See C.R.D.T.
for Kodiak

Volume 7. Fish, Plankton, Benthos, Littoral

Principal Investigators' Reports for the Year Ending March 1976

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

U. S. DEPARTMENT OF INTERIOR
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Annual Reports from Principal Investigators

Volume:
1. Marine Mammals
2. Marine Birds
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Environmental Assessment of the Alaskan Continental Shelf

Volume 7. Fish, Plankton, Benthos, Littoral

Fourth quarter and annual reports for the reporting period ending March 1976, from Principal Investigators participating in a multi-year program of environmental assessment related to petroleum development on the Alaskan Continental Shelf. The program is directed by the National Oceanic and Atmospheric Administration under the sponsorship of the Bureau of Land Management.

ENVIRONMENTAL RESEARCH LABORATORIES / Boulder, Colorado / 1976

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ANNUAL REPORT

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Plankton of the Gulf of Alaska - Ichthyoplankton

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1 April 1976

REF: A76-33

I. Task Objectives

The task of primary emphasis is to determine the seasonal density distributions and environmental requirements for principal species of ichthyoplankton in the Gulf of Alaska. This program will also cooperate with the zooplankton program to examine organisms generally larger than copepods.

II. Field Activities

A. Ship Schedule, Personnel

1. *Acona*, 28 August - 15 September 1975. This cruise was aborted due to engine trouble.

2a. *Surveyor*, 29 September - 24 October 1975.

Personnel: all are associated with Department of Oceanography, University of Washington, Seattle, Washington 98195

Leg I (30 Sep - 10 Oct)

Dr. T. Saunders English, Principal Investigator, 30 Sep - 03 Oct
Mike Macaulay, Graduate Student, 29 Sep - 03 Oct
Rich McKinney, Research Aide, 29 Sep - 10 Oct
Mike Tomlinson, Assistant Oceanographer, 29 Sep - 10 Oct

Leg II (10 Oct - 24 Oct)

Mike Tomlinson, Assistant Oceanographer, 10-24 Oct
Rich McKinney, Research Aide, 10-24 Oct

2b. *Surveyor*, 4 October - 9 October

PMEL personnel also collected samples for us using Puget Sound ring nets with a mesh size of 211 μm.

3. *Discoverer*, 21 October - 14 November

PMEL personnel collected samples for us using Bongo nets.

4. *Discoverer*

University of Alaska personnel collected samples for us in the Bering Sea using 1 m NIO nets and Tucker trawls.

B. Methods

1. Field Sampling

A Jered Oceanographic Winch mounted on the deck was used exclusively for net work. The drum presently holds approximately 3000 m of 5/16" 3-conductor wire with a resistance of 200 Ω. This wire is run through a block hanging from a hydraulic boom horizontally mounted approximately 10 feet above the deck. The hydraulics enable this boom to be extended eight feet out from the side of the ship. A stay was used to add strength to the boom during net tows. During the course of net tows the ship, depending on conditions, was requested to maintain slow headway. This was accomplished by heading the ship into the wind and either adding or subtracting turns in increments of five RPM. Requesting changes required some forethought due to the momentum of the vessel. The slow response of this vessel (or any vessel of this size) to the helm is perhaps the greatest difficulty encountered in towing nets.

The continuous acoustic surveys were conducted using a Ross 200 A Fine Line echosounder system operating at a frequency of 105 kHz. The ship's 10° by 20° transducer was used while underway and on station. When a deep scattering layer was seen, the UW's 10° transducer was lowered to approximately 0.5 m below the surface. A towed body (the "toad") was utilized in some instances in an effort to use the UW transducer while underway. The toad was found unsatisfactory because of rough seas (over 5 feet), speeds of approximately 3 knots, and possible design problems. In all cases the chart was marked with the time and date, and, when applicable, the station number, changes in gain, transducer in use, and other pertinent information.

Horizontal tows were made using the UW 1 m NIO net (571 μm mesh, 4:1 OAR) with a telemetry system furnishing depth (m), speed (m/sec), and two solenoids for opening and closing the net. The original plan was to use the ship's conducting cable on the oceanographic winch; however, due to a high resistance in the wire, the UW "second wire" system was used. This system was judged fair because the system is quite fragile. It was found that drag on the wire at approximately 30 turns (approximately 3 kts) caused the wire to part. The NIO net is lowered closed to the depth of interest, opened, fished for a certain amount of time (usually 5 min), closed, and hauled to the surface. The samples were placed in 500 ml jars, the jars were filled 3/4 full with sea water, and the sample was preserved with 25 ml of 100% formalin and 10 ml of saturated sodium borate solution. A label was filled out and inserted in the jar, the jar was filled close to the brim, and capped for storage. This procedure was used for all of the UW zooplankton samples.

Double oblique tows were made with a modified Brown-McGowan (Bongo) net. For our purposes the opening-closing mechanism was removed. A 2 mm mesh net (5.2:1 OAR) and a 571 μm mesh net (6.7:1 OAR) were used simultaneously (333 μm nets were not available for our use). The Bongo frame inside diameter was 71 cm, giving a mouth area of 0.3956 m^2. Centered within the mouth of each net was a General Oceanics Flowmeter to indicate water volumes. In deep water (over approximately 130 fms) 300 meters of wire were let out at a rate of 50 m/min. This descent rate was not always adhered to in seas or swell much over 5 feet. A rate of 50 m/min often produced too much slack in the wire which then snapped taut as the stern rose. This was deemed hazardous to both equipment and personnel. After the wire was out, the net was allowed to hold for 30 seconds before it was brought to the surface at a rate of 20 m/min. During ascent, the wire angle was measured every 10 m of wire recovered. This was accomplished using a telemetering inclinometer on loan to the UW from the east coast MARMAP group.

2. Laboratory Analysis

In the laboratory, the samples were sorted and the fish eggs and larvae removed. Identifications were made using dissecting microscopes.

C. Sample Localities

Stations and ship tracklines are shown in Figs. 1-3 and Table 1.

D. Data collected and analyzed

1. Data collected

See Tables 2-4, summary sheets of net hauls.

2. Data analyzed (number of samples)

a) *Surveyor* (UW)	88
b) *Surveyor* (PMEL/NOAA)	33
c) Univ. Alaska	41

III. Results

A. *Surveyor* (UW)

Fish eggs and/or larvae were found in 48 of 88 samples. Of these, 42 samples contained only fish larvae and 12 samples contained only eggs. A total of 388 fish larvae were distributed in 9 families, 9 genera, and 9 species. A total of 76 eggs were found in 13 samples (Table 5).

Table 6 lists the eggs and fish larvae by station. Table 7 gives the identification of fish larvae by station.

B. *Surveyor* (PMEL/NOAA)

Forty-three fish larvae and 2 eggs were found in 32 samples. The eggs were poorly preserved and could not be identified. The fish larvae were distributed in 7 families, 6 genera, and 6 species (Table 8). Table 9 lists the number of fish eggs and larvae found at each station; Table 10 gives the identification of fish larvae by station.

C. University of Alaska Bering Sea Samples

Of 41 samples given to us for identification, 29 contained fish larvae and/or eggs. Identifications are incomplete, but 302 fish larvae from 6 families and 6 species have been found. Seventeen fish eggs found in seven samples have not been identified. Table 11 lists the fish eggs and larvae found at each station.

IV. Preliminary Interpretation of Results

The continuous sonic survey revealed infrequent layers at depths around 40 meters. When the NIO net was lowered to this layer a few copepods, amphipods, an occasional euphausid and some jelly fish were caught. These could not account for the entire layer. This indicates that the echosounder was detecting small fish capable of avoiding the net. More frequently, a diffuse layer from the surface to about 30 meters was observed. The distinct dots appearing on the Ross chart and the lack of targets in the NIO net indicate fish. Diagonal dotted lines caused by interference from the ship's 200 kHz Raytheon Fathometer were also seen on the echosounder.

Tow quality of Bongo nets was difficult to control. Based on the NMFS/SWFC coefficient of variation of rates of ascent, the majority of the tows were unsatisfactory, that is cv > 60%; however, as long as changes in wire angle are noted and therefore the tow path as the net ascends, then bias in the sample can be detected and taken into account. The Bongo net was surprisingly effective in catching fish larvae and adult fishes such as lantern fish.

The most valuable piece of information to come from this leg is an understanding of sampling capabilities.

V. Problems Encountered/Recommended Changes

Most of our problems have been start-up difficulties which have been settled in the course of our work.

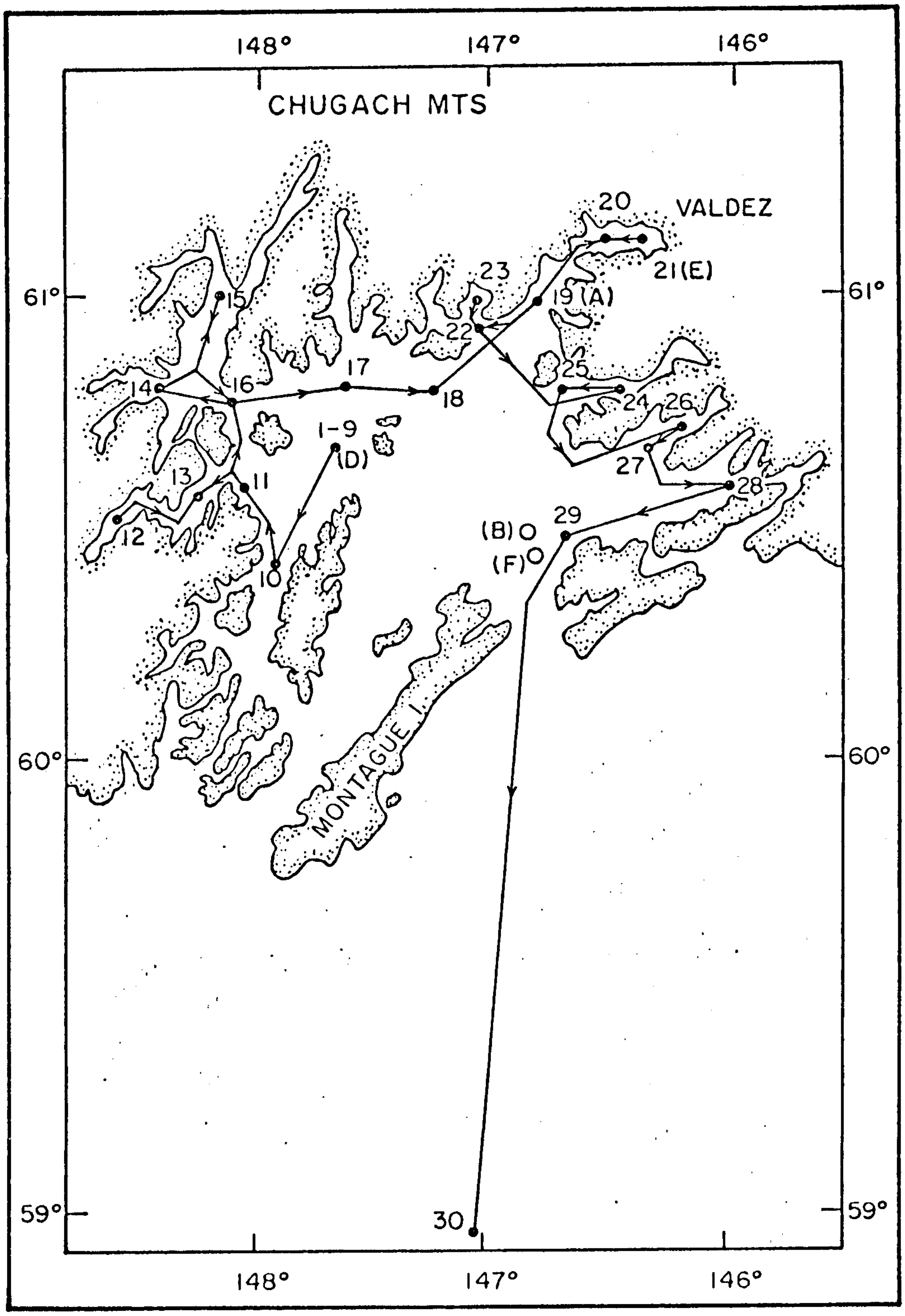

Fig. 1. Stations and ship tracklines for Leg I, *Surveyor*, 30 Sep - 10 Oct 1975. The cruise track was approximately 700 km.

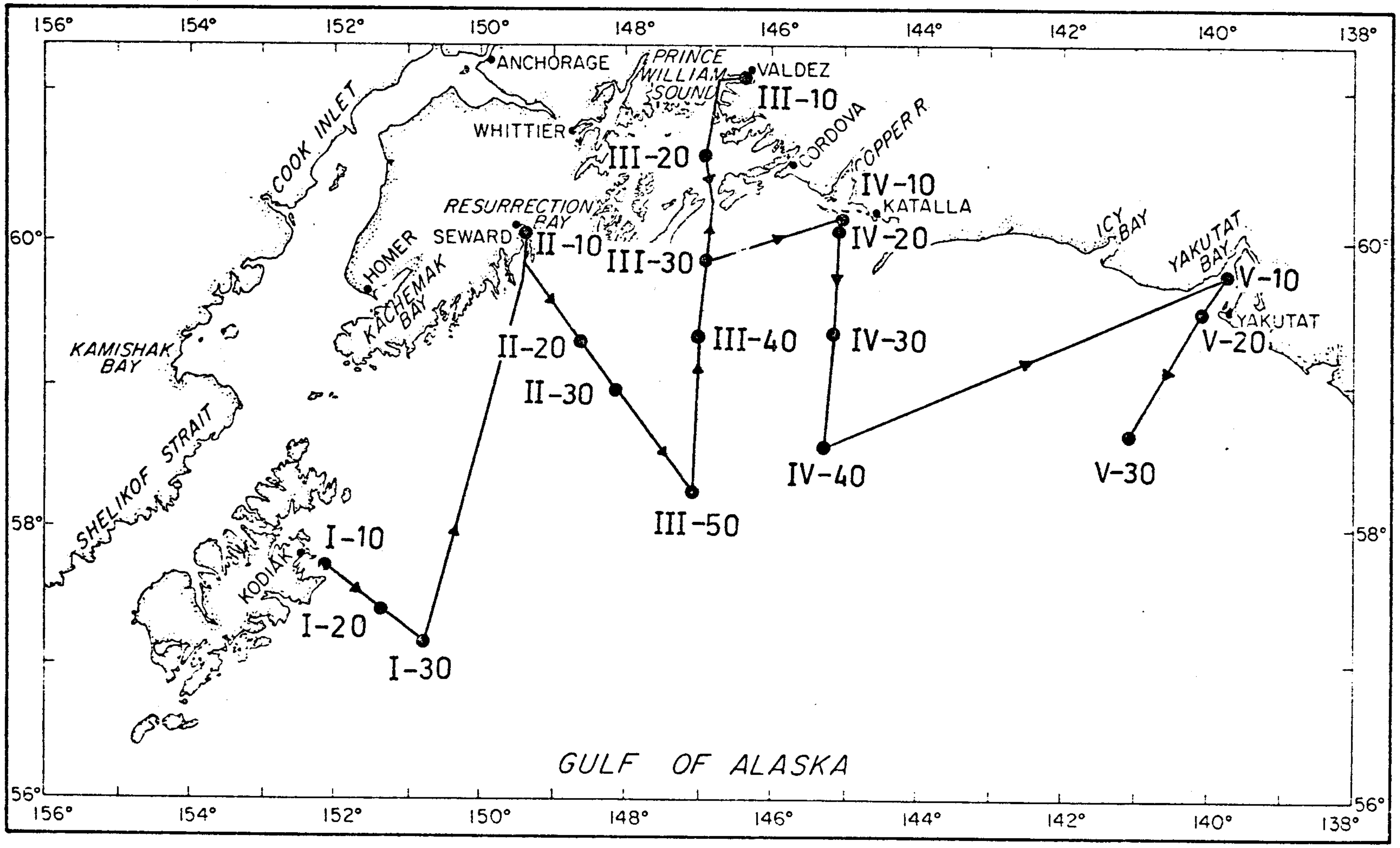

Fig. 2. Stations and ship tracklines for Leg II, *Surveyor*, 10 Oct - 24 Oct 1975. The cruise track was approximately 1600 km.

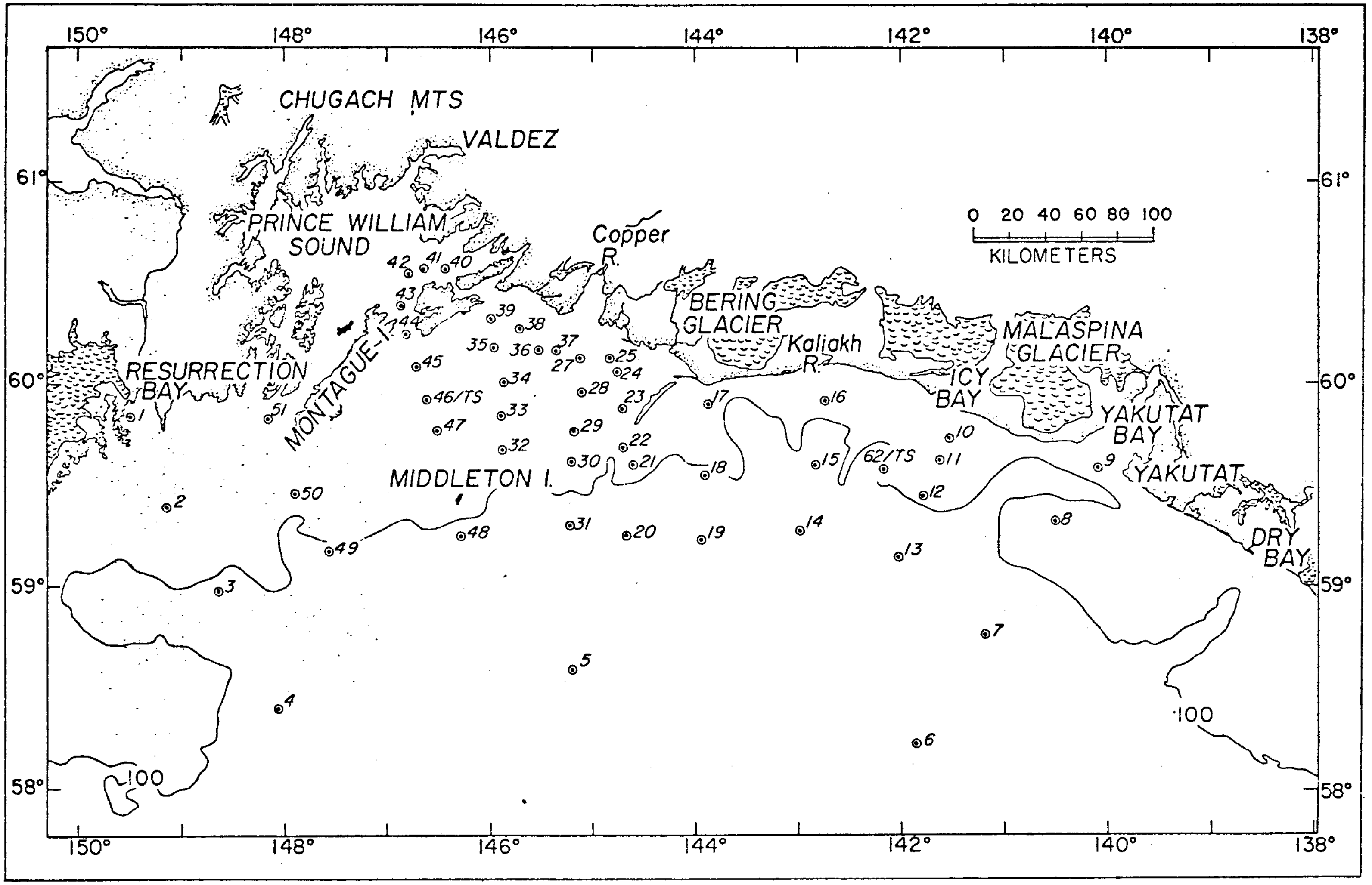

Fig. 3. Station locations, *Discoverer*, 21 Oct - 14 Nov 1975

Table 1. Charted Station Locations
(Chart #8500)

Station	Latitude (N)	Longitude (W)	Dist (nm)	Chart Depth (fm)	Origin
I-10	57° 41.8'	152° 05.0'	--	50	Kodiak
I-20	57° 27.3'	151° 27.5'	25	80	
I-30	57° 13.9'	150° 52.2'	24	100	
I-40	56° 58.4'	149° 44.3'	46	2500	
II-10	60° 06.1'	149° 24.3'	--	30	Seward
II-20	59° 19.4'	148° 38.5'	57	50	
II-30	58° 59.0'	148° 05.5'	26	100	
III-10	61° 06.4'	146° 21.3'	--	110	Valdez
III-20	60° 33.0'	146° 56.4'	43	240	
III-30	59° 49.4	146° 55.3'	48	50	
III-40	59° 18.8'	147° 00.0'	31	100	
III-50	58° 21.8'	147° 06.2'	58	1200	
IV-10	60° 10.0'	145° 00.0'	--	14	Copper R
IV-20	60° 05.1'	145° 00.9'	5	50	
IV-30	59° 23.7'	145° 07.1'	42	100	
IV-40	58° 41.3'	145° 15.7'	42	2300	
V-10	59° 47.0'	139° 45.5'	--	40	Yakutat
V-20	59° 31.0'	140° 03.8'	18	50	
V-30	59° 01.0'	140° 37.2'	35	100	
V-40	58° 39.2'	141° 02.2'	25	1500	

Table 2. UW Haul Summary Sheet, Leg I

Bongo Tows

Date (1975)	Time (ADT)	Station	PMEL Station	Haul	Latitude (N)	Longitude (W)	Wire Out(m)	First Wire<°	Depth (m)	Mesh Size (μm)	
										571	2000
2 Oct	1030	A	(19)	1	60° 58.9'	146° 47.0'	300	65	127	1	1
2 Oct	1320	B	(--)	2	60° 32.5'	146° 50.5'	300	42	223	1	1
2 Oct	1430	C	(--)	3	60° 27.9'	146° 47.6'	300	30	260	1	1
5 Oct	1300	D	(1-9)	4	60° 41.2'	147° 40.2'	300	55	172	*	*
5 Oct	1400	D	(1-9)	5	60° 41.2'	147° 40.8'	300	56	168	1	1
5 Oct	1450	D	(1-9)	6	60° 41.1'	147° 41.3'	300	62	141	1	1
7 Oct	0507	15	(15)	1	60° 57.2'	148° 07.6'	300	63	136	1	1
7 Oct	1619	21	(21)	1	60° 06.3'	146° 21.8'	240	45	170	1	1

* Haul aborted; PMEL has the sample

Table 2 (cont.). UW Haul Summary Sheet, Leg I

NIO Tows

Date (1975)	Time (ADT)	Station	PMEL Station	Haul	Latitude (N)	Longitude (W)	Depth (m)	Speed (m/sec)	Duration (min/sec)	Mesh Size 571μm
1 Oct	2107	E	(21)	1	61° 06.1'	146° 20.5'	19	1.8	5/0	1
2 Oct	0855	E	(21)	2	61° 06.6'	146° 23.1'	82	1.0	5/0	1
2 Oct	1621	F	(--)	3	60° 28.0'	146° 48.6'	18	1.4	6/10	1
5 Oct	0845	D	(1-9)	4	60° 41.4'	147° 40.2'	30	0.8	11/0	1
5 Oct	0906	D	(1-9)	5	60° 41.2'	147° 40.6'	30	1.5	11/0	1
5 Oct	2112	D	(1-9)	6	60° 40.2'	147° 40.6'	49	?	5/0	1

Table 3. UW Haul Summary Sheet, Leg II

Bongo Tows

Date	Time (ADT)	Sta.	Haul	Latitude (N)	Longitude (W)	Wire Out (m)	First Wire<°	Depth (m)	Mesh Size (μm) 571	Mesh Size (μm) 2000
14 Oct	1624	I-10	1	57° 41.7'	152° 05.0'	160	56	89	1	1
14 Oct	2107	I-20	1	57° 27.4'	151° 27.0'	210	74	58	1	1
16 Oct	0846	II-10	1	60° 06.1'	149° 24.1'	180	60	90	1	1
16 Oct	1705	II-20	1	59° 21.3'	148° 39.1'	90	60	45	1	1
16 Oct	2007	II-20	2	59° 21.3'	148° 39.1'	120	50	77	1	1
16 Oct	2043	II-20	3	59° 21.3'	148° 39.1'	120	60	60	1	1
17 Oct	0813	II-30	1	59° 00.0'	148° 10.1'	260	48	174	1	1
17 Oct	1445	III-50	1	58° 22.6'	147° 10.0'	300	60	150	1	1
17 Oct	2011	III-50	2	58° 22.6'	147° 10.0'	300	64	132	1	1
17 Oct	2104	III-50	3	58° 22.6'	147° 10.0'	300	60	150	3	1
18 Oct	0809	III-40	1	59° 19.1'	147° 00.5'	240	58	127	1	1
18 Oct	1641	III-20	2	60° 33.9'	146° 51.9'	300	80	52	1	1
18 Oct	2023	III-20	3	60° 33.9'	146° 51.9'	300	45	212	1	1
19 Oct	0833	III-10	1	60° 06.2'	146° 23.9'	250	58	132	1	1
19 Oct	1827	III-30	1	59° 49.5'	146° 56.5'	120	73	35	1	1
20 Oct	0821	IV-10	1	60° 09.1'	145° 01.8'	20	38	16	1	1
20 Oct	1100	IV-20	1	60° 05.0'	145° 01.0'	110	42	82	1	1
20 Oct	1504	IV-30	1	59° 22.8'	145° 08.2'	300	67	117	1	1
20 Oct	2054	IV-30	2	59° 22.8'	145° 08.2'	300	46	208	1	1
21 Oct	0804	IV-40	1	58° 40.0'	145° 15.2'	300	34	249	1	1
22 Oct	0814	V-10	1	59° 47.8'	139° 44.2'	130	67	51	1	1
22 Oct	0920	V-10	2	59° 47.8'	139° 44.2'	80	33	67	1	1
22 Oct	1233	V-20	1	59° 30.9'	140° 02.5'	120	45	85	1	1
22 Oct	1630	V-30	1	59° 01.0'	140° 38.0'	220	65	93	1	1

Table 4. UW Haul Summary Sheet, Leg II

NIO Tows

Date	Time (ADT)	Sta.	Haul	Latitude (N)	Longitude (W)	Depth (m)	Speed (m/sec)	Dur (min)	Mesh Size 571μm
14 Oct	1505	I-10	1	57° 41.7'	152° 05.0'	49	1.3	5	1
14 Oct	2152	I-20	1	abort	--	--	---	-	-
16 Oct	1043	II-10	1	60° 06.1'	149° 24.1'	24	0.9	5	1
16 Oct	1115	II-10	2	60° 06.1'	149° 24.1'	50	---	5	1
16 Oct	1636	II-20	1	59° 21.3'	148° 39.1'	37	1.5	5	1
17 Oct	0918	II-30	1	59° 00.0'	148° 10.1'	55	0.8	5	1
17 Oct	1416	III-50	1	58° 22.6'	147° 10.0'	14	1.0	5	1
18 Oct	0857	III-40	1	59° 19.1'	147° 00.5'	50	1.0	5	1
18 Oct	1548	III-20	1	60° 33.9'	146° 51.9'	45	1.6	5	1
18 Oct	2153	III-20	2	60° 33.9'	146° 51.9'	20	1.2	5	1
19 Oct	0914	III-10	1	61° 06.2'	146° 23.9'	20	1.0	5	1
19 Oct	1758	III-30	1	59° 49.5'	146° 56.5'	45	0.7	12	1
20 Oct	0915	IV-10	1	60° 09.1'	145° 01.8'	30	0.9	5	1
20 Oct	1038	IV-20	1	60° 05.0'	145° 01.0'	50	1.2	5	1
20 Oct	1551	IV-30	1	59° 22.8'	145° 08.2'	56	0.8	5	1
20 Oct	2030	IV-30	2	59° 22.8'	145° 08.2'	55	1.0	5	1
21 Oct	0848	IV-40	1	58° 40.0'	145° 15.2'	51	1.0	5	1
22 Oct	0951	V-10	1	59° 47.8'	139° 44.2'	52	0.9	9	1
22 Oct	1307	V-20	1	59° 30.9'	140° 02.5'	58	0.9	5.5	1
22 Oct	1612	V-30	1	59° 01.0'	140° 38.0'	48	1.0	5	1

Table 5. Summary of taxonomic categories of fish eggs and larvae found in Bongo and 1 m NIO net samples collected in the Gulf of Alaska, UW *Surveyor* cruise, 30 September - 24 October 1975

A total of 42 samples contained 388 fish larvae that were identified. They were distributed into 9 families, 9 genera, and 9 species:

Family Atherimidae

1 speciman, genus?, species?

Family Bathylagidae

31 specimens, Smoothtongue *Leuroglossus stilbius schmidti* Rass

Family Clupeidae

2 specimens, genus? species?

Family Cottidae

8 Blackfin sculpin *Malacocottus kincaidi* Gilbert & Thompson
5 specimens, genus?, species?

Family Gadidae

4 Pacific cod *Gadus macrocephalus* (Tilesius)

Family Myctophidae

4 Smallfin lanternfish *Stenobrachius leucosparus* (Eigenmann & Eigenmann)

Family Opisthoproctidae

1 Barreleye *Macropina microstoma* Chapman

Family Osmeridae

89 Caplin *Mallotus villosus* Muller
93 Longfin smelt *Spirinchus thaleichthys* (Ayres)
45 Eulachon *Thaleichthys pacificus* (Richardson)
3 specimens, genus?, species?

Family Scorpaenidae

93 *Sebastes* sp.
3 elongate larvae with pink pigments
5 compressed larvae with oil globule

There was a total of 76 fish eggs from 12 samples, the diameters ranged from 0.80 mm to 2.1 mm. 49 eggs measuring 1.67-1.94 mm may be *Theragra chalcogramma*; 3 measuring 2.0 mm are *Pleuronichthys decurrens*; 24 were not identified. The egg key is for live materials and could not be used.

Table 6. Number of Fish Eggs and Larvae at Each Station

Gulf of Alaska Bongo Tows, Leg I

Date	Time	Station	Haul	Mesh Size (µm)	Eggs	Fish or Larvae
2 Oct 75	1030	A(1)	1	571	0	1
2 Oct 75	1030	A(1)	1	2000	0	4
2 Oct 75	1320	B(2)	2	571	0	1
2 Oct 75	1320	B(2)	2	2000	0	0
2 Oct 75	1430	C(3)	3	571	0	3
2 Oct 75	1430	C(3)	3	2000	0	0
5 Oct 75	1400	D(4)	5	571	0	2
5 Oct 75	1400	D(4)	5	2000	0	3
5 Oct 75	1450	D(4)	6	571	0	1
5 Oct 75	1450-1500	D(4)	6	2000	0	0
7 Oct 75	0507	15	1	571	2	8
7 Oct 75	0507	15	1	2000	0	2
7 Oct 75	1619	21	1	571	0	0
7 Oct 75	1619	21	1	2000	0	1

NIO Tows

Date	Time	Station	Haul	Mesh Size (µm)	Eggs	Fish Larvae
1 Oct 75	2117-2112	PV-1	1	571	0	3
2 Oct 75	0855	F	2	---	0	0
2 Oct 75	1621	F	3	---	0	17
5 Oct 75	0845	D	4	---	0	0
5 Oct 75	0906	D	5	---	0	17
5 Oct 75	2112	D	6	---	0	5

Table 6 (cont.) Number of Fish Eggs and Larvae at Each Station

Gulf of Alaska 1M NIO Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae
14 Oct 75	1505	I-10	1	571	0	0
16 Oct 75	1043	II-10	1	571	0	3
16 Oct 75	1115	II-10	2	571	0	3
16 Oct 75	1636	II-20	1	571	0	0
17 Oct 75	0918	II-30	1	571	0	0
17 Oct 75	1416	III-50	1	571	0	1
18 Oct 75	0857	III-40	1	571	0	0
18 Oct 75	1548	III-20	1	571	0	4
18 Oct 75	2153	III-20	2	571	0	21
19 Oct 75	0914	III-10	1	571	0	2
19 Oct 75	1758	III-30	1	571	0	0
20 Oct 75	0915	IV-10	1	571	1	0
20 Oct 75	1038	IV-20	1	571	0	0
20 Oct 75	1551	IV-30	1	571	0	0
20 Oct 75	2030	IV-30	2	571	0	0
21 Oct 75	0848	IV-40	1	571	1	0
22 Oct 75	0951	V-10	1	571	0	1
22 Oct 75	1307	V-20	1	571	0	0
22 Oct 75	1612	V-30	1	571	0	0

Table 6 (cont.). Number of Fish Eggs and Larvae at Each Station

Gulf of Alaska Bongo Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae
14 Oct 75	1624	I-10	1	571	0	10
14 Oct 75	1624	I-10	1	2000	0	0
14 Oct 75	2107	I-20	1	571	1	185
14 Oct 75	2107	I-20	1	2000	0	16
16 Oct 75	0846	II-10	1	571	0	29
16 Oct 75	0846	II-10	1	2000	0	3
16 Oct 75	1705	II-20	1	571	0	2
16 Oct 75	1705	II-20	1	2000	0	0
16 Oct 75	2007	II-20	2	571	0	0
16 Oct 75	2007	II-20	2	2000	0	0
16 Oct 75	2043	II-20	3	571	0	1
16 Oct 75	2043	II-20	3	2000	0	0
17 Oct 75	0813	II-30	1	571	3	0
17 Oct 75	0813	II-30	1	2000	0	0
17 Oct 75	1445	III-50	1	571	11	0
17 Oct 75	1445	III-50	1	2000	0	0
17 Oct 75	2011	III-50	2	571	6	1
17 Oct 75	2011	III-50	2	2000	0	1
17 Oct 75	2104	III-50	3	571	2	1
17 Oct 75	2104	III-50	3	2000	0	0
18 Oct 75	0809	III-40	1	571	0	1
18 Oct 75	0809	III-40	1	2000	0	0
18 Oct 75	1641	III-20	2	571	0	3
18 Oct 75	1641	III-20	2	2000	0	0
18 Oct 75	2023	III-20	3	571	0	6
18 Oct 75	2023	III-20	3	2000	0	0
19 Oct 75	0833	III-10	1	571	0	1
19 Oct 75	0833	III-10	1	2000	0	0
19 Oct 75	1827	III-30	1	571	2	3
19 Oct 75	1827	III-30	1	2000	no preservative	
20 Oct 75	0821	IV-10	1	571	0	0
20 Oct 75	0821	IV-10	1	2000	0	0
20 Oct 75	1100	IV-20	1	571	0	0
20 Oct 75	1100	IV-20	1	2000	0	0
20 Oct 75	1504	IV-30	1	571	10	0
20 Oct 75	1504	IV-30	1	2000	0	0
20 Oct 75	2054	IV-30	2	571	27	1
20 Oct 75	2054	IV-30	2	2000	0	1

Table 6 (cont.) Number of Fish Eggs and Larvae and Each Station

Gulf of Alaska Bongo Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae
21 Oct 75	0804	IV-40	1	571	6	0
21 Oct 75	0804	IV-40	1	2000	4	1
22 Oct 75	0814	V-10	1	571	0	3
22 Oct 75	0814	V-10	1	2000	2	14
22 Oct 75	0920	V-10	2	571	0	0
22 Oct 75	0920	V-10	2	2000	0	0
22 Oct 75	1233	V-20	1	571	0	2
22 Oct 75	1233	V-20	1	2000	0	0
22 Oct 75	1630	V-30	1	571	0	0
22 Oct 75	1630	V-30	1	2000	0	0

Table 7. Identification of Fish Larvae by Station

Gulf of Alaska Bongo Tows, Leg I

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
2 Oct 75	1030	A(1)	1	571	0	1	20 mm* Smoothtongue** *Leuroglossus stilbius* Rass
2 Oct 75	1030	A(1)	1	2000	0	4	9 mm Blackfin sculpin *Malacocottus kincaidi* Gilbert & Thompson 19, 20, 24 mm *L. stilbius*
2 Oct 75	1320	B(2)	2	571	0	2	11, 21 mm *M. kincaidi*
2 Oct 75	1430	C(3)	3	571	0	3	18 mm *M. kincaidi* 6, 6.5 mm Cottids
5 Oct 75	1400	D(4)	5	571	0	2	22, 24 mm *L. stilbius*
5 Oct 75	1400	D(4)	5	2000	0	3	16, 19, 20 mm *L. stilbius*
5 Oct 75	1450	D(4)	6	571	0	1	21 mm *L. stilbius*
7 Oct 75	0507	15	1	571	1	8	6 (20-27 mm) *L. stilbius* 9 mm Caplin *Mallotus villosus* 62 mm Smallfin lanternfish *Stenobrachius leucosparus* Eigenmann & Eigenmann
7 Oct 75	0507	15	1	2000	0	2	25, 28 mm *L. stilbius*
7 Oct 75	1619	21	1	2000	0	1	25 mm *L. stilbius*

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* When there are one to three speciments, the standard lengths or notochord lengths are recorded. If more than three specimens, the standard length or notochord length of the smallest and the largest are recorded. Standard length is from the snout tip to the end of the hypural plate; notochord length is from the snout tip to the end of the notochord.

** Common name is presented for the first time for each species, thereafter only scientific name is recorded with the genus name abbreviated.

Table 7 (cont.). Identification of Fish Larvae by Station

Gulf of Alaska Bongo Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
14 Oct 75	1624	I-10	1	571	0	10	6 (10-27 mm) *Mallotus villosus* 3 (5 mm) *Sebastes* sp. 4 mm *Malacocottus kincaidi*
14 Oct 75	2107	I-20	1	571	1	185	48 (10-24 mm) *M. villosus* 55 (8-36 mm) *Spirinchus thaleichthys* 82 (6 mm) *Sebastes* sp.
14 Oct 75	2107	I-20	1	2000	0	16	9 (19-22 mm) *M. villosus* 4 (21-40 mm) *S. thaleichthys* 5 mm *Sebastes* sp. 7 mm elongate w/c pink pigments 11 mm compressed larva w/c oil globule
16 Oct 75	0846	II-10	1	571	0	29	4 (4 mm) *Sebastes* 8 mm Cottid 4 mm *Gadus macrocephalus* 7 (15-30 mm) *M. villosus* 17 (20-24 mm) *Thaleichthys pacificus* 20 mm smeltlike
16 Oct 75	0846	II-10	1	2000	0	3	2 (18 mm + ½ fish) *M. villosus* 23 mm *T. pacificus*
16 Oct 75	1705	II-10	1	571	0	2	16, 21 mm *M. villosus*
16 Oct 75	2043	II-10	3	571	0	1	9 mm damaged compressed larva larva w/c oil globule
17 Oct 75	0813	III-30	1	571	3	0	
17 Oct 75	1445	III-50	1	571	11	0	
17 Oct 75	2000	III-50	2	571	6	1	12 mm Barreleye *Macropina microstoma* Chapman

Table 7 (cont.). Identification of Fish Larvae by Station

Gulf of Alaska Bongo Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
17 Oct 75	2000	III-50	2	2000	0	1	54 mm *Stenobrachius leucosparus*
17 Oct 75	2100	III-50	3	571	2	1	32 mm *S. leucosparus*
18 Oct 75	0809	III-40	1	571	0	1	5 mm *M. kincaidi*
18 Oct 75	1504	IV-30	1	571	12	1	10 mm compressed larva w/c oil globule
18 Oct 75	1641	III-20	1	571	0	3	18 mm *M. kincaidi* 22 mm *M. villosus* 14 mm clupeid
18 Oct 75	2023	III-20	3	571	0	6	16 mm *M. kincaidi* 4 (20-27 mm) *S. thaleichthys* 6 mm *Sebastes* sp.
19 Oct 75	0833	III-10	1	571	0	1	19 mm *Leuroglossus stilbius*
19 Oct 75	1827	III-30	1	571	2	3	10 mm clupeid 25 mm *S. thaleichthys* 11 mm compressed larva
20 Oct 75	1504	IV-30	1	571	12	0	
20 Oct 75	2054	IV-30	2	571	27	1	56 mm *S. leucosparus*
20 Oct 75	2054	IV-30	2	2000	0	1	16 mm *Sebastes* sp.
21 Oct 75	0804	IV-40	1	571	6	0	
21 Oct 75	0804	IV-40	1	2000	4	1	29 mm *L. stilbius*

Table 7 (cont.). Identification of Fish Larvae by Station

Gulf of Alaska Bongo Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
22 Oct 75	0814	V-10	1	571	0	3	34, 36 mm *S. thaleichthys* 24 mm *T. pacificus*
22 Oct 75	0814	V-10	1	2000	2	14	31-42 mm *S. thaleichthys*
22 Oct 75	1233	V-10	1	571	0	2	8 mm *Sebastes* sp. 12 mm Atherinid?

Table 7 (cont.). Identification of Fish Larvae by Station

1M NIO Tows, Leg I

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
1 Oct 75	2117	PV-1	1	571	0	3	26 mm Longfin smelt *Spirinchus thaleichthys* (Ayres) 18 mm Eulachon *Thaleichthys pacificus* (Richardson) 13 mm damaged elongate larva
2 Oct 75	1621	F	3	571	0	17	9 (10-17 mm) *M. villosus* 7 (9-14 mm) *S. thaleichthys* 6 mm Cottid
5 Oct 75	0906	D	5	571	0	15	7 (11-15 mm) *M. villosus* 3 (15 mm) *I. pacificus* 5 (16-28 mm) *L. stilbius* 6 mm Cottid 5 mm Pacific cod *Gadus macrocephalus* (Tilesius)
5 Oct 75	2112	D	6	571	0	5	5 (16-28 mm) *L. stilbius*

Table 7 (cont.). Identification of Fish Larvae by Station

1M NIO Tows, Leg II

Date	Time	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Larvae
16 Oct 75	1040	II-10	1	571	0	3	3 (5 mm) *G. macrocephalus*
16 Oct 75	1107	II-10	2	571	0	3	5 mm *M. kincaidi* 4 mm elongate larva w/c pink pigments 17 mm elongate smelt
17 Oct 75	1416	III-50	1	571	0	1	9 mm compressed larva w/c oil globule
18 Oct 75	1543	III-20	1	571	0	4	18 mm *I. pacificus* ½ tail section smelt-like 22 mm *L. stilbius* 28 mm *S. thaleichthys*
18 Oct 75	2153	III-20	2	571	0	21	16 (19-30 mm) *S. thaleichthys* 3 (18, 19, 20 mm) *I. pacificus* 19 mm *M. villosus* 1 head unidentified
19 Oct 75	0910	III-10	1	571	0	2	19 mm *M. villosus* 16 mm *I. pacificus*
20 Oct 75	0915	IV-10	1	571	1	0	
21 Oct 75	0843	IV-40	1	571	1	0	
22 Oct 75	0946	V-10	1	571	0	1	6.5 mm *I. pacificus*

Table 8. Summary of Taxonomic Categories of Fish Eggs and Larvae Found in PMEL/NOAA Gulf of Alaska *Surveyor* Samples

A total of 32 samples contained 43 fishes and 2 fish eggs. The fishes were distributed in 7 families, 6 genera, and 6 species as follows:

Family Bathylagidae

14 Smoothtongue *Leuroglossus stilbius schmidti* Rass

Family Blenniidae

7 specimens genus? species?

Family Myctophidae

1 Smallfin lanternfish *Stenobrachius leucosparus* (Eigenmann & Eigenmann)

Family Osmeridae

5 Capelin *Mallotus villosus* Müller.
5 Longfin smelt *Spirinchus thaleichthys* (Ayres)
2 specimens genus? species?

Family Pleuronectidae

1 speciman genus? species?

Family Stichaeidae

2 Whitebarred prickleback *Poroclinus rothrocki* Bean

Family Zoarcidae

6 Pallid eelpout *Lycodapus mandibularis* Gilbert

Table 9. PMEL/NOAA Gulf of Alaska *Surveyor* Samples

Puget Sound Closing Net (211 μm)

Date	Time	Station	Sample	Depth (m)	Eggs	Fish or Larvae
Oct 4 75	1350	2	9	331-99	0	1
	1854	3	13	730-492	0	1
	1846	3	14	500-300	0	1
	1929	3	17	50-25	0	1
	1942	3 4	18	25-0	0	1
Oct 5 75	2355	4	22	100-48	0	1
	0502	5	27	300-95	0	1
	0521	5	28	100-25	0	2
	1722	7	39	500-293	0	2
	1750	7	40	300-100	0	3
	1922	7	43	25-0	0	1
	2113	8	44	735-485	0	1
Oct 6 75	0327	9	50	740-453	0	2
	0424	9	51	500-293	0	1
	0504	9	52	300-100	0	1
	0525	9	53	100-50	0	1
	0545	9	55	25-0	0	1
	1058	9	59	25-0	0	1
	1651	13	65	570-98	0	2
	1912	11	69	551-100	0	1
	2145	16	73	400-100	0	1
Oct 7 75	0228	15	81	350-98	0	1
		18	90	390-100	0	1
Oct 8 75	0510	22	107	100-50	0	1
	1237	24	114	210-92	1	0
	1308	24	117	25-0	0	1
	1734	26	123	100-50	1	1
	1808	26	124	50-25	0	3
	1814	26	125	25-0	0	2
	2026	27	127	100-49	0	1
	2041	27	128	50-25	0	1
	2209	28	133	25-0	0	2
Oct 9 75	0114	29	136	100-47	0	3

Table 10. Identification of Fish Larvae by Station
PMEL/NOAA Gulf of Alaska *Surveyor* Samples

Puget Sound Closing Net (211 μm)

Date	Time	Station	Sample	Depth (m)	No	Identification of Egg and/or Fish Larvae
4 Oct 75	1350	2	9	331-99	1	26.0 mm* Smoothtongue *Leuroglossus stilbius* Rass
	1854	3	13	730-492	1	70.0 mm Pallid eelpout *Lycodapus mandibularis* Gilbert
	1846	3	14	500-300	1	6.4 mm Osmeridae genus? species?
	1929	3	17	50-25	1	14.0 mm Longfin smelt *Spirinchus thaleichthys* (Ayres)
	1942	3	18	25-0	1	15.0 mm Osmeridae genus? species?
5 Oct 75	2335	4	22	100-48	1	20.0 mm *Leuroglossus stilbius* Rass
	0502	5	27	300-95	1	23.0 mm *Leuroglossus stilbius* Rass
	0521	5	28	100-50	2	22.0 mm *Leuroglossus stilbius* Rass
	1722	7	39	500-293	2	30.0 mm *Leuroglossus stilbius* Rass 40.0 mm *Lycodapus mandibularis* Gilbert
	1750	7	40	300-100	3	23.0, 27.0, 28.0 mm *Leuroglossus stilbius* Rass
	1922	8	44	735-485	1	29.0 mm *Leuroglossus stilbius* Rass
6 Oct 75	0327	9	50	740-453	2	28.0, 36.0 mm Whitebarred prickleback *Poroclinus rothrocki* Bean
	0424	9	51	500-293	1	68.0 mm *Lycodapus mandibularis* Gilbert
	0504	9	52	300-100	1	26.0 mm *Leuroglossus stilbius* Rass
	0525	9	53	100-50	1	25.0 mm *Leuroglossus stilbius* Rass
	0545	9	55	25-0	1	15.0 mm *Spirinchus thaleichthys* (Ayres)
	1058	9	59	25-0	1	5.6 mm Blenniidae?
	1651	13	65	570-98	2	80.0, 95.0 mm *Lycodapus mandibularis* Gilbert
	1912	11	69	551-100	1	72.0 mm *Lycodapus mandibularis* Gilbert
	2145	16	73	400-100	1	29.0 mm *Leuroglossus stilbius* Rass
7 Oct 75	0228	15	81	350-98	1	Not seen
	0943	18	90	390-100	1	14.0 mm Smallfin Lanternfish damaged *Stenobrachius leucosparus* (Eigenmann & Eigenmann)
8 Oct 75	0510	22	107	100-50	1	27.0 mm *Leuroglossus stilbius* Rass
	1237	24	114	210-92	1 egg	1.51 mm diameter with oil droplets
	1308	24	117	25-0	1	5.0 mm Blenniidae? similar to #59
	1734	26	123	100-50	1 egg	1.44 mm diameter with oil droplets 24.0 Caplin *Mallotus villosus* Müller

Table 10. Identification of Fish Larvae by Station
PMEL/NOAA Gulf of Alaska *Surveyor* Samples

Puget Sound Closing Net (211 μm)

Date	Time	Station	Sample	Depth (m)	No	Identification of Egg and/or Fish Larvae
8 Oct 76	1808	26	124	50-25	3	3.20, 4.0 mm + tail section Blenniidae similar to #59
	1814	26	125	25-0	2	16.0 mm *Mallotus villosus* Müller 27.0 mm *Spirinchus thaleichthys* (Ayres)
	2026	27	127	100-49	1	4.0 mm Blenniidae similar to #59
	2041	27	128	50-25	1	13.0 mm Pleuronectidae
	2209	28	133	25-0	2	24.0, 16.0 mm *Spirinchus thaleichthys* (Ayres)
9 Oct. 76	0114	29	136	100-47	3	13, 14 mm *Mallotus villosus* Müller 4.0 mm Blenniidae similar to #59

* Measurement for fish larvae is the standard length or notochord length when the hypural plate is not formed. Measurement for egg is the diameter of the egg.

Table 11. Number of fish eggs and larvae per station
University of Alaska Bering Sea *Discoverer* Samples

1M NIO Tows

Date	Time	Station	Depth	Eggs	Fish or Larvae
8-V-75	0415	16 PWS	0-185 FM	0	42
8-V-75	0310	17 PWS	0-181 FM	0	132
19-V-75	1000	5	--	1	0
20-V-75	2140	14	--	0	1
23-V-75	1200	33	--	2	0
24-V-75	1100	35	68/73M→0	0	2
26-V-75	0630	50	--	1	0
27-V-75	0000	55	--	8	0
28-V-75	0405	60	--	1	0
28-V-75	1700	62	200/1004M→0	0	1
4-VI-75	1530	65	--	0	4
5-VI-75	0500	70	--	0	1
5-VI-75	1032	71	100/22M→0	0	1
7-VI-75	1530	78	780-40M	0	4
7-VI-75	2000	79	0-45M	0	23
8-VI-75	1830	84	--	0	16
9-VI-75	1530	88	0-77M	0	1
10-VI-75	1915	94	0-42M	0	19
11-VI-75	0350	96	45/51M→0	2	2
12-VI-75	--	106	57/62M→0	0	4
13-VI-75	--	107	48/63M→0 10° Angle	0	2
13-VI-75	1300	110	--	3	0

Table 11 (cont.). Number of fish eggs and larvae per station University of Alaska Bering Sea *Discoverer* Samples

IM NIO Tows

Date	Time	Station	Depth	Eggs	Fish or Larvae
20-V-75	0210-0230	8 T.#2	--	0	6
21-V-75	0300-0330	16 T.#4	--	0	7
6-VI-75	0630-0715	74 T.#13	--	0	3
15-VI-75	0300-0320	117 T.#41	--	0	22
18-VI-75	--	42 T.#42	--	0	3
19-VIII-75	2245	T.#11	--	0	4
25-VIII-75	0350	T.#40	--	-	3

ANNUAL REPORT

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INITIAL ZOOPLANKTON INVESTIGATIONS

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I. SUMMARY

Zooplankton was sampled during two cruises to the northern Gulf of Alaska: in Prince William Sound in October, and on the continental shelf in November 1975. The zooplankton studies are part of a comprehensive environmental assessment of the Alaskan shelf, in light of present and future offshore petroleum resource development.

The fauna of the subarctic Pacific region is not particularly diverse, when compared to warm-water plankton. Nevertheless, we are dealing, in the net-zooplankton, with a complex that undoubtedly comprises several hundred species. We have identified about 100 species from the fall and early winter. As the study progresses into other seasons, additional species must be considered. Relatively few species might be treated as principal components, because of their numbers and mass, or because of their critical roles in the transfer and conversion of matter and energy within the ecosystem.

During late 1975, the most common zooplankton species were found to have vertical distributions fitting into four basic patterns, including an important group of species that spend the day in deep water, and rise into the surface layer at night. Though the bulk of the zooplankton remained below 100 m, there appeared to be a sixfold increase in zooplankton volume above this level during the night. Such active movements must be considered if the daily and seasonal cycles of distribution and abundance of organisms are to be adequately assessed. The migrating organisms include animals which are major grazers and which in turn are major food items for higher trophic levels, particularly commercial fishes. If pollutants are introduced into the surface layers, the pollutants may not be contained, but could quickly be transferred to deeper water by these active migrations.

II. INTRODUCTION

A. General scope of the study

Zooplankton are important components of the environment in terms of volume, in terms of their roles in the ecosystem, and in terms of probable sensitivity to the kinds of development anticipated on the Alaska OCS. Zooplankton are necessary for the maintenance of fish, shellfish, and other living resources. Zooplankton are also important in the movement and concentration of environmental contaminants. In the northeastern Pacific, particularly its estuaries and coastal seas, relatively little is known of the distribution and abundance, seasonal cycles, or vertical distributions and migrations of zooplankton. Assessments of these factors are necessary for the study of ecological processes relevant to environmental problems.

B. Specific objectives

The objectives of this project are to determine the seasonal distribution and abundance of zooplankton in selected areas of the Gulf of Alaska. Particular attention is being given to the distributions of copepods (the most abundant net-plankton and the key grazers), amphipods and euphausids (important food for fishes), chaetognaths (key carnivores), larval decapods, and some other groups. All major taxa are enumerated as such whether or not the individual species can be identified. This work will lead to development of a monitoring strategy. Also, it will ultimately contribute to an ecosystem model by defining pathways and amounts of energy or material flow and indicating the relative importance of the several populations.

C. Relevance to problems of petroleum development

There is no doubt that we would be indifferent to the marine environment were it not for the living systems it contains and supports. Except for possible esthetic effects, we would not be concerned about physical degradation of an environment without life. But our coastal waters do contain living things, in a great variety and abundance, many of which are utilized directly as valuable foods, and all of which, indirectly or directly, are part of a single closely-integrated environmental system. Exploration for and production and movement of oil on the continental shelf holds potential dangers for these sensitive organisms. Among these organisms, the zooplankton hold a major position. Many organisms are planktonic for their entire life cycle, and even organisms which are not usually thought of as plankton pass through critical early life stages in the plankton. For example, intertidal animals, which might be killed due to local disturbances, are dependent on distant breeding stocks for their recruitment, the new colonizers coming <u>via</u> the plankton. Most benthic and nektonic organisms have planktonic eggs and/or larval stages. These early stages are usually more sensitive than the adult forms.

We should be concerned about all levels of pollution and environmental perturbations. The environment need not be so drastically altered as to kill the plankton outright. The transfer of matter and energy through the various links of the living system is so subtle that very minor changes may easily upset the <u>timing</u> of these transfers or the <u>pathways</u> (species) on which they may occur. A seemingly small change in timing, or a seemingly insignificant shift in pathways, may drastically alter the occurrence and cycles of key members of the community.

The living systems are as much a part of the environment as are the more accessible physical features. An environmental assessment must therefore take into account the distribution and abundance of the living components. Subtle changes in water quality, through any man-caused perturbations, might initially be detected by the response of organisms. Probably these responses will first be noticed by shifts in the relative abundance of species, certain organisms being more responsive to change than others. Such changes are impossible to document solely after the fact.

Under normal circumstances the abundances of plankton organisms are extremely variable in time and space. Without a long series (several years) of closely-spaced observations it is not possible to delineate "typical" or "average" abundances. But with sufficient observations, the probable maxima and minima can be described, together with statistical statements as to variability, so that the likelihood of detecting given numerical changes can be predicted.

Only with such forehand knowledge of community composition and its variations in time and space could real changes in populations be noticed. Catastrophic changes are easy to monitor, and normally the environment is resilient and responsive enough to return relatively soon to a standard condition once the stress is removed. But a slow and steady degradation of the environment is the more serious alteration. And it is with such changes that we should be most concerned. These are the long-range subtle changes that ultimately would alter the environmental balance, possibly in a very undesirable and irreversible way.

III. CURRENT STATE OF KNOWLEDGE

North of about 45° N, the subarctic Pacific comprises a faunal as well as a hydrographic region. Most of the zooplankton of the upper layers are found throughout the subarctic but are not found in the central North Pacific (below 40° N), nor are many of the southernspecies common to the subarctic region. In the northeast Pacific, the Gulf of Alaska is dominated by the cyclonic Alaskan gyre, a tributary of the North Pacific's westwind drift. The center of this gyre is characterized by a slight upwelling, with higher salinities and nutrient concentrations than are found shoreward and to the south within the Gulf. As in the rest of the subarctic Pacific, there is a permanent halocline at about 100-150 m in the Gulf of Alaska, and a seasonal (summer) halocline at about 30-50 m. However, the permanent halocline is often absent over the shelf in winter, since the dominant winter winds result in coastal downwelling. There is a net dilution of the water mass as it passes counterclockwise around the Gulf, increasing in the summer at maximum runoff.

The seasonal thermocline varies in depth and extent during the summer, but is usually below 25 m though not below 100 m.

Plankton in the Gulf of Alaska has been studied for decades, but the efforts have been irregular and usually limited to near-surface waters in the summer. We have a fair idea of large-scale faunal distributions in the water masses of the whole North Pacific, but very little information on detailed distributions in specific areas within the Gulf of Alaska. Much is known about the kinds of plankton organisms in the Gulf and, except for larval stages and a few large and important groups like cyclopoid copepods, the general taxonomic problems are manageable. However, it is still necessary to be familiar with a diffuse literature when dealing with the taxonomy of Gulf of Alaska plankton, for there are no comprehensive "keys" for routine identifications.

Because of the irregular space/time investigations, there is not much information on the dynamics of plankton populations within the Gulf of Alaska, including seasonal cycles of single species, species successions, or recruitment. In addition, almost nothing is known about feeding patterns and rates, reproduction and growth, migrations, metabolic processes, and relative sensitivities. Limits of variability in time and space should be outlined in such a way that we can specify subsequent sampling efforts required to detect given changes. This is the fundamental problem and should be given high priority.

Most of the area's information is extrapolated from studies at Station "P" (50° N, 145° W), on the southern edge of the Gulf of Alaska. Studies at Station "P" have given us a reasonable idea of seasonal cycles of phytoplankton and zooplankton in general in this oceanic region, but the populations and their cycles are probably not equivalent in the waters of the Alaskan shelf.

Though it has not been well-substantiated, the "spring" increase in phytoplankton activity appears to begin in February or March around the perimeter of the Gulf of Alaska, and advances toward the center until April or May. This follows from the progression of water-column stability (Parsons, et al., 1966). In the oceanic region, in the deep water away from the shelf, there is no sudden increase in phytoplankton biomass as is typical for other temperate ocean areas (e.g., North Atlantic). This is due to the life histories of the main species of grazing copepods. In the North Pacific these species (*Calanus cristatus* and *C. plumchrus*) breed independently of the increase in phytoplankton biomass, in contrast to the related species in the North Atlantic whose breeding depends on and follows the spring increase in phytoplankton standing stock. Thus, in the central Gulf of Alaska, the main biomass increase of the spring period is expected in the zooplankton, not the phytoplankton. One might expect the typical "North Atlantic pattern" in the shallow shelf waters, since the critical effect of the large grazers is related to their sudden ascension from deep waters. The relationship between the phytoplankton and the zooplankton grazers of the shallow shelf waters, therefore, may include an important lag-time, enabling the phytoplankton standing stock to increase abruptly ("spring bloom"), although this has not yet been well-documented for the Gulf of Alaska.

At the southern edge of the Gulf of Alaska (LeBrasseur, 1965), the zooplankton biomass to about 150 m (the total depth is on the order of 4000 m, so that considerable zooplankton mass is not included) declines to a yearly minimum of approximately 10 g wet weight/1000 m^3. In March there is an increase in zooplankton standing stock, reaching a yearly maximum around late May of about 175 g wet weight/1000 m^3. Copepods by far dominate this biomass (greater than 90%), and the increase in the year's standing stock is in large part due to the seasonal ascent of overwintering populations. The second most abundant group, the chaetognaths, account for less than 5% of the biomass. Other major zooplankton groups are euphausids and amphipods. There is a year-to-year variation of roughly plus or minus 50% of the mean copepod biomass.

The vertical distributions of zooplankton are very important, for their occurrence at the surface is often related solely to their vertical movements. Their horizontal distributions are also determined to a great degree by the depth ranges occupied. The impact of zooplankton on the phytoplankton, growing only in the near-surface layer, is controlled by the vertical distribution of the principal grazers. And the active movement of zooplankton into deep water is a major biological mechanism of energy and matter transfer in the oceans. The study of vertical distributions of zooplankton in the Gulf of Alaska has barely begun. Most work is based only on surface samples or on integrated net tows (e.g., 150 m to the surface). Some data are available on the distributions of deep water forms, but the only data on the vertical distributions of near-surface plankton are from the southern edge of the Gulf of Alaska. Barraclough, _et al_. (1969), for example, have reported _Calanus cristatus_ in a dense layer migrating between about 30 m (day) and the surface (night). Marlowe and Miller (1975) have recently investigated summer vertical distributions of the most common zooplankton of the upper 500 m at Station "P." The zooplankton fit into five basic patterns of vertical distributions. Less than 10% of the species exhibited daily vertical migration (at that time), but these were large and abundant enough to result in a significant daily change in surface biomass.

IV. STUDY AREA

Original program guidelines called for broad area coverage a few times a year. Consequently, the first zooplankton investigation (on NOAA _Discoverer_) was to be conducted in the northeast Gulf of Alaska in

October and November, between Resurrection Bay and Yakutat (fig. 2). Prior to that cruise, the Principal Investigator was asked to use the University of Alaska's Acona in Prince William Sound, although the cruise ultimately was undertaken on the NOAA Surveyor, in early October (fig. 1).

Thirty stations were occupied in the Prince William Sound region (fig. 1). The first nine stations were at a single very deep locality well within Prince William Sound, and were occupied every 4-6 hrs for 48 hrs. This series has given a good indication of the incidence and magnitude of zooplankton diel vertical migration. The next 20 stations were at various locations and times throughout the Sound and its major fjords. Station 30 was in the open Gulf at 59° N, 147° W, during the return to Kodiak. Fifty-two stations were occupied on the open shelf (fig. 2). Two localities were sampled for 36 consecutive hrs (fig. 3).

V. SOURCES OF DATA

On both cruises zooplankton was sampled primarily with closing ring nets of 60 cm diameter and 211 μ mesh. These nets were hauled vertically through strata of varying thicknesses, obtaining discrete samples as follows: 25-0 m; 50-25 m; 100-50 m; 300-100 m; 500-300 m; the bottom-500 m. In addition, some samples were obtained with Tucker trawl, NIO net, and bongo net. In Prince William Sound, 143 zooplankton samples were taken with the vertically-hauled net, nine with Tucker trawl (by A. Adams, University of Alaska), six with NIO net, and eight with bongo net (by Dr. English's staff). On the shelf, 125 zooplankton samples were collected with the vertically-hauled net and 101 with the bongo net.

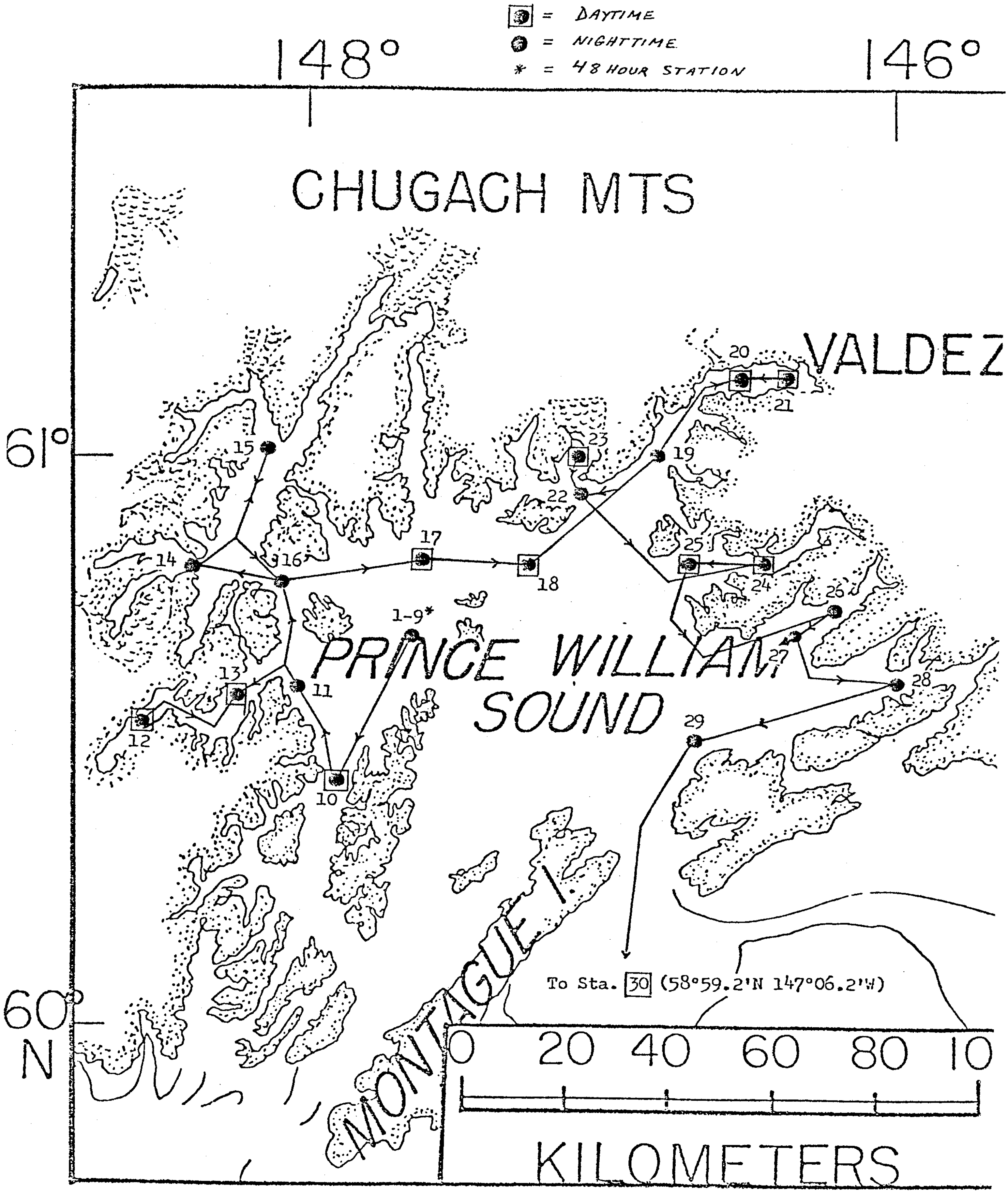


Figure 1. Sampling stations 1-30, Prince William Sound Cruise, 30 September-10 October, 1975, NOAA SURVEYOR.

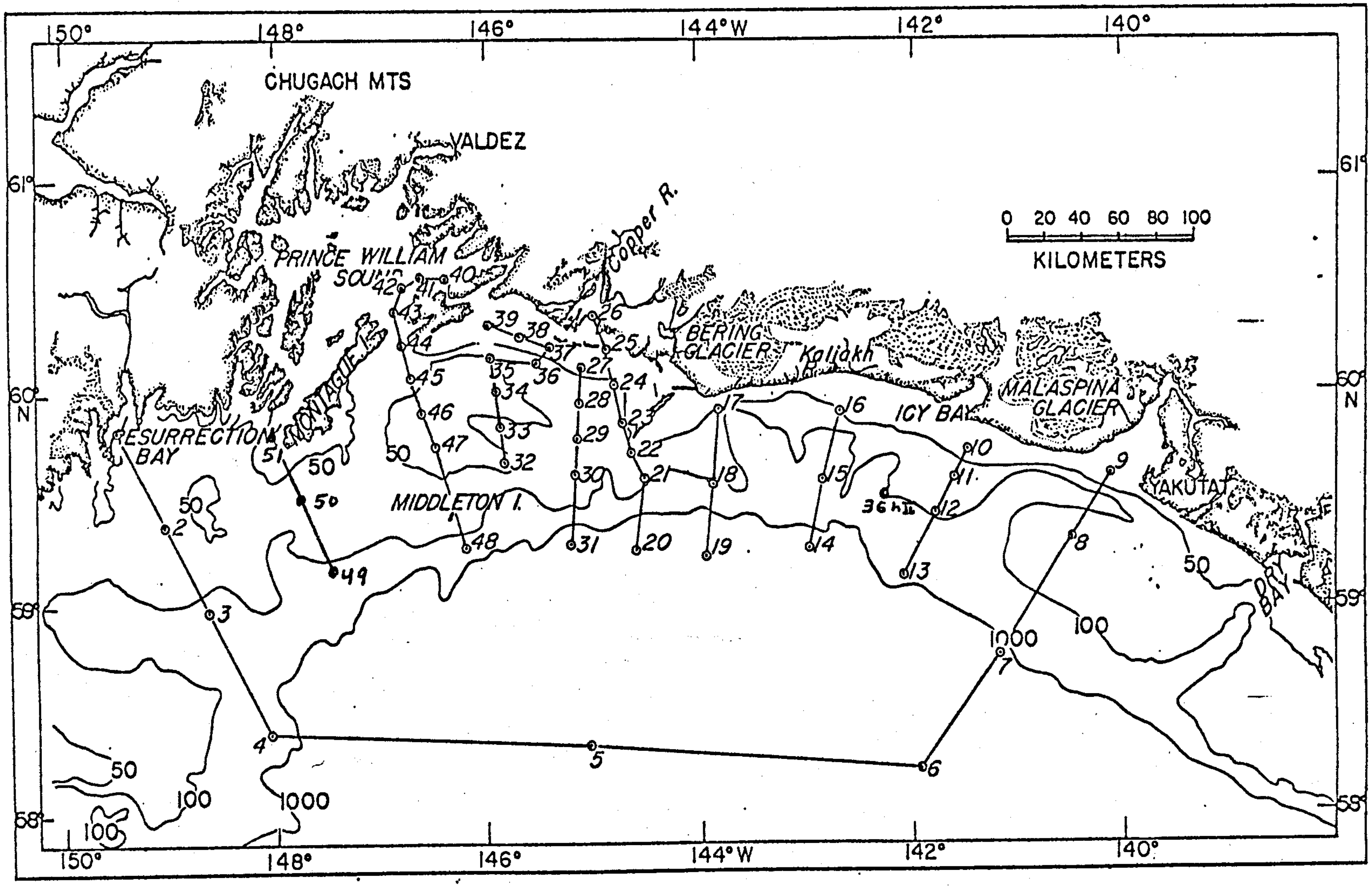
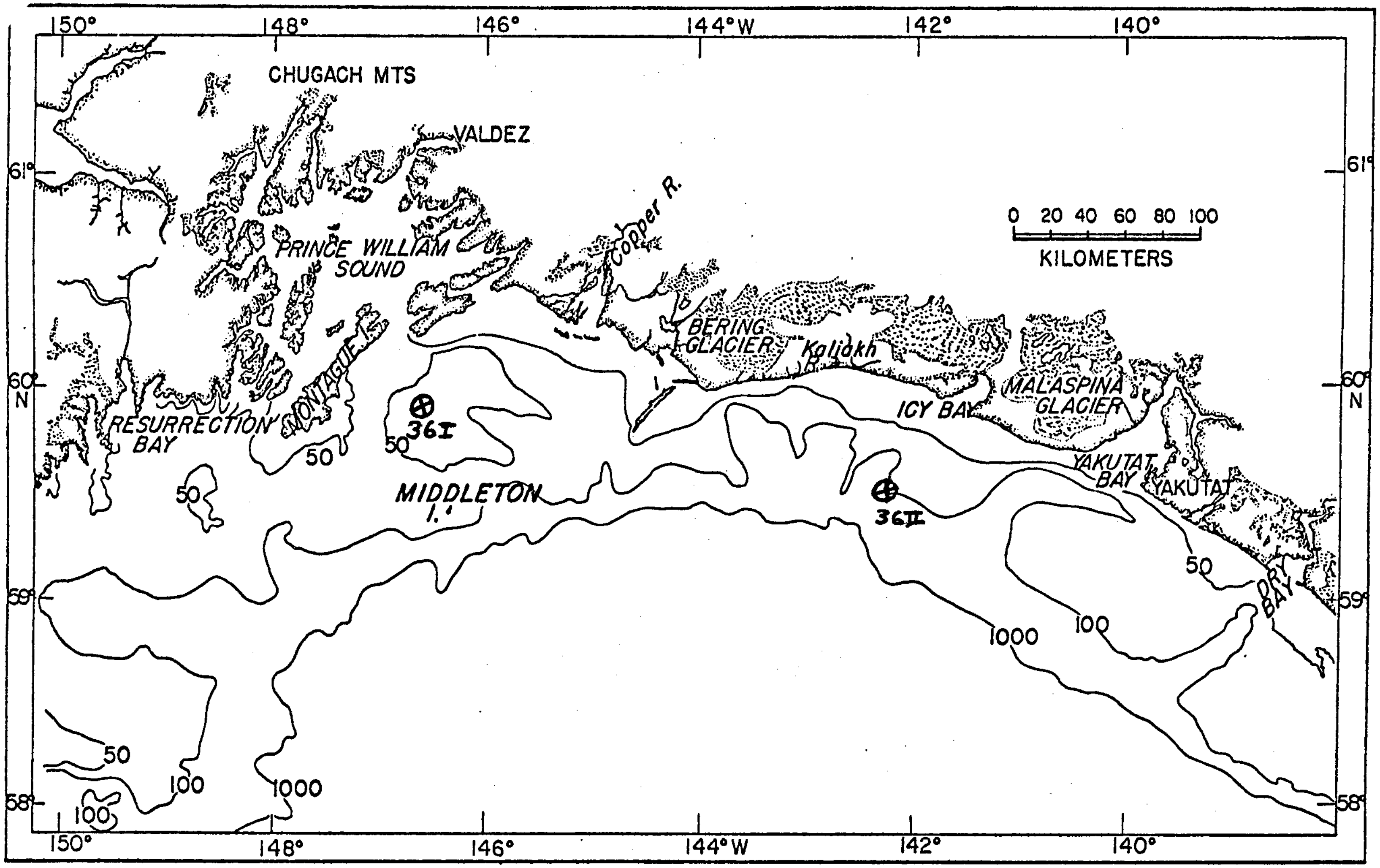


Figure 2. Sampling stations, Northeast Gulf of Alaska Cruise, 21 October-14 November, 1975, NOAA DISCOVERERER.



Disco 36 I & 36 II

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Figure 3. Zooplankton survey, northern Gulf of Alaska, 2 36-hour stations, November 1975.

Volume of water sampled was estimated as the product of wire length and the area of the net, assuming that filtration was 100%. There was no evidence of mesh clogging.

In the laboratory, each zooplankton sample is allowed to settle overnight in a graduated cylinder and the settled volume of the sample is recorded. The large or otherwise conspicuous organisms are then removed and enumerated. The smaller organisms are identified and enumerated from a subsample.

VI and VII. RESULTS AND DISCUSSION

Most of the samples from the Prince William Sound cruise have been analyzed. Only a few of the samples from the open shelf have been processed; the analyses are presently continuing.

In Prince William Sound (fig. 1) where the plankton were sampled in nine vertical series at one deep station (greater than 700 m) during 48 consecutive hrs, the estimated total zooplankton biomass (settled volume) varied between 0.1 and 7.4 ml/m^3. The average vertical distributions of zooplankton volume from three day samples (0600-1800 hrs) and six night samples (1800-0600 hrs) are shown in figure 4. There was a definite and consistent nighttime increase in zooplankton volume in the upper 100 m, and especially in the surface layer (0-25 m), due principally to daily upward migrations of some relatively large forms [copepods (especially *Metridia* spp.), amphipods, euphausids, and pteropods]. The relative *numerical* increase in plankton was small, but the migrants were large enough to increase the plankton *volume* significantly. The night volume in the 0-100 m layer was six times the day volume.

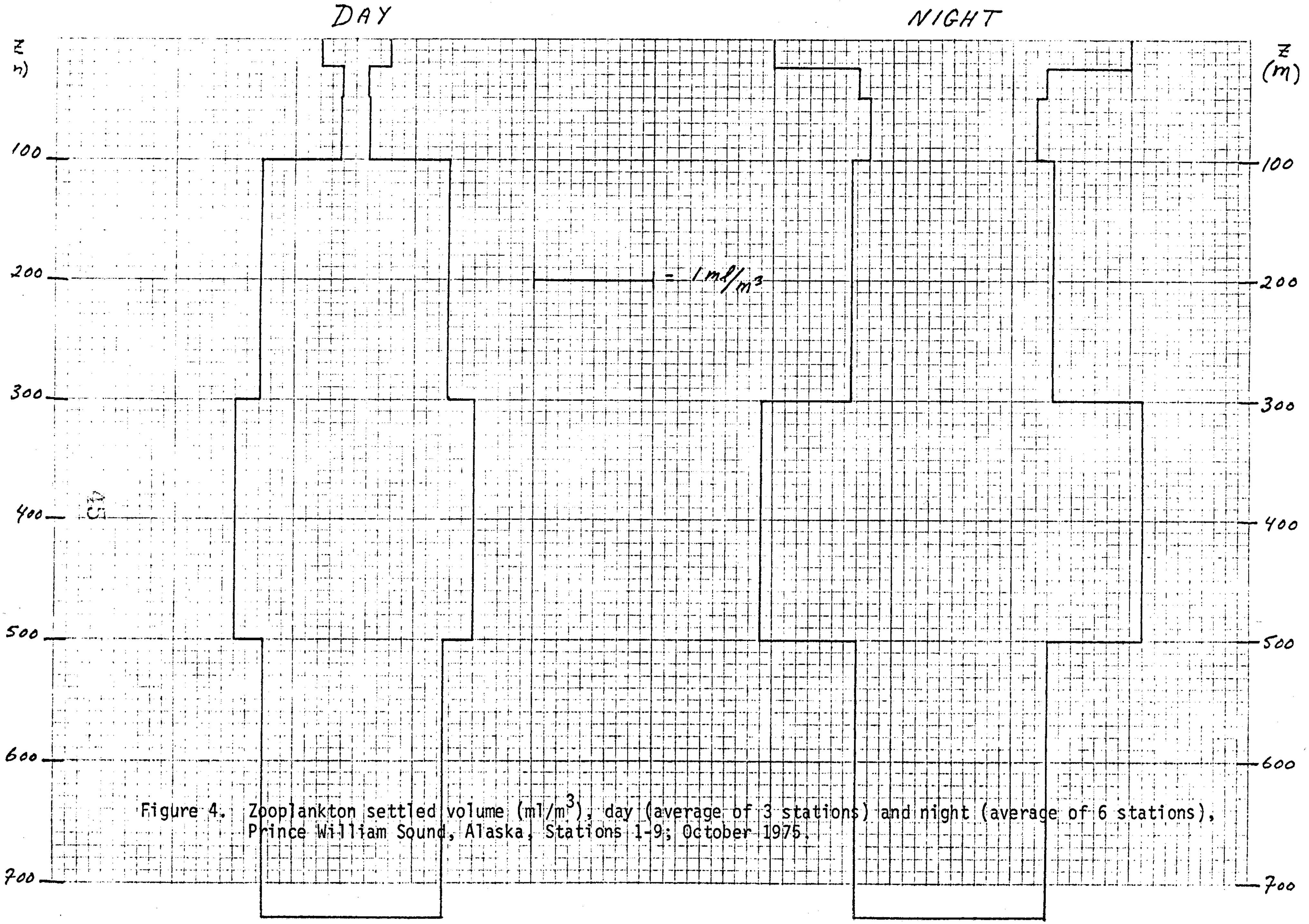

Figure 4. Zooplankton settled volume (ml/m^3), day (average of 3 stations) and night (average of 6 stations), Prince William Sound, Alaska, Stations 1-9; October 1975.

There was also an additional nighttime increase in the volume between 1-0 m and the greatest sampling depth (ca. 710 m), due to upward migration of organisms living in the unsampled layer above the bottom. There was probably also some avoidance of the net during daylight. The average daytime zooplankton volume down to 730 m at the deep station in Prince William Sound (stations 1-9, fig. 1) was ca. 1100 ml/m^2, while the average nighttime volume was ca. 1500 ml/m^2.

In the 0-25 m layer, the average daytime volume at stations 1-9 was 0.6 ml/m^3 (range: 0.4-0.7), compared to 3.0 ml/m^3 (range: 1.0-7.4) at night. The 0-25 m layer at that locality can be compared (table 1) with the 0-25 m layer in other localities within Prince William Sound (fig. 1). No geographic pattern can yet be discerned; stations 10 and 25 showed somewhat higher day plankton volumes than would be expected, while stations 16 and 22 showed somewhat less night volume than expected.

Table 1. Zooplankton, settled volume concentration (ml/m^3), 0-25 m, Prince William Sound, Alaska, October 1975.

Station	Day	Night	Station	Day	Night
1-9*	0.6	3.0	20	0.3	
10	1.4		21	0.3	
11		2.1	22		0.6
12	0.3		23	0.7	
13	1.0		24	1.0	
14		1.0	25	1.3	
15		1.0	26		4.9
16		0.4	27		1.4
17	0.4		28		2.0
18	1.1		29		1.4
19		1.4	30	1.0	

*Averages.

The average zooplankton volume concentration of all 14 day stations in the 0-25 m layer was 0.76 ml/m^3 (range: 0.3-1.4), while the comparable value for the 16 night stations was 2.14 ml/m^3 (range: 0.4-4.9).

In November on the open shelf (fig. 3), two 36 consecutive-hr stations were occupied, and zooplankton sampled with methods and depth intervals comparable to those used in Prince William Sound. The average zooplankton volume concentrations for the two day and two night sampling periods at each station did not indicate a marked nighttime increase in the upper layers. The average zooplankton volume concentration in the 0-25 m layer for the two shelf stations was about 1.2 ml/m^3, *day and night*. Neither station was as deep as most of the stations in Prince William Sound; station 36I was in only 55 m, although station 36II had 200 m depth. At station 36I the lesser depth may have precluded some deep migrants, but vertical migrations might not be significant on the shelf in November.

There was a substantial variety of plankton groups represented in these October-November samples. The most common groups were: Copepoda (by far the most numerous), Amphipoda, Euphausiacea, Ostracoda, Mysidacea, Decapoda, Chaetognatha, Tunicata, Medusae, Siphonophora, Ctenophora, Pteropoda, Polychaeta, and larval fishes.

The Copepoda of Prince William Sound were represented by about 30 species (table 2). The abundances and vertical distributions of some of the most significant species can be mentioned. These data are based on the 48 consecutive-hr station.

The most abundant copepods were small surface-living species, such as *Acartia longiremis*, *Oithona similis*, and adult *Pseudocalanus* spp. The significance of these small copepods comes from their key role in

Table 2. Copepoda, Prince William Sound, Alaska, October 1975

Calanidae
- *Calanus cristatus*
- *C. marshallae*
- *C. pacificus*
- *C. plumchrus*
- *C. tenuicornis*

Eucalanidae
- *Eucalanus bungii*

Pseudocalanidae
- *Microcalanus* spp.
- *Pseudocalanus* spp.

Aetideidae
- *Aetideus pacificus*
- *Chiridius gracilis*
- *C. poppei*
- *Gaetanus* sp.
- *Gaidius variabilis*

Euchaetidae
- *Euchaeta elongata*

Metridiidae
- *Metridia curticauda*
- *M. lucens*
- *M. okhotensis*
- *Pleuromamma robusta*

Centropagidae
- *Centropages abdominalis*

Heterorhabdidae
- *Heterorhabdus tanneri*

Candaciidae
- *Candacia columbiae*

Acartiidae
- *Acartia longiremis*

Oithonidae
- *Oithona similis*
- *O. spinirostris*

Oncaeidae
- *Lubbockia wilsonae*
- *Oncaea borealis*
- *Oncaea* sp.

the conversion of plant materials into animal form, in their high concentrations (up to 2000/m^3), and in their high metabolic rates and material/energy turnover. Some other small, though abundant (up to 500/m^3), copepods are more evenly distributed through the water column, or with perhaps minima at mid-depths: *Microcalanus* spp., *Oncaea borealis*, and juvenile *Pseudocalanus* spp.

Several common species of copepods are only found in the deeper layers; this category includes the most important "key" grazers *Calanus cristatus*, *C. marshallae*, and *C. plumchrus*. The latter showed some tendency toward upward migration at night, but possibly this response in all of these species is slight by October. One might expect a more definite daily vertical migration of these species early in the year.

The most abundant dielly migrating copepods were *Metridia lucens* (both adults and stage V) and *M. okhotensis*. *Euchaeta elogata* were not particularly abundant, but their large size made them an important migrator, probably following their prey populations.

Euphausids were not nearly as abundant as copepods, but their large size and critical link between phytoplankton and large carnivores give them an important place in any environmental assessment. Five species, *Euphausia pacifica*, *Thysanoessa inermis*, *T. longipes*, *T. raschii*, and *T. spinifera*, were found. The most numerous (ca. 1-3/m^3) adult euphausids were *T. longipes*, with a day depth maximum between 100-300 and none above 100 m. Their night depth extended into the 0-25 m layer, although the highest concentration was between 25-50 m, with uniform concentration below.

Euphausid juveniles were also abundant (2-3/m^3), and remained mostly in the 0-25 m layer day and night, decreasing in concentration to ca. 100 m, with very few below.

Only two species of chaetognath were found, *Eukrohnia hamata* (ca. 2/m^3) and *Sagitta elegans* (5-10/m^3). The vertical distributions of these important carnivores were very consistent. *Sagitta elegans* showed a definite day and night surface preference, with a maximum between 0-25 m, decreasing evenly to 600 m. *Eukrohnia hamata*, on the other hand, had a maximum below 300 m, and was never found above 50 m.

Ostracods showed a movement into the upper 25 m at night, with uneven concentrations (20-50/m^3) to 700 m.

The pteropod *Spiratella helicina* had a day maximum (ca. 1/m^3) below 50 m, with none above. However, the maximum (1-4/m^3) was found in the upper 50 m during the night.

