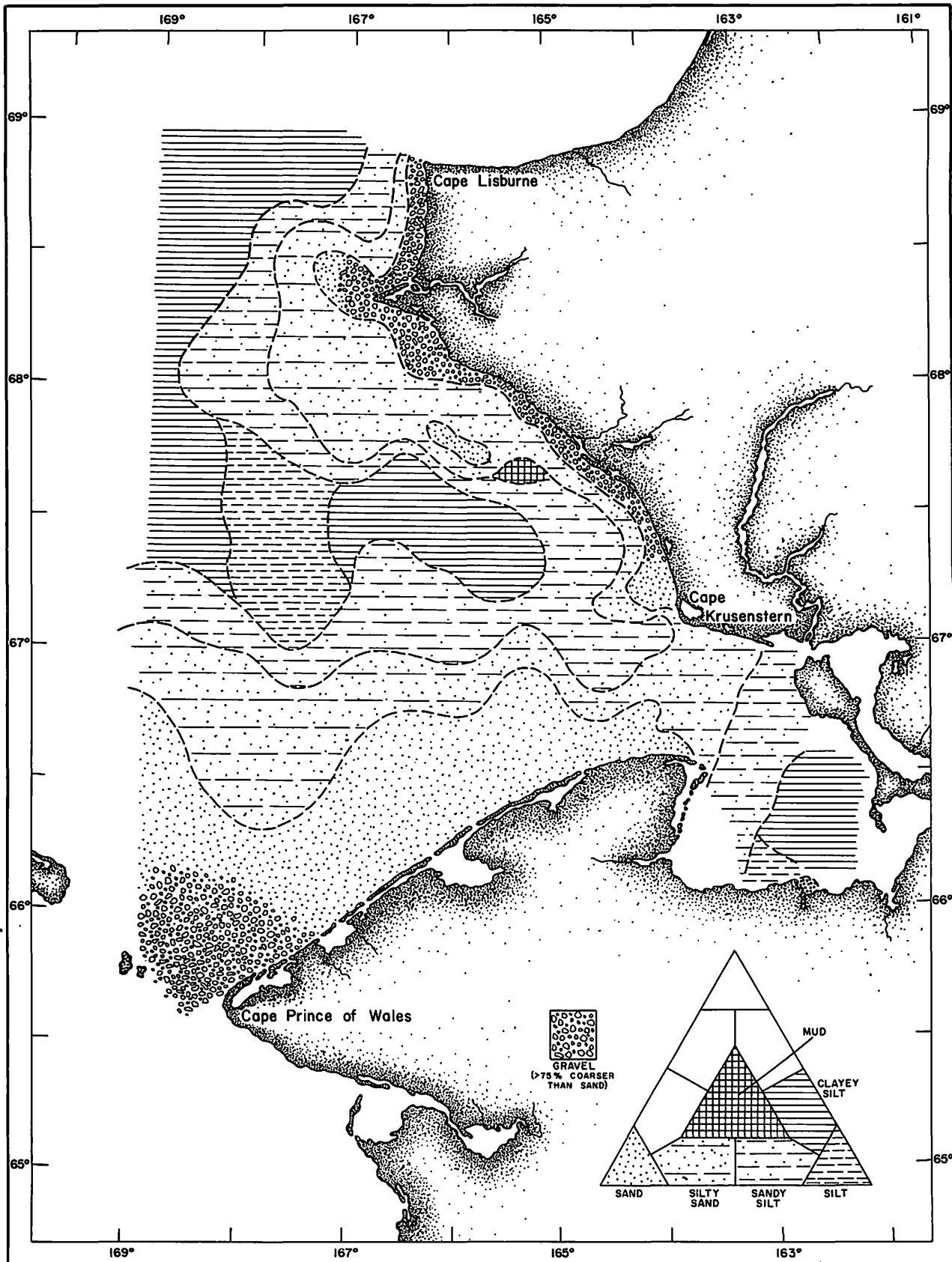


Fig. 7. Distribution of sediment types based on end-member relationships.

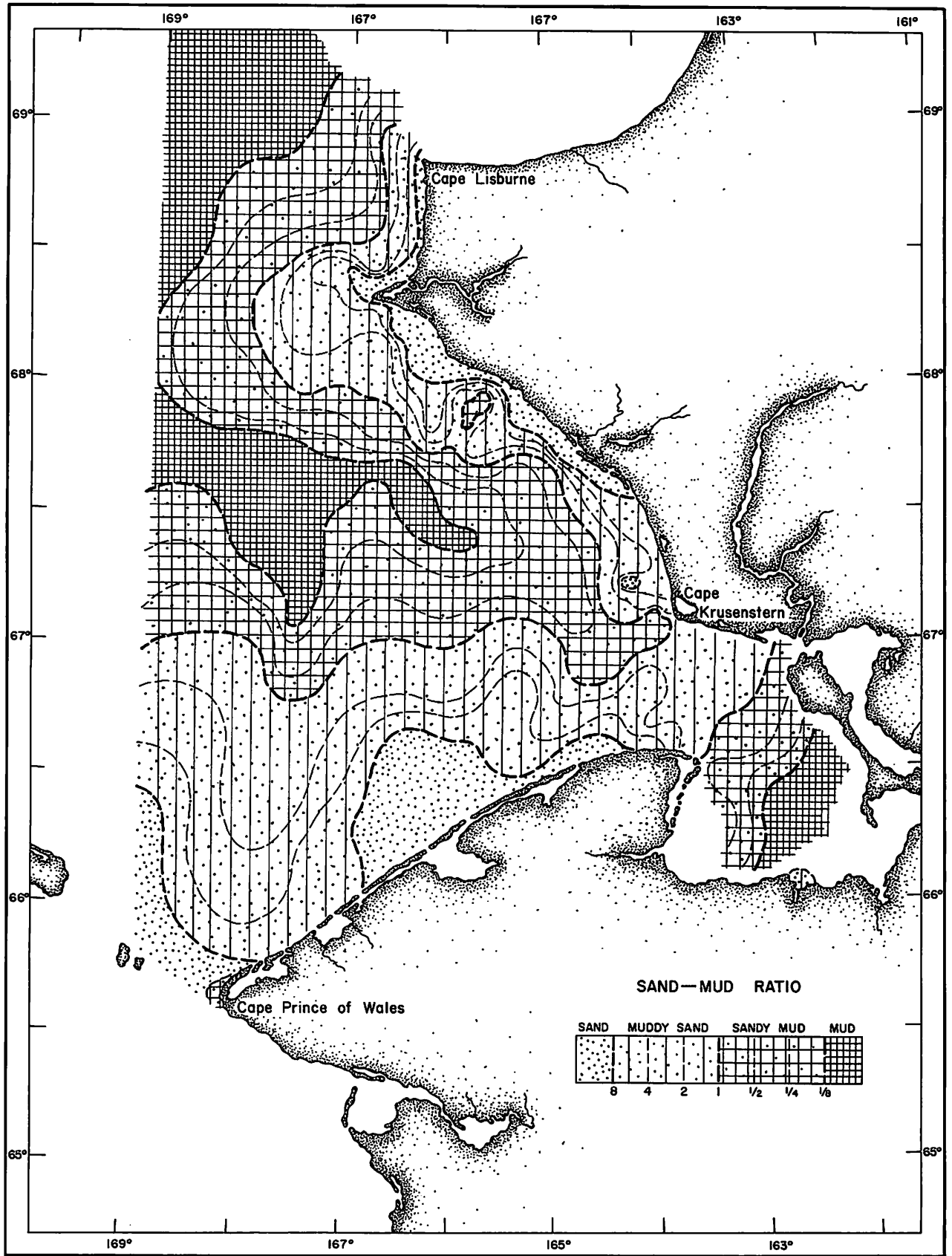


Fig. 8. Distribution of sediment based on sand-mud ratio.

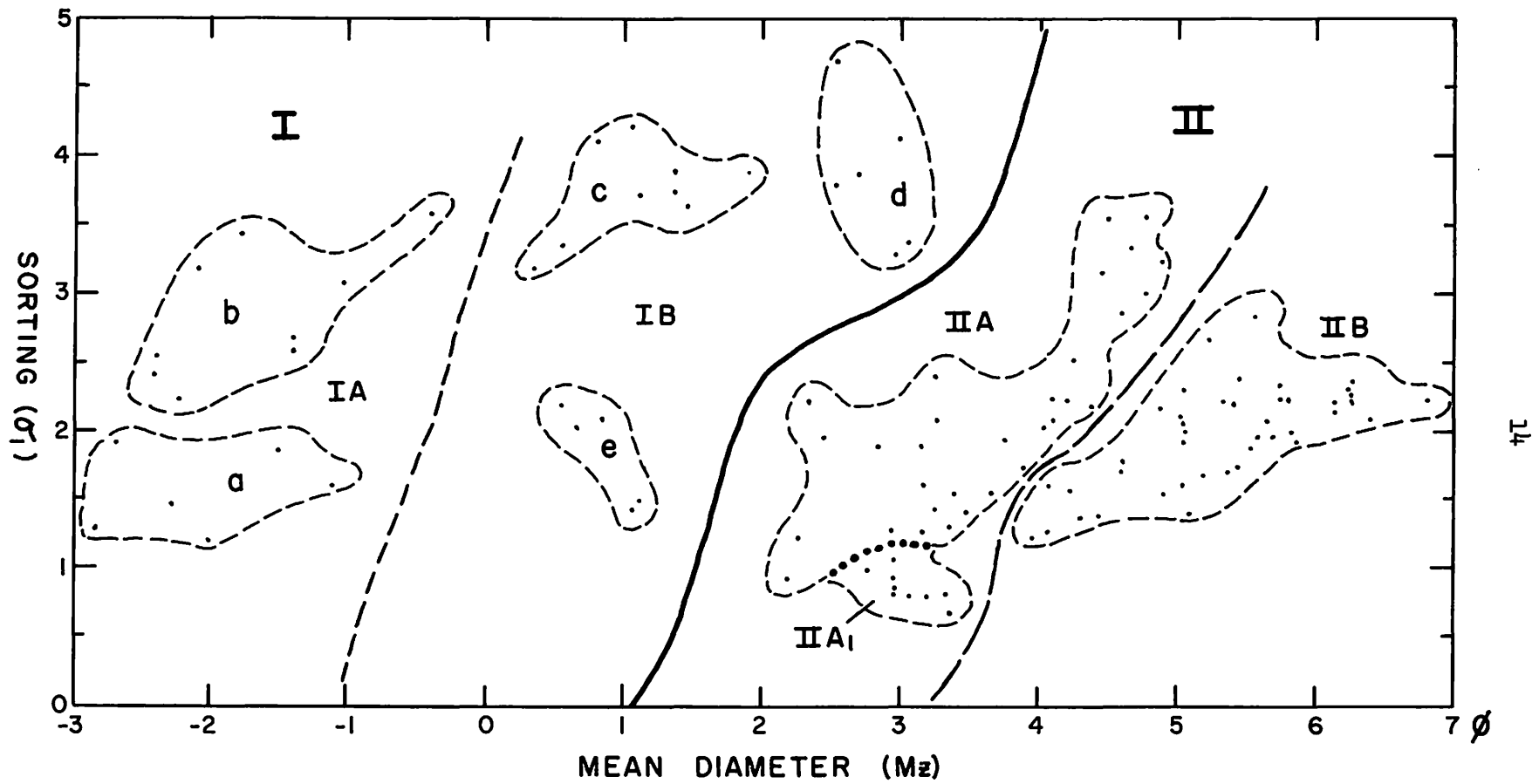


Fig. 9. Scatter diagram of mean diameter versus sorting.