Several amphipods were collected, the most numerous (1-5/m^3) being *Cyphocaris challengeri*, *Parathemisto japonica*, and *Primno* sp. The latter two species were more or less uniformly distributed night and day between 0-300 m, with very few at greater depths. *Cyphocaris challengeri* was not in the upper 25 m during the day, with a maximum below 100 m. At night, however, the maximum was above 100 m, including high numbers in the 0-25 m layer.

Therefore, the most abundant species seemed to exhibit only a few patterns of vertical distribution (table 3); (1) surface, day and night; (2) fairly uniform with depth; (3) only at depth (most species are in this category); and (4) daily migrators, with deep day maximum and shallow night maximum. Undoubtedly these patterns are a response to light, hydrographic features, and feeding relationships. At other times of the year, and with other species, these patterns would be expected to be modified.

Table 3. Zooplankton vertical distribution patterns,
Prince William Sound, Alaska, October 1975

I. Surface, day and night

Copepoda: *Acartia longiremis*, *Oithona similis*, *Pseudocalanus* spp. (adults)

Euphausid juveniles

Chaetognatha: *Sagitta elegans*

II. Fairly uniform with depth

Copepoda: *Microcalanus* spp., *Oncaea borealis*, *Pseudocalanus* spp. (juveniles)

Amphipoda: *Parathemisto japonica*, *Primno* sp.

III. Only at depth

Copepoda: *Calanus marshallae*, *C. plumchrus*

Chaetognatha: *Eukrohnia hamata*

IV. Diel migrators

Copepoda: *Euchaeta elongata*, *Metrida lucens*, *M. okhotensis*

Euphausiacea: *Thysanoessa longipes* (adults)

Amphipoda: *Cyphocaris challengeri*

Ostracoda

Pteropoda: *Spiratella helicina*

VIII. CONCLUSIONS

The determinations of zooplankton volumes and numbers of certain groups were consistent enough to give confidence in the estimates for Prince William Sound in October. Processing of samples from the shelf has not yet reached the stage where comparable data are available, except for the total volume estimates at the two 36-hr stations.

The volumes of zooplankton were moderately high, about what one would expect in that area in October. These data demonstrate the necessity of accounting for time of day when sampling, particularly in the upper 100 m, and especially in the upper 25 m, where there is a sixfold or so increase in zooplankton biomass at night (in October). One might expect even greater influences of diel vertical migrations in spring or summer. Obviously, the appearance of large organisms in the surface each night will have a great effect on the natural distributions of matter and energy, but will also be of great importance when deep-living organisms are exposed to pollutants in surface layers, when they incorporate such pollutants, and when they actively transport them to deep water.

In spite of the high numbers of species, even in an area of relatively low diversity like the subarctic Pacific, and the resultant potentially high number of vertical distribution patterns (one for each species), the most abundant species at this time could be grouped into one of four basic vertical distribution patterns (table 3).

No consistent geographic patterns of zooplankton volume concentration can yet be discerned within Prince William Sound. The same trend of night increases was noted throughout. Probably there will be species differences from place to place within the Sound, and these different species will result in different cycles of energy and matter transfer.

In November, the zooplankton volume on the shelf was similar to that in Prince William Sound in October, but there did not appear to be day-night changes in zooplankton volumes at these shallow shelf locations at that time.

IX. NEEDS FOR FURTHER STUDY

A major objective of this study is to outline the seasonal cycles of zooplankton; obviously this cannot be done until samples have been obtained from all times of the year. Even with a single year's survey, because of the expected great variability in zooplankton concentrations, doubt will remain as to the representativeness of the data. It would be essential to continue these assessments for a few years, to evaluate the year-to-year variability. In subsequent years, however, we should have a better estimate of the principal zooplankters and could limit the survey to a study of their cycles as a first approximation to modeling the zooplankton as a whole.

It is also likely that the principal zooplankton components (species) would change with season, one set of species dominating the system for a time, and succeeded by a different combination of species. With each change in species or life history stage, the potential pathways of matter transfer alter, and concurrently the environmental relationships of greatest concern.

It is likely that the gross patterns of matter and energy transfer within the net zooplankton are controlled by the vertical movements of relatively few species. Therefore, comparisons of shallow and deep areas should continue, to test this assumption.

Since changes in zooplankton abundance can be very rapid at any one locality, it would be desirable to have frequent (perhaps biweekly) samples during parts of the year. These samples could be used for studies of certain basic zooplankton processes, such as growth rates, reproductive cycles, mortality rates, etc. Such studies are best conducted in limited areas where the most background information is available.

Eventually the question of potential impacts of selected pollutants will arise. There might be a tendency to rely on laboratory studies for this information, but the reactions of laboratory animals to laboratory stresses bears slight if any relationship to the reaction of natural populations in the field. Laboratory studies could possibly suggest sensitivities and cause-effect relations, but the final assay is the response of the affected populations. And this response can only be judged in light of distributions and abundances of populations in time and space. And proper judgments can be made only if the "natural" levels and variabilities are understood. Then population deviations in quantity or quality might subsequently be related to environmental perturbations.

X. SUMMARY OF 4th QUARTER OPERATIONS

No field activities were scheduled in the 4th quarter (ending March 1976).

Program guidelines have recently changed, taking the emphasis from infrequent broad areal coverage and placing it on frequent sampling within a few smaller areas of greatest interest. Four approximately week-long cruises have been planned for the northern Gulf of Alaska for the next quarter. Each cruise will be a transect through Lower Cook Inlet, across the shelf, and into Prince William Sound (fig. 5). The dates and vessels scheduled for these cruises are:

6-13 April	*Discoverer*
29 April - 5 May	*Surveyor*
17-25 May	*Discoverer*
26 June - 2 July	*Acona*

Methods will be identical to those used on the 1975 cruises, i.e., closing nets hauled vertically through discrete depth layers, and bongo nets hauled obliquely from 200 m to the surface. The vertical series will be taken around noon and midnight regardless of the ship's position. The bongo nets will be towed at each station. Three 24-hr stations are planned (see fig. 5).

Analyses continue on the plankton collected in 1975. Of the 143 samples collected in October in Prince William Sound, all have been sorted to major groups, and the principal species have been identified from the 48-hr stations. Of the 125 samples collected on the shelf in November, the major groups have been sorted from the two 36-hr stations.

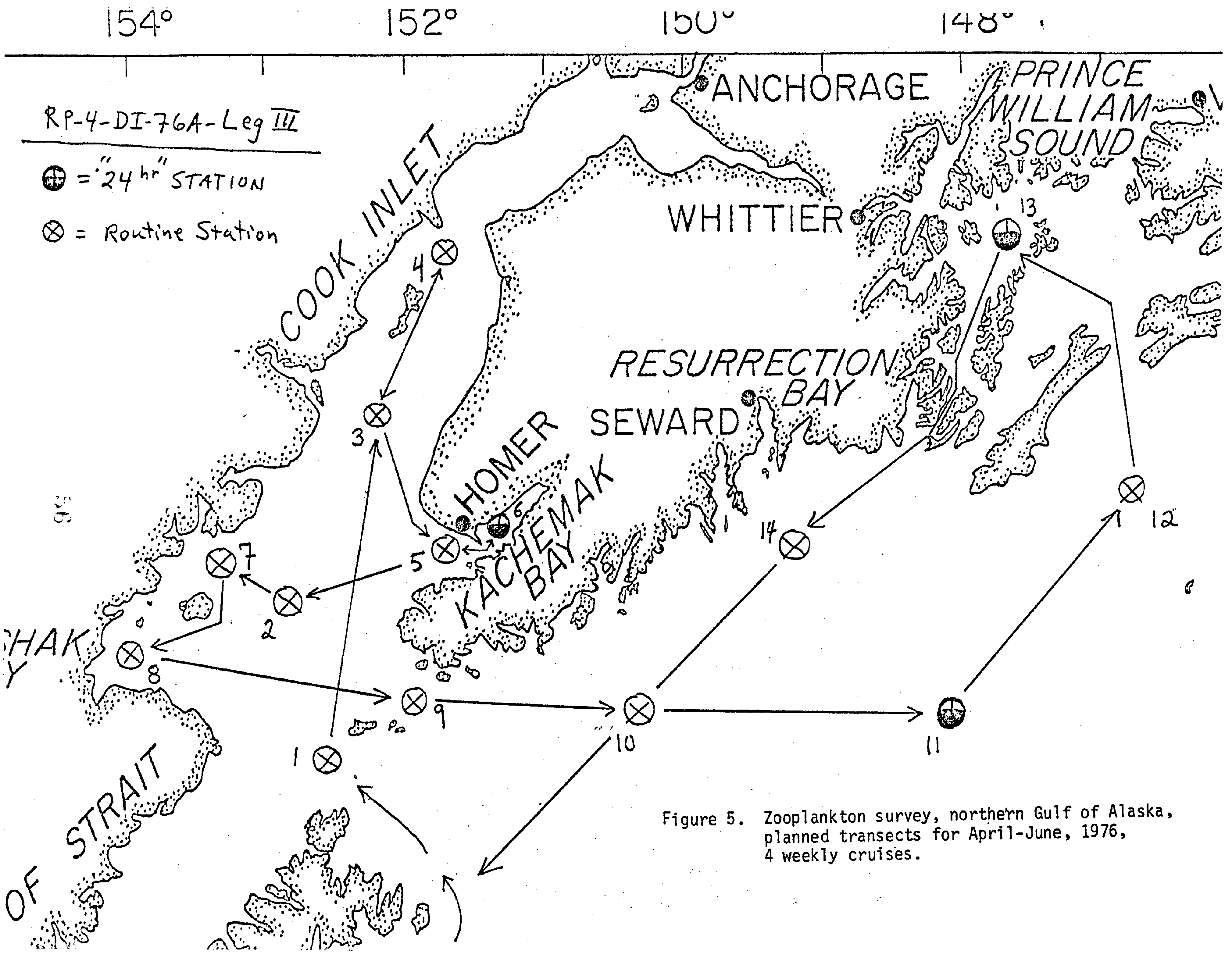

Figure 5. Zooplankton survey, northern Gulf of Alaska, planned transects for April-June, 1976, 4 weekly cruises.

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PHYTOPLANKTON AND PRIMARY PRODUCTIVITY IN THE NORTHEAST GULF OF ALASKA

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I. SUMMARY

The chief objective of the phytoplankton and primary productivity studies in the Gulf of Alaska for the first year of OCSEAP was to provide a baseline of phytoplankton standing stocks and rates of primary production. The investigations were also intended to identify the environmental factors controlling production and to determine quantitative relationships between these factors and production. The baseline includes the species compositions and population densities of the phytoplankton, rates of carbon assimilation, nutrient concentrations, intensity of light available to the cells, concentrations of chlorophyll *a* and phaeopigments, and other related variables.

One cruise was conducted in the northern Gulf of Alaska in cooperation with the zooplankton, light hydrocarbon, and suspended matter investigations during October-November 1975. The results presented here are tentative pending detailed analysis of the data. Furthermore, they describe only autumn conditions.

Primary productivity ranged from 39 to 736 mgC/m^2 day and averaged about 400 mgC/m^2 day in the Gulf. A local bloom of the diatom, *Skeletonema costatum* was in progress at one station in Prince William Sound where daily production was 2.9 gC/m^2. The chief environmental factor controlling production appeared to be light available to the cells. High extinction of light in the water was observed in nearshore areas influenced by glacial runoff. The attenuation was caused by large loads of suspended matter (1-3.5 mg/L) and primary productivity values were significantly lower in these areas. Nutrient concentrations were sufficient to sustain vigorous phytoplankton growth.

Several species of microflagellates were ubiquitous throughout the area and dominated the phytoplankton community. Other dominant groups showing distinct distributions included a silicoflagellate, Dictyocha fibula, and the diatoms Thalassionema nitzschioides, Fragillariopsis sp., and Skeletonema costatum.

The baseline information can be compared to future conditions for purposes of determining effects of oil contamination when it occurs. Repopulation of phytoplankton following damaging contamination may result in a species composition much different than the previous one. Productivity may also be significantly different than previous levels. Chronic effects of continuous low-level contamination would be difficult,if not impossible,to assess without data on predevelopment conditions. The information can also be applied to help develop models for estimating timing and size of phytoplankton blooms.

II. INTRODUCTION

The phytoplankton and primary productivity studies in the Gulf of Alaska for the first year of OCSEAP were designed to provide a baseline of phytoplankton standing stocks and rates of primary production. Although initial guidelines placed emphasis on broad areal distributions of these parameters in the Gulf, a recent shift has been made to concentrate the investigations in selected nearshore areas, principally Lower Cook Inlet. This concentration of effort will permit more thorough descriptions to be made of seasonal sequences of phytoplankton and related parameters. It will also focus the studies in areas of high probable impact caused by oil and gas development activity, i.e., potential lease areas.

The general intent of the study is to document the species composition and standing stock of the phytoplankton, primary productivity, and the environmental factors controlling production. These parameters will be measured in Lower Cook Inlet with sufficient frequency (especially during spring and summer) to develop a picture of succession of events seasonally involving productivity and species composition.

One cruise (RP-4-DI-75C, Leg I) was made over a more extensive area in the northern Gulf of Alaska in October-November 1975. Measurements were made of chlorophyll a and primary productivity within the upper 50 m, and the several dominant phytoplankton species and their population densities were determined. Measurements of inorganic nutrient concentrations and incident and underwater ambient irradiance were also made. Data on light, temperature, salinity, nutrients, zooplankton and suspended matter can subsequently be related to productivity and standing stocks to gain insights into the major driving forces of primary production.

The information obtained during this study can be used as a baseline against which future data can be compared in an attempt to ascertain effects of possible contamination. It can be used more immediately to help define areas and seasons of particularly high biological production. The data can further be applied to develop models for estimating timing and size of phytoplankton blooms controlled by natural factors (sunlight, temperature, nutrients, etc.). Models may be used in the future in conjunction with monitored variables to facilitate such estimates.

Although phytoplankton are likely to repopulate an area shortly following an oil spill, the species composition may be very different. The new dominant species may be inadequate to nourish grazers, and thus significant changes may occur in the food web. In addition to large spills, almost continuous low-level contamination is almost certain to exist in the area around and downstream of an oil field. The resultant chronic effects on phytoplankton production is virtually unknown. Unless predevelopment conditions are determined, these chronic effects cannot be detected.

III. CURRENT STATE OF KNOWLEDGE

The information available in the literature on phytoplankton standing stocks in the Gulf of Alaska is limited mainly to open waters of the southern portion of the Gulf. Studies conducted inshore include Iverson *et al*. (1974), who reported successive summer blooms of the *Thalassiosira aestivalis* and *Skeletonema costatum* in Auke Bay, Alaska; and Horner *et al*. (1973), who found a major diatom bloom in March-April in the Valdez area followed by a summer population composed principally of small flagellates and dinoflagellates in the fall. The major peaks of chlorophyll and primary production coincided with the spring diatom bloom (Goering *et al*., 1973).

Several Japanese workers have reported diatom species from the southern Gulf of Alaska sampled by fine mesh nets. Karohji (1972) summarized Alaskan Gyre populations as dominated by *Nitzschia seriata*, *Phaeoceros* and *Rhizosolenia hebatata* f. *spinifera*. Ohwada and Kon (1963) concentrated algae from water samples by centrifugation. Their results from open water agree in general with Karohjii's (1972) and they found 3 x 10^6 cells L^{-1} near Juneau of which 88 percent were *Skeletonema costatum*.

Koblents-Mishke, O.I. (1961) attempted to show the phytogeograp regionalization of the northeastern Pacific. She characterized a borea group of phytoplankton including *Thalassiothrix longissima*, *Denticula marina*, *Chaetoceros decipiens*, and *Ceratium pentagonum*.

Larrance (1971) reported primary productivity,nutrients and chlorophyll *a* data south of Adak Island. During and before the 1960's, Canadian scientists of the Pacific Oceanographic Group at Nanaimo, B.C., measured chlorophyll *a* at Ocean Station "P" (latitude 50°N, longitude 145°W), along with studies of primary production and zooplankton. The data from these measurements can be found in several numbers of the Fisheries Research Board of Canada, Manuscript Report Series (Oceanographic and Limnological). From the Canadian data, McAllister (1969) estimated the mean annual primary production at Station "P" was 48 gCm^{-2} and Larrance (1971) estimated annual production between 80 and 100 gCm^{-2} at the 176°W meridian. Koblents-Mishke (1965) estimated annual production of 102 gCm^{-2} in the Gulf of Alaska, and Goering *et al*. (1973) estimate net annual primary production in the Prince William Sound area at 185 gCm^{-2}.

Although the referenced information given here is incomplete, three pertinent points are apparent: (1) The existing information describes primarily the southern offshore portion of the Gulf of Alaska and limited data are available along the northern Gulf of Alaska continental shelf. (2) No sampling program has produced phytoplankton and primary production data applicable to the OCSEAP objectives in terms of spatial and temporal continuity and frequency in the study region. (3) A coherent picture of phytoplankton species distribution cannot be presented from information in existing reports.

IV. STUDY AREA

The area sampled is depicted in figures 1 and 2. It covers potential oil lease areas off Icy Bay and southwest of Kayak Island. The general circulation pattern along the outer continental shelf in the area is a net westward transport with the flow often paralleling the bathymetry. The station pattern extended to the east and west to measure populations in contiguous water advecting into and out of these lease areas. Stations were also located over deep water for comparison of coastal and mid-Gulf conditions. A high concentration of stations was located to the west and south of Kayak Island because the circulation has been described as weak and variable over this broad shelf area.

V. METHODS

For appropriate interpretation and estimation of primary productivity, simultaneous measurements of phytoplankton standing stock (by chlorophyll and cell concentrations by species), ambient solar radiation, inorganic nutrients, salinity and temperature are needed. The factors controlling the extent of primary productivity are generally the algal standing stock, nutrients (usually nitrate), and available visible light. All of these variables were measured within the upper 50 m of water during the cruise in October and November 1975 aboard NOAA ship Discoverer.

Water samples were collected by Niskin bottles on a Rosette sampler equipped with a CTD (Conductivity-Temperature-Depth) sensor. Portions of the sample were taken for phytoplankton, nutrient, and chlorophyll a and phaeopigment analyses and for primary productivity experiments. Chlorophyll fluorescence was also measured in a continuous stream of seawater

(Lorenzen,1966) pumped directly from a bow probe 5 m below the water line. The sampling was coordinated with the suspended particulate matter and low-molecular-weight hydrocarbon programs and samples for these activities were also often extracted from the same Niskin bottles. Therefore the data from these three investigations can be easily compared in subsequent interpretations.

The phytoplankton samples were preserved in 1% formalin buffered with sodium acetate and returned to Seattle for analysis using the Utermöhl (1931) inverted microscope technique. Cells were identified to the lowest practicable taxon and counted. Sufficient numbers of cells of the dominant species were counted to bring the random counting error within acceptable limits (Lund _et al_., 1958).

Chlorophyll _a_ and phaeopigment concentrations were determined by fluorometric techniques described in Strickland and Parsons (1968) and Yentsch and Menzel (1963). Modifications to the basic techniques were applied so that a smaller sample volume could be used and more complete extraction of pigments could be obtained using sonification. Seawater samples of 253 ml were filtered through glass-fiber filters with a few mg $MgCO_3$ on top. The filter was placed in a centrifuge tube with 10 ml of 90% distilled acetone and sonicated for 1 min using a Megason Sonic Disintegrator Ⓡ. [1] The samples were then centrifuged and the fluorescence of the supernatant determined according to the standard techniques. All pigment analyses were conducted immediately after sampling.

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1. ⓇUltrasonic Instruments, International, Ltd., Farmingdale, New York.

Primary productivity was measured by standard carbon-14 techniques (Strickland and Parsons, 1968). Two bottle casts were taken each day--predawn and prenoon. Half-day photosynthesis experiments were conducted using simulated *in situ* incubations. Incubation periods were dawn to LAN (local apparent noon) and LAN to dark. One successful simultaneous *in situ* and simulated *in situ* experiment was completed for calibration purposes. Five to seven depths at each station down to the 1% light depth were sampled according to light transmission ratings of neutral density filters used in the photosynthesis experiments. These light depths were 95, 75, 50, 30, 18, 5.5, and 2% of the incident surface light. At noon stations, sampling depths were determined from secchi disk readings. Sampling depths for the morning stations were identical to those from the previous day's noon station.

Two light and one dark bottle from each depth were incubated. The resulting filters were immersed in scintillation-fluor solution and returned to Seattle and analysed by liquid-scintillation techniques.

Incident solar radiation between wave lengths of 3 and 0.3 mm was measured at the ship's deck by an Eppley®[1/] Model 8-48 pyronometer. Continuous recordings were made by a strip chart recorder equipped with an integrator to give total energy over a given time period, e.g., each day or each incubation period.

Seawater samples for determination of dissolved inorganic nutrient concentrations were frozen and returned to the University of Washington,

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1. ®Eppley Laboratory Inc., Newport, Rhode Island.

Department of Oceanography, for analysis. Dissolved nitrate, nitrite, ammonia, silicate, and phosphate were determined using Auto Analyzer® 1/ techniques.

VI. RESULTS

The detailed data have been submitted to the Environmental Data Service according to procedures outlined by the OCSEAP Project Office. Formats for tabular and graphical presentation of data in report form are being devised. The results presented here are included to show some relationships thought to occur from preliminary interpretation.

A. Chlorophyll, Primary Productivity, and Light

Station locations, incident solar radiation, and integrated water column values of chlorophyll *a* and carbon assimilation are given in table 1. Chlorophyll in the upper 50 m is generally more abundant offshore of the continental shelf than on the shelf (fig. 1). The mean chlorophyll value on the shelf (omitting stations in Prince William Sound) was 18 mg chlorophyll *a* m^{-2} while the mean in deeper water was 33 mg m^{-2}. The distribution appeared somewhat patchy to the west and south of Kayak Island, which may be related to the plumes of the Copper River and other drainages east of Kayak Island.

At station 40 in Prince William Sound there was about twice as much chlorophyll *a* (80.6 mg/m^2) as the next highest value measured (45.5 mg/m^2 at station 13 which is offshore). A bloom of *Skeletonema costatum* was in progress at station 40 and Prince William Sound was the only place this

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1. ®Technicon Instrument Corp., Tarrytown, New York.

species was found in the phytoplankton samples. Clearly, population size and composition at station 40 were anomalous for autumn conditions in the Gulf, but similar local blooms may be common in the inshore waters.

Daily primary productivity integrated from the surface down to the 1% light depth ranged between 39 and 736 mg C/m^2, except for station 40 where daily production was 2.9 gC/m^2. The areal distribution of productivity (fig. 2) was somewhat similar to chlorophyll in that the values were higher offshore. However, on the continental shelf west of 146° 30'W, the productivity inside the 100 fathom (183 m) isobath east of Prince William Sound averaged 141 mg C/m^2 with a range of 39-204 mg C/m^2, and in the remainder of the area the mean was 522 with a range of 193-736 mg C/m^2.

Vertical profiles of primary productivity and chlorophyll at those stations where productivity was measured are given in figure 3. The chlorophyll was somewhat uniform with depth while subsurface maxima of productivity often occurred with a decrease to low values near the bottom of the euphotic zone. The general character of these productivity profiles signifies the dependence of productivity on available light energy. A detailed analysis of the data to describe the response of photosynthesis to light will be made in a subsequent report.

B. Nutrients

Nitrate at the surface ranged between 2.7 and 12 μg-at/L. The surface nitrate was less than 5 μg-at/L at all the Prince William Sound stations and only one other (nearshore). Values greater than 10 were found offshore and near Yakutat Bay. Although nitrate concentrations less than 5 μg-at/L are in the normal range to limit primary production, that did

Table 1. Chlorophyll and phaeopigments in the upper 50 m, primary productivity in the euphotic zone and daily light intensities at the surface in October-November 1975

Station	Latitude (N)	Longitude (W)	Chlorophyll a (mg/m^2)	Carbon Assimilation (mgC/m^2 day)	Incident Solar Radiation (ly/day)
01A	59°51'	149°30'	13.6	451	101
002	59°24'	149°09'	17.7	736	101
003	59°00'	148°40'	39.3		
004	58°24'	148°04'	28.8	673	114
049	59°10'	147°37'	7.0		
050	59°20'	147°56'	17.0		
051	59°50'	148°11'	7.8		
51A	59°25'	147°01'	15.1	451	146
048	59°16'	146°16'	20.3	193	146
047	59°48'	146°34'	13.3		
46A	59°56'	146°39'	21.2		
46B	59°56'	146°39'	7.9	409	132
46C	59°55'	146°37'	14.5		
46D	59°55'	146°39'	14.6		
46E	59°55'	146°39'	16.3	373	132
46F	59°54'	146°39'	13.7		
46G	59°54'	146°39'	14.7		
46H	59°54'	146°39'	11.1		
46I	59°54'	146°38'	17.1	384	123
46J	59°55'	146°38'	14.8	434	123
045	60°02'	146°42'	16.5		
044	60°14'	146°47'	22.5		
043	60°23'	146°54'	24.3		
042	60°31'	146°47'	15.8		
041	60°33'	146°37'	14.5	471	63
40A	60°33'	146°27'	78.4		
40B	60°33'	146°27'	82.7	2918	63
039	60°15'	145°56'	15.1		
038	60°16'	145°43'	25.8		

Table 1 (Continued)

Station	Latitude (N)	Longitude (W)	Chlorophyll a (mg/m^2)	Carbon Assimilation (mgC/m^2 day)	Incident Solar Radiation (ly/day)
037	60°09'	145°22'	19.5		
027	60°08'	145°06'	10.2	132	65
025	60°08'	144°50'	21.6	210	65
024	60°03'	144°47'	21.1		
028	59°59'	145°08'	10.5		
036	60°08'	145°30'	24.2		
035	60°11'	145°58'	10.6	39	40
034	60°01'	145°53'	24.1		
033	59°51'	145°55'	30.2		
032	59°41'	145°53'	15.6		
005	58°38'	145°15'	29.7		
05A	58°53'	145°15'	31.4		
031	59°19'	145°16'	35.2	529	71
030	59°37'	145°14'	25.5		
029	59°46'	145°12'	17.5		
023	59°52'	144°43'	10.8		
022	59°40'	144°39'	14.6	86	61
021	59°37'	144°39'	8.5		
020	59°15'	144°40'	42.9	728	73
22A	59°44'	144°37'	24.3	322	73
019	59°14'	143°56'	40.9		
018	59°33'	143°56'	22.5		
017	59°54'	143°53'	22.8	183	35
014	59°17'	142°59'	28.3	552	54
016	59°55'	142°45'	24.7		
015	59°36'	142°50'	29.5		
62A	59°34'	142°10'	38.2		
62B	59°34'	142°10'	45.1	546	56
62C	59°34'	142°10'	45.3	565	56
62D	59°34'	142°10'	39.0		

Table 1 (Continued)

Station	Latitude (N)	Longitude (W)	Chlorophyll *a* (mg/m^2)	Carbon Assimilation (mgC/m^2 day)	Incident Solar Radiation (ly/day)
62E	59°34'	142°10'	34.8		
62F	59°34'	142°10'	12.7		
62G	59°34'	142°10'	26.5		
62H	59°34'	142°10'	38.4	464	57
62I	59°34'	142°10'	32.4	724	57
013	59°09'	142°03'	45.5		
012	59°27'	141°48'	13.2		
011	59°37'	141°38'	13.5		
010	59°44'	141°32'	18.8	75	30
009	59°34'	140°06'	7.7	84	30
008	59°19'	140°31'	33.2		
007	58°46'	141°12'	30.7		
06A	58°13'	141°55'	40.0	360	69
06B	58°13'	141°55'	45.4	541	69
06C	58°13'	141°55'	37.1		

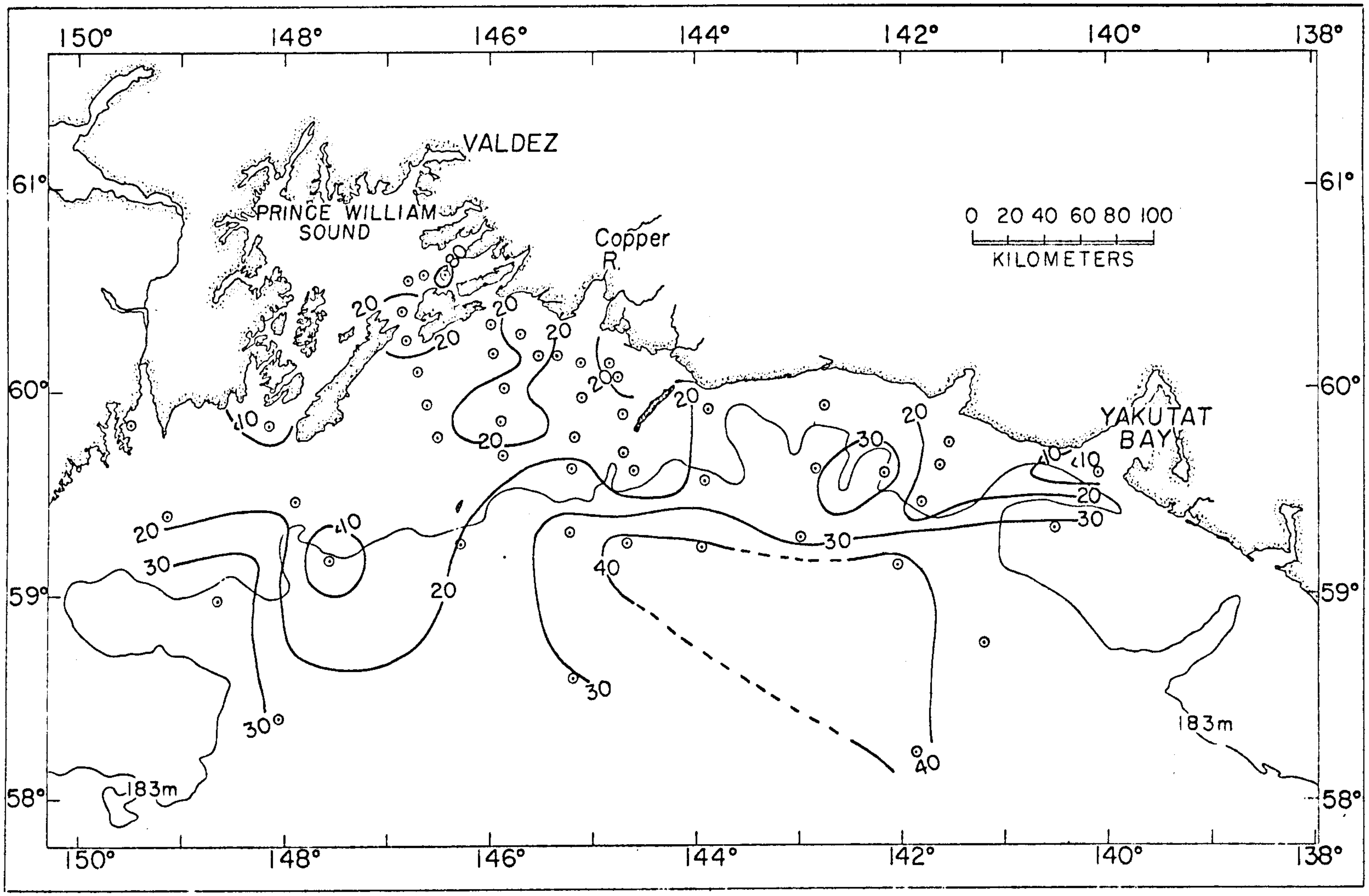


Figure 1. Chlorophyll a (mg/m^2) in the upper 50 m, October - November, 1975.

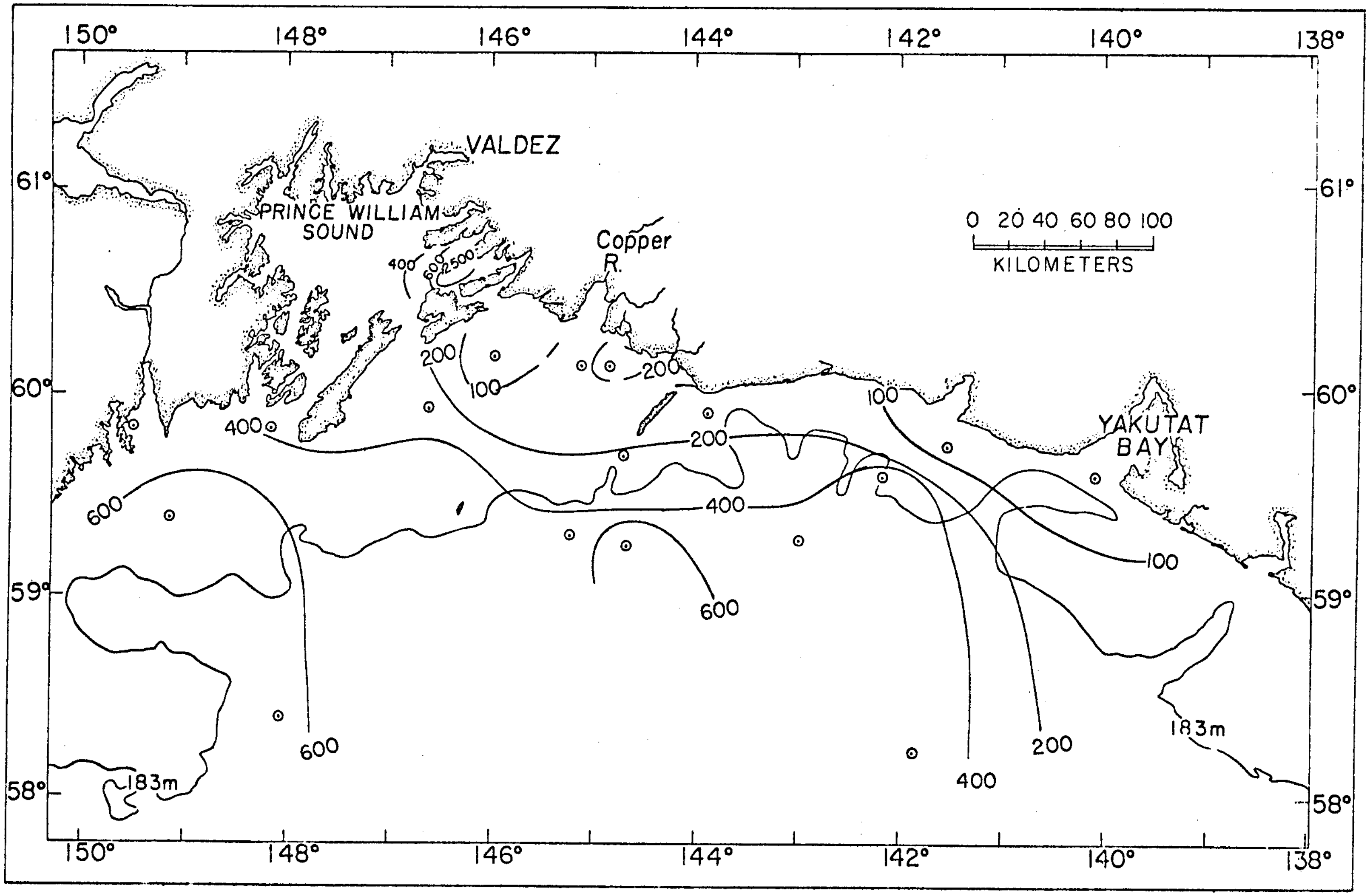


Figure 2. Primary production (mgC/m^2-day) in the euphotic zone, October - November, 1975.

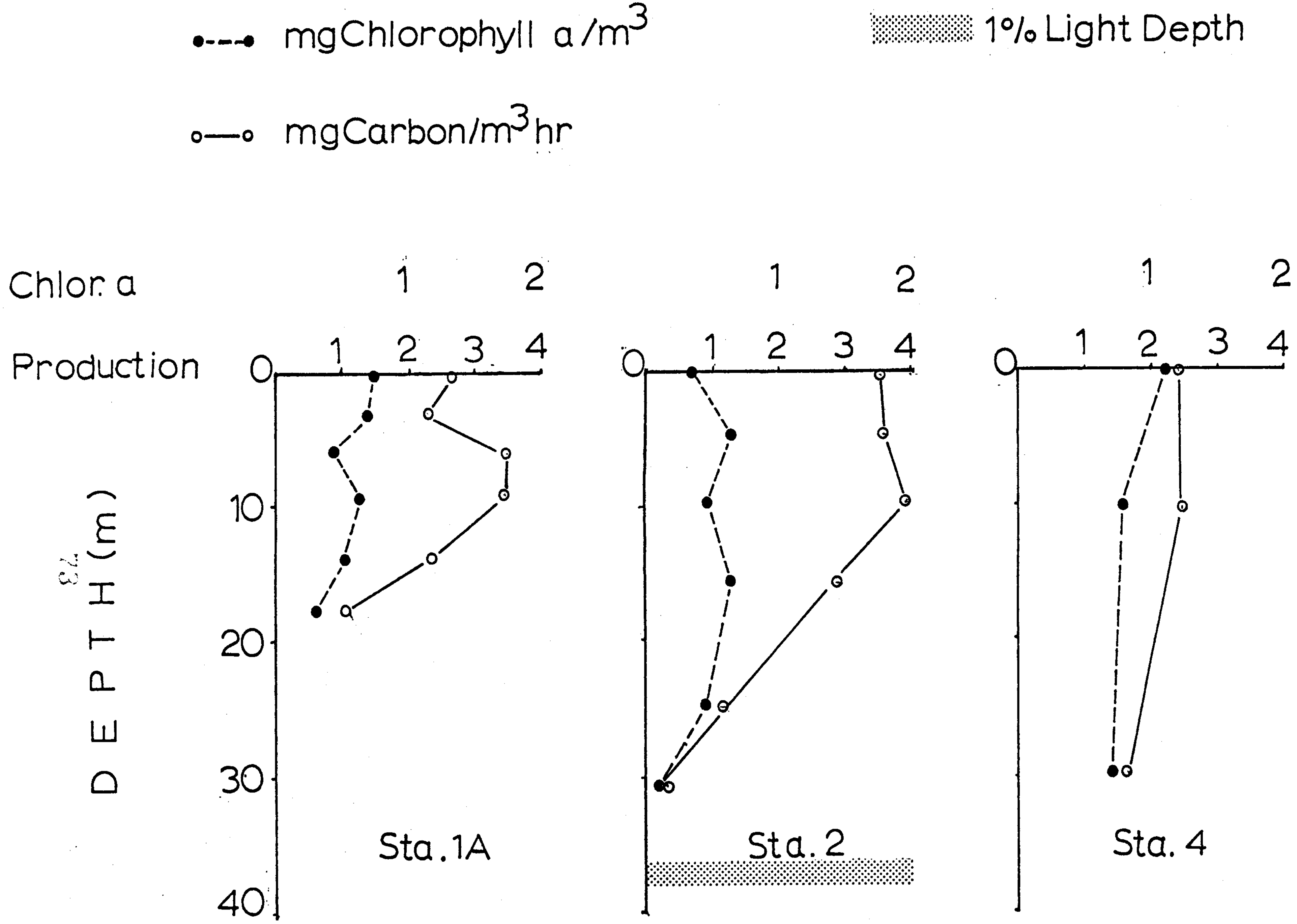
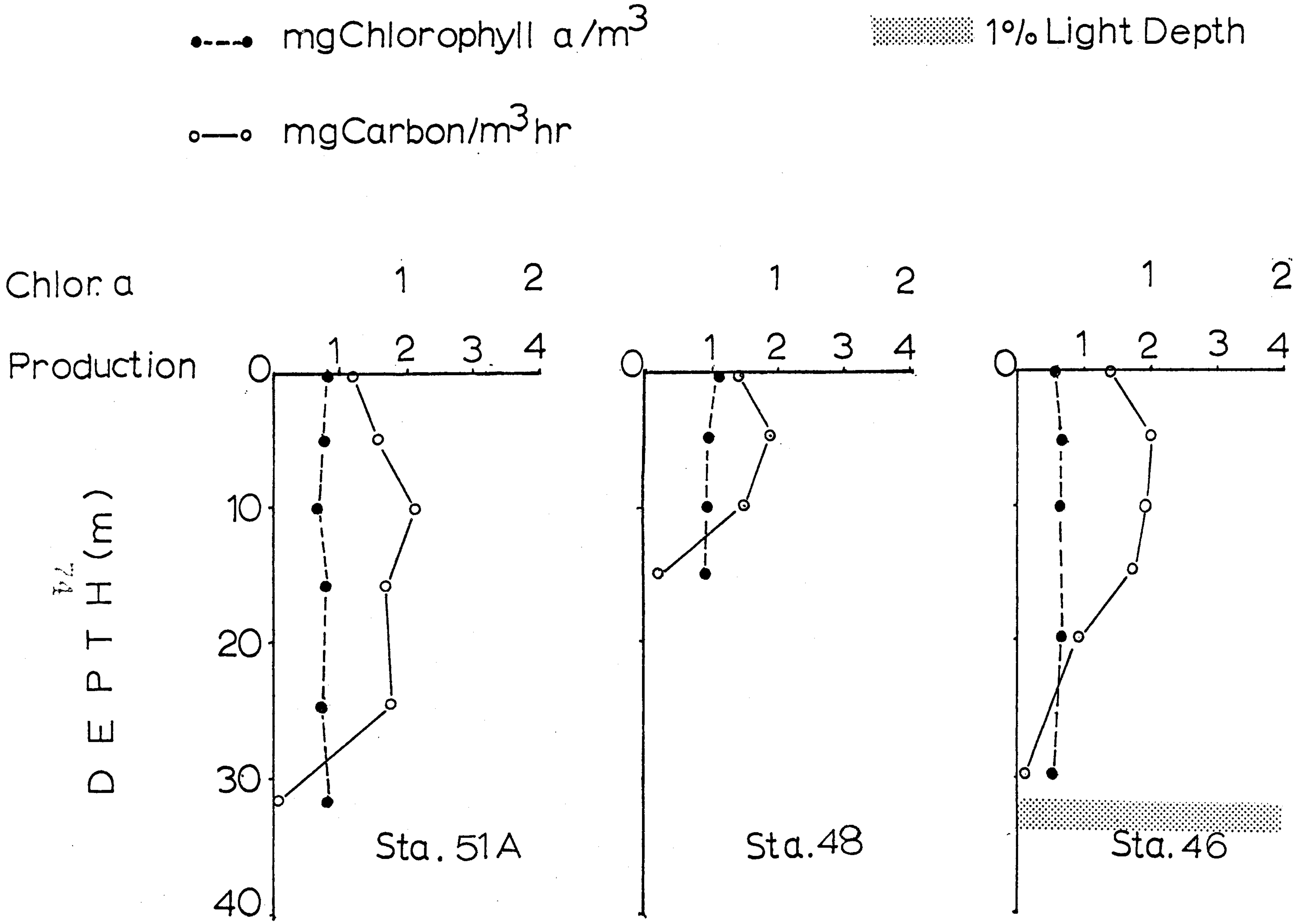


Figure 3. Vertical distributions of chlorophyll-a and primary production, October - November, 1975.



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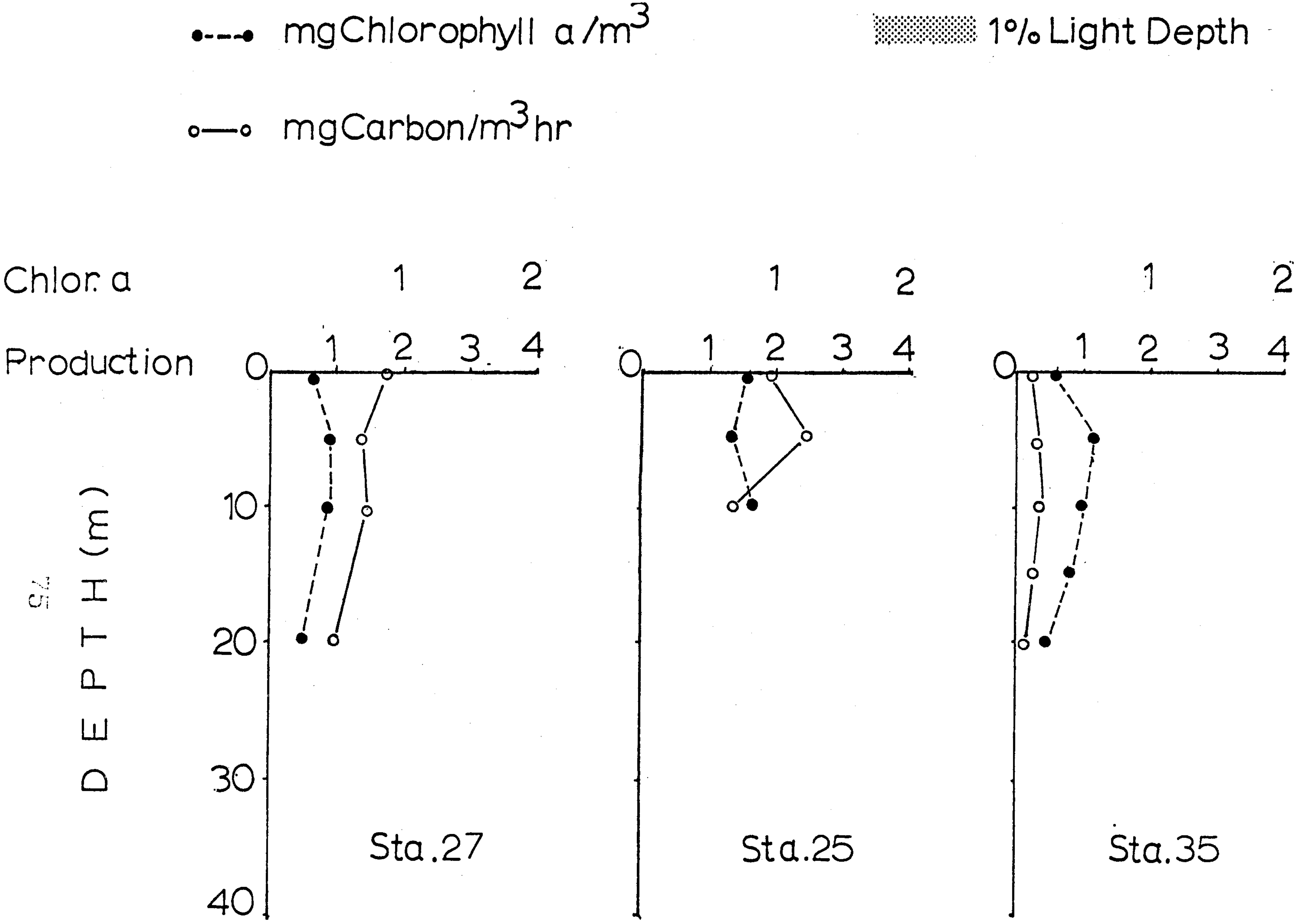

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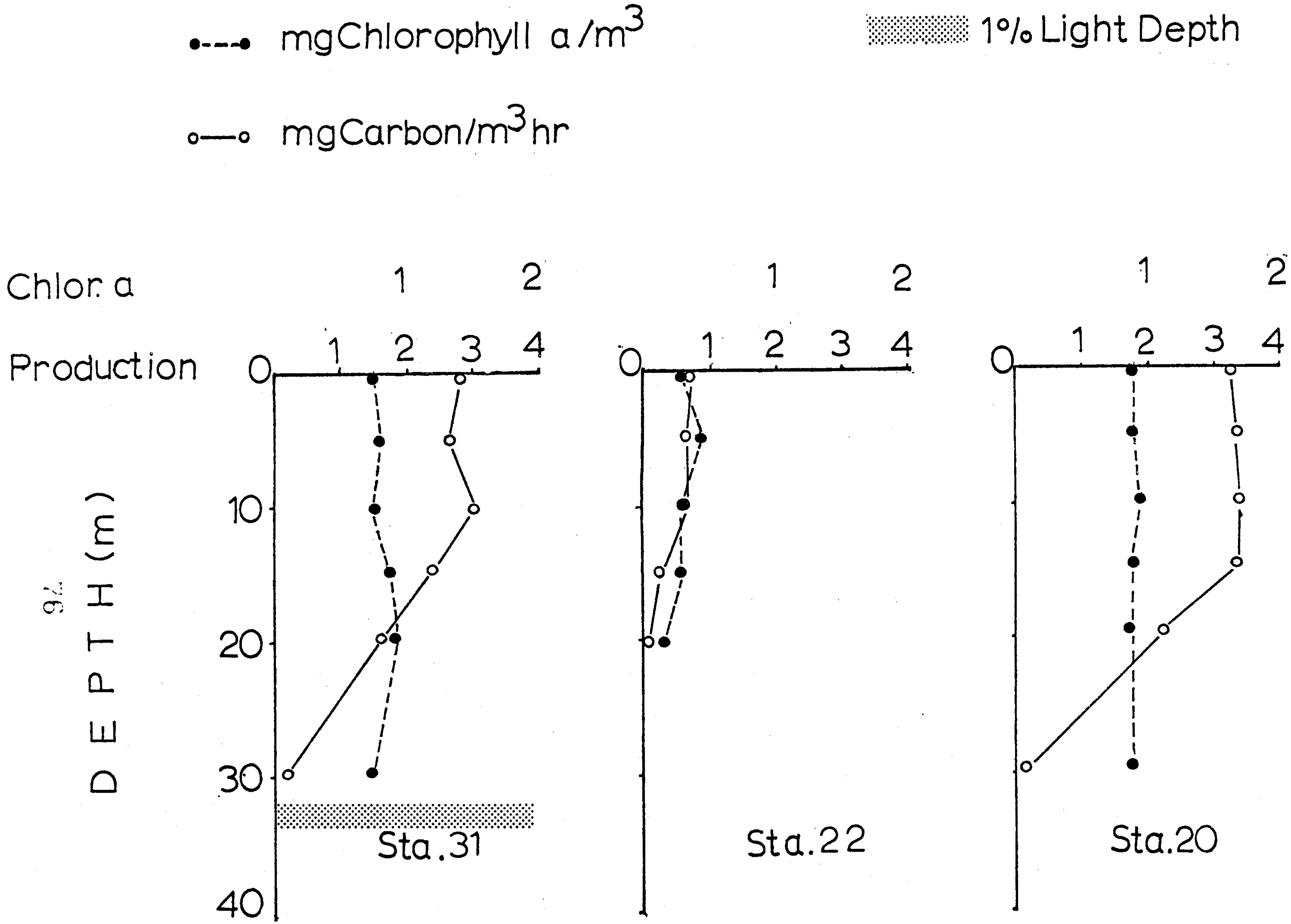

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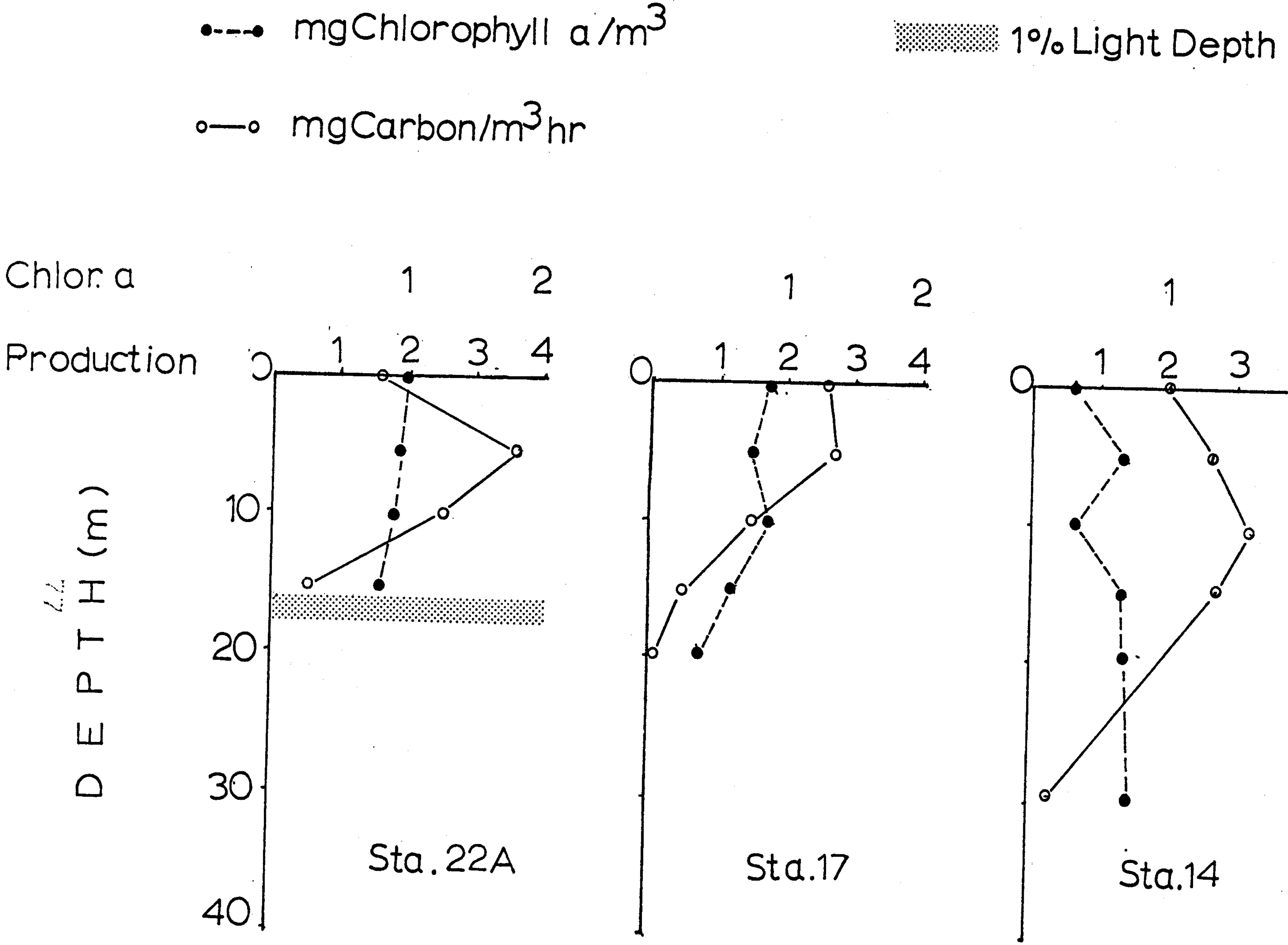

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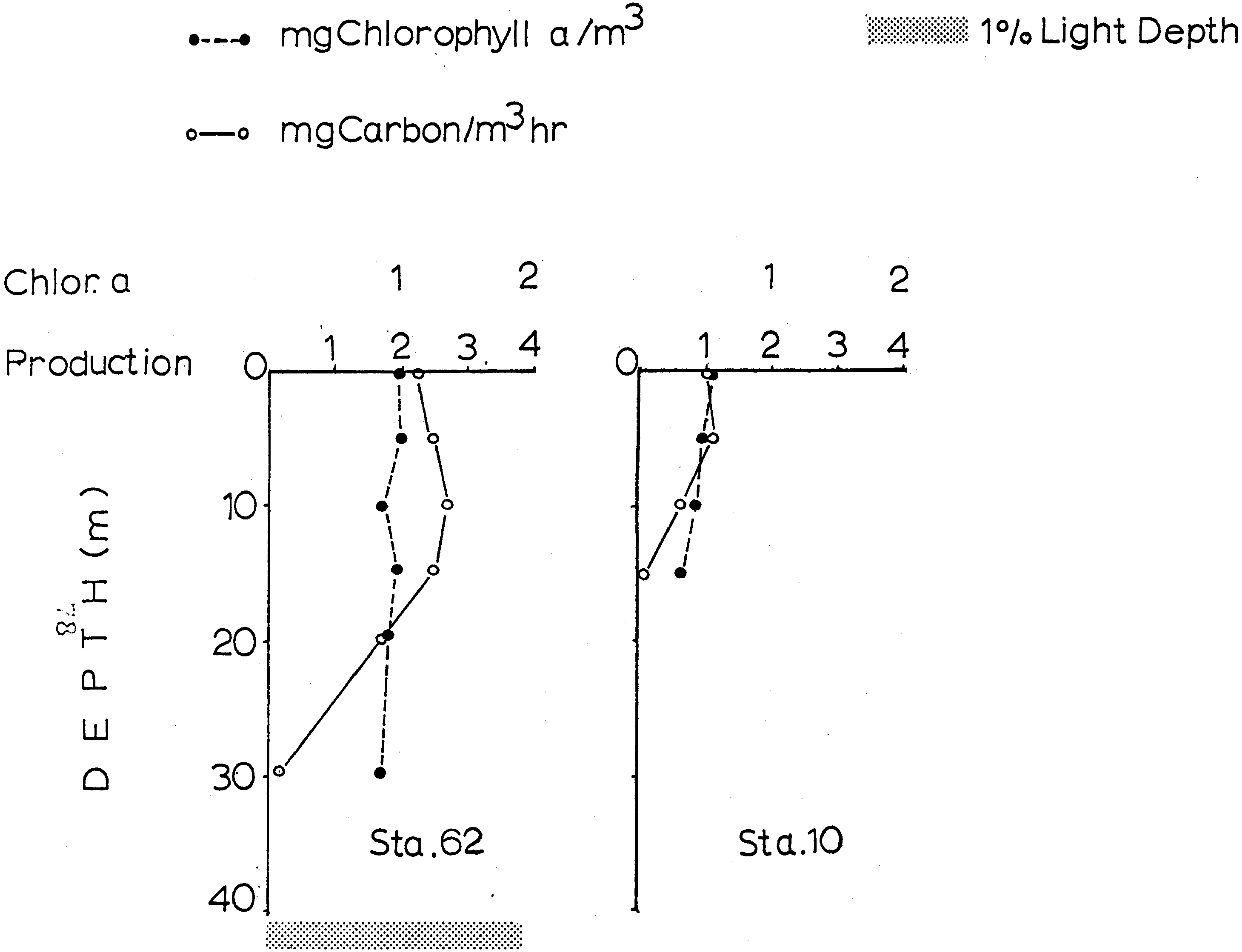

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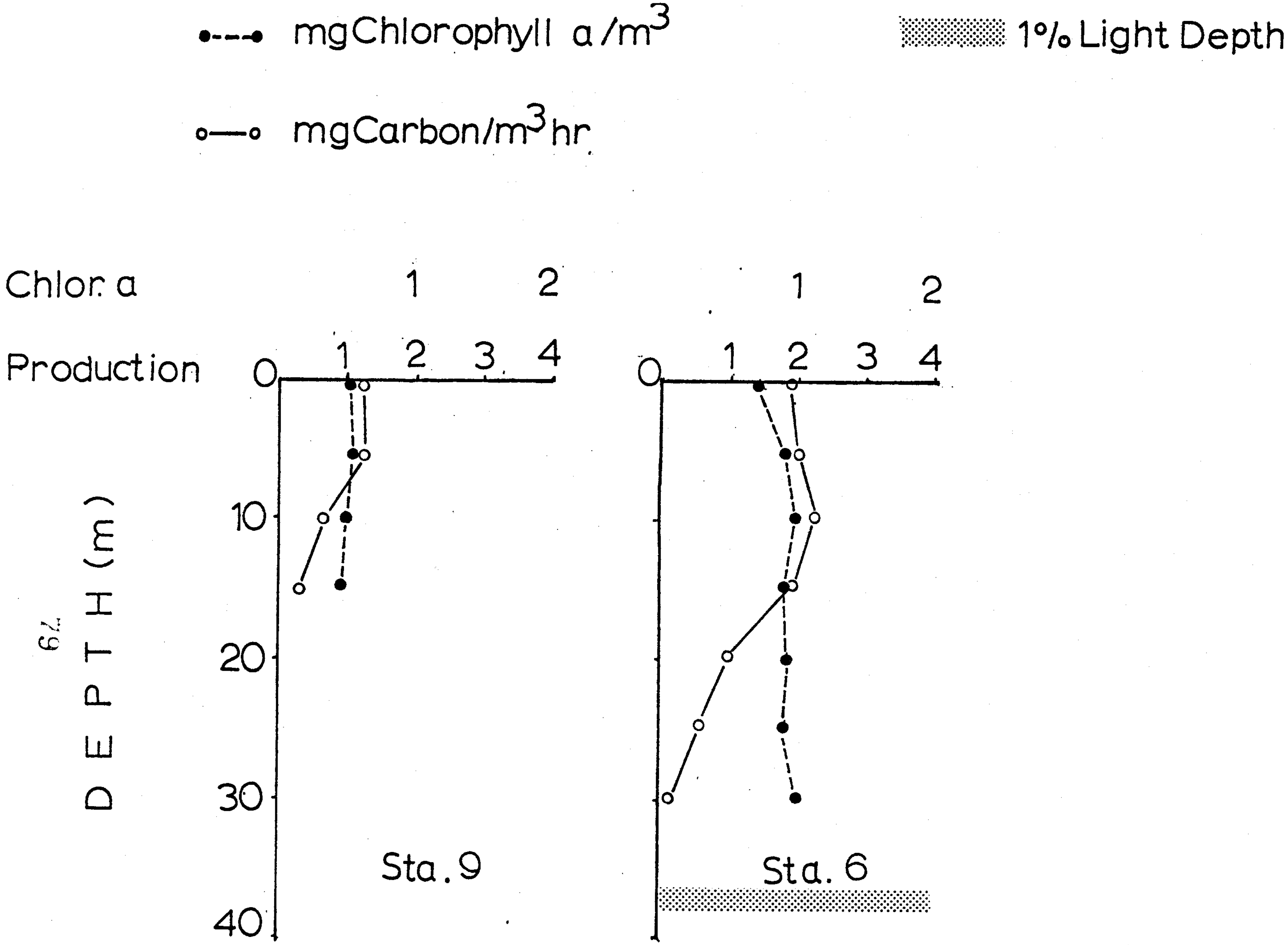

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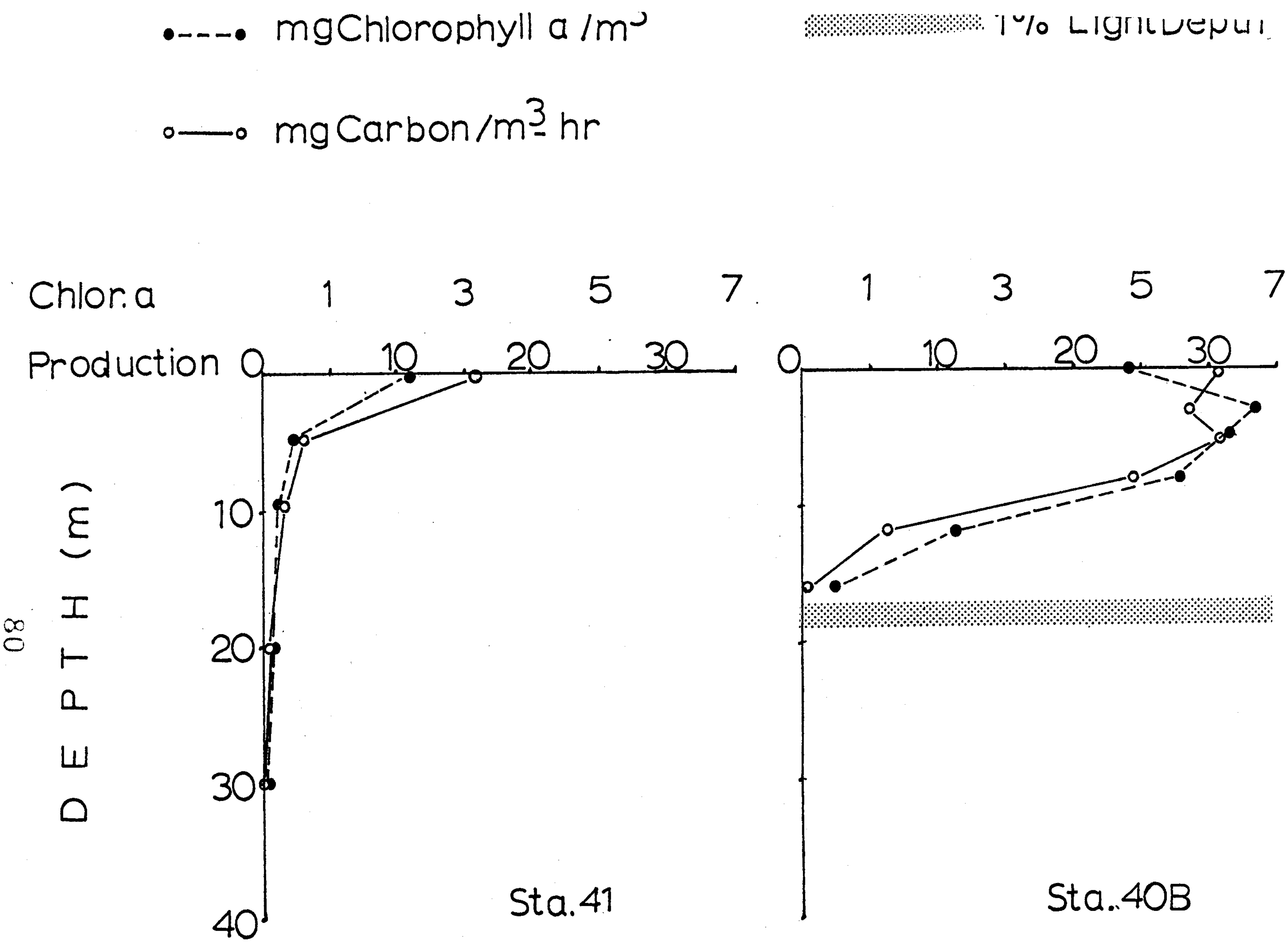

Figure 3. Continued.

not appear to be the case here. The assimilation numbers (mg carbon assimilated/hour x mg chlorophyll a) were moderate to high (greater than 6) in Prince William Sound. Low assimilation numbers could indicate possible nutrient limitation.

Surface silicate concentrations ranged between 15 and 20 µg-at/L except in Prince William Sound where values were 8.7 - 14.6, and in the vicinity of Icy Bay and Yakutat Bay where silicates were as high as 23.1 µg-at/L. These higher values could be associated with runoff from glaciers in the region.

A more detailed analysis of the nutrient data is in progress, but it does not appear that any of the measured nutrients (nitrate, ammonia, nitrite, phosphate, and silicate) limited phytoplankton production.

C. Phytoplankton

Although all the phytoplankton samples collected during the autumn cruise have not been analyzed, some tentative distributional patterns of species are presented. These findings are based on analyses of 10 m samples at 31 stations.

Unidentified microflagellates of various species ranging in diameter from 5-25 µm were ubiquitous in the study area. They were the most numerous group at 15 stations and were within the five most numerous groups at all stations, except at station 40 in Prince William Sound and one station (34) southwest of the Copper River (table 2).

Two areas of high abundance of microflagellates occurred off the continental shelf south of Copper River and nearshore southeast of Prince William Sound, but they were not abundant in the Sound (fig. 4). Their

Table 2. Rank order of cell concentrations of most frequently recurring phytoplankton groups

Station	microflagellates	Thalassionema nitzschioides	Fragillariopsis sp.	Dictyocha fibula	Skeletonema costatum	Thalassiosira sp.	Coccolithophorids
1A	2			1			
2	1	4		2		5	
3	1	2		4		3	5
4	3	2		1		4	
49	2	1		3		5	
50	3	1		2		4	
51	3	2		1		4	
51A	3	1		2		5	
48	2	1		3			
45	1	2		3			
43	2	1				4	
42	3				1	5	
40		2			1		
39	2	1		5			
38	2	1					
27	2	1				5	3
34		1		2		4	
33	1	2		3		4	
32	1	2					
5	1		2				
31	1						
30	1		3				
21	1	3	2				
20	1		2				5
19	1		2			5	3
18	1	3					
13	1		3				2,4
12	1		2				3,5
11	5	1					2
8	1	3	5				2,4
7	2		1				3

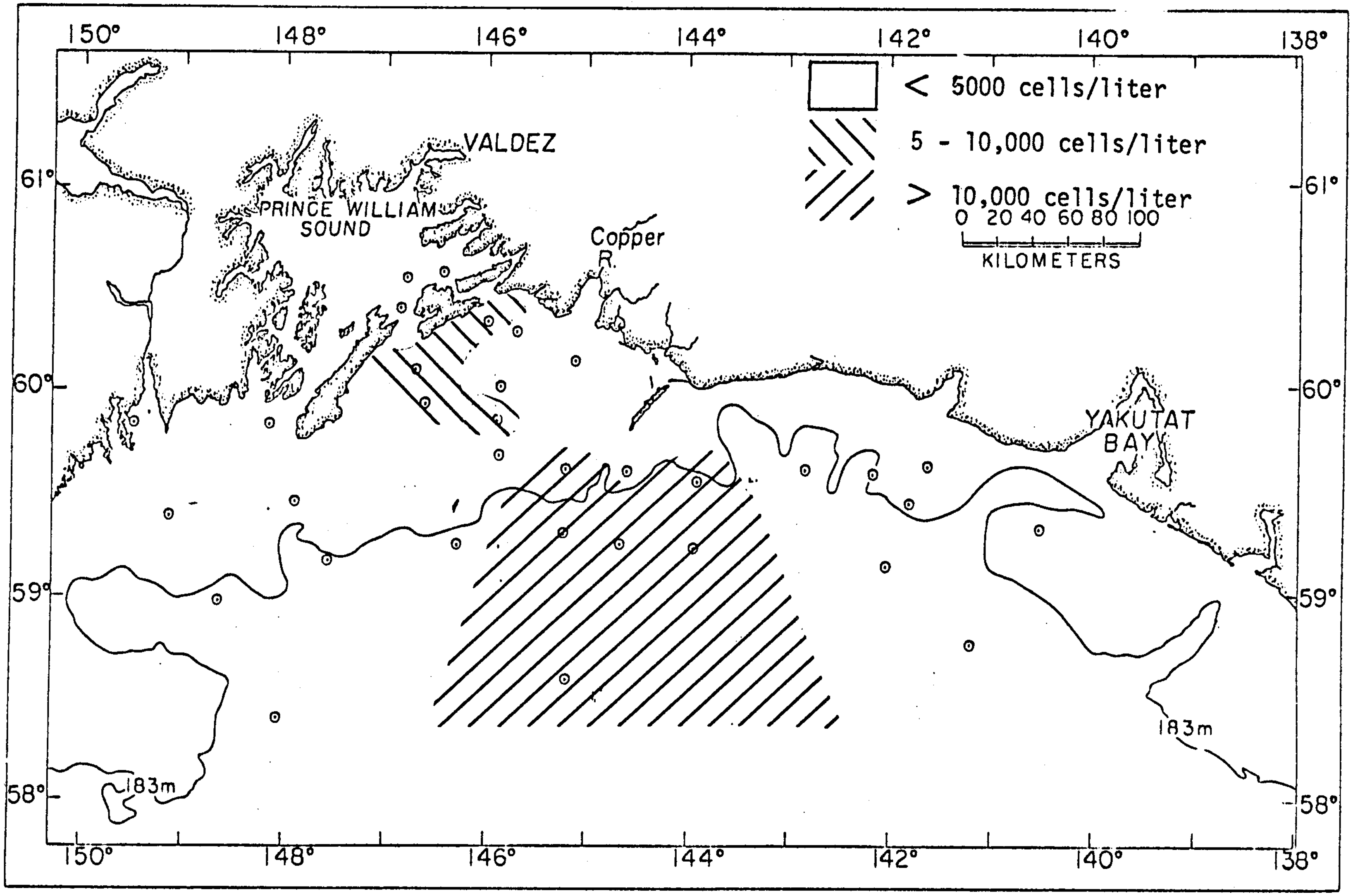

Figure 4. Distribution of micro-flagellates at 10 m, October - November, 1975.

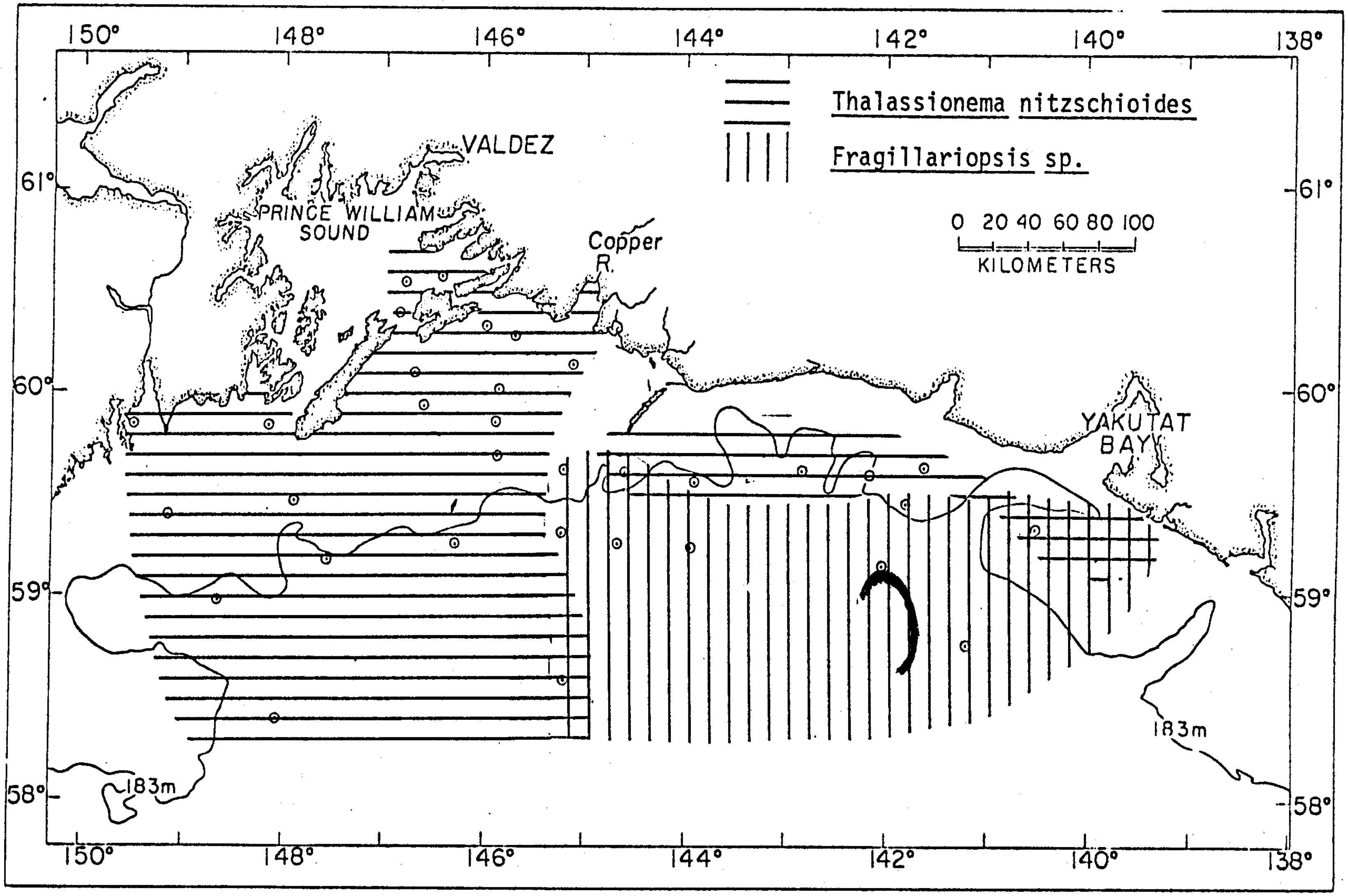

Figure 5. Distribution of Thalassionema nitzschioides and Fragillariopsis sp. at 10 m, October - November, 1975.

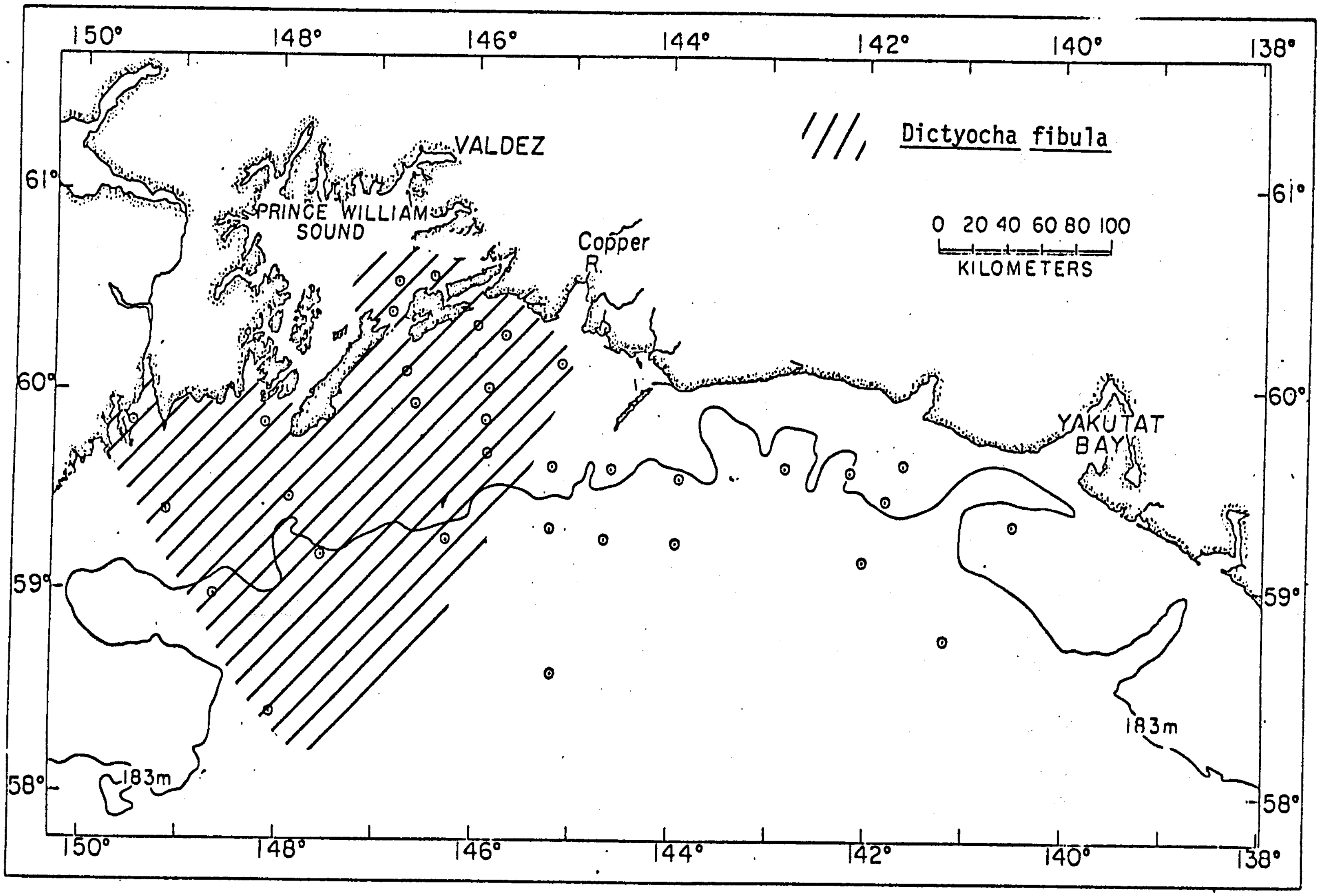

Figure 6. Distribution of Dictyocha fibula at 10 m, October - November, 1975.

concentrations were as high as 21,000 cells/L offshore (station 5) and averaged 4900 cells/L for all stations.

The distributions of substantial quantities of two species, *Thalassionema nitzshioides* and *Fragillariopsis sp*., were nearly mutually exclusive (fig. 5). These distributions are based on population densities greater than 100 cells/L; lower concentrations were not considered. *T. nitzschioides* averaged 2000 cells/L among those samples in which it was found and reached a maximum of 9400 cells/L. The mean concentration of *Fragillariopsis* was 1700 cells/L and ranged up to 5300 cells/L. Both species occurred simultaneously at only three stations.

Two other major species appeared to have distinct distributions. The silicoflagellate *Dictyocha fibula* was limited to the western portion of the study area (fig. 6). *Skeletonema costatum* was found only in Prince William Sound where it was responsible for the large bloom at station 40. The concentration at 5 m was $1.7 \cdot 10^6$ cells/L. The populations in Prince William Sound were almost all diatoms as contrasted to the other areas where flagellates were always a large proportion of the community.

VII. DISCUSSION

Data from the one cruise completed describes phytoplankton populations and abundances and their production only in the fall season. Because phytoplankton communities normally display short-term changes in their composition of species and in levels of production, conditions at other seasons can be expected to be very different. To obtain an "adequate" baseline of phytoplankton and primary productivity in an area, observations must be made at intervals frequent enough to determine the sequence of major events such as initiation of blooms, change in dominant species, depletion of nutrients, etc. In the coming months we hope to describe the spring and summer succession of species and production in the Lower Cook Inlet area.

Because the data presented here have only recently become available, they have received no more than a cursory analysis. More phytoplankton samples will be analyzed to provide a more complete picture of the species distributions and assemblages. Computer techniques will be applied to ascertain the environmental factors controlling primary production, although the major factor seems to be available light. Correlations will be sought between productivity and circulation, salinity, temperature, etc., to better explain the occurrence and production of phytoplankton. For the present, the few interpretations discussed here shall be considered tentative.

The significant difference between primary productivity in the nearshore area east of Prince William Sound and the remainder of the area (fig. 2) may be explained by suspended particulate matter distributions. Values are given in table 3 for mean 1% light depths (determined from Secchi disk readings) and corresponding suspended matter and productivity. The suspended matter data were kindly provided by Dr. Richard Feely of our Laboratory, whose field studies were conducted concurrently with ours. The high total suspended particulate matter at the surface correlated with low productivity and with a shallow euphotic zone (table 3).

Table 3. Mean values of 1% light depths, total suspended matter (TSM) in the upper 20 m, and daily primary production at three nearshore and five offshore stations

	1% light depth (m)	TSM (mg/L)	Productivity (mgC/m^2 day)
Nearshore	16	1.12	163
Offshore	34	0.31	538

These data suggest that the nearshore waters east of Prince William Sound contained large amounts of suspended matter draining from nearby glaciers in the Icy Bay and Copper River drainages which caused high attenuation of light in the water, and thus lowered primary productivity.

A comparison of the suspended matter and chlorophyll distributions indicates that a smaller proportion of the high suspended matter concentrations in the nearshore area was attributable to phytoplankton than in the offshore area. An inverse correlation existed between the two, similar to that between primary production and suspended matter. The mean chlorophyll _a_ concentration was 16 mg/L in the upper 50 m at those stations where suspended matter was greater than 1.0 mg/L and in the remainder of the area (except Prince William Sound) the chlorophyll averaged 24 mg/L. Although these numbers have not yet been statistically analyzed, it appears, tentatively, that the correlation will hold up under more rigorous treatment.

The phytoplankton are likely to be affected by oil contamination (if it occurs) in two major ways: toxic effects and depression of primary production through reduction of available light by surface oil slicks and films. The present data can be useful in estimating the extent of -vic effects if they are interpreted with results of laboratory or field "challenge" type experiments and with knowledge of likely physical dispersion. The time required for repopulation of an area after contamination is an essential facet of such estimates as well as the quality (species composition) of the new population. Estimation of the effect on production caused by increased attenuation of light can be approached through further treatment of the available data. Phytosynthesis-light relationships which can be approximated using the present data, should provide a key to estimating the impact on the phytoplankton populations caused by less available light.

VIII. CONCLUSIONS

The conclusions summarized here must be regarded as tentative for reasons discussed in the previous section.

1. Primary productivity in the northern Gulf of Alaska during mid-autumn was on the order of 400 mgC/m^2 day.

2. The chief environmental factor controlling primary production at this season was intensity of light available to the cells.

3. Primary productivity was inhibited in nearshore areas influenced by runoff where suspended matter loads were high. The suspended matter increased light attenuation which decreased the euphotic zone and, hence, primary productivity.

4. Nutrient concentrations were sufficient to sustain high rates of primary production.

5. Several unidentified species of microflagellates were dominant in the phytoplankton populations of the Gulf. Two diatoms, _Thalassionema nitzshioides_ and _Fragillariopsis sp_., appeared to have nearly mutually

exclusive distributions. *Dictyocha fibula*, a silicoflagellate, occurred in substantial numbers only in the western portion of the study area. Diatoms dominated the Prince William Sound populations with *Skeletonema costatum* principally responsible for a local bloom.

IX. NEEDS FOR FURTHER STUDY

The principal requirements for further phytoplankton studies involve frequent observations of production, size, and composition of phytoplankton populations. This approach will be applied to lower Cook Inlet, beginning in April 1976, to document successions of events through spring and summer regarding phytoplankton populations and production. Photosynthesis-light experiments should be performed to provide data for primary productivity models.

Accompanying studies should also be conducted to study the effects of dissolved petroleum fractions (e.g., naphthalene) on carbon assimilation of natural phytoplankton populations. Appropriate experiments could be conducted during scheduled field activities for describing seasonal successions.

In addition to the phytoplankton and net zooplankton investigations, a description of the microzooplankton populations should be made. This group is comprised of organisms too small to be caught by nets and too sparse to be accounted for adequately in the phytoplankton samples. (Seawater samples of about 1 liter are required for representative results.) These organisms can be ecologically significant as grazers where large numbers of small flagellates or other similar sized autotrophs are the chief constituents of the primary producers.

Analyses of the results from the descriptive studies mentioned above must be made for the purpose of estimating the impact of oil contamination on the phytoplankton populations and indirectly on grazers and animals higher in the food web.

X. SUMMARY OF 4th QUARTER LABORATORY ACTIVITIES

No shipboard activities have been conducted since November 1975. The activities outlined below apply to laboratory analyses since January 1, 1976.

1. Scientific staff

   Jerry Larrance, Principal Investigator
   David Tennant, Primary productivity, logistics, oversees technicians
   Patricia Ruffio, Taxonomic Technician
   Mona Beckert, Taxonomic Technician (part-time)
   Alex Chester, Data analysis (part-time)

2. Methods--see main body of report.
3. Samples analyzed in laboratory
   - a. Phytoplankton samples analyzed: 46.
   - b. Carbon-14 samples analyzed by liquid scintillation techniques: 613.
   - c. Nutrient (nitrate, nitrite, ammonia, phosphate, and silicate) samples analyzed: 459.

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ZOOPLANKTON AND MICRONEKTON STUDIES IN THE BERING - CHUKCHI/BEAUFORT SEAS

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SUMMARY

This report details progress and results from field studies initiated in May-June, 1975, as one part of the overall BLM/NOAA environmental assessment of Alaska's continental shelf. The distribution, abundance, and species composition of the zooplankton and micronekton communities of the southeastern Bering Sea are discussed in as much detail as the data set permits, with emphasis on the late summer season.

The preliminary analysis of the summer data reveals a close similarity with long term (15 year) observations reported by Japanese workers for this region. However, the detailed spatial resolution of the present study permits a more refined view of certain distributional properties. A well-defined "discontinuity" in species composition appears at mid-shelf in central Bristol Bay; few oceanic species are encountered as adults, but east of this location larvae and juveniles are present. It is surmised that physical oceanographic measurements taken at this time but not yet available will substantiate the presence of a boundary feature at this location.

Since the zooplankton community includes the early life history forms of most commercially valuable or subsistence species in the Bering Sea and provides forage for higher trophic levels, the implications of offshore oil development are certainly obvious. In this regard, critical times of year, locations, and biological associations which define the "survival windows" for selected species must be understood before hypotheses describing the most probable impact can be structured.

INTRODUCTION

This investigation is one of several baseline characterizations of the living marine resources in the waters adjacent to and over Alaska's continental shelf. The unobtrusive pelagic fauna, the zooplankton and micronekton, forms a diverse and abundant assemblage of small animals most of which is supported directly by water column plant production. Ecologically, this sector of the pelagic community in turn provides forage for higher order consumers through a web of trophic relationships culminating in a variety of larger species, some being of subsistence, economic, or esthetic value.

The purpose of this study was to determine the most probable effects of offshore and coastal oil development on the animal plankton and small nekton portions of the pelagic community in the Bering Sea and the subsequent ramifications of such effects particularly as they may be reflected in higher trophic levels. This evaluation is theoretically possible only after the specifics of biological dependencies and tolerances to physical factors are understood. As a basis for this understanding, the following specific objectives are being pursued during the initial funding period, 1 April, 1975 to 30 September, 1976:

1. Determine seasonal density distributions and environmental requirements of principal species of zooplankton, micronekton, and ichthyoplankton.
2. Determine the relationships of zooplankton and micronekton populations to the edge of the seasonal ice pack as it occurs in the Bering, Chukchi, and Beaufort Seas.
3. Identify and characterize critical regions and habitats required by egg and larval stages of fish and shellfish species.

4. Describe the food dependencies of commonly occurring species of pelagic fishes as this task applies to dielly migrating bathypelagic species.

5. Identify pathways of matter and energy transfer between synthesizers and animal plankton consumers.

6. Summarize the existing literature and unpublished data on the transfer of synthesized organic matter to zooplankton, micronekton and ichthyoplankton.

Presently, the implications regarding problems related to shelf and coastal petroleum development can only be conjecture, since the nature of the interaction between animals and oil is at best poorly understood for only a few dominant species and we are still fairly ignorant of even the normal functioning of the unstressed living system. However, there is cause for concern. With the exception of the marine birds and mammals, the majority of the animals (benthic as well as pelagic) inhabiting the Bering Sea spend some, if not all, of their life history as members of the plankton community. The commerically important shellfishes and finfishes are no exception. Also, it is generally conceded that the numbers of progeny surviving annually to harvestable age for any species are determined during a critical early planktonic phase where survival is related not only to food availability, but also to the timely absence of predators and favorable physical conditions.

The survival ploy exercised by most higher order consumers in this region is to produce seasonally large numbers of floating reproductive products (eggs and larvae), assuring the probable annual survival of a few individuals. Occasionally, exceedingly favorable environmental conditions will allow a species to flourish. This year-class phenomenon is particularly noticeable for commercial species where a single year's progeny may support a fishery at high levels for several seasons. However, since failure of a year class is the normal event, added environmental stress could act to reduce levels of annual recruitment below the ecologically controlled average.

It should suffice to say that the animal plankton and micronekton community supports and includes representatives (life history stages) of most of the animal populations found in the Bering Sea, and as such represents a particularly critical component of this marine ecosystem.

CURRENT STATE OF KNOWLEDGE

Much of the present state of knowledge concerning seasonal distributions of zooplankton and micronekton in the Bering Sea has been summarized in Hood and Kelley (1974) and Hood and Takenouti (1975). Although U.S. workers have been active in northern ocean studies, most of the recent descriptive information concerning the pelagic community is the result of Japanese efforts in conjunction with hydrographic and high-sea fishery surveys, 1956-1970. The buik of these data is now available as generalized distributional maps for dominant species or composites occurring in the near surface (shelf) water during the summer season. The net zooplankton biomass is consistently highest over the shelf in the eastern Bering Sea (Fig. 1).

Motoda and Minoda (1974) report the spatial characteristics of several zooplankton and micronekton species in the Bering Sea. A typically northern

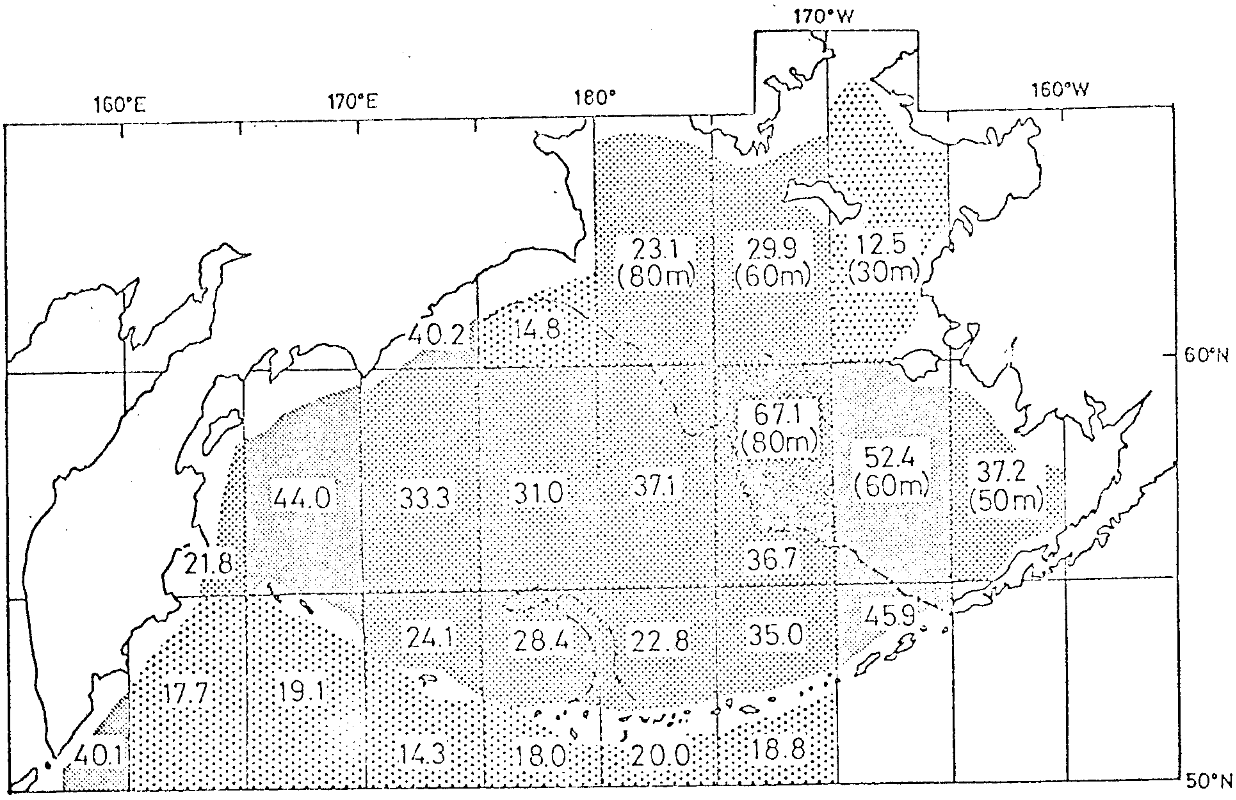

Figure 1. Average summer zooplankton biomass for 15 years from 1956 to 1970 in each 5-degree grid. Values are expressed in wet wt g/m^2 in 80-m water column (Motoda and Minoda, 1974).

Pacific oceanic community is described for the deep water south of the shelf break grading through a mixed assemblage to more neritic species occurring over the shelf to the north and east (Figs. 2, 3, 4). The southeastern Bering Sea appears to be very complex in this respect, probably reflecting the nature of the oceanographic circulation and interaction with the north Pacific through the Aleutian passes to the south. For reasons not fully understood, the immense area of the shelf, the water circulation patterns, and possibly the presence of seasonal sea ice interact to make this region one of the most productive in the world.

Trophic relationships are exceedingly complex in any marine system and the pelagial system of the southeast Bering Sea is no exception. Most organic matter synthesis occurs in the water column as a short period pulse during the oceanographic spring season, but a "benthic" algal community developing on the undersurface of the sea ice in late winter together with seagrasses and nearshore epibenthic algae also contribute to the overall annual production. McRoy and Goering (1975) estimate the total shelf primary production to be approximately 140 million metric tons of carbon per year. A simple conversion of average wet weight standing stock per square meter to carbon (0.1 x wet weight) for net zooplankton provides an estimate of 5.2 million metric tons at this level consuming probably no more than 50 million tons of plant matter or about one-third of the yearly production. Thus, much of the organic matter synthesized in the water column (perhaps nearly two-thirds) is available for benthic filter and deposit feeders. Indeed, the shelf benthos is very abundant in the Bering Sea.

Measurements of secondary productivity are nearly non-existent for this region, although the very obvious populations of sea birds and

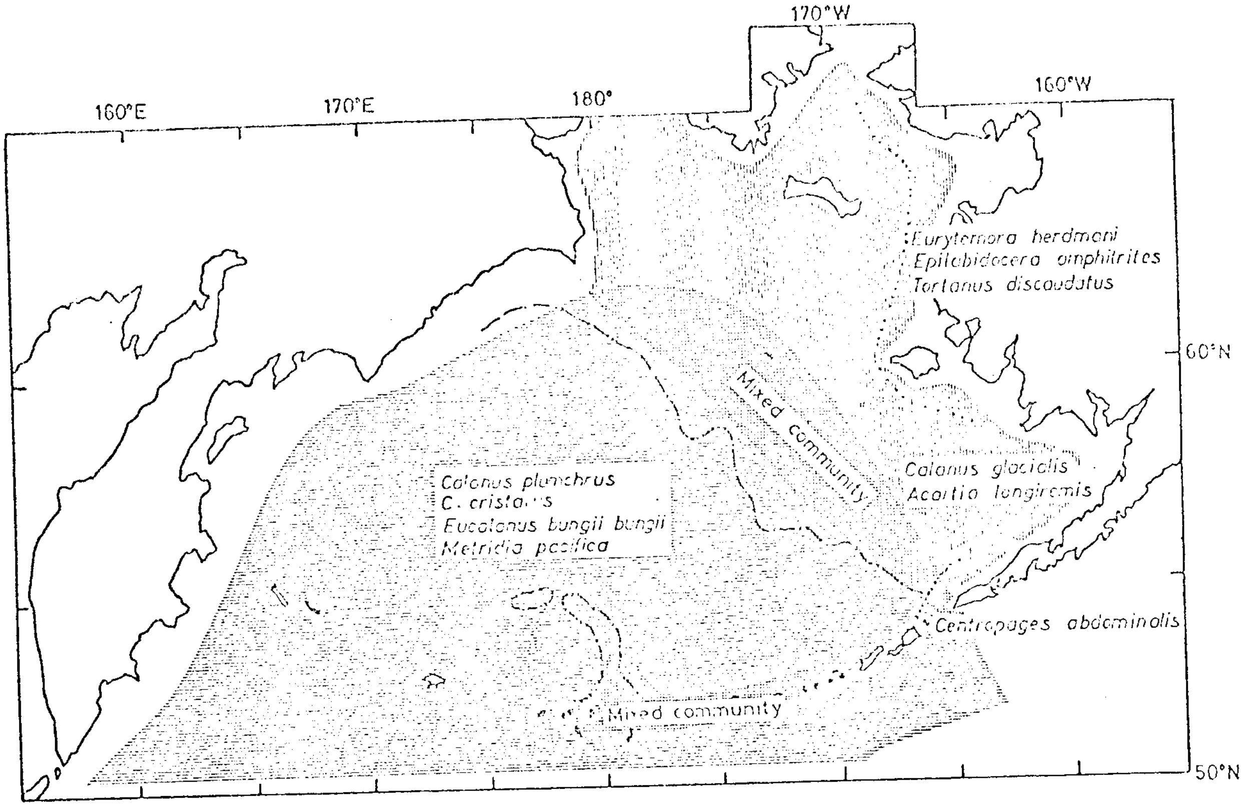

Figure 2. Composite figure showing regional characteristics of species composition of copepod communities in the upper water in early to mid-summer (Motoda and Minoda, 1974).

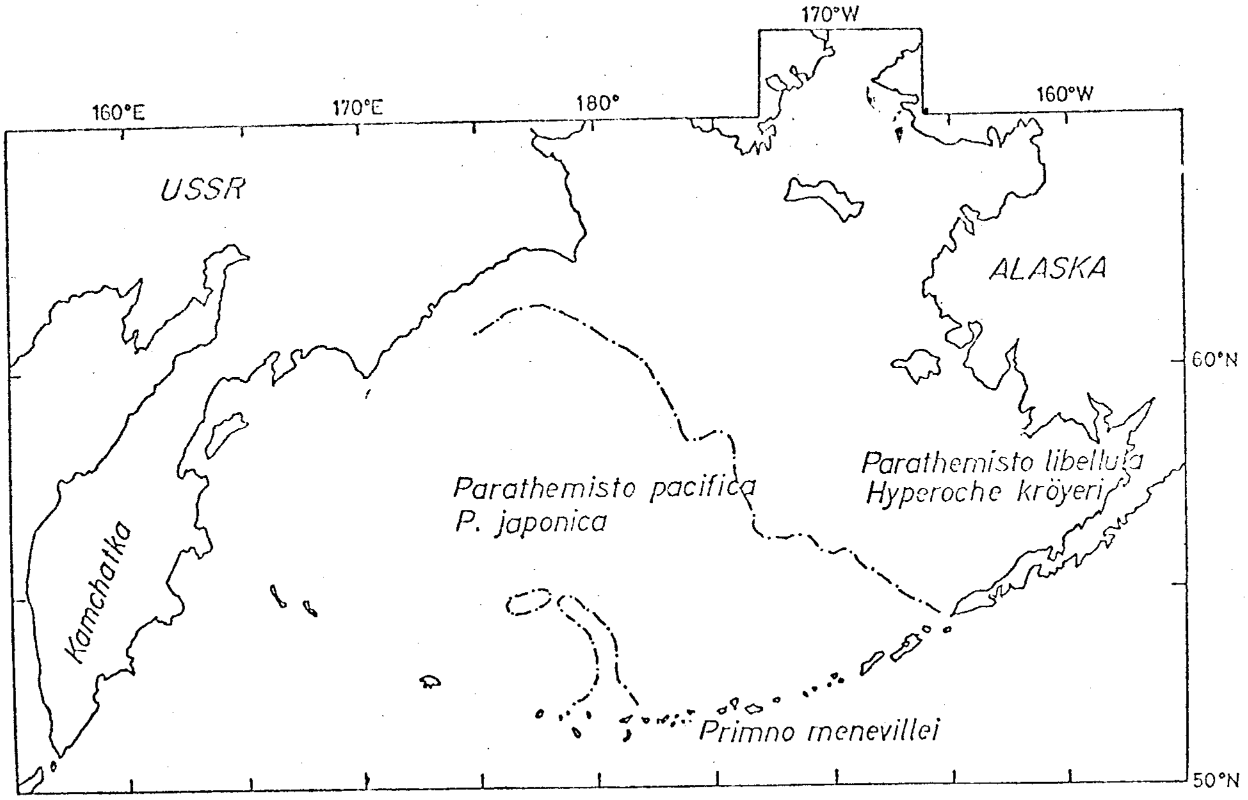

Figure 3. Regional difference in dominant species of amphipods in early to mid-summer (Motoda and Minoda, 1974).

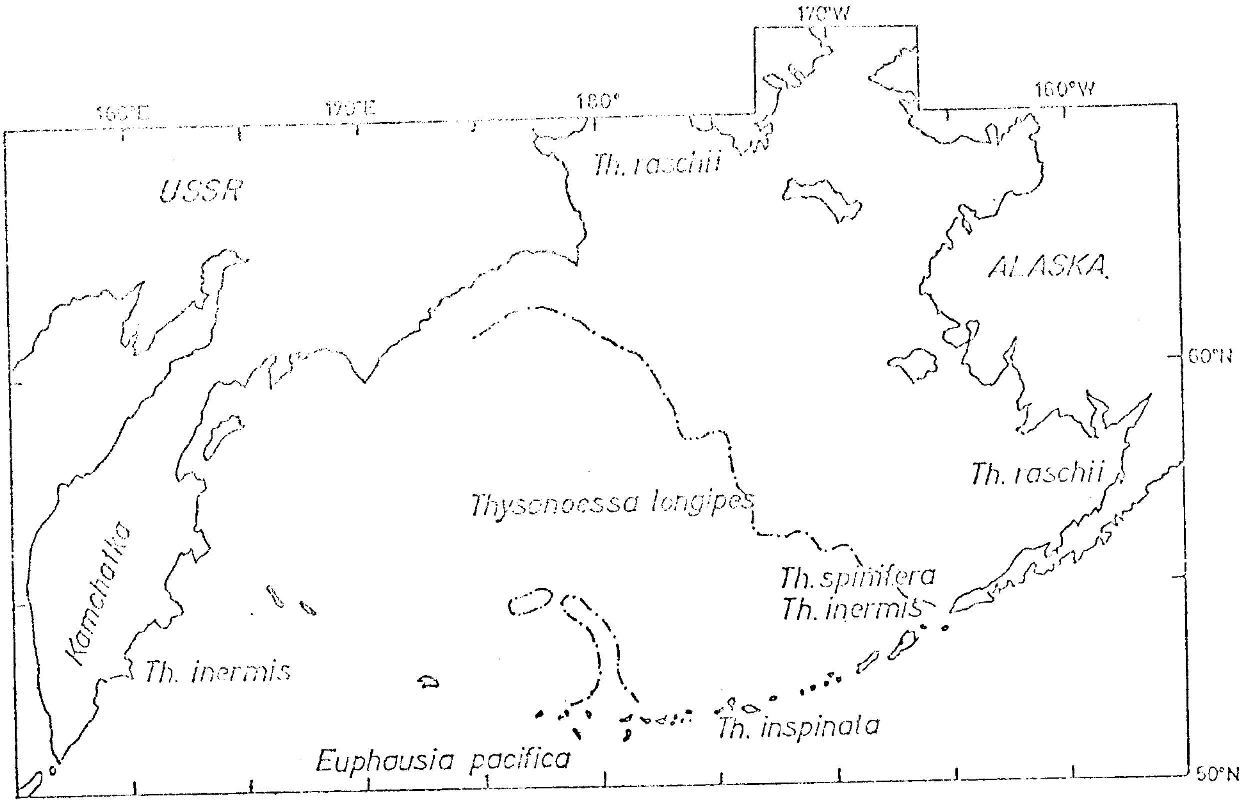

Figure 4. Regional difference in dominant species of euphausiids in early to mid-summer (Motoda and Minoda, 1974).

marine mammals, coupled with the size of the historical commercial fisheries catch suggests a very efficient transfer mechanism to higher trophic levels. This problem will be the focus of an international study of processes and resources of the Bering Sea shelf (PROBES) scheduled to begin in the spring of 1976.

STUDY AREA

Zooplankton and micronekton are being studied in a specific region of the southeast Bering Sea including Bristol Bay north to Nunivak Island and west to the open ocean adjacent to the Pribilof Islands (Fig. 5). For comparative purposes this region has been arbitrarily subdivided into two major areas which in turn have been further divided into eight statistical sub-regimes (Fig. 6).

In addition to this specified area of study, collections and experiments are being conducted at the edge of the seasonal ice pack as it occurs in the Bering Sea during the spring and fall seasons.

SOURCES, MATERIALS AND METHODS

The field program described here, and the subsequent analysis of data (following completion of the March-April, 1976 cruise) is based on the powerful statistical procedures of Analysis of Variance and Cluster Analysis. In a general sense I have randomly sampled specified (fixed) spatial strata on a periodic basis. Sampling error will be estimated from a subset of replicated (time and space) observations selected from all strata and periods; gear types will be treated separately. Count data

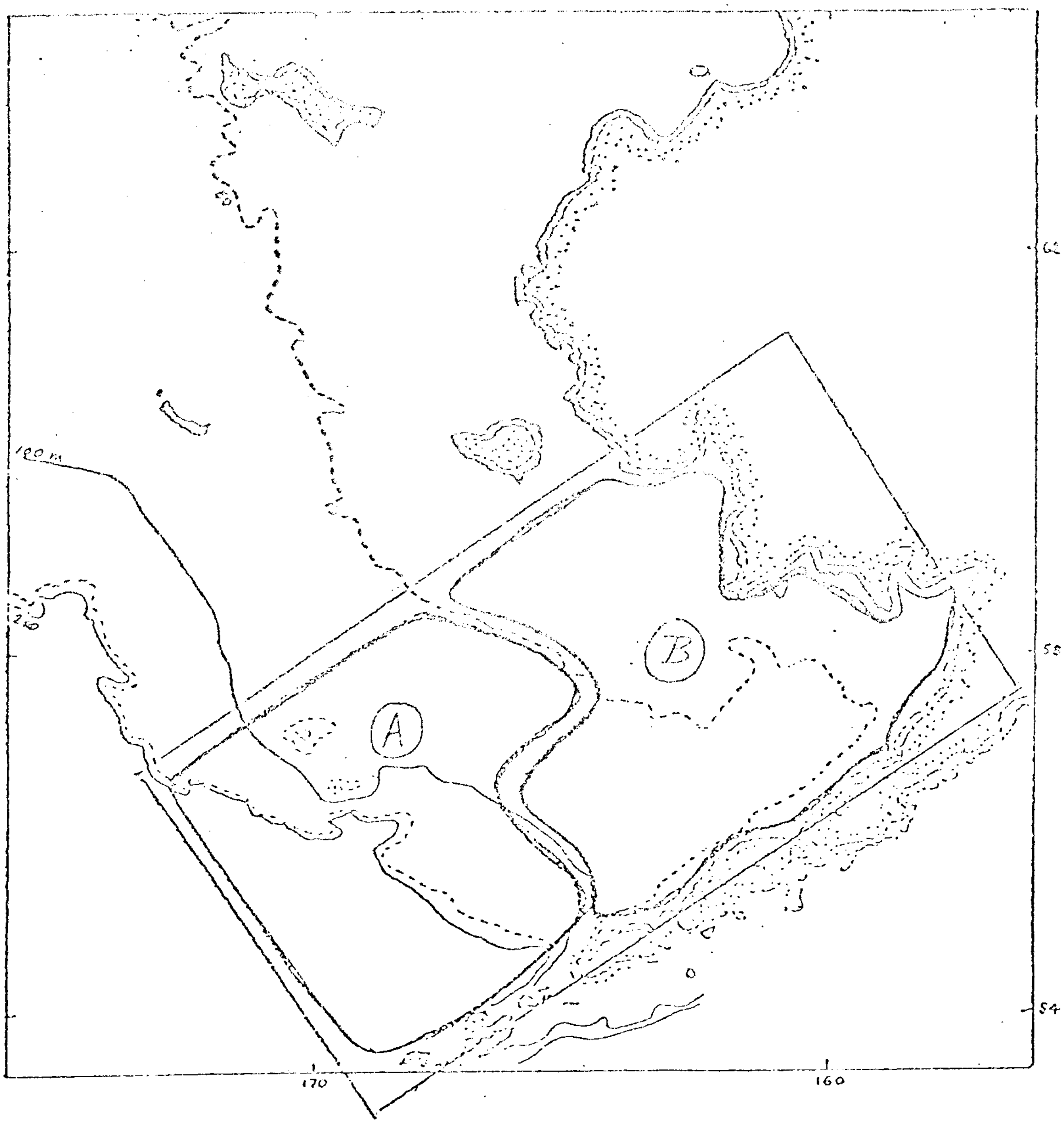

Figure 5. The study area in the southeastern Bering Sea.

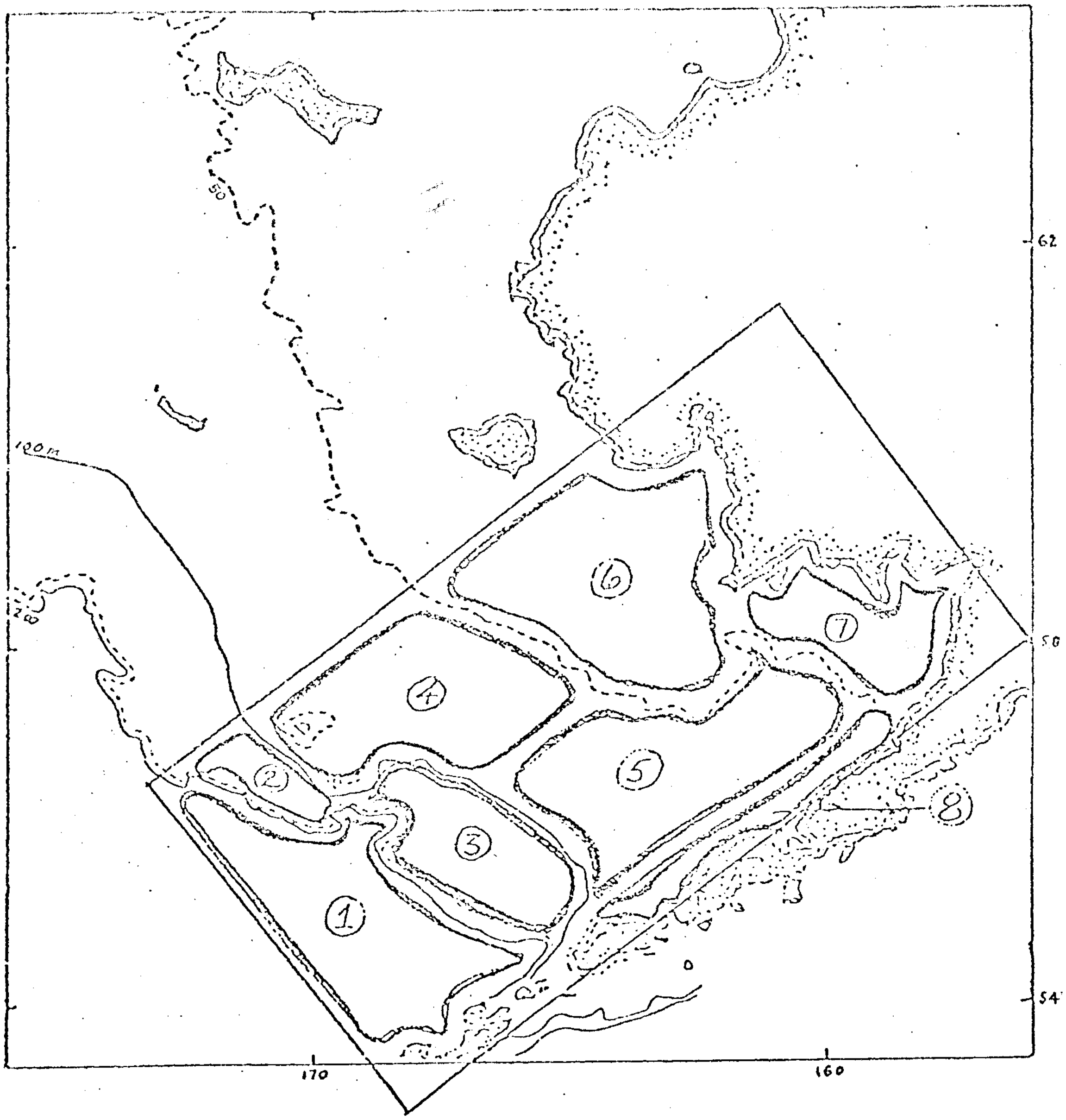

Figure 6. Major study sub-regimes in the southeastern Bering Sea.

(numbers per m^3 or m^2) will be transformed by base 10 logarithms, a technique commonly used to stabilize the variance in cases where standard deviations and means tend to be proportional rather than additive.

The specific design for the two field studies is as follows:

1) Zooplankton and micronekton studies in the southeastern Bering Sea.

Two regions of this area as described above will be examined: the St. Matthew Basin and Bristol Bay (Fig. 5). Four subareas have been selected on the basis of depth within each of these regions for detailed study (Fig. 6). These subareas include three nearshore or coastal regimes (depths less than 50 m, denoted as 6, 7, and 8), central Bristol Bay (subarea 5; 50-100 m deep), one oceanic regime (subarea 1; > 200 m), two shelf break regions (subareas 2 and 3; 100 - 200 m) and a central shelf area north of the St. George Basin (subarea 4; 50 - 100 m).

Within these eight subareas, samples are being taken using a 1-m diameter net (0.333 mm Nitex mesh) fished vertically through the water column between the sea surface and 10 m above the bottom. Catches are preserved in 5-10 percent buffered formalin-sea water and returned to the University of Alaska Marine Sorting Center for processing.

The number of samples per subarea is tentatively specified in each cruise plan. Early critiques of planned OCS zooplankton work suggested levels of effort sufficient to detect real differences of one-half order of magnitude or more. On the basis of previous experience (Cooney, BLM/NOAA Northern Gulf of Alaska, 1975), between 6 and 10 observations per subarea will likely be necessary to approach this precision on each cruise. Once a suite of subarea data is on hand, the appropriate statistical analyses will be used to evaluate the sufficiency of this design and appropriate changes made.

Dielly migrating bathypelagic fishes and other micronekton are sampled in the upper 75 m of the water column by fishing a 2-m NIO Tucker trawl after dark at specified locations. The net is lowered open to depth and then retrieved with the vessel underway at 3-4 knts. A flowmeter in the mouth of the trawl is used to determine volumes filtered. A bathykymograph has been used on occasion to establish an average maximum fishing depth to wire-out relationship.

Sample processing is conducted according to accepted procedures. Since large volumes of water are filtered at sea (thousands of m^3) individual catches often contain many more organisms than can be directly counted. These collections are examined in their entirety for the obvious and usually rarer organisms (i.e. bathypelagic fishes, large shrimps, squids, etc). Following this screening, a portion of the sample (one-half, one-fourth, etc.) will be archived for future reference. The remaining fraction will be sorted to remove all zooplankters except copepods and perhaps chaetognaths. These latter taxa will be enumerated and identified in even smaller subsamples of 100 - 200 organisms.

This technique provides estimates of numbers of animals per sample for numerically dominant species, and direct counts for the larger, rarer organisms. Identification of specimens will be taken to genus and species whenever possible. Taxonomic verification is coordinated with workers sampling the northern Gulf of Alaska for plankton and micronekton.

2) Zooplankton and micronekton studies near the edge of the seasonal icepack as it may occur in the Bering, Chukchi, or Beaufort Seas.

Zooplankton and micronekton are sampled directly at the ice-edge using nets and trawls, and indirectly using a portable high-frequency acoustic data acquisition system. Animals in the size range 0.3-10.0 mm are censused with 1-m nets fished through selected strata between the sea bed and the surface. The larger organisms, 10.0 - 100 mm, are taken in 2-m Tucker trawl tows.

A high-frequency (100 kHz) recording (precision echogram; magnetic tape) echosounder will be operated in March-April, 1976, to obtain quantitative sonic data for correlation with observed animal plankton and micronekton standing stocks. Measurements of acoustic volume-scattering intensity, corrected for distance from the transducer and gated for specific depth intervals, will be the parameter of initial interest. Additional signal processing will be undertaken using computer software when it becomes desirable to reduce large numbers of observations to discrete estimates of standing stocks measured along continuous transects adjacent to and along the ice edge.

Organic matter pathway information describing exchange between primary producers (phytoplankton) and pelagic grazers will be obtained from shipboard culture experiments in cooperation with Dr. Alexander and her associates. Representative samples of naturally occurring plant cells (composites from several depths or discrete portions of the water column based on chlorophyll profiles) will be incubated with subsamples of the grazing community (from net tows) and the relative change in cell abundance by species used as a measure of selective feeding (manual counting or Colter counter system augmented with direct identification and enumeration).

As described in Task A-22 of the O.C.S.E.P. study proposal, a literature search is presently under way to compile a bibliography of published and unpublished information concerning energy transfer from primary producers to zooplankton, micronekton, and nekton in Bering Sea ecosystems. The efficiency of energy transfer is determined by ecosystem diversity, maturity, and stability and has been estimated on the basis of measurements of physiological processes (such as grazing rates, assimilation rates, excretion rates, etc.) in individual organisms, and productivity in populations. As a result, contributions to the body of knowledge have come from nearly all fields of scientific discipline and the literature search must therefore include a considerable number of data sources. This search has been implemented by: a computer search of Biological Abstracts (1972 to present) and B.I.R.S. (1964 to present) through the N.O.A.A. OASIS program; a search of Biological Abstracts (1926-1950) and Zoological Record (all years available) at the University of Alaska and the University of Washington (Seattle); and communication with individuals from several of the organizations involved in past and present studies of Bering Sea ecosystems. So far, 56 pertinent references have been identified; approximately 350 additional potentially important sources need to be examined.

RESULTS

To date, three cruises addressing the study objectives as outlined have been successfully completed. These include Legs I and II of the *Discoverer* cruise in May-June, 1975, Leg I of the *Discoverer* cruise in August, 1975, and Leg I of the *Miller Freeman* cruise in November, 1975. These efforts have generated 102 Tucker trawl samples and 229 1-m net tows to provide spatial and seasonal coverage as depicted in Figures 7 and 8. The 1-m net sampled 198 species or other taxonomic categories, while 171 taxa have appeared in the coarser mesh midwater trawl catches (Appendix I and II). Of these, only nine species were consistently numerically abundant in 1-m net tows, while sixteen categories were obvious in the 2-m Tucker trawl (Table 1).

For purposes of comparison with the bulk of the available published (summer) data, some preliminary results for late summer (August, 1975) are presented here. The occurrence and abundance of several numerically dominant zooplankters are examined on a single transect extending from the open ocean south of the Pribilof Islands across the shelf and into the head of Bristol Bay (Fig. 9). This transect intercepts a variety of oceanographic regimes and presumably different sectors of the marine pelagic community. Table 2 lists the species composition for 1-m net samples taken along this transect and grouped by hydrographic subarea. The community in the upper 200 m in the open ocean is slightly more diverse.

Three copepods, *Metridia lucens, Eucalanus b. bungii, and Calanus plumchrus*, occur in densities of several thousand per square meter of sea surface along the transect until the mid-shelf region where they suddenly diminish significantly in abundance (Fig. 10). Two other abundant copepods, *Oithona helgolandica* and *Acartia longiremis*, are found at all stations, although they too exhibit greatly reduced numbers in the vicinity of stations 72 and 83 (Fig. 10). Conversely, *Pseudocalanus* spp. seems to be minimally affected at the same locations. The chaetognath

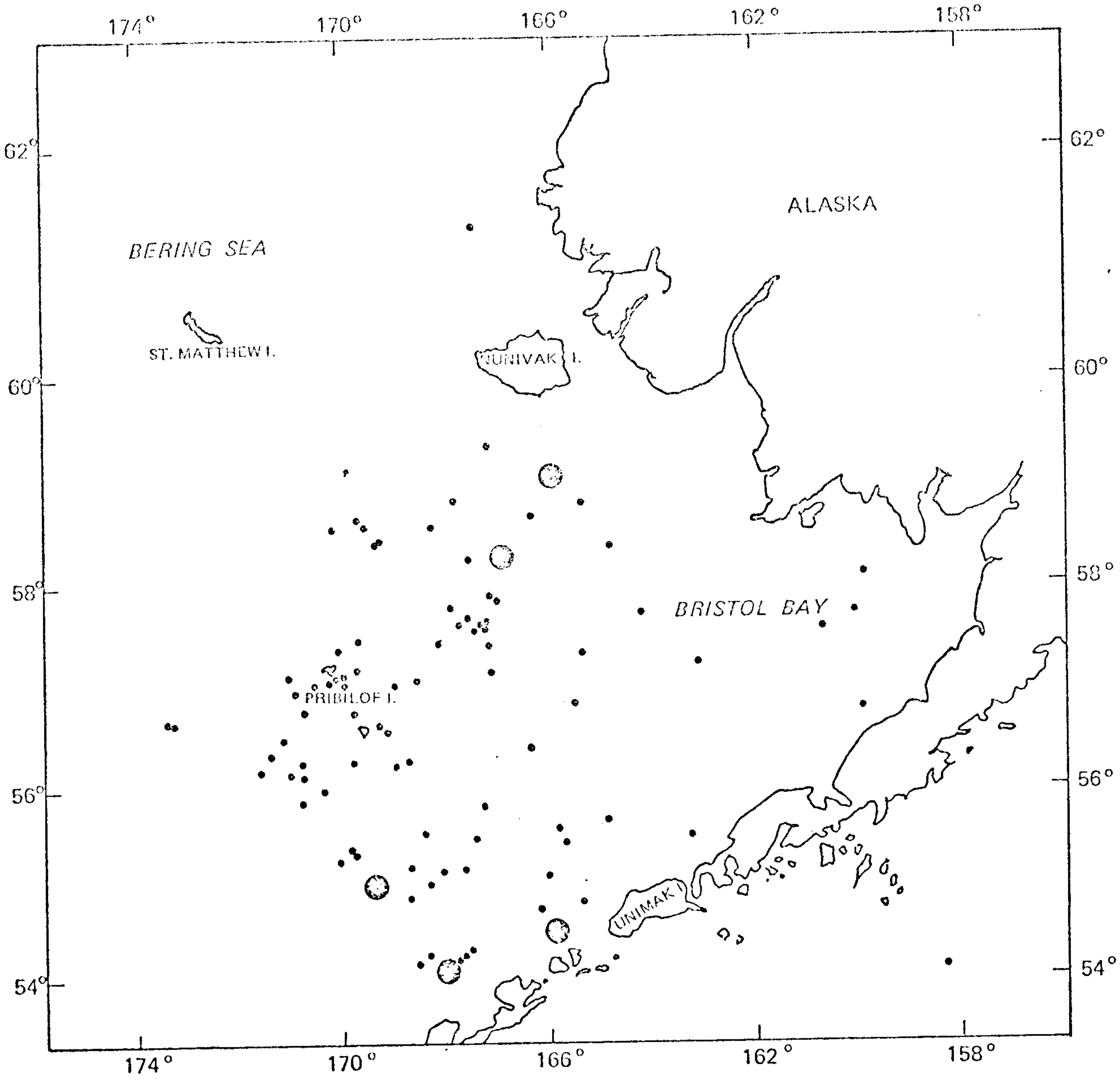

Figure 7. The distribution of Tucker trawl samples in the southeast Bering Sea. Large closed circles indicate locations which have been sampled on more than one cruise.

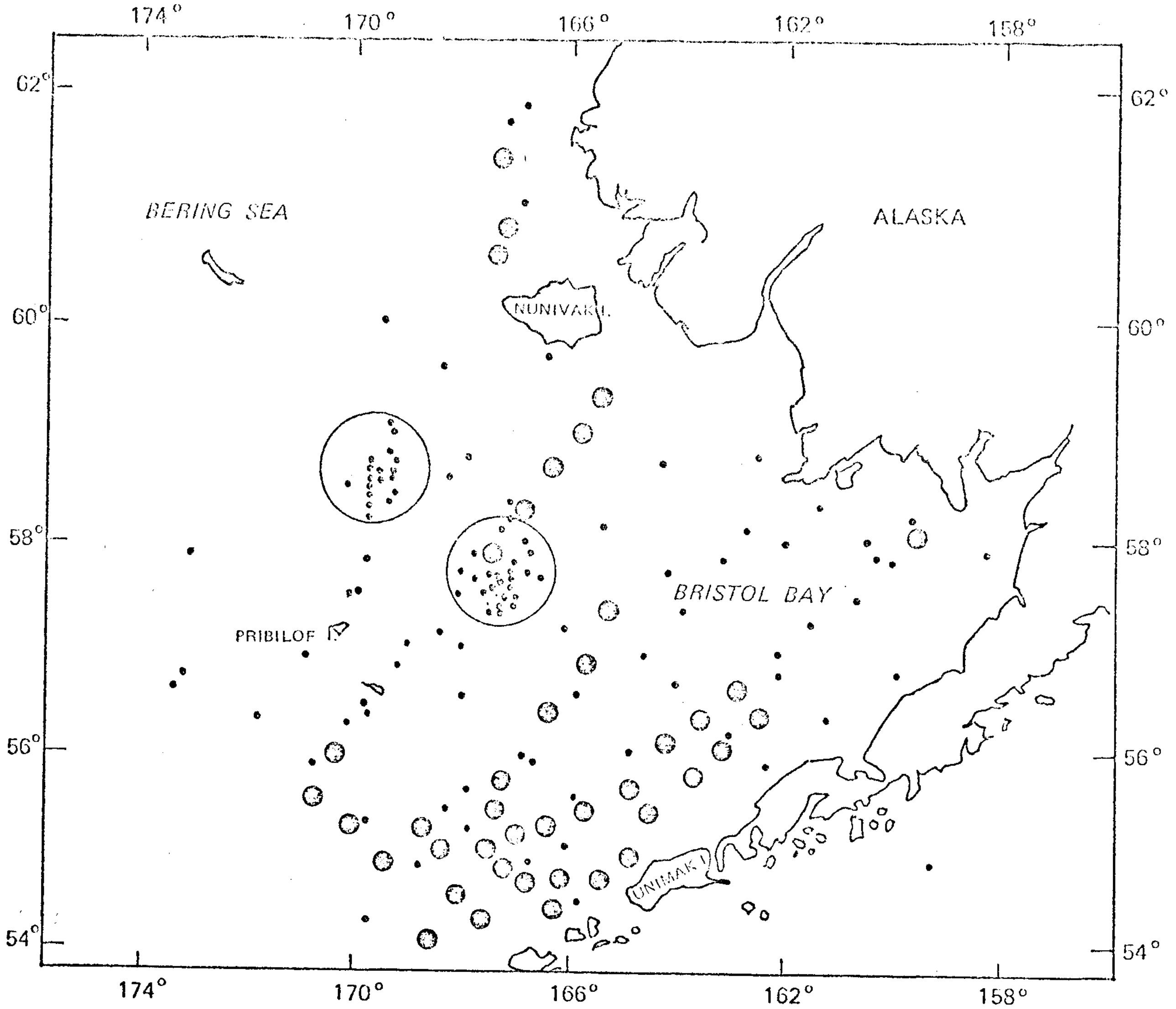

Figure 8. The distribution of 1-m net samples in the southeast Bering Sea. Large closed circles indicate locations that have been occupied on more than one cruise.

Table 1. Numerically dominant species or higher taxa by gear type for samples taken in the southeast Bering Sea, May-June, 1975 and August, 1975

GEAR	TAXONOMIC CATEGORY
1-m net	Copepoda
	Calanus marshallae
	Pseudocalanus spp.
	Eucalanus b. bungii
	Metridia lucens
	Acartia longiremis
	Oithona helgolandica
	Amphipoda
	Parathemisto pacifica
	Euphausiacea
	Thysanoessa raschii
	Chaetognatha
	Sagitta elegans
2-m Tucker trawl	Hydrozoa
	Aglantha digitale
	Chaetognatha
	Sagitta elegans
	Eukrohnia spp.
	Copepoda
	Eucalanus b. bungii
	Euphausiacea
	Thysanoessa raschii
	T. longipes
	Cumacea
	Diastylis bidentata
	Amphipoda
	Parathemisto libellula
	P. pacifica

GEAR	TAXONOMIC CATEGORY
2-m Tucker trawl	Decapoda
	Hymenadora frontalis
	Chionoecetes megalopa
	Oregoniinae zoeae
	Teleostei
	Mallotus villosus
	Reinhardtius hippoglossoides
	Stenobrachius leucopsarus
	Bathylagus stilbius schmidti

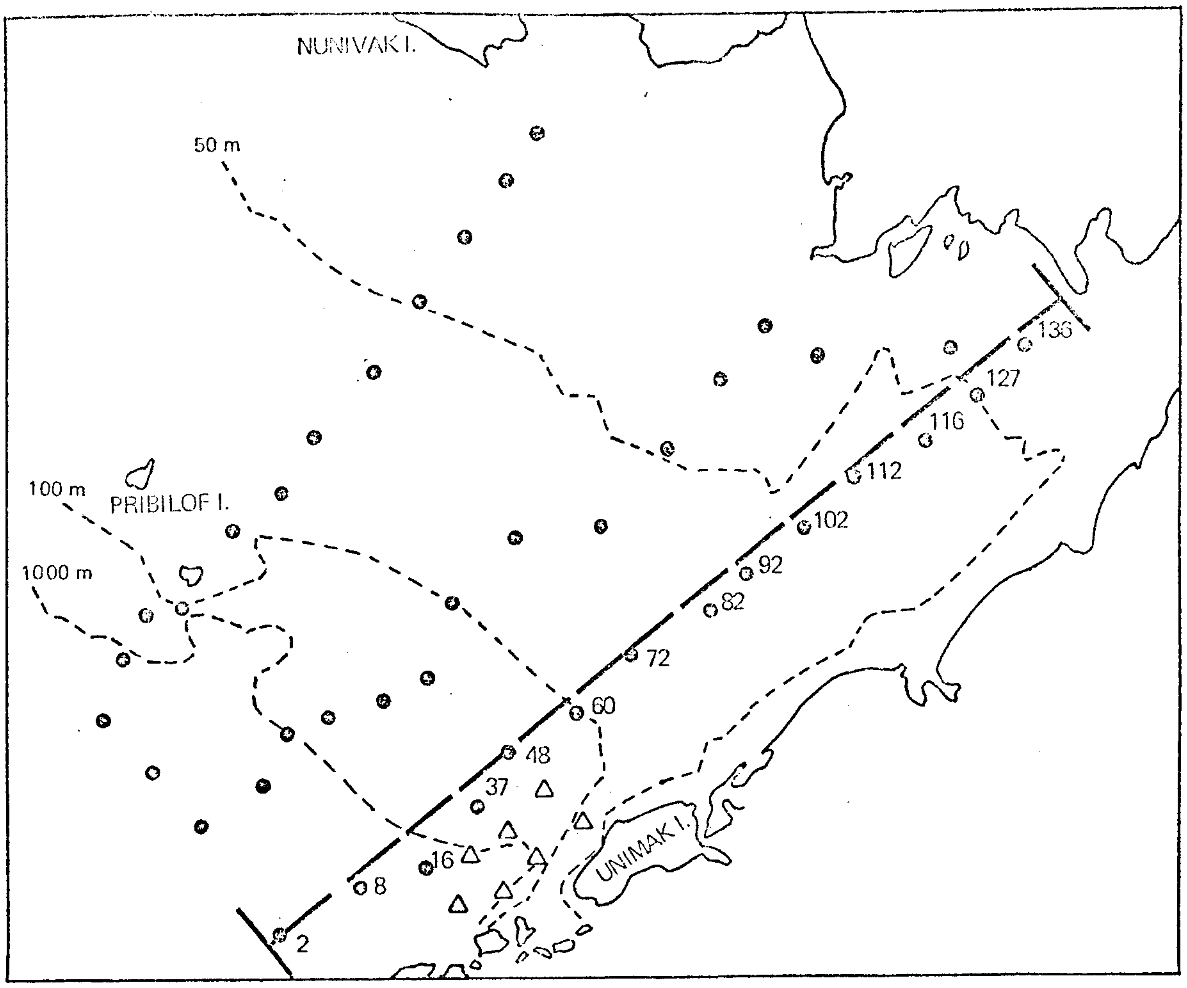

Figure 9. The August, 1975, cross-shelf transect. Numbers refer to oceanographic station name.

Table 2. Species composition by location along the study transect occupied in August, 1975 (see Fig. 9)

	REGIME			
Taxonomic category	Open Ocean Sta. 2,8,16	Shelf break 37,48	Shelf 60,72,82,92 102,112,116	Coastal 127,136
Foraminifera (unident. spp.)	X	X	X	
Hyrozoa				
Perigonimus yoldia-arcticae			X	
P. spp.			X	X
Corymorpha flammea	X	X	X	
Tubularia prolifer			X	
Coryne tubulosa		X		
C. principes		X		
Ptychogena lactea		X		
Eirene indicans				X
Aglantha digitale	X	X	X	X
Aegina rosea	X			
Dimophyes arctica	X	X		
Scyphozoa				
Periphylla hyacinthina	X			
Chrysaora helova			X	
Unident. spp.				X
Polychaeta				
Eteone longa				X
Lopadorrhynchus sp.	X			
Pelagobia longicirrata	X			
Typhloscolex muelleri	X			
Tomopteris septentrionalis	X	X		
Spionidae (unident. spp.)			X	X
Oweniidae (unident. sp.)	X			
Pelecypoda (unident. juveniles)			X	X

	REGIME			
Taxonomic category	Open Ocean Sta. 2,8,16	Shelf break 37,48	Shelf 60,72,82,92 102,112,116	Coastal 127,136
Gastropoda				
Unidentified juveniles	X			
Limacina helicina	X	X	X	
Clione limacina		X		
Gonatidae (unident. juveniles)	X			
Gonatus sp.	X			
Octopodidae (unident. juvelines)	X			
Cladocera				
Podon sp.				X
Evadne sp.				X
Ostracoda (unident. spp.)	X			
Copepoda-Harpacticoid				
Ectinosoma sp.				X
Copepoda-Calanoid				
Calanus cristatus	X	X		
C. glacialis			X	
C. marshallae	X	X	X	X
C. plumchrus	X	X	X	
Eucalanus bungii bungii	X	X	X	
Microcalanus spp.	X			
Pseudocalanus spp.	X	X	X	X
Aetideus pacificus	X			
A. sp.	X	X		
Gaetanus intermedius	X			
Gaidius variabilis	X			
Euchaeta elongata	X			
Xanthocalanus kurilensis	X			
X. sp.	X			

Taxonomic category	REGIME			
	Open Ocean Sta. 2,8,16	Shelf break 37,48	Shelf 60,72,82,92 102,112,116	Coastal 127,136
Calanoid (cont'd.)				
Racovitzanus antarcticus	X			
Scolecithricella minor		X		
S. ovata	X			
Eurytemora herdmani		X		X
Metridia lucens	X	X	X	
M. okhotensis	X			
Pleuromamma scutullata	X			
Centropages abdominalis		X	X	X
Lucicutia sp.	X			
Heterorhabdus compactus	X			
H. sp.	X			
Candacia columbiae	X			
Acartia longiremis	X	X	X	X
A. tumida				
unidentified nauplii			X	
Copepoda-Cyclopoid				
Oithona helgolandica	X	X	X	X
O. spinirostris	X			
Oncaea sp.	X			
Thoracica				
Unidentified nauplii & cypris larvae	X			X
Mysidacea				
Eucopia sp.	X			
Acanthomysis dybowskii				X
A. pseudomacropsis				X
Neomysis rayii				X
N. spp.				X
Cumacea				
Lamprops quadriplicata typica				X

	REGIME			
Taxonomic category	Open Ocean Sta. 2,8,16	Shelf break 37,48	Shelf 60,72,82,92 102,112,116	Coastal 127,136
Cumacea (cont'd.)				
Eudorella pacifica			X	
Diastylis alaskensis				X
Amphipoda				
Photis sp.			X	
Ischyrocerus sp.				X
Koroga megalops	X			
Lepidepecreum comatum		X		
Oedicerotidae (unident. spp.)				X
Monoculodes zernovi				X
Dulichia sp.			X	
Scina borealis	X			
Parathemisto libellula			X	
P. pacifica	X	X	X	
P. spp.		X		
Euphausiacea				
Euphausia pacifica	X	X		
Thysanoessa inermis	X	X	X	
T. longipes	X	X		
T. raschii			X	
T. spinifera		X		
Unident. eggs, nauplii, metanauplii, calyptopis & furcilia stages	X	X	X	X
Decapoda				
Pandalidae (unident. spp.)	X		X	X
Pandalus spp.				X
Hippolytidae (unident. spp.)	X	X	X	X
Crangonidae (unident. spp.)		X		
Paracrangon echinata	X	X		

	REGIME			
Taxonomic category	Open Ocean Sta. 2,8,16	Shelf break 37,48	Shelf 60,72,82,92 102,112,116	Coastal 127,136
Decapoda (cont'd.)				
Paguridae (unident. spp.)		X	X	X
Paralithodes camtschatica				X
Oregoniinae (unident. spp.)		X	X	
Chionoecetes spp.			X	
Hyas spp.			X	
Erimacrus isenbeckii	X			
Asteroidea (unident. spp.)		X	X	X
Ophiuroidea (unident. spp.)	X			
Chaetognatha				
Eukrohnia spp.	X	X		
Sagitta elegans	X	X	X	
Unident. juveniles	X	X	X	X
Ascidiacea				
Unident. eggs & larvae	X			
Larvacea				
Fritillaria borealis	X	X	X	
Oikopleura spp.		X	X	
Unident. juveniles	X		X	X
Teleostei				
Clupea harengus pallasi		X		X
Pleuronectidae (unident. spp.)				X
Unidentified fish eggs	X			X
Unidentified eggs	X	X	X	X
TOTAL	66	43	41	40

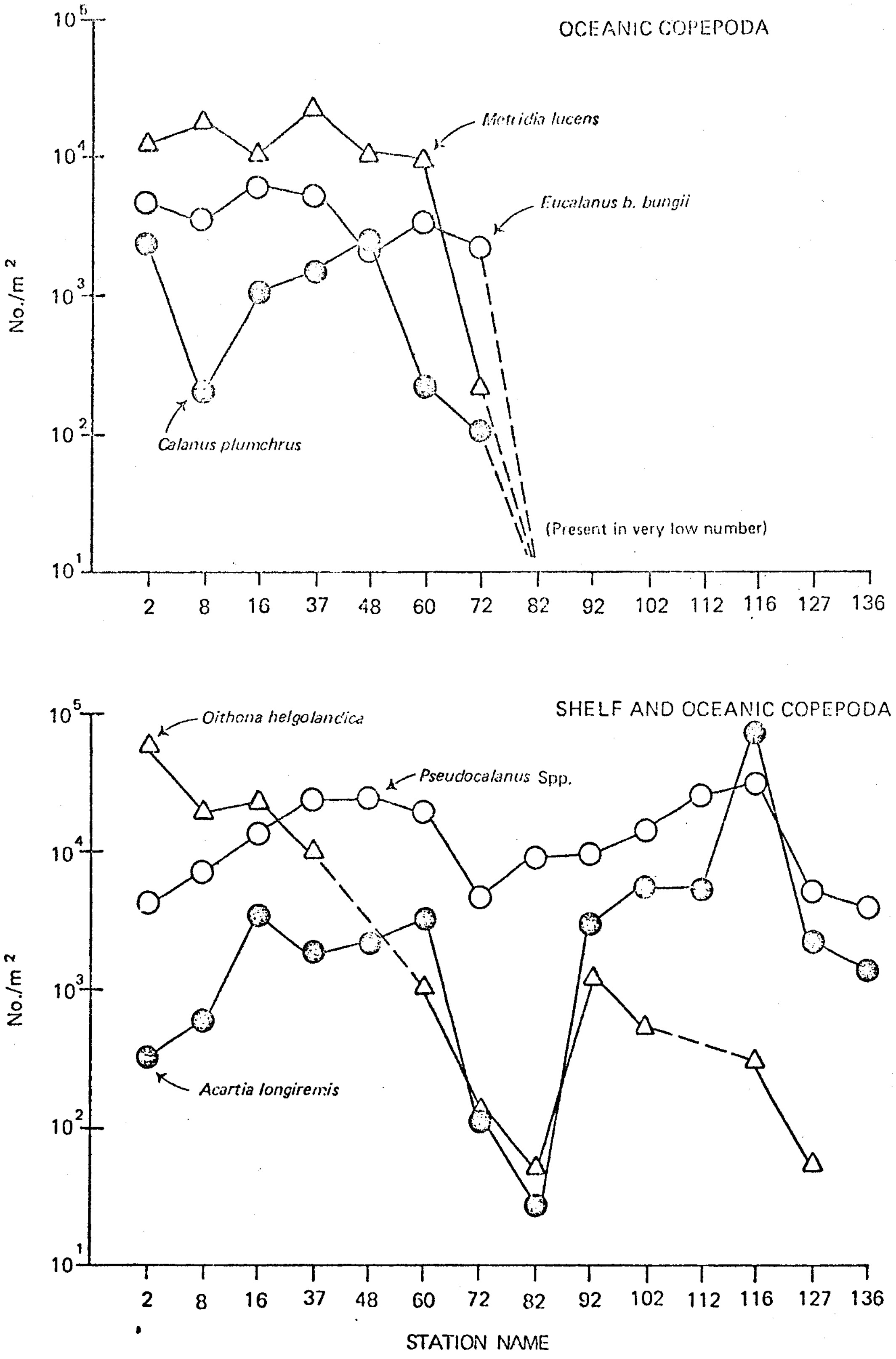

Figure 10. Standing stock by location of selected taxa sampled along the August, 1975 transect.

Sagitta elegans resembles *Pseudocalanus* in this respect, while the oceanic amphipod *Parathemisto pacifica* exhibits a distributional pattern most similar to *Metridia, Eucalanus,* and *Calanus plumchrus* (Fig. 11).

The dominant euphausiids also reflect a distributional preference, with *Thysanoessa longipes* the more oceanic of the group, *T. inermis* preferring the shelf break and outer edge zone, and *T. raschii* found at about midshelf (Fig. 11).

In a two-dimensional spatial sense, the distribution of snow crab larvae, *Chionoecetes* spp. megalops stage, illustrates the patchiness of the early life history forms of this commercial species (Fig. 12). While the larvae are present in small quantities over the open ocean and midshelf, very high concentrations are present only in the area close to the Pribilof Islands.

The lantern fish, *Stenohrachius leucopsarus*, is being routinely collected to describe its trophic involvement in the open ocean and slope regime. Three distinct size classes were taken in night samples during the May-June cruise (Fig. 13) which agree with lengths frequencies reported by Fast (1960) for completion of 1, 2 and 3 years of growth. The spawning season for *S. leucopsarus* off the Oregon coast occurs from December to March (Smoker and Pearcy, 1970); this very likely occurs later in the Bering Sea and would thus coincide with the spring peak in productivity. Larval and juvenile Alaska pollock, *Theragra chalcogramma*, Greenland halibut (turbot), *Reinhardtius hippoglogssoides*, capelin, *Mallotus villosus*, and deepsea smelt, *Bathylagus stilbius schmidti,* also occur in some abundance in the midwater trawl samples.

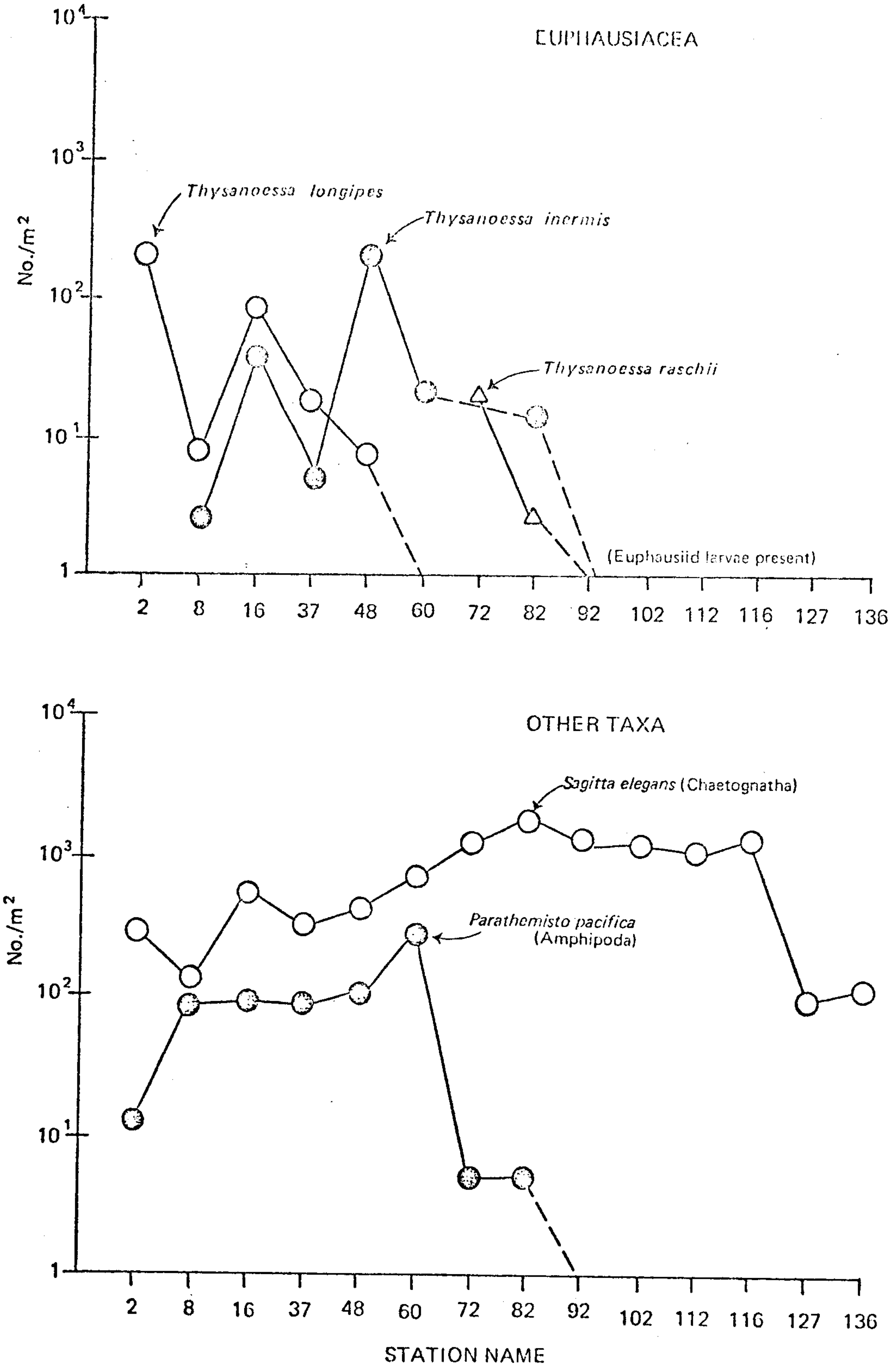

Figure 11. Standing stock by location of selected taxa sampled along the August, 1975 transect.

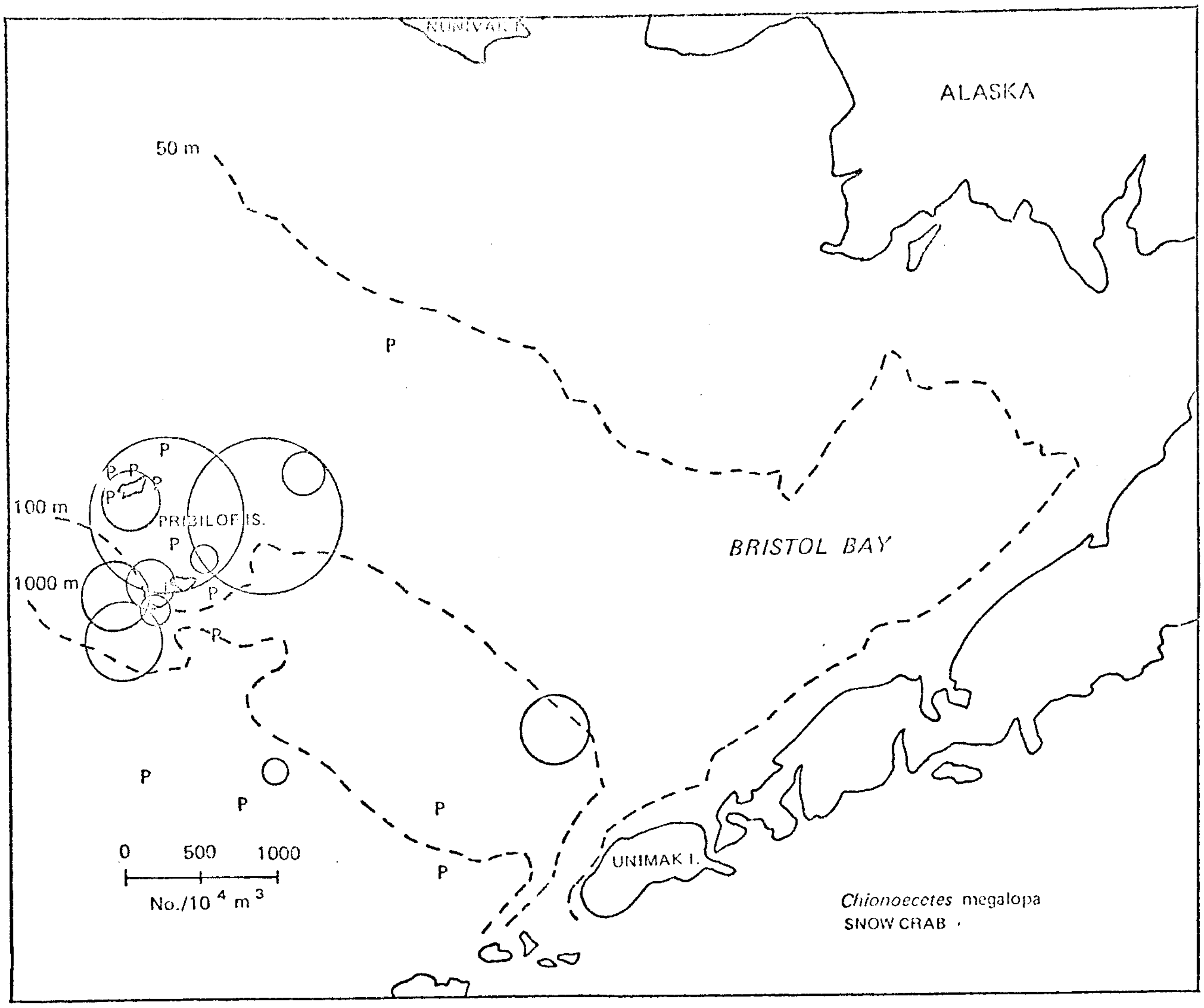

Figure 12. Distribution of snow crab larvae (megalopa) sampled with the 2-m Tucker trawl in August, 1975.

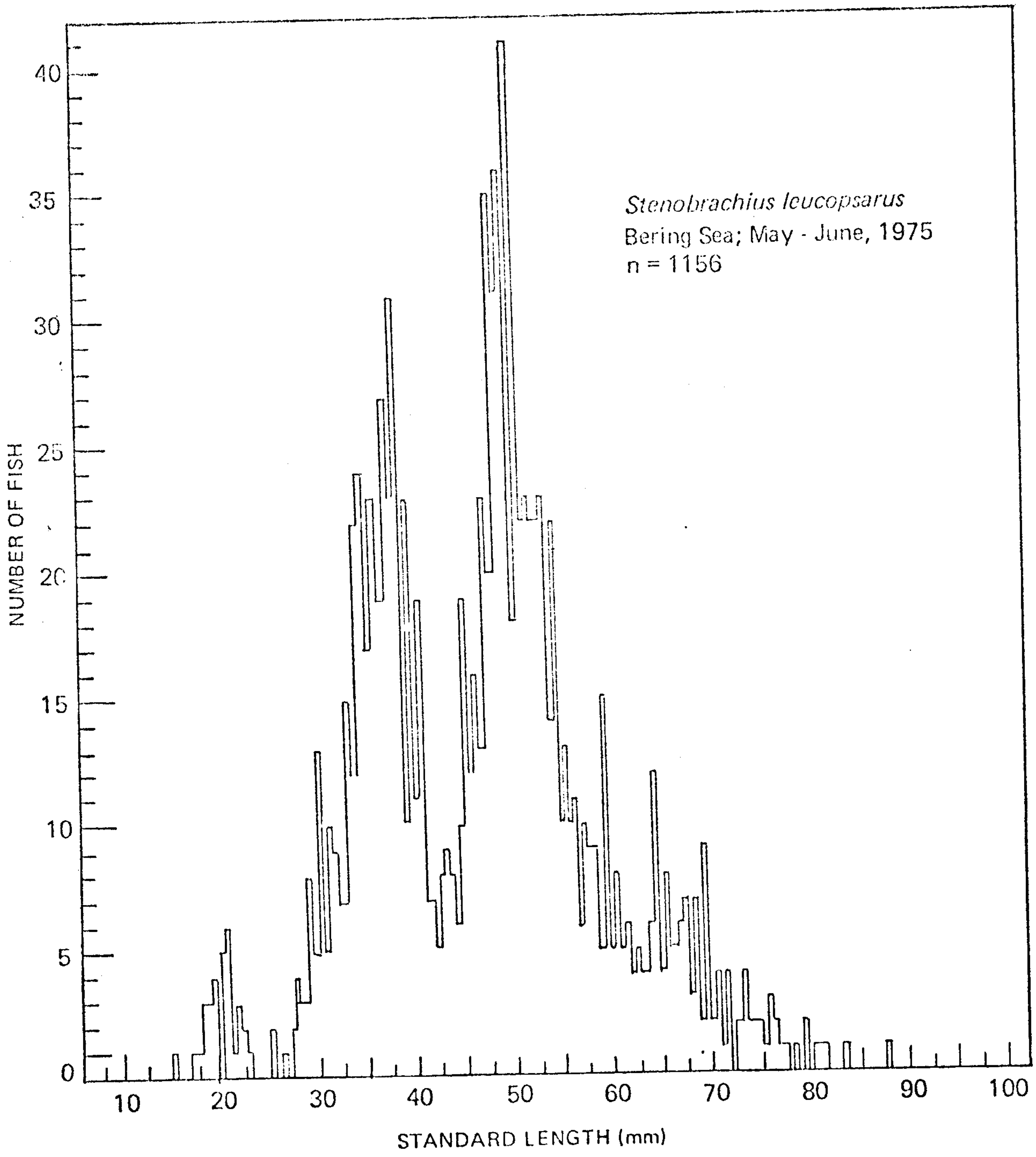

Figure 13. Size distribution (standard length) of the lantern fish *Stenobrachius leucopsarus* taken with the Tucker trawl at night in May-June, 1975.

DISCUSSION

The animal plankton and micronekton community in the waters adjacent to and over the shelf in the southeastern Bering Sea is diverse and abundant during the spring and late summer as observed at these times in this study. The gradation from oceanic to neritic described by Motoda and Minoda (1974) was obvious along a transect running landward up the middle of Bristol Bay. A marked biological discontinuity in midshelf cannot be explained by shoaling depth alone, and must be related to physical features measured but not available for analysis in this report.

The eggs and larvae of several fishes and shellfishes (some of commercial value) are conspicuous members of the seasonal zooplankton and micronekton of this region. Their survival is dependent upon suitable foods, escape from predators, and tolerance to fluctuations in temperature and salinity in the shelf waters.

Motoda and Minoda (1974) list 170 species of animal plankton from the Bering Sea, exclusive of fishes and other seasonal components. Only six amphipods are recorded. This present study reports 48 amphipods, establishing this group as ecologically important, particularly over the shelf and in the near shore region.

The distribution of snow crab larvae (*Chionoecetes* megalopa) is remarkably patchy and centered in the area of the Pribilof Islands. This area is acknowledged as a very productive shrimp ground (*Pandalus borealis*) and is also the rookery for the northern fur seal. Catches of juvenile Alaska pollock were highest here, suggesting a local enhancement of productivity in these waters.

The sampling equipment employed in this study, while in no way sophisticated, has provided samples of the pelagic fauna which seem representative of numbers and species when compared with long term averages reported by Japanese and other workers. The bongo net was not used because difficulties in fishing the whole of the water column over the shelf were encountered. Only the *Miller Freeman* was equipped with "real-time" depth telemetry which could have been used to monitor the net as it was being lowered close to the bottom. In the standard MARMAP ichthyoplankton survey this gear is used to sample the near-surface waters in situations where there is little chance of hitting bottom. Since the thrust of this investigation was to study the zooplankton and micronekton community as a whole rather than focusing on temporary plankton (fish eggs and larvae), a 1-m net, towed vertically, was selected. It is realized that volumes filtered were probably insufficient to obtain "best" estimates of egg and larvae abundance. However, as mentioned above, the survival of eggs and larvae is an ecosystem process involving not only distribution and abundance of the developing fishes but also the animals occurring in association with them as potential food, predators, or competitors. I believe the information being gathered by this study will address ichthyoplankton questions in a more complete manner than if only fish eggs and larvae had been considered.

CONCLUSIONS

1. With the presently available vessel and laboratory support, the zooplankton and micronekton communities in the Bering Sea are being representatively sampled and evaluated within the context of the research objectives stated;

2. The animal plankton and micronekton sector of the marine ecosystem of the Bering Sea is diverse and abundant. A planktonic early life history stage, usually very critical in subsequent survival, is characteristic of most marine organisms in the Bering Sea; sea birds and marine mammals are exceptions;

3. The unobtrusive fauna is in part responsible for the transfer of energy from primary producers to higher order consumers. The Bering Sea is commercially exceedingly productive, and an unusually high efficiency of this transfer process is suspected;

4. Until the nature of the tolerances of marine organisms to oil or oil related pollutants is documented, the effect of offshore development can only be imagined. However, since failure is the normal event in this system (i.e., few survivors annually from large numbers of eggs and larvae), additional stresses during the planktonic stage of any species would tend to further reduce the probability of its survival;

5) The "survival window" for higher order consumers passing through a planktonic stage in early life history is defined in time and space through food web relationships, predation, and competition by other members of the animal plankton and micronekton assemblage, in addition to tolerances to varying physical features. As such, the "critical habitat" notion must include an understanding of biological as well as physical dependencies occurring at the level of the plankton.

NEEDS FOR FURTHER STUDY

With the completion of the field effort in March-April of this year it should be possible to delineate some seasons which are biologically more important than others. If present levels of shipboard activity could be focused more intently at these times, the sampling design could be altered to discriminate temporal events on a much finer time scale than is now possible. This would permit descriptions of relationships pertinent to annual survival schedules and provide characterizations of critical habitats in the specific rather than general sense.

Furthermore, as the ecologically dominant plankton organisms are identified either as prominent in the transfer of matter to higher order consumers, or as predator or competitor organisms in association with larval fish or shellfish species of commercial or subsistence value, emphasis can be placed on defining their biological and physical dependencies.

The general problem of the annual recruitment of shelf species (zooplankton and micronekton) must continue to receive attention. The influence of water and associated plankters entering the region through the Aleutian passes may be important. Also, since there is a flow of water northward across the shelf and into the Chukchi and Beaufort Seas, animals drifting near the surface over deep water to the south may eventually be carried into environments for which they are poorly adapted. An understanding of the nature of the change in the zooplankton community composition will be helpful in discriminating real deviations associated with offshore oil development.

SUMMARY OF FOURTH QUARTER OPERATIONS

There have been no field operations since the *Miller Freeman* cruise described in the last quarterly report. Our efforts following the November cruise to the Bering Sea have involved sample processing and preparation for the *Surveyor* cruise scheduled for this March and April. At present, the Tucker trawl samples and the macroplankton from 1-m net tows have been worked up through the last cruise. The more tedious work required to sort and identify microzooplankton finds us about midway through the August samples. We envision no problem meeting our proposed deadline for data sumbission and final reports.

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APPENDIX I

1-m net

A listing of species and composites sorted from samples taken with a vertically towed 1-m net in the southeast Bering Sea, May-June and August, 1975. Numerically dominant species are indicated by an asterisk.

Foraminifera (unident. spp.)

Hydrozoa

- *Perigonimus yoldia-arcticae*
- *P. multicirratus*
- *P. breviconis*
- *P.* spp.
- *Calycopsis nematophora*
- *Bougainvillia superciliaris*
- *Corymorpha flammea*
- *Tubularia prolifer*
- *Coryne tubulosa*
- *C. principes*
- *Obelia longissima*
- *Ptychogena lactea*
- *Eirene indicans*
- *Aglantha digitale*
- *Aegina rosea*
- *Dimophyes arctica*

Scyphozoa

- *Periphylla hyacinthina*
- *Chrysaora helova*
- Unident. spp.

Ctenophora

- *Beroe* spp.

Polychaeta

- Polynoidae (unident. spp.)
- *Eteone longa*
- *Lopadorrhynchus* sp.
- *Pelagobia longicirrata*
- *Typhloscolex muelleri*
- *Tomopteris septentrionalis*
- Syllidae (unident. spp.)
- *Glycera capitata*
- *Lumbrinereis* sp.

*Abundant species

Polychaeta continued
  - *Scoloplos armiger*
  - Spionidae (unident. spp.)
  - Capitellidae (unident. spp.)
  - *Capitella capitata*
  - *Maldane sarsi*
  - Oweniidae (unident. sp.)
  - Ampharetidae (unident. sp.)
  - *Terebellides stroemii*
  - Sabellidae (unident. sp.)

Pelecypoda
  - Unidentified juveniles

Gastropoda
  - Unidentified juveniles
  - *Euclio* sp.
  - *Limacina helicina*
  - *Clione limacina*
  - Gonatidae (unident. spp.)
  - *Gonatus* sp.
  - Octopodidae

Cladocera
  - *Podon* sp.
  - *Evadne* sp.

Ostracoda
  - Unidentified spp.

Copepoda
  - Harpacticoid
    - *Microsetella rosea*
    - *Bradya* sp.
    - *Ectinosoma* sp.
    - *Tisbe* sp.
    - Unident. spp.
  - Calanoid
    - *Calanus cristatus*
    - *C. glacialis*
    - **C. marshallae*
    - *C. plumchrus*

Calanoid continued

Eucalanus bungii bungii

Microcalanus spp.

**Pseudocalanus spp.*

Aetideus pacificus

A. sp.

Bradyidius saanichi

Chiridius gracilis

Gaetanus intermedius

Gaidius variabilis

Euchaeta elongata

Xanthocalanus kurilensis

X. sp.

Racovitzanus antarcticus

Scolecithricella minor

S. ovata

Eurytemora herdmani

**Metridia lucens*

M. okhotensis

Pleuromamma scutullata

Centropages abdominalis

Lucicutia sp.

Heterorhabdus compactus

H. sp.

Candacia columbiae

**Acartia longiremis*

A. tumida

Unidentified nauplii

Cyclopoid

**Oithona helgolandica*

O. spinirostris

Oncaea borealis

O. spp.

Thoracica

Unident. nauplii
& cypris larvae

- Nebaliacea
  - *Nebalia* sp.
- Mysidacea
  - *Eucopia* sp.
  - *Acanthomysis nephrophthalma*
  - *A. dybowskii*
  - *A. pseudomacropsis*
  - *A. stelleri*
  - *Boreomysis kincaidi*
  - *Holmesiella anomala*
  - *Neomysis rayii*
  - *N.* spp.
  - *Pseudomma truncatum*
- Cumacea
  - *Lamprops quadriplicata typica*
  - *Leucon nasica orientalis*
  - *L. fulvus*
  - *L.* sp.
  - *Eudorella pacifica*
  - *Eudorellopsis deformis*
  - *Diastylis bidentata*
  - *D. alaskensis*
- Isopoda
  - Unidentified spp.
- Amphipoda
  - *Argissa hamatipes*
  - *Corophium* sp.
  - *Guernea* sp.
  - *Rhachotropis natator*
  - *Pontoporeia femorata*
  - *Photis* sp.
  - *Ischyrocerus commensalis*
  - *I.* spp.
  - *Protomedia* sp.
  - *Anonyx lilljeborgi*

Amphipoda continued

- *Cyclocaris guilelmi*
- *Cyphocaris challengeri*
- *Koroga megalops*
- *Lepidepedereum kasatka*
- *L. comatum*
- *Orchomene lepidula*
- *O. nugax*
- *Melphidippa* sp.
- Oedicerotidae (unident. spp.)
- *Bathymedon obtusifrons*
- *B. nanseni*
- *Monoculodes diamesus*
- *M. packardi*
- *M. zernovi*
- *Westwoodilla coecula*
- *Paraphoxus* sp.
- Pleustidae (unident. spp.)
- *Stenopleustes glaber*
- *Dulichia* sp.
- *Metopa alderi*
- *Stenula* sp.
- *Scina borealis*
- *Hyperia medusarum*
- *Hyperoche medusarum*
- *Parathemisto libellula*
- **P. pacifica*
- *P.* spp.
- *Primno macropa*

Euphausiacea

- *Euphausia pacifica*
- *Thysanoessa inermis*
- *T. longipes*
- **T. raschii*
- *T. spinifera*
- Unidenti. eggs. nauplii, metanauplii, calyptopis & furcilia

Decapoda
  Pandalidae (unident. spp.)
  Pandalus borealis
  P. sp.
  Hippolytidae (unident. spp.)
  Eualus macilenta
  Crangonidae (unident. spp.)
  Paracrangon echinata
  Paguridae (unident. spp.)
  Lithodidae (unident. spp.)
  Paralithodes camtschatica
  Oregoniinae (unident. spp.)
  Chionoecetes spp.
  Hyas spp.
  Telmessus cheiragonus
  Erimacrus isenbeckii
  Pinnotheridae (unident. spp.)
Ectoprocta
  Unidentified cyphonautes larvae
Phoronida
  Unidentified actinotroch larvae
Asteroidea
  Unidentified spp.
Ophiuroidea
  Unidentified spp.
Chaetognatha
  Eukrohnia spp.
  **Sagitta elegans*
  Unident. juveniles
Ascidiacea
  Unident. eggs & larvae
Larvacea
  Fritillaria borealis
  Oikopleura spp.
  Unident. juveniles

Teleostei

- *Clupea harengus pallasi*
- *Mallotus villosus*
- *Bathylagus pacificus*
- *B. stilbius schmidti*
- *Stenobrachius leucopsarus*
- Gadidae (unident. spp.)
- *Theragra chalcogramma*
- *Sebastes* spp.
- Cottidae (unident. spp.)
- Agonidae (unident. spp.)
- *Liparis* spp.
- *Nectoliparis pelagicus*
- Stichaeidae (unident. spp.)
- Pleuronectidae (unident. spp.)
- *Atheresthes stomias*
- *Hippoglossoides elassadon*
- Unidentified fish eggs

Unidentified eggs

APPENDIX II

2-m Tucker Trawl

A listing of species and composites sorted from samples taken with a 2-m Tucker trawl in the southeast Bering Sea, May-June and August, 1975. Numerically dominant species are indicated by an asterisk.

Hydrozoa
**Aglantha digitale*
Perigonimus breviconis
Perigonimus c.f. P. yoldia arcticae
Perigonimus multicirratus
Calycopsis nemataphora
Bougainvillia superciliaris
Rathkea jaschnowi
Corymorpha flammea
Coryne principes
Ptychogena lactea
Eirene indicans
Aegina rosea
Aequores forskalea
Pantachogan haeckeli
Melicertum campanula
Botrynema brucei
Halicreas minimum
Crossota brunnea
Scyphozoa
Periphylla hyacinthina
Atolla wyvillei
Chrysaora melanaster
Chrysaora helvola
Cyanea capillata
Phacellophora camtschatica
Aurelia limbata
Siphonophora
Dimophyes arctica
Vogtia serrata
Ramosia vitiazi
Rosacea plicata
Chaetognatha
**Sagitta elegans*
**Eukrohnia* spp.

Chaetognatha (continued)

- *Sagitta scrippsae*

Mollusca

- *Galiteuthis armata*
- *Chiroteuthis veranyi*
- *Gonatus fabricii*
- *Gonatus magister*
- *Gonatopsis* sp.
- Octopodidae larvae (unident. spp.)
- *Clione limacina*
- *Limacina helicina*

Polychaeta

- *Tomopteris septentrionalis*
- *Hesperone complanata*
- *Chaetozone setosa*
- *Krohnia excellata*
- *Lopadorrhynchidae* (unident. spp.)
- *Antinoella sarsi*
- *Nereis pelagica*

Copepoda

- *Calanus cristatus*
- **Eucalanus bungii bungii*
- *Euchaeta elongata*
- *Pachyptilus pacificus*
- *Candacia columbiae*

Euphausiacea

- *Euphausia pacifica*
- *Tessarabrachion oculatus*
- **Thysanoessa raschii*
- *Thysanoessa inermis*
- *Thysanoessa spinifera*
- **Thysanoessa longipes*

Isopoda

- *Ilyarachna* sp.
- *Synidotea bicuspida*

Mysidacea

- *Acanthomysis stelleri*
- *Acanthomysis dybowskii*
- *Pseudomma truncatum*
- *Neomysis rayii*
- *Neomysis czerniawskii*
- *Holmesiella anomala*
- *Eucopia* sp.
- *Boreomysis kincaidi*
- *Boreomysis californica*

Cumacea

- **Diastylis bidentata*
- *D. alaskensis*
- *Leucon quadriplicata typica*

Amphipoda-Hyperiidea

- **Parathemisto pacifica*
- **Parathemisto libellula*
- *Hyperia medusarum*
- *Hyperia springera*
- *Hyperoche medusarum*
- *Primno macropa*
- *Phronima sedentaria*
- *Hyperia galba*
- *Paraphronima crassipes*
- *Scina borealis*
- *Scina rattrayi*
- *Archoeoscina steenstrupi*
- *Parathemisto japonica*

Amphipoda-Gammaridea

- *Anonyx nugax*
- *Cyphocaris challengeri*
- *Byblis gaimardi*
- *Protomedia* sp.
- *Metopa alderi*
- *Monoculodes zernovi*

Amphipoda-Gammaridea (continued)

- *Ampelisca macrocephala*
- *Westwoodilla coecula*
- *Dulichia unispina*
- *Pontoporeia femorata*
- *Dulichia arctica*
- *Melitoides makarovi*
- *Rhachotropis oculata*
- *Pleustes panopla*
- *Monoculodes diamesus*
- *Rhachotropis natator*
- *Priscillina armata*
- *Eusirella multicalceola*
- *Parandania boecki*
- *Anonyx compactus*
- *Stenopleustes glaber*
- *Melita dentata*
- *Paramphithoe polyacantha polyacantha*
- *Monoculopsis longicornis*
- *Anisogammarus macginitiei*
- *Hippomedon kurilicus*
- *Orchomene c.f. O. lipedula*
- *Pontogenia ivanovi*
- *Atylus bruggeni*
- *Atylus collingi*
- *Socarnes bidenticulatus*
- *Ischerocerus anguipes*
- *Melphidippa goesi*
- *Cyclocaris guilelmi*

Decapoda

- *Pasiphaea pacifica*
- *Cancer* sp.
- *Crangon dalli*
- *Argis lar*
- **Hymenodora frontalis*
- *Eualus macilenta*

Decapoda (continued)

- *Eualus stonyei*
- *Pandalus goniurus*
- *Pandalus borealis*
- *Sergestes similis*
- **Chionoecetes* megalopa (unident. spp.)
- **Oregoniinae* zoeae (unident. spp.)
- *Erimacrus isenbecki* megalopa
- *Erimacrus isenbecki* zoeae
- *Telmessus cheirigonus* megalopa
- *Telmessus cheirigonus* zoeae
- *Paralithodes camtschatica* zoea
- *Paralithodes camtschatica* glaucothoe
- Paguridae zoeae (unident. spp.)
- Paguridae juvenile (unident.spp.)
- *Hyas* sp. megalopa
- *Pandalus montagui tridens*
- *Pandalopsis* zoeae (unident. spp.)
- Hippolytidae zoeae (unident. spp.)
- Crangonidae zoeae (unident. spp.)