TABLE 2. Sediment size parameters
Cruise BB 236

Station No.	Sand, Silt, Clay Relationships					Folk and Ward Values			
	Larger	Sand	Silt	Clay	Sand/Mud	Cl*	Mean	Dev.	Skew
002	96.08	02.76	01.16	00.00	85.21	1	-3.65	0.63	0.31
003	82.41	11.17	05.13	01.28	14.60	1	-2.09	2.02	0.88
004	33.69	42.83	18.17	05.32	03.26	1	01.34	3.02	0.70
005	00.00	88.52	10.15	01.34	07.70	1	03.24	0.63	0.14
006	00.00	58.34	34.29	07.35	01.40	2	03.95	1.62	0.46
008	00.00	69.12	26.08	04.81	02.24	2	03.46	1.40	0.70
009	00.00	55.55	35.04	09.42	01.25	2	04.60	1.73	0.66
011	00.05	06.99	71.60	21.36	00.08	7	06.33	2.18	0.44
012	00.28	75.62	16.46	07.64	03.15	1	03.32	2.13	0.61
013	93.00	05.24	01.76	00.00	55.82	1	-3.52	1.14	0.79
014	65.17	23.83	07.87	03.14	08.08	1	-0.93	3.08	0.70
015	36.14	42.67	14.75	06.46	03.72	1	00.68	3.88	0.08
016	02.14	44.58	36.57	16.71	00.88	2	04.71	2.75	0.31
017	00.00	13.19	62.89	23.93	00.15	7	06.23	2.33	0.41
018	00.34	03.69	65.14	30.84	00.04	7	06.85	2.07	0.26
019	00.00	15.62	65.37	18.98	00.19	7	05.81	2.21	0.60
021	63.54	35.87	00.59	00.00	68.49	1	-1.46	1.68	0.36
022	00.11	25.02	59.13	15.75	00.34	3	05.46	2.15	0.60
024	00.00	27.68	65.54	06.77	00.38	3	04.34	1.35	0.21
025	00.00	04.36	73.63	22.02	00.05	7	06.41	2.02	0.37
026	69.24	19.49	08.66	02.61	07.87	1	-1.62	3.28	0.68
028	08.48	57.37	25.47	08.69	01.93	2	02.95	3.27	0.22
029	00.00	03.20	79.68	17.12	00.03	4	05.95	1.86	0.64
030	00.00	14.31	67.11	18.59	00.17	7	05.81	2.21	0.65

(continued)

Table 2 (continued)

Station No.	Larger	Sand, Silt, Clay Relationships				Sand/Mud	CI*	Folk and Ward Values		
		Sand	Silt	Clay	Mean			Dev.	Skew	
031	00.37	42.36	47.67	09.59	00.75	3	04.65	1.69	0.55	
032	00.00	07.30	80.99	11.71	00.08	4	05.40	1.64	0.65	
033	00.05	03.40	80.00	16.54	00.04	4	05.91	1.93	0.66	
034	01.26	44.58	42.53	11.64	00.85	2	04.85	2.13	0.48	
039	00.00	10.78	67.90	21.32	00.12	7	06.24	2.27	0.44	
040	00.00	24.27	63.71	12.02	00.32	3	05.13	1.94	0.42	
042	00.00	31.64	61.19	07.18	00.46	3	04.56	1.31	0.49	
044	00.11	61.07	33.10	05.72	01.58	2	04.08	1.14	0.59	
045	00.00	52.60	38.86	08.52	01.11	2	04.09	1.96	0.38	
047	00.00	85.58	12.35	02.08	05.93	1	03.39	0.73	0.20	
048	00.00	90.21	08.30	01.51	09.20	1	02.97	0.73	0.37	
049	00.00	84.09	11.74	04.19	05.28	1	03.01	1.23	0.62	
050	05.32	81.02	08.96	04.70	06.32	1	02.49	1.96	0.12	
051	00.55	28.63	62.38	08.45	00.41	3	04.20	1.54	0.13	
052	01.28	89.45	06.13	03.14	09.79	1	02.27	1.12	0.29	
053	00.00	77.19	18.86	03.96	03.38	1	03.57	1.26	0.53	
054	00.00	56.32	36.82	06.86	01.29	2	04.15	1.57	0.46	
055	01.50	55.92	33.93	08.64	01.35	2	04.17	2.02	0.48	
056	00.34	59.80	27.85	11.99	01.51	2	04.30	2.44	0.64	
057	00.00	78.93	16.15	04.91	03.75	1	03.37	1.32	0.59	
058	00.76	37.62	47.25	14.37	00.62	3	05.18	2.25	0.50	
059	00.00	79.36	14.56	06.08	03.84	1	03.26	1.59	0.63	
060	00.00	90.15	08.00	01.87	09.13	1	02.98	0.70	0.43	
061	00.00	89.27	08.88	01.84	08.33	1	03.19	0.66	0.38	
062	00.00	61.19	31.45	07.36	01.58	2	03.82	1.84	0.76	
070	00.00	07.59	83.79	08.61	00.08	4	05.12	1.33	0.55	
071	00.00	13.36	76.22	10.40	00.15	4	05.10	1.56	0.55	
076	00.10	07.43	80.11	12.37	00.08	4	05.53	1.71	0.55	

(continued)

Table 2 (continued)

Station No.	Sand, Silt, Clay Relationships					Folk and Ward Values			
	Larger	Sand	Silt	Clay	Sand/Mud	Cl*	Mean	Dev.	Skew
077	00.37	13.02	72.09	14.53	00.15	7	05.70	1.97	0.43
078	00.08	13.62	72.79	13.53	00.16	3	05.57	1.88	0.50
079	00.00	12.34	72.97	14.69	00.14	7	05.64	1.93	0.56
080	01.19	07.59	70.53	20.68	00.10	7	06.32	2.21	0.29
081	03.04	80.52	10.90	05.54	05.08	1	02.33	2.22	0.18
082	15.60	52.20	20.91	11.28	02.11	2	02.71	3.84	0.21
083	22.05	38.71	28.40	10.82	01.55	2	02.75	3.80	0.05
084	43.60	27.29	20.45	08.66	02.44	2	01.10	3.74	0.30
085	77.24	13.63	06.93	02.22	09.93	1	-1.96	2.93	0.76
086	00.00	86.80	11.74	01.48	06.57	1	03.40	0.61	0.04
088	00.00	56.76	32.22	11.01	01.31	2	04.47	2.10	0.58
089	00.17	75.67	18.05	06.10	03.14	1	03.21	1.82	0.57
090	00.00	72.89	18.87	08.24	02.69	2	03.35	2.30	0.73
092	00.00	42.81	44.07	13.12	00.75	3	05.09	1.98	0.68
093	00.00	79.58	16.35	04.06	03.90	1	03.44	1.50	0.49
094	00.00	37.09	50.82	12.11	00.59	3	05.01	2.08	0.38
095	00.00	15.57	70.72	13.72	00.18	3	05.61	1.97	0.38
096	00.07	74.75	18.98	06.20	02.97	2	03.71	1.45	0.52
097	00.41	60.05	28.70	10.83	01.53	2	04.29	2.19	0.56
098	07.42	42.52	34.97	15.09	01.00	2	04.62	3.33	0.16
099	00.00	25.60	54.98	19.44	00.34	3	05.97	2.22	0.30
108	00.00	13.65	68.41	17.94	00.16	7	06.18	2.14	0.12
110	00.43	28.62	50.11	20.84	00.41	6	05.57	2.79	0.17
112	29.29	44.69	19.39	06.64	02.84	2	01.48	3.44	0.16
113	57.89	41.00	01.02	00.09	89.09	1	-1.12	1.44	0.24
115	71.34	18.59	08.25	01.80	08.95	1	-1.31	2.54	0.73
116	84.25	12.29	02.63	00.84	27.82	1	-2.66	1.84	0.46
117	10.33	37.13	40.81	11.72	00.90	2	04.52	3.10	0.08

(continued)

Table 2 (continued)

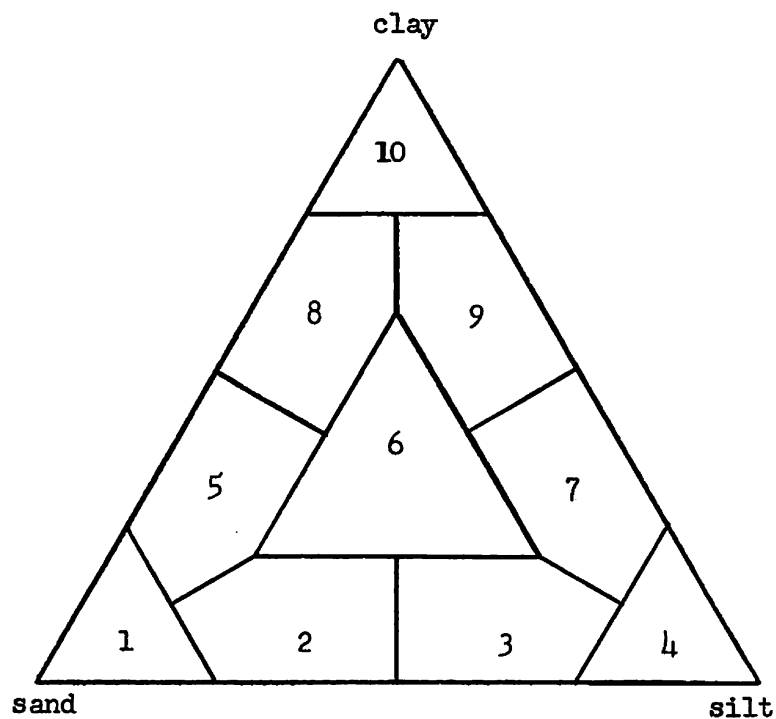
Station No.	Sand, Silt, Clay Relationships					C1*	Folk and Ward Values		
	Larger	Sand	Silt	Clay	Sand/Mud		Mean	Dev.	Skew
119	10.47	57.96	21.73	09.84	02.17	2	03.05	3.36	0.20
127	03.03	43.06	40.86	13.05	00.85	2	04.60	2.87	0.16
128	23.18	38.49	26.09	12.23	01.61	2	02.53	4.23	0.07
129	19.87	40.37	29.76	09.99	01.52	2	01.85	3.73	-0.20
130	09.17	42.27	32.25	16.31	01.06	2	04.51	3.52	0.14
131	13.96	75.36	07.46	03.23	08.36	1	00.62	2.03	0.16
132	50.60	34.80	11.38	03.25	05.84	1	-0.25	3.06	0.47
133	08.06	86.66	03.59	01.72	17.84	1	01.00	1.38	-0.10
134	40.39	32.65	20.16	06.81	02.71	2	01.28	3.61	0.04
136	43.11	37.09	15.40	04.39	04.05	1	00.60	3.19	0.47
137	34.25	41.92	17.94	05.90	03.20	1	01.33	3.50	-0.09
138	09.09	78.63	09.60	02.69	07.14	1	00.87	2.19	0.52
141	01.92	91.89	04.29	01.89	15.18	1	02.22	1.02	0.21
142	23.61	29.08	39.39	07.92	01.11	2	02.65	3.44	-0.26
143	79.11	18.85	01.52	00.55	47.32	1	-2.15	1.31	0.61
144	77.74	21.88	00.38	00.00	62.16	1	-2.03	1.13	0.38
145	89.20	10.30	00.43	00.07	99.00	1	-2.82	1.27	0.35
146	86.71	12.73	00.56	00.00	77.57	1	-2.54	1.20	0.18
147	08.93	35.19	39.46	16.41	00.79	2	04.72	3.95	0.05
150	00.00	89.87	08.71	01.42	08.87	1	02.89	0.95	0.07
151	00.09	92.07	06.26	01.58	11.76	1	02.70	0.94	0.17
152	00.00	82.52	13.61	03.87	04.72	1	03.22	1.58	0.38
153	00.00	88.67	08.64	02.69	07.83	1	02.92	1.20	0.38
155	00.00	26.79	57.64	15.57	00.37	3	05.42	2.18	0.51
156	00.39	34.44	52.84	12.31	00.53	3	05.08	2.05	0.59
158	00.00	09.76	79.65	10.59	00.11	4	05.02	1.98	0.54
159	40.97	41.38	16.44	01.20	04.67	1	00.38	2.45	0.15
160	00.21	05.99	71.44	22.37	00.07	7	06.32	2.20	0.43