Cyclostomata

- *Lampetra tridentatus*

Teleostei

- **Mallotus villosus*
- *Lycodes palearis*
- *Lumpenus maculatus*
- **Reinhardtius hippoglossoides*
- *Liparis herschelinus*
- *Agonus acipenserinus*
- *Theragra chalcogramma*
- *Liparis dennyi*
- *Clupea harengus pallasi*
- *Lumpenus medius*
- *Artediellus pacificus*
- Cottidae (unident. spp.)
- **Stenobrachius leucopsarus*

Teleostei (continued)

- *Bathylagus pacificus*
- *Bathylagus alascanus*
- *Ptilichthys goodei*
- *Stenobrachius nannochir*
- *Nectoliparis pelagicus*
- Hexagrammidae (unident. spp.)
- **Bathylagus stilbius schmidti*
- *Hippoglossus stenolepis*
- *Malacocottus zonurus*
- *Hemilepidotus* sp.
- *Chauliodus macouni*
- *Bathymaster signatus*
- *Triglops pingeli*
- *Ammodytes hexapterus*

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 13 R.U. NUMBER: 156/164

PRINCIPAL INVESTIGATOR: Dr. R. T. Cooney

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]		
	From	To	Batch 1		
Discoverer Leg I #808	5/15/75	5/30/75	5/15/76		
Discoverer Leg II #808	6/2/75	6/19/75	5/15/76		
Discoverer Leg I #810	8/9/75	8/28/75	6/30/76		
Miller Freeman #815	11/10/75	11/26/75	6/30/76		
Contract #03-5-022-34	Last	Year	5/15/76		

Notes: [1] Data Management Plan has been approved and made contractual. We await receipt and approval by all parties of necessary Data Format.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 13

PRINCIPAL INVESTIGATOR: Dr. R. Ted Cooney

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	82,764.00	52,678.84	30,085.16
Staff Benefits	13,970.00	8,877.85	5,092.15
Equipment	40,000.00	20,216.90	19,783.10
Travel	7,600.00	5,400.70	2,199.30
Other	22,250.00	13,314.12	8,935.88
Total Direct	166,584.00	100,488.41	66,095.59
Indirect	47,341.00	30,132.30	17,208.70
Task Order Total	213,925.00	130,620.71	83,304.29

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 156/164(D) for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

1917

UNIVERSITY OF ALASKA
FAIRBANKS, ALASKA 99701

January 13, 1976

RECEIVED
JAN 19 1976
NEGOA

Dr. John Robinson
Outer Continental Shelf Energy Program
NOAA/ERL
Boulder, Colorado 80302

Reference: Contract 03-5-022-56

Dear John:

Enclosed are quarterly reports for the period ending December 31, 1975, for Task Orders #13 and 24 to the above referenced contract.

Sincerely,

Donald H. Rosenberg
OCS Coordination Office

DHR/hg

c.c.: H. Bruce with enclosures ✓
G. Weller with enclosures

RECEIVED
JAN 19 1976
NEGOA

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title: Zooplankton and Micronekton Studies in the Bering - Chukchi/Beaufort Seas

Contract Number: 03-5-022-56

Task Order Number: 13

Principal Investigator: Dr. R. Ted Cooney

Fish
R.U. 164 D

I. Task Objectives

This research addresses six (6) tasks (or parts thereof) pertaining to zooplankton and micronekton in the Bering - Chukchi/Beaufort Seas.

A. A-9; describe the food dependencies of commonly occurring species of pelagic fishes as this task applies to dielly migrating bathypelagic species sampled with bongo nets and NIO Tucker midwater trawls.
B. A-22; summarize the existing literature and unpublished data on the transfer of synthesized organic matter to zooplankton and micronekton (including ichthyoplankton).
C. A-23; determine seasonal density distributions and environmental requirements of principal species of zooplankton, micronekton, and ichthyoplankton.
D. A-24; identify pathways of matter (energy) transfer between synthesizer and consumers.
E. A-25; identify and characterize critical regions and habitats required by egg and larval stages of fish and shellfish species.
F. A-31; determine the relationships of zooplankton and micronekton populations to the edge of the seasonal icepack as it occurs in the Bering and Chukchi Seas.

Of these tasks, all but A-24 (Organic matter transfer pathways) have been addressed. Pathway information is expected as a result from two major spring cruises (March-April; 1976) at a time when the area is biologically very active.

II. Field or Laboratory Activities

A. Ship Schedule

A successful cruise was undertaken aboard the NOAA vessel

Miller Freeman; 10 November - 26 November, 1975 (Biological and Physical Oceanographic cruise - Leg II). Several locations in the southeast Bering Sea were sampled and the edge of the newly forming seasonal icepack was visited.

B. Scientific Party

Mr. David Brickell, Dr. T. Nishyama, Dr. J. Roberts, Mr. Ken Coyle, Ms. J. McKenney, and Mr. C. Zimmerman shared the collecting duties on the Miller Freeman cruise.

C. Methods

Details of the methodology are listed as an OCSEP program work statement "Environmental Assessment of the Alaska Continental Shelf", No. 3, Fish, Plankton, Benthos, and Littoral; pp. 89-103.

D. Sample Localities

Station locations and cruise tracklines have been described in detail in the cruise report submitted for this effort. (Miller Freeman; November 10 - 30, Leg II).

E. Data Collected or Analysed

Number and type of samples/observations

1. 40 1-m net samples were taken (39 locations).
2. 16 2-m NIO Tucker trawl samples were acquired (12 locations).

III. Results

Although our sample processing is on schedule, there has been no analysis of the raw data presently on hand. However, our field observations indicate a rich and diverse community of zooplanktons present at all times adjacent to and over the continental shelf. A distinct neritic fauna is encountered in the nearshore zone, at least during the late spring and summer seasons. Since our last scheduled deep-water cruise is in April of this coming year (1976), we anticipate no difficulty regarding the reporting schedule in addressing the tasks outlined above with the observations gathered up to that time. Our variance and cluster analyses testing various distributional hypotheses cannot be undertaken until the sample processing is completed for all cruises and gear types.

IV. Preliminary Interpretation of Results

Not applicable.

V. Problems Encountered/Recommended Changes

The zooplankton and micronekton collecting efforts have been greatly enhanced by the help and attitude of the officers and crew of the NOAA vessels we have used; the Miller Freeman was no exception. Even in marginal working conditions (November is getting a bit hairy in the Bering Sea) we were able to gather samples. However, we did find that the Tucker trawl is no match for the Freeman at 10 knots. Apparently with a following sea, even at low RPM's, the vessel speed was too much for this gear, resulting in a couple of "blown" nets. This is no real problem though as we expect to replace nets from time to time. The fact we were able to sample at all is most significant.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 13 R.U. NUMBER: 156/164

PRINCIPAL INVESTIGATOR: Dr. R. T. Cooney

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates(1)		
	From	To	Batch 1		
Discoverer Leg I #808	5/15/75	5/30/75	3/31/76		
Discoverer Leg II #808	6/2/75	6/19/75	3/31/76		
Discoverer Leg I #810	8/9/75	8/28/75	6/30/76		
Miller Freeman #815	11/10/75	11/26/75	6/30/76		
Contract #03-5-022-34	Last	Year	3/31/76		

Notes: (1) Estimated submission dates are contingent upon final approval of draft data management plan submitted to NOAA Nov. 20, 1975 and final agreement by all parties on the data format.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 13

PRINCIPAL INVESTIGATOR: Dr. R. Ted Cooney

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	82,764.00	33,403.50	49,360.50
Staff Benefits	13,970.00	5,389.73	8,580.27
Equipment	40,000.00	17,991.90	22,008.10
Travel	7,600.00	3,248.86	4,351.14
Other	22,250.00	16,384.43	5,865.57
Total Direct	166,584.00	76,418.42	90,165.58
Indirect	47,341.00	19,106.80	28,234.20
Task Order Total	213,925.00	95,525.22	118,399.78

* Preliminary cost data, not yet fully processed.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title:	Administrative Support NODC/OCSEP Representative
Contract Number:	03-5-022-56
Task Order Number:	24
Principal Investigator:	Mr. David M. Hickok

I. Task Objective

To provide office and secretarial support for an EDS employee.

II. Field and Laboratory Activities

None.

III. Results

EDS employee, Mike Crane, occupied the office in November, 1975.

IV. Problem Encountered

A problem occurred between EDS and contractor over final budget. It is our understanding that this problem has been resolved. An estimated addition to the budget was submitted to Mr. C. E. Cotton of EDS to cover such items as long distance telephone calls, supplies and xerox services.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 24 R.U. NUMBER:

PRINCIPAL INVESTIGATOR: Mr. David M. Hickok

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable(1).

NOTE: (1)Data management plan was submitted to NOAA in draft form on October 9, 1975 and University of Alaska approval given on November 20, 1975. We await formal approval from NOAA.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 24

PRINCIPAL INVESTIGATOR: Mr. David M. Hickok

Period September 1 - December 31, 1975 * (4 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	4,165.00	728.95	3,436.05
Staff Benefits	708.00	123.92	584.08
Equipment	-0-	-0-	-0-
Travel	-0-	-0-	-0-
Other	2,691.00	1,294.07	1,396.93
Total Direct	7,564.00	2,146.94	5,417.06
Indirect	2,382.00	416.96	1,965.04
Task Order Total	9,946.00	2,563.90	7,382.10

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract # 03-5-022-56

Research Unit # 159/164 (E)

Reporting Period 4/1/75-3/31/76

Number of Pages 42

PHYTOPLANKTON STUDIES - BERING SEA

Vera Alexander

Institute of Marine Science

University of Alaska

March 31, 1976

I. TASK OBJECTIVES

The principal task involved in this program is to study the dynamics of phytoplankton populations, particularly along the edge of the seasonal ice-pack in the Bering Sea, and with emphasis on describing the probable effects of petroleum development impact. The southeastern Bering Sea is a highly productive area in terms of fisheries, and as such is very important to the Alaskan economy. In addition, the Bering Sea shelf as well as the southeast shelf-break area supports large populations of birds and mammals. This suggests a rather dynamic system in terms of phytoplankton productivity. The problem is, however, that the phytoplankton primary productivity which supports all the activity higher in the food chain is highly seasonal in this area, and its timing and the mechanisms of food chain transfer are probably extremely important to maintaining the integrity of the system. Prior to determining safe human development, it is absolutely essential that the exact nature of the highly seasonal phytoplankton production peaks is known, and the major pathways and rates of transfer of this food chain base to higher levels is understood. This is a very large and difficult task, certainly beyond any short-term project capability. However, by obtaining certain minimum data on seasonal productivity of phytoplankton populations, understanding inparticular the unique role of ice in this system, and by carrying out a program coordinated with zooplankton studies, a significant beginning can be made which will provide sufficient understanding for a first cut opinion and estimate of impact. This, then, describes two of the tasks originally laid out in the proposal for this program: to study the seasonal dynamics of production with emphasis on the ice-edge and to cooperate with the zooplankton program in designing and executing experiments to measure organic matter transfer between primary producers and zooplankton. The third aspect is to be a review of the foreign and domestic literature dealing with phytoplankton in the eastern Bering Sea south of St. Matthew Island, and obtain and incorporate currently unpublished material dealing with the region.

II. FIELD OR LABORATORY ACTIVITIES

A. Ship Schedules

Three separate cruises have been undertaken. They are listed here, and most of the additional information below will be separated out by cruise or cruise leg.

1. Cruise 808. *Discoverer*, Leg I. May 15-May 30, 1975. NOAA
   Cruise 808. *Discoverer*, Leg II. June 2-June 20, 1975. NOAA
2. Cruise 810. *Discoverer*, Leg I. August 9-August 28, 1975. NOAA
3. Cruise 815. *Miller Freeman*, Leg II. November 10-November 30, 1975. NOAA

B. Scientific Party

Cruise 808, Leg I:

Vera Alexander, Chief Scientist, University of Alaska,
David Brickell, Technician, University of Alaska

Cruise 808, Leg II:

David Brickell, Technician, University of Alaska

Cruise 810:

David Brickell, Technician, Chief Scientist, U. of A.
Carl Zimmermann, Technician, University of Alaska
Greg Malinky, Graduate assistant, University of Alaska
John Yurek, Technician, University of Alaska

Cruise 815:

David Brickell, Technician, University of Alaska
Carl Zimmermann, Technician, University of Alaska

C. Methods

1. Field sampling and laboratory analysis

The following analyses were carried out on all cruises:

Chlorophyll a - samples taken from CTD casts from several depths were filtered through glass micropore filters, and either frozen immediately, or alternatively when possible the filters were extracted immediately in 5 ml of 90% acetone, extracted in the dark for 24 hrs, centrifuged and spectrophotometric analysis of the pigments carried out. For the frozen filters, a similar analysis was carried out upon return to the laboratory.

Nutrients - The water samples were filtered through glass micropore filters into well-aged polyethylene bottles (125 ml) and immediately frozen. Analyses were carried out for nitrate and nitrite, ammonia, silicate and phosphate upon return to the laboratory, using automated methods.

Phytoplankton populations - aliquots of the CTD cast were placed in screw-top glass vials, and preserved with a modified acetic acid Lugol's solution. Counting was carried out upon return to the laboratory using sedimentation and an inverted microscope technique.

Primary productivity - samples from five depths were placed into glass bottles, dark and duplicate light, and each was treated with 5 uCi ^{14}C as $HCO_3^=$. Incubation was carried out on deck at approximately *in situ* light conditions in a light graded incubator kept at constant temperature by running sea water. Following 6 hours incubation, the samples were filtered through an HA Millipore filter, the filter dried, and counted upon return to the laboratory. Calculations use pH and alkalinity information to determine the inorganic carbon available. This was done as follows: pH was determined on shipboard using a Coleman pH meter. Alkalinity was done by addition of a standard volume of acid and back titration with NaOH.

During the ice-covered season, SIPRE cores were taken from the ice pack, and the lower portion analyzed for chlorophyll and on one occasion, primary productivity as above.

On one occasion, sediment cores were squeezed in sections to obtain water for interstitial nutrient gradient determinations. On this occasion, measurement of uptake of ^{15}N labelled ammonia and nitrate in the water column was carried out. Standard mass spectrometry using a modified Bendix Time-of-Flight mass spectrometer was used to determine ^{15}N content of particulate material recovered on a glass micropore filter.

D. Sample Localities

Cruise tracks and stations for the major cruises undertaken by this project are shown in Figure 1. The specific nature of the stations was determined by the ice edge location for Cruise 808, and by the locations of stations selected for other biological programs from the station grid for other cruises. Emphasis in all cruises was to get some stations on either side of the shelf break in order to assess the role of mixing in this area in possibly enhancing primary productivity, some in the area under the influence of the Aleutian Passes for the same reason, and some up onto the shelf to determine the seasonal activity in the system in order to better estimate the relative significance of the spring bloom phenomena.

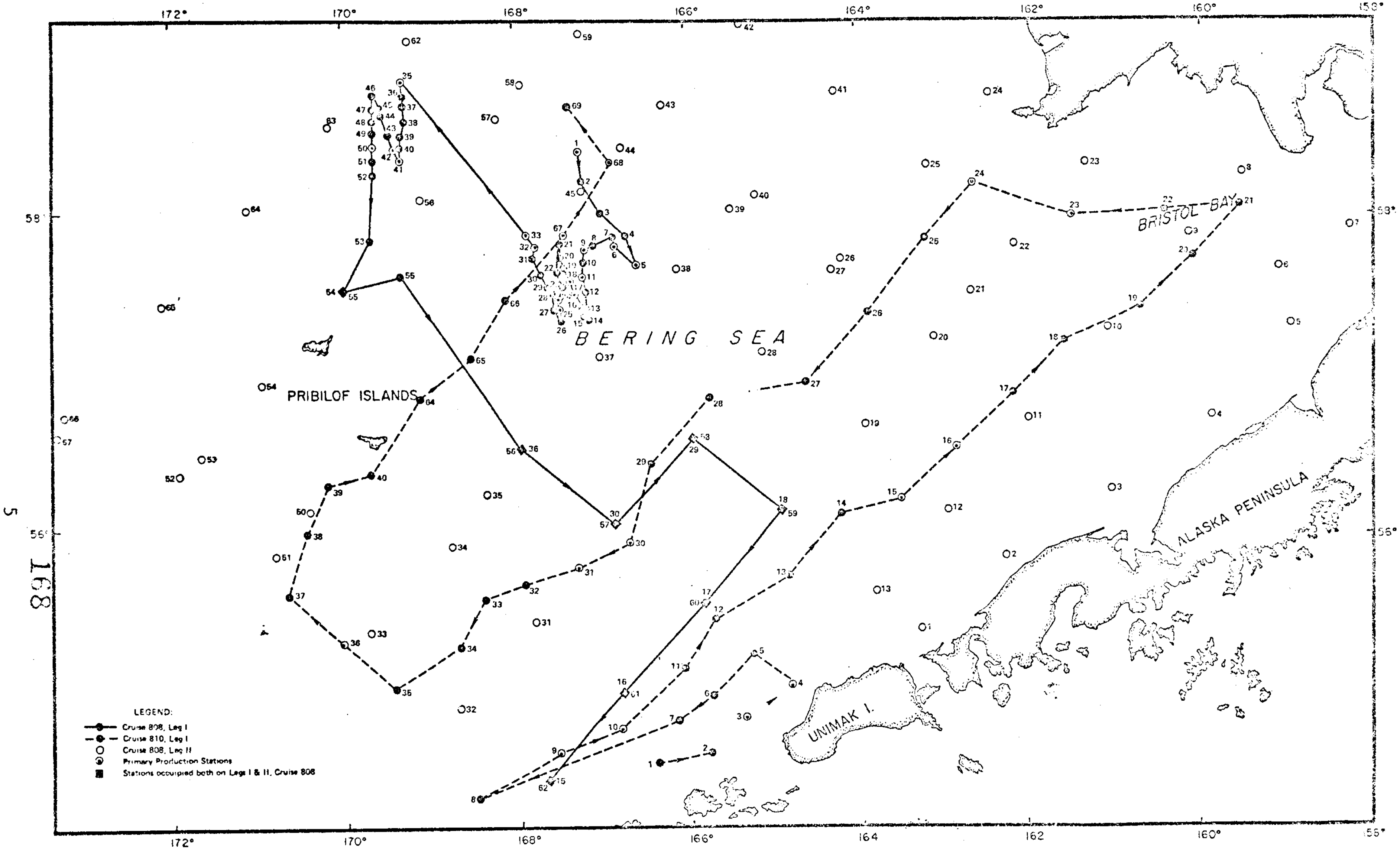

Figure 1. Major cruise tracks and stations occupied during the 1975 field program.

E. Data Collected or Analyzed

Cruise 808

1. Number and types of samples:

Phytoplankton samples	65 from 19 stations
Chlorophyll a	442 from 57 stations
Nutrients	187 from 28 stations
pH	96 from 17 stations
Alkalinity	96 from 17 stations
Primary productivity	96 from 17 stations

12 ice cores were obtained and examined for chlorophyll in the lower sections, and an attempt was made to measure primary productivity on one.

2. Number and types of analyses:

All phytoplankton counts, chlorophyll analyses, major nutrient analyses (Phosphate, silicate, nitrate and nitrite and ammonia) are complete. Primary productivity samples have been counted, and alkalinity determinations carried out. Key punching for final calculations is underway, but temporarily interrupted by all technical personnel being involved in the current Surveyor Bering Sea cruise.

3. Miles of trackline:

Not known, and not significant for this program.

Cruise 808, Leg II

1. Number and types of observations/samples:

Phytoplankton samples	18
Chlorophyll a	140
Nutrients	145
pH	25
Alkalinity	25
Primary productivity	25
Oxygen	52

2. Number and types of analyses:

Same as for Leg I, above. All analyses are completed except for the final calculation of the primary productivity results.

3. Miles of trackline:

See Leg I, above.

Cruise 810

1. Number and types of samples/observations

Phytoplankton samples	67
Chlorophyll *a*	200
Nutrients	200
Primary productivity	74
Alkalinity	74
pH	75
Sediment nutrients	2
^{15}N uptake	4

2. Number and types of analyses

Same as above. Each nutrient sample was analyzed for four nutrients. All analyses are completed and calculated except that primary productivity results still need final calculation.

3. Miles of trackline:

Not known

Cruise 815

1. Number and types of samples:

Phytoplankton samples	50 from 13 stations
Chlorophyll *a*	106 from 39 stations
Nutrients	276 from 39 stations
pH	63 from 14 stations
Alkalinity	63 from 14 stations
Primary productivity	63 from 14 stations

2. Number and types of analyses:

Processing of the samples according to the methodology presented above has been underway, and is now complete with the exception of finalizing the phytoplankton counts and calculating the primary productivity results. All chemical procedures are complete.

3. Miles of trackline:

Not known

III. RESULTS

The timing of this report precludes detailed presentation of results, since all personnel involved in the project are currently out at sea on the major seasonal effort for this project, and the past weeks have in part been occupied by preparing for the cruises as well as completing sample and data processing to date. We are attempting to submit all the data for 1975 within a short time. However, some preliminary analyses have been done with the data to determine relative processes between season and location. In this present discussion, I will start with the main thrust of this project, which is the role of ice-edge phenomena in the annual production cycle.

A. The Ice-Edge Studies

Results obtained during the zig-zag maneuvers near the ice edge (within 25 miles) are shown in Table I. These data do not, of course, include the primary production data since these are still in the final calculation stage. Also, details of the phytoplankton are not given here, but rather the total numbers in cells/liter. Considerable work needs to be done with raw phytoplankton data in the way of synthesis, since significant changes with depth and region seem to occur.

The bloom along the ice-edge appears to extend out to at least 50 miles, and has many of the characteristics of a normal spring bloom. Within the ice pack itself, surface chlorophyll a levels were considerably lower than outside the ice, although there was some variability in this between areas. The stations far to the east showed this effect much more

Table I. A Preliminary Synthesis of the Ice-Edge Transects - May 1975

In-ice stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
0.0	1	6.03×10^5	9.2	00.3	042.	3.12	4.32
	2	-	-	-	-	-	2.89
	3	4.33×10^6	0.0	01.0	015.	0.71	6.01
	21	-	-	-	-	-	32.73
	35	1.10×10^6	0.0	00.9	000.	0.97	12.42
	45	-	-	-	-	-	16.97
10.0	1	1.71×10^6	11.7	00.1	046.	1.03	2.50
	2	-	-	-	-	-	3.32
	3	3.09×10^6	03.7	00.7	034.	1.37	5.20
	21	-	-	-	-	-	29.41
	35	3.98×10^6	00.0	00.8	001.	1.32	22.94
	45	-	-	-	-	-	12.35
20.0	1	1.66×10^5	19.2	00.7	056.	0.68	0.90
	2	-	-	-	-	-	1.11
	3	2.32×10^5	20.4	00.9	054.	1.45	1.03
	21	-	-	-	-	-	8.64
	35	6.98×10^5	06.1	00.7	020.	1.57	5.22
	45	-	-	-	-	-	15.85
40.0	1	-	11.3	00.4	048.	3.71	0.95(30m)
	2	-	-	-	-	-	0.30(30m)
	3	2.77×10^5	17.8	01.1	050.	2.03	0.74(30m)
	21	-	-	-	-	-	2.73
	35	-	06.8	01.1	023.	1.77	3.90
	45	-	-	-	-	-	2.17

In-ice stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N (µg-atoms/liter)	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
0.0	4	6.59×10^6	-	-	-	-	7.42
	6	-	00.0	00.5	009.	1.12	16.52
	9	5.09×10^6	00.0	00.5	011.	1.26	21.82
	20	-	00.8	00.4	002.	1.62	27.65
	31	-	-	-	-	-	23.45
	32	4.67×10^6	00.1	00.7	003.	1.20	35.70
	36	-	-	-	-	-	20.72
	46	-	00.8	00.3	006.	1.15	21.24
10.0	4	3.59×10^6	-	-	-	-	8.31
	6	-	00.0	00.4	008.	1.46	26.04
	9	6.45×10^6	01.2	00.5	019.	1.86	27.64
	20	-	00.8	00.6	008.	1.67	22.73
	31	-	-	-	-	-	25.38
	32	1.71×10^6	00.2	00.6	002.	1.15	35.79
	36	-	-	-	-	-	26.52
	46	-	00.9	00.2	006.	1.14	20.17
20.0	4	1.16×10^6	-	-	-	-	6.31
	6	-	08.4	00.4	026.	0.56	6.46
	9	7.07×10^5	17.7	00.9	056.	3.46	3.93
	20	-	15.2	00.2	050.	3.48	3.10
	31	-	-	-	-	-	7.80
	32	7.52×10^5	09.8	00.6	028.	1.69	5.81
	36	-	-	-	-	-	6.32
	46	-	04.9	00.7	018.	1.25	11.53
40.0	4	-	-	-	-	-	1.20
	6	-	11.0	00.4	035.	1.02	2.64
	9	-	16.2	00.3	055.	0.95	1.86
	31	-	-	-	-	-	5.09
	32	-	06.0	01.6	016.	1.51	4.57
	36	-	-	-	-	-	2.62
	46	-	10.7	00.7	036.	1.85	2.26

5 miles from ice-edge stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
0.0	5	5.85×10^6	00.0	00.6	006.	1.20	7.80
	10	-	-	-	-	-	31.59
	19	-	-	-	-	-	27.16
	22	-	-	-	-	-	21.07
	30	-	00.2	00.1	002.	1.23	25.08
	31	-	-	-	-	-	23.45
	37	-	-	-	-	-	25.56
	45	-	-	-	-	-	16.97
	47	-	-	-	-	-	8.89
10.0	5	6.84×10^6	00.0	00.6	008.	1.21	11.71
	10	-	-	-	-	-	7.60
	19	-	-	-	-	-	21.02
	22	-	-	-	-	-	20.89
	30	-	04.3	00.7	020.	0.93	21.13
	31	-	-	-	-	-	25.38
	37	-	-	-	-	-	31.16
	45	-	-	-	-	-	12.35
	47	-	-	-	-	-	10.28
20.0	5	4.80×10^5	19.3	00.9	057.	3.54	1.40
	10	-	-	-	-	-	1.86
	19	-	-	-	-	-	1.91
	22	-	-	-	-	-	4.26
	30	-	08.0	00.5	006.	0.97	35.41
	31	-	-	-	-	-	7.80
	37	-	-	-	-	-	5.36
	45	-	-	-	-	-	15.85
	47	-	-	-	-	-	10.43

5 miles from ice-edge stations (cont'd.)

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
40.0	5	2.80×10^5	16.5	01.0	049.	2.15	-
	10	-	-	-	-	-	2.07
	19	-	-	-	-	-	1.88
	22	-	-	-	-	-	9.86
	30	-	11.7	02.6	040.	1.96	7.56
	31	-	-	-	-	-	5.09
	37	-	-	-	-	-	4.19
	45	-	-	-	-	-	2.17
	47	-	-	-	-	-	2.33

10 mile from ice-edge stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
0.0	11	2.80×10^6	00.0	00.2	001.	1.27	21.02
	18	-	00.6	00.4	003.	1.40	25.56
	23	-	-	-	-	-	15.57
	29	-	-	-	-	-	22.63
	38	-	00.1	00.3	002.	1.01	22.00
	44	-	-	-	-	-	21.86
	48	-	-	-	-	-	10.94
10.0	11	4.10×10^6	00.0	00.1	002.	1.26	17.21
	18	-	00.6	00.3	003.	1.04	21.40
	23	-	-	-	-	-	17.14
	29	-	-	-	-	-	19.17
	38	-	00.3	00.4	002.	1.03	21.33
	44	-	-	-	-	-	20.59
	48	-	-	-	-	-	10.31
20.0	11	1.83×10^6	11.7	00.2	034.	2.30	14.02
	18	-	06.3	00.3	019.	2.21	21.02
	23	-	-	-	-	-	16.21
	29	-	-	-	-	-	14.28
	38	-	06.0	00.5	021.	1.45	14.72
	44	-	-	-	-	-	15.82
	48	-	-	-	-	-	8.54
40.0	11	-	15.7	00.5	045.	3.42	2.47
	18	-	14.9	00.2	049.	3.49	3.03
	23	-	-	-	-	-	3.28
	29	-	-	-	-	-	6.85
	38	-	15.1	00.8	041.	1.90	4.02
	44	-	-	-	-	-	4.22
	48	-	-	-	-	-	1.68

15 mile from ice-edge stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (μg/liter)
				(μg-atoms/liter)			
0.0	12	-	-	-	-	-	14.34
	17	-	-	-	-	-	12.43
	24	2.58×10^6	00.0	00.3	003.	0.89	13.85
	28	-	-	-	-	-	15.60
	39	-	-	-	-	-	17.24
	43	-	-	-	-	-	21.61
	49	-	-	-	-	-	15.04
10.0	12	-	-	-	-	-	19.21
	17	-	-	-	-	-	16.22
	24	1.91×10^6	00.8	00.2	003.	1.52	18.05
	28	-	-	-	-	-	12.79
	39	-	-	-	-	-	-
	43	-	-	-	-	-	18.32
	49	-	-	-	-	-	21.94
20.0	12	-	-	-	-	-	4.97
	17	-	-	-	-	-	18.06
	24	1.79×10^6	00.9	00.3	003.	1.24	17.55
	28	-	-	-	-	-	14.39
	39	-	-	-	-	-	16.00
	43	-	-	-	-	-	20.68
	49	-	-	-	-	-	23.84
40.0	12	-	-	-	-	-	3.66
	17	-	-	-	-	-	7.25
	24	-	11.2	00.1	038.	3.23	4.33
	28	-	-	-	-	-	7.53
	39	-	-	-	-	-	2.54
	43	-	-	-	-	-	3.06
	49	-	-	-	-	-	4.79

20 mile from ice-edge stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (μg/liter)
				(μg-atoms/liter)			
0.0	13	2.26×10^6	00.5	00.2	000.	0.36	8.81
	16	-	-	-	-	-	5.31
	25	1.98×10^6	-	-	-	-	13.61
	27	-	0.00	00.6	002.	0.67	7.87
	40	-	-	-	-	-	19.52
	42	-	02.1	00.4	004.	0.81	29.95
	50	3.46×10^6	00.1	00.1	006.	1.17	27.48
10.0	13	3.57×10^6	00.5	00.2	000.	1.26	8.41
	16	-	-	-	-	-	7.82
	25	2.92×10^6	-	-	-	-	14.29
	27	-	00.2	00.8	003.	0.92	17.34
	40	-	-	-	-	-	11.53
	42	-	00.6	00.4	006.	1.07	21.36
	50	4.68×10^6	00.1	00.1	006.	1.06	28.99
20.0	13	2.33×10^6	12.7	00.2	040.	3.05	6.76
	16	-	-	-	-	-	10.83
	25	1.77×10^6	-	-	-	-	14.22
	27	-	00.9	00.9	006.	1.05	22.65
	40	-	-	-	-	-	8.86
	42	-	04.5	00.3	016.	1.37	18.58
	50	2.51×10^6	00.1	00.0	005.	1.71	26.31
40.0	13	-	13.1	00.4	041.	3.16	6.89
	16	-	-	-	-	-	7.32
	25	-	-	-	-	-	7.43
	27	-	11.3	02.4	037.	1.81	8.25
	40	-	-	-	-	-	2.94
	42	-	14.4	00.5	043.	1.96	3.43
	50	-	00.1	01.7	028.	1.52	5.36

25 mile from ice-edge stations

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
0.0	14	-	-	-	-	-	18.63
	26	-	-	-	-	-	6.58
	41	4.23×10^6	00.0	00.3	004.	0.86	19.11
	51	-	-	-	-	-	18.88
10.0	14	-	-	-	-	-	21.98
	26	-	-	-	-	-	6.31
	41	3.92×10^6	00.7	00.4	006.	1.02	24.81
	51	-	-	-	-	-	17.45
20.0	14	-	-	-	-	-	10.78
	26	-	-	-	-	-	7.39
	41	2.57×10^6	06.6	00.6	019.	1.10	6.88
	51	-	-	-	-	-	8.52
40.0	14	-	-	-	-	-	8.81
	26	-	-	-	-	-	9.37
	41	-	15.9	00.8	044.	2.04	6.99
	51	-	-	-	-	-	4.21

strongly (1, 2, 3), whereas rather high chlorophyll levels were found at stations 21, 35 and 45. The nutrient situation was also variable between stations. Station 1, with its lower chlorophyll and cell numbers, had relatively high nutrients in the surface waters, with a tendency towards lower quantities at the 10 and 20 meter levels, returning to maximum once again at 40 meters. At stations outside the ice, all stations showed signs of nutrient depletion, particularly for nitrate in the surface waters. Silicate levels were much lower than in the ice. Uniformly high chlorophyll levels were found in all stations except one, and these extended down through the 10 meters depth level. The situation was similar at the 5 mile stations with nitrate low, silicate lower than at the ice edge, and phosphate about the same. Once again, high chlorophyll levels (17-31 ug/liter) were found at the surface except for two stations, and once again these levels extended through the ten meter depth level. At the ten mile stations, silicate was even lower in concentration in the surface waters, nitrate was still low, and phytoplankton populations as evidenced by chlorophyll and cell count data were somewhat lower than at 5 miles. At 15 miles, this trend downwards in chlorophyll and cell numbers (for the water column as a whole) continued. Surface phosphate levels showed a significant decline for the first time, and silicate levels are extremely low (3 μg-atoms/liter). By 20 miles from the ice edge chlorophyll levels at 10 the surface ranged from 5.3 to 29.9, but with more stations at the low end of the spectrum. There was now a tendency for a larger proportion of the population to exist at greater depth (20 meters).

A transect away from the ice edge which extended for 100 miles (Table II) showed that surface chlorophyll did not, on the average, show a marked

TABLE II. Transect away from ice-edge May 1975

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (μg/liter)
				(μg-atoms/liter)			
0.0	46-ice-edge	-	00.8	00.3	006.	1.15	21.24
	47-5 miles	-	-	-	-	-	8.89
	48-10 miles	-	-	-	-	-	10.94
	49-15 miles	-	-	-	-	-	15.04
	50-20 miles	3.46×10^6	00.1	00.1	006.	1.17	27.48
	51-25 miles	-	-	-	-	-	18.88
	52-30 miles	-	-	-	-	-	19.98
	53-50 miles	-	-	-	-	-	13.49
	55-100 miles	-	01.1	00.1	008.	0.92	5.11
10.0	46	-	00.9	00.2	006.	1.14	20.17
	47	-	-	-	-	-	10.28
	48	-	-	-	-	-	10.31
	49	-	-	-	-	-	21.94
	50	4.68×10^6	00.1	00.1	006.	1.06	28.99
	51	-	-	-	-	-	17.45
	52	-	-	-	-	-	23.70
	53	-	-	-	-	-	15.06
	55	-	00.8	00.1	006.	0.24	4.41
20.0	46	-	04.9	00.7	018.	1.25	11.53
	47	-	-	-	-	-	10.43
	48	-	-	-	-	-	8.54
	49	-	-	-	-	-	23.84
	50	2.51×10^6	00.1	00.0	005.	1.71	26.31
	51	-	-	-	-	-	8.52
	52	-	-	-	-	-	25.15
	53	-	-	-	-	-	4.04
	55	-	00.7	00.1	006.	1.73	5.40

TABLE II. Transect away from ice-edge May 1975 (cont'd.)

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
40.0	46	-	10.7	00.7	036.	1.85	2.26
	47	-	-	-	-	-	2.33
	48	-	-	-	-	-	1.68
	49	-	-	-	-	-	4.79
	50	-	00.1	01.7	028.	1.52	5.36
	51	-	-	-	-	-	4.21
	52	-	-	-	-	-	5.56
	53	-	-	-	-	-	5.50
	55	-	04.8	00.6	013.	2.27	8.69

decline with distance from ice edge within the first 30 miles, but that by 50 and 100 miles the levels had dropped significantly. At a distance of 100 miles from the ice edge, maximum chlorophyll was found at 40 meters, a situation found in this area on a previous cruise during early summer. All surface nutrient levels measured within the 100 mile zone were low.

Much more sophisticated data analysis must be carried out before we can discuss in detail the distribution of phytoplankton species during the spring bloom period. In one station within the ice, there appeared to be very low species diversity, although the total numbers of cells were not extremely low. There were simply not many species present. The population was dominated by *Fragilariopsis* spp., *Melosira moniliformis* and *Parvicorbicula socialis* cf. and other choanoflagellates. At a station outside the ice-edge, diversity was much increased and the total number of different species present was much higher. Dominant forms were *Fragilariopsis* spp., *Chaetoceros socialis, Thalassiosira nordenskioldi* and Craspedophyceaea (choanoflagellates). In addition, at 10 and 20 meters depths, but not at the surface, *Navicula pelagica, Melosira moniliformis* and *Thalassiosira rotula* also occured. These forms were found at other ice-edge stations at the surface as well as at greater depths. At a station 20 miles from the ice edge (station 50), there was low species diversity at the surface and an increase with depth. *Fragilariopsis* was still the major form, and choanoflagellates were relatively less important.

B. Transect Along the 50 Meter Contour

Three stations along the 50 meter contour were summarized in Table III. Here, although chlorophyll levels are lower than in the ice-edge vicinity,

Table III. Stations along the 50 meter contour - May 1975

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll a (µg/liter)
				(µg-atoms/liter)			
0.0	56	1.34×10^6	05.7	00.1	022.	1.90	6.78
	57	-	00.6	00.0	005.	1.47	6.18
	58	-	00.4	00.0	009.	0.53	10.11
10.0	56	1.27×10^6	05.7	00.0	021.	1.97	4.30
	57	-	01.1	00.0	008.	0.32	13.64
	58	-	01.5	00.1	006.	0.94	11.16
20.0	56	1.18×10^6	06.0	00.0	022.	1.80	7.36
	57	-	03.9	00.1	014.	1.68	15.77
	58	-	02.6	00.2	008.	1.05	11.18
30.0	56	-	06.0	00.1	022.	1.20	5.10
	57	-	04.0	00.1	015.	1.73	14.20
	58	-	03.7	00.1	010.	1.14	10.70
40.0	56	-	06.7	00.1	022.	1.45	4.41
	57	-	04.6	00.2	016.	0.46	11.78
	58	-	03.9	00.2	010.	1.16	6.33
60.0	56	-	12.4	00.5	032.	2.47	5.10
	57	-	15.8	00.5	040.	1.36	1.78
	58	-	10.2	00.6	028.	1.64	11.04

it can be seen that they are still not very low, and that significant chlorophyll concentrations are found down to a depth of 60 meters. The total chlorophyll under a square meter of surface, then, may be considerably greater than the amount near the ice edge, although it is unlikely that the chlorophyll in excess of 30 meters is very active in terms of photosynthetic efficiency. Principal species in this transect was *Chaetoceros debilis*, and this comprised a very marked majority of the cells present. Also present in abundance was *Thalassiorsira decipiens* at the surface. At 10 meters, *Chaetoceros debilis* was the most abundant form, and at 20 meters the same species was dominant, with choanoflagellates also present in abundance. Cell numbers were markedly lower than at the ice-edge.

C. Stations Under the Influence of the Aleutian Passes (Table IV)

These stations showed high phytoplankton numbers and variable but substantial chlorophyll levels, although these are not comparable to the ice edge levels. However, here again, the relatively high levels persist through the 30 meter depth level, and could account for a considerable production.

Nutrient levels are quite low in the surface 30 meters and thereafter increase substantially. Nitrogen nutrients are very low in the surface waters. There are very large varieties of species present, and although *Chaetoceros debilis* is present in significant numbers, it is not one of the major contributors to the population here. Most abundant at the surface are *Chaetoceros septenrionalis, Thalassiosira decipiens, Thalassiosira nordenskioldi, Chaetoceros furcellatus,* but the major

Table IV. Synthesized data from the Aleutian Pass area - May 1975

Depth (m)	Station	Phytoplankton (cells/liter)	NO_3-N	NH_3-N	SiO_3-Si	PO_4-P	Chlorophyll *a* (µg/liter)
				(µg-atoms/liter)			
0.0	59	-	00.3	00.2	006.	0.81	15.27
	60	-	00.1	00.3	004.	0.80	4.58
	61	5.72×10^6	00.3	00.2	005.	0.72	15.25
	62	-	-	-	-	-	5.46
10.0	59	-	00.7	00.2	006.	0.79	12.56
	60	-	01.7	00.3	006.	0.86	5.84
	61	4.47×10^6	00.3	00.3	005.	0.75	17.78
	62	-	-	-	-	-	6.97
20.0	59	-	01.6	00.2	007.	0.71	11.22
	60	-	01.9	00.2	005.	0.94	4.73
	61	4.50×10^6	02.8	00.2	008.	0.90	16.10
	62	-	-	-	-	-	7.56
30.0	59	-	03.1	00.2	010.	1.07	12.85
	60	-	04.3	00.2	009.	1.13	4.59
	61	-	04.9	00.3	012.	1.14	10.85
	62	-	-	-	-	-	2.93
50.00	59	-	02.6	00.2	008.	0.94	3.52 (60 m)
	60	-	13.3	00.6	021.	1.66	0.67 (60 m)
	61	-	14.7	00.2	037.	1.62	5.38
	62	-	-	-	-	-	1.64
75.00	59	-	11.6	00.4	030.	1.87	4.55 (80 m)
	60	-	16.9	00.4	039.	1.81	-
	61	-	24.5	00.3	065.	2.15	0.73
	62	-	-	-	-	-	0.78

organism in the phytoplankton population was *Phaeocystis* sp., accounting for more than 70% of the population. At 10 meters, *Chaetoceros socialis* increases in abundance, although the other components found at the surface are also present.

D. A Very Preliminary Look at the Summer and Fall Situation.

Chlorophyll a levels during the cruise taken in August were extremely low, ranging from 0.03 to 2.40 ug/liter. This is a marked contrast to the spring bloom situation encountered in May. Similarly during the November cruise, the only significant activity was associated with the Aleutian passes or the Yukon River. These data have not been synthesized yet in sufficient depth for detailed analysis, but the picture of a relatively inactive system is clear.

E. Zooplankton Grazing and Trace Metal Toxicity Results.

In an attempt to further the understanding of the effects of trace metals on the growth rates of marine plankton algae, a set of experiments was done on the first Leg of the KG-75-4 cruise of the *Hakuho-Maru* of the Ocean Research Institute, University of Tokyo. The cruise began 21 June 1975 at Tokyo, and of the work reported here three stations (3, 4, and 5) were done off the Kuril Islands or Kamchatka. A west-east line of stations across the Bering Sea at 57° N started near Kamchatka (Station 7, 167°E) and ended in Bristol Bay (Station 15, 163° W). The work terminated in Dutch Harbor on 14 July 1975.

The primary activity of this project was to follow phytoplankton growth responses to copper using Coulter Counter techniques. As time permitted, trace metal analyses using anodic stripping voltammetry also were done. Scientists from the Ocean Research Institute and other Japanese organizations collected information on many parameters (including nutrients and algal speciation) which will be helpful in the interpretation of these data.

The volume of particles in the size range from 4 to 80 μ was determined on natural seawater samples and on subsamples which had been incubated in a running seawater deck tank. Preparations for incubation included extraordinary care to avoid trace metal contamination, the removal of zooplankters, and the addition of a moderate amount of nutrients (0.3 μg at. PO_4-P and 4.5 μg at NO_3-N). The change in particle volumes in subsamples with and without added copper was assessed routinely after *ca.* 100 hours. In addition some samples were measured also at shorter time intervals to check for changing growth rates and lag phases. A summary of the results (Table V) indicated that in almost all cases a distinct suppression in growth was associated with the addition of as little as 2 μg Cu/l, and growth was inhibited further at higher copper concentrations.

The plots of cell volume in the various cell size categories (Fig. 2-9) indicate that responses often were not uniform and that the nannoplankton, which generally were abundant in the nutrient-poor samples, displayed a wide variety of responses to added metals, while the larger microplankton almost always were suppressed by added metals.

Zooplankton grazing produced dramatic changes in the particle volume distributions in this work, as evidenced in Figure 10, (Station 7, 0 m), where *Calanus plumchrus* deliberately were added at the rate of 3.3 organisms per liter, or in Figure 11, (Station 15, 0 m), which had a high natural abundance of polychaete larvae. Obviously grazing is a variable that somehow must be controlled in this kind of experimental work.

Table V. Changes in particulate volume (% of controls without Cu) following copper additions and incubation in natural light at seawater surface temperature for *ca.* 100 hours.

Station Depth (m)	Copper added (μg Cu/1) 2	4	8
3/0	102	101	36
4/0	70	48	16
4/50	47	14	8
5/0	77	79	60
5/50	61	57	46
7/0	51	51	31
7/0 + EDTA	74	66	39
11/0	93	50	43
11/30	52	43	90
15/20	89	79	74

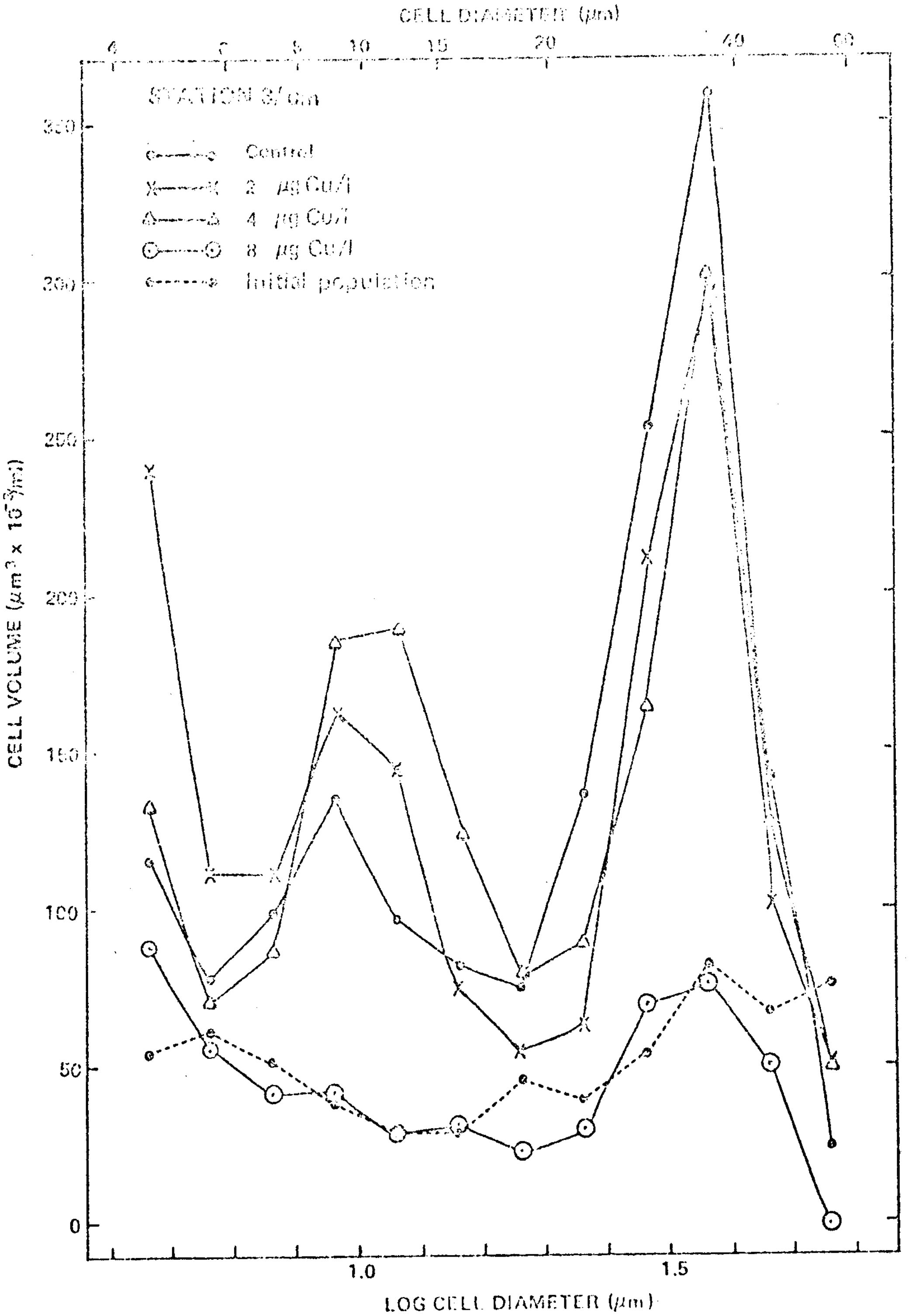

Figure 2. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

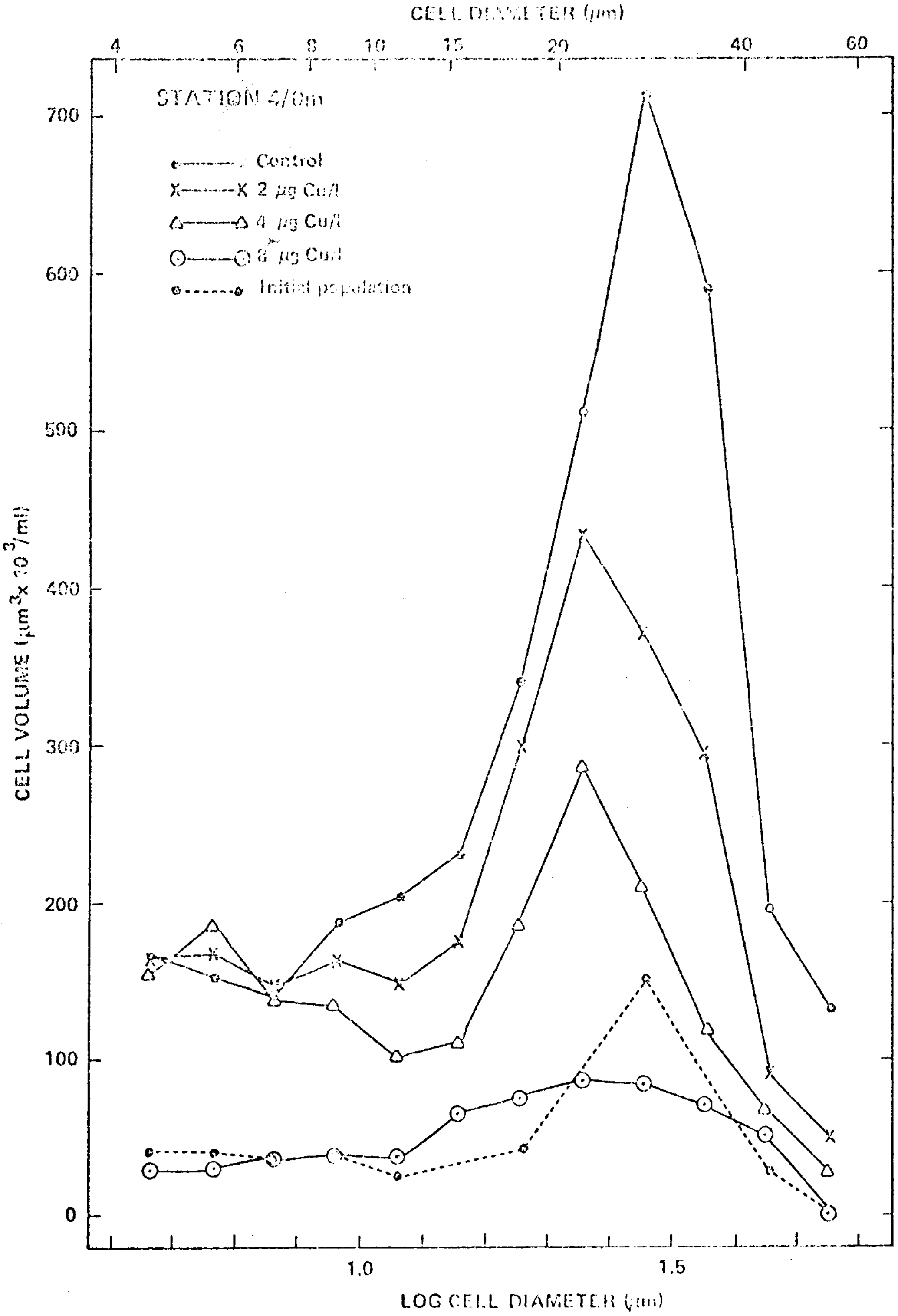

Figure 3. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

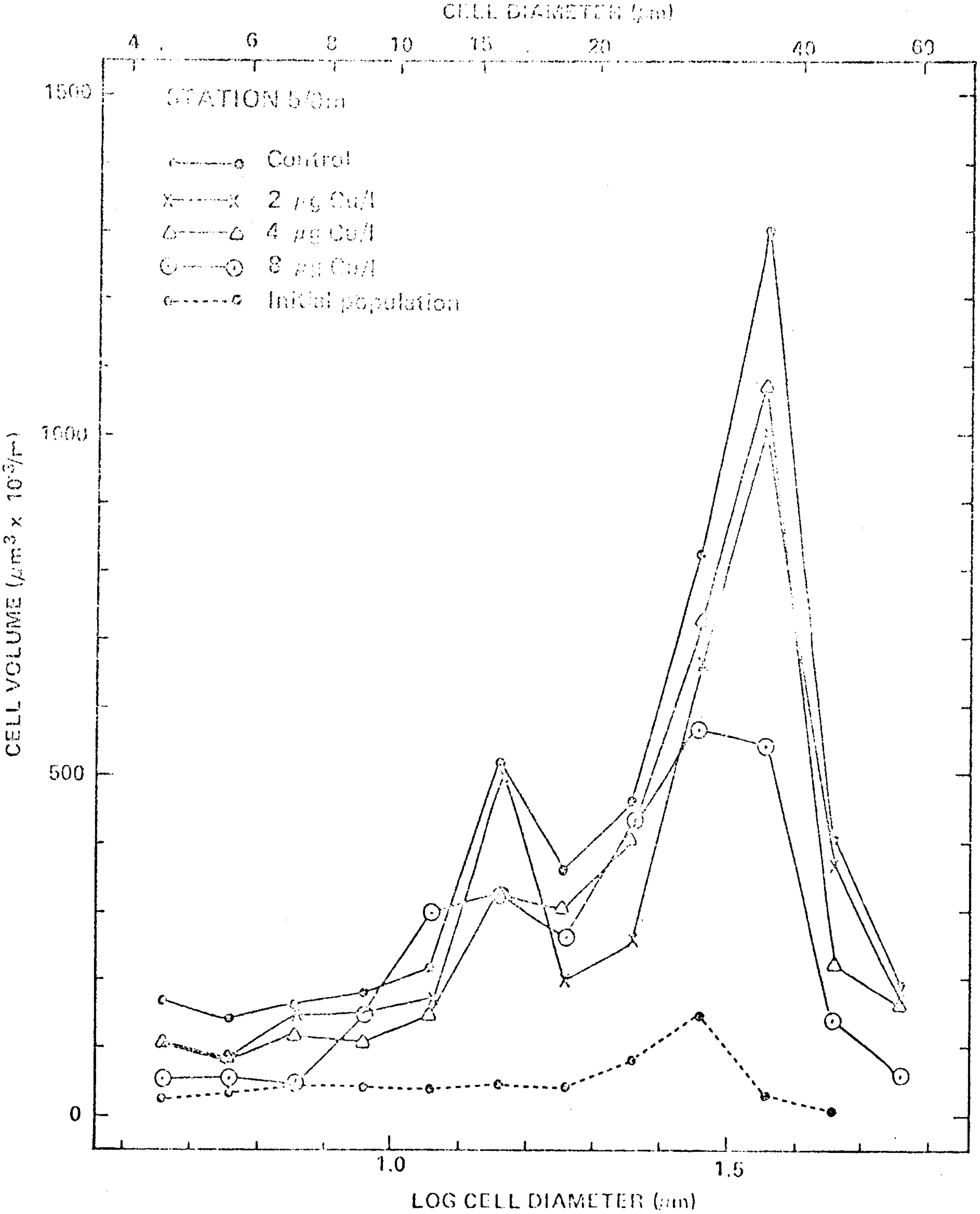

Figure 4. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

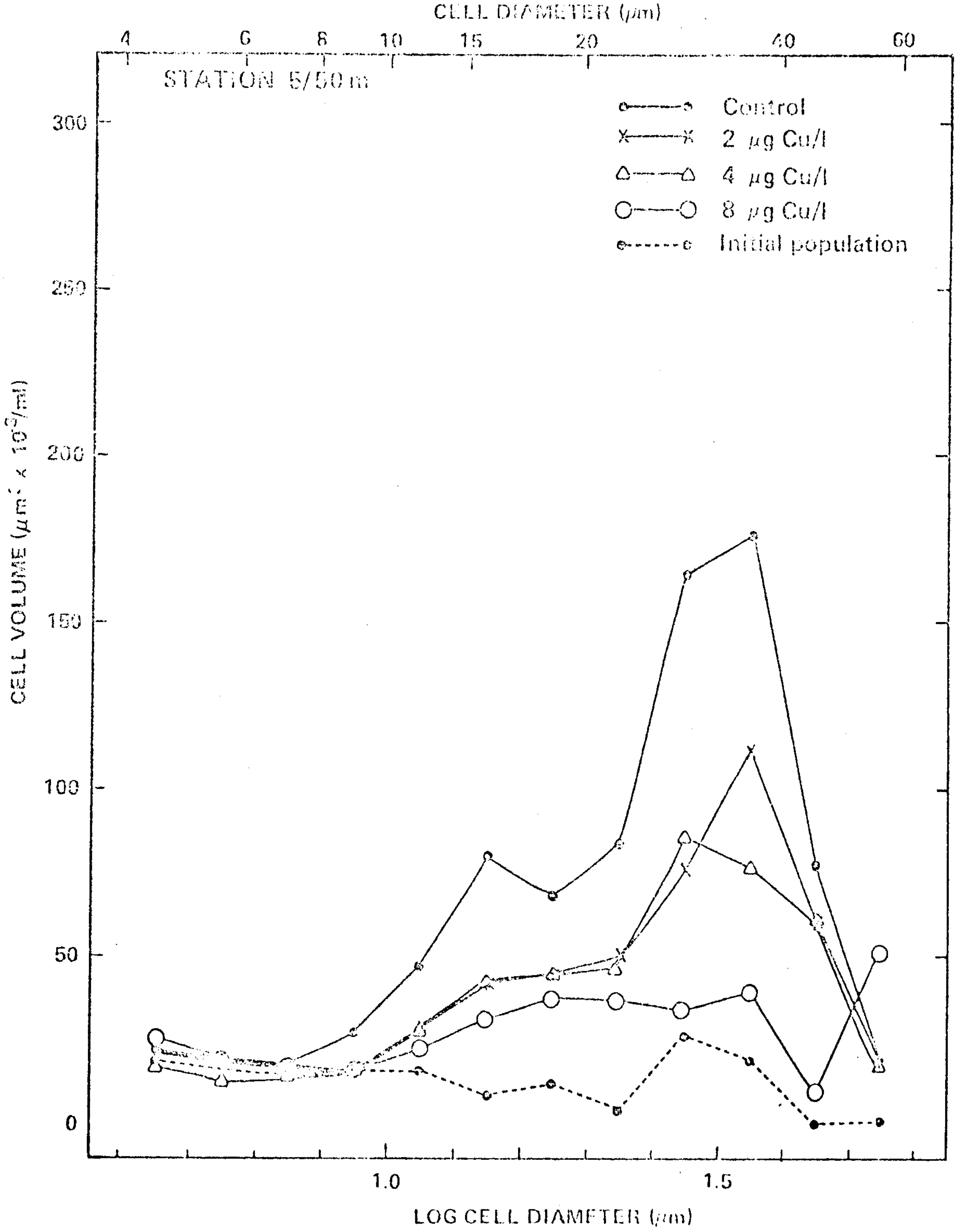

Figure 5. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

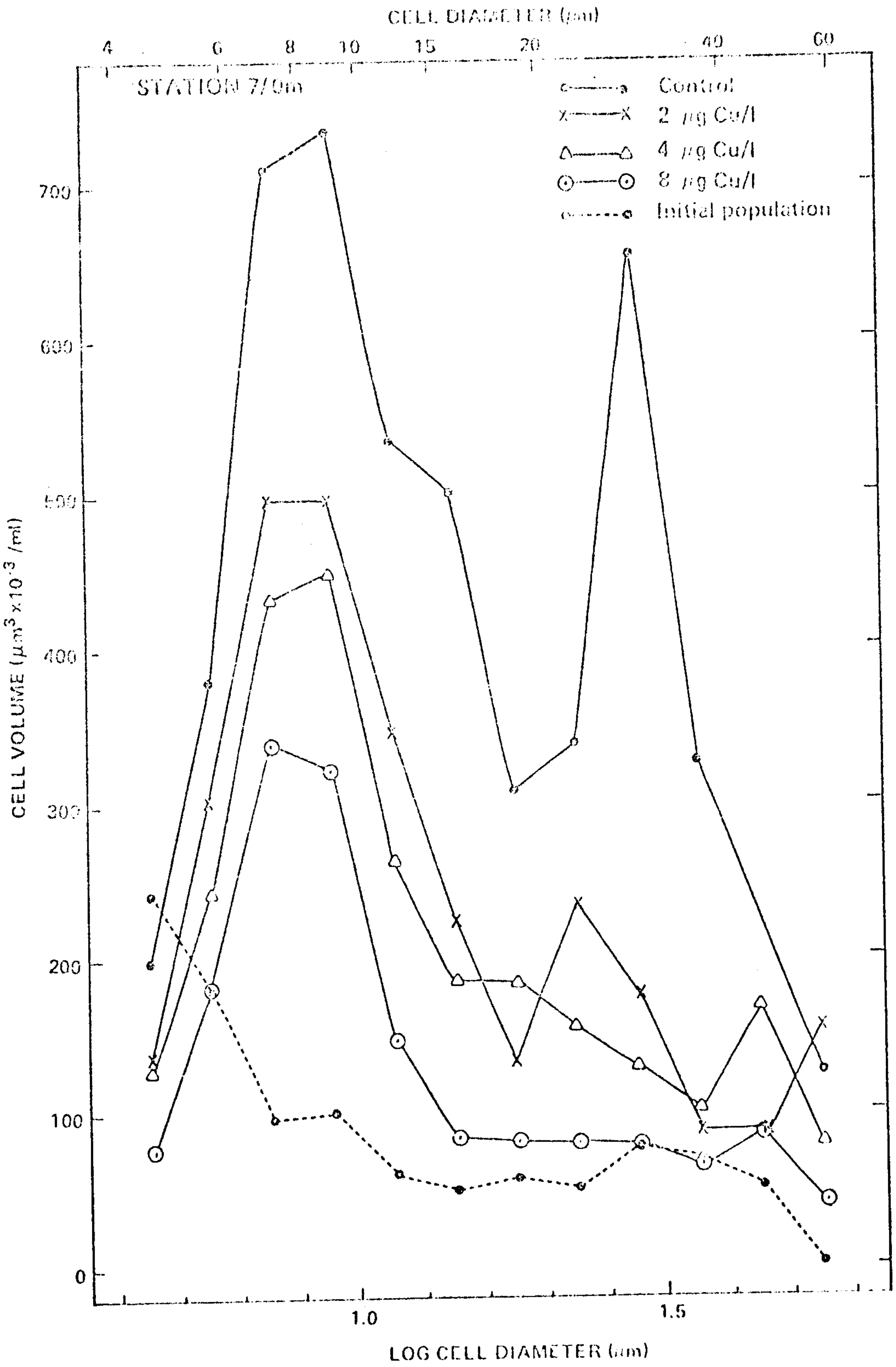

Figure 6. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure..

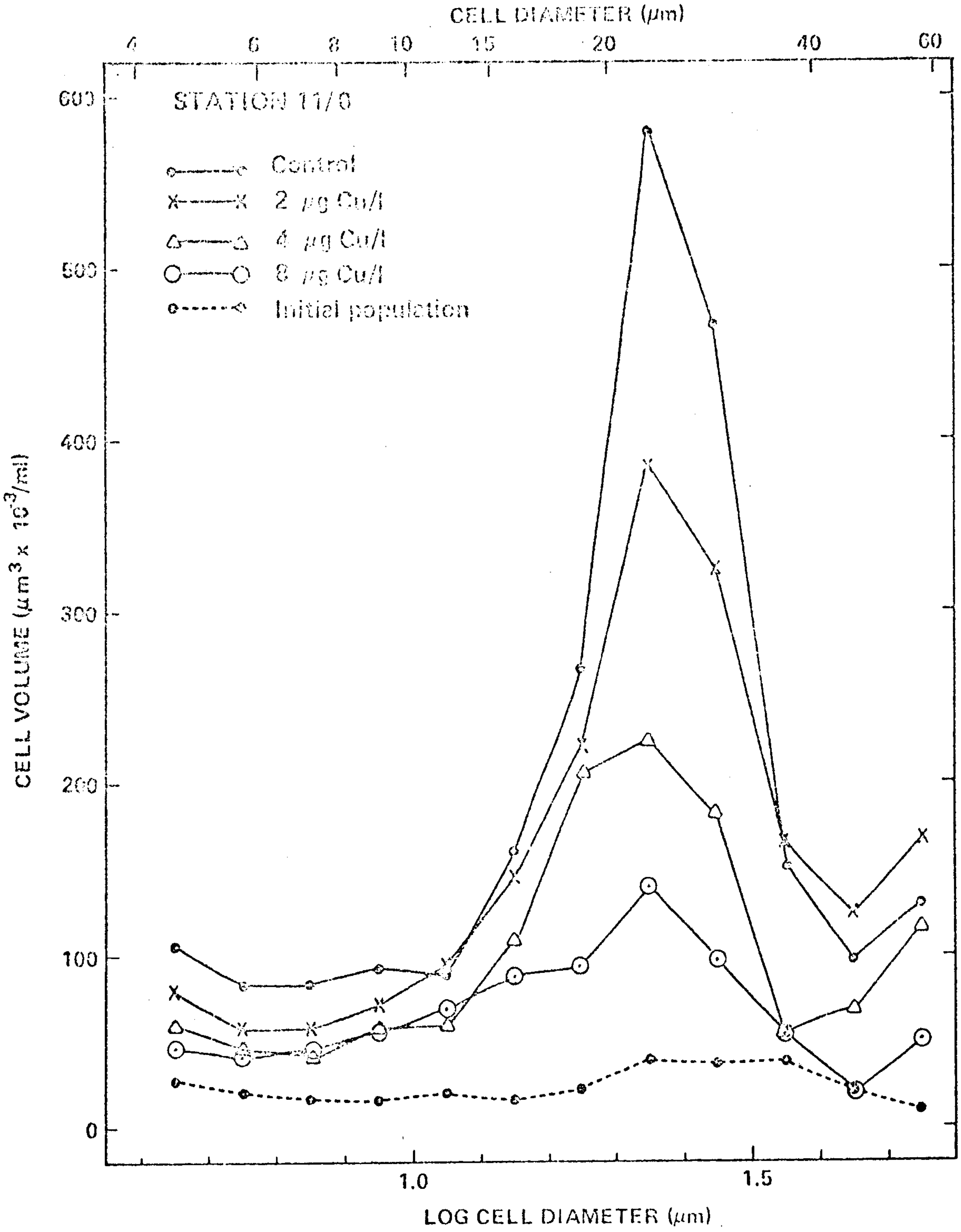

Figure 7. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

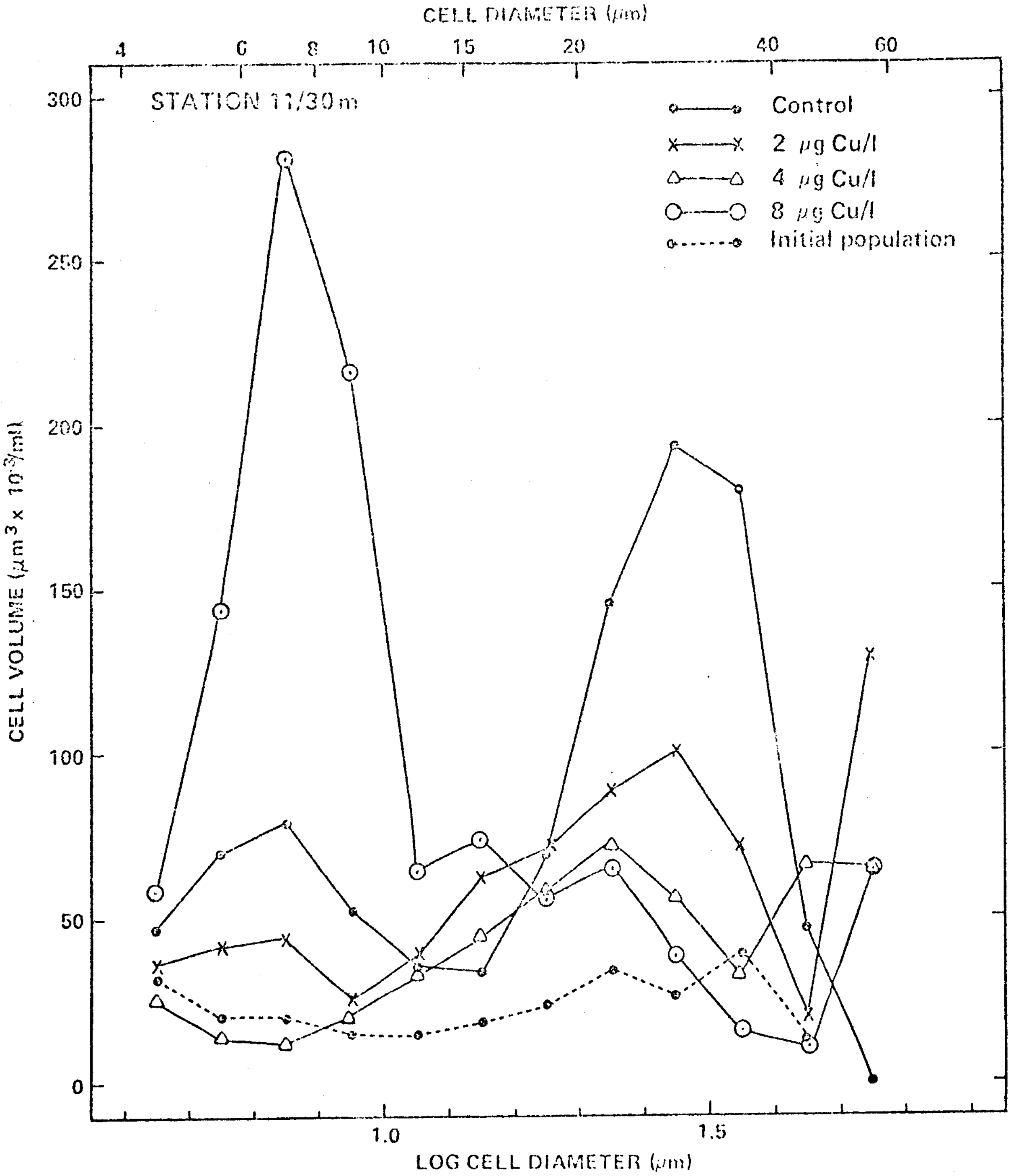

Figure 8. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

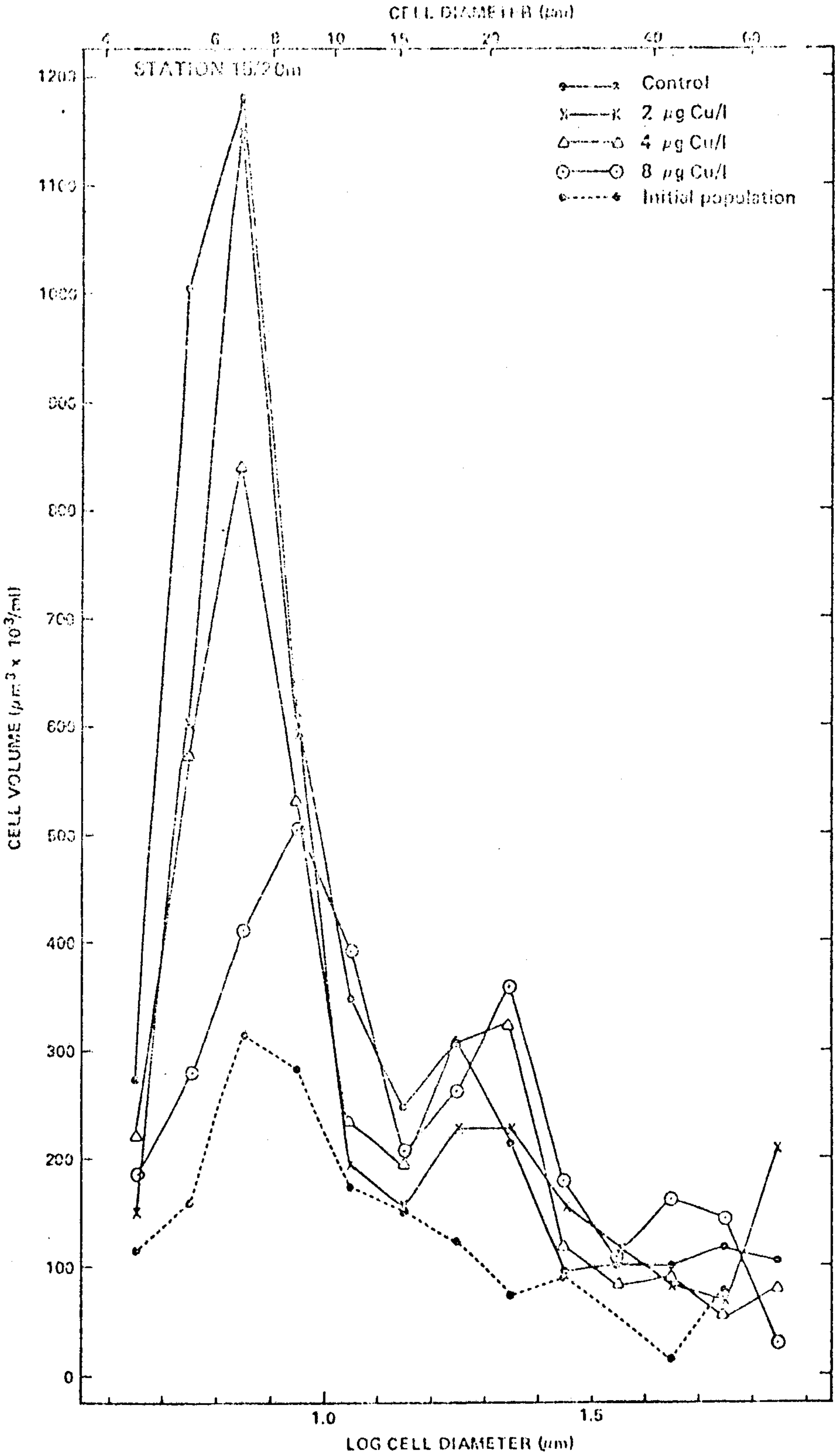

Figure 9. Effect of incubation for *ca.* 100 hours with 0, 2, 4 or 8 μg Cu/ℓ initially added station and depth information on each figure.

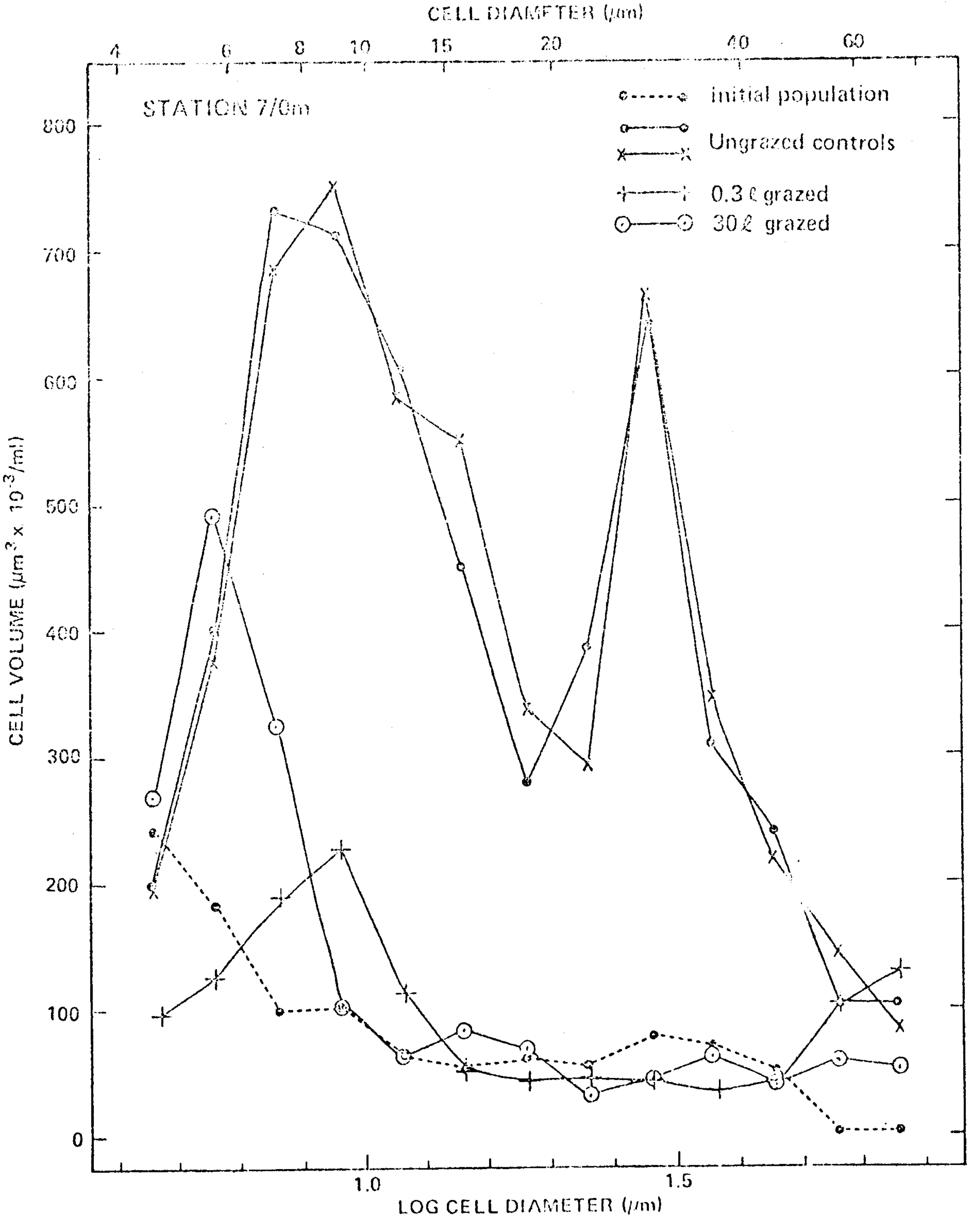

Figure 10. Effect of grazing by the copepod *Calanus plumerus*. Results appear to be little affected by size of container.

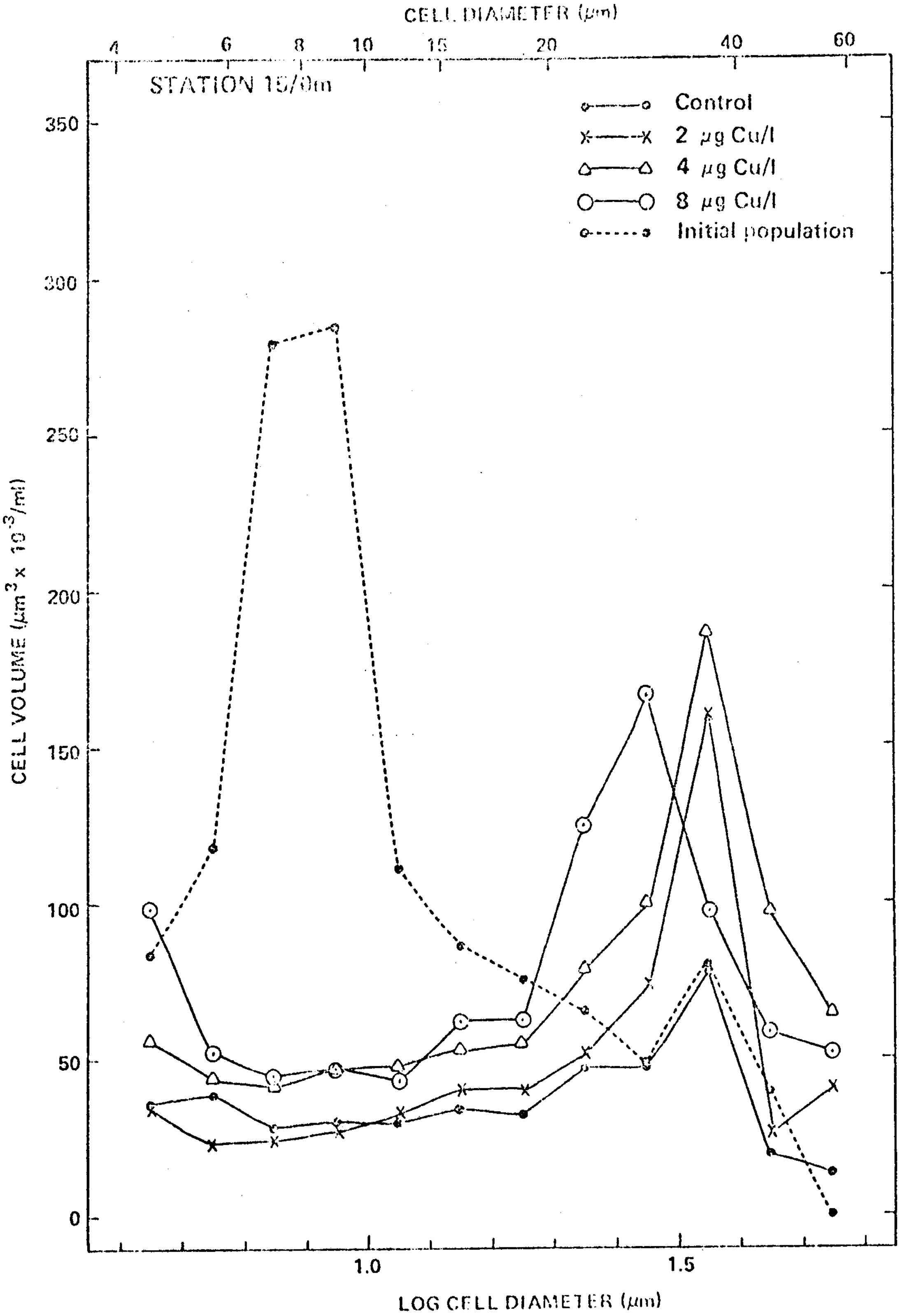

Figure 11. Dramatic decrease in nannoplankton due to grazing polychaete larvae. Compare with Figure 9, which is very similar sample without grazers.

The date base is too small to place much confidence in detailed generalizations, but it appears that the inshore stations with their greater continental influence were less dramatically affected by metal additions than were the open ocean samples. In several samples nannoplankton appeared to grow vigorously at high copper concentrations after a several day lag period, suggesting that population changes rather than productivity changes may be the long-term major result of environmental trace metal perturbations.

IV. PRELIMINARY INTERPRETATION OF RESULTS

The annual cycle of primary productivity in the Eastern Bering Sea appears to follow the following type of pattern. The period of ice melting in May (and probably also earlier) is a time of high phytoplankton activity, particularly in the region behind the retreating ice. This activity appears to be a normal spring bloom phenomenon, which develops in response to exposure of the sea to light concommitant with ice removal, and which strips the water of essential nutrients. Nitrate (and possibly silicate) are reduced to very low levels at a short distance from the ice, and presumably the activity terminates shortly thereafter. By the time we have completed another spring cycle and covered the early spring period, we will have a better idea of this. During our spring cruise, the ice was sufficiently far south so that it was not a great distance from the ice to the 50 meter contour and then to the major shelf break. Much of this area is under the influence of mild upwelling and mixing due to passage of water through the Aleutian Passes, and it is not surprising to find substantial phytoplankton activity, although lower than ice edge, at many of the stations.

We have previously observed that shortly after the spring bloom time, when the ice has retreated to its summer latitude, the only significant chlorophyll a can be found at greater depths in the water column, at 30 or 40 meters. In this shelf area, this can be rather close to the bottom. There was a hint of this developing in the May *Discoverer* Cruise, where a transect away from the ice showed a depression of chlorophyll with a maximum at 40 meters 100 miles from the ice edge. By the August cruise, however, no such deep chlorophyll was found, and the phytoplankton activity was extremely low at almost all locations. The same was true for the November cruise.

The first seasonal cycle, then suggests that spring bloom time is extremely important to the Bering Sea ecosystem, and that most of the primary organic matter input probably takes place at this time. A fall bloom does not appear to occur on the shelf, although fall activity may well increase somewhat in the Aleutian area. By the time the current March and April cruises are completed, we will have completed a year's cycle, essentially. More data are yet needed to quantify the input accurately on a seasonal and spatial basis. Even more important, a considerable effort must now be put into synthesis of the existing data to obtain a clear picture of the distribution of activity.

There appears to be a considerable variation in the detailed structure of the phytoplankton population spatially, with the ice-edge community having some dominant species which are absent in the open water community away from the ice edge, and this may again differ with populations found near the Aleutian Pass region.