(continued)

Table 2 (continued)

Station No.	Larger	Sand, Silt, Clay Relationships				Sand/Mud	Cl*	Folk and Ward Values		
		Sand	Silt	Clay	Mean			Dev.	Skew	
161	00.00	07.85	71.50	20.67	00.09	7	06.19	2.13	0.48	
162	00.00	33.05	50.43	16.51	00.49	3	05.45	2.28	0.31	
163	00.29	59.07	30.38	10.24	01.46	2	04.18	2.29	0.69	
165	00.00	52.88	41.35	05.76	01.12	2	04.15	1.57	0.57	
167	00.11	75.77	18.68	05.44	03.15	1	02.97	2.08	0.54	
168	02.29	87.91	06.92	02.89	09.19	1	01.19	2.03	0.15	
170	29.06	65.50	03.88	01.56	17.38	1	00.28	2.12	-0.24	
172	63.36	30.16	05.26	01.22	14.43	1	-1.28	2.38	0.60	
174	74.27	21.40	03.45	00.89	22.04	1	-2.25	2.35	0.62	
176	76.97	17.45	04.42	01.17	16.89	1	-2.29	2.55	0.67	
178	00.00	42.17	39.68	18.15	00.73	2	05.33	2.46	0.36	

* Class designation:



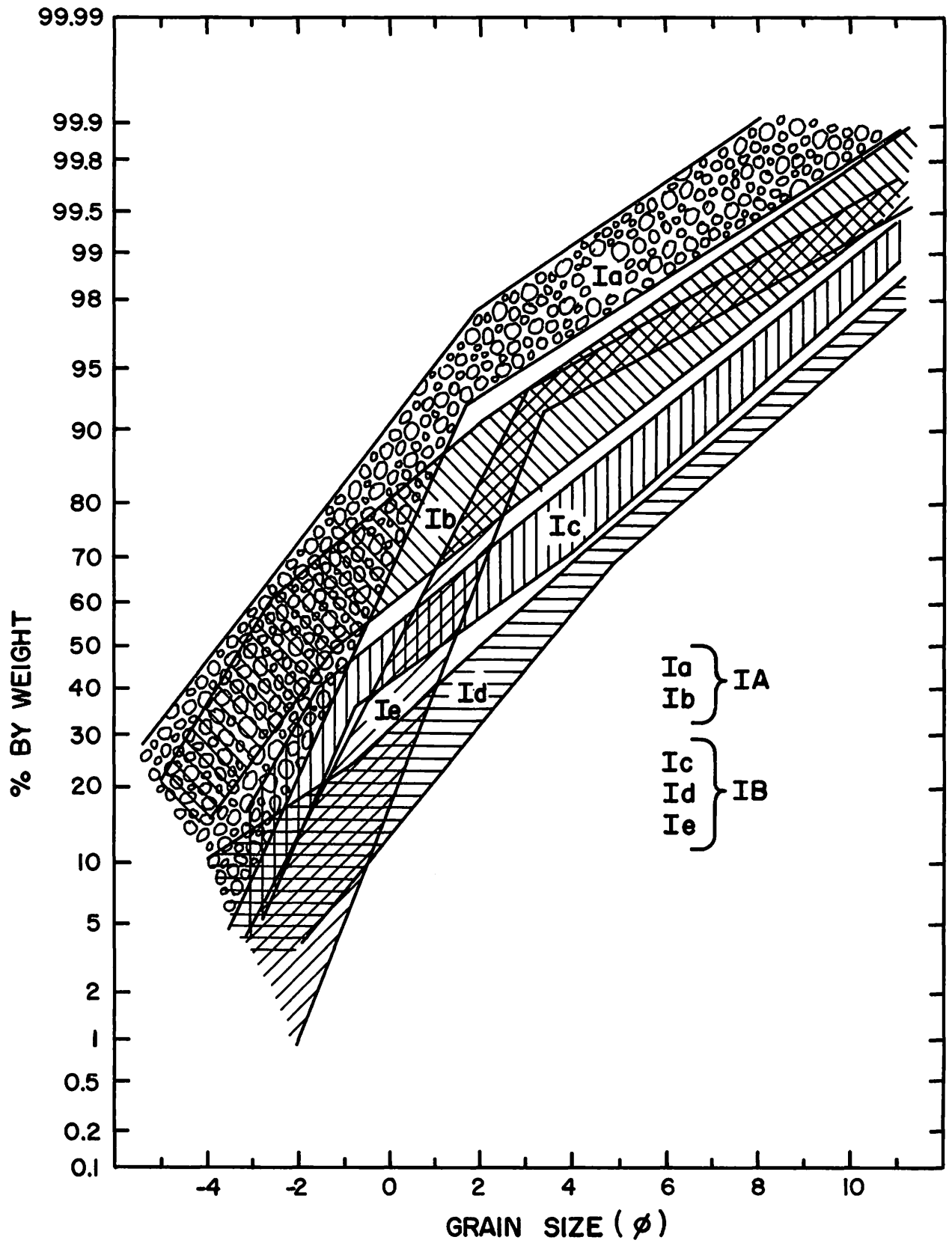


Fig. 10. Cumulative size-frequency relationships of Group I sediments.

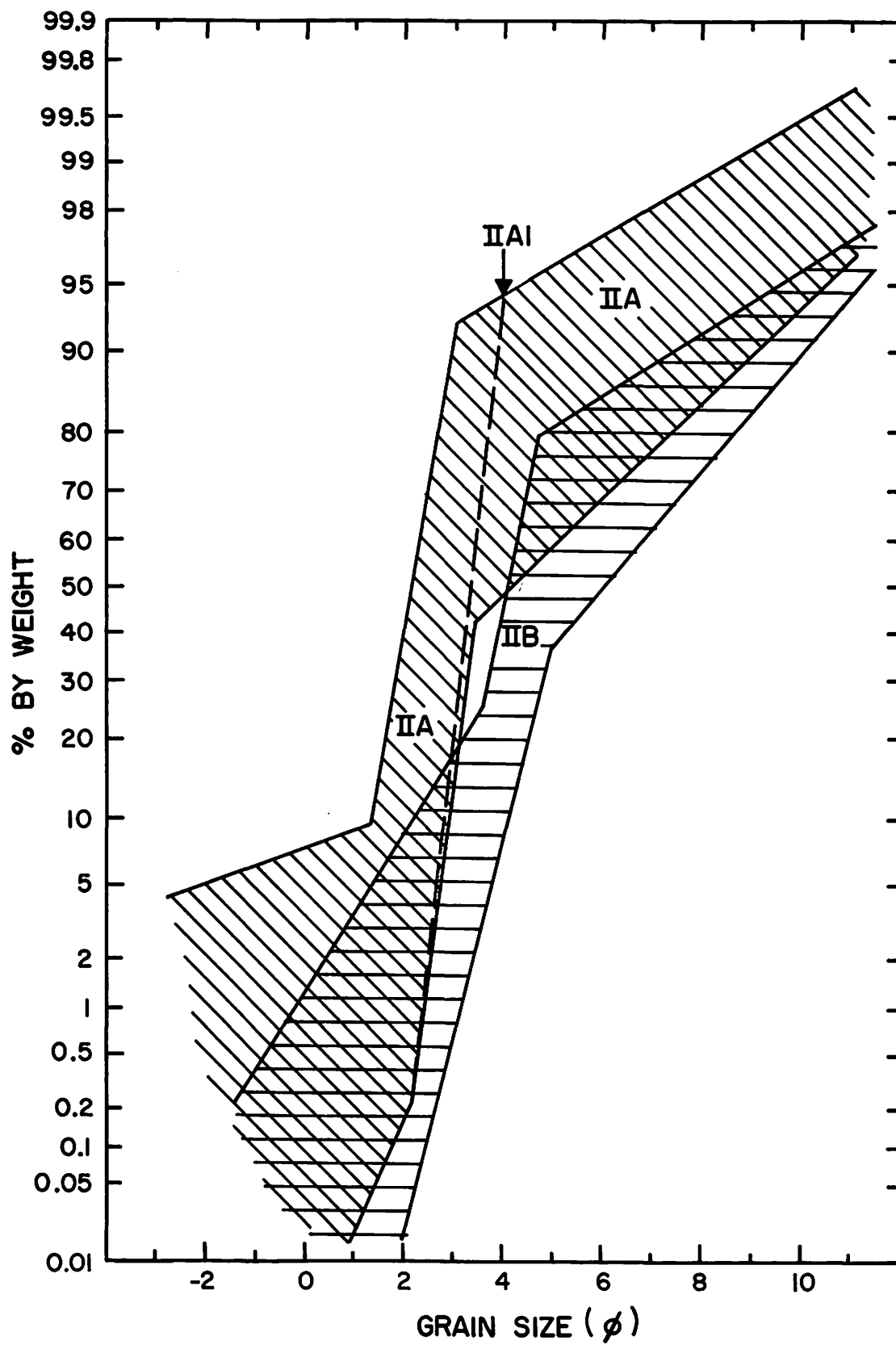


Fig. 11. Cumulative size-frequency relationships of Group II sediments.

Within Group I there are five families of size distribution. In Group II, two families, and possibly a third, are recognized. Families, which are of approximately equal depositional significance, are collectively called subgroups (I-A, I-B, II-A, and II-B as in Figures 9, 10 and 11).

The frequency distribution of mean diameter for the sediments of the Chukchi Sea is polymodal, with a primary mode at about 5.5ϕ and two subordinate modes at -2ϕ and 1ϕ (Figure 12). The subordinate modes are due to Group I materials, the primary mode to Group II.

Sorting

The sediment groupings mentioned in the previous section are dependent on degree of sorting as well as on size. Nowhere in the region is the sediment well-sorted ($\sigma < 0.5$); however, the sand area along the Shishmaref coast is moderately sorted and represents the best-sorted sediment in the region. The poorest sorting ($\sigma > 4$) is in the sand and gravel area along the northeast shore, although the sorting is highly variable there. The rest of the survey area consists of two broad areas of intermediate values, both of which indicate either poor or very poor sorting.

Sorting values for the sediments show a polymodal distribution with the primary mode at about 2.2 (Figure 13). A very indistinct mode occurs near the value of 1.0, and a definite subordinate mode is present at 3.5. The latter subordinate mode represents the major part of the Group I sediments, whereas the low-value mode is formed by the clean Shishmaref sand.

Sedimentary Environments

Discussion of the sedimentary environments is based upon the families of curves of grain size distribution, since this method seems to give a meaningful approach to the problems of sedimentation. The two main environments, represented by Group I and Group II sediments, are unevenly distributed in the Chukchi Sea (Figure 14).