V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

Very few major problems have been encountered and the data gathering and analysis has gone very smoothly on the whole. Our major difficulty has been carrying on the laboratory analyses and data processing and at the same time maning 5 cruises within a 10 month period. So far, we have kept up, but the primary productivity results have not been calculated yet as a result of this type of problem. However, the coverage obtained during this first year has been outstanding, and we have a wealth of data to work with.

For the next year, we would like to continue the field program to fill in time gaps and to confirm activity levels. One season is never considered an adequate base for estimates of total input. In addition, we will need to spend more time on working with data in order to obtain maximum benefit from the work done.

In order to approach the problem of how important and how vulnerable is the spring bloom, a little experimental work needs to be incorporated into the design for next year. The importance will be estimated as total proportion of annual input during this period, and also by looking at the food chain implications using grazing rate determinations as a first approach. Divers could also make visual observations on the role of the under-ice bloom (in the lower few centimeters of sea ice) in the food chain. This would be highly desirable, since several people have reported observing juvenile cod or amphipods actively grazing on the ice underside, there has been no quantitative or even semi-quantitative work done on this to my knowledge.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56   T/O NUMBER: 1   R.U. NUMBER: 159/164

PRINCIPAL INVESTIGATOR: Dr. Vera Alexander

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
Discoverer Leg I #808	5/15/75	5/30/75	5/15/76	5/15/76	5/15/76	Unknown
Discoverer Leg II #808	6/2/75	6/19/75	5/15/76	5/15/76	None	None
Discoverer Leg I #810	8/9/75	8/28/75	6/30/76	5/15/76	None	Unknown
Miller Freeman #815	11/10/75	11/26/75	9/30/76	6/30/76	None	None

Note: [1] Data Management Plan and data Formats have been approved and are considered contractual.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 1

PRINCIPAL INVESTIGATOR: Dr. Vera Alexander

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	123,857.00	67,132.13	56,724.87
Staff Benefits	20,912.00	10,933.15	9,978.85
Equipment	13,200.00	2,899.38	10,300.62
Travel	7,000.00	3,962.07	3,037.93
Other	16,900.00	7,328.13	9,571.87
Total Direct	181,869.00	92,254.86	89,614.14
Indirect	70,846.00	38,399.58	32,446.42
Task Order Total	252,715.00	130,654.54	122,060.56

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 156/164(E) for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

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OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

NEGOA

R.U. 164 E

Project Title: Phytoplankton Studies in the Bering Sea

Contract Number: 03-5-022-56

Task Order Number: 1

Principal Investigator: Dr. Vera Alexander

I. Task Objectives

To study the dynamics of phytoplankton populations at the edge of the retreating ice pack in the Bering Sea in order to assess the significance of the ice edge in the productivity of the Bering Sea. Secondly, to assess the levels of phytoplankton productivity in the southeast Bering Sea during the ice-free season in order to compare seasonal activity, and also to look at the role of the shelf-break and Aleutian upwelling in Bering Sea production dynamics. The seasonal role of algae growing in the underside of the ice is also included in the study.

II. Field Activities

A cruise in the Bering Sea was undertaken on the Miller Freeman during November, 1975, in which the principal aims of the phytoplankton component was to look at the status of phytoplankton activity in the ice edge vicinity during the period of time when ice is being formed and is moving south. Additionally, we wanted to look at the shelf-break and Aleutian area at this time of year. The work carried out was similar to that of the previous cruises. The current status of sample processing is as follows:

1. Nutrient analyses for Cruise 808 (Discoverer, May, 1975) and 810 (Discoverer, August, 1975) are completed.

2. Nutrient analyses for the Beaufort Sea (Morita and Atlas) are completed and the results have been sent to the two principal investigators.

3. Chlorophyll data for Cruises 808 and 810 and the November Miller Freeman Cruise have been completed.

4. Phytoplankton counts and identifications for both *Discoverer* cruises are completed, and data synthesis is being started.

5. Alkalinity data are available for the *Discoverer* cruises, and the *Miller Freeman* samples are currently being run.

6. Phytoplankton primary productivity samples(^{14}C) will be counted within the next two weeks.

III. Results

Preliminary data from the November cruise shows that there is very little phytoplankton activity during this time, with the exception of certain areas under the influence of the Yukon River or the Aleutian passes. There are very few phytoplankton in the waters of the Bering Sea shelf. So far, our hypothesis that the major production activity on the Bering Sea shelf is in the form of a bloom following the receding ice in spring seems to be well supported by the data. Nutrient availability is apparently the major limitation to production, even during the early winter months, although obviously this needs confirmation. The nature and role of the bottom chlorophyll maximum in midsummer needs further study, although this appears at present to be highly transient phenomenon and probably not important on a seasonal basis. Regions of high productivity during the summer appear highly restricted in number and very localized.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 1 R.U. NUMBER: 159/164

PRINCIPAL INVESTIGATOR: Dr. Vera Alexander

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates (1)			
	From	To	Batch 1	2	3	4
Discoverer Leg I #808	5/15/75	5/30/75	3/31/76	3/31/76	3/31/76	Unknown
Discoverer Leg II #808	6/2/75	6/19/75	3/31/76	3/31/76	None	None
Discoverer Leg I #810	8/9/75	8/28/75	6/30/76	3/31/76	None	Unknown
Miller Freeman #815	11/10/75	11/26/75	9/30/76	6/30/76	None	None

Note: (1) Estimated submission dates are contingent upon final approval of data management plan submitted in draft form Oct. 9, 1975, and University of Alaska's approved form Nov. 20, 1975, to NOAA. Also, final agreement by all parties on the data formats is necessary.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE:	December 31, 1975
CONTRACT NUMBER:	03-5-022-56
TASK ORDER NUMBER:	1
PRINCIPAL INVESTIGATOR:	Dr. Vera Alexander

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	123,857.00	47,586.71	76,270.29
Staff Benefits	20,912.00	7,610.47	13,301.53
Equipment	13,200.00	2,861.50	10,338.50
Travel	7,000.00	3,086.91	3,913.09
Other	16,900.00	4,446.46	12,453.54
Total Direct	181,869.00	65,592.05	116,276.95
Indirect	70,846.00	28,363.60	42,482.40
Task Order Total	252,715.00	93,955.65	158,759.35

* Preliminary cost data, not yet fully processed.

Annual Report for the Period

July 1, 1975 to March 31, 1976

RU 174--Baseline Studies of Demersal Resources of the Northern Gulf of Alaska Shelf and Slope: An Historical Preview.

I. Summary of objectives and conclusion

A. Objectives

1. Provide an historical perspective on the demersal fish and shellfish resources residing in the continental shelf and slope waters of the Gulf of Alaska between the Semidi Islands (157^{o} W. long.) and Yakutat Bay (140^{o} W. long.).
2. Provide growth and age composition information on selected demersal fish species of importance to man as food resources.

B. Conclusions

Not applicable at present.

II. Introduction

A. General nature and scope of study

1. Historical data

   Along with a review of the biological literature, existing data bases will be examined to provide historical perspective to the status of demersal populations in the baseline period.

2. Growth and age composition

   Age indicator structures collected during the BLM funded demersal fish and shellfish survey in May - August, 1975 will be read for age. From age and length data, estimates of growth parameters and age composition will be made on selected species.

B. Specific objectives

1. Comparison of information in the distribution and abundance of demersal fishes and shellfishes from the baseline survey of the North Pacific in 1975 with historical information from the literature and existing data sources (e.g. the International Halibut Commission trawl surveys in 1961-1963 and those of the NMFC in the early 1960's).
2. Historical treatment of the foreign and domestic fisheries and research in demersal resources in the baseline study area (Continental Shelf and Slope waters from the Semidi Islands to Yakutat Bay). This treatment would include annual catch trends, changing emphasis by the fisheries on specific resources, and the condition of resources past and present.
3. Annotated bibliography on the demersal fish and shellfish resources residing in the baseline study area.
4. The specific demersal fishes and shellfishes that are to be included in the historical survey are listed below (Growth and age composition estimates will be given for these species marked with an asterisk):

*Pacific pollock (Theragra chalcogramma)
*Dover sole (Microstomus pacificus)
*Flathead sole (Hippoglossoides elassodon)
Pacific halibut (Hippoglossus stenolepis)
*Pacific cod (Gadus macrocephalus)
Sablefish (Anoplopoma fimbria)
Pacific ocean perch (Sebastes alutus)
*Arrowtooth flounder (Atheresthes stomias)
*Rex sole (Glyptocephalus zachirus)
King crab (Paralithodes camtschatica)

Dungeness crab (Cancer magister)

Snow crab (Chionoecetes opilio, C. bairdi)

C. Relevance to problems of petroleum development.

The study area, from the Semidi Islands to Yakutat Bay, is an important region for commercial fishing. The Bureau of Land Management (BLM) is required by law to provide an environmental impact statement (EIS) covering petroleum exploration and development. BLM has contracted with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), to provide necessary data for preparation of the EIS.

III. Current state of knowledge

A comprehensive survey of demersal resources in the Northern Gulf of Alaska was completed by the International Pacific Halibut Commission with cooperation from the (then) U.S. Bureau of Commercial Fisheries during 1961-63. A number of less ambitious survey efforts preceded and followed the Halibut Commission survey, but nothing approaching the scope of this operation has taken place until the present plans were formulated. During the years since 1963, however, large fisheries by Japan and the Soviet Union have brought considerable fishing pressure to bear on the demersal resources. Fishery scientists of the United States, Japan, and the Soviet Union have agreed informally that some of the resources have been endangered by the combined fishing effort during the past 15 years.

Japan has furnished systematic and detailed statistical information on her catches, fishing efforts and size compositions, but the data supplied by the USSR are much less refined and of questionable accuracy.

IV. Study area

The study area includes that part of the northern Gulf of Alaska between the Semidi Islands (157^{o} W. long.) and Yakutat Bay (140^{o} W. long.) Depths included in the study area are from near shore (approximately 40 m) to approximately 500 m.

The study area has been divided into 3 sub-areas (140°00 - 144°30' W., 144°30' - 150°30' W., and 150°30' - 157°00' W.) and 4 depth zones (near shore to 100 m, 101-200 m, 201-400 m, and 401 m and greater).

V. Sources, methods, and rationale of data collection

A. Sources. Existing data sources to be examined include:

1. International Pacific Halibut Commission (IPHC) trawl survey (1961-63).
2. Bureau of Commercial Fisheries (BCF) scallop survey.
3. National Marine Fisheries Service (NMFS)/BCF groundfish surveys.
4. Alaska Department of Fish and Game domestic catch statistics.
5. Foreign fisheries statistics, including catch and effort data, from the Japanese fisheries (1964-73).
6. U. S. Foreign Fisheries Observer Program (1972-74).
7. IPHC halibut fishery catch-effort statistics.

B. Methods

1. Literature and documentary research of published and unpublished materials.
2. Laboratory analysis of age structures will follow standard techniques.

C. Rationale of data collection

No field activities are scheduled. The research will be concerned with compilation and analysis of existing data sources.

IV. Results

A. The field data collected in 1975 on distribution of demersal fish and shellfish resources has been analyzed so that it may be compared with the results of earlier surveys.

B. All the age structures (about 5,000) collected from 7 species of demersal fishes in 1975 have been read by the Age Determination Unit of the Northwest Fisheries Center; the information has been entered on ADP cards and the cards checked for errors.

C. Trawl catch data from the IPHC survey of 1961-63 have been entered on ADP cards so that they may be analyzed for comparison with results of the 1975 NEGOA field survey.

VII. Discussion

Because of preoccupation with completion of the final report on the NEGOA Project, an otter trawl survey of demersal fish and shellfish resources of the northeastern Gulf of Alaska in 1975, progress on RU174 has been limited during this reporting period. The final report on the NEGOA survey has now been completed and submitted so that full attention may now be given to RU174.

VIII. Conclusions

Not applicable at the present time.

IX. Needs for further study

Not applicable at the present time.

X. Summary of 4th quarter operations

A. Field or laboratory activities

1. Ship or field trip schedule--none.

2. Scientific party (all are Northwest Fisheries Center Personnel)

Lael L. Ronholt (Principal Investigator)
Herbert H. Shippen
Ronald A. Payne
Eric S. Brown

3. Methods

a. Laboratory analysis of age structures will follow standard techniques.

   b. Literature and documentary research of published and unpublished materials.

4. Sample localities

   a. The area of consideration is the continental shelf and slope off Alaska from the Semidi Islands (157°W long.) to Yakutat Bay (140°W long.).

   b. The growth and age composition information to be provided on important food fishes is from specimens collected between Cape Cleare (148°W long.) and Yakutat Bay (140°W Long.).

5. Data collected and analyzed

   a. Age structures (approximately 5,000) readings by the Age Determination Unit of the Northwest Fisheries Center were completed. The data has been entered on ADP cards; reviewed for error and is now ready for analysis.

   b. The field data collected in 1975 on distribution of demersal fish and shellfish resources has been analyzed so that it may be compared with results from earlier surveys.

Annual Report

Contract No.
Research Unit No. 175
Reporting Period: 1 April 75-
31 March 1976

Baseline Studies of Demersal Resources of the Eastern Bering Sea Shelf and Slope

Prinicpal Investigators: Dr. Walter T. Pereyra,
Dr. Jerry E. Reeves, and Richard G. Bakkala

Affiliation: Northwest Fisheries Center,
National Marine Fisheries Service,
2725 Montlake Blvd. East
Seattle, Washington 98112

24 March 1976

I. Summary

The objectives of RU175 are to 1) conduct baseline studies of demersal fish and shellfish of the eastern Bering Sea and to estimate values of those biological parameters which could change due to environmental stress caused by oil contamination; 2) review and summarize the pertinent biological literature on demersal fish and shellfish of the eastern Bering Sea; 3) analyze the historical fishery data from the eastern Bering Sea.

A three vessel synoptic survey of demersal resources was conducted in August-October 1975 in the eastern Bering Sea. A total of 654 stations were sampled. Catches or subsamples of catches occurring in standard one-half hour bottom tows were identified, weighed, enumerated and, for selected species, other biological data collected. Approximately 150,000 ADP cards were generated from the fall 1975 survey. These data are presently being analyzed.

Additionally, comparative fishing was conducted among the three survey vessels to establish differences in relative fishing power among the vessels so as to be able to adjust catches to an equivalent base.

Another three vessel baseline survey will be conducted in April-June 1976, to provide comparative data to the fall 1975 survey.

Summarization of pertinent biological literature on selected species of demersal fishes, crabs, and snails was undertaken. These summaries cover distribution, abundance, life history, population attributes, and exploitation patterns.

Analysis of historical data on demersal fishes and crabs is also underway. These data include catch statistics from commercial fisheries in the Bering Sea, U.S. and foreign research cruises, and other data sets.

No conclusions have been drawn here as to the potential effects of oil and gas exploration in the study area on demersal resources. Data presented herein are considered only tentative and subject to further analysis and interpretation.

II. Introduction

General nature and scope of study

To undertake baseline studies of demersal resources of the eastern Bering Sea shelf and slope areas, a three vessel synoptic survey was conducted in August, September, and October 1975. A second three vessel synoptic survey will be conducted in April, May, and June 1976.

The purposes of these baseline surveys are to (1) describe the composition, distribution, and abundance of demersal fish, shellfish, and principal epibenthic invertebrate resources of the eastern Bering Sea by season (spring and summer) and within season by area and depth; (2) establish for selected demersal fish and invertebrate populations, parameters which could change because of environmental stresses, e.g. stock size, size and age composition, growth rates, and length-weight relationships; and (3) compare information from the baseline period with historical information available from the literature and existing data sources.

Specific objectives

The research unit is divided into two tasks, with the following objectives:

Task A-13

Summarize existing literature and unpublished data on the distribution, abundance, and productivity of demersal fish, shellfish, and other epibenthic organisms.

Task A-14

Determine the distribution and abundance of demersal fish, shellfish, and other epibenthic organisms in the eastern Bering Sea. Estimate the productivity, length, weight, and age distribution of selected demersal fish and shellfish. Develop growth models and provide a data base against which subsequent changes in these parameters may be compared.

Relevance to problems of petroleum development

Oil and gas development in the eastern Bering Sea can be expected to significantly increase the input of petroleum hydrocarbons to that ocean area. The toxicity and/or chemical interference of continuous low-level oil leakages or unpredictable major oil-spill accidents may adversely affect demersal fish and shellfish resources.

The direct toxicity of certain petroleum hydrocarbons may cause increased mortality or sub-lethal stress. Although the chemical toxicity of oil would probably affect adult demersal fish and large invertebrates only after exposure to a major oil spill and sedimentation of petroleum to the bottom, the egg and larval stages of these organisms are more sensitive to harmful effects. The eastern Bering Sea is a spawning area for essentially all of the fish and shellfish species supporting major Bering Sea commercial fisheries. Areas of egg release, larval drift, and nursery grounds overlap several of the outer continental shelf areas under consideration for petroleum development. Large inputs of petroleum to these critical areas might affect year-class survival and change population characteristics of some species.

Indirect effects may also result from ecosystem shifts and changes in sediment quality. If petroleum development causes changes in the qualitative or quantitative composition of eastern Bering Sea plankton or benthic infaunal communities, then shifts in the distribtutions and abundances of demersal fish and shellfish may also be expected to occur. On a more local scale, sedimentation of oil residues to critical nursery areas may smother or poison infaunal food organisms, decreasing juvenile fish survival. These and other "tainted" bottom areas may subsequently be avoided by adult fish and large invertebrates.

In order to be able to understand the magnitude of the impact of oil and gas development on the demersal resource community it is essential to have current baseline information on resource distribution and abundance in time and space, and the manner in which these resources behave with regard to environmental stress and other major activities of man, e.g. commercial fishing. Such baseline information is also required to permit rational decision making with regard to oil and gas development in order to minimize or possibly prevent a deleterious impact on the demersal resource community.

III. Current State of Knowledge

Knowledge of the demersal fish and shellfish resources of the eastern Bering Sea is relatively limited. Some scientific literature is available on some commercially important species, but generally these studies have dealt only with a single season and with only a portion of the species' geographical distributions. Biological information has usually been inadequate to describe population parameters from any single species.

Additionally, many studies of the demersal resources of the eastern Bering Sea date back to the early and mid-1960's. Although these studies provide an historical perspective to some recent population parameters, they do not provide a complete description of species distributions or population attributes at any point in time nor do they provide information on the recent condition of stocks.

The demersal fish and shellfish resources of the eastern Bering Sea have been the target of an intensive fishery by foreign nationals since the mid-1950's. Total catches of groundfish by foreign nations have exceeded one million metric tons annually since 1968, and in 1971, 1972, and 1973, have exceeded two million metric tons. From 63 to 86% of this catch has been Pacific pollock.

Thus, we are examining bottom communities which have already been disturbed substantially by man--most of it within the last 10 years.

IV. Study area

The survey area consists of approximately 165,000 square miles (Fig. 1). The area has been divided into five subareas, as follows:

Sub-area I - Containing about 24,000 square miles, including nearshore waters (less than 20 fathoms) along the north side of the Alaska Peninsula and in Bristol Bay, where oil exploration might have the greatest environmental impact.

Sub-area II - Containing approximately 21,000 square miles, is a site of proposed oil exploration and also a region of large concentrations of adult king crab, Tanner crab, and pollock, and spawning-nursery area for these and other species.

Sub-area III - Covering nearly 40,000 square miles, this is another area of possible oil exploration and location of major concentrations of pollock in the summer.

Sub-areas IV and V - Containing approximately 60,000 and 20,000 square miles, respectively, these sub-areas are nursery areas for many of the adult populations residing in Areas I, II, and III.

A stratified-systematic sampling design has been used for the baseline trawl surveys. Station densities vary, depending on the geographical distribution and concentration areas of the more important species, and the potential exposure of areas to future environmental impact. Densities are lowest (one per 800 square miles) in subarea V, where the abundance of demersal species is lowest. Station densities are increased to one per 400 square miles in subarea IV which is a nursery area for many of the commercially-important species. For subareas II and III, where major concentrations of adult fish and shellfish occur and which contain potential sites of oil leases, station densities are further increased to one per 250 square miles. The highest station density, approximately one per 125 square miles, is used in Subarea I,

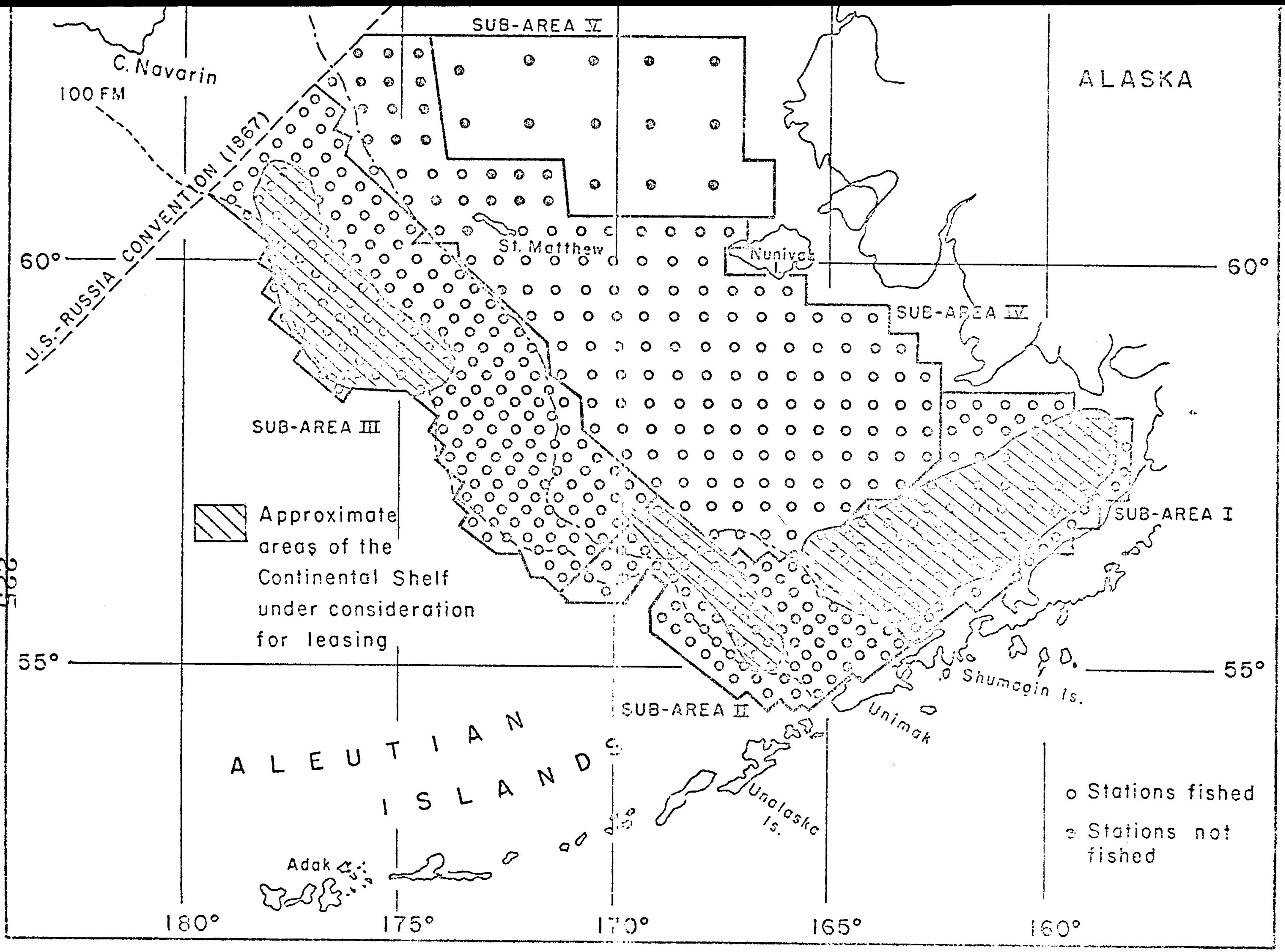


Figure 1. Survey area and stations sampled during demersal trawl survey, August-October 1975.

where there is a high potential for environmental impact from oil and gas exploration in nearshore waters.

All subareas, except V, were sampled in the fall 1975 survey, but only Subareas I, II, and III (except northern part) and the southern part of Area IV will probably be surveyed in the spring of 1976 due to anticipated ice cover of the northern areas of the sampling grid.

The timing of the spring survey (April-June) is designed to provide information on the more restricted winter-spring distribution of species relative to their broader summer distribution and to sample pollock in their spawning season.

V. Sources, methods, and rationale of data collection

Gear

Modified eastern fish trawls were used for the survey. The trawls had 112' footropes, 83' headropes, and are constructed of 4" mesh in the wings and body and 3½" mesh in the intermediate and codends. There are 31 8" diameter plastic floats on the headrope and four 25-fathom dandylines, two connected to each wing. The codends are lined with 1¼" mesh web for the retention of small fish and invertebrates. Doors were 6' x 9' on the charter vessels and 7' x 10' on the Miller Freeman.

Temperature profiles were made by XBT probes from the Anna Marie and Miller Freeman, and salinity and temperature data at depth were measured by a CTD instrument from the Freeman.

Methods

The survey was designed to synoptically cover the major part of the ranges of commercially important species of demersal fish and shellfish in the eastern Bering Sea. Depths ranged from less than 20 fathoms in near-shore waters to about 250 fathoms on the continental slope. A stratified-systematic station pattern was used for the survey. Station densities varied depending on the known distribution of main concentrations of the more important fish and shellfish species, the probable location of oil lease sites, and areas with high potential for environmental impact (Figure 1). One-half hour tows were made at each station.

Methods of processing the catches for fish and miscellaneous invertebrates differed from those used for crabs. For fish and invertebrates other than crabs, catches of less than about 2,500 pounds were entirely processed--that is, sorted by species, and weights and numbers determined for each species. For larger catches, a subsample of about 25 to 50% of the total catch was processed. After the catch was sorted, random samples of selected fish were taken for biological data collection (length frequencies, length-weights, and age structures by sex group). Biological information was taken from the following species of fish:

Pollock (*Theragra chalcogramma*)

Yellowfin sole (*Limanda aspera*)

Rock sole (*Lepidopsetta bilineata*)

Flathead sole (*Hippoglossoides ellasodon*)

Pacific halibut (*Hippoglossus stenolepis*)

Pacific cod (*Gadus macrocephalus*)

Sablefish (*Anoplopoma fimbria*)

Pacific ocean perch (*Sebastes alutus*)

Arrowtooth flounder (*Atheresthes stomias*)

Alaska plaice (*Pleuronectes quadrituberculatus*)

Greenland turbot (*Reinhardtius hippoglossoides*)

Commercial species of crab were removed from almost all catches, including those of more that 2,500 pounds. These were sorted by species and sex, and weights and numbers recorded. All crabs were measured except in the case of large catches when a subsample was taken to provide measurements on a minimum of approximately 300 crabs. In addition to carapace measurements, shell condition, clutch size and egg color were recorded for many of the specimens. Species examined were:

Red king crab (Paralithodes camtschatica)

Blue king crab (P. platypus)

Golden king crab (Lithodes aquispinis)

Tanner crab (Chionoecetes bairdi and C. opilio)

Korean hair crab (Erimacrus isenbeckii)

Also receiving quantitative study were several genera of snails including Neptunea, Buccinum, Volutopsius, Fusitriton, Beringius, and Plicifusus. Qualitative information describing the distributions and abundances of other invertebrates such as sea anemones, other crabs, nudibranchs, clams, starfish, sand dollars, sea urchins, starfish, sea cucumbers, sponges, and sea pens was also collected by the three vessels. Additional detailed information on these epibenthic invertebrates was collected on the Miller Freeman by personnel from the Institute of Marine Sciences, University of Alaska.

Six days of intercalibration tests were carried out by the three survey vessels during which 28 comparative tows were completed. Half of the tows were made at 40-70 fathoms and the other half at 75-100 fathoms to detect any differences in relative fishing power between vessels with depth. Alternate tows of one-half and one hour were used to determine if catches from the shorter tows provided the same information as those of longer duration. All aspects of these tests were successfully completed and have provided data adequate to adjust catches from each vessel into a single unbiased data base.

VI. Results

Data collection

Table 1 summarizes the fishing effort and data collection of each vessel. During the 148 vessel-days in the survey area, 654 tows were made for an average of 4.4 tows per day despite several days of unfishable weather. Of this total, 642 tows were successfully completed without damage to the net. The number of stations in the survey area was 588. Some low priority stations in the northern part of the survey area were not sampled (Figure 1). The number of tows exceeded the number of stations because replicate hauls were made at or near some stations during the comparative fishing experiments and some stations were repeated in subarea I at the request of the OCSEAP Office so that requirements of the Institute of Marine Sciences studies on invertebrates could be met. Additional non-standard stations were fished near St. Mathew and St. Paul Islands to examine the availability of blue king crab and Korean hair crabs in these areas.

All catches were processed in the manner described in the methods section. Length measurements were taken from nearly 181,000 fish. Independent otolith or scale and length-weight samples were taken for selected species from five regions of the survey area. The location of these regions was based on prior evidence of the possible existence of independent spawning populations or growth differences for some species in certain of these areas. Growth data were collected for pollock, yellowfin sole, flathead sole, rock sole, Alaska plaice and Pacific cod in those regions where the species appeared in adequate numbers. About 7,400 otoliths and 5,900 length-weight measurements were taken.

Carapace measurements were taken from about 81,000 crabs. Most of these were from Tanner crab (74,466), and the remainder from red king crab (6,390) and blue king crab (414). Additionally about 12,000 snails were collected during the survey.

Table 1. Summary of fishing activity and data collection by each vessel during the eastern Bering Sea demersal survey, August-September 1975.

Vessel	Days on fishing grounds	Number of hauls	Data collected			
			Groundfish			Crab
			Length Measurments	Otoliths and scales	Length-weights	Carapace Measurements
			(Preliminary numbers)			
Anna Marie	49	224	66,868	3,159	1,542	27,989
Miller Freeman	50	219	76,318	2,139	1,754	27,389
Pat San Marie	49	211	37,648	2,129	2,602	25,392
Total	148	654	180,834	7,427	5,893	81,270

Preliminary findings

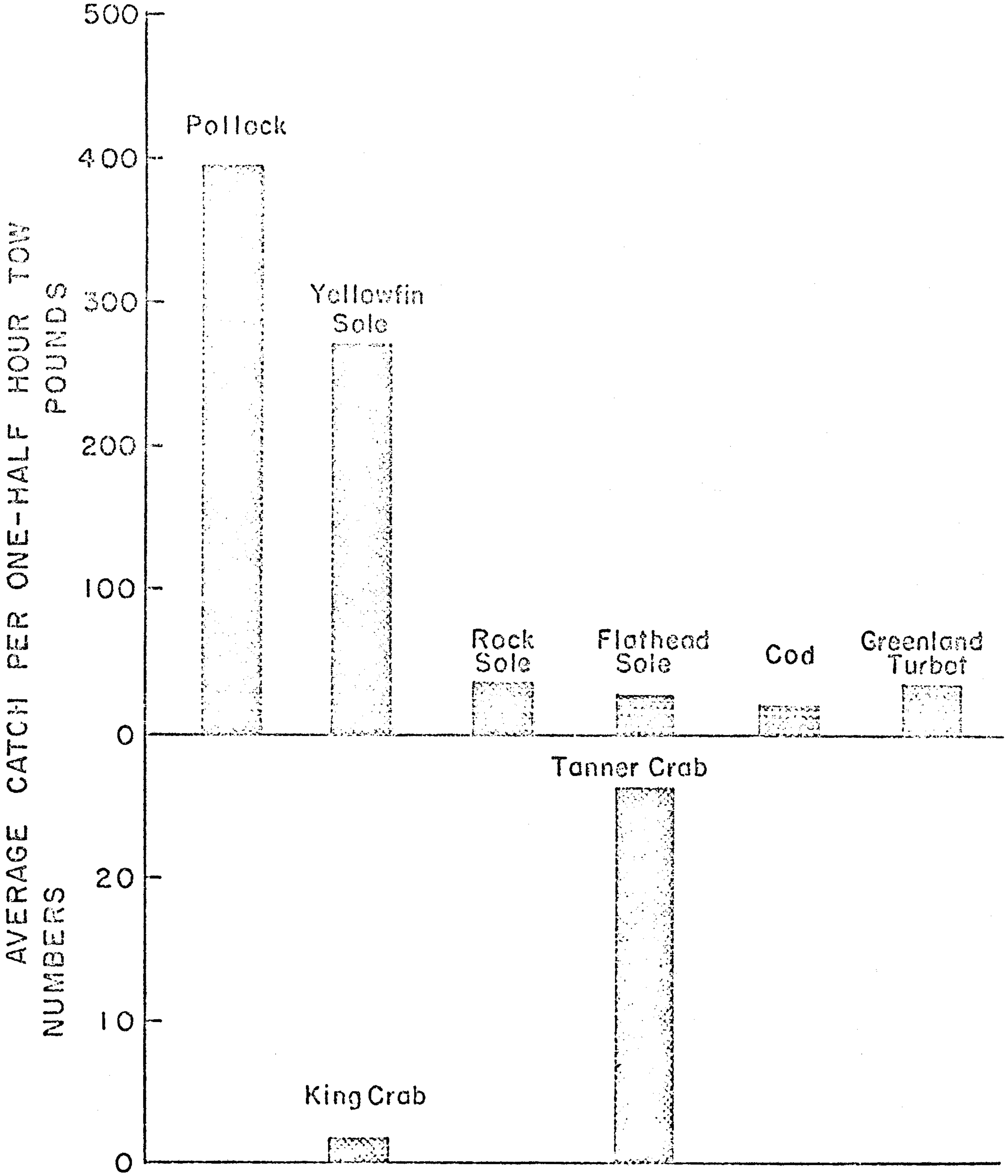
The most frequently occurring and abundant species in the survey area were generally those of most importance in the commercial fisheries of the eastern Bering Sea. Among the fish species these were, in order of their abundance: pollock, yellowfin sole, rock sole, Greenland turbot, flathead sole, and cod (Figure 2). Principal crab species were king crab and Tanner crab (Figure 2).

Preliminary catch data for some commercial species are summarized in Table 2. Pollock dominated the catches in subareas II and III, outer shelf and slope areas with depths ranging approximately 50-240 fathoms. They occurred in almost all hauls and far exceeded catches of other species in average weight per haul (about 470 pounds per tow in subarea III and 1,200 pounds/tow in subarea II).

Catches ranged up to 9,300 lbs per half-hour tow, with the largest catches occurring southeast of the Pribiloff Islands and west and south of St. Mathew Island (Figure 3).

Other species occurring frequently in catches on the outer shelf, although at much lower abundance than pollock, were Greenland turbot, flathead sole, Pacific cod and, in subarea II, Arrowtooth flounder. The deeper-water species, Pacific ocean perch and blackcod, were taken infrequently and in relatively low aboundance.

In subareas I and IV, covering the upper shelf (depths usually less than 50 fathoms), yellowfin sole was the predominate species, appearing in nearly all hauls and being the most abundant species by weight. Catches of yellowfin sole ranged up to 4,500 pounds per half-hour tow (Figure 4), largest catches occurring in pockets north of Unimak Island.



igure 2. Average catch per one-half hour tow of the most frequently encountered species of demersal fishes and crabs occurring in the survey area (all subareas combined) August-October 1975.

Table 2.--Summary of catches by sub-area (see figure 1) of the principal commercial species of crab and groundfish taken during the BLM-MARMAP trawl survey in the eastern Bering Sea. Figures are preliminary and subject to correction.

Occurrence in hauls		Average catch	Occurrence in hauls		Average catch
Species rank	Percent	per 30-min. tow	Species rank	Percent	per 30-min. tow
NORTHWESTERN SUB-AREA (III) Depth range 29-240 fathoms Total hauls 205			NORTHEASTERN SUB-AREA (IV) Depth range 13-57 fathoms Total hauls 133		
Groundfish		Pounds	Groundfish		Pounds
Pollock	97	469	Yellowfin sole	95	253
Greenland turbot	92	69	Alaska plaice	87	64
Flathead sole	92	23	Pollock	83	127
Pacific cod	63	28	Greenland turbot	74	12
Rock sole	53	8	Rock sole	71	22
Arrowtooth flounder	20	3	Pacific cod	32	2
Yellowfin sole	20	3	Flathead sole	25	5
Alaska plaice	7	<1	Arrowtooth flounder	2	<1
Pacific ocean perch	3	<1	Blackcod	0	--
Blackcod	1	<1	Pacific ocean perch	0	--
Crabs			Crabs		
Tanner crab	98	140	Tanner crab	65	84
King crab	21	4	King crab	15	3
SOUTHWESTERN SUB-AREA (II) Depth range 42-210 fathoms Total hauls 93			SOUTHEASTERN SUB-AREA (I) Depth range 15-52 fathoms Total hauls 113		
Groundfish			Groundfish		
Pollock	97	1197	Yellowfin sole	100	715
Flathead sole	95	94	Rock sole	94	79
Arrowtooth flounder	92	32	Pollock	84	58
Pacific cod	87	47	Pacific cod	65	7
Greenland turbot	76	16	Alaska plaice	59	24
Rock sole	53	43	Flathead sole	58	11
Yellowfin sole	41	78	Greenland turbot	55	5
Alaska plaice	27	7	Arrowtooth flounder	13	1
Pacific ocean perch	11	2	Blackcod	2	<1
Blackcod	6	<1	Pacific ocean perch	0	--
Crabs			Crabs		
Tanner crab	96	97	King crab	81	128
King crab	41	53	Tanner crab	64	56

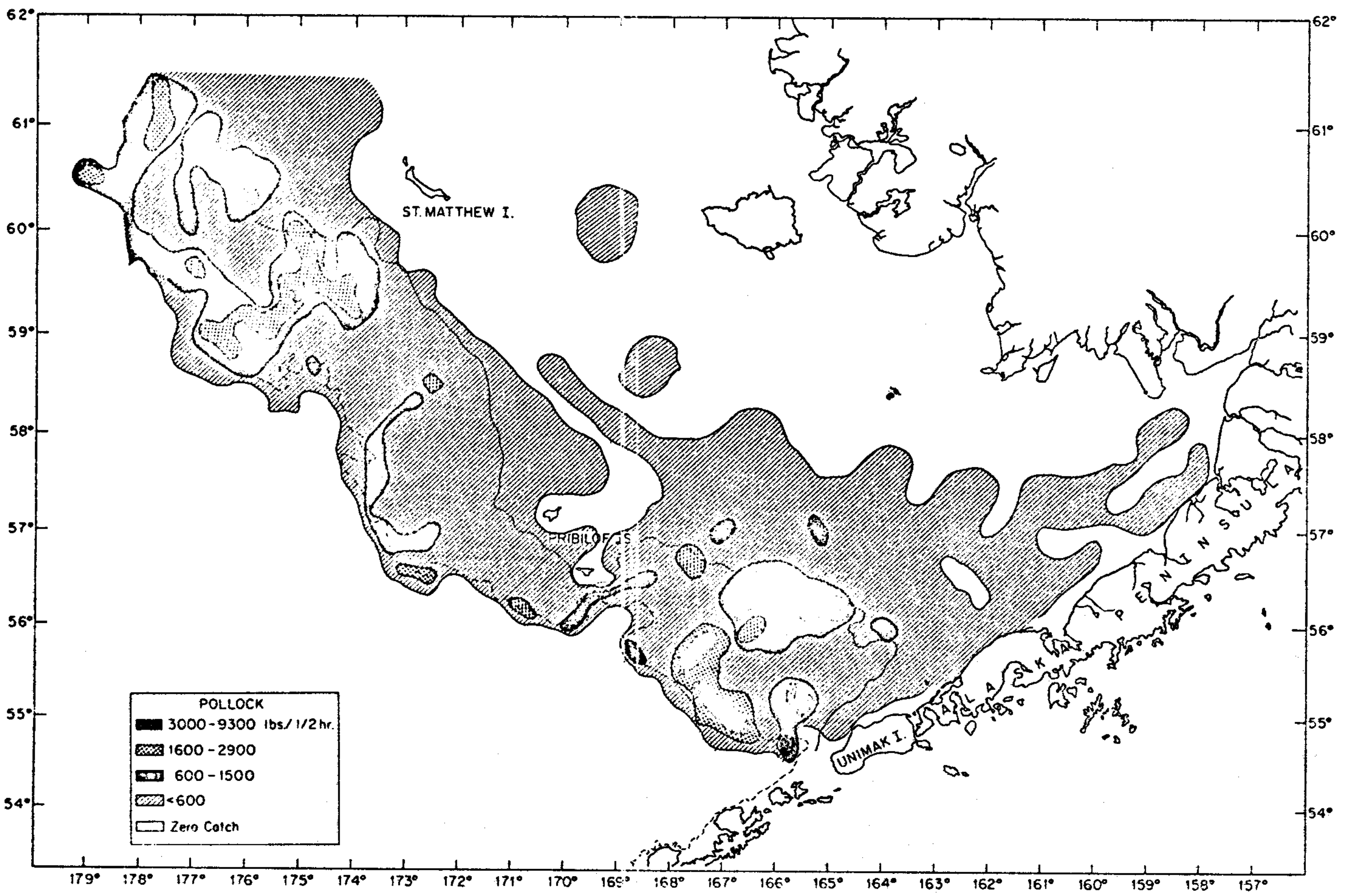


Figure 3. Distribution and apparent abundance of pollock in the eastern Bering Sea, August-October 1975.

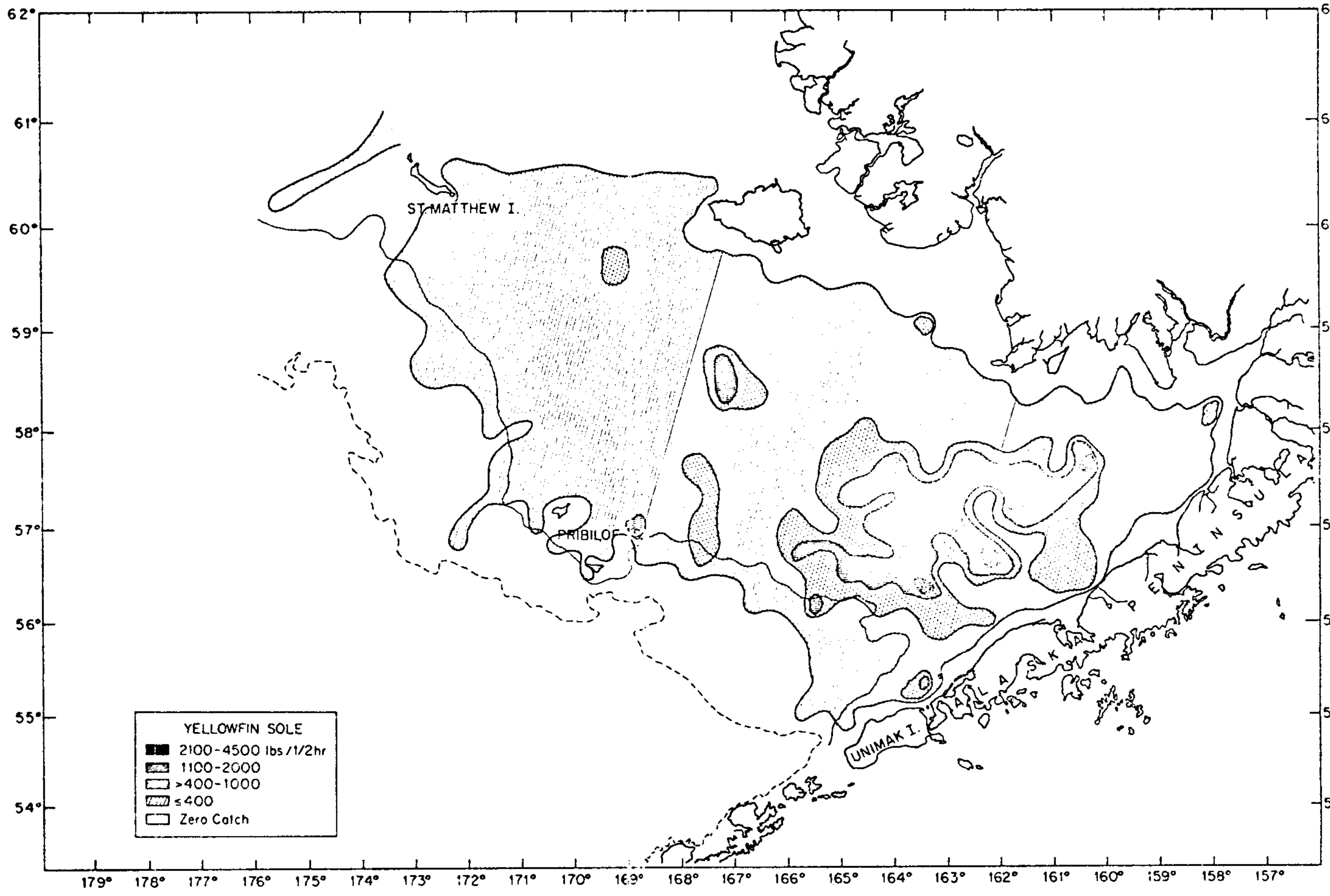


Figure 4. Distribution and apparent abundance of yellowfin sole in the eastern Bering Sea, August-October 1975.

Although much less abundant than yellowfin sole, other species frequently taken in hauls on the upper shelf were Alaska plaice, pollock, Greenland turbot, and rock sole. The occurrences of Pacific cod and flathead sole were also relatively high in subarea I.

Some species were mainly restricted to the shallower waters of the upper shelf whereas others occurred frequently over all depths fished. Yellowfin sole and Alaska plaice were primarily found in waters less than 50 fathoms, whereas pollock, Greenland turbot, flathead sole, Pacific cod, and rock sole generally ranged over most of the survey area. This is illustrated in Table 3 by the frequency of occurrence of these species in hauls by subarea.

Table 3.--Percent frequency of occurrence of principal species taken in trawls from deep and shallow shelf areas.

	Deep Shelf Areas		Shallow Shelf Areas	
Species	(II)	(III)	(I)	(IV)
Pollock	97	97	83	84
Greenland turbot	92	76	74	55
Flathead sole	92	95	25	58
Pacific cod	63	87	32	65
Rock sole	53	53	71	94
Yellowfin sole	20	41	95	100
Alaska plaice	7	27	87	59

Tanner crab appeared consistently in catches in all subareas, more so on the lower shelf than the upper shelf (Table 2). Their average weight in catches was also relatively high compared to most species of groundfish. Of the two species of Tanner crab, Chionoecetes opilio was by far the most abundant in the northern subareas. The second species, C. bairdi, which is larger than C. opilio, became more abundant in the two southern subareas and predominated in subarea II.

Catches of legal size Tanner crab (males >110 mm carapace width), both species combined, exceeded 200 crabs per one-half hour tow north and northwest of the Pribilof Islands (Figure 5). Catches of 50-200 legal size crab per tow occurred throughout subareas II and III.

The occurrence and abundance of king crab was highest in subarea I, which is the subarea in which the U.S. commercial fishery is located. Their abundance was also relatively high in subarea II, but they occurred in only about 40% of the hauls.

Catches of king crab in subareas I and II were almost entirely red king crab (*Paralithodes camtschatica*). Those in subareas III and IV were mainly blue king crab (*P. platypus*). The blue king crab were taken in two localized areas, one near the Pribilof Islands, and the other southwest of St. Mathew Island.

Catches of legal size king crab (males >134 mm carapace width) ranged up to 200 per one-half hour tow (Figure 6), but the largest catches occurred in only two localized pockets in subarea I.

Comparative fishing

Twenty-eight comparative tows were completed during the fall survey. The three vessels lined up about one-quarter mile apart and towed simultaneously for a specified time. Analysis of the resulting data for catches of demersal fish indicates that significant differences in fishing power existed between vessels (Table 4). In the case of pollock, it was necessary to calculate separate fishing power coefficients for small (<20 cm) and large pollock.

Table 4 .--Fishing power coeficients calculated for the three vessels participating in the eastern Bering Sea groundfish survey, August-October 1975.

	Species				
Vessel	Small Pollock	Large Pollock	Flathead Sole	Yellowfin Sole	Rock Sole
Miller Freeman	1.00	1.00	1.00	1.00	1.00
Anna Marie	0.52	0.79	1.17	0.81	0.65
Pat San Marie	0.34	0.61	1.07	1.00	0.76

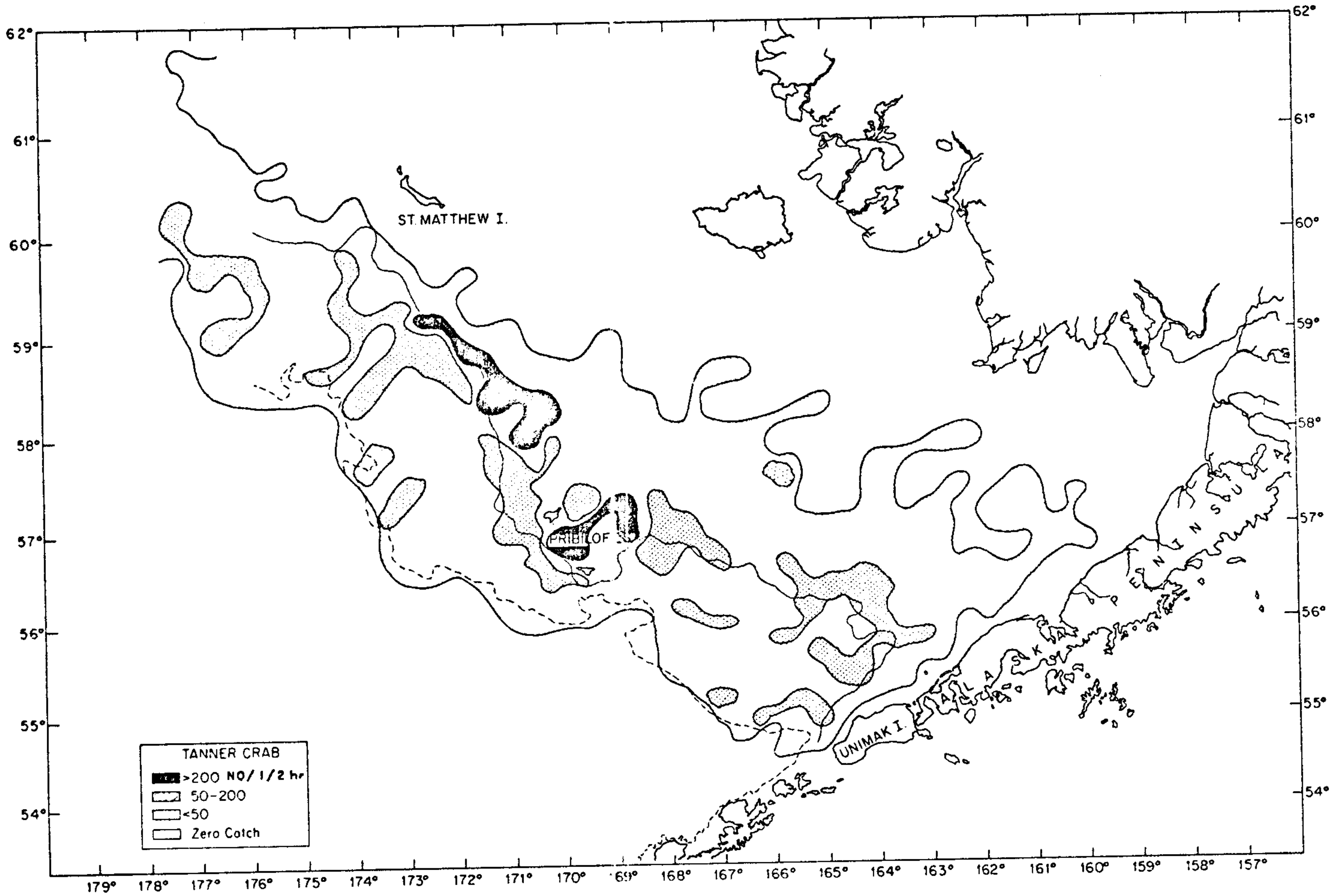


Figure 5. Distribution and apparent abundance of legal (males >110 mm carapace width) Tanner crab in the eastern Bering Sea, August-October 1975.

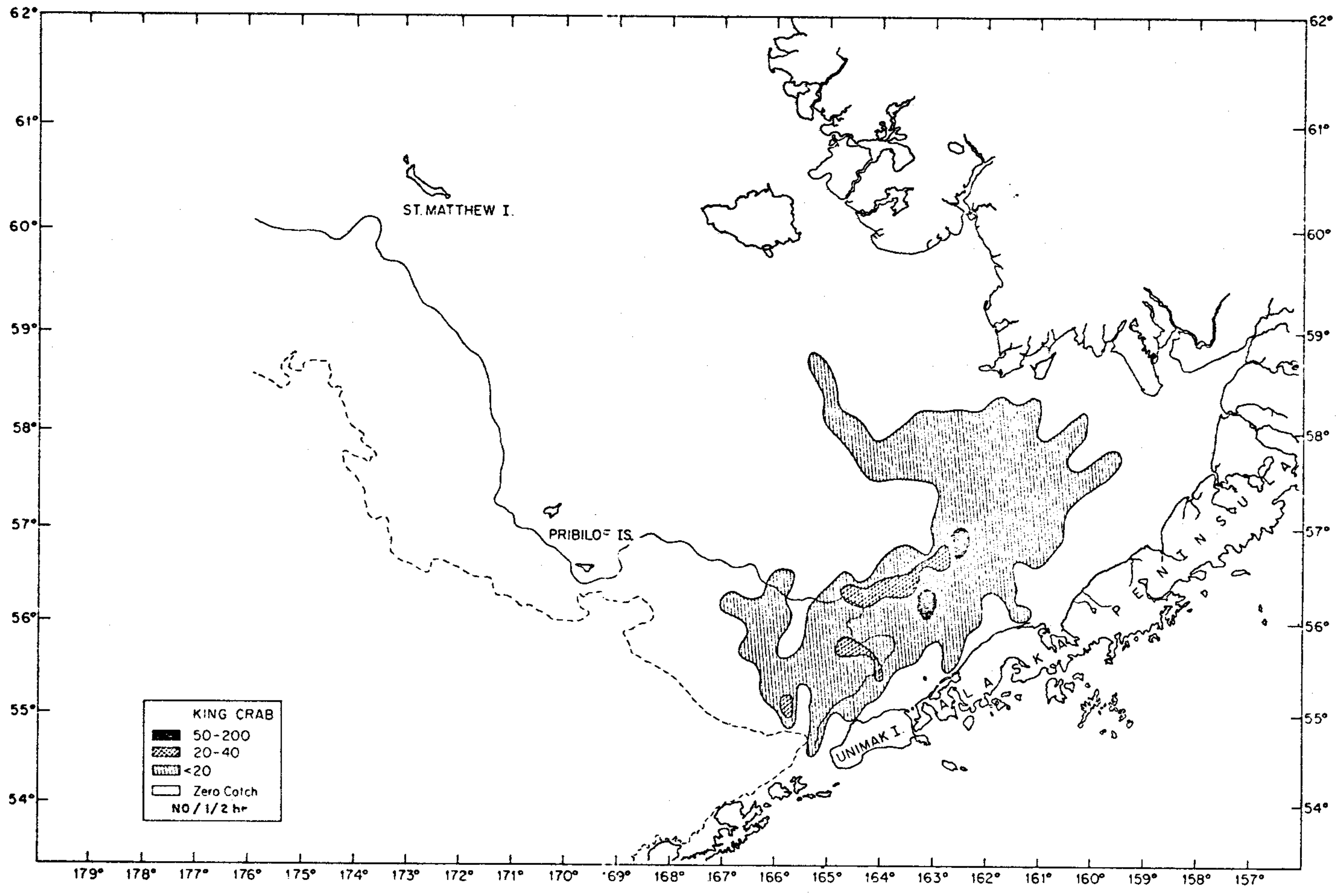


Figure 6. Distribution and apparent abundance of legal (males >134 mm carapace width) king crab in the eastern Bering Sea, August-October 1975.

Similar analysis is underway on king and Tanner crab comparative data.

Comparison of survey results and objectives

Major objectives of the survey were successfully accomplished. All essential stations in the survey area were sampled and catches from each station processed for species weights and, in most cases, for species numbers to allow descriptions of the distribution and abundance of demersal fish, shellfish, and other epibenthic invertebrates by area and depth. The size and age data will enable descriptions for major species of size and age composition, growth rates and length-weight relationships by regions of the eastern Bering Sea. These data will also provide standing stock estimates by size and age groups. Temperature and CTD profiles will provide information on the association of these environmental features with species distribution.

Not accomplished during the survey was coverage of stations in subarea V and some stations in the northern portion of subarea IV. These were low priority stations and fishing in adjacent areas indicated that catches at these stations would have been minor.

VII. Discussion

Only preliminary data are included here and discussion of the specifics of the survey must await detailed analyses of the data. The preliminary results, however, yield insight into the distribution of the major fish and shellfish components of the epibenthic community and their abundance by subarea.

VIII. Conclusions

No conclusions will be made until analysis of the data is complete.

IX. Needs for further study

Potential needs for further study will depend on the outcome of analysis of survey data.

X. Summary of 4th quarter operations

Laboratory activities

Task A-13

Summarization of literature on eleven species of demersal fishes of the eastern Bering Sea was continued. Literature summaries were completed on yellowfin sole, rock sole, flathead sole, and Pacific cod. Summaries are nearly complete for sablefish and Pacific ocean perch. In preparation are literature summaries for pollock Greenland turbot, arrowtooth flounder, and Alaska plaice.

Summarization of literature on crabs was continued with an estimated 75 percent of documented literature pertaining to king and Tanner crabs accounted for.

Although literature on the most abundant genera of snails in the eastern Bering Sea, Buccinum and Neptuna is not extensive, a bibliography, including papers on taxonomy, life history, biogeography and population dynamics is being compiled.

Analysis of historical data on demersal fisheries of the eastern Bering Sea was continued. ADP programs were written to transfer the historical data format to one compatible with NWFC data formats, and preparations have been made for distributional plots for selected species.

Task A-14

Analysis of groundfish data collected during the fall 1975 survey is continuing. Approximately 56,500 ADP cards have been punched, verified, and edited for errors. These cards have been loaded into a disk file, using computer programs developed by our staff. A program that updates the data on the disk file has been written, allowing the user to correct or amend any record on the disc file.

Corresponding programs have been written for length-frequency data and should be operational soon. Programs have been modified to calculate distance fished from LORAN readings.

Analysis of comparative fishing data to determine relative fishing power of the three vessels was completed for demersal fishes and is underway for crab data.

All crab data collected during the fall cruise has been punched and verified, and is now recorded on approximately 82,000 ADP cards. These cards are being transferred to magnetic tape.

Samples of approximately 12,000 snails collected from the eastern Bering Sea in 1975 have been examined and all data entered on ADP cards. The twelve species of snails that were most abundant in the area surveyed are being described in terms of distribution, abundance, sex, and size composition.

Field activities

The NOAA FRV *Miller Freeman* departed Seattle on March 15, 1976, enroute to the Bering Sea to undertake the spring survey. Boarding the vessel in Kodiak on March 22 will be Richard Bakkala, Field Party Chief, Doyne Kessler, Terry Sample, Jerry Berger, and Joo Yeoul Lim (visiting Korean scientist), all of the Northwest Fisheries Center.

Sampling methods will follow those used in 1975.

The charter vessels *Anna Marie* and *Pat San Marie* will depart for the Bering Sea in early April to participate in the survey.

As the *Miller Freeman* will not be available for demersal trawling on leg III, the NOAA FRV *Oregon* will sample some survey stations in June during its annual crab/groundfish survey of the southeastern Bering Sea. The *Oregon* and *Pat San Marie* will conduct a comparative fishing experiment to permit the *Oregon* data base to be integrated into that generated by the other three survey vessels.

Annual Report

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Research Unit #233
Reporting Period - July 1975 -
1 March 1976

Beaufort Sea Estuarine Fishery Study

Principal Investigator:

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1 April 1976

I. Introduction

Petroleum exploration and development is rapidly increasing throughout the nearshore areas of the Beaufort Sea. Already, the demands by industry for construction material, gravel sources, fresh water, and transportation avenues are substantial. Alterations of the physical environment resulting from water and gravel removal or the construction of roads and causeways are imminent. Knowledge of fish in the Beaufort Sea is minimal.

The objectives of this study are to determine the distribution and relative abundance of the various species of fish occupying the nearshore environs of the Beaufort Sea. Correlating important life history data with knowledge of habitat needs, we hope to obtain baseline information that can be used to direct the activities of people and industry in the proposed lease area.

Specifically, the objectives of the study are:

A. To determine the seasonal distribution, relative abundance, size and species composition, growth rates, feeding habits and reproductive capabilities of Beaufort Sea nearshore fishes in the area from the Colville to the Canning rivers and between shore and the barrier islands, including river deltas.

B. To determine migration patterns and timing of these fishes.

C. To identify critical habitats including spawning, overwintering, feeding, rearing and migration areas.

D. To determine the interrelationship of Arctic fishes to lower food-web organisms.

E. To determine the present rate of exploitation of the anadromous fishes of the area and to monitor changes in this usage as development of the areas petroleum resource progresses.

II. Current state of knowledge

Prior to the accelerated interest and development in the Arctic by major oil companies, there have been few investigations of the fishes in the Beaufort Sea. The Alaska Department of Fish and Game (Roguski and Komarek, 1970) initiated a study to assess the environmental characteristics and fish species in coastal waters of the Arctic National Wildlife Range. The following year, a four year investigation of the waters draining into Prudhoe Bay was initiated (Yoshihara 1972, 1973 and Furniss 1974, 1975). These past investigations emphasized the life histories and distributions of anadromous species with special emphasis on Arctic char. Other fisheries studies on North Slope drainages were conducted by McCart, Craig and Bain (1972) and Johnson (1973). With the advent of designing and proposing utility corridors to transport natural gas south of the

Arctic, several more investigations were initiated, many of which stressed the life history and biology of fish in their freshwater habitats of North Slope drainages. More recently, fisheries investigations have been centered along the northern coastlines of Alaska and Canada. Furniss (1975) investigated the age, growth, fecundity, species composition and distribution of fishes in Prudhoe Bay. Griffiths and Craig et al. (1975) conducted a site specific study of the fishes in Nunaluk Lagoon, along the Arctic coast of the Yukon Territory. Griffiths et al., (1976) conducted a similar study at Barter Island, and other investigators have conducted studies aimed at evaluating the importance of the Mackenzie (Percy, Eddy and Munro, 1974) and Colville (Kogl and Schell. 1975) river deltas to Arctic Ocean fish. Studies of overwintering fish in the Arctic have been directed towards the larger bodies of fresh water, including river deltas (Mann, 1975; Kogl and Schell, 1975) and spring areas or unfrozen pockets of river water under thick ice (Furniss, 1976; Craig and McCart, 1974). These studies have led to a much greater understanding of the habitat requirements and life histories of Arctic fishes; however, much remains to be understood of these fishes during their occupation of the shallow nearshore environments along the Beaufort Sea coast.

III. Study area

The OCS Beaufort Sea studies encompass an area between the eastern margin of Harrison Bay and Flaxman Island, a linear distance of approximately 102 miles (163 km) (Fig. 1). Centrally located along this stretch of coastline is Prudhoe Bay, the development and staging area for North Slope oil fields and the beginning of the Trans Alaska oil pipeline. A barrier island system consisting of raised pebble reefs extends intermittently along the entire length of the study area. These islands, lying from 1/2 to 12 miles (1-16 km) offshore, tend to prevent large quantities of fresh water and nutrients entering the Beaufort Sea from readily mixing with the cooler, more saline waters of the Arctic Ocean. They also shelter the mainland coastline from pack ice during the summer months, thus providing a low salinity, relatively ice free lagoon system inhabited by several species of anadromous, freshwater or marine fish throughout much of the year. Physical features of the mainland coastline include river deltas, spits, shallow bays, and narrow pebble or fine sediment beaches. Direct wave action and thermal erosion of permanently frozen shore banks produce local beaches composed of humus and decayed vegetation. Sharp variations in water temperatures and salinities were noted, both between short distances and with time, during the open water season (Table 1). Physiographic and environmental characteristics of the Beaufort Sea and coast are described by Namtvedt, et al. (1974) and State of Alaska, Division of Policy Development and Planning (1975).

IV. Sources, methods and rationale of data collection

A. Methods of capture and observations

Multifilament graduated mesh sinking gill nets measuring 125' x 6' and consisting of five 25' panels of 1/2" through 2 1/2" square mesh were used most extensively for capturing and sampling fish. Multifilament gill nets measuring 25' x 3' and consisting of single mesh sized from 1/2" to 1 1/2" were used for capturing fish during under-ice surveys.

Beach seines measuring 100' x 4' were used to sample fish in confined locations within small bays and lagoons, and along exposed beaches where water was sufficiently shallow to allow the seaward end of the seine to be maneuvered on foot.

Fyke traps were operated at two locations within Prudhoe Bay. Traps were 20' in length overall and were supported by five "D" shaped, 3/4" aluminum tube frames. Two troats measuring 10" in diameter were located at the first and third frames. Netting was 1/2" square mesh knotless nylon. The fyke traps were anchored in approximately 4' of water and were attached to shore by a 150' center lead. Two 25' x 4' wings funneled fish into the first frame.

A try trawl measuring 12' in width and constructed on 3/4" square measure knotted nylon mesh was used to sample fish offshore.

Hook and line sampling was employed to capture fish in river deltas and under the ice.

An underwater closed circuit television system was experimented with under the ice in the Sagavanirktok River Delta to determine its usefulness for detecting and observing overwintering fish occupying isolated pockets of unfrozen water. The system is sold by Hydro Products, Box 2528, San Diego, California. The operation employed the following five components:

1. Underwater television camera with 12.5 mm optics.

2. High resolution 9" monitor

3. Gas discharge lamp ballast.

4. 250 watt Thallium iodide lamp.

5. Portable 115V power source.

Rotary wing aircraft were used for transporting field personnel and gear and for monitoring movements of fish along the coastline and into river deltas.

Arctic char over 200 mm in fork length, which were not sampled, were tagged with numbered spaghetti tags. Ciscos over 200 mm were tagged with Floy FD-67 internal anchor tags and those under 200 mm were "fin clipped" to indicate location of capture.

A YSI meter was used to determine water temperature, salinity and conductivity.

B. Processing of fish

Fish samples were preserved in 10% formalin or frozen and sent to Fairbanks via commercial airlines for further laboratory analysis. All samples were grouped by date and location. Fish were weighed to the nearest gram on a triple-beam balance. Fork lengths were measured to the nearest milimeter. Sex and stage of maturity were determined by examining gonads.

Fecundity counts were determined by displacing a volume of water with a known quantity of eggs. The total number of eggs was then calculated using the quantity of water displaced by the entire ova mass.

Arctic char, Arctic cod and fourhorn sculpins were aged by reading otoliths wetted in zylene. Scales were used to age all other species. Scales used for age determination were cleaned and impressed on 20 mil acetate. A Bausch and Lomb microprojector was used to read the scales.

Selected fish stomachs were slit and preserved in 10% formalin. The gut contents were later examined, sorted and identified.

C. Data management

All data collected thus far have been recorded on one of three different data collection forms of our own design. A preliminary data management plan for this project has been prepared and submitted. At the time of this writing, the OCSEAP data management format is in the final stages of completion and upon receipt our initial data batches will be submitted for computer punching and storage on magnetic tape.

V. Results

A. Species composition and relative abundance

Thirty sampling sites were established between Point Sorensen (long 148° 49' lat 70° 24') and Brownlow point (long 145° 53' 70° 10') in the eastern one-half of the study area (Fig. 2). An attempt was made to sample all of the dominant habitat types within this area. These include outer islands, nearshore islands, spits, points, bays, lagoons, and river deltas. Salinity, temperature, conductivity, and depth of water were recorded at each station.

A total of 1,264 fish representing six families and thirteen species has been captured. Following is a list of the species captured from Point Sorensen east to Brownlow Point:

Scientific name:	Common name:	Species Abbreviation:
Salmonidae		
<u>Salvelinus</u> <u>alpinus</u>	Arctic char	AC
<u>Coregonus</u> <u>sardinella</u>	least cisco	LCI
<u>C.</u> <u>autumnalis</u>	Arctic cisco	ACI
<u>C.</u> <u>nasus</u>	broad whitefish	BWF
<u>C.</u> <u>pidschian</u>	humpback whitefish	HWF
<u>Thymallus</u> <u>arcticus</u>	Arctic grayling	GR
Osmeridae		
<u>Osmeris</u> <u>mordax</u>	boreal smelt	BSM
<u>Mallotus</u> <u>villosus</u>	capelin	CAP
Gadidae		
<u>Boreogadus</u> <u>saida</u>	Arctic cod	ACD
<u>Eleginus</u> <u>gracilis</u>	saffron cod	SCD
Cottidae		
<u>Myoxocephalus</u> <u>quadricornis</u>	fourhorn sculpin	FSC
Pleuronectidae		
<u>Liopsetta</u> <u>glacialis</u>	Arctic flounder	AFL
Liparidae		
<u>Liparis</u> <u>sp</u>.	snail fish	LIP

Gill nets were the most extensively used method of capture; however, it became obvious late in the season that the use of gill nets was not conducive to the capture of gadioids, liparids, and the early life stages of salmonids. Fyke traps were subsequently stationed at several locations in Prudhoe Bay and proved more effective at catching the above mentioned species. Table 1 compares total catches of all species by the major types of gear used during the open water season.

Beach seines, effectively captured fish on shallow waters; however, adverse weather conditions and wave activity frequently prohibited their use. A shrimp try trawl was used in Prudhoe Bay. Transects were run for twenty minutes with the lead line of the trawl riding on the bottom. Larval and early life stages of Arctic cod, capelin and liparids dominated the offshore trawl catches.

The most widespread group of fishes captured along the coast were the salmonids. Arctic char were captured at 74% of the gill net stations. Arctic cisco and least cisco were captured at 65% and 37% of the stations respectively. Least cisco, however, were captured in the greatest abundance followed by Arctic cisco and Arctic char. Marine species represented 45% of the total catch.

Catch data showed a more widespread distribution for adult Arctic char and Arctic cisco than for other anadromous species. Arctic char and Arctic cisco were captured at all of the barrier island stations except sta 018-75, as well as along mainland sites. Least cisco showed a greater affinity for nearshore areas throughout the study area. Adult broad whitefish and humpback whitefish were only captured in and near the Kuparuk and Sagavanirktok River deltas. Immature broad whitefish, however, feed and migrate along the coastline inhabitating shallow bays and lagoons as far east as Foggy Bay; 100 miles (160 km) east of the Colville River, the only known spawning habitat for broad whitefish within the study area.

1. Arctic char

Arctic char, found along the entire northern coast of Alaska are the object of a traditional subsistence and expanding sport fishery. Several recent investigations have been conducted on the life history of Arctic char in major North Slope drainages (Yoshihara, 1972, 1973; Furniss, 1974, 1975; McCart and Craig, 1973 and Griffiths and Craig et al. 1975).

Anadromous Arctic char enter the Beaufort Sea at spring break-up and remain in the coastal waters until mid-July to September; at which time they again return to fresh water to spawn. The major Arctic char spawning drainage within the study area is the Sagavanirktok River.

Once in marine waters, char migrate and feed along the coastline and barrier island system. Tag recoveries made along the Beaufort Sea coast (Furniss, 1975) indicate that char from the Sagavanirktok River utilize the nearshore areas between Point Barrow and Barter Island.

One hundred and thirty-two Arctic char were captured throughout the study area, 86% of which were processed for meristic and life history data. Char ranged in size from 170 mm to 685 mm with a length mode occurring between 520 mm to 529 mm. The mean fork length of char in the study area was 427 mm (n=116).

Char varied from 3 to 12 years in age, with the majority between 7 and 9. Age-length frequency data agreed closely with that found by Yoshihara (1972) for Sagavanirktok River char. The sex ratio of Arctic char captured within the study area was skewed in favor of females. The female to male ratio of 116 Arctic char was 2:1. Similar disproportions in sex ratios of char were observed by Furniss (1975), Glova and McCart (1974), and others.

A total of 30 char stomachs was collected from fish taken at various locations within the study area. Of the guts collected, 36% were empty. The food items were identified and grouped by frequency of occurrence. No attempt was made to determine the "fullness" of the gut. Following is a list of the food items in decending order of frequency, omitting those stomachs that were empty:

Amphipods	95%
Cod (*B. saida*)	42%
Mysids	32%
Isopods	11%

The final analysis of food habits for all species has not been made at this time.

2. Arctic cisco.

Arctic cisco is one of the most common and widely distributed fish found between the Colville and Mackenzie rivers. They are utilized by local residents in the coastal subsistence fishery and in a small commercial fishery at the Colville River delta. Arctic cisco life history data are discussed by Craig and McCart (1975) and Hatfield, Stein et al. (1972).

Two hundred and twenty-two Arctic cisco were captured during the summer of 1975. Fork lengths ranged from 115 mm to 390 mm, with a mode occurring between 320 and 329 mm. The mean fork length for the total sample was 315 mm (n=158). Ages varied from 1 through 8 years. Seventy-two percent of the sample consisted of immature fish of age class VI. Only 3% of the sample was made up by age classes I, II and VIII. The female to male sex ratio of Arctic cisco was 0.9:1 (n=140).

Fifteen Arctic cisco stomachs were collected within the study area. All of stomachs examined contained food. Following is a list of the gut contents in descending order of frequency:

Mysids	60%
Amphipods	53%
vegetation/detritus	40%

3. Least cisco.

Least cisco were the most frequently captured coregonid within the study area. The absence of least cisco in catches along the outer barrier islands suggests that this species has a strong affinity for the brackish waters of the mainland coastline. Life history aspects of least cisco are described by Mann, 1974; Kendel et al., 1974; Percy et al., 1974 and others.

A total of 302 least cisco was captured during 1975. Fork lengths ranged from 105 mm to 360 mm with a mean of 263 mm (n=201). A length mode was observed between 310 mm and 319 mm. Ages varied from 1 through 11 years. Mature fish of age class VII or greater represented 55% of the sample. The ratio of females to male was 2.9:1 (n=192). Mature females collected in mid-August had egg diameters ranging from 1.0 mm to 1.3 mm and fecundities from 17,500 to 25,500.

Twelve least cisco stomachs have been examined from fish taken during 1975. Of the twelve, one was empty. Following is a list of the gut contents in descending order of frequency, omitting the empty stomach:

Mysids	91%
Amphipods	45%
Dipterans (adult)	27%
Isopods	9%
vegetation/detritus	9%

4. Broad whitefish.

Broad whitefish were distributed along the mainland coast between the Kuparuk River delta and the eastern boundary of Foggy Bay. Adult broad whitefish were only captured in the deltas of the Kuparuk and Sagavanirktok rivers; however, juveniles appear to forage along the coastline in areas further removed from the influence of these larger rivers.

Thirty-three broad whitefish were captured during 1975. Fork lengths ranged from 100 mm to 555 mm with a mean of 300 mm. Ages varied from 1 through 13 years. Age classes V through VIII were absent in the sample. Forty-five percent of the fish captured were in age class III (175 to 230 mm). The ratio of females to male was .86:1.

Four of the seven broad whitefish stomachs that were examined were empty. All of the remaining stomachs contained chironomid larva, and one also contained amphipods.

5. Humpback Whitefish.

Only three humpback whitefish were captured during 1975. The humpback whitefish were captured west of the Sagavanirktok River delta and were female potential spawners. The mean fork length was 433 mm and ages were 10, 12 and 13 years.

6. Fourhorn Sculpins.

The fourhorn sculpin is a common species throughout the study area. It occupies nearly all available habitats and was captured off several of the outer barrier islands, as well as in the low salinity waters of the major river deltas. Some life history aspects of fourhorn sculpin in the Beaufort Sea are discussed by Griffiths et al., (1975).

One hundred and twelve fourhorn sculpins captured in the study area ranged in size from 50 to 228 mm with a mean of 125 mm. A bimodal length distribution was observed with peaks occurring between 100 and 109 mm and 160 mm to 169 mm.

Ages of fourhorn sculpin varied from 1 through 7 years with the majority of fish captured in age classes II and III.

Sculpins within the study area feed primarily on immature isopods and amphipods. Two of eight guts examined contained the remains of juvenile Arctic cod (B. saida).

7. Arctic Cod.

Arctic cod, commonly referred to as "tom cod" by residents of the North Slope, are sought for both human consumption and for animal food by coastal residents. They also constitute a major food source for marine birds, mammals and Arctic fish. Cod were seasonally abundant in the study area; however, this variability in abundance may reflect the use of inappropriate capture gear throughout much of the open water season. Various life history aspects of Arctic cod are discussed by Quast (1970).

Four hundred and eighteen Arctic cod ranging in size from 20 mm through 193 mm were captured during 1975. Cod averaged 120 mm in fork length and ranged from young-of-the-year through 3 years of age. The female to male ratio of 119 cod was 1.7:1.

The examination of twelve stomachs indicated that cod feed primarily on mysids.

8. Smelt.

Two species of smelt were captured in the study area during 1975. Capelin were gill netted along exposed gravel beaches from Stump Island to Foggy Bay. Catches of smelt were low and sporadic. The presence of young-of-the-year capelin in trawl catches in Prudhoe Bay suggests they may spawn in the near vicinity.

A single Boreal smelt was captured in a fyke trap along the western border of Prudhoe Bay.

9. Liparids.

An as yet unidentified species of the genus Liparus was captured throughout Prudhoe Bay. Adults as well as young-of-the-year and early life stages were captured by bottom trawling in 8-10' of water.

10. Arctic flounder.

Only two Arctic flounder were captured during 1975. Both specimens were captured on western boundary of Prudhoe Bay by gill net.

VI. Conclusions

The following conclusions are based on information available to date:

A. Information dealing with the life histories of fish inhabiting the Beaufort Sea is minimal.

B. Species diversity within the study area is low.

C. The anadromous species within the study area migrate and concentrate along the shallow, nearshore water of the mainland coast.

D. The most frequently caught and wide ranging anadromous species within the study area are least cisco, Arctic cisco and Arctic char.

E. Adult broad and humpback whitefish seldom range beyond the influence of the largest streams draining into the study area.

F. The presence of larval Arctic cod, capelin and fourhorn sculpins suggests that these species spawn in the coastal marine or estuarine waters of the study area.

VII. Summary of 4th Quarter operations and future field work

The fourth quarter of this study was spent collating data obtained during the 1975 field season. Preparations for a fish resource computer format were concluded and field observations of activities in Prudhoe Bay were made monthly. The use of a closed circuit underwater television camera for identifying and observing overwintering fish was explored in December and this system is now being used in the Sagavanirktok and Kuparuk River deltas as well as in Prudhoe Bay.

Field studies will continue through break-up, at which time activities will be concentrated in the western half of the study area. A tag and recapture effort will be conducted to identify migration patterns and timing of fish moving along the coast as well as the seasonal abundance of fish at permanent capture sites. Life history and food habits information will be added to that obtained during 1975. An emphasis will be placed on the early life stages of fish species inhabiting the Beaufort Sea to aid in identifying and delineating spawning and rearing habitats.

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Table 1. Temperature, salinity and conductivity at capture stations between Point Sorensen and Brownlow Point, Beaufort Sea, 1975.

Station No*	West Longitude	North Latitude	Date of Capture	Water Temp. °C	Salinity, PPT	Conductivity µmhos
002-75	148° 32'	70° 22'	8/1	4°	12.0	12,000
003-75	147° 45'	70° 15'	8/2	5.5°	4.5	4,900
007-75	145° 56'	70° 10'	8/12	3.5°	13.5	14,000
008-75	146° 11'	70° 12'	8/12	4°	14.0	14,000
009-75	145° 53'	70° 10'	8/12	3.5°	15.0	14,000
010-75	146° 23'	70° 11'	8/12	5.5°	14.5	15,000
011-75	146° 45'	70° 10'	8/12	6.0°	14.0	14,500
012-75	146° 34'	70° 13'	8/12	6.0°	14.0	15,000
013-75	147° 03'	70° 09'	8/13	7.0°	13.0	14,000
014-75	147° 14'	70° 12'	8/13	9.0°	4.0	5,000
015-75	147° 04'	70° 18'	8/13	6.0°	15.0	15,000
016-75	147° 32'	70° 12'	8/13	9.5°	12.5	14,500
017-75	147° 46'	70° 13'	8/13	11.5°	11.0	13,500
018-75	147° 55'	70° 27'	8/14	2.0°	14.0	13,000
019-75	148° 14'	70° 28'	8/14	2.5°	13.0	12,000
020-75	148° 35'	70° 25'	8/14	5.0°	11.5	12,000
021-75	148° 38'	70° 24'	8/14	6.5°	10.0	11,000
022-75	148° 49'	70° 24'	8/14	7.0°	9.0	9,500
023-75	148° 32'	70° 22'	8/21	5.0°	13.5	14,000
024-75+	148° 18'	70° 19'	9/17	2.5°	14.5	14,000
025-75++	148° 18'	70° 19'	9/17	2.0°	15.5	14,500

Table 1. (continued)

Station No*	West Longitude	North Latitude	Date of Capture	Water Temp. °C	Salinity PPT	Conductivity μmhos
026-75	145° 56'	70° 10'	9/24	-1.0°	18.5	15,500
027-75	146° 11'	70° 12'	9/24	-1.0°	18.5	15,500
029-75	146° 25'	70° 14'	9/24	-1.0°	17.0	14,500
030-75	146° 45'	70° 10'	9/24	-1.0°	14.0	12,000
031-75	147° 10'	70° 13'	9/24	-1.0°	18.5	15,500
034-75	147° 34'	70° 12'	8/18	4.5°	9.0	9,500
038-75	148° 32'	70° 22'	8/21	5.0°	10.5	11,000
041-75	148° 32'	70° 22'	8/24	3.5°	17.0	17,000

* See Fig. 3 for mapped locations of capture stations.
\+ West side of old causeway.
++ East side of old causeway.

Figure 1. Map of the State of Alaska showing Beaufort Sea study area.

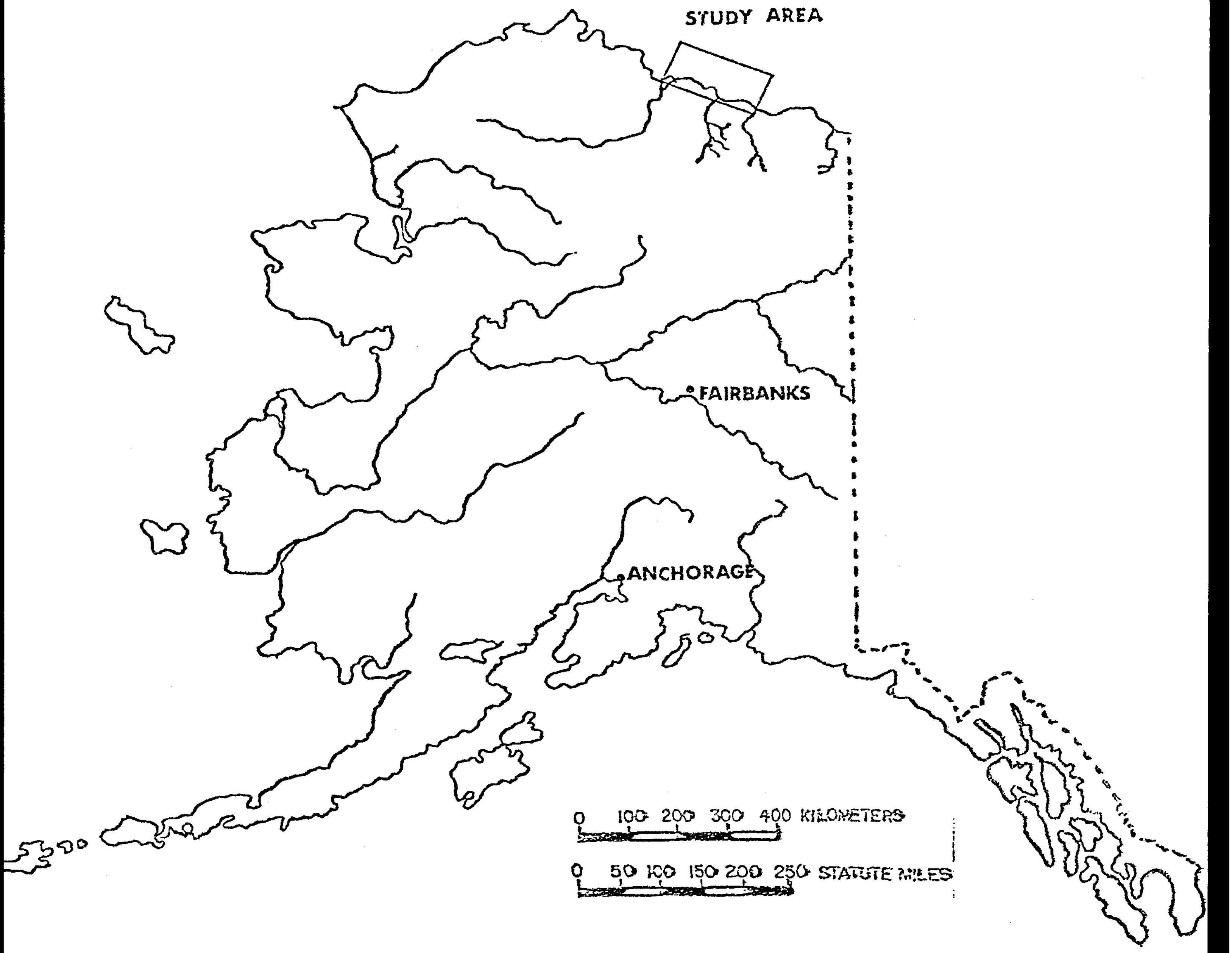
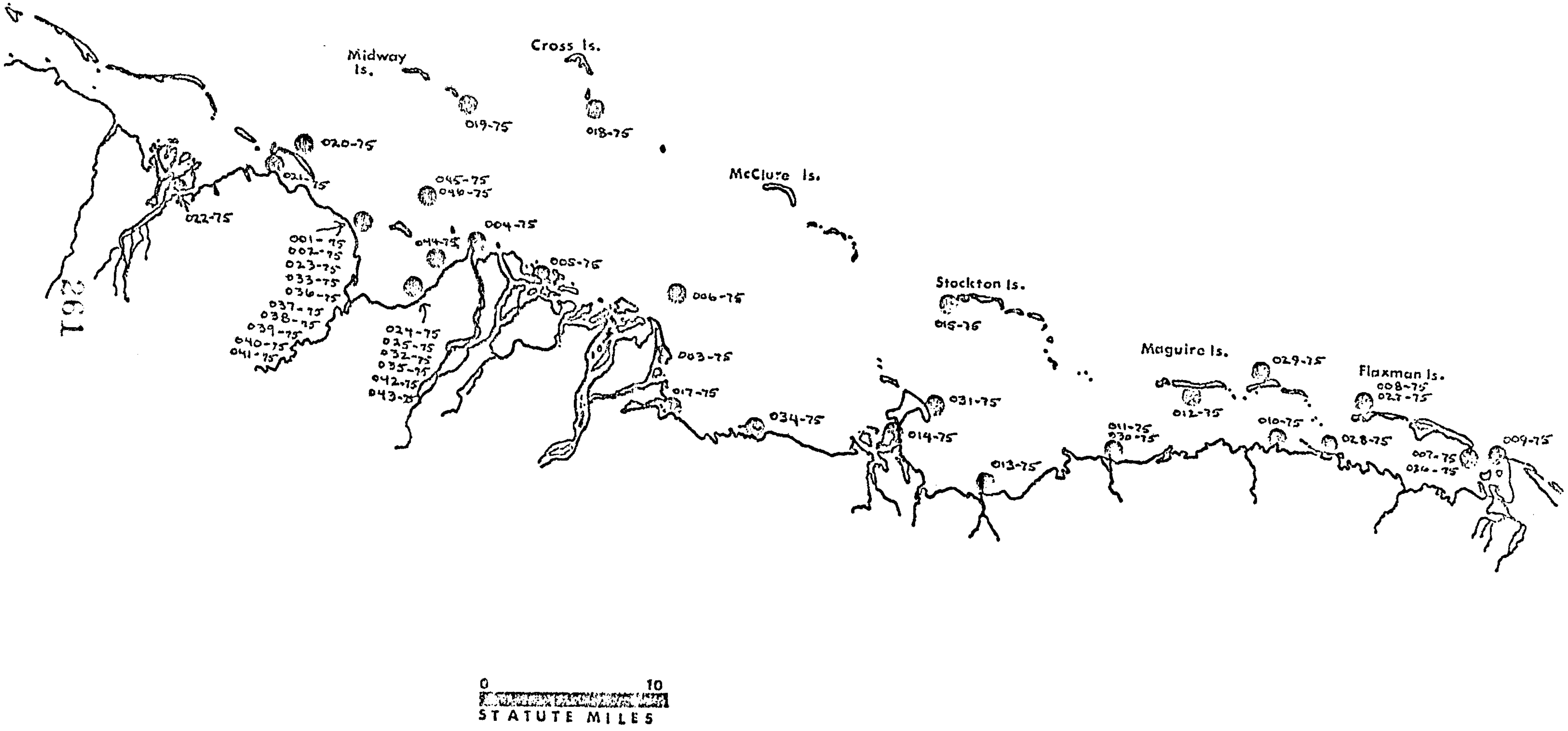


Figure 2. Capture site locations in eastern one-half of study area, 1975.