Group I sediments occur in the Bering Strait and along the shore from Cape Lisburne to Kivalina. The coarseness of the sediments in these areas suggests that they occur either in high energy environments (high speed currents or heavy wave action) or near the source of sediment supply. The very poor sorting of these sediments further suggests a nearness of source area or that the area is only intermittently one of high energy. Characteristics of a similar environment are found locally, at the southern end of Kotzebue Sound, where erosion products dumped from the cliffs exhibit the same sizes and sorting, although strong currents are absent.

The strongest currents in the region, (a) the northward current through Bering Strait, and (b) the northwestward current along the Kivalina-Point Hope coast (Figure 15), are found in main areas of Group I sediments. These areas are also characterized by neighboring source areas furnishing fairly coarse material. The Diomed Islands in Bering Strait are bordered by the I-A sediments in which most of the silt and much of the sand has been winnowed out and carried off by the strong currents. The adjacent area of I-B sediments has been subjected less to the current action, and thus has a smaller concentration of the very coarse material. However, current action

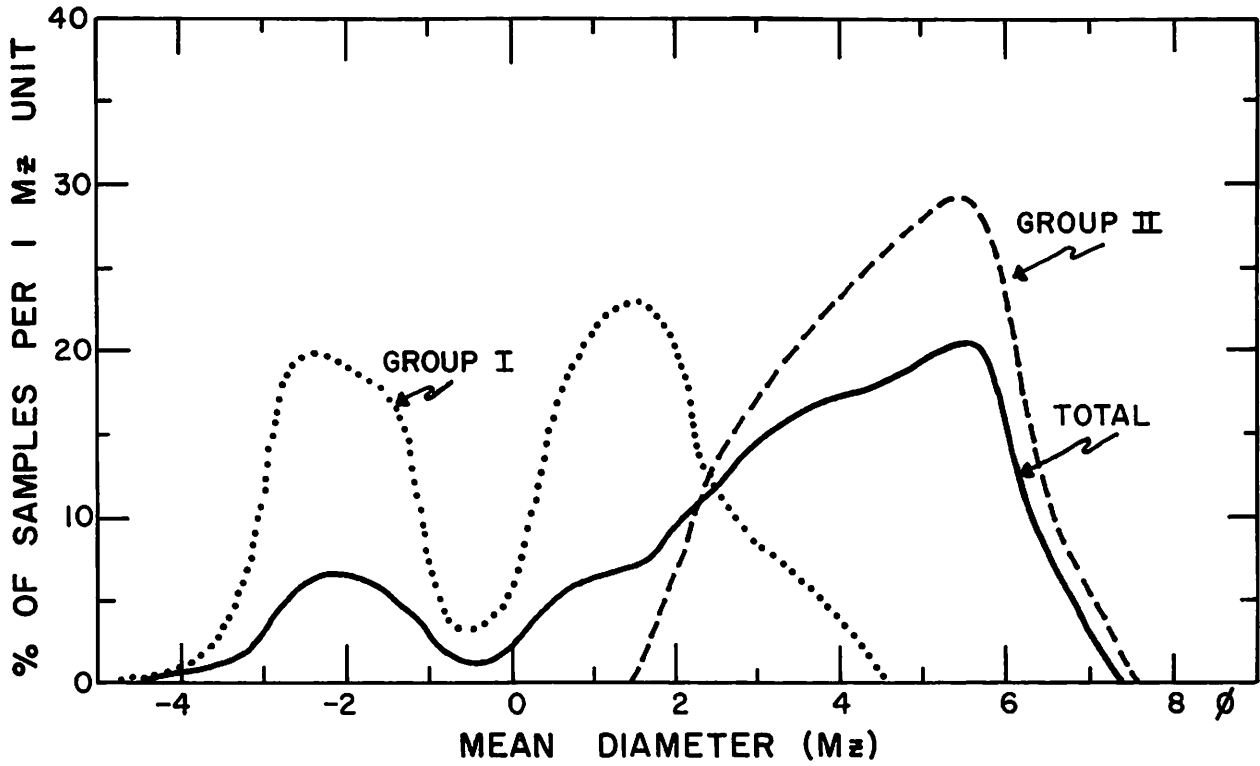


Fig. 12. Frequency distribution of mean diameters.

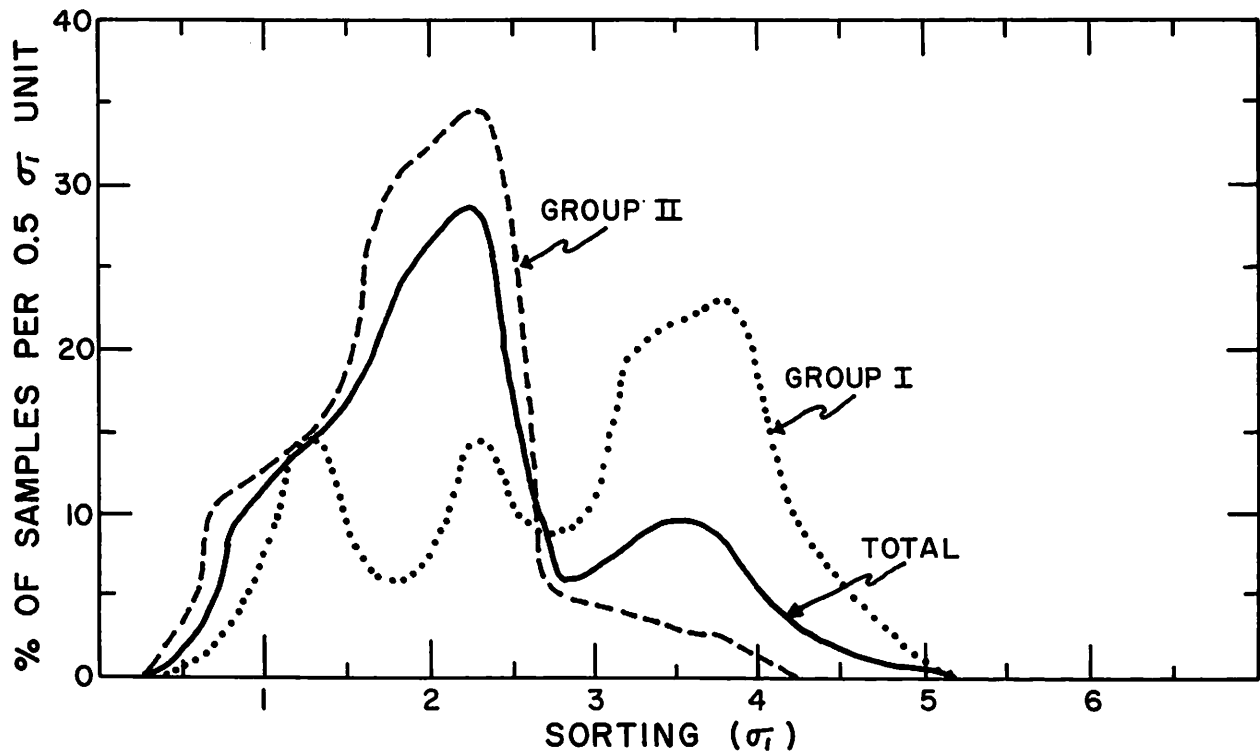


Fig. 13. Frequency distribution of sorting.

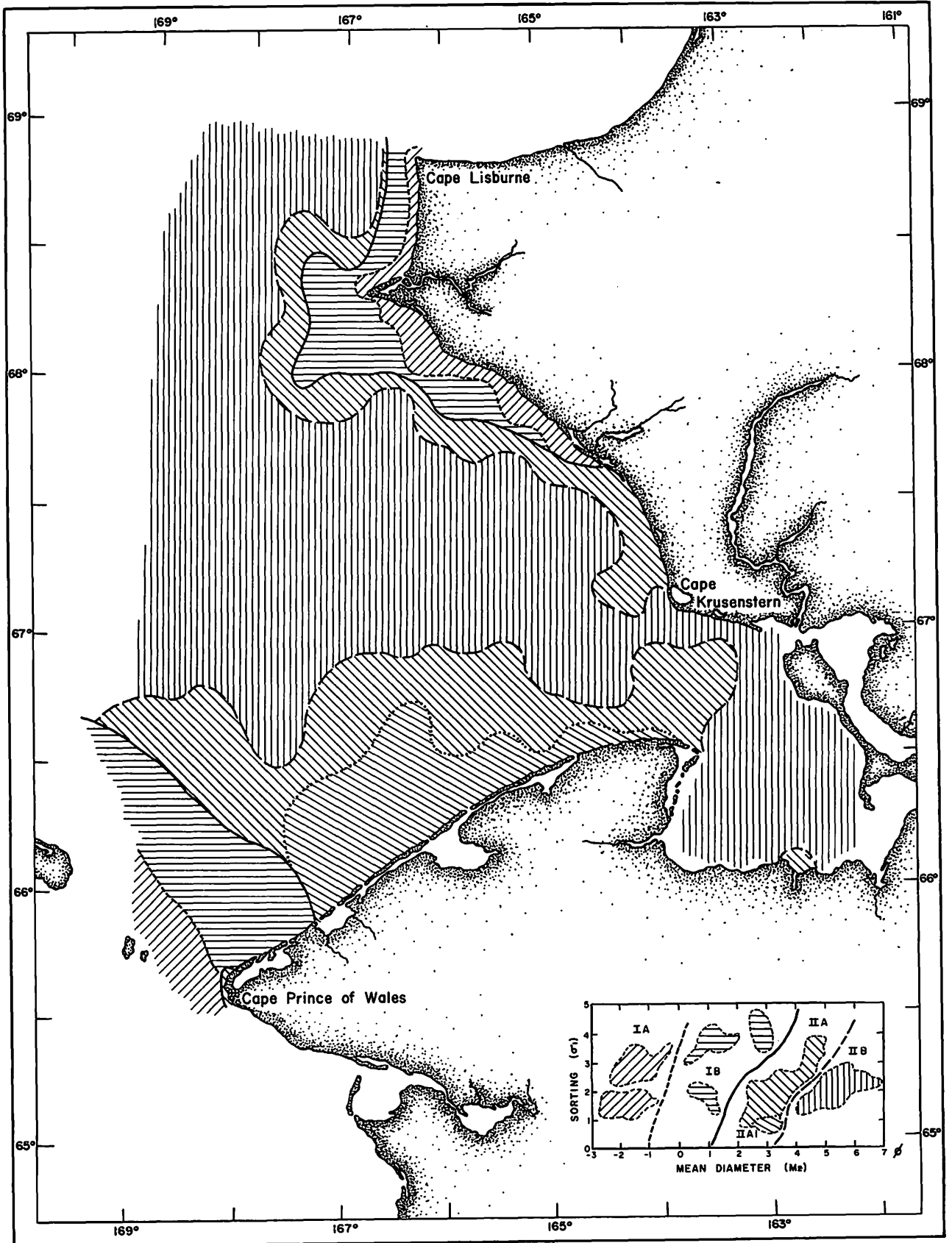


Fig. 14. Sedimentary environments as delineated by a mean diameter versus sorting scatter plot.

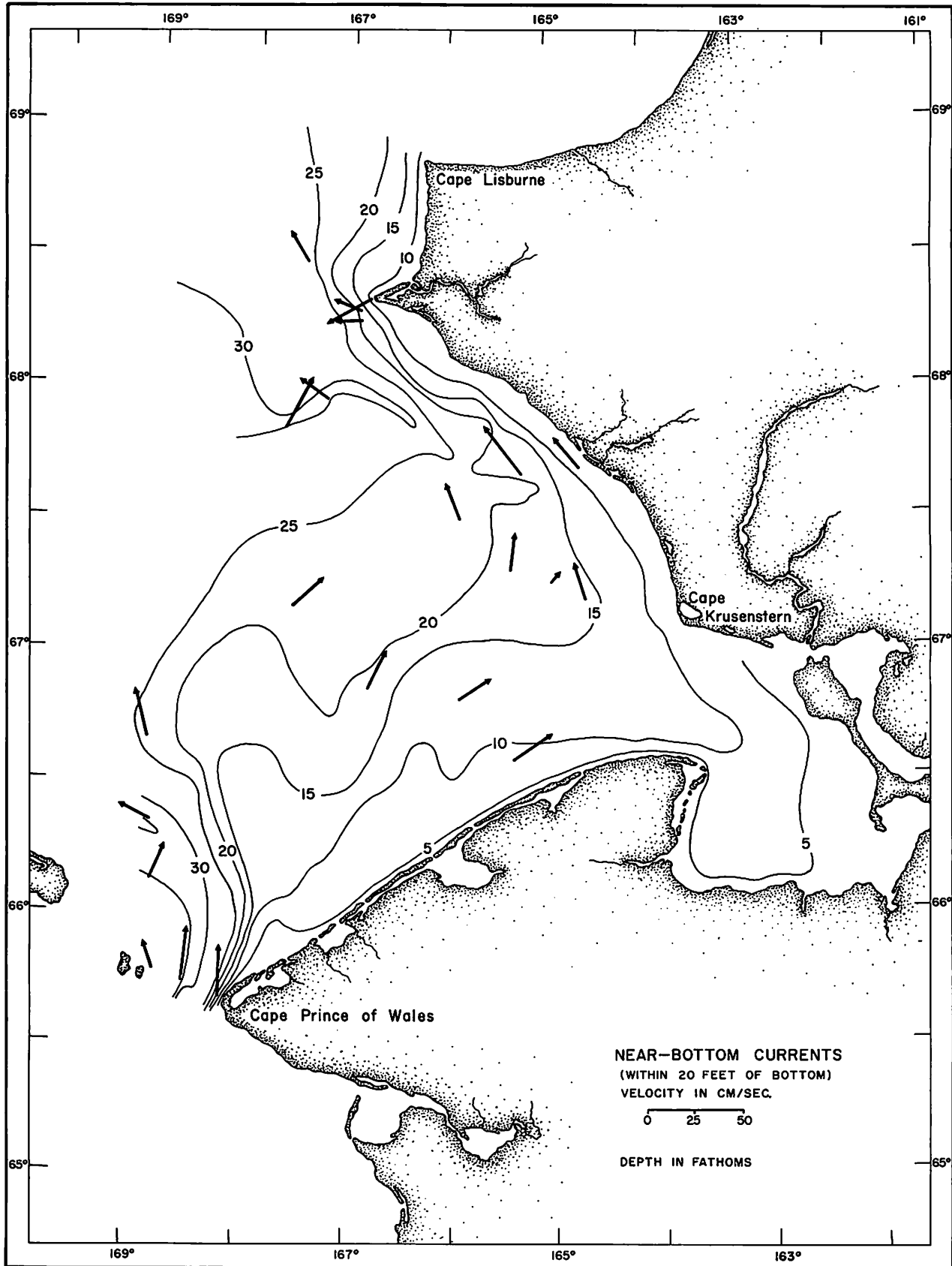


Fig. 15. Near-bottom currents.

is not the sole factor differentiating the environments, inasmuch as proximity to source area is also of great importance.

Along the shore of the other area of Group I sediments are the cliffs of Paleozoic rocks extending from Cape Lisburne to Cape Thompson, and the more topographically subdued Mesozoic rocks continuing to Kivalina. The nearshore sediments are coarse I-A gravels such as adjoin the Diomedes. Seaward of this zone is the zone of I-B sediments. Although the sediments in this area are characteristically very poorly sorted, improved sorting exists locally in the I-A sediments at Cape Lisburne, at Kivalina, and north of Point Hope.

Most of the sediments, however, fall into Group II, silts and fine sands, which indicate a lower-energy environment. The two subgroups are the II-A sediments, which are mainly sand but include some poorly-sorted silts, and the II-B sediments, which are the finest deposits in the region.

The II-A sediments seem to be mainly a transitional sequence and border either the Group I sediments or the coast. Although in some areas the currents are relatively strong, the sorting is generally poor to very poor; an improvement in sorting tends to be associated with an increase in grain size. A certain part of this environment, however, is thought to deserve delimitation and recognition as a separate environment. This is the area of moderately sorted sand near Shishmaref (II-A-1). This isolated area is not subjected to strong currents, is not bordered by a cliffed coastline, nor is it affected by the fluvial material carried out of Kotzebue Sound; instead, the winnowing action of the waves and a relative lack of currents may control the environment. These sediments (II-A-1) do not occur in any other part of the region.

The final environmental type, II-B, is the most extensive one and occupies Kotzebue Sound as well as the central part and western margin of the survey area. Although some sand is present in sediments adjoining the previously described environments, the II-B deposits are primarily silts. Clay-size material is present to a significant degree only locally, and even in such localities the sediment is a clayey silt. Clay-size particles are noteworthy (a) in the area underlying the very shallow water in southeastern Kotzebue Sound; (b) midway between Shishmaref Lagoon and Point Hope, probably in the eye of a broad eddy; and (c) in the northwestern corner of the survey area. The remainder of the area, including a narrow band along Cape Krusenstern, apparently marking an outflow of fluvial material from Kotzebue Sound, consists of rather poorly-sorted silts.

In summary, the sediments of the Chukchi Sea reflect two general environments:

1. A high-energy environment in Bering Strait and extending along the coast from Cape Lisburne to Kivalina. This seems to represent a state of dynamic equilibrium, regardless of whether introduced material is winnowed and separated or merely falls in from adjacent cliffs. Since these are areas of maximum current velocities, any movement away from the present equilibrium probably would result in a drop in energy level, producing less winnowing and, in general, a deposition of finer material which could affect the biota by filling the interstices of the sediment.

2. The low-energy environments of silts and sands occupying the rest of the survey area. These environments include (a) a relatively stable development of fairly clean sand off the coast of Shishmaref Lagoon, (b) a transitional and somewhat unstable environment of sands of the II-A sediments, and (c), the relatively stable silts of the II-B sediments forming the bulk of the sediments of the Chukchi Sea.

HEAVY MINERALS

Heavy mineral separations were performed on 24 representative bottom samples (Figure 16 and Table 1). The 3-phi size of each sample was separated into heavy and magnetic heavy fractions (Table 3). In addition, the heavy minerals were determined in the entire coarse fraction of 8 of the samples (Table 4). The heavy minerals separated from the 3-phi size of the 8 selected samples were examined for the frequency of occurrence of certain representative minerals.

The 3-phi size consists of grains whose intermediate diameters are between 0.125 mm and 0.250 mm. This size group was selected for detailed heavy mineral analysis because: (a) the group is common in almost all the samples in quantities sufficient for analysis, and (b) material of this size is small enough to yield relatively pure minerals, yet is large enough to be handled easily for separation, picking, and microchemical testing. Although the bulk of the heavy minerals is usually found in the finest sand sizes, the one remaining finer sand size (4 ϕ) was rejected because the separations were less precise and required more time than was available.

All extractions were made with bromoform (sp. gr. 2.85). Heavy minerals in the 3- and 4-phi size grades were removed using the frozen bromoform technique developed by R. A. Mackay of the Royal School of Mines, London. All 3- and 4-phi fractions weighing more than 2.5 grams were first split down to workable quantities with an Otto type microsplitter. The laboratory error was estimated by comparing three splits from Sample 90; the calculated percentage of heavy minerals differed by ± 0.10 percent, consequently percentages are reported to the nearest whole tenth of one percent.

Distribution of Heavy Minerals

Percentages of heavy minerals in the 3-phi fraction are plotted in Figure 16. Although these samples represent only 20 percent of the bottom samples, the pattern may be significant. A concentration of heavy minerals in the 3-phi size range exists at the entrance to Kotzebue Sound, with values decreasing away from Station 90. The major rivers in the area, the Kobuk and the Noatak, both discharge within the confines of Kotzebue Sound--in harmony with the indicated distribution of heavy minerals. Detailed conclusions, however, must await more analyses.

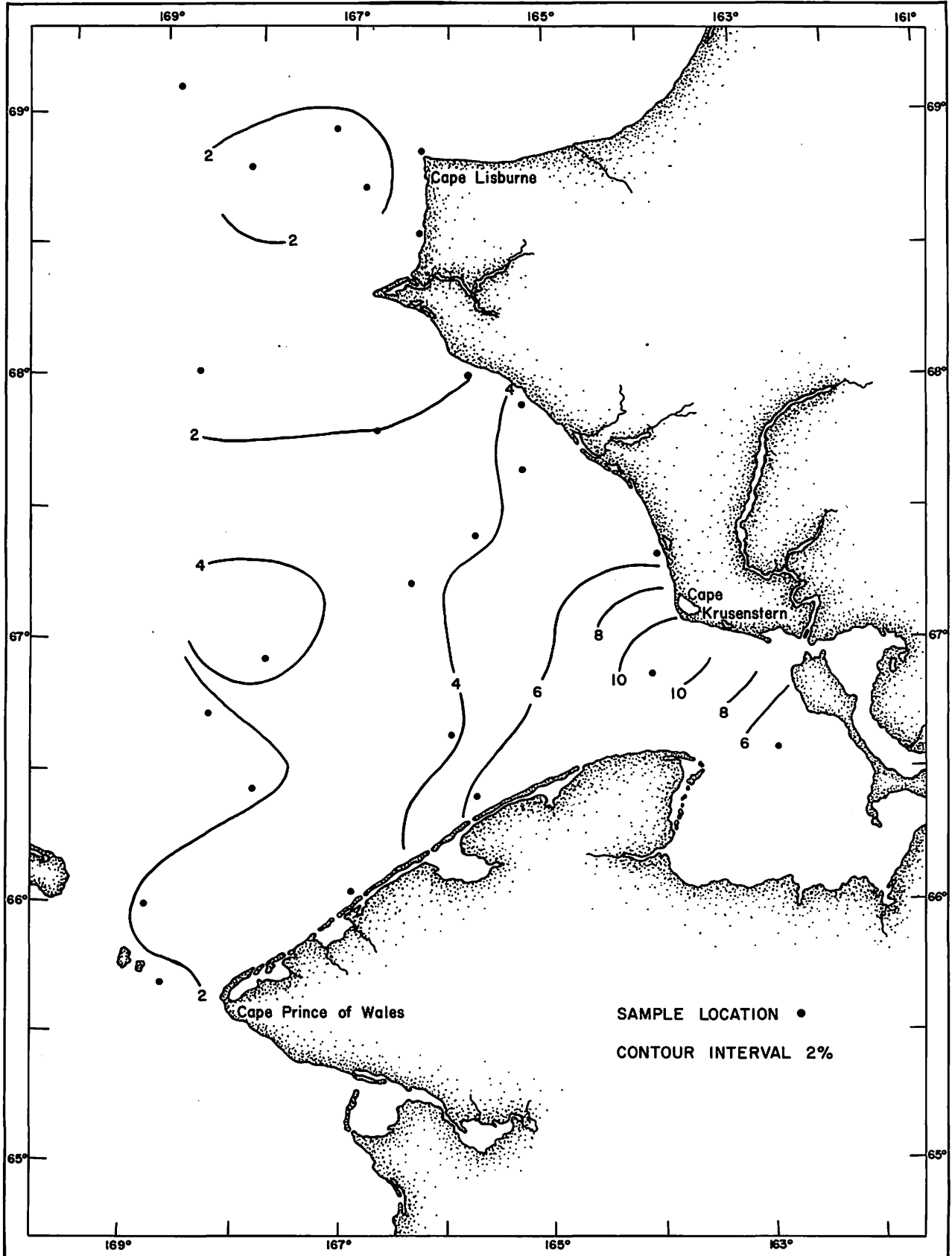


Fig. 16. Distribution of percentage of heavy minerals present in 3-phi size heavy minerals (per cent by weight).