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THE DISTRIBUTION, ABUNDANCE, DIVERSITY, AND PRODUCTIVITY OF BENTHIC ORGANISMS IN THE GULF OF ALASKA

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objectives of this study are; 1) a qualitative and quantitative inventory census of dominant benthic species within the identified oil-lease sites in the Gulf of Alaska, 2) a description of spatial and seasonal distribution patterns of selected species in the designated study areas, 3) a preliminary comparison of dominant species with physical, chemical and geological features with emphasis on the latter parameter, and 4) preliminary observations of biological inter-relationships between selected segments of the benthic biota in the designated study areas.

Forty-two widely dispersed permanent stations for quantitative grab sampling have been established in the northeastern Gulf of Alaska, and these stations represent a reasonable nucleus around which a monitoring program can be developed. Twenty-nine widely dispersed stations were occupied in the northwestern Gulf. Substrate characteristics in this region made it difficult to sample with quantitative gear.

The general patchiness of the fauna at the stations noted in the first year of study indicated that at least five replicates be taken per station, and at least this number of replicates have been taken at all stations during the current project period. Quantitative field testing for the optimum number of replicates per station has been accomplished; laboratory analysis is not available yet for this material.

Three hundred and eleven species have been determined from the grab sampling program, and 168 species from the trawl program. It is probable that all species with numerical and biomass importance have been collected over the past two sampling years and that only rare species will be added in future sampling.

Basic information on Diversity, Dominance and Evenness for grab stations is now available for all permanent stations on the northeastern grid. Caution is indicated in the interpretation of these values until further data is available over a longer time base.

Criteria established for Biologically Important Taxa (BIT) have delineated 95 species. These species have been used to comprehend station species aggregations by cluster analysis. Preliminary groupings of stations into three basic clusters have been accomplished. Further understanding of stations clustering has been gained by clustering species, and construction of a two-way coincidence table of species *vs* station groups. By this means, specific groupings of species can be related to station clusters, and intermediate positions of stations (or clusters) can be determined by the particular groupings of species they have in common.

The joint National Marine Fisheries Service trawl charter for investigation of demersal fishes and epifaunal benthos was effective, and excellent spatial coverage on the shelf of the northeastern portion of the Gulf was achieved. Integration of this information with the infaunal benthic data will enhance our understanding of the shelf ecosystem.

Initial qualitative assessment of data suggests that; 1) sufficient station uniqueness exists to permit development of an adequate monitoring program based on species composition at selected stations, and 2) that adequate numbers of unique, abundant, and/or large species are available to ultimately permit nomination of likely monitoring candidates.

The principal food groups for cod at all sizes were molluscs, crustaceans, and fishes. There were some small quantities (less than 10% of the total occurrence) of coelenterates, annelids, euphausids, isopods and echinoderms. The frequency of occurrence of snow crab, *Chionoecetes bairdi* for 1972-1974 was 33, 40 and 36 percent respectively.

II. INTRODUCTION

A. General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the Gulf of Alaska present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse affects on the environment of the Gulf cannot be quantitatively assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development.

Insufficient long-term information about an environment, and the basic biology and recruitment of species in that environment can lead to erroneous interpretations of changes in types and density of species that might occur if the area becomes altered (see Nelson-Smith, 1973; Pearson, 1971, 1972; Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas). Populations of marine species fluctuate over a time span of a few to 30 years (Lewis, 1970, and personal communication). Such fluctuations are typically unexplainable because of absence of long-term data on physical and chemical environmental parameters in association with biological information on the species involved (Lewis, 1970 and personal communication).

Benthic organisms (primarily the infauna and sessile and slow-moving epifauna) are particularly useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to accurately reflect the biological health of a marine area (see Pearson, 1971, 1972; and Rosenberg, 1973 for discussions on long-term usage of benthic organisms for monitoring pollution).

The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (crabs, shrimps, scallops, snails, fin fishes) in the Gulf of Alaska further dictates the necessity of understanding benthic communities since many commercial species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963 for a discussion of the interaction of commercial species and the benthos). Any drastic changes in density of the food benthos would affect the health and numbers of these fisheries organisms.

Experience in pollution-prone areas of England (Smith, 1968), Scotland (Pearson, 1972), and California (Straughan, 1971) suggests that at the completion of an initial exploratory study, selected stations should be examined regularly on a long-term basis to determine any changes in species content, diveristy, abundance and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration. An intensive investigation of the benthos of the Gulf is also essential to an understanding of the trophic interactions involved there and the potential changes that may take place once oil-related activities are initiated. The ongoing benthic biological program has emphasized the development of a qualitative and quantitative inventory of prominent species of the benthos as part of the overall examination of the biological, physical and chemical components of the portions of the Gulf of Alaska shelf slated for oil exploration and drilling activity. In addition, initiation of a program designed to quantitatively assess assemblages (communities) of benthic species on the shelf will expand the understanding of distribution patterns of species here. A developing investigation concerned with the biology of selected species will also further the overall Gulf of Alaska trophic dynamics program.

B. Specific Objectives

1) A qualitative and quantitative inventory census of dominant benthic species within the identified oil-lease sites.
2) A description of spatial and seasonal distribution patterns of selected species in the designated study areas, with emphasis on assessing patchiness and correlation with microhabitat.
3) A preliminary comparison of the distribution of dominant species with physical, chemical and geological features with emphasis on the latter parameter.
4) Preliminary observations of biological interrelationships between selected segments of the benthic biota in the designated study areas.

C. Relevance to Problems of Petroleum Development

The effects of oil pollution on subtidal benthic organisms have been seriously neglected, although a few studies, conducted after serious oil spills, have been published (see Boesch *et al.*, 1974 for review of these papers). Thus, lack of a broad data base elsewhere makes it difficult at present to predict the effects of oil-related activity on the subtidal benthos of the Gulf of Alaska. However, the rapid expansion of research activities in the Gulf should ultimately enable us to point with some confidence at certain species or areas that might bear closer scrutiny once industrial activity becomes a reality. It must be emphasized that a considerable time frame is needed to understand long-term fluctuations in density of many marine benthic species, and it cannot be expected that a short-term research program will result in total predictive capabilities. Assessment of the environment must be conducted on a continuing long-term basis.

As indicated previously, infaunal benthic organisms tend to remain in place and consequently have been useful as an indicator species for disturbed areas. Thus, close examination of stations in the Gulf with substantial complements of infaunal species is warranted (see Feder and Mueller, 1975 for examples of such stations). Changes in the environment at these and other stations with a relatively large number of species might be reflected in a decrease in diversity of species with increased dominance of a few (see Nelson-Smith, 1973 for further discussion of oil-related changes in diversity). Likewise, stations with substantial numbers of epifaunal species should be assessed on a continuing basis (see Feder and Mueller, 1975 for references to relevant stations). The potential effects of loss of specific species to the overall trophic structure in the Gulf cannot be assessed at this time, but the problem can probably at least be addressed once benthic food studies are initiated by R. Smith (1975).

Data indicating the effects of oils on most subtidal benthic invertebrates are fragmentary, but echinoderms are "notoriously sensitive to any reduction in water quality" (Nelson-Smith, 1973). Echinoderms (ophiuroids, asteroids, and holothuroids) are conspicuous members of the benthos of the Gulf (see Feder and Mueller, 1975 for references to relevant stations), and could be affected by oil activities there. Asteroids (sea stars) and ophiuroids (brittle stars) are often important components of the diet of large crabs (for example king crab feed on sea stars) and demersal fishes. The tanner or snow crab (*Chionoecetes bairdi*) is a conspicuous member of the shallow shelf of the Gulf, and supports a commercial fishery of considerable importance there. Laboratory experiments with this species have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil; obviously this aspect of the biology of the snow crab must be considered in the continuing assessment of this benthic species in the Gulf (J. Karinen and S. Rice, in press: cited in Evans and Rice, 1974). Little other direct data based on laboratory experiments is available for subtidal benthic species (see Nelson-Smith, 1973). Experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged for the near future in the overall OCS program.

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated by Rhoads (see Rhoads, 1974 for review). A diesel-fuel oil spill resulted in oil becoming adsorbed on sediment particles with the resultant mortality of many deposit feeders living on sublittoral muds. Bottom stability was altered with the death of these organisms, and a new complex of species became established in the altered substratum. The most common members of the infauna of the Gulf of Alaska are deposit feeders; thus, oil-related mortality of these species could result in a changed near-bottom sedimentary regime with alteration of species.

As suggested above, upon completion of initial baseline studies in pollution prone areas, selected stations should be examined regularly on a long-term basis. Cluster analysis techniques discussed below, supplemented by principal components and/or principal coordinate analysis, should provide excellent techniques for the selection of stations for continuous monitoring in the Gulf of Alaska. In addition, these techniques should provide an insight into normal ecosystem variation (Clifford and Stephenson, 1975; Williams and Stephenson, 1973; Stephenson *et al.*, 1974).

D. Acknowledgements

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III. CURRENT STATE OF KNOWLEDGE

Little is known about the biology of the invertebrate benthos of the Gulf of Alaska, although a compilation of some relevant data on the Gulf of Alaska is available (Rosenberg, 1972). A short but intensive survey in the summer of 1975 added some specific benthic biological data for an area south of the Bering Glacier (Bakus and Chamberlain, 1975). Results of the latter study are similar to those reported by Feder and Mueller (1975). Some scattered data based on trawl surveys by the Bureau of Commercial Fisheries is available, but much of the information on the invertebrate fauna is so general so as to have little value. Some unpublished information on the epifauna is available (i.e., Alaska Department of Fish and Game King Crab Indexing Surveys in the vicinity of Kodiak Island).

In the summer and fall of 1961 and spring of 1962 otter trawls were used to survey the bottomfish and shellfish on the Continental Shelf and upper continental slope in the Gulf of Alaska (Hitz and Rathjen, 1965) the survey was part of a long-range program begun in 1950 to determine the size of bottomfish stocks in the northeastern Pacific Ocean between southern Oregon and northwest Alaska. Invertebrates taken in the trawls were of secondary interest, and only major groups and/or species were recorded. Invertebrates that comprised 27 percent of the total catch were grouped into eight categories; heart urchins (Echinoidea), tanner crab (*Chionoecetes bairdi*), starfish (Asteroidea), Dungeness crab (*Cancer magister*), scallop (*Pecten caurinus*), shrimp (*Pandalus borealis, P. platypus,* and *Pandalopsis dispar*), king crab (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.) (Hitz and Rathjen, 1965). Heart urchins accounted for about 50 percent of the invertebrate catch and tanner crab

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ranked second representing about 22 percent. Approximately 20 percent of the total invertebrate catch was composed of starfish.

Further knowledge of invertebrate stocks in the north Pacific is scant. The International Pacific Halibut Commission (IPHC) surveys parts of the Gulf of Alaska annually and records selected commercially important invertebrates but non-commercial species are discarded. The benthic investigations of Feder and Mueller (1975 and this report) represent the first intensive qualitative and quantitative examination of the biota of the benthic infauna and epifauna of the Gulf of Alaska.

Data collected in the first year (1974-1975) of the OCS study in the Gulf has served as a springboard and an intensive data base for the studies in 1975-1976. Additional data are available from the cruises of 1975-1976, and will set the basis of analysis needed to meet the study objectives. Additional information obtained by way of the literature search will probably uncover data which will aid in the interpretation of the biology of the organisms to be studies (Feder, 1975). The use of Cluster and Multivariate techniques for the analysis of benthic biological data (now being applied to our data from the Gulf of Alaska) has been widely used by numerous investigators examining shallow-water marine environments. Techniques are well reviewed in Clifford and Stephenson (1975).

IV. STUDY AREA

In the grab sample program a series of stations were occupied with a van Veen grab on a grid established in conjunction with the physical, chemical, hydrocarbon and trace metal programs in the northeastern (Fig. 1; Table 1) and northwestern Gulf of Alaska (Fig. 2; Table 2). Thirty-four stations

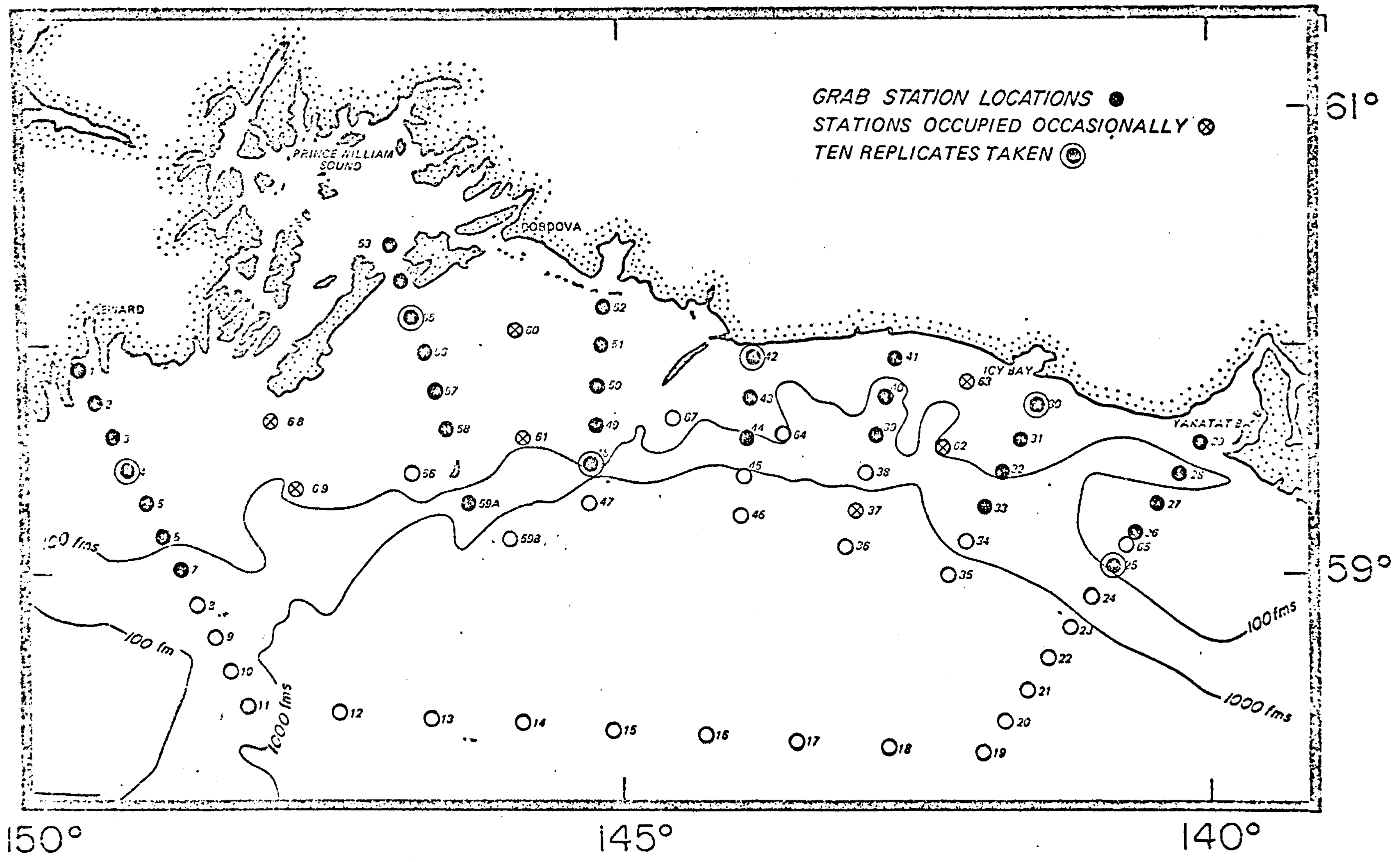

Figure 1. Station grid established for oceanographic investigations in the northeastern Gulf of Alaska. Shaded circles = major stations sampled with van Veen grab. Crossed circle = station occasionally occupied. Open circles = physical, chemical and zooplankton stations. See Table 1 for additional station data.

Table 1. Stations sampled by van Veen grab in the northeastern Gulf of Alaska, July 1974 to February 1975. Number at each entry under Cruise Number refers to number of replicate samples.

GASS Station	Latitude (N)	Longitude (W)	Approx. Depth (m)	Jul.	Oct.	Nov.	Feb.	May	Sept.	Nov.-Dec.
				Cruise Number						
				193	200	202	805	807	811	816
1	59°50.2'	149°30.5'	263	-	-	3	-	-	5	-
2	59°41.5'	149°22.0'	219	-	-	-	-	5	5	-
3	59°33.0'	149°13.2'	220	3	-	-	-	-	5	-
4	59°24.5'	149°04.9'	200	-	-	-	-	4	10	-
5	59°16.0'	148°56.0'	174	-	-	-	-	4	5	-
6	59°07.2'	148°47.5'	151	3	-	-	-	-	5	-
7	58°58.7'	148°38.7'	220	-	-	-	-	1	5	5
25	59°02.5'	140°49.8'	179	-	-	-	-	3	5	10
26	59°10.8'	140°38.9'	148	3	-	-	-	4	5	5
27	59°18.6'	140°27.9'	129	-	-	-	-	3	5	-
28	59°26.5'	140°16.9'	239	-	-	-	-	4	5	-
29	59°34.6'	140°06.0'	68	3	-	-	-	-	0	-
30	59°44.1'	141°27.9'	43	1[a]	-	-	6[a]	-	10[a]	-
31	59°35.2'	141°36.8'	117	-	-	-	4	-	5	-
32	59°26.3'	141°45.0'	179	3	-	-	4	-	5	-
33	59°17.5'	141°54.8'	219	-	-	-	1[a]	-	5	-
37	59°16.2'	142°59.2'	2,620	-	-	-	1[a]	-	-	-
39	59°35.7'	142°49.5'	549	1[a]	-	-	1[a]	-	3	5
40	59°45.5'	142°44.5'	195	-	-	-	4	-	5	-
41	59°55.1'	142°39.5'	119	3	-	-	4	-	5	-
42	59°55.1'	143°51.2'	93	3	-	-	23	-	10	-
43	59°45.0'	143°52.8'	117	-	-	-	23	-	5	-
44	59°35.0'	143°54.2'	181	3	-	-	1	-	3	5
48	59°27.5'	145°11.5'	117	3	-	-	-	-	5	10
49	59°37.5'	145°10.0'	186	-	-	-	4	4	5	-
50	59°47.7'	145°09.0'	164	2	3	-	-	-	5	-
51	59°57.6'	145°07.8'	135	-	-	-	4	-	5	-
52	60°07.6'	145°06.5'	53	3	3	-	-	41	5	-
53a	60°23.0'	146°54.0'	279	-	3	-	2	1	5	-
53b	-	-	384	-	-	-	-	-	-	-
54	60°13.9'	146°48.6'	204	-	-	-	3	-	2	5
55	60°04.5'	146°42.6'	117	3	-	-	4	-	5	10
56	59°55.2'	146°36.8'	64	-	-	-	4	-	5	-
57	59°45.6'	146°31.0'	69	-	3	-	3	-	5	-
58	59°36.2'	146°25.5'	97	-	-	-	4	-	5	-
59	59°17.1'	146°14.0'	334	1	-	-	-	-	5	5
60	60°01.5'	145°51.2'	90	-	-	-	-	-	-	5
61	59°34.2'	145°46.9'	170	-	-	-	-	-	-	5
62	59°33.2'	142°16.0'	240	-	-	-	-	-	-	5
63	59°49.5'	142°03.8'	80	-	-	-	-	-	-	5
68	59°38.2'	147°36.5'	120	-	-	-	-	-	-	5
69	59°20.0'	147°32.0'	120	-	-	-	-	-	-	5

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[a] Grabs volume less than 5 liters.

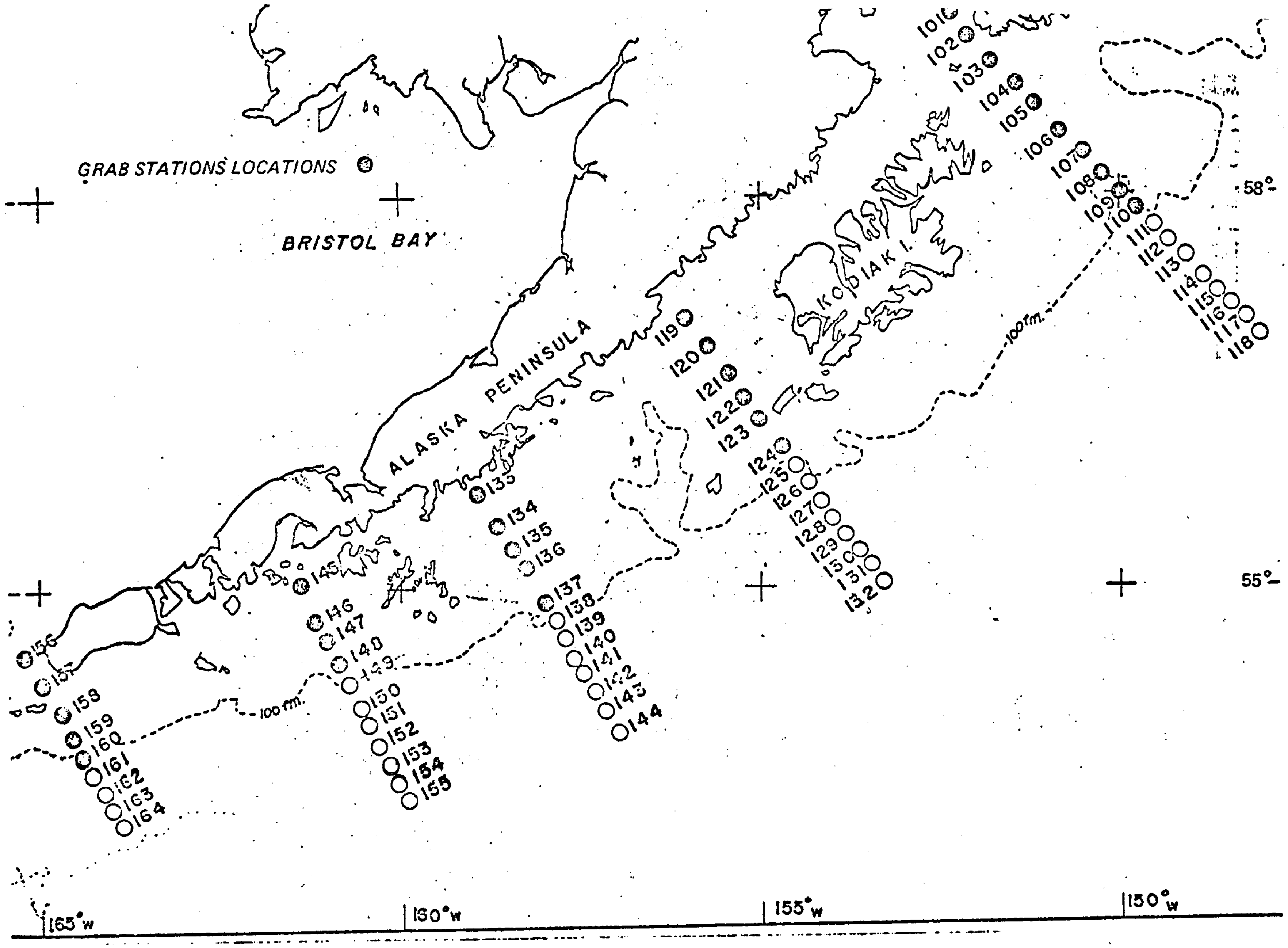

Figure 2. Station grid established for oceanographic investigations in the northwestern Gulf of Alaska. Shaded circles are stations occupied with van Veen grab. See Table 2 for additional station data.

Table 2. Stations sampled by van Veen grab in the northwestern Gulf of Alaska (NEGOA), October to December 1975. Number at each entry under Cruise Number refers to number of replicate samples.

GASS Station	Latitude (N)	Longitude (W)	Approx. Depth (m)	Oct.	Nov.-Dec.
				Cruise Number	
				812	816
101	59°19.8'	152°24.1'	90	5	-
102	59° 9.9'	152° 4.1'	112	5	-
103	59° 0.0'	151°45.1'	135	5	-
104	58°50.0'	151°26.4'	104	5	-
105	58°39.9'	151° 7.1'	185	3	-
106	58°28.1'	150°47.7'	86	-	0
107	58°18.6'	150°28.0'	53	-	0
108	58° 9.1'	150° 9.1'	57	-	0
109	58° 2.5'	148°56.3'	176	-	1[a]
110	57°55.5'	149°43.4'	180	-	4[a]
119	57° 6.9'	156° 0.0'	207	5	-
120	56°55.0'	155°44.1'	290	1[a]	-
121	56°43.2'	155°27.9'	230	5	-
123	56°31.3'	155°12.0'	43	5	-
124	56°19.1'	154°55.1'	110	6	-
133	55°46.3'	158°51.0'	73	6	-
134	55°33.4'	158°38.3'	154	6	-
135	55°20.3'	158°25.1'	150	5	-
136	55° 7.5'	158°12.4'	140	0	-
137	54°54.3'	157°59.0'	109	1	-
145	53°03.1'	161°24.4'	75	0	-
146	54°49.4'	161°12.5'	73	3	-
147	54°36.2'	161° 0.7'	106	0	-
148	54°23.5'	160°49.1'	109	0	-
156	54°29.2'	165°11.3'	160	0	-
157	54°17.0'	164°58.8'	70	1[a]	-
158	54°04.5'	164°46.2'	104	1[a]	-
159	53°51.9'	163°34.0'	96	1	-
160	53°43.3'	164°25.4'	140	1	-

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[a] Grab volume less than 5 liters.

on this grid were occupied as frequently as possible in the northeastern Gulf of Alaska (NEGOA) and seven other stations occupied at least once in order to increase the coverage of the area. Twenty-five stations were occupied in the northwestern Gulf of Alaska, but many of these stations did not yield satisfactory samples due to the nature of the substratum. All stations typically extended from inshore (depth of 43 meters) to a maximum depth of approximately 200 meters.

A large number of stations were occupied in conjunction with the Resource Assessment trawl survey which sampled a grid existing from the western tip of Montague Island (148° longitude) to Yakatat Bay (140° longitude) (Fig. 3). This survey sampled to a maximum depth of approximately 500 meters (250 fathoms).

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Benthic infauna discussed in this report was collected on three cruises of the R/V *Acona* (July, October and November, 1974), one cruise of the R/V *Oceanographer* (February, 1975), and one cruise on the R/V *Townsend Cromwell* (May, 1975). To satisfy the objectives of the project, stations were selected over the entire study area, and these stations were occupied whenever a vessel was available.

During the period from 1 July 1975 to 1 March 1976 three cruises were made for the collection of benthic infauna on the USNS *Silas Bent* (cruise 811, 1-17 September 1975) and the R/V *Discoverer* (cruise 812, 10-16 October 1975 and cruise 816, 23 November to 8 December 1975). An additional cruise was completed on the R/V *Discoverer* (17 March to 2 April 1975) in the northeastern Gulf of Alaska. During these cruises, 263 samples were collected at

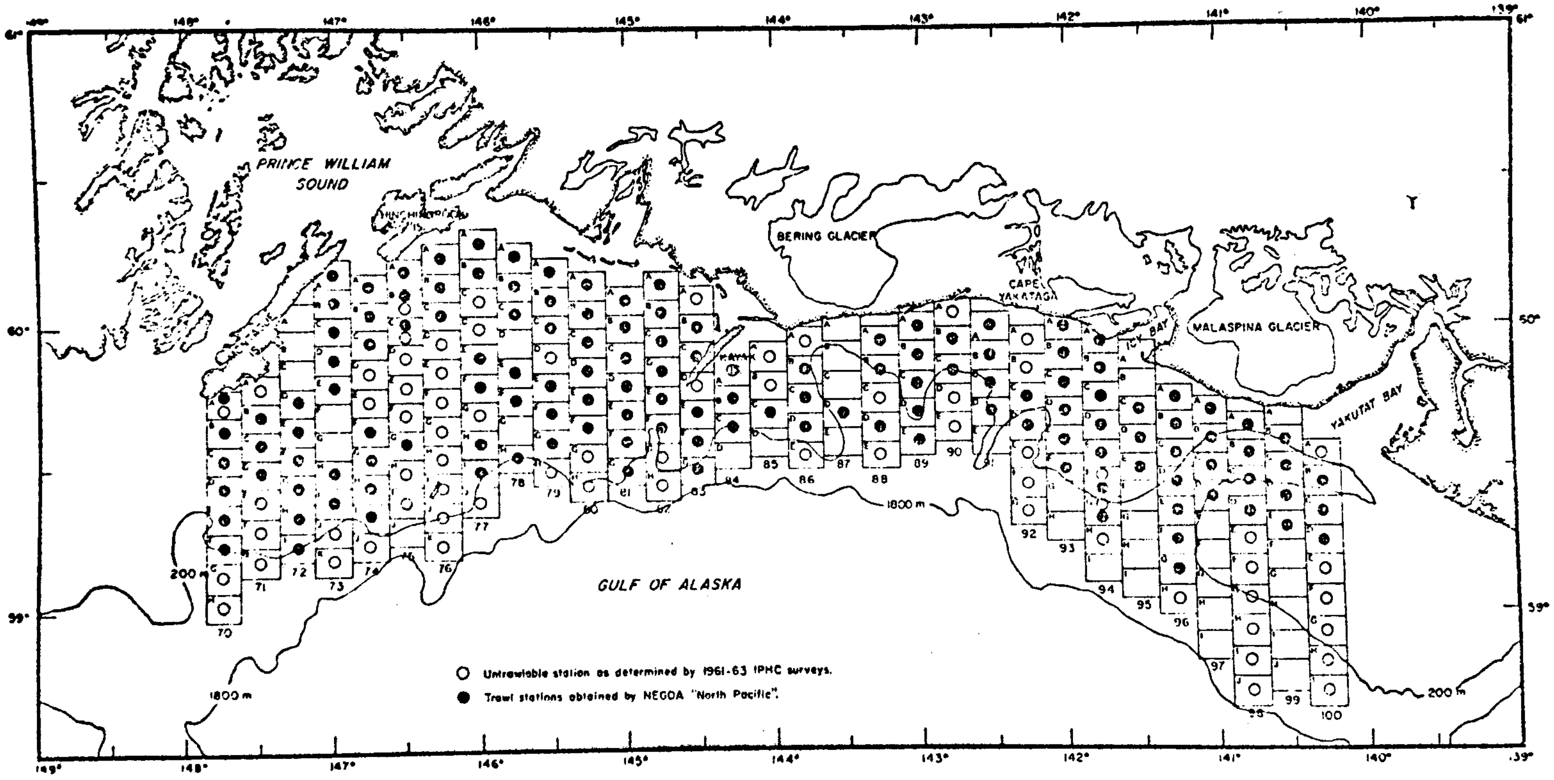

Figure 3. Station grid established for trawl survey on the shelf of the northeastern Gulf of Alaska. See Annual Report on "Baseline Studies of Demersal Resources of the Northern Gulf of Alaska Shelf and Slope" for station data.

40 stations in the northeastern Gulf of Alaska (Table 1), and 70 samples were collected at 21 stations in the northwestern Gulf of Alaska (Table 2).

Samples were taken with a 0.1 m^2 van Veen grab with bottom penetration facilitated by addition of 70 pounds of lead weight to each grab. Two 1.0 mm mesh screen doors on top of the grab permitted removal of undisturbed sediment samples by members of the hydrocarbon and heavy metals study groups. In addition, the screen doors served to decrease shock waves produced by bottom grabs (see Feder *et al.*, 1973 for discussion of grab operation and effectiveness of the van Veen grab in sediments of the type found in the Gulf of Alaska). A minimum number of samples, three replicates, were taken in the July, October and February cruises to increase the possibility of complete station coverage in the study area; the number of replicates was increased to 4-5 in the May cruise of the R/V *Townsend Cromwell*. All subsequent cruises sampled 5 replicates per station. Material from each grab was washed on a 1.0 mm stainless steel screen and preserved in 10 percent formalin buffered with hexamine. Samples were stored in plastic bags.

In the laboratory (Marine Sorting Center, University of Alaska, Fairbanks) all samples were rinsed to remove the last traces of sediment, spread on a gridded tray, covered with water and rough-sorted by hand. The material was then transferred to fresh preservative (buffered 10 percent formalin), and identifications made. All organisms were counted and wet-weighed after excess moisture was removed with absorbent towel.

Trawl material was collected with commercial gear on board the M/V *North Pacific*. One hour tows were made at predetermined stations (Fig. 3) using a commercial size 400 mesh Eastern otter trawl. All invertebrates of non-commercial importance were sorted out on shipboard, given tentative identifications, counted, weighed when time permitted and aliquot samples of individual species preserved and labeled for final identification at the Institute of Marine Science, University of Alaska. All weights of the Family Paguridae (hermit crabs) from the Gulf of Alaska were inclusive of their shells. Counts and weights of commercially important invertebrate species were recorded by the National Marine Fisheries Service biologists, and the data was made available to the benthic invertebrate program.

For obvious logistic reasons all invertebrates could not be returned to the laboratory for verification. Therefore, a subsample of each field identification was returned to the University. Closer laboratory examination often revealed more than one species of what was designated in the field as one species (e.g., field identifications of *Pandalus borealis* was later found to also contain *P. montagui tridens*). The difficulty is apparent in assessing total counts and weights of each taxon. In such cases the counts and weights of the species in question were expanded from the laboratory species ratio to the entire catch of the trawl.

A selected series of fish species were collected or their stomachs removed and preserved; this material was given to Dr. Ron Smith for further intensive analysis.

All invertebrate species were assigned code numbers after final identifications in Fairbanks.

Pacific cod stomachs were obtained during 1972, 1973, and 1974 by two fishing methods, pots and trawls. During 1972, 1973 and 1974, stomachs were obtained as a by-product of the Alaska Department of Fish and Game King Crab-Snow Crab Indexing Study. In 1973, samples were also obtained on the NOAA National Marine Fishery Service Bottomfish Survey. All fishes came from the vicinity of Kodiak Island, Alaska.

The 1972 ADF&G King Crab-Snow Crab Indexing Study was conducted by the M/V *Marten* and the M/V *Peggy Jo* from June 22 to August 4. The fishing gear was Seattle-type wrap-around pots, each measuring 80" by 80" by 30" inside and weighing approximately 750 pounds. The webbing was #72 tarred nylon thread stretched to three inches.

The 1973 King Crab-Snow Crab Indexing Study was more thorough, and offered the largest sample of stomachs as three vessels fished for a total of 70 days. The R/V *Resolution*, the M/V *Rosie G*, and the M/V *Rosemary* fished from June 26 to August 3. The M/V *Rosemary* substituted for the R/V *Resolution* as mechanical problems prevented the latter from continuing the charter.

During this charter period, two fishery biologists and three technicians were employed on each vessel with one vessel fishing mostly the ocean stations and the other fishing mostly the bay stations. Stations that were fished during the 1973 Indexing Study were similar to the 1972 stations with minor additions and omissions. The fishing gear in 1973 was also the Seattle-type king crab pots.

The 1974 Crab Indexing Study was carried out by two vessels for a total of 62 fishing days.

All fishes caught during the 1972, 1973, and 1974 ADF&G King Crab-Snow Crab Indexing Studies were obtained using the same sampling procedure.

In 1972, each offshore station consisted of a five-mile string of 20 pots (four pots per mile). During the 1973-1974 study, 2 1/2 to 3 mile strings of 12 pots (four per mile) were fished. During all three years, bay stations consisted of four pots at a station length of one mile.

To determine the distribution of these stations on the ocean floor, a scattered sampling plan was devised. Because the elaborate sampling design

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was directed toward "crab" assessment and not "cod" assessment, it is not necessary to describe this procedure.

Only one vessel, the M/V *Peggy Jo*, was able to collect fish stomachs and associated information in 1972. Forty pots with two stations of 20 pots each, were fished daily by each vessel. In 1973-1974, each vessel fished from 30 to 36 pots daily with 10 to 12 pots per station except for bay stations. Pots were pulled every 18 to 24 hours except when weather conditions prolonged the fishing time.

As pots were pulled, various miscellaneous fishes were caught in addition to the crabs. All fish were measured, however, not all were examined for stomach contents. Fish, primarily cod, were often caught as they were drawn by the bait (chopped frozen herring and occasionally cod or bullhead).

Often the time factor and manpower prevented the examination of stomachs as sexing and measuring of crab plus recording other miscellanous species was the priority of the day's work.

All stomachs were examined and recorded in the field by an ADF&G fishery biologist. The contents were identified to the lowest possible taxon. Date, station and pot number, depth of catch and frequency of occurrence as well as relative abundance of contents were also recorded. Contents unidentifiable in the field were preserved for later identification.

As fish were caught in the pots, they were measured (standard length) and if time did not permit (immediate) examination of the stomach contents, the fish were thrown into a basket for later examination. This method did not allow a look at fish from specific pots rather from the overall station.

Stomachs of the bullheads, Great Sculpin *Myoxochephalus polyacanthocephalus* (Pallas, 1811), the Yellow Irish Lord *Hemilepidotus jordani*, Bean, and the Red Irish Lord *Hemilepidotus hemilepidotus* (Tilesius, 1810) were also examined along with various miscellaneous species.

During September 1973, the NOAA R/V *John N. Cobb* conducted a groundfish survey southwest of Kodiak Island. Trawling was performed with a standard 400 mesh liner in the cod end. The trawl was constructed of 4" mesh throughout the wings, square and belly, and 3 1/2" mesh throughout the intermediate and cod end. Headrope and footrope lengths were 71 and 94 feet, respectively. Three-eighths inch (3/8") single braid polypropylene chafing gear was attached along the cod end. Cod were taken during this 30-minute tow in 98 fathoms at 57°46.6'N and 154°18.1'W. This was the only trawl sample that was obtained.

All cod stomachs that came from trawls were subsequently removed, separately placed in muslin bags, preserved in 10 percent formaldehyde with the pertinent data for each fish recorded and held for later examination. Each fish was also sexed. Stomach contents were carefully enumerated and identified in the laboratory.

Selection of species from pots posed little difficulty as cod and sculpin were the dominant species. Cottids -- the Great Sculpin and the Yellow Irish Lord were commonly found. Other fishes such as rockfish, searchers, lumpsuckers, eels and pollock were also found but to a lesser extent. They were nearly always examined. Halibut was examined only when found dead as mortality was readily caused by sand fleas.

As fish were caught, they were placed in a large wooden tagging bin with a fiberglassed meter stick used for measuring. All fish were chosen at random for examination. Bias was minimized as most cod in a specific pot were relatively equal in lengths. The bullheads, Yellow Irish Lord and Red Irish Lord were also similar in size.

The selection of fish from each pot was flexible and no strict sampling guidelines were followed. If time allowed the examination of two or three fish from a pot before the next pot was lifted, the remainder were returned to the sea or saved for later examination.

Often stomach contents could not be identified in the field and were returned to the laboratory for examination.

In order to determine frequency of occurrence, the number of individual samples was recorded in which each kind of food item is found. The results are usually expressed as percentage of the total number of specimens analyzed containing various food items.

Identification of many mollusks to species was carried out by Mr. Rae Baxter of Bethel, Alaska. Certain invertebrates and fishes were identified by Mr. George Mueller, curator and Mr. Kenneth Vogt, respectively of the University of Alaska's Marine Collections.

Criteria developed by Feder *et al.* (1973) to recognize Biologically Important Taxa (BIT) were applied to the data collected in the Gulf of Alaska. By use of these criteria, each species was considered independently (items 1 and 2 below) as well as in combination with other benthic species (items 3 and 4 adopted from Ellis, 1969). Each taxon classified as BIT in this study met at least one of the four conditions.

1. It was distributed in 50 percent or more of the total stations sampled.

2&3. It comprised over 10 percent of either the composite population density or biomass collected at any one station.

4. Its population density was significant at any given station. The significance was determined by the following test:

    a. A percentage was calculated for each taxon with the sum of the population density of all taxa equalling 100 percent.

b. These percentages were then ranked in descending order.

c. The percentages of the taxa were summed in descending order until a cut-off point of 50 percent was reached. The BIT were those taxa whose percentages were used to reach the 50 percent cut-off point. When the cut-off point of 50 percent was exceeded by the percentage of the last taxon added, this taxon was also included.

5. Its biomass was significant at any given station. This significance was determined by the following test:

   a. A percentage was calculated for each taxon with the sum of all taxa equalling 100 percent.

   b. These percentages were then ranked in descending order.

   c. The percentages of the taxa were summed in descending order until a cut-off point of 50 percent was reached. The BIT were those taxa whose percentages were used to reach the 50 percent cut-off point. When the cut-off point of 50 percent was exceeded by the percentage of the last taxon added, this taxon was also included.

Species diversity was examined by way of three Indices of Diversity:

1. Shannon-Wiener Index

$$H = -\Sigma\ p_i \log_e p_i \quad \text{where} \quad p_i = \frac{n_i}{N}$$

n_i = number of individuals of species $i_1, i_2, i_3 \ldots i_x$

N = total number of individuals

s = total number of species

2. Simpson Index

$$s = \Sigma \frac{n_i}{n} \frac{n_{i-1}}{N-1}$$

3. Brillouin Index of Diversity

$$H = \frac{1}{N} (\log_{10}N! - \Sigma\log_{10}N_2!) \text{ where}$$

N = total number individuals in all species

N_i = number of individual in the i^{th} species.

These indices were calculated for all stations sampled.

The Simpson index is an index of dominance since the maximum value, 1, is obtained when there is a single species (complete dominance), and values approaching zero are obtained when there are numerous species, each a very small fraction of the total (no dominance). The Shannon and Brillouin indices are indices of diversity in that the higher the value, the greater the diversity and the less the community is dominated by one or a few kinds of species (see Odum, 1975 for further discussion and additional references).

All species taken by grab were coded according to the 10 digit VIMS system used for fauna collected in a benthic study in Chesapeake Bay (Swartz *et al.*, 1972); coding was suitably modified by G. Mueller to conform to species collected in the Gulf of Alaska (Mueller, 1975). Data was recorded on computer cards, and will be converted to magnetic tape. Data printout was accomplished by means of special programs written by Mr. James Dryden (Data Processing Services, Institute of Marine Science, University of Alaska). Data output consisted of a listing of stations occupied and replicates (samples) taken, a species-coding number list associated with a printout of Biologically Important Taxa (BIT) for all grab stations, and a series of station printouts (species collected, number of individuals, percentage of each species (number), biomass of individuals, percentage of each species (biomass), Simpson Index, Shannon Diversity Index and Brillouin Index).

Ten van Veen grabs have been taken at six stations with varying sediment types and species assemblages scattered throughout the northeastern Gulf of

Alaska study area (Fig. 1). These samples are presently being analyzed at the Marine Sorting Center. When available this data will be analyzed by the grab sampling simulation program developed by Feder *et al.* (1973) in order to determine the optimum number of grabs required to adequately sample a station. In addition these samples will be analyzed for dispersal patterns using the "k" parameter of the negative binomial distribution [$k = \bar{X}^2/(S^2-\bar{X})$] as a measure of patchiness, as well as the coefficient of dispersion. The "k" parameter is independent of sample size (Taylor, 1953) and thus is preferable to the coefficient of dispersion for measuring patchiness (Lie, 1968). The data can then be transformed to approximate a normal distribution, statistical limits set about the mean, and the number of samples required to give a satisfactory population estimate determined (McIntyre, 1971).

In order to improve our understanding of the diversity of stations an additional program was written to determine the Shannon Wiener evenness component, the Brillouin Index of diversity, and its evenness component (Table 3).

Shannon-Wiener Evenness

$$J' = \frac{H'}{H'\text{max}}$$

H' = Shannon Wiener diversity measure

where $H'\text{max} = \log S$

S = total number of species

Brillouin Evenness

$$J = H/H\text{max}$$

$$H\text{max} = \frac{1}{N} \log \frac{N!}{\{[N/S]!\}^{s-r}\{([N/S]+1)!\}^{r}}$$

where N = total number of individuals of all species

S = number of species

$[N/S]$ = the integer part of N/S

$r = N-S[N/S]$

Both the Brillouin, H, and the Shannon Wiener, H', diversity indices are based on the information theory. The difference between the two measures is that the Shannon Wiener index assumes that a random sample has been taken from an infinitely large population and that "all species in the community population are represented in the sample" (Poole, 1974) while the Brillouin Index is simply a measure of the diversity of the species sampled (see Poole, 1974; Pielou, 1966a, 1966b, 1975 for a discussion of the use of these measures). Feder *et al.* (1973) and Lie (1968) using cumulative plots of species recruited with increasing sampling found that 5 grabs contained 75 to 85% of the total species found in 8 and 10 grabs respectively. As the number of grabs sampled declines these percentages decline logarithmically. Thus, if the number of samples is low or if the grab inadequately samples the community due to poor penetration or patchiness in distribution of organisms a considerable error is introduced in the Shannon Wiener estimate of diversity. This error makes itself apparent when the Shannon Wiener Evenness is calculated.

Diversity as measured by the Shannon-Wiener and the Brillouin information theory indices can be divided into two components, one component is simply the number of species represented in the sample and the other is the relative numbers of individuals in the community or sample. Thus, if two communities (or samples) contained the same number of species but in one community one of two species dominated the community while in the other the number of individuals (or biomass) per species was relatively even, the latter would have a higher diversity. The relative number of individuals/species is called the evenness component of the diversity index. It is calculated as shown in the equations above by dividing the calculated diversity by the maximum diversity (the diversity of a community in which all species occurred

Table 3. Diversity indices and evenness measures for all quantitative stations occupied by van Veen grab in the Gulf of Alaska, July 1974 through May 1975.

03/12/76 15.7122

STATION	NO. IND	NO.SPEC	SIMPSON	SHANNON	SW EVEN	BRILLOUIN	BRILL EVEN
193003	51.0	21.0	0.061961	2.757249	2.085319	0.993179	0.911455
193006	342.0	79.0	0.031212	3.727787	1.996065	1.507667	0.870156
193026	135.0	43.0	0.039912	3.384649	2.072063	1.292416	0.902361
193032	98.0	33.0	0.036819	3.247819	2.138814	1.223369	0.931034
193041	258.0	31.0	0.127620	2.502198	1.677794	1.012611	0.726832
193042	392.0	38.0	0.135785	2.491999	1.577431	1.020748	0.682527
193044	166.0	51.0	0.040526	3.467721	2.030793	1.335156	0.884986
193048	194.0	57.0	0.033919	3.628206	2.066324	1.407312	0.901290
193050	57.0	27.0	0.040727	3.065586	2.141724	1.098408	0.933838
193052	241.0	37.0	0.125761	2.593619	1.653881	1.036395	0.715240
193055	128.0	32.0	0.091781	2.869763	1.906629	1.104813	0.824974
193059	23.0	9.0	0.166008	1.858761	1.947892	0.636673	0.845621
200050	140.0	35.0	0.058787	3.054237	1.978045	1.184803	0.860240
200052	191.0	36.0	0.084982	2.934917	1.885827	1.159862	0.817901
200053	269.0	37.0	0.108611	2.720957	1.735081	1.097235	0.752237
200057	368.0	73.0	0.047788	3.533722	1.896462	1.415739	0.824382
202001	20.0	11.0	0.105263	2.154783	2.069136	0.707067	0.902239
805031	113.0	28.0	0.060209	2.941255	2.032435	1.133742	0.883518
805032	161.0	50.0	0.028106	3.606649	2.122844	1.388103	0.925984
805040	123.0	35.0	0.048914	3.160702	2.046997	1.212286	0.892822
805041	157.0	30.0	0.088519	2.760782	1.869029	1.086305	0.811190
805042	45.0	19.0	0.090909	2.531967	1.980027	0.901504	0.862842
805043	32.0	13.0	0.137097	2.154619	1.934227	0.751353	0.839418
805044	19.0	11.0	0.076023	2.232694	2.143951	0.728442	0.943271
805049	154.0	39.0	0.065529	3.103912	1.950840	1.203837	0.847056
805051	53.0	23.0	0.071843	2.752791	2.021543	0.987843	0.881931
805053	29.0	15.0	0.093596	2.404905	2.044828	0.817083	0.886500
805054	108.0	24.0	0.158532	2.448742	1.774179	0.939609	0.765240
805055	79.0	27.0	0.057124	2.947102	2.058947	1.098618	0.895726
805056	384.0	71.0	0.102127	3.278286	1.770842	1.311503	0.766404
805057	66.0	35.0	0.030769	3.326573	2.154421	1.189017	0.940998
805058	133.0	26.0	0.185578	2.280293	1.611545	0.883574	0.692167
807002	90.0	42.0	0.026966	3.500732	2.156620	1.282983	0.941369
807004	77.0	24.0	0.094668	2.637334	1.910819	0.985753	0.829767
807005	170.0	35.0	0.109154	2.736344	1.772166	1.072310	0.767277
807007	38.0	23.0	0.072546	2.312754	2.065577	0.956209	0.904035
807025	53.0	23.0	0.052409	2.827799	2.076626	1.015195	0.906350
807026	78.0	30.0	0.066600	2.950235	1.997287	1.083022	0.871021
807027	249.0	42.0	0.279052	2.219129	1.367091	0.871490	0.582650
807028	164.0	34.0	0.064268	2.996171	1.956391	1.177996	0.850995
807050	66.0	24.0	0.070862	2.806985	2.033735	1.032333	0.885761
807052	36.0	19.0	0.052381	2.745778	2.147230	0.948219	0.936546
807053B	8.0	5.0	0.107143	1.559591	2.231256	0.462504	1.000000

in the same proportion). Note that in Table 3 the Shannon Wiener Evenness component is >1. This results because we have not sampled all the species in the "community" and the value for H'max = logS we calculated is lower than the actual value for all species in the community.

Classification and Ordination

Station groups and species assemblages have been identified using several classificatory techniques. These techniques can be broken down into 3 basic steps (Field, 1971).

1. Calculation of similarity (or dissimilarity) coefficients between the entities to be classified.
2. Sorting through the matrix of similarity coefficients to arrange the entities in a hierarchy or dendrogram.
3. Recognition of classes within the hierarchy.

Initially data reduction in our studies (as matter of convenience) prior to calculation of similarity coefficients consisted of eliminating all species except the biologically important taxa (BIT). However, this results in an unacceptably large loss of information and a less drastic method of data reduction will be used in the future. Elimination of all species which have only a single occurrence and thus contribute very little to the recognition of a station group, reduces the list of species analyzed to date to about 180 species. This technique will be used in the future.

As a matter of convenience initially to enable us to more effectively interface the cluster analysis programs with MSCLST (Marine Sorting Center List program -- a listing of all tabulated data from all stations), some higher taxa that could not be analyzed to species were used. These higher taxa pooled with identified species could confuse the analysis, and it is intended to eliminate most of them in future analyses.

Station data listed in Appendix Table I and II (and completely listed on magnetic tape at the National Environment Data Center) are grouped as "All Stations" (qualitative and quantitative) and "Quantitative Stations". Qualitative stations are those in which grab volumes were less than 5 liters. Analyses were performed with data from both types of stations. Some of the qualitative stations are quite unique in the Gulf sampling grid, and much important information would be omitted from analysis if these stations were rejected. Comments in the body of this report refer to qualitative and quantitative stations as defined above.

Two similarity coefficients have been used in the initial classification of the benthic infuana, the Sørensen coefficient which is based on the presence or absence of attributes and the Motyka (synonymous with the Czekanowski (Field, 1969) and Bray-Curtis (Clifford and Stephenson, 1975) coefficients) quantitative modification of the Sørensen coefficient.

Sørensen

$C_{s_{1,2}} = \frac{2c}{A+B}$ where A = total number of attributes of entity one

B = total number of attributes of entity 2

c = total number of attributes shared by entities 1 and 2

Motyka

$C_s = \frac{2W}{A+B}$ where W = is the sum of the lesser measure of attributes shared by entities 1 and 2

A = is the sum of the measures of attributes in entity 1

B = is the sum of the measures of attributes in entity 2

The Motyka coefficient has been used effectively in marine benthic studies by Field and Macfarlane (1968), Field (1969, 1970 and 1971), Day *et al.* (1971), Stephenson and Williams (1971), and Stephenson *et al.* (1972). Compared with the similar "Canberra metric" (Lance and Williams, 1966) coefficient the Motyka coefficient tends to emphasize the effects of dominant species (for a discussion see Clifford and Stephenson, 1975) and it is often used with some form of transformation. However, Raphael and Stephenson (1972) found that the Motyka coefficient produces site groups that are more closely related to changes in abiotic attributes (i.e. sediment type). Clifford and Stephenson state that "the implications of this appear to be that a reasonable stress on dominant species is preferable to stress on the infrequently occurring ones if indications of the importance of abiotic factors are required. Contrary to expectation the best 'indicator' species, at least in the above studies of marine benthos were not the uncommon ones". A similar comment has also been made independently by Dr. B. Dicks for the shallow benthos of the North Sea (B. Dicks, Orielton Oil Pollution Research Unit, personal communication).

The Jaccard coefficient has been used successfully by Field (1969) for binary data and we plan to compare the results obtained with this coefficient with those obtained with the Sørensen coefficient.

Jaccard Coefficient

$$C_{s_{1,2}} = \frac{c}{a+b+c}$$

where a = total number of attributes of entity 1 alone

b = total number of attributes of entity 2 alone

c = as above

The Motyka, quantitative, coefficient will be used to classify all stations except those in which quantitative grabs (sediment volume $\geq 5\ell$) could not be obtained due to lack of penetration of the grab. The Jaccard or Sørensen coefficient will be used on the entire data set including qualitative data in an attempt to determine the relationship of these stations to the previously clustered stations. Stations (and species) will be clustered both on the basis of numbers and wet biomass/m^2 for untransformed and log transformed data. The log transformation $Y = \ln(x+1)$ reduces the influence that dominant species have on the similarity determination.

Sorting strategies have been classified into three groups by Lance and Williams (1967) depending on the intensity of clustering. Space contracting strategies tend to form clusters which upon formation have closer to all other clusters or individuals. These strategies tend to form chains. The nearest neighbor (single linkage) technique is an example of space contracting strategy. Space dilating strategies tend to form discrete clusters which upon formation move further from other clusters or individuals thus once a cluster has formed there is a smaller chance that it will join another cluster or individual. Space conserving strategies form clusters which move neither closer nor further away from other clusters or individuals. We plan to use three sorting strategies: 1) single linkage (nearest neighbor), a space contracting strategy, 2) average linkage (group average; Lance and Williams, 1967), a space conserving strategy, and 3) Lance and Williams' (1967) flexible sorting strategy which is a space contracting strategy when B is set to equal -0.25. Results from these methods will be compared to determine which one forms clusters which make the most ecological sense. Initial analyses have been completed using the single linkage and average linkage techniques. The flexible sorting strategy will also be utilized as soon as the algorythms arrive from CSIRO Division of Computing Research, Canberra, Australia.

Both a normal and inverse analysis have been used to delineate station groups and species groups. In a normal analysis, stations are classified and species are the attributes. For example, using the Motyka coefficient of similarity for a normal analysis the similarity between two stations would be:

$$C_{s_{\text{Sta. } 1,2}} = \frac{2W}{A+B}$$ where $W =$ is the sum of the smaller measure (numbers or biomass) of each species for the two stations being compared.

An inverse analysis yields a classification of species where their presence or numbers at a station are the attributes. Station groups and species groups are then compared using a two way coincidence table.

We are currently developing programs to analyze both the species distributions and such environmental parameters as sediment type, organic carbon content, and salinity, temperature, oxygen concentrations of the bottom water by principal component and principal co-ordinate analysis (Gower, 1967, 1969; Field, 1971, personal communication; Cassie and Michael, 1968; Moore, 1974; Hughes and Thomas, 1971a, 1971b). Canonical Correlation Analysis (Cassie and Michael, 1968; Williams and Lance, 1968) and/or Multiple Regression analysis will also be used to investigate the relationship between physical parameters and species distributions.

VI. RESULTS

A. Benthic Infaunal Programs

The basic plan of operation suggested in the proposal (and presented in Methods) was completed for the northeastern portion of the study area (Fig. 1; Table 1) substratum differences encountered in the northwestern Gulf study area during the October 1975 cruise resulted in only partial quantitative coverage of the sampling grid (Fig. 2; Table 2). Although vessel time and weather constraints did not permit complete sampling of all stations in the northwestern grid on a seasonal basis, it was possible to accumulate data in three time blocks -- July through November (1974); February through May (1975); and September through October (1975). No vessel time was made available for the summer of 1975.

The van Veen grab functioned effectively in the fine sediments of the Gulf of Alaska, and typically delivered sample volumes of 13 to 19 ℓ with the exception of stations 26 (6 to 9 ℓ), 29 (1 to 3 ℓ) and 30 (2 ℓ). These stations tend to be sand or sand-gravel dominated, and penetration was reduced. The surface of all samples, examined through the top door of the grab, was undisturbed as evidence by the smooth detrital cover. (see Feder *et al.*, 1973 for a review on use of the van Veen grab in soft sediments of the type found in the Gulf of Alaska.) The three (3) replicates typically taken at each station in the first year of the study appeared to be a minimal number as evidenced by qualitative examination of the station data (see Appendix Tables II, III in Feder and Mueller, 1975); fauna was obviously very patchy. The five (5) replicates taken at all stations in the next sampling year should be sufficient, but this value will be tested by way of 10 replicate samples taken at selected stations (see Feder *et al.*, 1973 for discussion on the optimum number of replicate samples needed in a grab-sampling program).

The size of screen chosen for the onboard washing process, 1.0 mm, was appropriate for the sediments sampled, and was the minimal size that could efficiently be used at most stations. A smaller size mesh would greatly increase the overall shipboard washing time which in turn would reduce the overall station coverage possible on each cruise.

All of the station data for the northeast Gulf for the July, October, November, February and May cruises have been processed and tabulated (Feder and Mueller, 1975; stored on magnetic tape). The balance of the archived samples from September and October 1975 will be processed and analyzed by the end of the contract year. See data available on magnetic tape; also see selected stations Appendix I. Station data for the northwest Gulf is not available as yet. All samples are being processed at present, and data will be available for the final report.

Isolation of 311 species was made from the grab samples examined to date (Feder and Mueller, 1975; Appendix Table II). Station occurrence of these species is found in Appendix Table I. Members of fourteen marine phyla were collected with polychaetous annelids comprising the most important group with 132 species. Molluscs were next in importance with 69 species, and Arthropod crustaceans next with 66 species. Echinoderms were fourth in significance with 24 species. Other groups were less important. One hundred and two (102) new species were added in the second year of the investigation.

The indices (Simpson, Shannon, Shannon Evenness, Brillouin and Brillouin Evenness) calculated for all species in the quantitative grab stations are included in Table 3. Examination of the data in this table indicates that the indices are reflecting dominance (Simpson) and diversity (Shannon and Brillouin). In the Simpson Index, the higher values in the series of indices in Table 3 are a reflection of the dominance in numbers of individuals of a few species. Lower Shannon and Brillouin diversity indices also tend to reflect species dominance or lower diversity at some of the stations. Higher diversity indices are found at stations with many species but no particular dominance by any one species. The calculated evenness indices further clarify dominance relationships at any particular station.

Utilization of the criteria for Biologically Important Taxa has delineated 95 species (see Appendix Table I). The data used to determine the BIT were pooled from the cruises in July, October, November, February, and May. Thirty-two (32) of the BIT were identifiable as important by way of biomass at one or more stations. Some of the latter species were well distributed throughout the study area, for example - the clams *Axinopsida serricata, Nucula tenuis, Nuculana pernula*; the polychaete *Sternaspis scutata*; the echinoderms *Ctenodiscus crispatus, Ophiura sarsi* and *Molpadia* sp. These species may be ones with great influence on the trophic interactions in their particular localities, and should be followed in succeeding years (see Feder and Mueller, 1975; Appendix Table I; current data on magnetic tape for a listing of the species dominating at stations by Biomass).

The distribution of selected BIT species are plotted in Figures 4 through 41.

The feeding methods for the majority of the species collected are included in Appendix Table VI of Feder and Mueller (1975). The data are compiled from the literature and from personal observations (see Feder *et al.*, 1973; Feder and Mueller, unpublished data and interpretations). Some of the species probably utilize two feeding methods, and such dual feeding methods where known, are included in the table. Deposit feeding

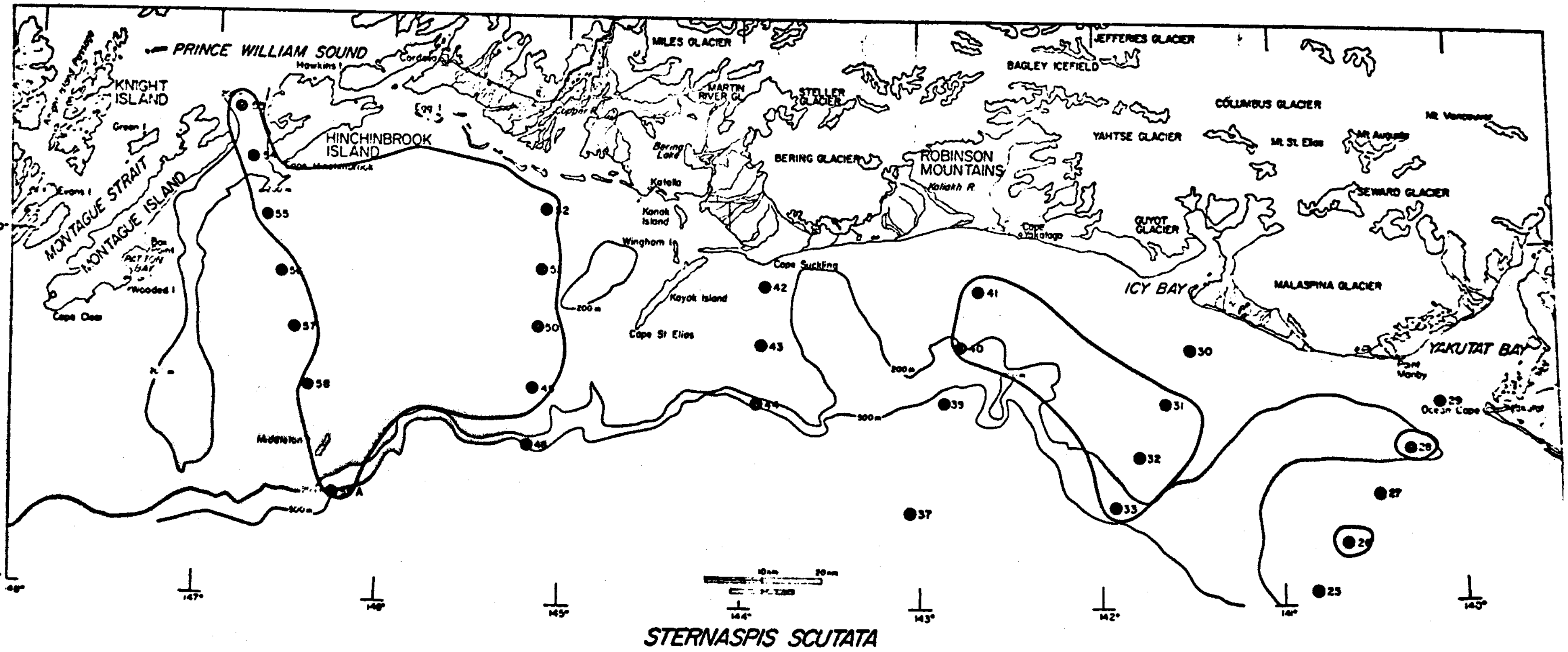
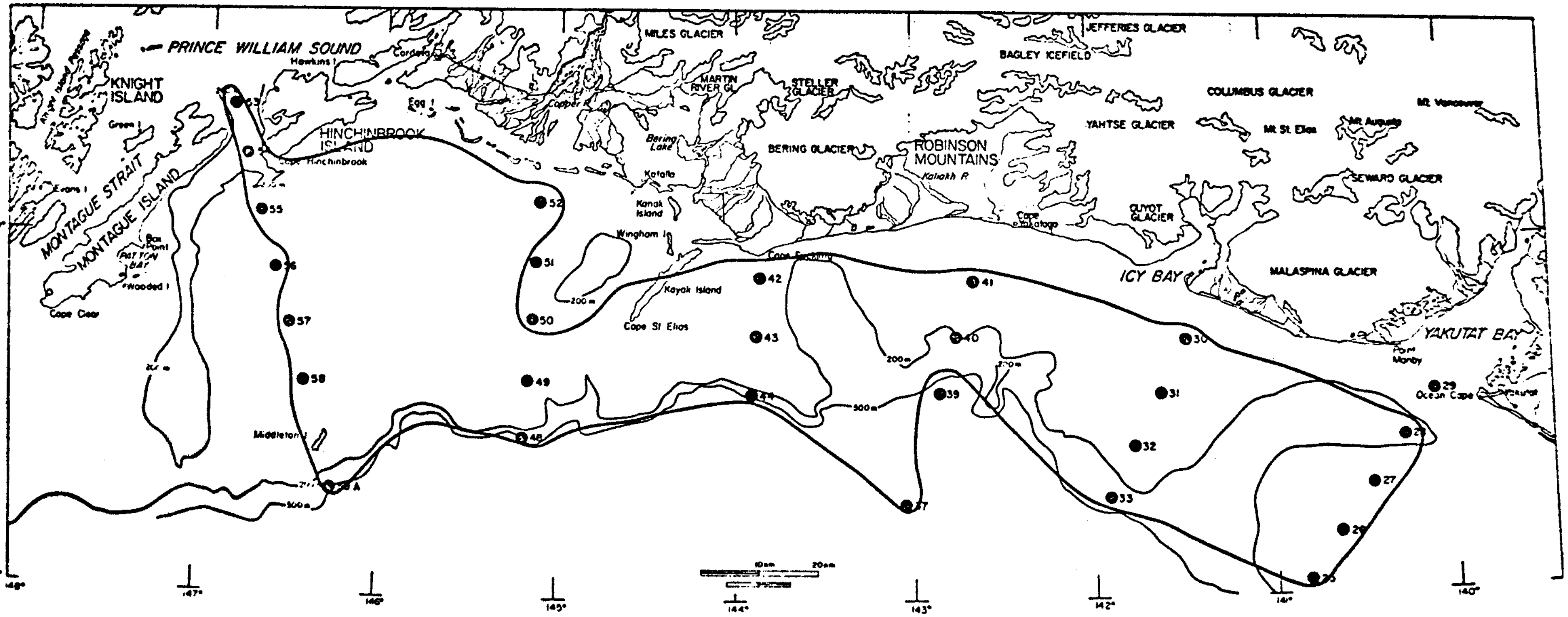


Figure 4. The distribution of the polychaetous annelid *Sternaspis scutata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January- May 1975.



MYRIOCHELE HEERI

Figure 5. The distribution of the polychaetous annelid *Myriochele heeri* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

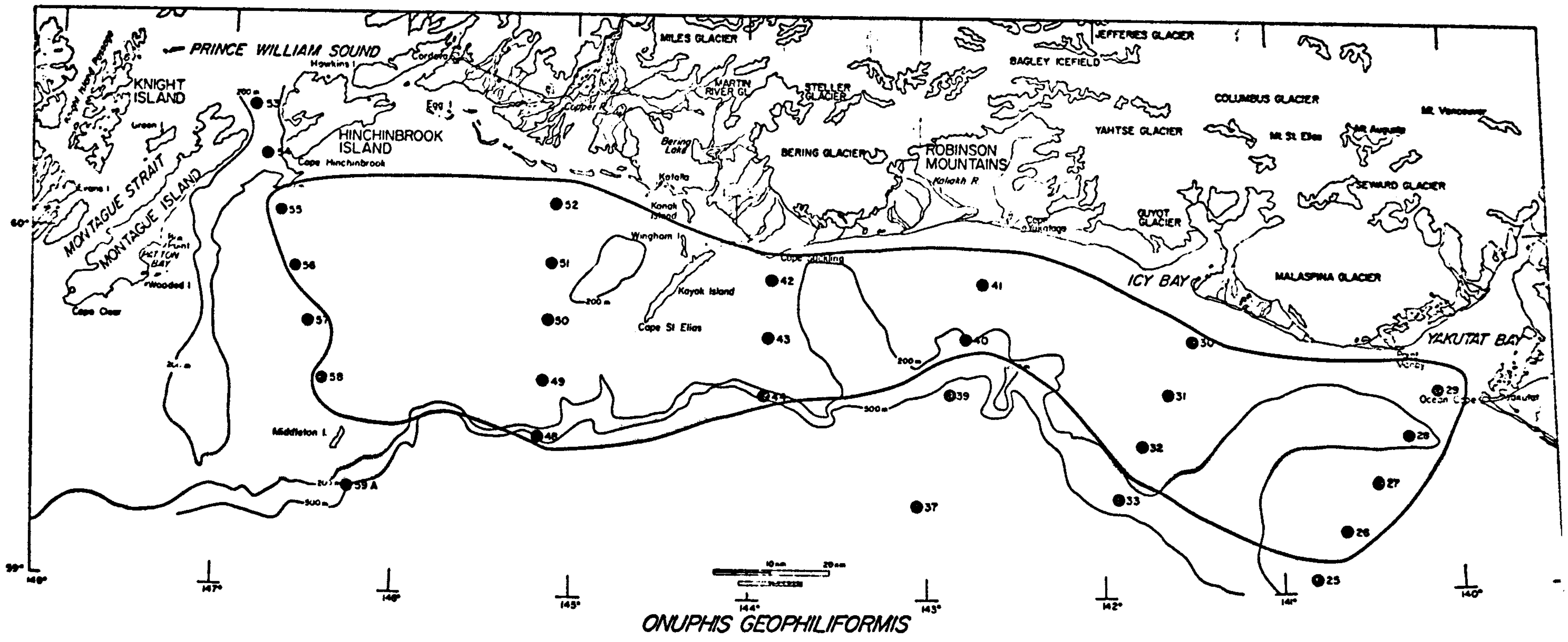


Figure 6. The distribution of the polychaetous annelid *Onuphis geophiliformis* on the shelf of the northeaste section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

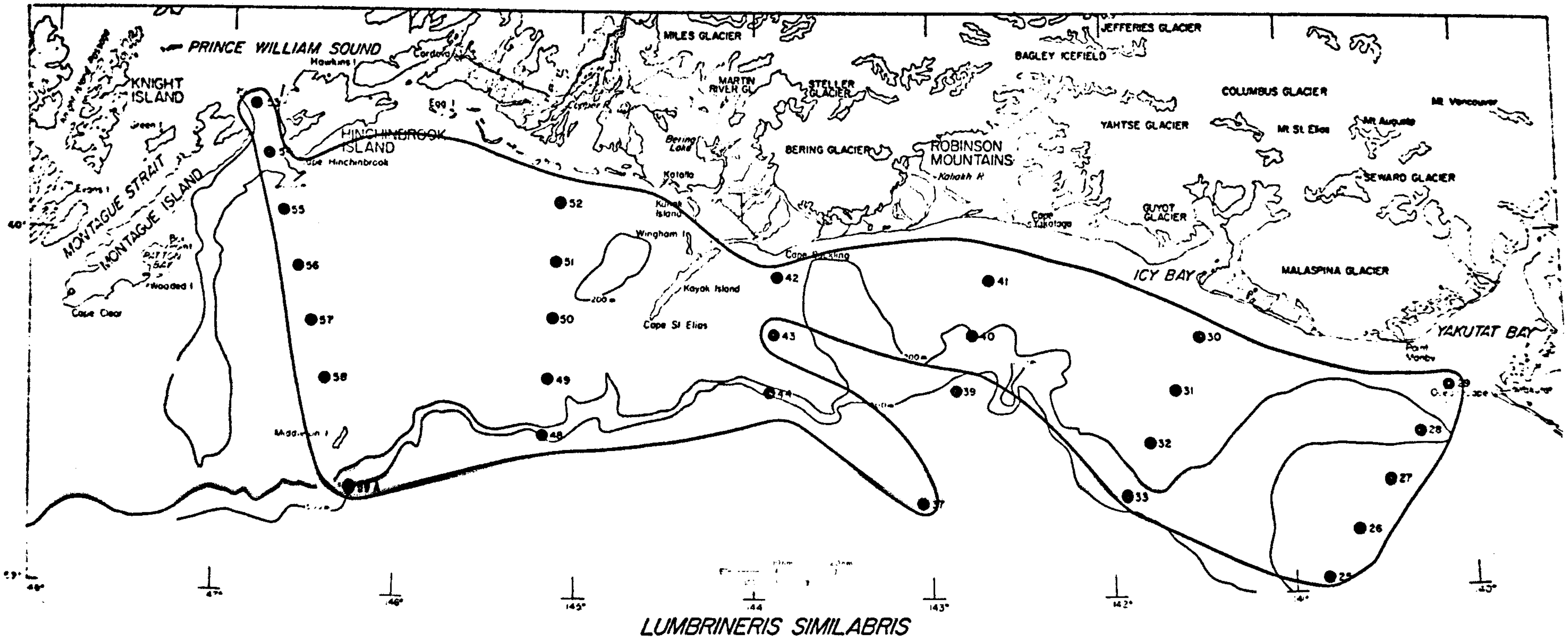


Figure 7. The distribution of the polychaetous annelid *Lumbrineris similabris* on the shelf of the northeast section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

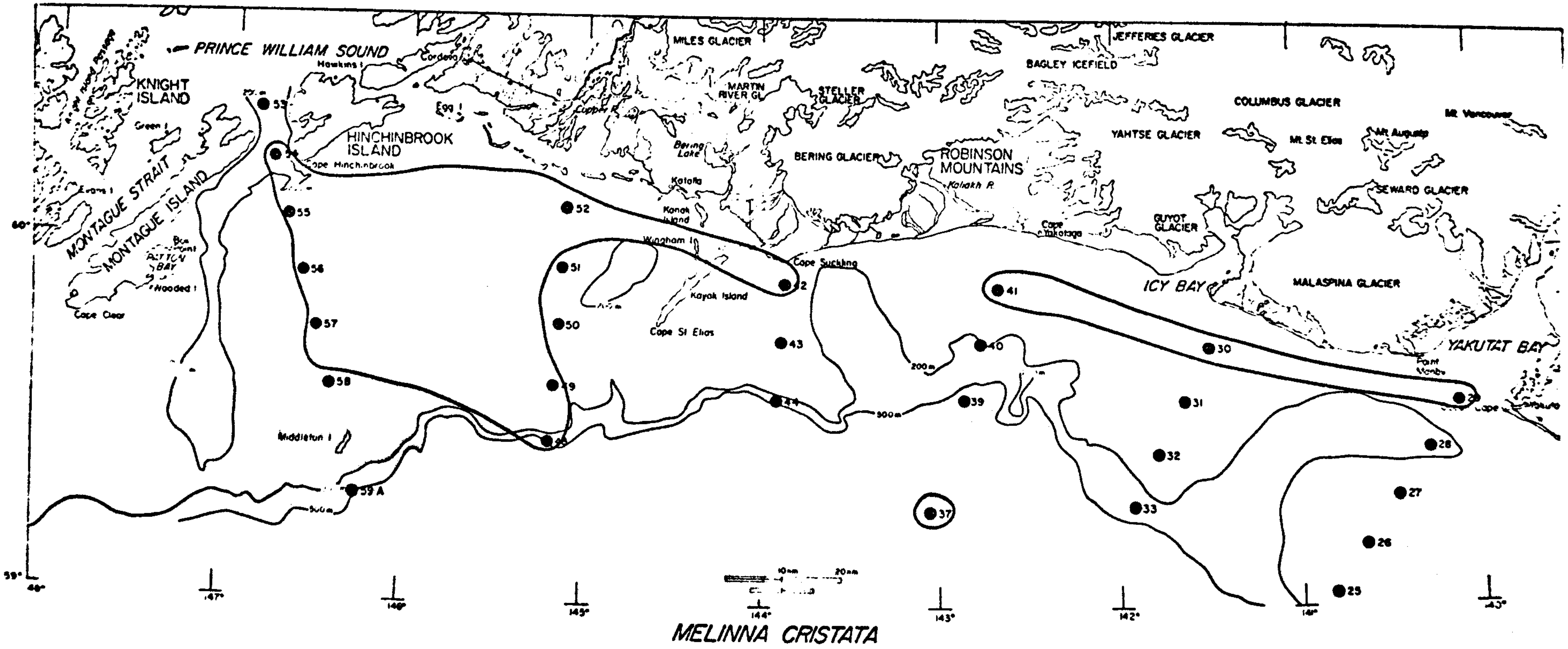


Figure 8. The distribution of the polychaetous annelid *Melinna cristata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-M 1975.