TABLE 3. Heavy minerals and magnetic heavy minerals
in 3-phi size fraction
(percent by weight)

Sample No.	Heavy Minerals	Magnetic Heavy Minerals in Heavy Minerals
2	1.9	7
3	2.3	4
5	3.2	2
6	1.6	2
8	1.2	5
9	5.2	2
13	4.9	7
17	2.5	17
18	1.2	60
19	2.1	12
21	0.5	7
22	2.8	7
24	1.0	6
26	0.9	2
34	2.0	7
39	2.8	6
40	3.7	4
49	2.5	2
53	5.1	4
60	6.4	5
85	2.0	13
90	12.1	7
110	5.3	8
162	4.3	5

TABLE 4. Percentage of heavy minerals in coarse fractions of eight selected samples*

Sample No.	Size									Total Percent by weight in Coarse Fraction	Percent Coarse Fraction in total sample
	-4 ϕ	-3 ϕ	-2 ϕ	-1 ϕ	0 ϕ	+1 ϕ	+2 ϕ	+3 ϕ	+4 ϕ		
5	-	-	-	-	-	1.4	1.0	3.2	21.1	13.5	88.5
8	-	-	-	-	-	-	2.2	1.2	9.2	3.3	69.1
18	-	-	-	0	8.2	6.2	2.1	1.2	3.8	3.4	4.0
26	0	0	0	0.7	0.5	0.8	0.6	0.9	1.9	0.2	88.7
49	-	-	-	-	-	13.0	1.0	2.5	28.7	5.8	84.1
53	-	-	-	-	0	2.1	4.2	5.1	18.5	11.8	77.2
85	0	0	0	0	0.3	0.9	1.4	2.0	5.6	0.3	90.9
90	-	-	-	-	0	1.5	4.5	12.1	21.8	7.4	72.9

31

* The "-" symbol indicates lack of sediment in this size in this sample.

Magnetic Minerals

Magnetic minerals were removed from the heavy minerals in the 3-phi size fraction with an ordinary horseshoe magnet. Table 3 records the magnetic minerals as the weight by percent of the heavy minerals. Most of these grains were lithic fragments containing inclusions of magnetite. Relatively pure magnetite and ilmenite usually represented less than one-third of the magnetic fraction.

A notable increase in magnetic heavy minerals occurs seaward of the coast, between Point Hope and Cape Lisburne, as shown by Samples 26, 22, 19, 17, and 18, in that order (Figure 17). The very high value of 60 percent found in Sample 18 should be disregarded, however, because the total weight of material (0.5 mg) present in the 3-phi heavy fraction is relatively small. A decrease in magnetic heavy minerals occurs toward the east and south from Station 85 off Cape Thompson. No other regular patterns are indicated by the data at hand.

Selected Minerals

To describe more fully the distribution pattern of bottom sediment and to resolve source areas, the remaining heavy minerals were studied. The following requirements were established for selecting the minerals for study:

1. Ease of recognition under a binocular microscope in reflected light.
2. Recurrence in many of the samples.
3. Ease of concentration by a laboratory method.

The ten minerals thus selected, in order of decreasing abundance in all samples studied, were zoisite, pink garnet, hornblende, chlorite, muscovite, arsenopyrite?, chalcopyrite, phlogopite, biotite, and pyrite.

The selected minerals were concentrated by placing the heavy minerals on a slanted sheet of paper, which was tapped gently to remove the platy minerals. All heavy fractions which weighed more than 15 mg were run through a Frantz isodynamic magnetic separator (S. G. Frantz Company, Trenton, New Jersey), which groups minerals according to their relative magnetic susceptibilities. The technique employed was almost identical to that described by Rosenblum (1958). The four most abundant minerals of those listed above were over 99 percent concentrated with a setting of 0.35 to 0.45 amperes. Pyrite and arsenopyrite?, were found in the residue after the peak amperage of 1.2 was attained.

Total grain counts were made on all portions of the heavy mineral fraction. The grains were spread evenly on a gridded micropaleontological assemblage slide. Samples of 2000 grains or less were all counted. Random squares of larger samples were counted until at least 200 grains of each of the 10 selected minerals had been counted. The precision of the methods justifies reporting figures only to the nearest whole percent, according to Krumbein and Pettijohn (1938, p. 471). Percentages less than 0.5 percent were recorded with appropriate symbols. Table 5 presents the counts completed on 8 samples.

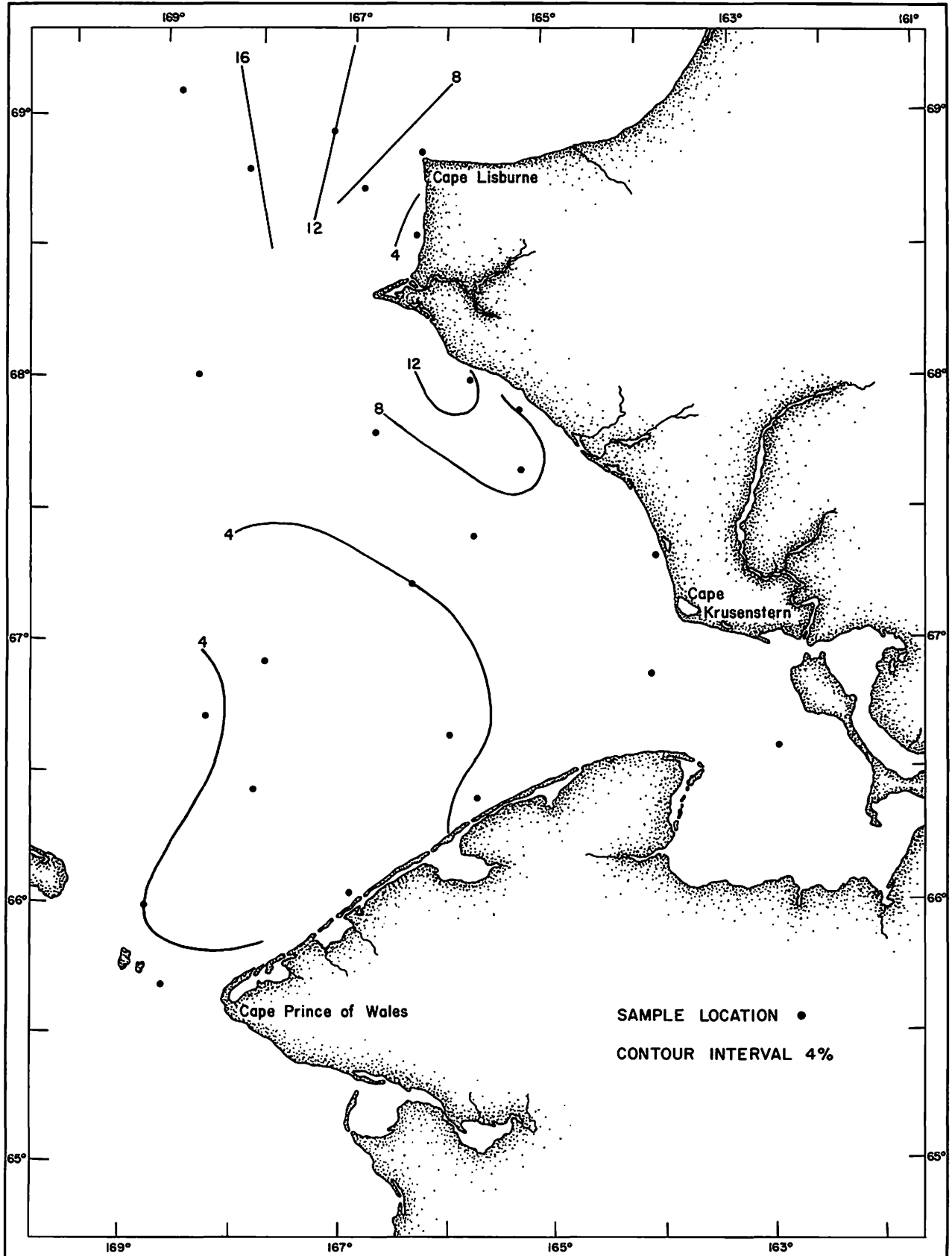


Fig. 17. Distribution of percentage of magnetic minerals in 3-phi size heavy minerals (per cent by weight).

TABLE 5. Selected heavy minerals in the 3-phi size fraction
(Percent by grain count)

Key: - = missing; T = trace (less than 0.05%); R = rare (0.05 to 0.5%)

	Sample Number							
	2	18	19	26	39	60	85*	90
? ARSENOFYRITE	-	-	-	-	1	R	-	-
BIOTITE	1	1	2	-	-	-	R	-
CHALCOPYRITE	-	-	-	R	4	T	-	-
CHLORITE	3	7	5	3	4	R	1	7
PINK GARNET	5	1	R	2	3	4	2	4
HORNBLENDE	10	-	R	R	1	1	R	4
MUSCOVITE	2	19	38	R	1	T	3	R
PHLOGOPITE	R	R	3	-	-	-	T	-
PYRITE	-	-	-	R	R	T	-	T
ZOISITE	2	1	1	2	1	8	-	1
TOTAL	24	29	49	7	15	13	7	16

* Sample 85 is from the offshore grab located nearest the "Chariot" site. The heavy minerals were therefore studied more completely. Percentages were estimated by grain count. The heavy minerals in the 3-phi size group are:

Lithic fragments and mineral aggregates . .	48%
Zircon	12
Magnetic lithic fragments	10
Iron oxide (mostly hematite) aggregates . .	6
Ilmenite	5
Muscovite	4
Magnetite	2
Pink garnet	2
Chlorite	1
Enstatite	1
Other minerals	<u>9</u>
Total	100%

"Other minerals" are those present in amounts less than 1 percent. These include biotite, clinopyroxene, hornblende, leucosene, phlogopite and flesh-colored garnet.

FORAMINIFERA

The types and quantities of Foraminifera were determined for 30 selected grab samples (Figure 18 and Table 1). Each sample was size-graded, the heavy minerals were removed, and then the Foraminifera were identified and counted. Total counts were made of the specimens in the larger size grades and representative counts were made in the smaller size grades. These counts were combined and adjusted by weight; they are reported as numbers of specimens per 10-gram sample so that populations can be compared (Table 6). All Foraminifera were benthonic except for one occurrence of Globigerina bulloides at Station 113. Table 6 shows the occurrence of each species as a percentage of the total population.

The dominant characteristic of the foraminiferal assemblages is the small number of both specimens and species. Of the 30 samples examined, one was barren of Foraminifera and 12 had fewer than 50 specimens per 10-gram sample. Seventeen of the samples contained five or more species; only six samples contained 10 or more species, with 18 species the greatest number noted. Samples from north of Little Diomedé Island and from the inshore areas between Cape Lisburne and Kivalina contain the greatest number of species. With the data presently available there appears to be no pattern to the concentration of specimens. Elphidium clavatum, Eggerella advena, and Buccella frigida are the most abundant species, with Elphidium the dominant genus.

CALCIUM CARBONATE

The percentage of calcium carbonate in a 1-gram random split was determined from 48 selected grab samples (Table 1). The method of determination was that proposed by Herrin et al. (1958) and consisted of allowing a known amount of ground sample to react with a known amount of standard H_2SO_4 . The amount of acid remaining was determined by back-titration with standard NaOH, using phenolphthalein as the indicator. The method was checked against a chemically precipitated $CaCO_3$ (99.65 percent pure) and was found to be reasonably accurate. The analysis gave a result of 95.75 percent. The slightly low value may be due to incomplete reaction of the acid with the pure $CaCO_3$.

Percentages of $CaCO_3$ in the 48 selected samples are given in Table 7 and are plotted as Figure 19 to give a generalized picture of the distribution. The highest values (7 to 14 percent) were encountered north of Little Diomedé Island and nearshore between Cape Lisburne and Point Hope. Intermediate values (3 to 5 percent) occur nearshore between Cape Krusenstern and Cape Thompson, and lower values (<1 to 2 percent) occur along the southern shore and in the central portion of the survey area.

The higher values of carbonate tend to occur with the coarser bottom material. The carbonate is associated not only with rock fragments, but also with shell material, including locally abundant Foraminifera. Off the coast between Cape Lisburne and Kivalina carbonates are associated with limestone occurrences along the shore. The high carbonate content of the bottom material north of Little Diomedé Island is due to shell material and

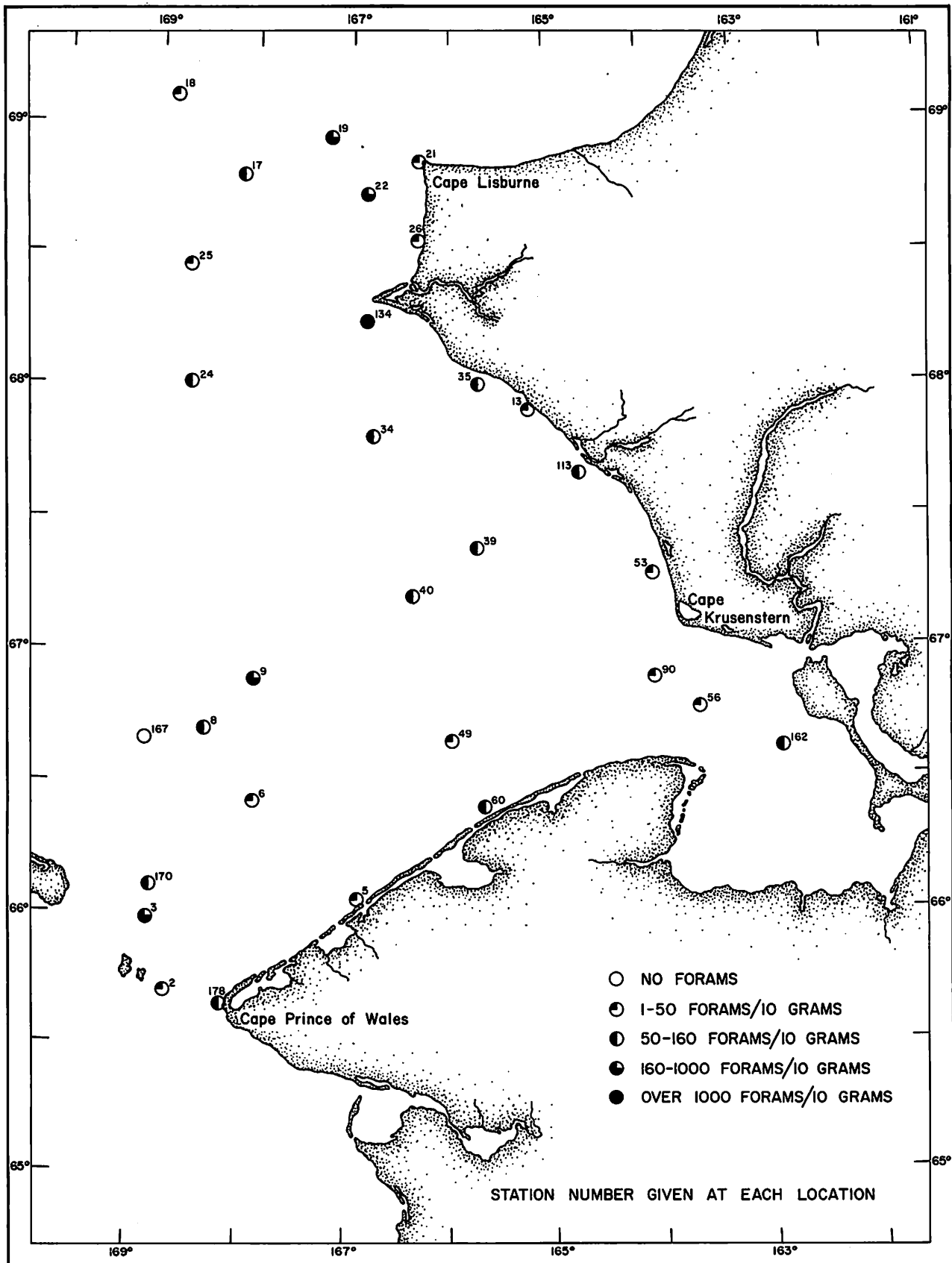


Fig. 18. Distribution of Foraminifera abundance.

TABLE 6. Frequency of Foraminifera

Sample Number	2	3	5	6	8	9	13	18
Depth of Water (Fathoms)	28	29	6	13	17	17	7	28
Foraminifera/10 grams	35	302	13	47	103	360	14	30
Number of Species	18	14	3	2	5	6	16	6
Total Population	175	1452	55	228	343	1167	80	41
<i>Bigenerina artica</i>	3.4							
<i>Bucella frigida</i>	3.4	8.2			.3	39.4	12.5	
<i>B. inusitata</i>	16.0	5.6			.3	4.9	13.8	
<i>Cassidulina islandica</i>	1.1	2.5						
<i>Cibicides lobatus</i>	4.6	5.7						
<i>Discorbis chasteri</i>	1.7						1.3	
<i>Eggerella advena</i>	8.6	1.3		66.6		17.0	8.8	41.5
<i>Elphidiella artica</i>	.6	.07					1.3	
<i>Elphidium bartletti</i>					.3		13.8	
<i>E. clavatum</i>	8.6	36.0	50.8		74.5	28.5	11.3	36.6
<i>E. frigidum</i>	10.9	11.8						
<i>E. subarticum</i>		1.6					11.3	
<i>E. oregonese</i>							1.3	
<i>E. orbicular</i> and var.	20.6			33.3		6.8	7.5	2.4
<i>E. sp. 1</i>	3.4	19.3	1.8		24.2		7.5	2.4
<i>E. sp. 2</i>	2.9	3.5						2.4
<i>Epinoides sp.</i>	8.0	3.0				3.4	2.5	
<i>Fissurina marginata</i>	1.7	.6						
<i>Frondicularia sp.</i>							1.3	
<i>Miliammina sp.</i>	1.1							
<i>Nonion auricula</i>							1.3	
<i>N. labradoricum</i>							1.3	14.6
<i>N. sp.</i>		.6	47.2					
<i>Proteonina atlantica</i>	.6							
<i>Quinquiloculina sp.</i>	2.3						3.8	

(continued)

Table 6, continued

Sample Number	17	19	21	22	24	25	26	34
Depth of Water (Fathoms)	28	25	13	21	32	28	9	30
Foraminifera/10 grams	146	369	38	333	82	10	22	151
Number of Species	3	5	9	7	2	4	9	1
Total Population	379	1146	180	1014	247	13	162	390
<i>Bigenerina artica</i>						15.4		
<i>Bucella frigida</i>			8.8				13.0	
<i>B. inusitata</i>		.4		1.4			18.5	
<i>Discorbis chasteri</i>			4.4					
<i>Eggerella advena</i>	96.6	89.5	27.2	80.3		38.4		100
<i>Elphidiella nitidea</i>			1.1					
<i>Elphidium bartletti</i>		.2	7.8				3.1	
<i>E. clavatum</i>	2.1	8.5	20.6	7.8	77.3	38.4	45.1	
<i>E. hanni</i>	1.3		10.5	.5				
<i>E. orbicular</i> and var.		1.1	10.5	1.8			9.2	
<i>E. sp. 1</i>							1.9	
<i>E. sp. 2</i>			8.8			7.7	6.8	
<i>Epinoides sp.</i>				7.3	22.7		1.9	
<i>Frondicularia sp.</i>							.6	
<i>Nonion labradoricum</i>		.4		.9				
<i>Quinqueloculina sp.</i>								

(continued)

Table 6, continued

Sample Number	39	40	49	53	56	60	85	90
Depth of Water (Fathoms)	21	25	12	7	12	9	9	12
Foraminifera/10 grams	12	151	11	3	25	77	101	3
Number of Species	4	5	1	1	1	1	9	1
Total Population	396	459	60	1	92	328	865	11
<i>Bigenerina artica</i>								
<i>Buccella frigida</i>	35.6	13.3	100			100	26.2	100
<i>B. inusitata</i>							7.5	
<i>Eggerella advena</i>	13.1	66.6					4.6	
<i>Elphidium bartletti</i>							17.7	
<i>E. clavatum</i>	44.7	17.6					36.5	
<i>E. frigidum</i>		.2						
<i>E. hanni</i>				100				
<i>E. orbicular</i> and var.							.9	
<i>E. sp. 1</i>		2.2			100		5.3	
<i>E. sp. 2</i>	6.6							
<i>Esorinx curta</i>							.9	
<i>Miliammina sp.</i>							.5	

(continued)

Table 6, continued

Station Sample	113	134	162	170	178	167	
Depth of Water (Fathoms)	7	18	8	29	8	19	
Foraminifera/10 grams	71	2771	104	119	155	--	
Number of Species	14	14	2	10	6	--	
Total Population	401	10832	248	607	359	--	
<i>Ammotium cassis</i>	1.2						
<i>Bigenerina artica</i>	1.2						
<i>Buccella frigida</i>	10.2	28.8		9.7	50.7		
<i>B. inusitata</i>	5.0	8.2		15.5			
<i>Cassidulina artica</i>		9.3		2.3			
<i>Cibicides lobatus</i>	3.7	1.3		.8			
<i>Discorbis chasteri</i>	.5						
<i>Eggerella advena</i>	30.0	10.9	94.8				
<i>Elphidiella artica</i>				13.8			
<i>Elphidium bartletti</i>	7.7				.6		
<i>E. frigidum</i>		1.8		13.7			
<i>E. clavatum</i>	19.5	23.8	5.2	27.7	15.9		
<i>E. hanni</i>	1.2	3.2		13.2	14.8		
<i>E. orbicular</i> and var.	16.5	10.0					
<i>E. sp. 1</i>		1.1					
<i>E. sp. 2</i>	1.7			1.5			
<i>Epinoides sp.</i>	.5						
<i>Globobulimina auriculata</i>		.7					
<i>Globigerina bulloides</i>	.5						
<i>Lagena apioplura</i>		.6					
<i>Miliammina sp.</i>		.02			.3		
<i>Nonion sp.</i>		.3		2.3	17.8		