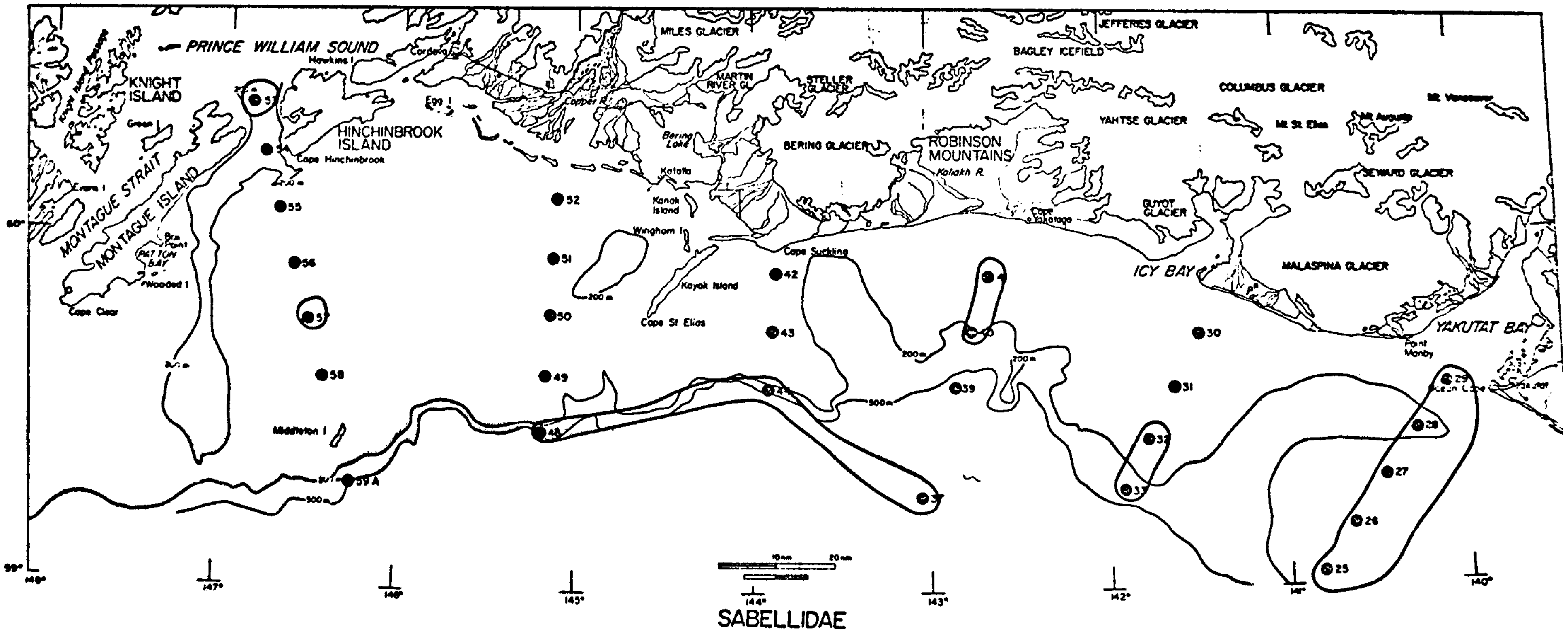


Figure 9. The distribution of the polychaetous annelid *Sabellidae* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

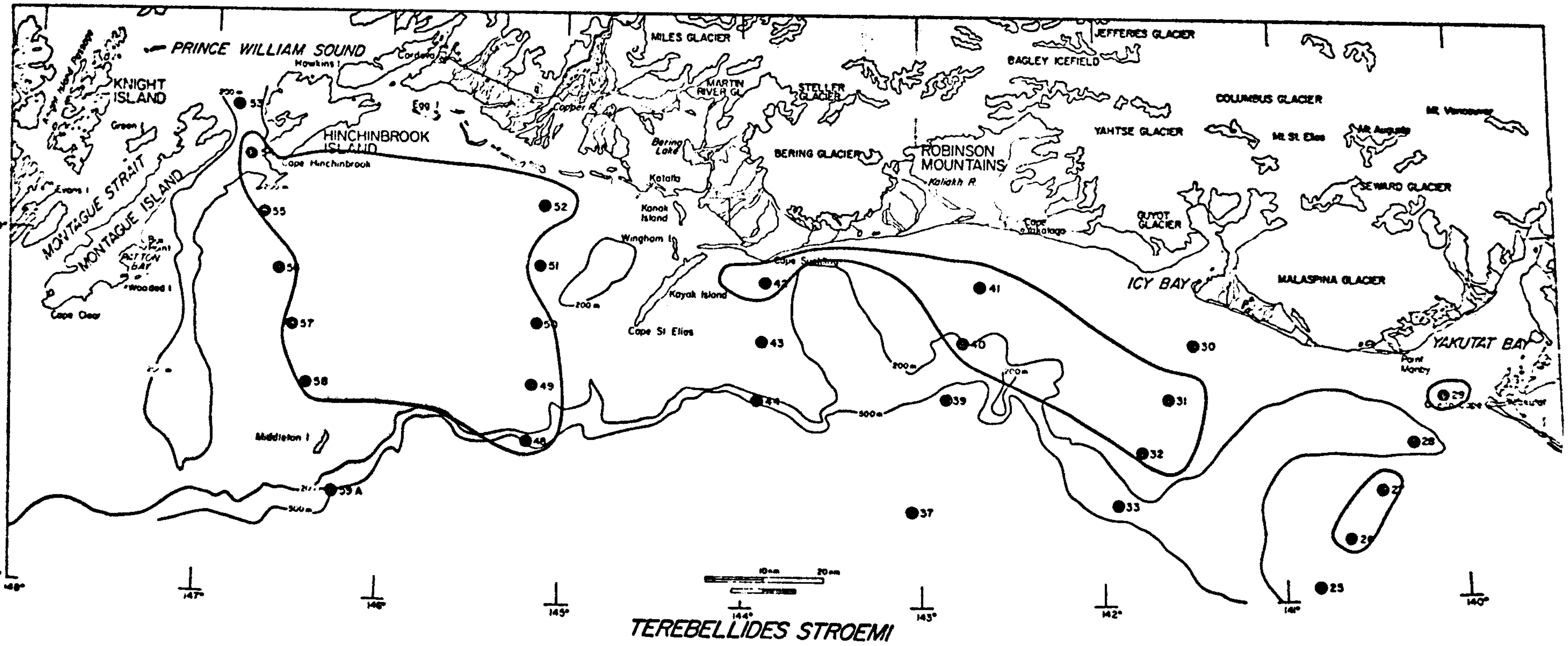


Figure 10. The distribution of the polychaetous annelid *Terebellides stroemi* on the shelf of the northeaster section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

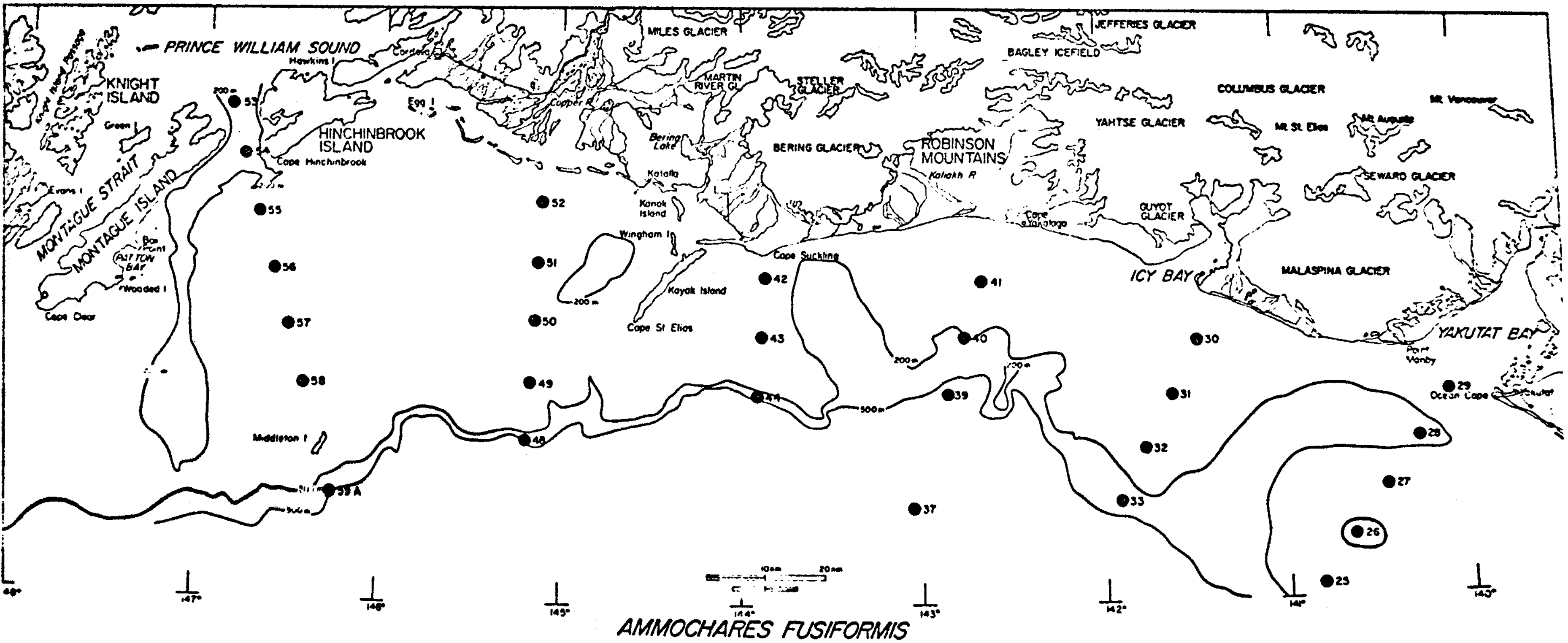


Figure 11. The distribution of the polychaetous annelid *Ammochares fusiformis* on the shelf of the northeaste section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

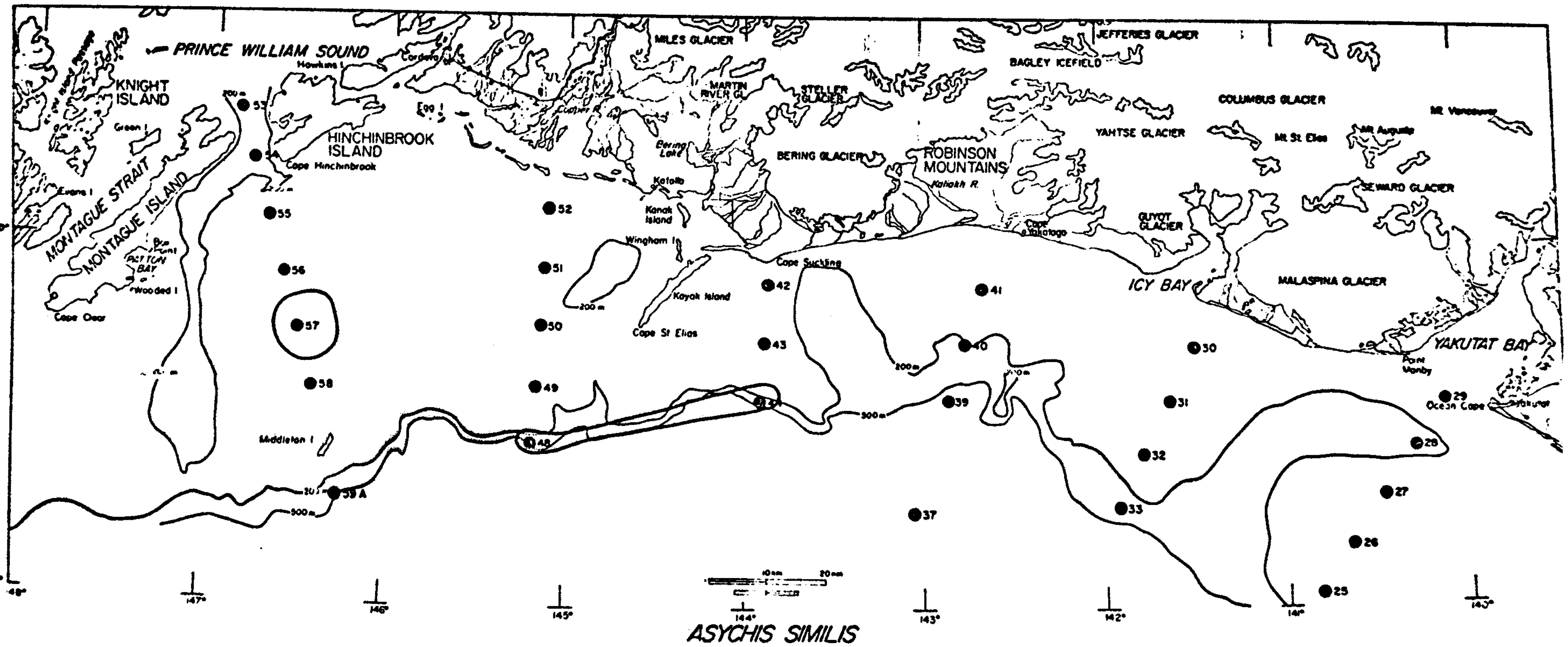


Figure 12. The distribution of the polychaetous annelid *Asychis similis* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

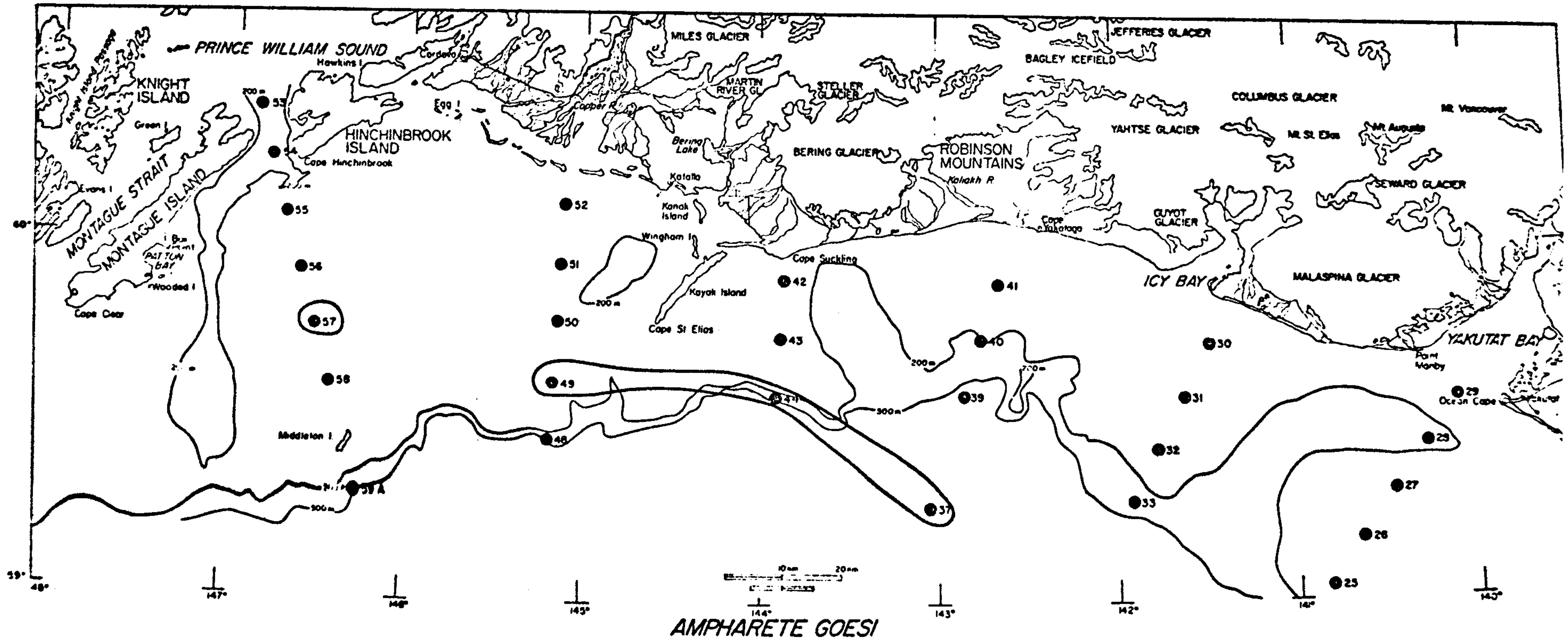
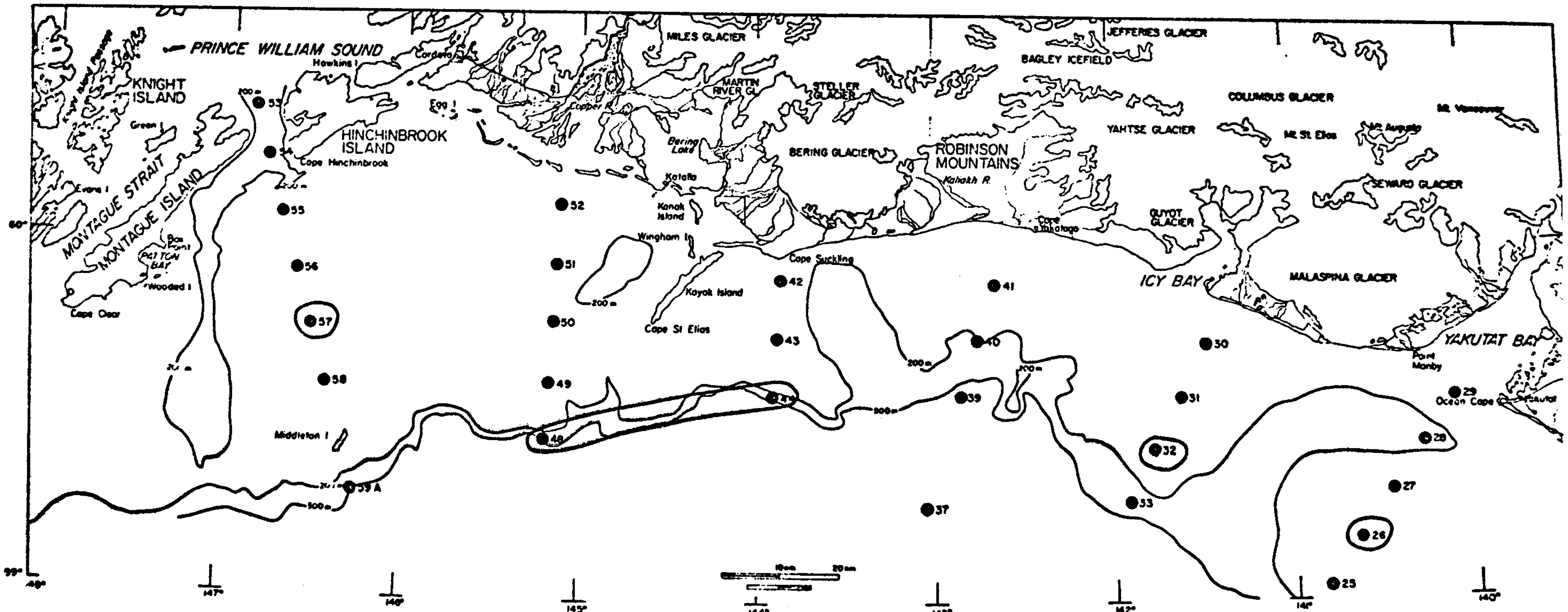


Figure 13. The distribution of the polychaetous annelid *Ampharete goesi* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



NOTOPROCTUS PACIFICUS

Figure 14. The distribution of the polychaetous annelid *Notoproctus pacificus* on the shelf of the northeaste section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

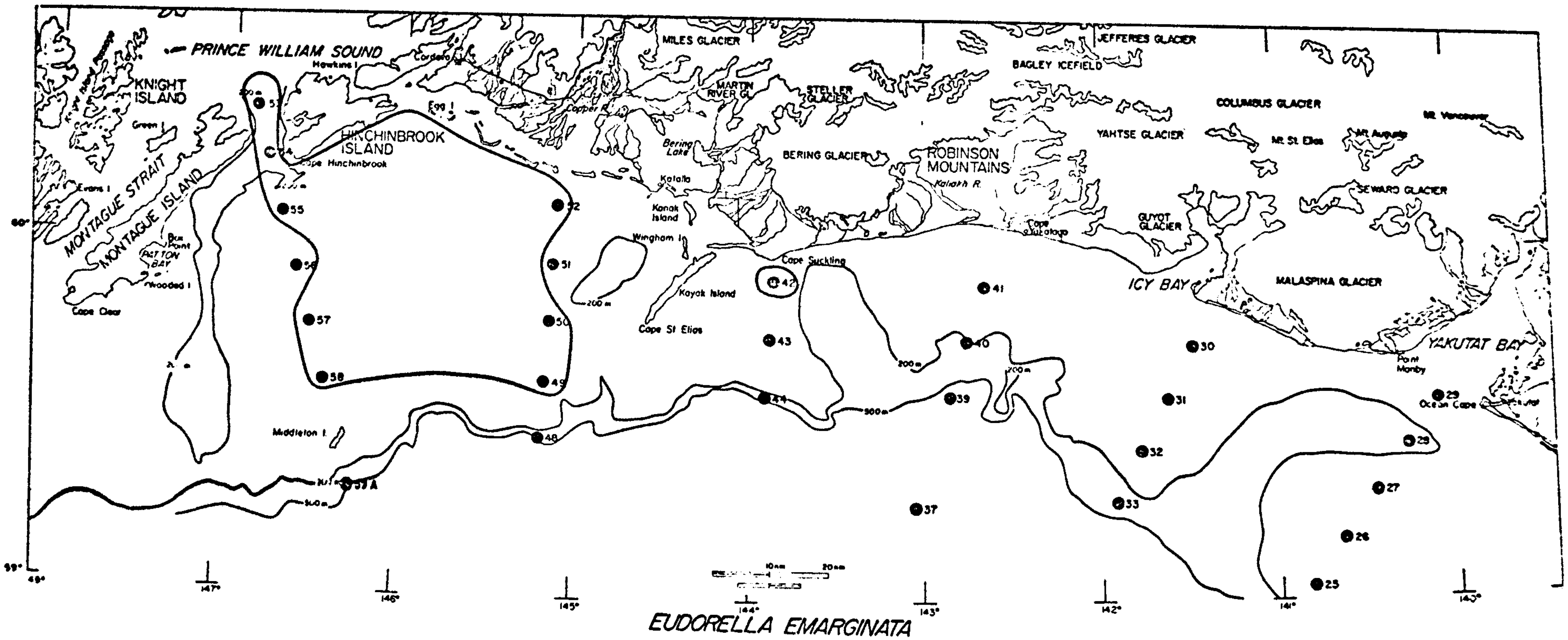


Figure 15. The distribution of the cumacean *Eudorella emarginata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

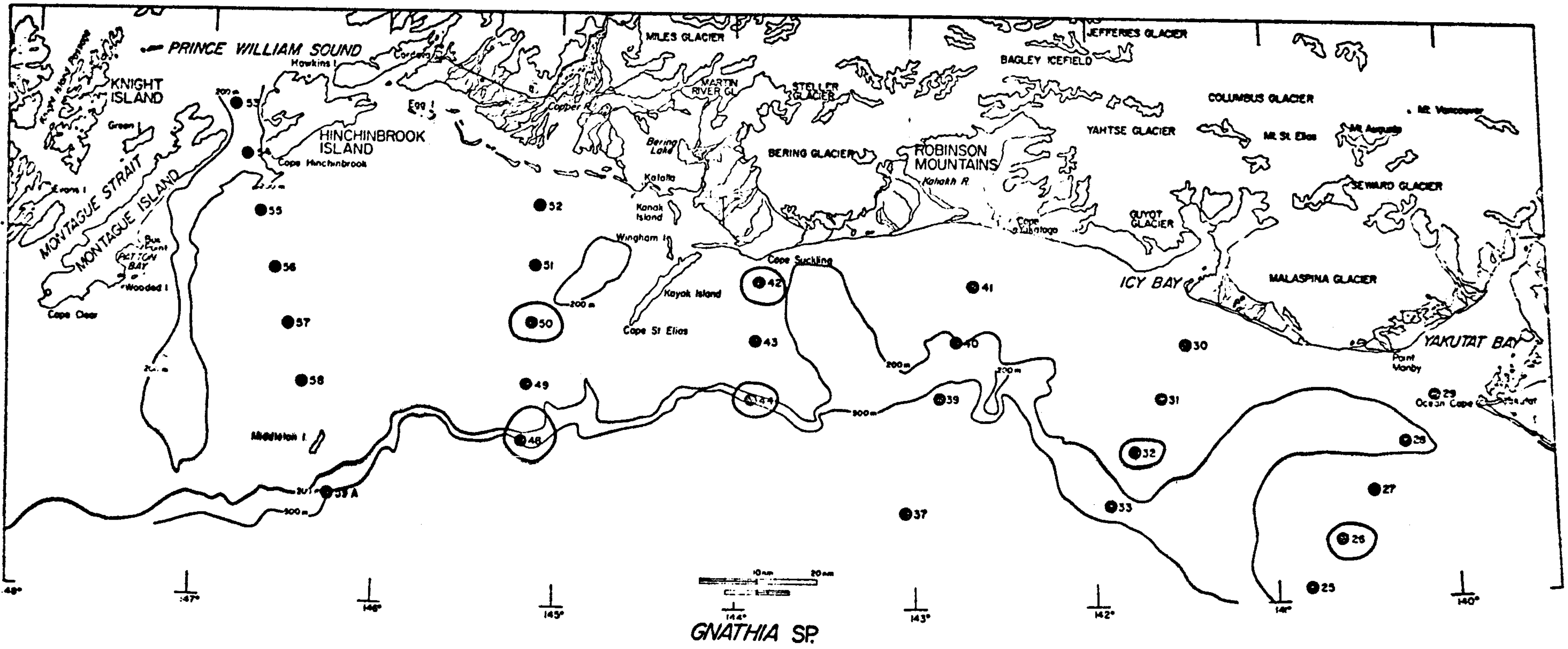
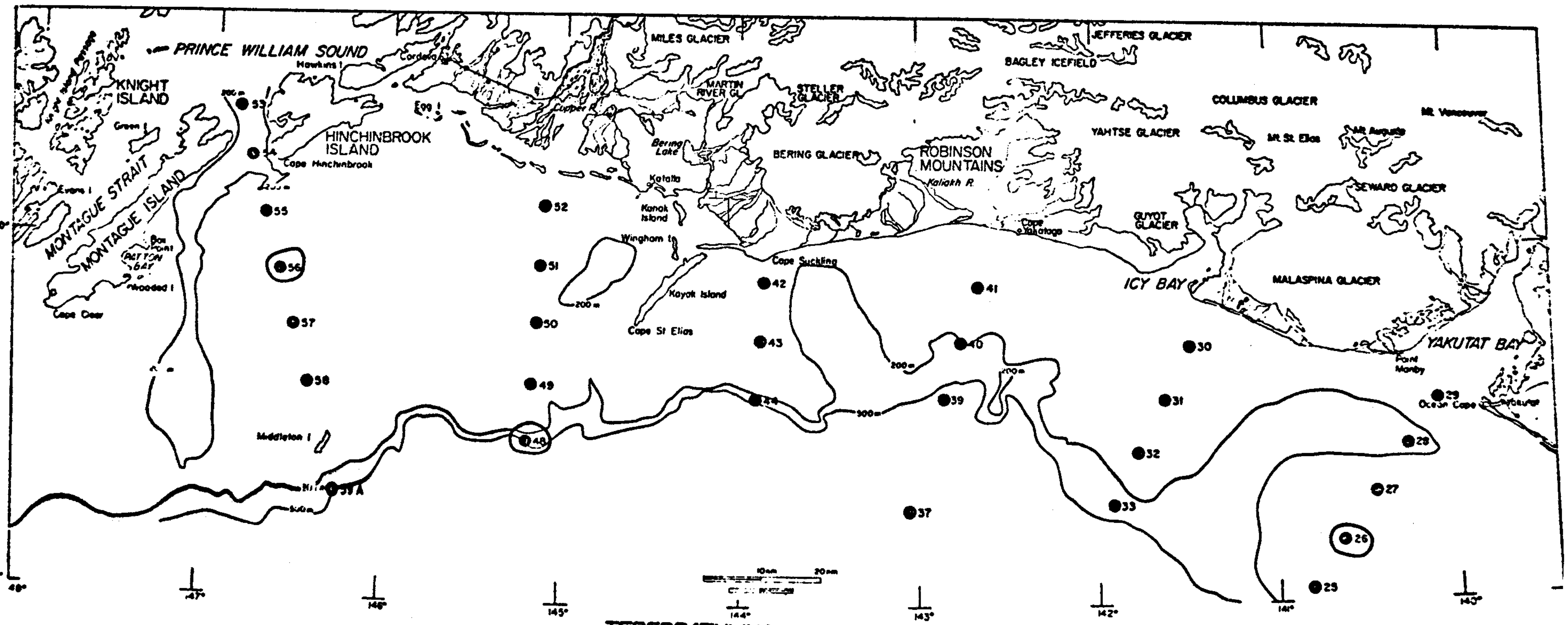


Figure 16. The distribution of the isopod *Gnathia* Sp. on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



TEREBRATULINA UNGUICULA

Figure 17. The distribution of the brachiopod *Terebratulina unguicula* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 197 January-May 1975.

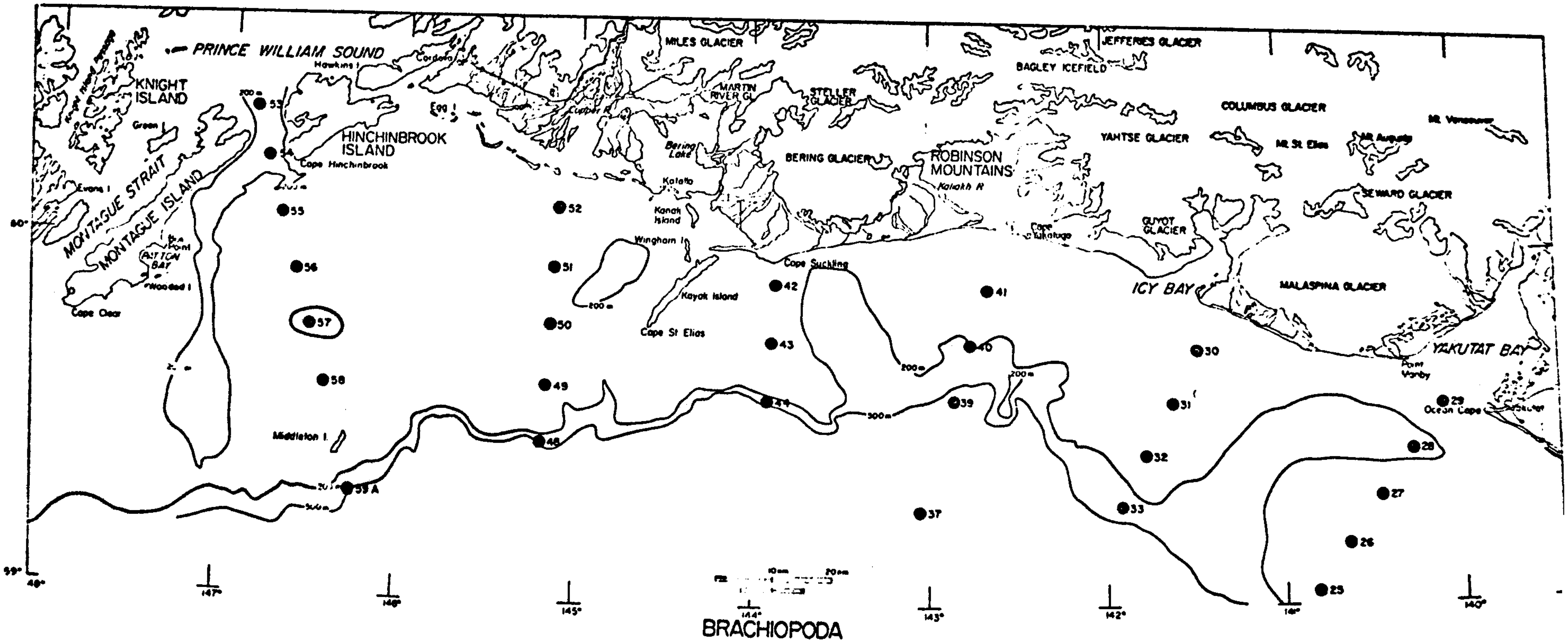


Figure 18. The distribution of the *Brachiopoda* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

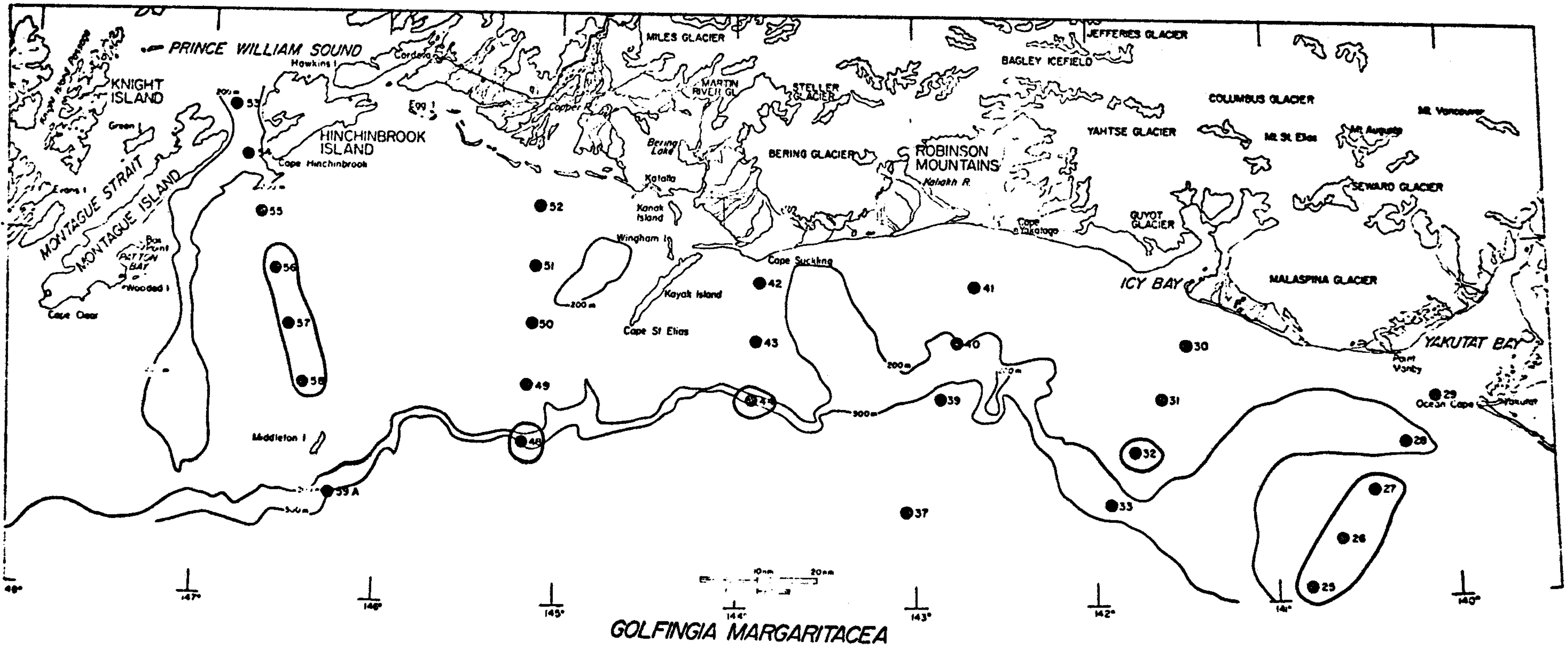


Figure 19. The distribution of the sipunculid *Golfingia margaritacea* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

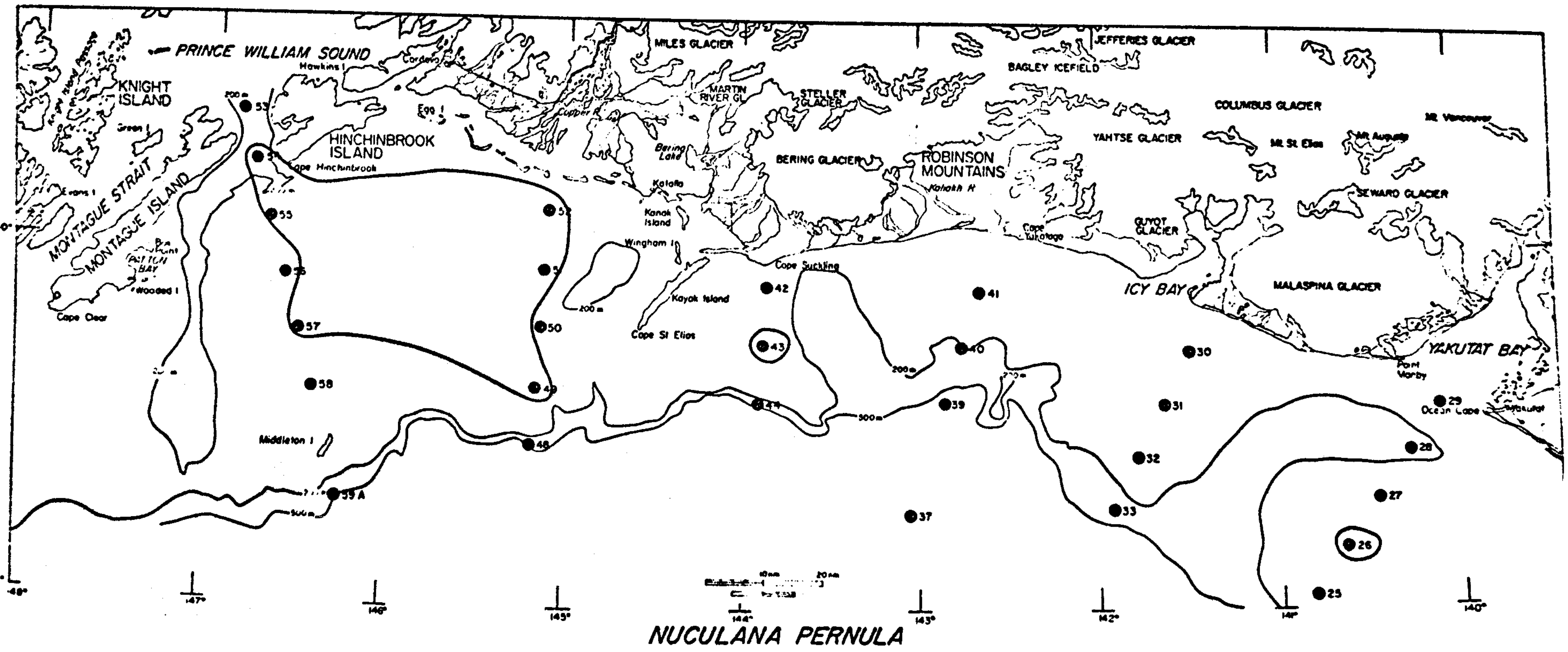


Figure 20. The distribution of the clam *Nuculana pernula* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

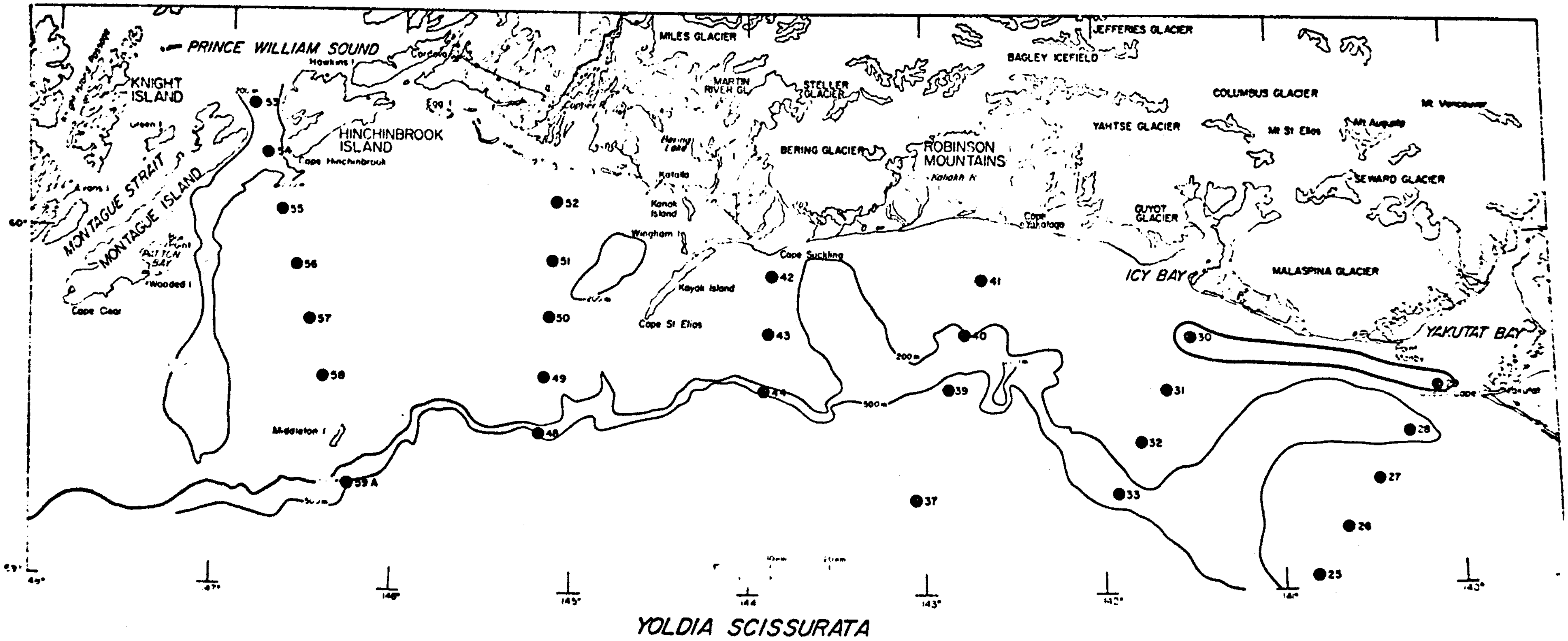


Figure 21. The distribution of the clam *Yoldia scissurata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

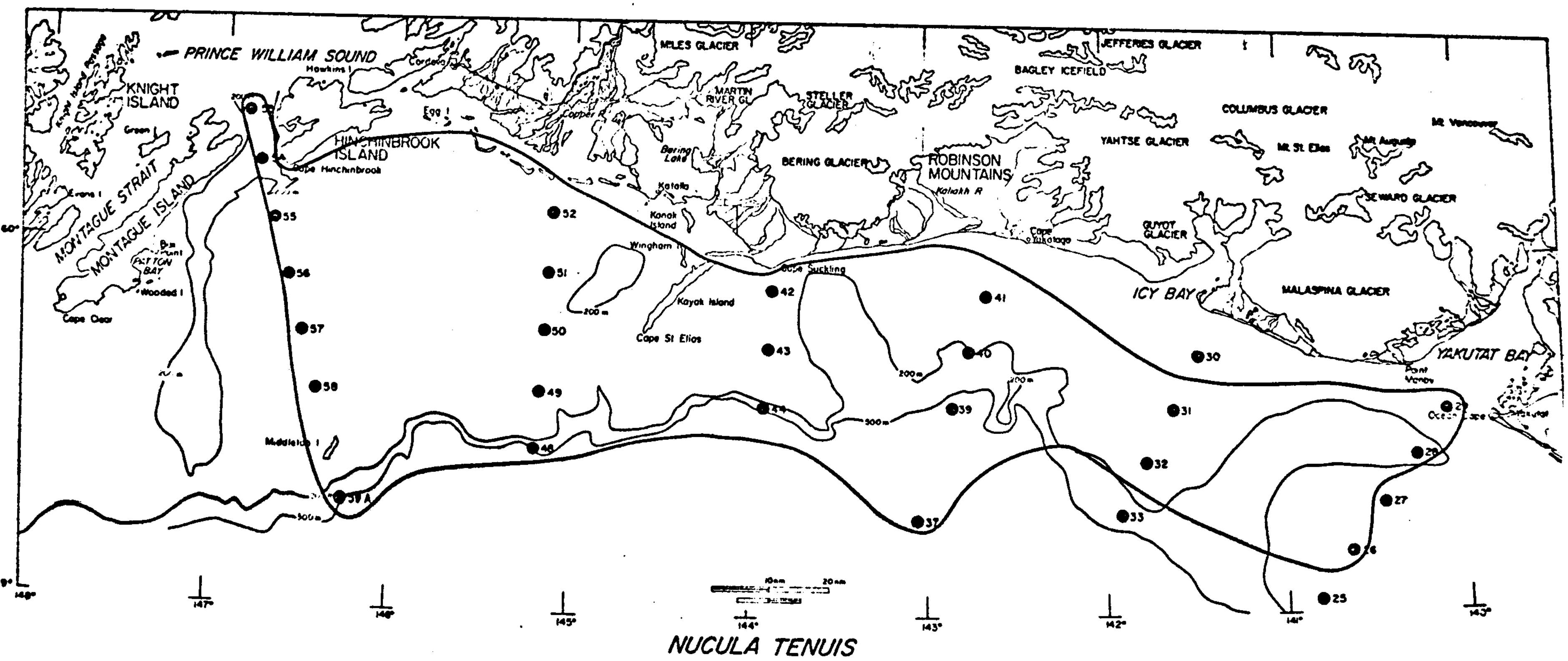


Figure 22. The distribution of the clam *Nucula tenuis* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

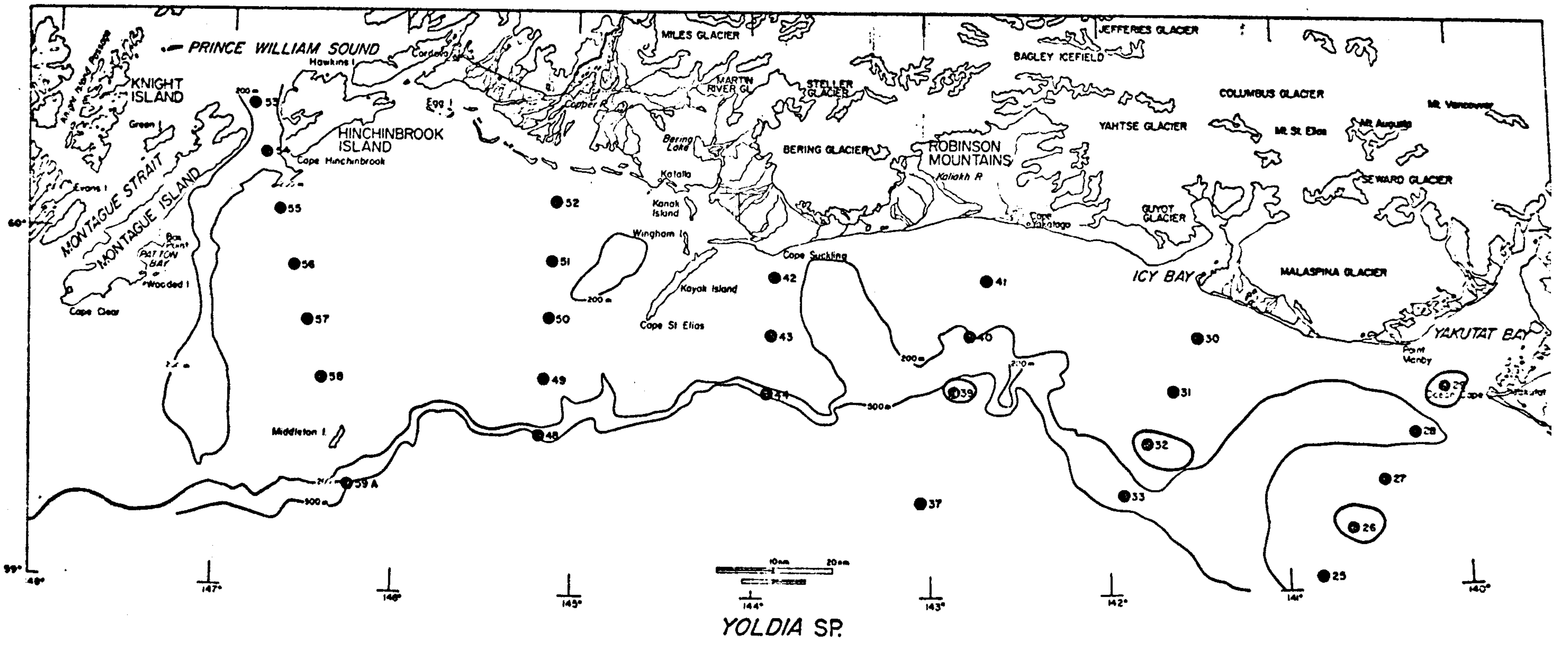


Figure 23. The distribution of the clam *Yoldia* Sp. on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January- May 1975.

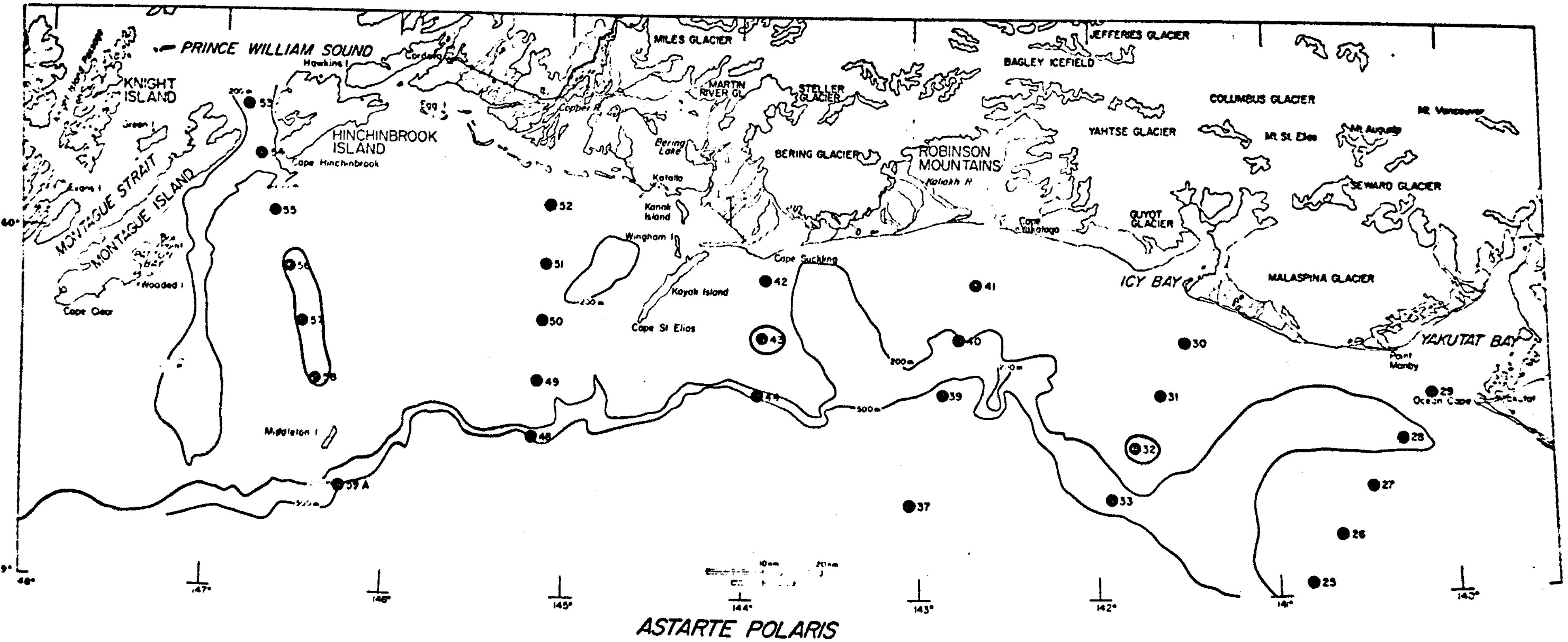


Figure 24. The distribution of the clam *Astarte polaris* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

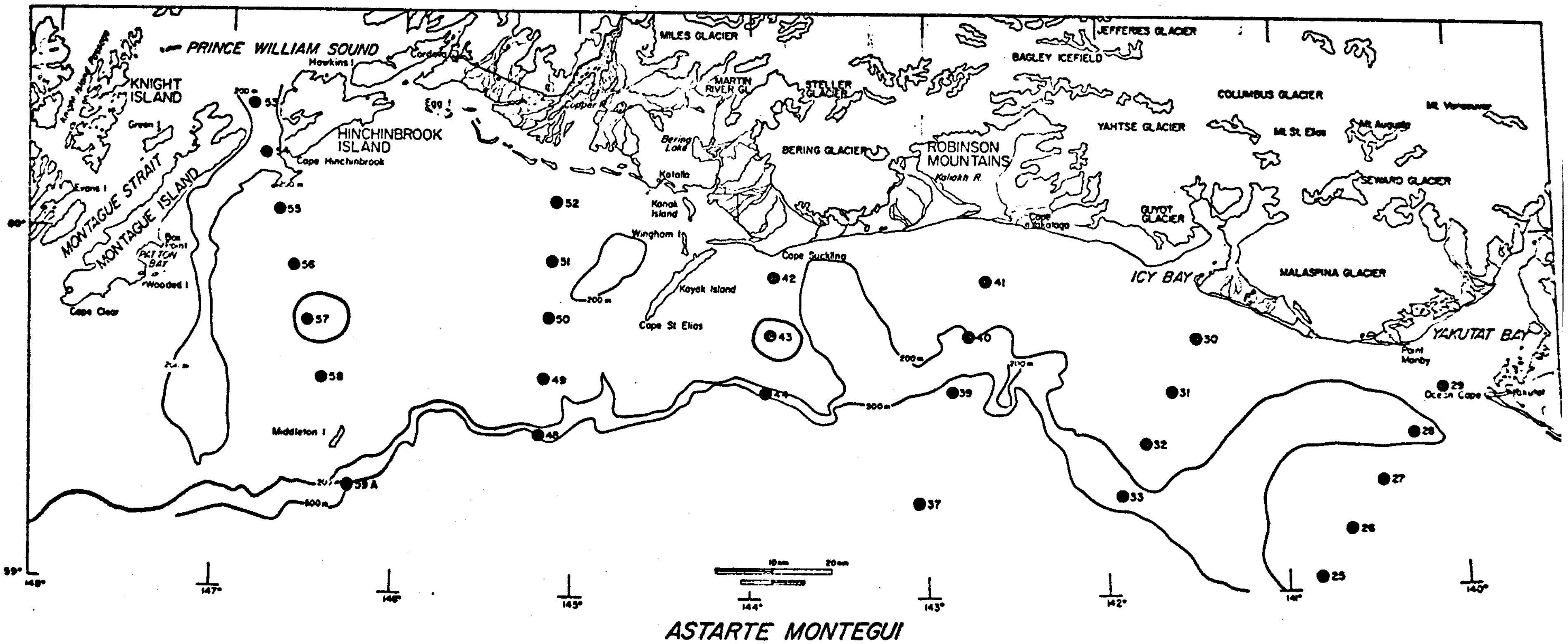
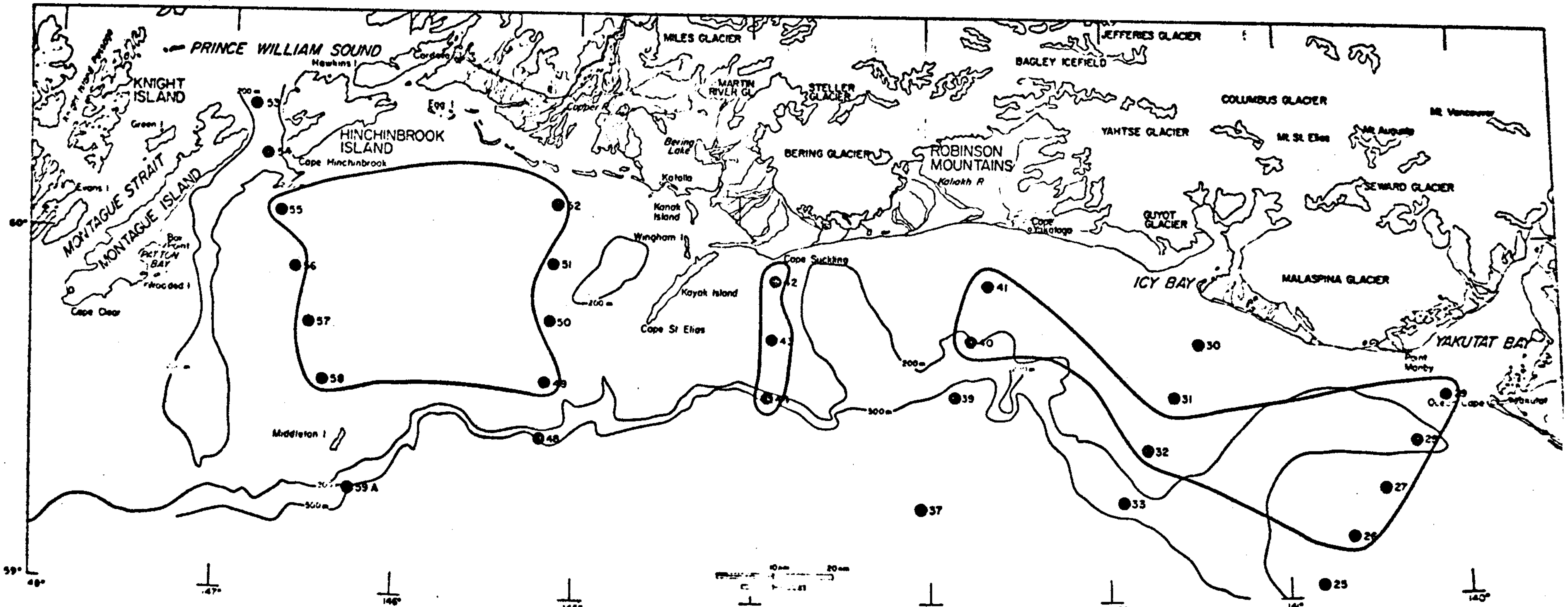
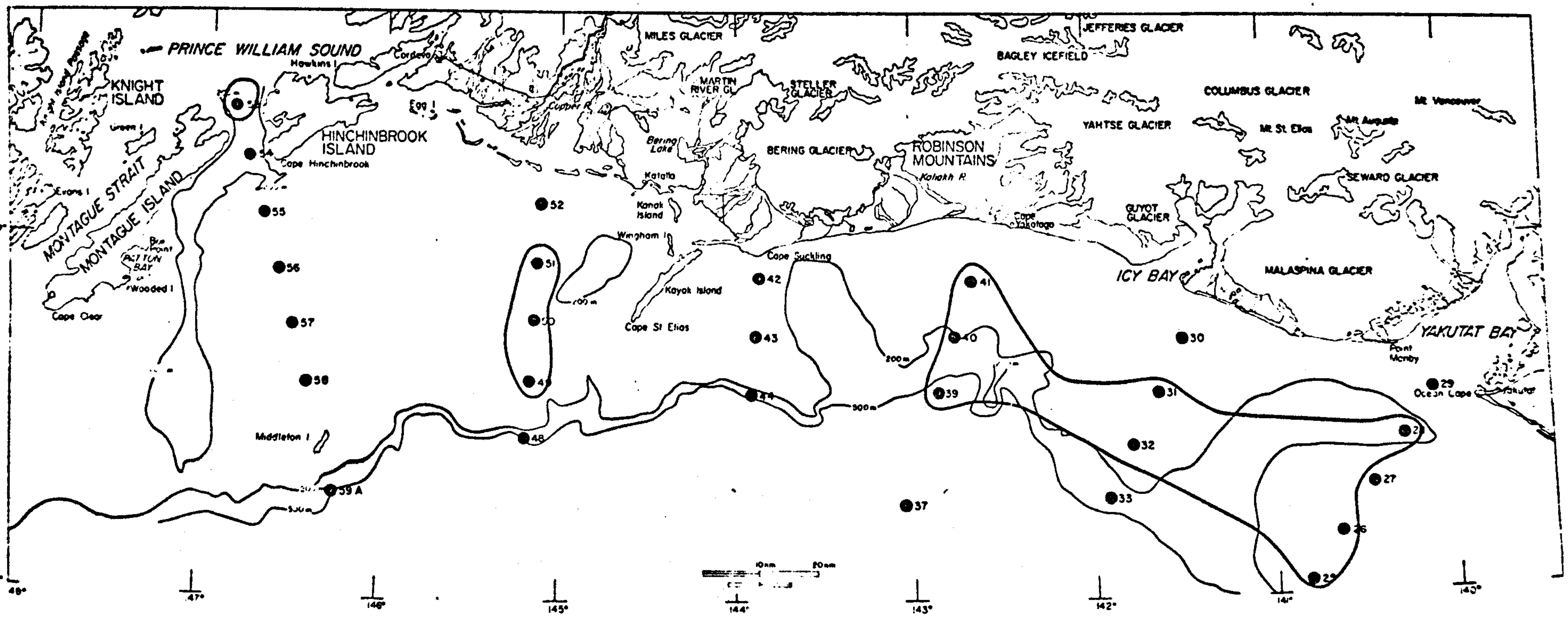


Figure 25. The distribution of the clam *Astarte montegui* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



PSEPHIDIA LORDI

Figure 26. The distribution of the clam *Psephidia lordi* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January- May 1975.



PORTLANDIA ARCTICA

Figure 27. The distribution of the clam *Portlandia arctica* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

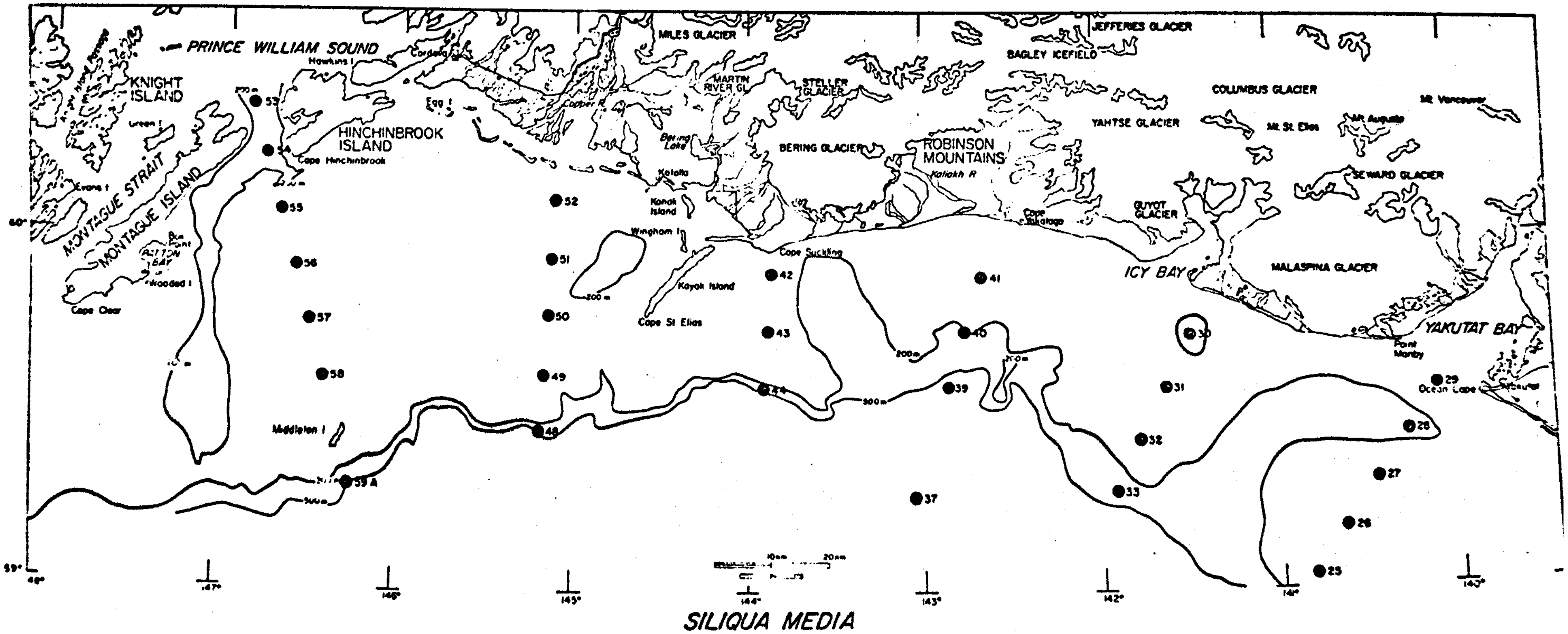


Figure 28. The distribution of the clam *Siliqua media* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January- May 1975.

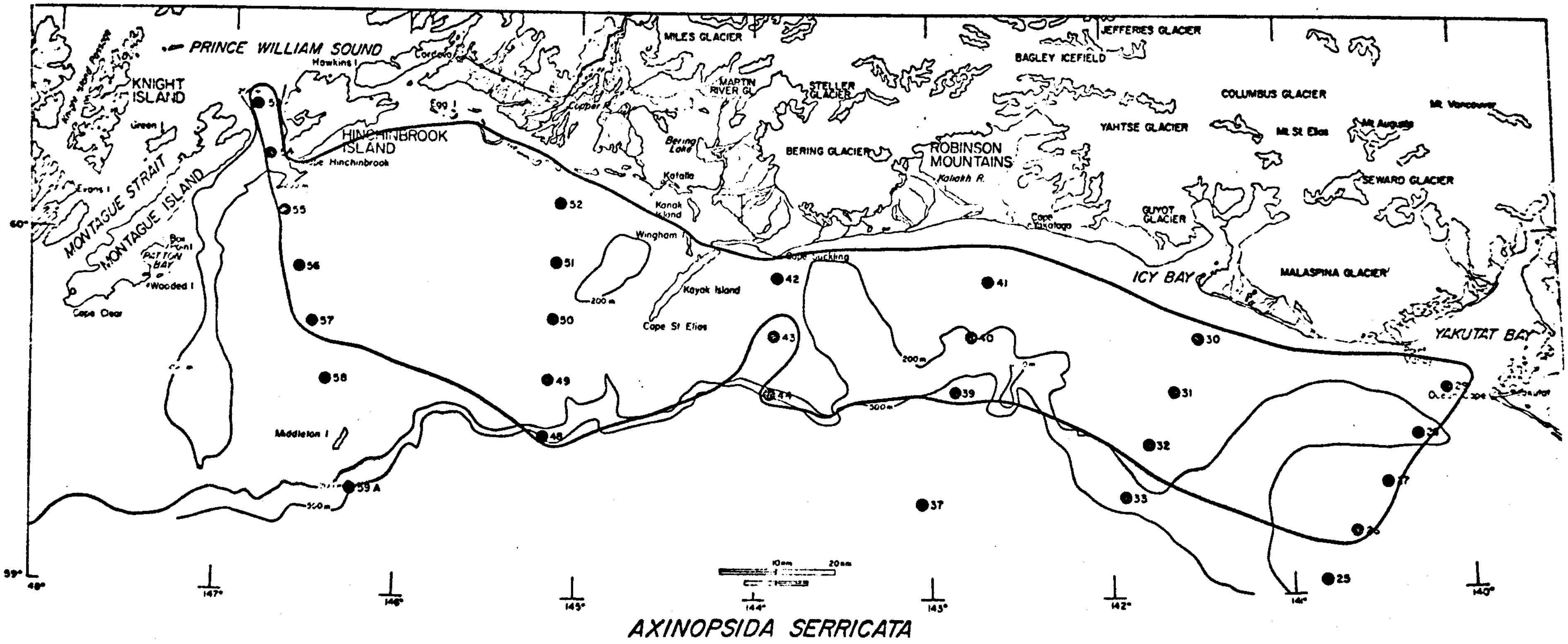


Figure 29. The distribution of the clam *Axinopsida serricata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

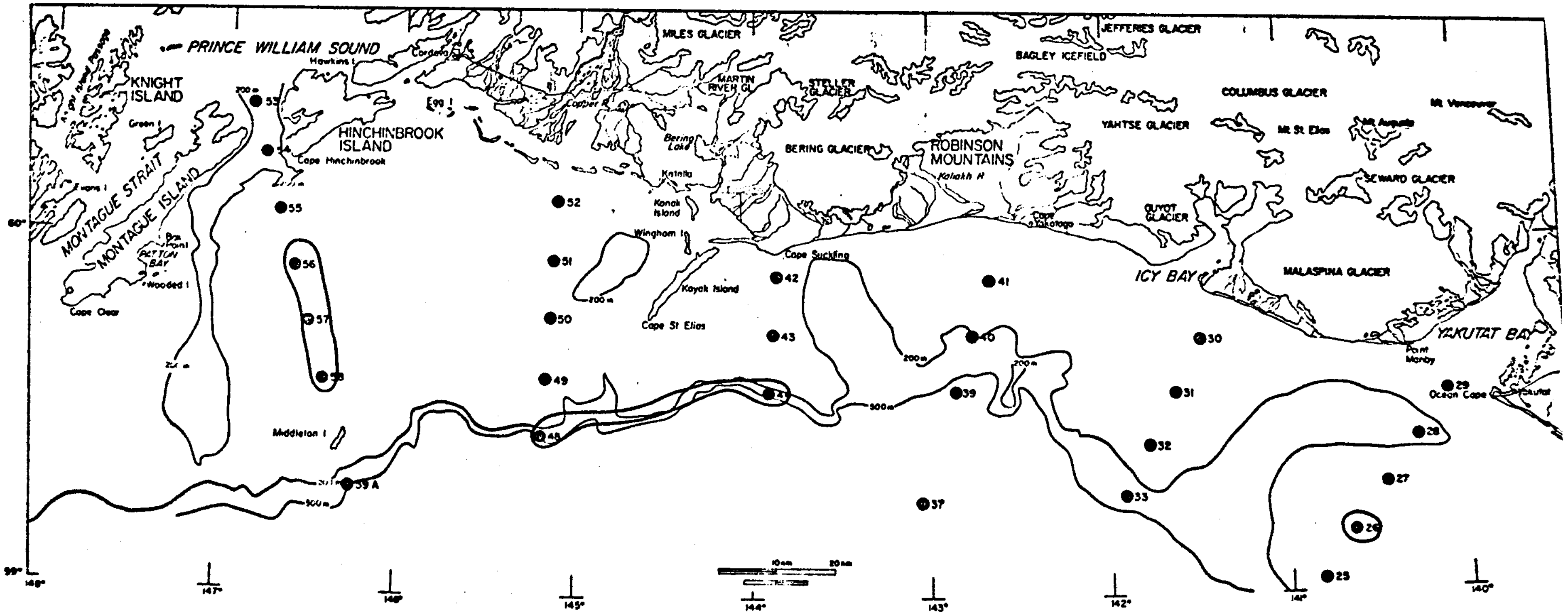
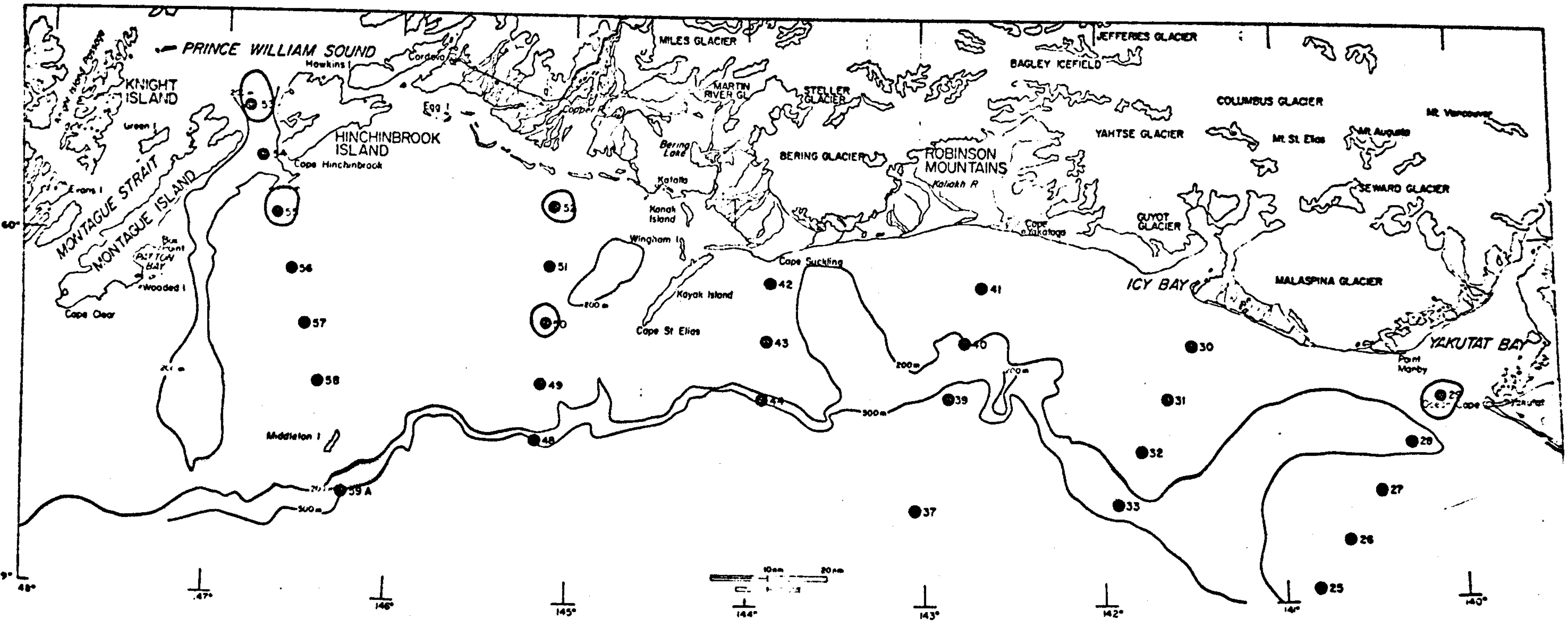


Figure 30. The distribution of the clam *Crenella dessucata* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



MACOMA CALCAREA

Figure 31. The distribution of the clam *Macoma calcarea* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

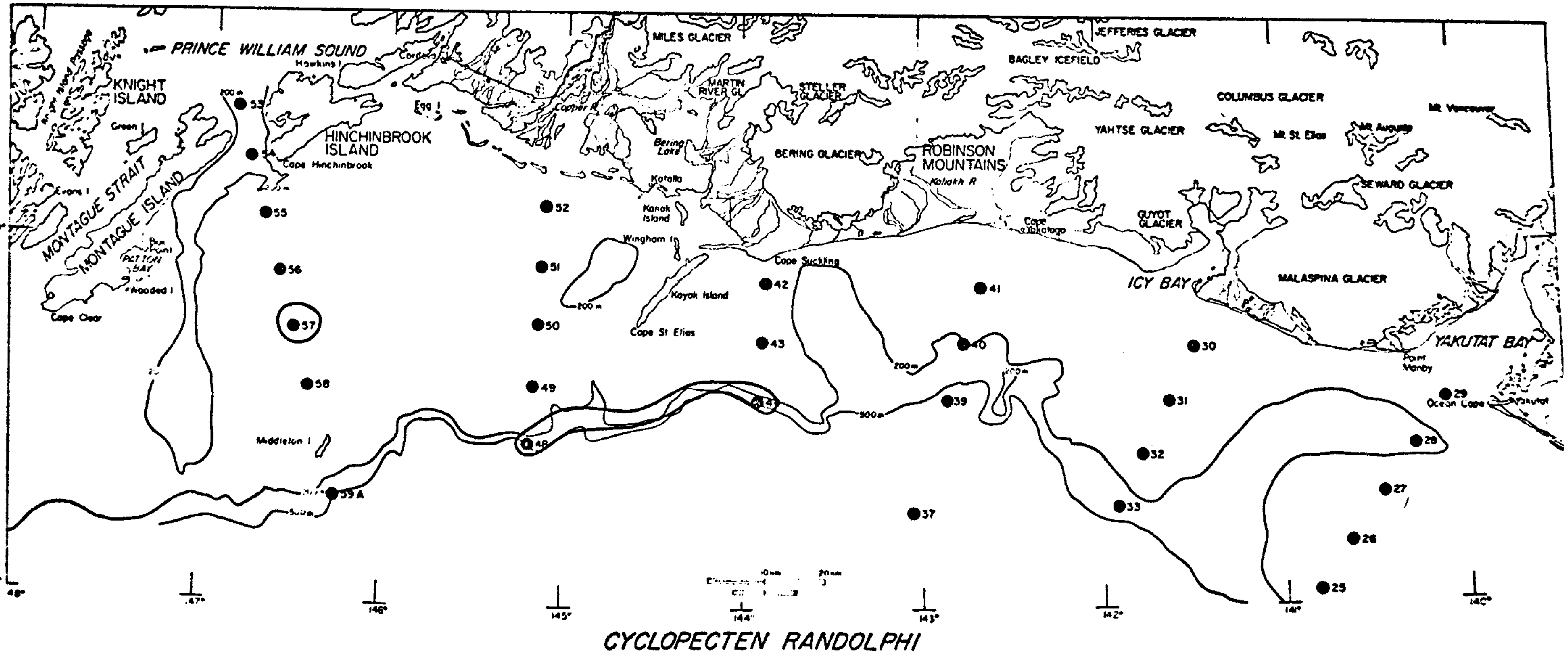


Figure 32. The distribution of the scallop *Cyclopecten randolphi* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

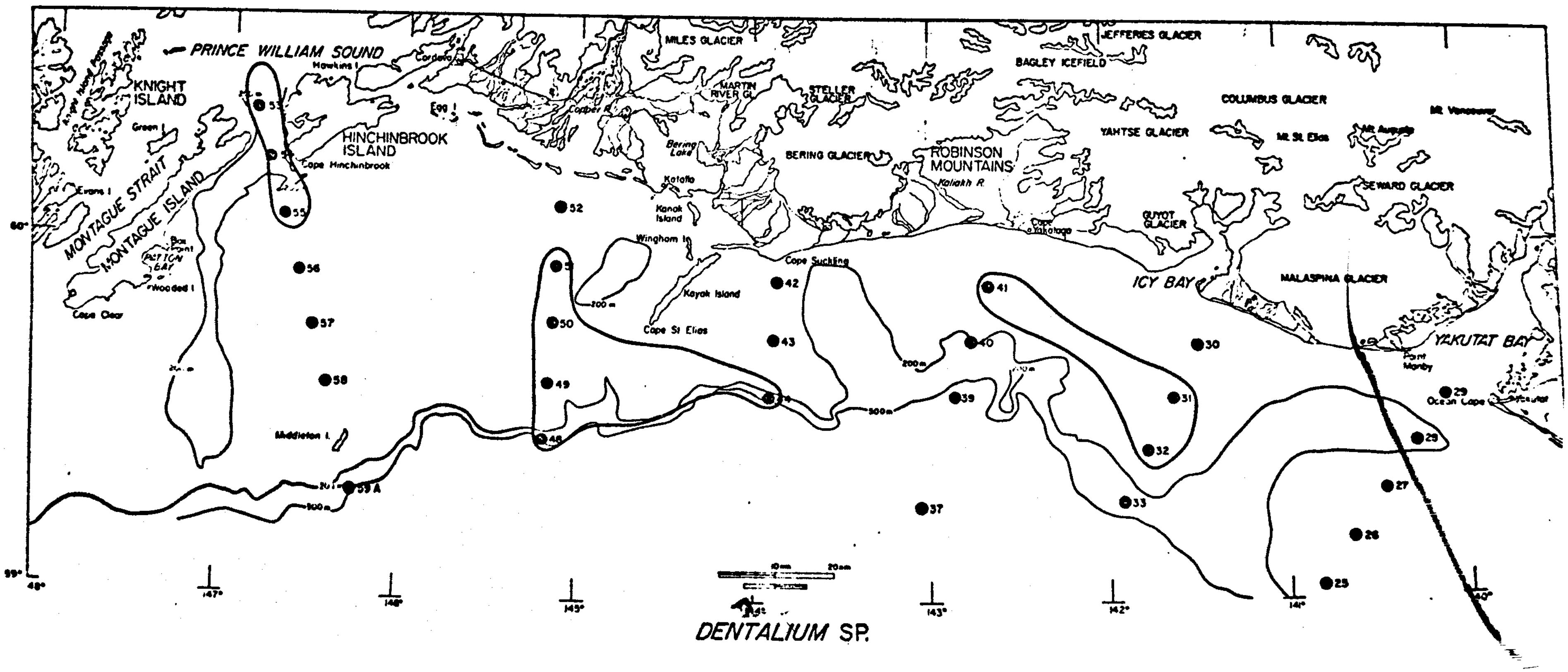


Figure 33. The distribution of the scaphopod *Dentalium* Sp. on the shelf of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

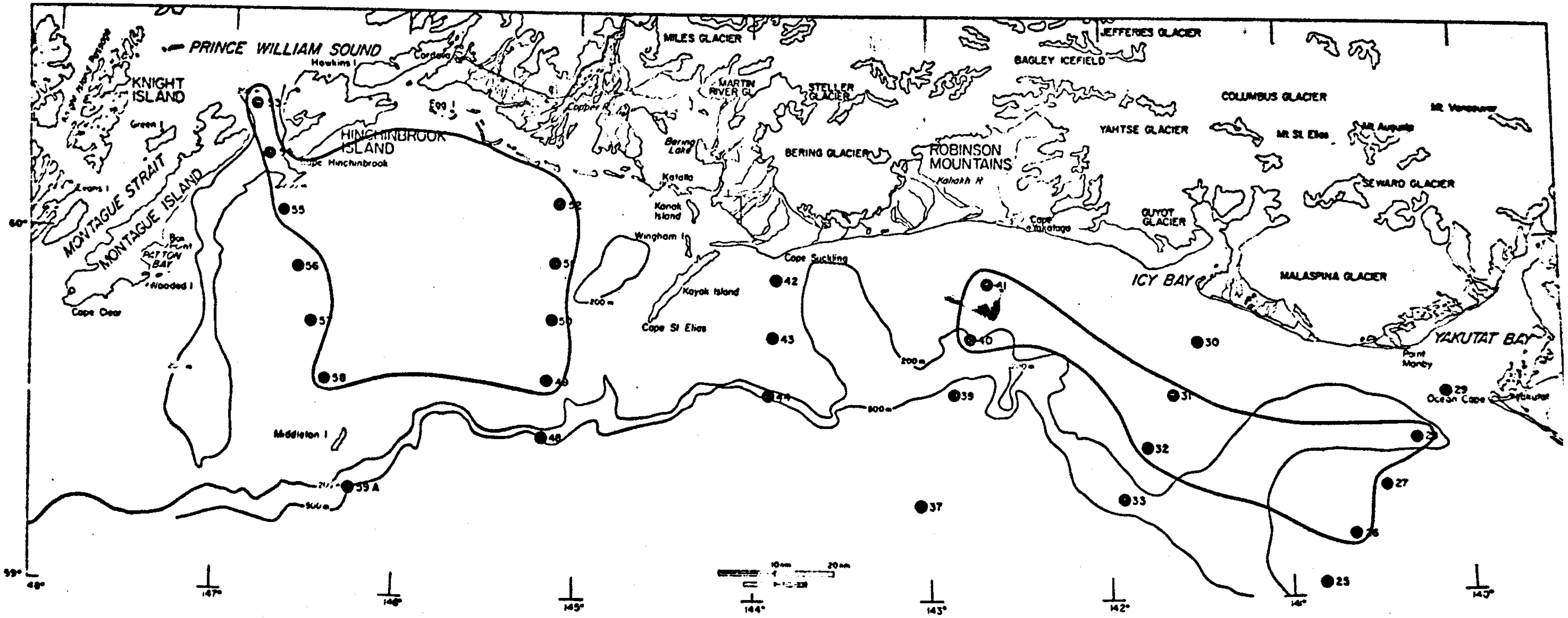
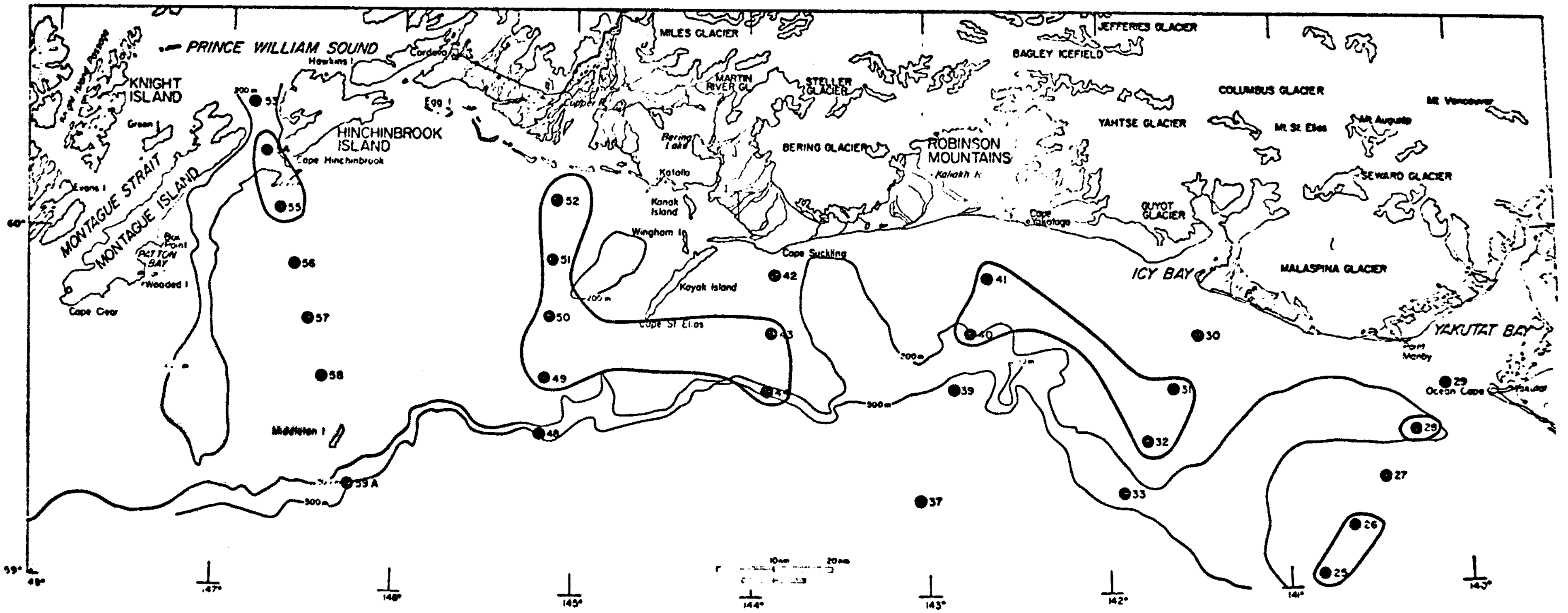


Figure 34. The distribution of the mollusc *Chaetoderma robusta* on the shelf of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



CTENODISCUS CRISPATUS

Figure 35. The distribution of the sea star *Ctenodiscus crispatus* on the shelf of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

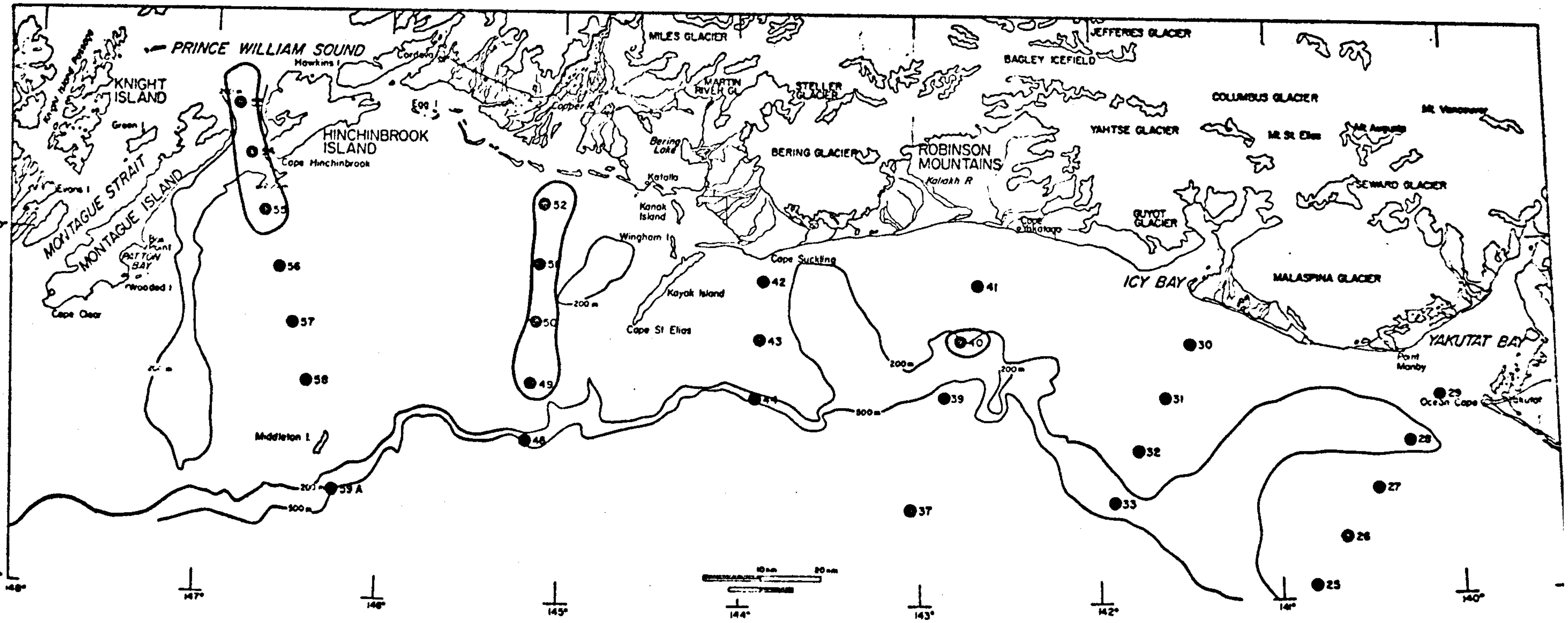


Figure 36. The distribution of the sea cucumber *Molpadia* Sp. on the shelf of the Gulf of Alaska. Distribution based on data from July-December, 1974; January- May 1975.