Barren

TABLE 7. Calcium carbonate and organic carbon content of sediments

Sample No.	Calcium Carbonate (in percent)	Organic Carbon (in percent)
3	14.2	0.4
5	3.0	0.2
6	1.8	0.5
8	1.3	0.5
13	5.6	0.7
17	1.6	1.5
18	1.6	1.8
19	3.0	1.4
21	7.2	1.5
22	1.6	1.1
24	0.8	1.7
25	1.6	1.8
26	6.9	0.5
28	2.0	0.7
29	0.8	1.5
30	3.4	1.3
31	1.9	0.9
32	2.0	1.8
34	1.6	1.0
39	1.8	1.4
40	0.7	1.0
45	2.0	0.7
47	2.0	0.4
48	1.4	0.2
49	0.1	0.3
53	3.8	0.6
56	3.9	0.7
57	1.2	0.7
60	1.6	0.0
71	0.8	0.9
79	0.5	0.7
85	3.6	1.2
90	3.0	0.5
93	3.2	0.4
99	1.8	1.2
110	2.0	1.2
113	2.0	0.4
128	3.2	---
134	9.0	0.9
138	3.2	0.5
151	2.2	0.2
155	1.6	1.9
158	1.0	1.1
161	0.6	1.3
163	1.7	0.8
167	4.4	0.5
170	7.1	0.2
178	1.8	0.8

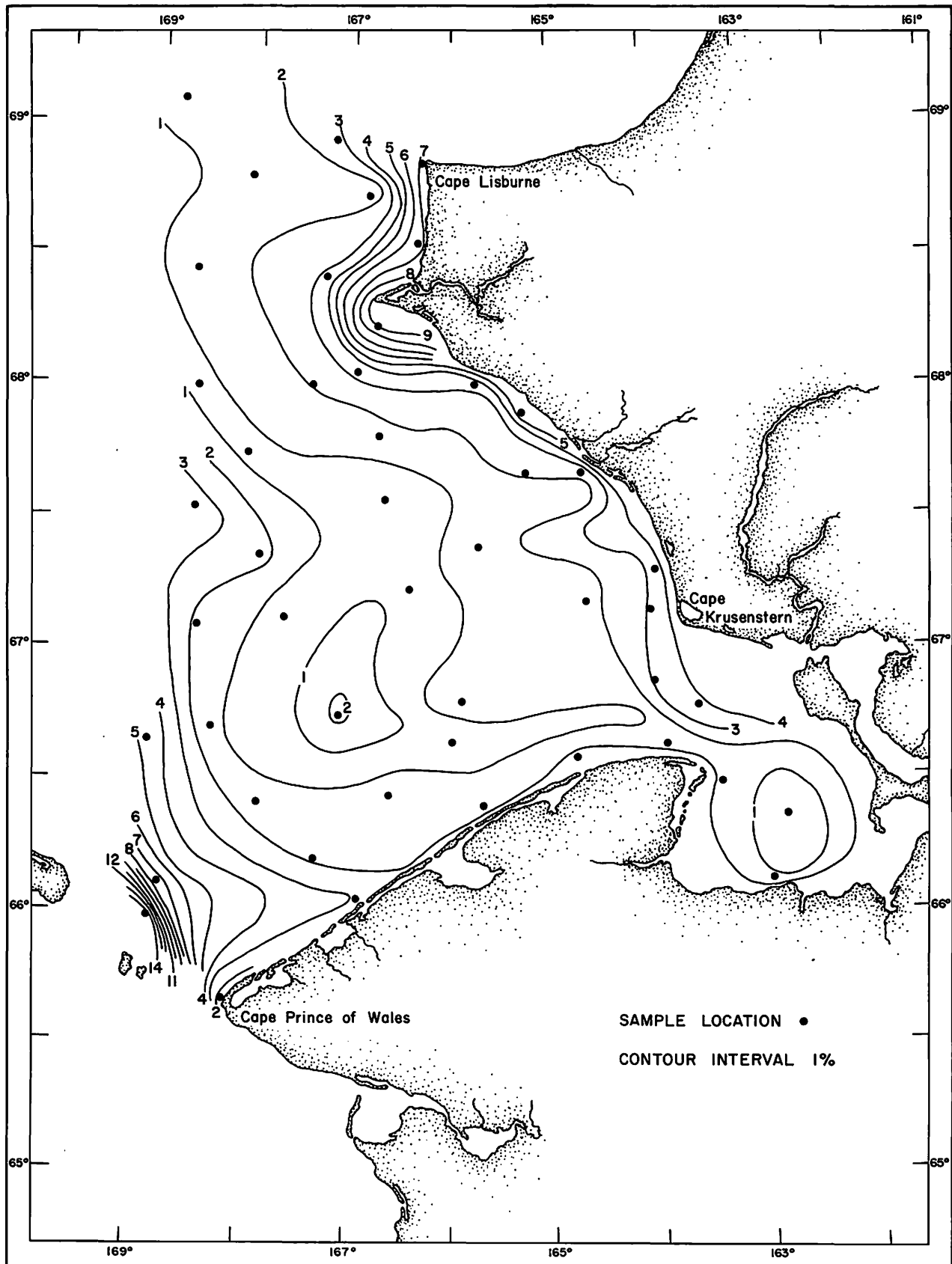


Fig. 19. Calcium carbonate distribution (per cent of total sample).

cannot be correlated with a limestone area along the coast. The finer material in the central portion of the survey area is very low in carbonate.

ORGANIC CARBON

The percentage of organic carbon in a 1-gram random split was determined in 47 selected grab samples (Table 1) by the method of Allison (1935). A known amount of ground sample (<100 mesh) was allowed to react with a known amount of chromic acid. The amount of acid remaining was determined by back-titration with ferrous ammonium sulfate, using barium diphenylamine sulfonate as the indicator. A six-fold replicate of a single sample produced a standard deviation of 0.6*. Allison's standard deviation was 1.90 and his standard deviation using the "more accurate" combustion method was 1.50. Thus, the accuracy achieved was at least as high as that obtained by Allison, indicating an average error of reproducibility of not more than 0.89 percent of the organic carbon present. The error in the laboratory analysis for total carbon content is insignificant as compared to errors of sampling.

Table 7 shows the percentages of organic carbon, and the distribution is plotted in Figure 20. The bathymetry, sorting of sediments, size distribution of sediments, and carbonate content were used as controls in contouring the distribution of organic carbon. The 47 samples show a range from no observable organic carbon to a maximum of 1.9 percent. The values are lowest along the southern coast between Cape Prince of Wales and Cape Espenberg, with a range from zero to 0.4 percent. Along the northern coast the values are variable, ranging from 0.4 percent at Cape Krusenstern to 1.5 percent at Cape Lisburne. The central portion of the survey area contains high values, ranging from 0.7 to 1.8 percent. The inner portion of Kotzebue Sound also exhibits high values, ranging from 1.1 to 1.9 percent.

The higher values of organic carbon tend to occur with the finer-size sediment, as seen in the northwest portion of the survey area in the deeper water and in the inner portion of Kotzebue Sound. The organic carbon of the sediment is low where the sediment is coarser, as along the northern coast, and is also low where the sediment is much better sorted, as along the southern coast.

FUTURE PLANS

An additional 183 grab samples and a 744 cm piston core were collected from the same area during the 1960 summer field season. These were taken to fill in the gaps in the 1959 survey. The final report will include results of the findings on all samples from both field seasons. The primary effort will be confined to further studies of grain-size, heavy mineral, and Foraminifera distributions.

* Standard deviations (Allison, 1935) were computed by considering differences between duplicate samples as deviations of the carbon value of duplicate "b" from that of duplicate "a", the latter serving as the base of comparison. The standard deviation is then a percent of the "a" value.

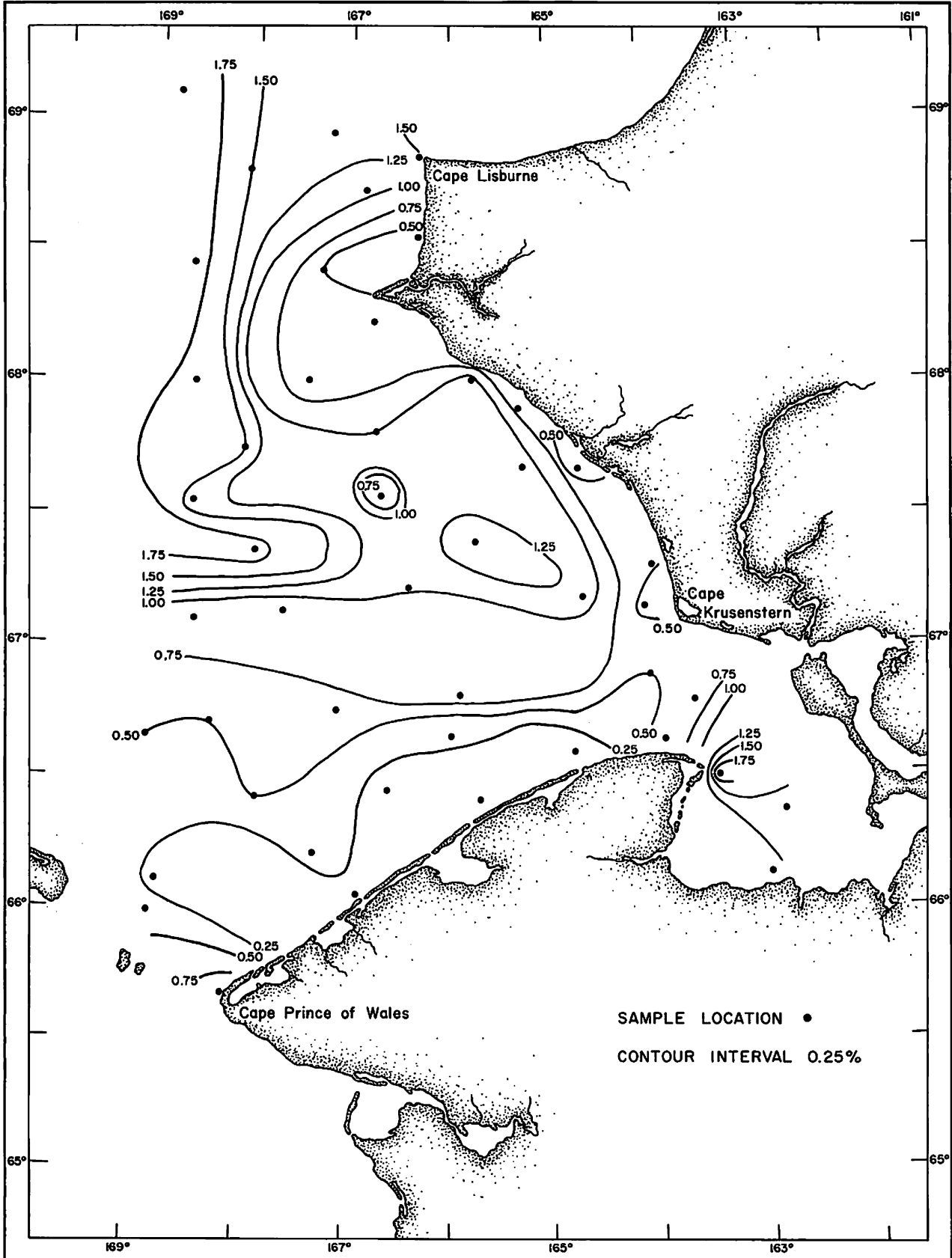


Fig. 20. Organic carbon distribution (per cent of total sample).

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