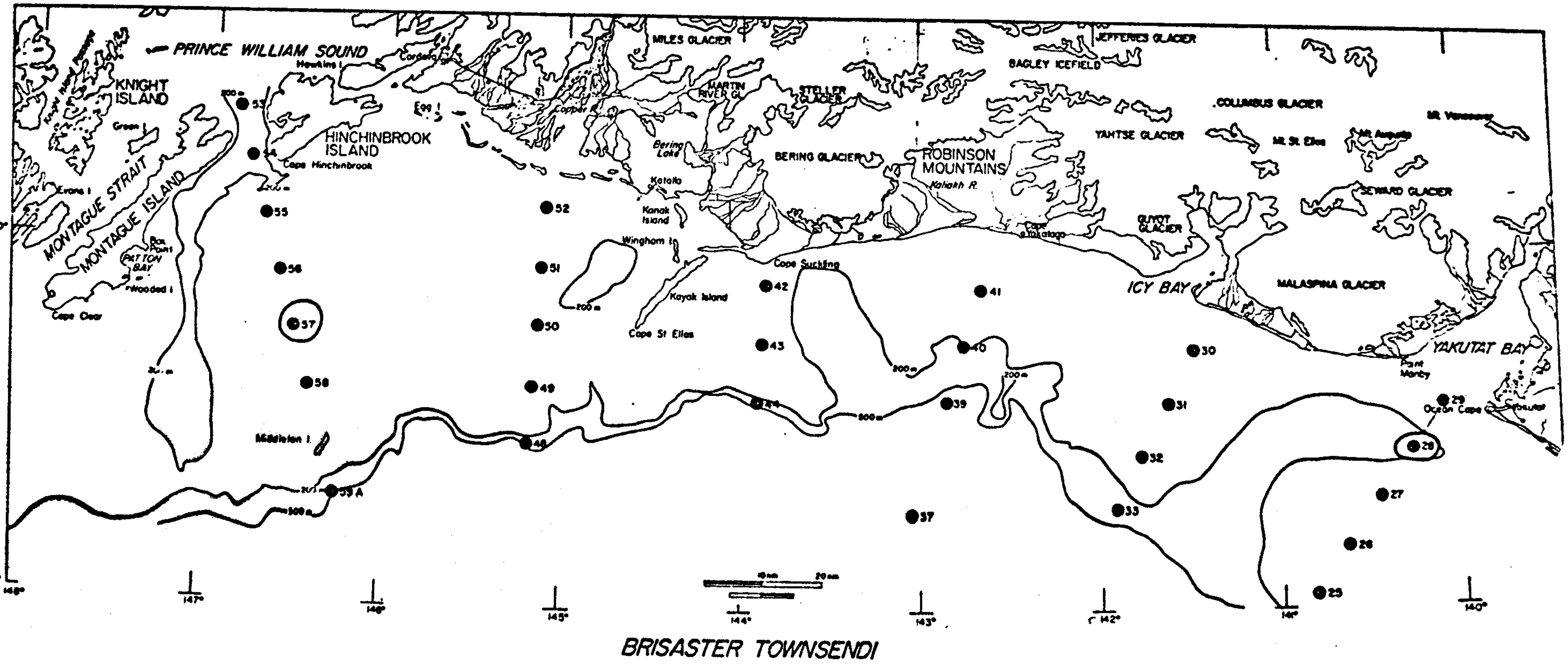
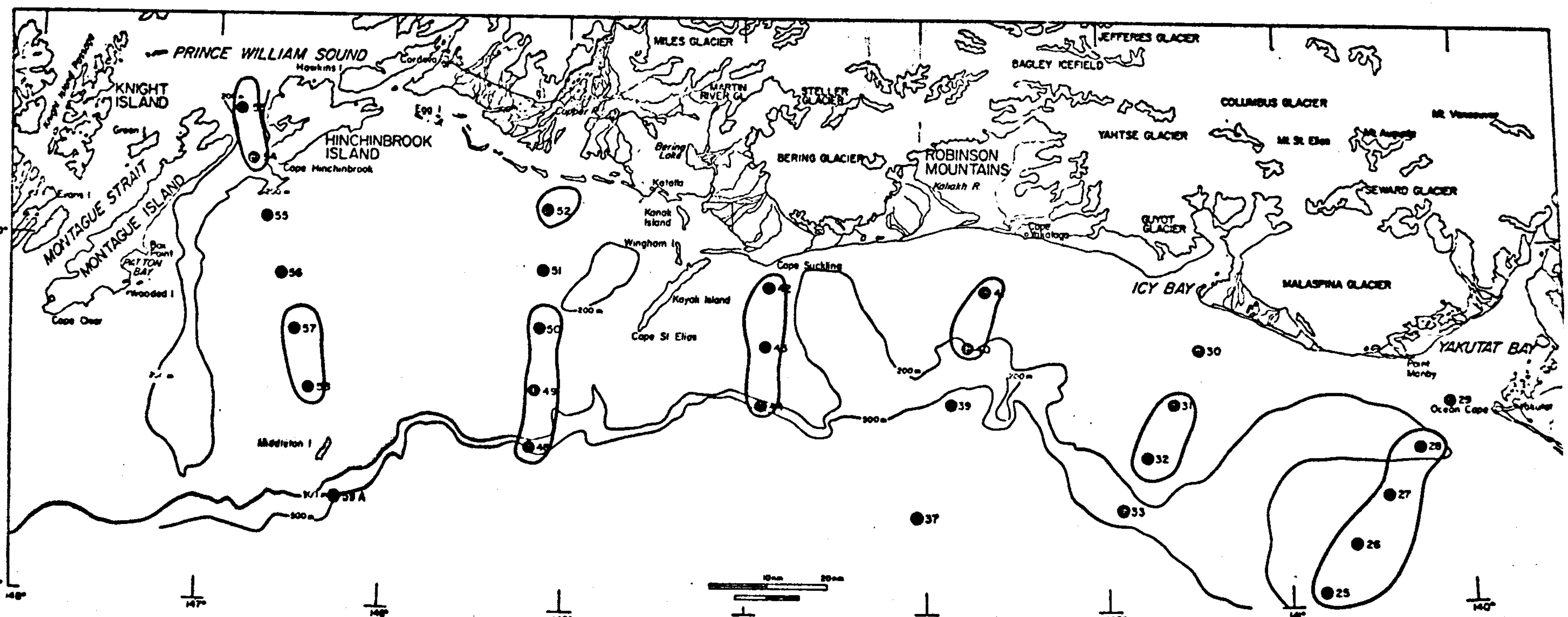


Figure 37. The distribution of the heart urchin *Brisaster townsendi* on the shelf of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



OPHIURA SARSI

Figure 38. The distribution of the brittle star *Ophiura sarsi* on the shelf of the Gulf of Alaska. Distributi based on data from July-December, 1974; January-May 1975.

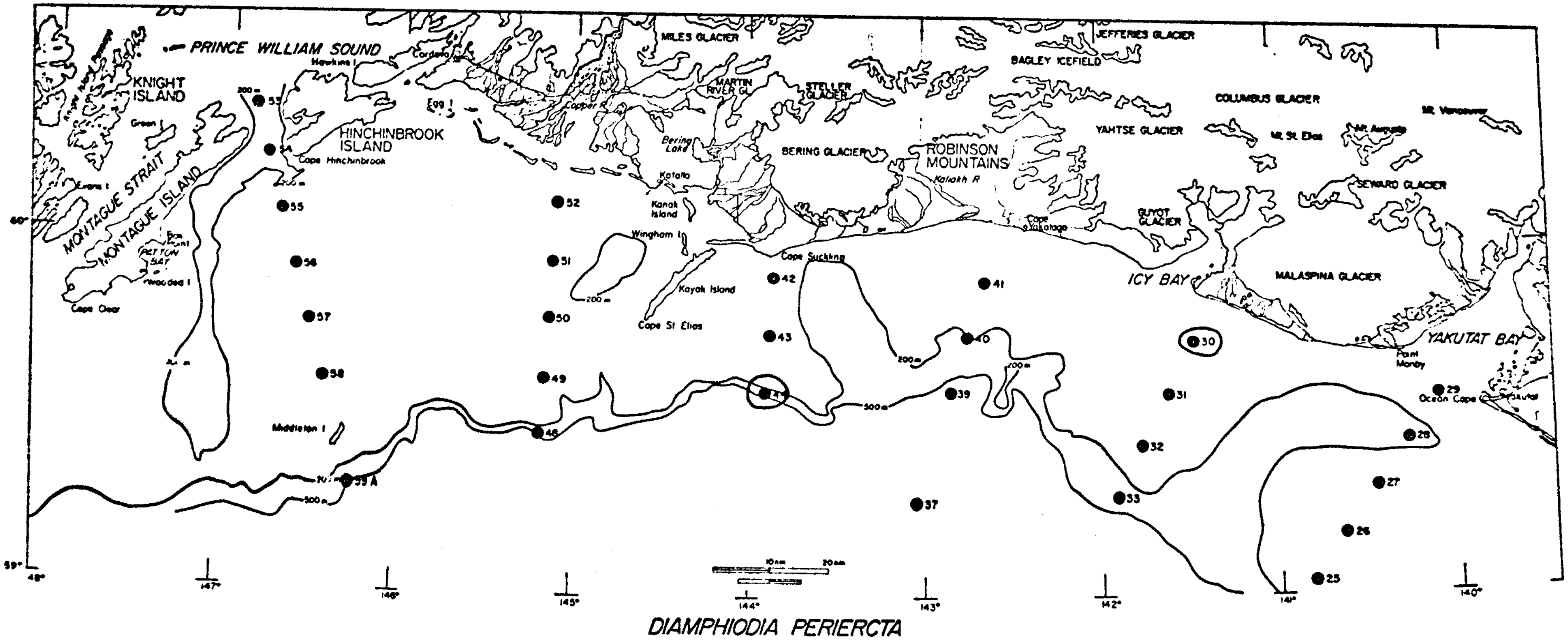
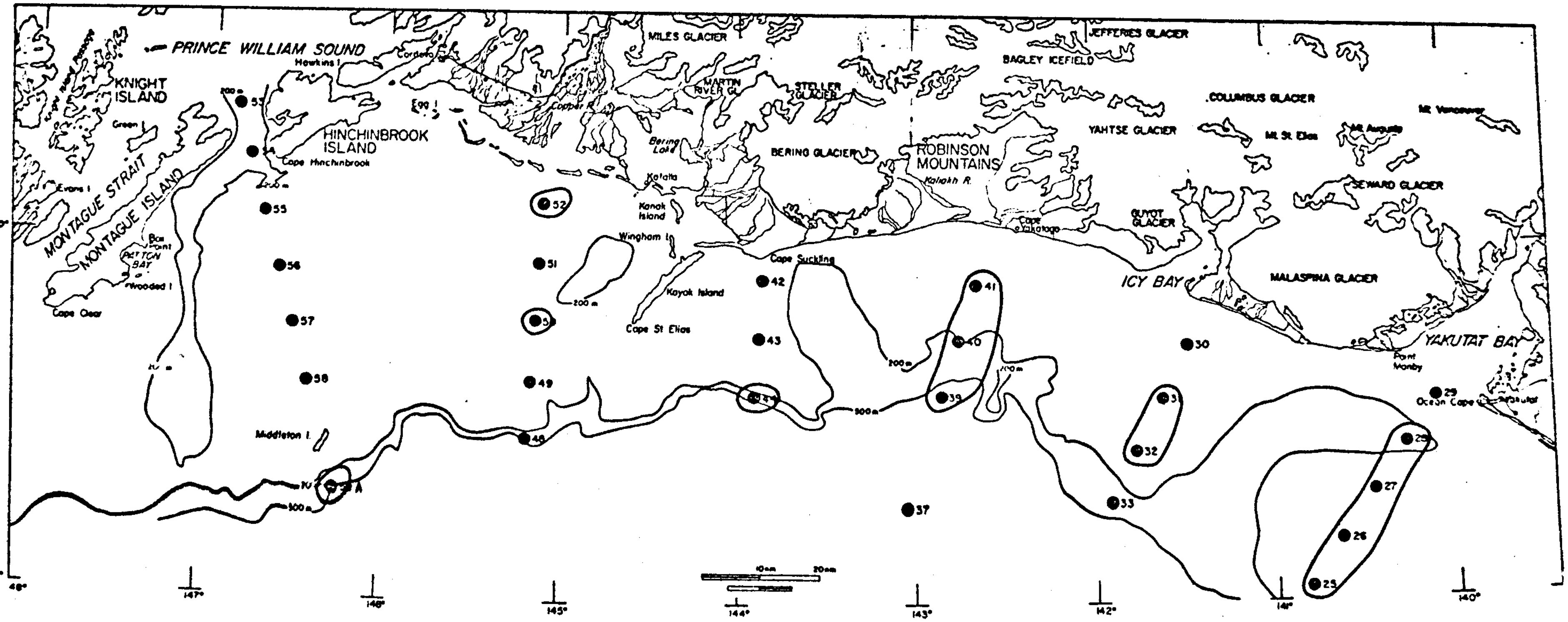
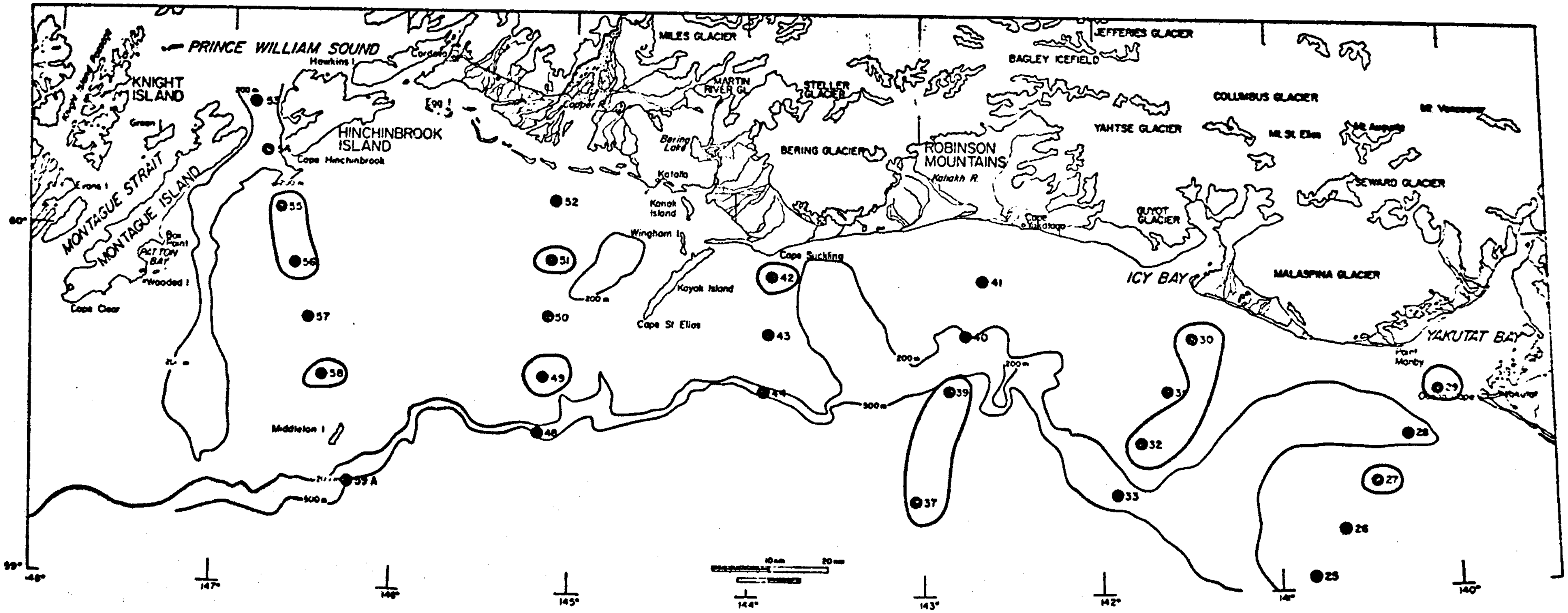


Figure 39. The distribution of the brittle star *Diamphiodia deriercta* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



UNIOPLUS MACRASPIS

Figure 40. The distribution of the brittle star *Unioplus macraspis* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.



OPHIUROIDEA

Figure 41. The distribution of an unidentified brittle stars. *Ophiuroidea* on the shelf of the northeastern section of the Gulf of Alaska. Distribution based on data from July-December, 1974; January-May 1975.

is the most common method used (90 examples: 39%) with suspension feeding next in importance (58 examples: 25%). The predominant feeding methods utilized by species at each station have not been determined as yet. It is presumed that the methods used will tend to vary with local currents and be reflected to a certain extent by the substrate type at each station. Feeding methods for the additional species taken during the current year have not been examined as yet, comments should be available for the Final Report.

Initial cluster analyses were performed on an incomplete data set which included all of the stations occupied on cruises 193, 200, 202 and part of the stations occupied during cruise 805. All cluster analyses of this "incomplete" data set were carried out using untransformed counts of the number of individuals/m^2 for 71 BIT. Normal analysis of that data set including the "qualitative" stations was carried out using the Sørensen presence-absence coefficient and the single linkage (Fig. 42) and average linkage (Fig. 43) sorting strategies. The dendrogram formed by the single linkage strategy was difficult to interpret because of excessive chaining (Fig. 42). Station groups formed by the average linkage sorting strategy are shown in Figure 44. Division of the dendrogram was carried out at the 8th level. Dendrograms of the inverse analysis to form species groups are shown in Figures 45 and 46. Tables 6 and 7 include a list of the BIT used in the classification and a station *vs* species matrix showing species distributions.

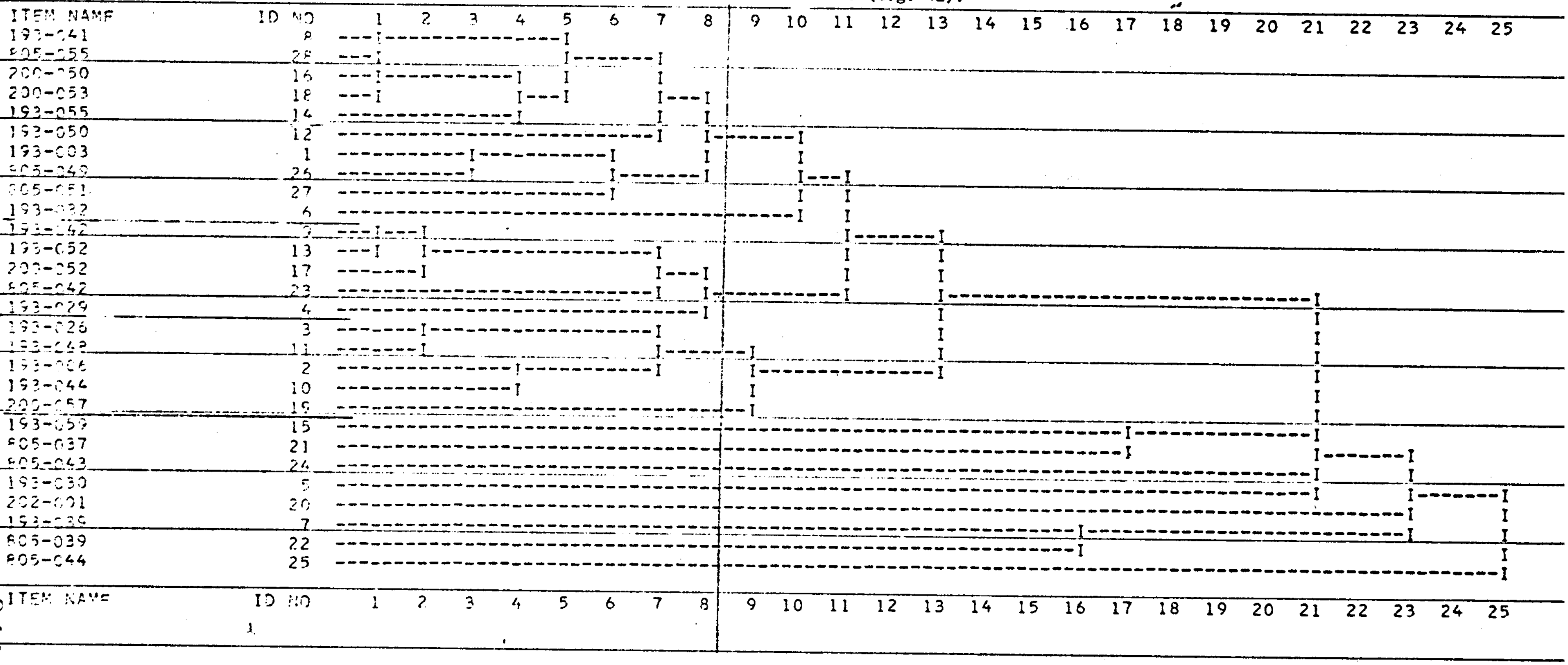
Classification of the "incomplete" data set excluding "qualitative" stations was carried out using the Motyka quantitative similarity coefficient and both the single linkage and average linkage sorting strategies. Results of the normal analysis are presented in Figures 47 through 50. Figures 51

Figure 42. Gulf of Alaska Sørenson presence/absence station-station for BIT species, single linkage sorting strategy. "Item Name" refers to Cruise Number (e.g. 193) and Station Name (e.g. 41).

```
  ITEM NAME            ID NO     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
  0193-041                 8  ---I---I
  0205-055                28  ---I   I
  0205-049                26  -------I---I
  0193-055                14  -------I   I
  0193-003                 1  -----------I
  0200-050                16  ---I-------I---I
  0200-053                18  ---I       I   I
  0193-032                 6  -----------I   I---I
  0193-042                 9  -------I       I   I
  0193-052                13  -------I-------I   I
  0200-052                17  -------I           I---I
  0193-050                12  -------------------I   I
  0193-029                 4  -------------------I   I
  0193-026                 3  -----------I-------I   I
  0193-048                11  -----------I       I---I
  0193-006                 2  -------------------I   I
  0193-044                10  -------------------I   I---I
  0205-051                27  -----------------------I   I-------------------------------I
  0200-057                19  -----------------------I   I                               I
  0205-042                23  ---------------------------I                               I---I
  0205-039                22  -----------------------------------------------------------I   I
  0205-037                21  -----------------------------------------------------------I   I-----------I
  0193-059                15  ---------------------------------------------------------------I           I---I
  0202-001                20  ---------------------------------------------------------------I           I   I-----------I
  0205-043                24  ---------------------------------------------------------------------------I   I           I-------I
  0193-039                 7  -------------------------------------------------------------------------------I           I       I
  0193-030                 5  -------------------------------------------------------------------------------------------I       I
  0205-044                25  ---------------------------------------------------------------------------------------------------I

  ITEM NAME            ID NO     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
<*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*>
ERROR #35; TRACE OF CALLS IN REVERSE ORDER
      CALLING        ID      ABSOLUTE        ARGUMENT             ARGUMENT             ARGUMENT             ARGUMENT             ARGUMENT
      ROUTINE         #      LOCATION           #1                   #2                   #3                   #4                   #5
      .FEET.         97      025552         000000000043
      TREF          211      033646         000000000006
      CNTRL         155      036306         000000000010         000000000034         000600000000         000000000000         000000000000
      ......          9      061770         000000000010         000000023420
REQUEST TO WR EOF ON 06
WAS IGNORED
<*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*><*>
```

Figure 43. Gulf of Alaska Sørenson presence/absence station-station for BIT species, average linkage sorting (see Fig. 44). "Item Name" refers to Cruise Number (e.g. 193) and Station Name (e.g. 41).



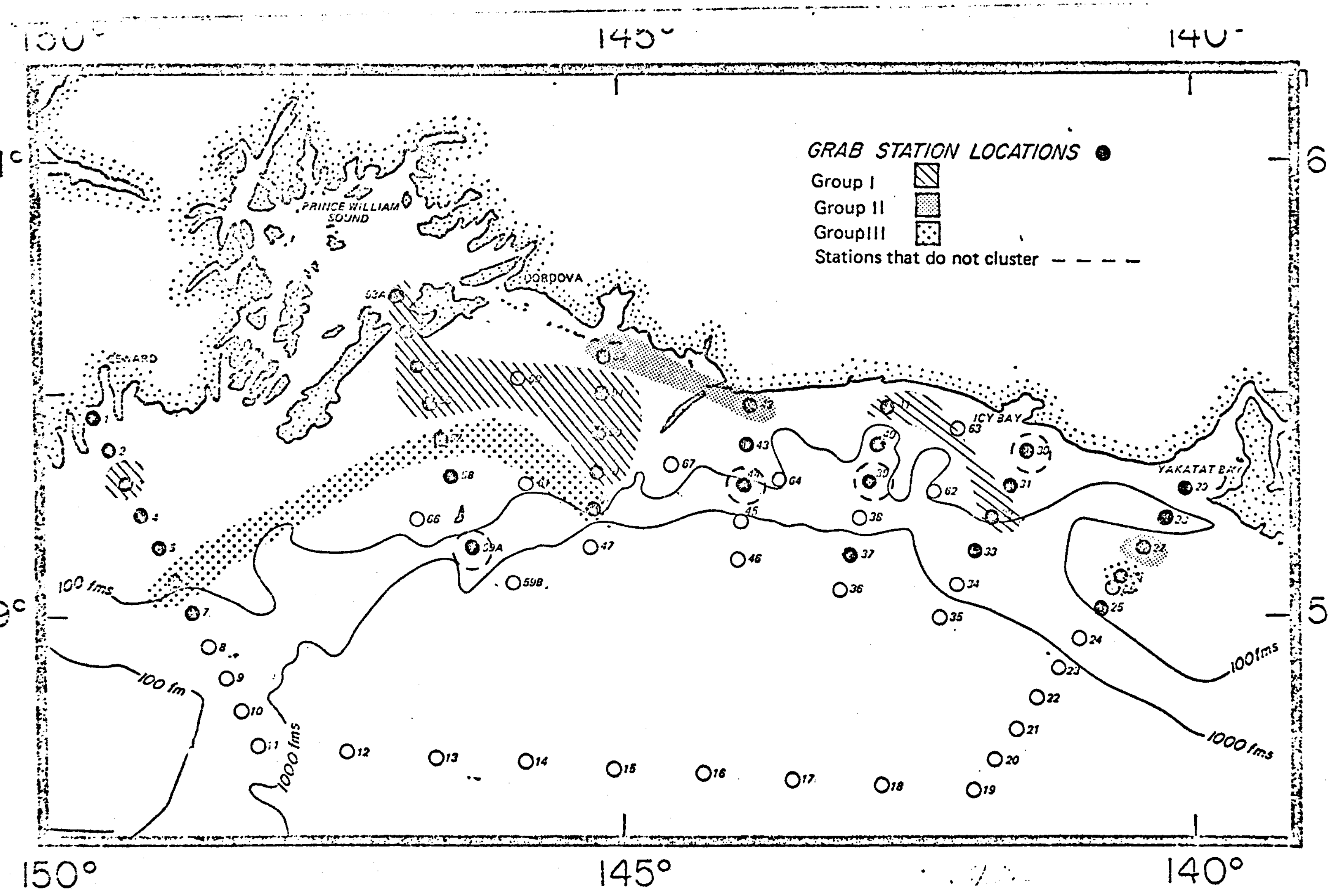


Figure 44. Qualitative and quantitative stations clustered using Sørensen (presence-absence) coefficient with average linkage sorting. Dashed circle represent stations that do not cluster.

Figure 45. Gulf of Alaska Sørenson presence/absence taxon-taxon for BIT species, single linkage sorting. "I.D. Numbers" match sorted Taxon codes and names in Table 6.

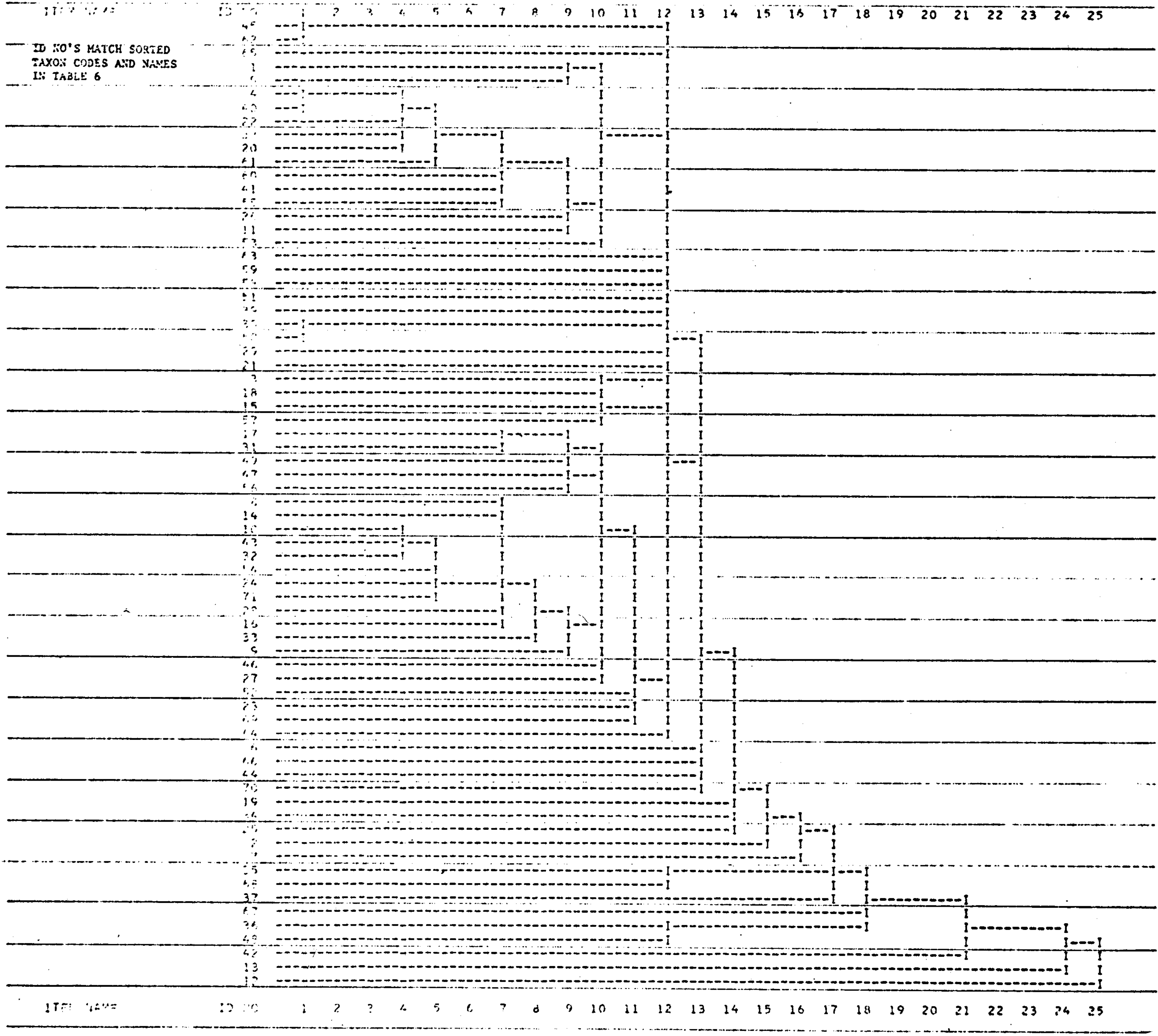


Figure 46. Gulf of Alaska Sørenson presence/absence taxon-taxon for BIT species, average linkage sorting. "I.D. Numbers" match sorted Taxon codes and names in Table 6.

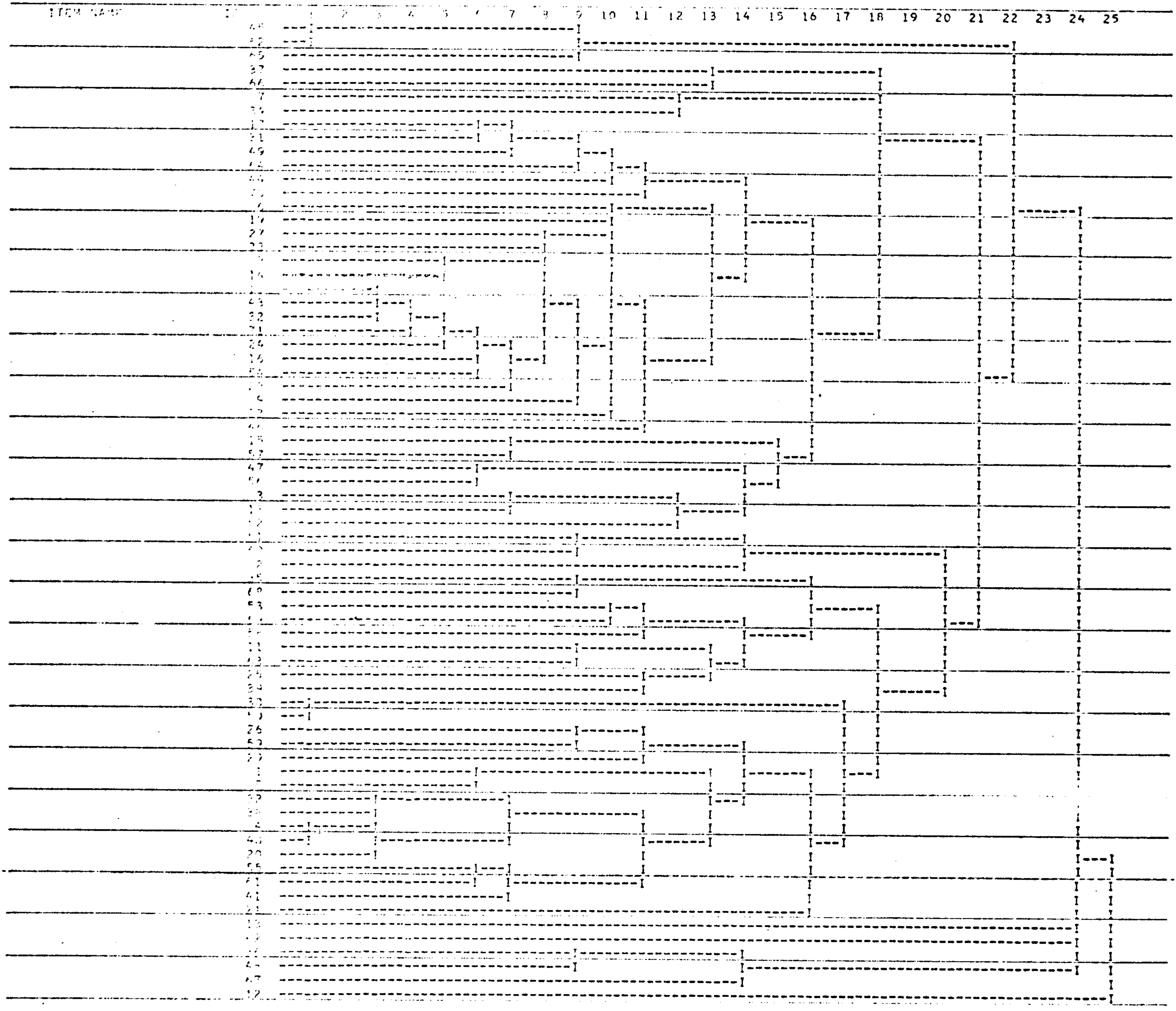


Table 6. Gulf of Alaska Taxon codes in sorted order for species obtained by van Veen grab and used in Sørenson coefficient calculations.

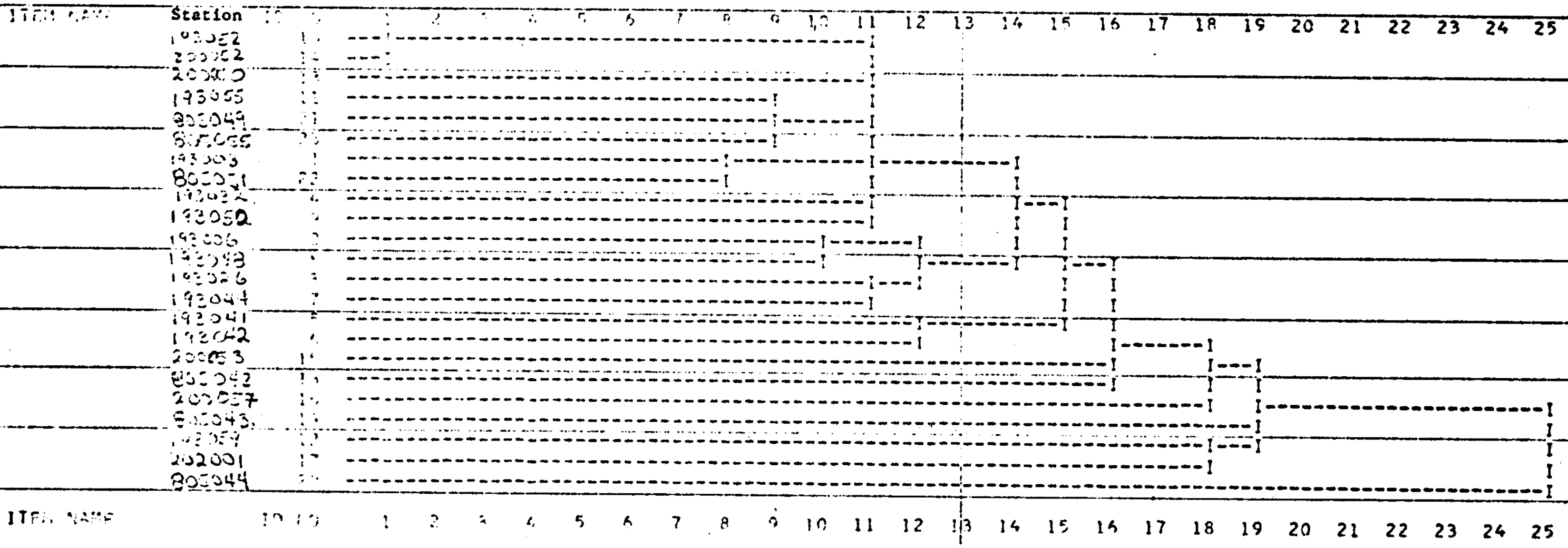
1	[illegible]	[illegible]
2	[illegible]	CNIDARIA ANTHOZOA
3	[illegible]	CNIDARIA ANTHOZOA SEA PEN
4	4801020101	POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA
5	[illegible]	POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA
6	[illegible]	POLYCHAETA NEREIDAE
7	[illegible]	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA
8	[illegible]	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA
9	[illegible]	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS
10	[illegible]	POLYCHAETA LUMBRINERIDAE LUMBRINERIS SIMILAPRIS
11	4801400102	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII
12	4801400104	POLYCHAETA PARAONIDAE ARICIDEA LONGICORNUTA
13	[illegible]	POLYCHAETA SPIONIDAE SPIO FILICORNIS
14	[illegible]	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA
15	[illegible]	POLYCHAETA MAGELONIDAE MAGELONA JAPONICA
16	[illegible]	POLYCHAETA CIRRATULIDAE THARYX SP.
17	[illegible]	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA
18	[illegible]	POLYCHAETA CAPITELLIDAE HETEROMASTUS FILIFORMIS
19	[illegible]	POLYCHAETA MALDANIDAE
20	[illegible]	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS
21	[illegible]	POLYCHAETA MALDANIDAE MALDANE GLEBIFEX
22	[illegible]	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS
23	[illegible]	POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS
24	[illegible]	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI
25	[illegible]	POLYCHAETA OWENIIDAE AMMOCHARES FUSIFORMIS
26	4801450207	POLYCHAETA AMPHARETIDAE AMPHARETE GOESI
27	[illegible]	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA
28	[illegible]	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI
29	[illegible]	POLYCHAETA SABELLIDAE
30	[illegible]	POLYCHAETA SABELLIDAE MEGALOMMA SPLENDIDA
31	[illegible]	MOLLUSCA APLACOPHORA CHAETODERMA ROBUSTA
32	[illegible]	MOLLUSCA PELECYPODA NUCULA TENUIS
33	[illegible]	MOLLUSCA PELECYPODA NUCULANA PERNULA
34	[illegible]	MOLLUSCA PELECYPODA NUCULANA MINUTA
35	4904030500	MOLLUSCA PELECYPODA YOLDIA SP.
36	4904030504	MOLLUSCA PELECYPODA YOLDIA SCISSURATA
37	[illegible]	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA
38	[illegible]	MOLLUSCA PELECYPODA CRENELLA DESSUCATA
39	[illegible]	MOLLUSCA PELECYPODA DACRYDIUM SP.
40	[illegible]	MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI
41	4904110103	MOLLUSCA PELECYPODA ASTARTE MONTEGUI
42	[illegible]	MOLLUSCA PELECYPODA ASTARTE POLARIS
43	[illegible]	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA
44	4904150301	MOLLUSCA PELECYPODA THYASIRA FLEXUOSA
45	[illegible]	MOLLUSCA PELECYPODA CLINOCARDIUM CALIFORNIENSIS
46	[illegible]	MOLLUSCA PELECYPODA PSEPHIDIA LORDI
47	[illegible]	MOLLUSCA PELECYPODA MACOMA CALCAREA
48	[illegible]	MOLLUSCA PELECYPODA SILIQUA MEDIA
49	[illegible]	MOLLUSCA SCAPHOPODA DENTALIUM SP
50	[illegible]	CRUSTACEA HARPACTICOIDA
51	[illegible]	CRUSTACEA THORACICA LEPADIDAE SCALPELLUM COLUMBIANA
52	[illegible]	CRUSTACEA CUMACEA LEUCONIDAE EUDORELLA EMARGINATA
53	[illegible]	CRUSTACEA ISOPODA GNATHIA SP.
54	[illegible]	CRUSTACEA AMPHIPODA
55	[illegible]	CRUSTACEA AMPHIPODA HAPLOOPS TUBICULA
56	[illegible]	CRUSTACEA AMPHIPODA AMPELISCA MACROCEPHALA
57	[illegible]	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS
58	[illegible]	CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS
59	[illegible]	SIPUNCULIDA
60	[illegible]	SIPUNCULIDA GOLFINGIA MARGARITACEA
61	[illegible]	[illegible] CLAVOPORA OCCIDENTALIS
62	[illegible]	BRACHIOPODA
63	[illegible]	BRACHIOPODA ARTICULATA TEREBRATULINA UNGUICULA
64	[illegible]	[illegible] CTENODISCUS CRISPATUS
65	[illegible]	ECHINODERMATA ECHINOIDEA BRIASTER TOWNSENDI
66	[illegible]	ECHINODERMATA OPHIUROIDEA
67	[illegible]	ECHINODERMATA OPHIURIDAE DIAMPHIODIA PERIERCTA
68	[illegible]	ECHINODERMATA AMPHIURIDAE UNIOPLUS MACRASPIS
69	[illegible]	ECHINODERMATA OPHIUROIDEA OPHIURIDAE OPHIURA SARSI
70	[illegible]	ECHINODERMATA HOLOTHUROIDEA MOLPADIA SP.
71	9999999999	UNIDENTIFIABLE

Table 7. Gulf of Alaska matrix showing the occurrence of 71 BIT at 28 van Veen grab stations. "X" indicates species present. Species I.D. Numbers match sorted taxon codes and names in Table 6.

Species ID No.

```
        ....5.. 10....5.. 20....5.. 30....5.. 40....5.. 50....5.. 60....5.. 70....5.. 80....5.. 90....5..100....5..110....5..120
Station
193003         XXX     XX                X    X X   XX X  X   X X    X    X      X    X
193015     XX   XXX    X  XXXXXXXXXXXXXXX    XXXX X     XX  XXX  XX X    X  X X
193026  X   XX XXXX    X     X XX  X   XX X  XX   X  X      XX   X    XX   XX X
193029  XX  X  XXX   XXX          XXX   X XXX       X  XX      X X         X    X
193030          XX             X           X       X    X     X            X
193032          XX     XX       XXX  X  XX  X X X  XX  X  X    XX         X   XX
193039       X              X             X       X          X   X         X
193041       X XXX   X  X   X XX   X  XX          XX X  X     X          X   XX X
193042        XXXX   XXX X     X  XX  XXXX        XX X     XXX  X              X X
193044  XX XX  XXX     X  XX XXX X  X  X     X X  XX    X X XX   XXXX  X  XXX
193048  X  X XXXXXX  X X   X XXX  XX   XX    XXX  X   X X   XX XXX    X     X X
193050    X   XX X   X  X     XX      XX X        XX    X   X          X     X
193052  X X XX XXX   XXXXXX X XX  X   XXX         XX       X X  X           XX X
193055         XXXXX  X XXX    X   XX    XXX      XX  X X  X X         X     XX
193059           X      X      X       X  X   X                  X         X
200050    X    XXXXX  X XXXX   XX   X   XX    X     X   X    X X X         X      X
200052    X XX X X   XXX XX    XX  XX    XXX      X  XX       X XX          X   X
200053       X X X   X XXXX    X      XX          X   X X  X X X             XXX
200057  X XXXX X X   X X XXXXX  X XXX   XX    XXXXX X XX     X XXXX  XXX  XX    X
202001        X X       X X       X   X                   X                XX
805037           X             X XX X   X                                  X    X
805039       X     X      X             X    X     X          X            X
805042           X  X XX      XX  XX    XX        X  X          XX         X  X X
805043        X           X X  X        XX      XX   X          X     X    X
805044     X   X                          X     X       X              X
805049         XXX  X   X      X XXX  XXX   X     X  X  X  X X    X     X X   XX
805051   X   X  XX      X X           XXX   X     XX    X              X X   XX
805055         XXX   X  X     XX   X  X X         XX XX X  X           X     XX
```

Figure 47. Gulf of Alaska Motyka Number of individuals station-station for BIT taxa, single linkage. See Fig. 48.



193052 200052 200050 193055 805049 805055 193003 805051 193032 193050 193006 193048 193026 193044 193041 193042
200053 805042 200057 805043 193059 202001 805044

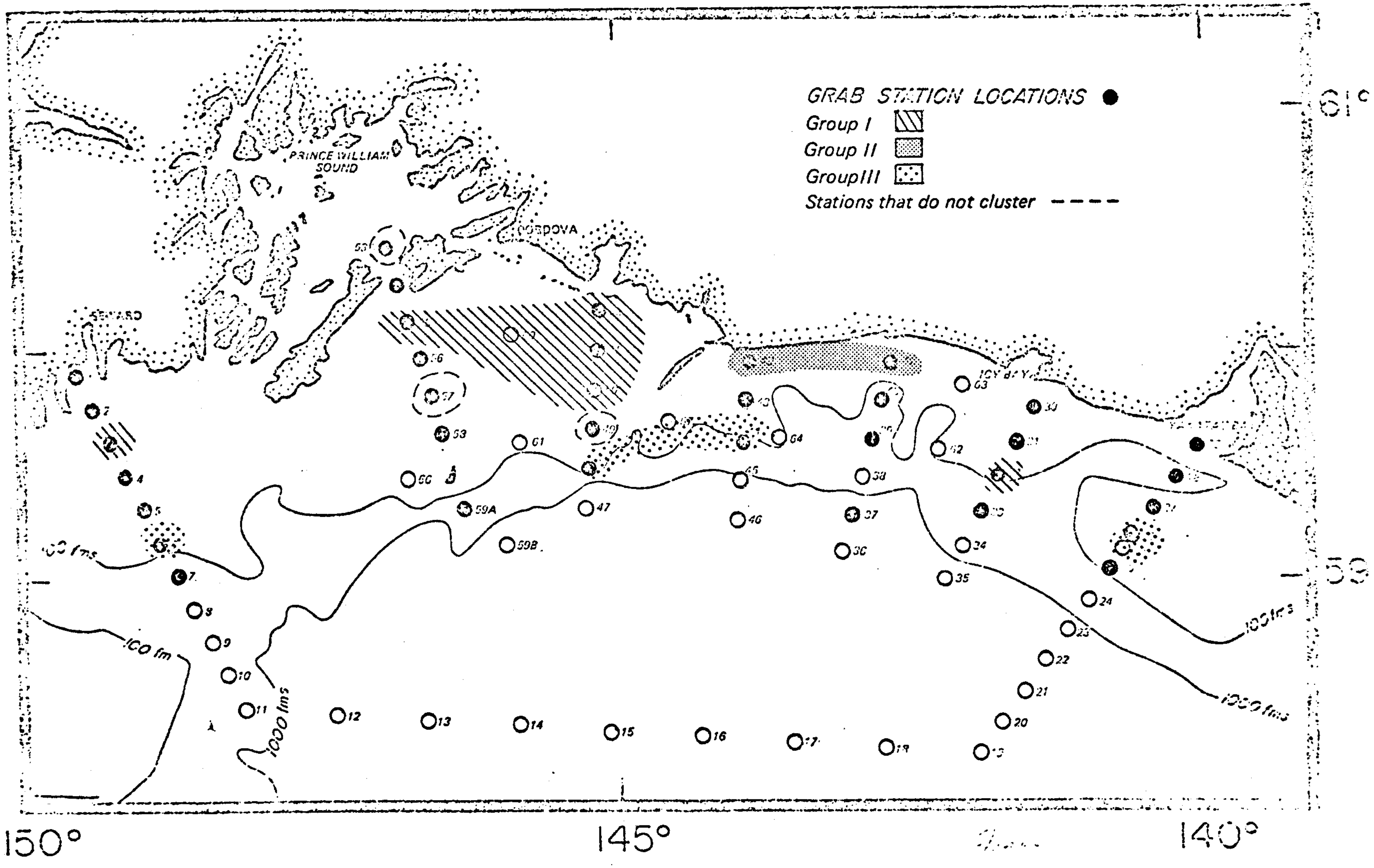
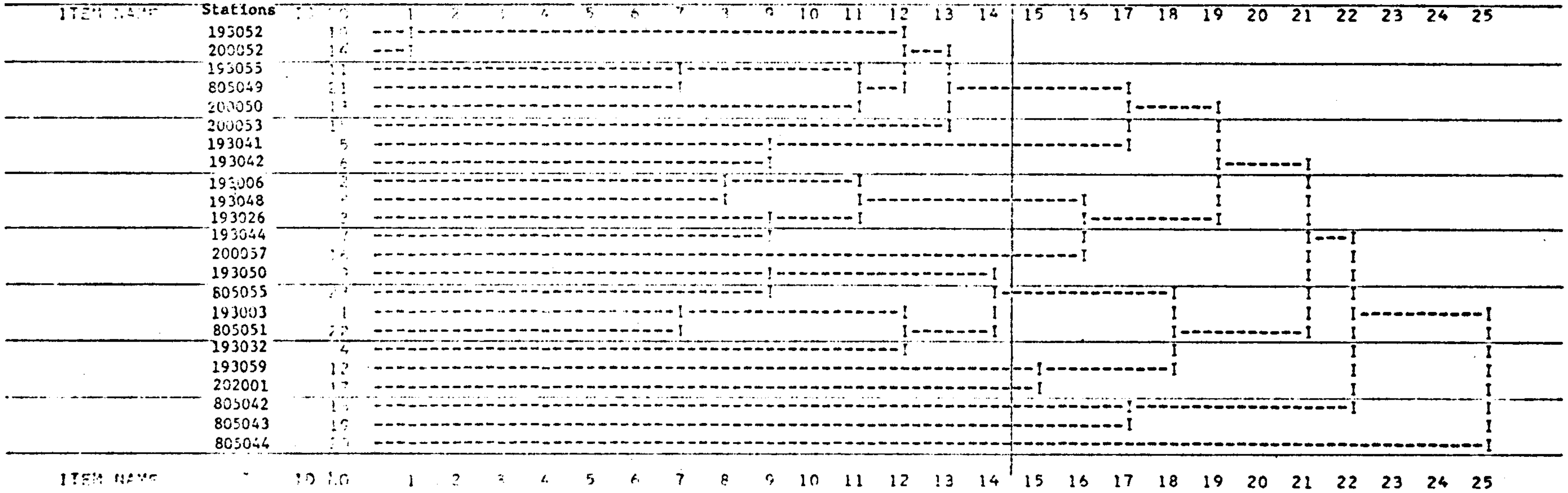


Figure 48. Quantitative stations only clustered using Motyka coefficient with single linkage sorting.

Figure 49. Gulf of Alaska Motyka Number of individuals station-station for BIT taxon, average, linkage. See Fig. 50.



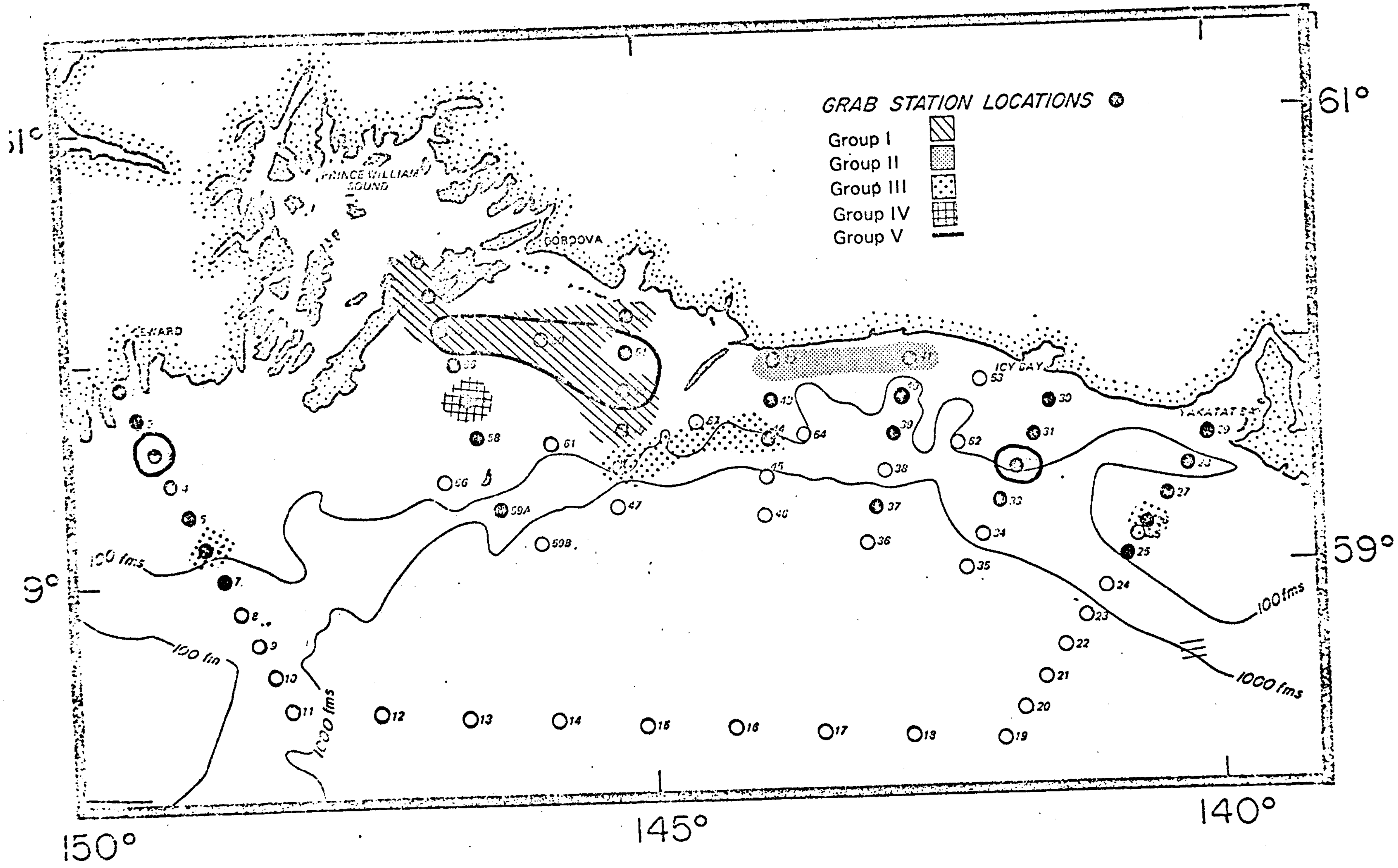
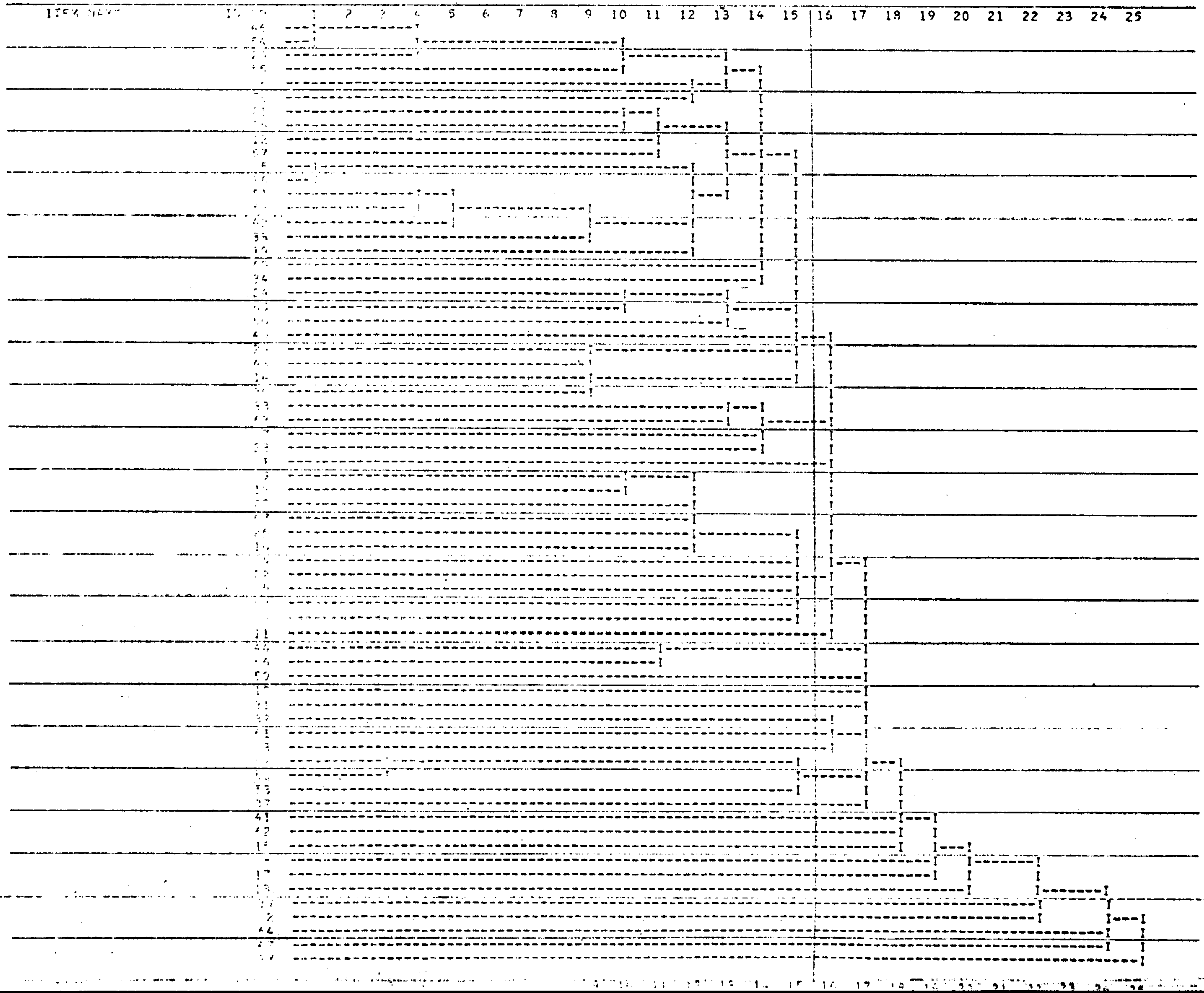


Figure 50. Quantitative stations only clustered using Motyka coefficient with average linkage sorting.

Figure 51. Gulf of Alaska Motyka Number of individual taxon-taxon for BIT taxon, single linkage. Refer to Table 6.



and 52 are dendrograms of the inverse analysis using the Motyka similarity coefficient. Lists of the BIT and a station *vs* species matrix showing the individuals of each taxon at each station are found in Tables 8 and 9. A two way coincidence table (Table 10) comparing the species groups and station groups delineated by average linkage clustering of Motyka similarities was constructed. The species (or Taxa) within each species group and the stations within each station group are listed. Entries in the table represent the number of species i at station j.

B. Trawl Program

The basic intent of the joint benthic invertebrate-demersal fish program has been fullfilled by way of the invertebrate samples and fish stomachs taken on three legs (25 days per leg) of the Northwest Fishery Center trawl charter, from May through August, 1975. In addition, hydrocarbon and trace metal samples were taken from invertebrates and fishes on these cruises. Many of the stations were located in the general areas of the grab stations (Figs. 1 and 3). All epifaunal invertebrates were typically counted, although in some cases only weights were taken, for very abundant species. At some stations it was possible to count and weigh most invertebrate species; conversion factors have been developed to approximate wet weights for all invertebrate species at all stations (Appendix Table III).

All samples have been processed, species identified, and all data tabulated (Appendix Table III; stored on magnetic tape).

Taxonomic analysis has delineated nine (9) phyla, 19 classes, 82 families, and 168 species of invertebrates from the collections made on the M/V *North Pacific* (Appendix Table III; Tables 11, 12 and 13). The molluscs and crustaceans

Figure 52. Gulf of Alaska Motyka Number of individual taxon-taxon for BIT taxon, average linkage. Refer to Table 6.

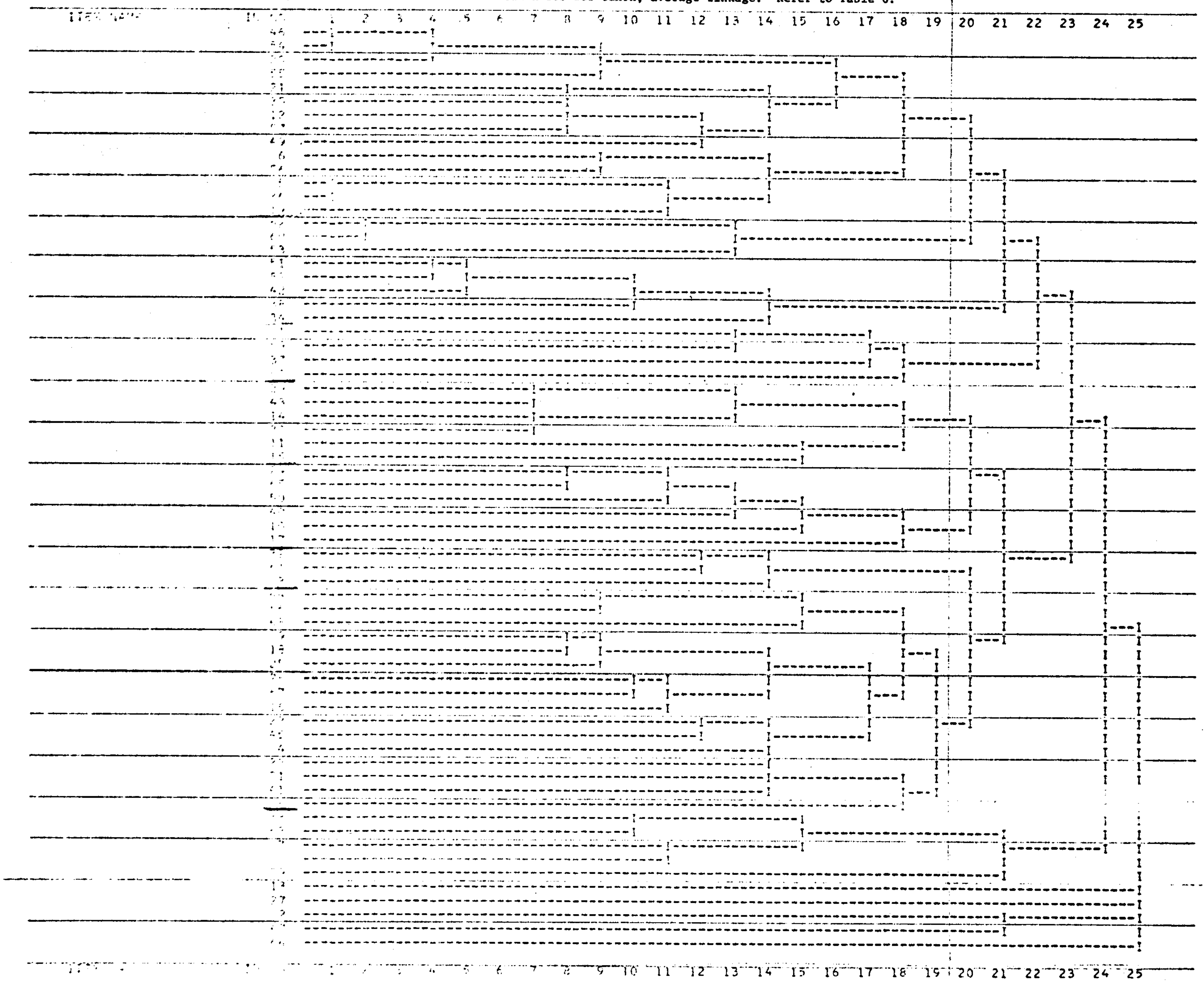


Table 6. Gulf of Alaska BII taxon codes in sorted order for quantitative stations using Motyka similarity coefficient.

```
TAXON CODES IN SORTED ORDER

  1   3200000000   SPONGES
  2   3303000000   CNIDARIA ANTHOZOA
  3   3303010000   CNIDARIA ANTHOZOA SEA PEN
  4   4000000000   NEMERTEANS RHYNCHOCOELA
  5   4801020101   POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA
  6   4801221001   POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA
  7   4801221201   POLYCHAETA SYLLIDAE HAPLOSYLLIS SPONGICOLA
  8   4801240111   POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA
  9   4801260101   POLYCHAETA GLYCERIDAE GLYCERA CAPITATA
 10   4801250102   POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS
 11   4801300105   POLYCHAETA LUMBRINERIDAE LU RINERIS SIMILABRIS
 12   4801400204   POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII
 13   4801420701   POLYCHAETA SPIONIDAE SPIO FILICORNIS
 14   4801421003   POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA
 15   4801430101   POLYCHAETA MAGELONIDAE MAGELONA JAPONICA
 16   4801490300   POLYCHAETA CIRRATULIDAE THARYX SP.
 17   4801570101   POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA
 18   4801580201   POLYCHAETA CAPITELLIDAE HETEROMASTUS FILIFORMIS
 19   4801610102   POLYCHAETA MALDANIDAE ASYCHIS SIMILIS
 20   4801610302   POLYCHAETA MALDANIDAE MALDANE GLEBIFEX
 21   4801610601   POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS
 22   4801610901   POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS
 23   4801620102   POLYCHAETA OWENIIDAE OWENIA FUSIFORMIS
 24   4801620201   POLYCHAETA OWENIIDAE MYRIOCHELE HEERI
 25   4801650501   POLYCHAETA AMPHARETIDAE MELINNA CRISTATA
 26   4801670101   POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI
 27   4801680401   POLYCHAETA SABELLIDAE MEGALOMMA SPLENDIDA
 28   4901050101   MOLLUSCA APLACOPHORA CHAETODERMA ROBUSTA
 29   4904020201   MOLLUSCA PELECYPODA NUCULA TENUIS
 30   4904030201   MOLLUSCA PELECYPODA NUCULANA PERNULA
 31   4904030202   MOLLUSCA PELECYPODA NUCULANA MINUTA
 32   4904030301   MOLLUSCA PELECYPODA PORTLANDIA ARCTICA
 33   4904050500   MOLLUSCA PELECYPODA YOLDIA SP.
 34   4904070201   MOLLUSCA PELECYPODA CRENELLA DESSUCATA
 35   4904070500   MOLLUSCA PELECYPODA DACRYDIUM SP.
 36   4904080201.  MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI
 37   4904110100   ASTARTE SP.
 38   4904110103   MOLLUSCA PELECYPODA ASTARTE MONTEGUI
 39   4904110104   MOLLUSCA PELECYPODA ASTARTE POLARIS
 40   4904150201   MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA
 41   4904150301   MOLLUSCA PELECYPODA THYASIRA FLEXUOSA
 42   4904200105   MOLLUSCA PELECYPODA CLINOCARDIUM FUCANUM
 43   4904210501   MOLLUSCA PELECYPODA PSEPHIDIA LORDI
 44   4904240101   MOLLUSCA PELECYPODA MACOMA CALCAREA
 45   4905010100   MOLLUSCA SCAPHOPODA DENTALIUM SP
 46   5311000000   CRUSTACEA HARPACTICOIDA
 47   5310010201   CR THORACICA LEPADIDAE SCALPELLUM COLUMBIANA
 48   5328040201   CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA
 49   5330110000   CRUSTACEA ISOPODA GNATHIA SP.
 50   5331000000   CRUSTACEA AMPHIPODA
 51   5331020101   CRUSTACEA AMPHIPODA AMPELISCA MACROECEPHALA
 52   5331020200   BYBLIS SP.
 53   5331020201   CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS
 54   5331020301   CRUSTACEA AMPHIPODA HAPLOOPS TUBICULA
 55   5331420100   HARPINIA SP.
 56   5331420201   CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS
 57   5901010101   SIPUNCULIDA GOLFINGIA MARGARITACEA
 58   6603060101   BRYOZOA CLAVOPORA OCCIDENTALIS
 59   6700000000   BRACHIOPODA
 60   6702133101   BRACHIOPODA ARTICULATA TEREBRATULINA UNGUICULA
 61   6801060101   EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS
 62   6802050101   ECHINODERM ECHINOIDEA BRIASTER TOWNSENDI
 63   6803020801   ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS
 64   6803090600   OPHIURA SP.
 65   6803090611   ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI
 66   6804050100   ECHINODERM HOLOTHUROIDEA MOLPADIA SP.
 67   9999999999   UNIDENTIFIABLE
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[redacted] Ta[redacted] Gu[redacted] Alas[redacted] tion[redacted] pecie[redacted] rix. [redacted] e nu[redacted] and s[redacted] num[redacted] ove [redacted] crui[redacted], St[redacted] 3); [redacted] [redacted] [redacted] [redacted]
Taxon (species) numbers to the side. See Table 8 for taxon codes and names.

NUMBER OF INDIV IN EACH TAXON AT EACH STATION

	193003	193006	193026	193032	193041	193042	193044	193048	193050	193052	193055	193059	200050	200052	200053
3200000000	0.	0.	2.0	0.	0.	0.	1.0	1.0	0.	1.0	0.	0.	0.	0.	0.
3303000000	0.	0.	0.	0.	0.	0.	1.0	0.	0.	0.	0.	0.	0.	0.	0.
3303010000	0.	0.	0.	0.	0.	0.	0.	0.	2.0	1.0	0.	0.	8.0	3.0	0.
4000000000	1.0	2.0	0.	1.0	2.0	0.	0.	1.0	1.0	0.	1.0	0.	2.0	2.0	1.0
4801220101	0.	2.0	0.	0.	0.	0.	11.0	4.0	0.	0.	0.	0.	0.	0.	0.
4801221001	0.	6.0	1.0	0.	0.	0.	7.0	0.	0.	1.0	0.	0.	0.	4.0	0.
4801221201	0.	0.	4.0	0.	0.	0.	4.0	0.	0.	0.	0.	0.	0.	0.	0.
4801240111	0.	0.	0.	0.	0.	6.0	0.	1.0	1.0	0.	2.0	0.	0.	0.	0.
4801260101	1.0	0.	2.0	0.	1.0	2.0	1.0	2.0	2.0	4.0	1.0	0.	1.0	8.0	2.0
4801260102	7.0	10.0	1.0	5.0	6.0	1.0	3.0	5.0	0.	1.0	0.	0.	2.0	0.	0.
4801300105	2.0	6.0	4.0	4.0	12.0	17.0	3.0	5.0	4.0	53.0	31.0	2.0	20.0	41.0	36.0
4801400204	0.	15.0	1.0	0.	0.	0.	0.	10.0	0.	0.	0.	0.	5.0	0.	0.
4801420701	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4801421005	0.	0.	0.	0.	6.0	68.0	0.	1.0	7.0	25.0	3.0	0.	17.0	19.0	13.0
4801430101	0.	0.	0.	0.	0.	1.0	0.	0.	0.	52.0	0.	0.	0.	27.0	0.
4801490300	1.0	2.0	3.0	1.0	0.	9.0	4.0	3.0	0.	4.0	0.	0.	6.0	1.0	2.0
4801570101	6.0	0.	0.	3.0	5.0	0.	0.	0.	4.0	1.0	6.0	8.0	1.0	0.	68.0
4801580201	0.	0.	0.	0.	0.	3.0	0.	0.	0.	5.0	0.	0.	1.0	8.0	6.0
4801610102	0.	1.0	0.	0.	0.	0.	1.0	3.0	0.	0.	0.	0.	0.	0.	0.
4801610302	0.	10.0	0.	0.	1.0	0.	0.	0.	0.	1.0	0.	0.	0.	0.	0.
4801610601	0.	16.0	15.0	0.	0.	0.	4.0	3.0	0.	0.	0.	0.	0.	0.	0.
4801610901	0.	2.0	0.	8.0	1.0	0.	2.0	1.0	5.0	2.0	3.0	0.	2.0	5.0	0.
4801620102	0.	0.	5.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4801620201	0.	23.0	4.0	4.0	16.0	4.0	4.0	1.0	3.0	3.0	0.	1.0	9.0	2.0	9.0
4801650501	0.	2.0	0.	0.	0.	5.0	0.	1.0	0.	6.0	1.0	0.	0.	8.0	0.
4801670101	0.	1.0	6.0	1.0	5.0	7.0	0.	1.0	0.	0.	5.0	0.	9.0	4.0	0.
4801680401	0.	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4901030101	0.	1.0	0.	1.0	1.0	3.0	0.	0.	1.0	2.0	0.	0.	1.0	0.	3.0
4904020201	5.0	4.0	4.0	4.0	40.0	49.0	2.0	1.0	1.0	4.0	1.0	1.0	5.0	6.0	1.0
4904030201	0.	2.0	4.0	0.	0.	97.0	0.	2.0	0.	35.0	6.0	0.	0.	7.0	0.
4904030202	0.	0.	0.	0.	0.	2.0	0.	0.	5.0	0.	5.0	0.	0.	3.0	0.
4904030301	2.0	0.	0.	4.0	0.	0.	0.	0.	0.	0.	0.	0.	10.0	0.	0.
4904030500	0.	0.	2.0	6.0	0.	0.	0.	0.	0.	0.	0.	5.0	0.	0.	0.
4904070201	0.	1.0	3.0	0.	0.	0.	2.0	4.0	0.	0.	0.	0.	0.	0.	0.
4904070500	4.0	5.0	13.0	1.0	0.	0.	1.0	5.0	0.	0.	0.	1.0	0.	0.	0.
4904080201	0.	1.0	0.	0.	0.	0.	13.0	4.0	0.	0.	0.	0.	0.	0.	0.
4904110100	0.	0.	0.	3.0	0.	0.	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
4904110103	0.	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4904110104	0.	0.	0.	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4904150201	7.0	27.0	11.0	8.0	64.0	2.0	6.0	9.0	1.0	9.0	19.0	0.	2.0	3.0	1.0
4904150301	1.0	0.	0.	0.	7.0	1.0	1.0	0.	2.0	2.0	5.0	0.	0.	0.	0.
4904200105	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4904210501	1.0	0.	1.0	7.0	46.0	60.0	0.	0.	0.	0.	0.	0.	0.	1.0	0.
4904240101	0.	0.	0.	0.	0.	0.	0.	1.0	0.	0.	3.0	0.	1.0	2.0	3.0
4906010100	2.0	3.0	0.	2.0	1.0	0.	2.0	1.0	3.0	0.	2.0	0.	0.	0.	7.0
5311000000	0.	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5314010201	0.	0.	0.	0.	0.	0.	1.0	0.	0.	0.	0.	0.	0.	0.	0.
5324040201	2.0	0.	0.	0.	0.	5.0	0.	0.	0.	3.0	3.0	0.	1.0	0.	9.0
5320110000	0.	8.0	1.0	3.0	0.	1.0	2.0	24.0	1.0	0.	0.	0.	0.	0.	0.
5331000000	1.0	17.0	6.0	2.0	11.0	6.0	20.0	8.0	0.	1.0	4.0	0.	6.0	1.0	14.0
5331020101	0.	0.	0.	0.	0.	0.	0.	1.0	0.	0.	0.	0.	1.0	2.0	1.0
5331020200	0.	0.	0.	0.	0.	0.	0.	6.0	0.	0.	0.	0.	0.	0.	0.
5331020201	0.	0.	0.	0.	0.	5.0	0.	8.0	0.	1.0	0.	0.	0.	0.	0.
5331020301	0.	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5331420100	0.	9.0	0.	1.0	0.	0.	0.	3.0	0.	1.0	0.	0.	0.	4.0	1.0
5331420201	0.	4.0	2.0	0.	0.	0.	5.0	1.0	0.	0.	0.	1.0	0.	0.	0.
5900010101	0.	20.0	5.0	0.	0.	0.	9.0	10.0	0.	0.	0.	0.	0.	0.	0.
6603060101	0.	1.0	0.	0.	0.	0.	2.0	0.	0.	0.	0.	0.	0.	0.	0.
6700000000	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6702030101	0.	0.	1.0	0.	0.	0.	0.	5.0	0.	0.	0.	0.	0.	0.	0.
6801060101	0.	0.	1.0	1.0	2.0	0.	1.0	0.	1.0	0.	1.0	0.	7.0	0.	0.
6802030101	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6803020401	0.	0.	4.0	5.0	2.0	0.	7.0	0.	0.	2.0	0.	3.0	0.	0.	0.
6803090500	0.	0.	0.	0.	0.	0.	0.	0.	1.0	0.	0.	0.	0.	0.	0.
6803090611	0.	23.0	2.0	3.0	13.0	9.0	3.0	9.0	0.	1.0	0.	0.	0.	0.	31.0
6804050100	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.0	0.	0.	0.	4.0
9999999999	2.0	2.0	5.0	0.	2.0	2.0	0.	5.0	0.	1.0	1.0	0.	5.0	3.0	2.0

Tab[redacted] Con[redacted]

NUMBER OF INDIV IN EACH TAXON AT EACH STATION

	200057	202001	805042	805043	805044	805049	805051	805055
3200000000	2.0	0.	0.	0.	0.	0.	0.	0.
3303000000	0.	0.	0.	0.	0.	0.	10.0	0.
3303010000	1.0	0.	0.	0.	0.	0.	0.	0.
4000000000	1.0	0.	0.	0.	0.	4.0	0.	0.
4801020101	5.0	0.	0.	0.	3.0	0.	0.	0.
4801221001	3.0	0.	0.	0.	0.	0.	0.	0.
4801221201	0.	0.	0.	0.	0.	0.	0.	0.
4801240111	0.	2.0	0.	1.0	0.	0.	0.	0.
4801260101	2.0	0.	0.	0.	1.0	2.0	0.	2.0
4801260102	0.	1.0	0.	0.	0.	14.0	8.0	1.0
4801300135	32.0	0.	6.0	0.	0.	29.0	1.0	11.0
4801400204	0.	0.	0.	0.	0.	0.	0.	0.
4801420701	0.	0.	8.0	0.	0.	11.0	0.	0.
4801421003	2.0	0.	0.	0.	0.	0.	0.	3.0
4801430101	0.	0.	0.	0.	0.	0.	0.	0.
4801490300	9.0	0.	2.0	0.	0.	0.	0.	0.
4801570101	0.	6.0	0.	0.	0.	14.0	5.0	7.0
4801580201	1.0	0.	0.	0.	0.	0.	0.	0.
4801610102	5.0	0.	0.	0.	0.	0.	0.	0.
4801610302	3.0	0.	0.	1.0	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	5.0
4801620102	0.	0.	0.	0.	0.	0.	0.	0.
4801620201	1.0	0.	1.0	1.0	0.	4.0	0.	1.0
4801650501	7.0	1.0	1.0	0.	0.	2.0	0.	0.
4801670101	3.0	0.	0.	0.	0.	2.0	0.	1.0
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	3.0	0.	0.	0.	3.0	1.0	2.0
[illegible]	1.0	0.	3.0	2.0	0.	6.0	1.0	0.
4904030201	2.0	0.	0.	1.0	0.	1.0	1.0	4.0
4904030202	0.	0.	0.	0.	0.	0.	0.	0.
4904030301	0.	0.	0.	0.	0.	8.0	2.0	0.
4904030500	0.	0.	0.	0.	0.	0.	0.	0.
4904070201	45.0	0.	0.	0.	0.	0.	0.	0.
[illegible]	1.0	0.	0.	0.	0.	0.	0.	0.
[illegible]	3.0	0.	0.	0.	3.0	0.	0.	0.
4904110100	1.0	0.	0.	0.	0.	0.	0.	0.
[illegible]	4.0	0.	0.	0.	0.	0.	0.	0.
4904110104	0.	0.	0.	9.0	0.	0.	0.	0.
4904150201	9.0	0.	1.0	0.	0.	7.0	3.0	3.0
4904150301	0.	0.	0.	0.	0.	0.	4.0	1.0
4904200103	13.0	0.	0.	0.	0.	0.	0.	0.
4904210501	26.0	0.	3.0	8.0	1.0	2.0	0.	3.0
4904240101	0.	0.	0.	0.	0.	0.	0.	1.0
[illegible]	0.	1.0	0.	0.	0.	2.0	1.0	4.0
5311000000	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	1.0	0.	0.	0.	0.	1.0	0.	9.0
5330110000	0.	0.	0.	0.	0.	0.	0.	0.
5331000000	38.0	0.	0.	0.	2.0	1.0	0.	0.
[illegible]	13.0	0.	0.	0.	0.	0.	0.	0.
5331020200	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	3.0	0.	1.0	0.	0.	0.	0.	0.
[illegible]	1.0	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
5331420201	0.	0.	1.0	2.0	0.	0.	0.	0.
[illegible]	6.0	0.	0.	0.	1.0	0.	0.	0.
6603060101	17.0	0.	0.	0.	0.	0.	0.	0.
6700000000	2.0	0.	0.	0.	0.	0.	0.	0.
6702060101	0.	0.	0.	0.	0.	0.	0.	0.
6601060101	0.	0.	0.	1.0	0.	1.0	3.0	1.0
[illegible]	1.0	2.0	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	2.0	2.0	4.0	0.	0.	0.
6204050100	0.	0.	0.	0.	0.	0.	0.	3.0
9999999999	2.0	0.	2.0	0.	0.	1.0	1.0	2.0

Table 10a. Gulf of Alaska Stations two-way table, Stations Group *vs* Species Groups. See Table 8 for species relating to code numbers.

	Species Code	STATIONS																					
		Grp I						Grp II		Grp III				Grp IV	Grp V					Grp VI	Grp VII	Grp VIII	Grp IX	Grp X
		52^a	52^b	55^a	49	50	53	41	42^a	6	48	26	44^a	57	50^a	55^c	3	51	32	12	42^c	43	44^c	59
	46	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	54	-	-	-	-	-	-	-	-	10	-	-	-	18	-	-	-	-	-	-	-	-	-	-
	20	1	-	-	-	-	-	1	-	10	-	-	-	3	-	-	-	-	-	-	-	1	-	-
	55	1	4	-	-	-	1	1	-	9	3	-	-	-	-	-	-	-	1	-	-	-	-	-
	21	-	-	-	-	-	-	-	-	16	3	15	4	-	-	-	-	-	-	-	-	-	-	-
Group I	35	-	-	-	-	-	-	-	-	5	5	13	1	1	-	-	4	-	1	-	-	-	-	1
	12	-	-	-	-	5	-	-	-	15	10	1	-	-	-	-	-	-	-	-	-	-	-	-
	57	-	-	-	-	-	-	-	-	20	10	5	9	8	-	-	-	-	-	-	-	-	1	-
	49	-	-	-	-	-	-	-	-	8	24	3	2	-	1	-	-	-	3	-	1	-	1	-
	6	1	4	-	-	-	-	-	-	6	7	1	-	3	-	-	-	-	-	-	-	-	-	-
	56	-	-	-	-	-	-	-	-	4	1	2	8	-	-	-	-	-	-	-	1	2	-	-
	5	-	-	-	-	-	-	-	-	2	4	-	11	5	-	-	-	-	-	-	-	-	3	-
	36	-	-	-	-	-	-	-	-	1	4	-	13	3	-	-	-	-	-	-	-	-	3	-
	19	-	-	-	-	-	-	-	-	1	3	-	1	5	-	-	-	-	-	-	-	1	-	-
	52	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	60	-	-	-	-	-	-	-	-	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-
	53	1	-	-	-	-	-	-	5	-	8	-	-	3	-	-	-	-	-	-	1	-	-	-
	51	-	1	-	-	1	1	-	-	-	1	-	-	18	-	-	-	-	-	-	-	-	-	-
Group II	58	-	-	-	-	-	-	-	-	1	10	5	9	17	-	-	-	-	-	-	-	-	-	-
	42	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
	38	-	-	-	-	-	-	-	-	3	-	-	-	8	-	-	-	-	-	-	-	-	-	-
	34	-	-	-	-	-	-	-	-	1	4	3	2	45	-	-	-	-	-	-	-	-	-	-
	1	1	-	-	-	-	-	-	-	-	1	2	1	2	-	-	-	-	-	-	-	-	-	-
Group III	59	-	-	-	-	-	-	-	-	0	0	0	-	2	-	-	-	-	-	-	-	-	-	-
	37	-	-	-	-	-	-	-	-	-	1	-	1	1	1	-	-	-	3	-	-	-	-	-
	62	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-
	29	4	6	1	6	5	1	40	49	4	1	4	2	1	-	-	5	1	4	-	8	2	-	1
	43	-	1	-	2	-	-	46	60	-	-	1	-	26	-	8	1	-	7	-	3	8	1	-
Group IV	14	25	19	3	-	17	13	6	68	-	1	-	-	2	7	3	-	-	-	-	-	-	-	-
	30	33	7	6	1	-	-	-	99	2	2	4	-	2	-	4	-	1	-	-	-	1	-	-
	11	53	41	31	29	20	36	12	17	6	5	4	3	32	4	1	2	8	4	-	8	-	-	2
	15	52	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 10a. Continued

	Species Code	STATIONS																								
		Grp I						Grp II		Grp III				Grp IV	Grp V					Grp VI	Grp VII	Grp VIII	Grp IX	Grp X
		52[a]	52[b]	55[a]	49	50	53	41	42[a]	6	48	26	44[a]	57	50[a]	55[c]	3	51	32	12	42[c]	43	44[c]	59
Group V	24	3	2	1	4	9	9	16	4	23	4	1	4	1	3	-	-	-	4	-	1	1	-	1
	65	1	-	-	-	-	31	13	9	23	9	2	3	-	-	-	-	-	3	-	2	2	4	-
	50	1	1	4	1	6	14	11	6	17	8	6	20	38	-	-	1	-	2	-	-	2	-	-
	40	9	3	7	19	2	1	64	2	27	9	11	8	9	1	3	7	3	8	-	1	1	-	-
	10	1	-	-	14	2	-	6	1	10	5	1	3	9	-	1	7	8	5	1	-	-	-	-
	17	1	0	6	14	1	68	5	-	-	-	-	-	-	4	7	6	5	3	6	-	-	-	8
Group VI	32	-	-	-	8	10	-	-	-	-	-	1	-	-	-	-	2	2	4	-	-	-	-	-
	61	1	-	1	1	7	-	2	-	-	-	1	1	-	-	1	-	3	1	-	-	1	-	-
	3	1	3	-	-	8	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-
Group VII	44	-	2	3	-	1	3	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
	66	-	-	2	-	-	4	-	5	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
	48	3	-	3	1	1	9	-	-	-	-	-	-	1	-	9	-	-	-	-	-	-	-	-
	9	4	8	1	2	1	2	1	2	-	2	2	1	2	2	2	1	-	-	-	-	1	-	-
	18	5	8	2	-	1	6	-	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	25	6	8	1	-	-	-	-	5	2	1	-	-	7	-	-	-	-	-	1	1	-	-	-
	26	-	4	5	2	9	-	5	7	1	1	6	-	3	-	1	-	-	1	-	-	-	-	-
	16	4	1	-	-	6	2	-	9	2	3	3	4	9	-	-	1	-	1	-	6	-	-	-
	22	2	5	5	3	2	-	1	-	2	1	-	-	-	5	-	-	-	8	-	-	-	2	-
	45	-	-	2	2	-	7	1	-	3	1	2	2	-	3	4	2	1	-	1	-	-	-	-
	4	-	2	1	4	2	1	2	-	2	1	-	-	1	1	-	1	-	1	-	-	-	-	-
Group VIII	28	2	-	-	-	1	3	1	3	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
	31	-	3	5	-	5	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	41	2	-	5	-	-	-	7	1	-	-	-	1	-	2	1	1	4	-	-	-	-	-	-
	8	-	-	2	-	-	-	-	6	-	1	-	-	-	1	-	-	-	-	2	-	1	-	-
Group IX	33	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	6	-	-	-	-	3
	63	2	-	-	-	-	-	2	-	-	-	4	7	-	-	-	-	-	5	-	-	-	-	3
	7	-	-	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-
	23	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	2	-	-	-	-	-

[a] = Cruise 193

[b] = Cruise 200

[c] = Cruise 805

Table 10b. Gulf of Alaska Species Groups resulting from cluster analysis (see Table 9) and feeding types of species in the groups. DF=Deposit Feeder, S=Scavenger, SF=Suspension Feeder, P=Predator, G=Grazer. Data sources for feeding types are Feder *et al.* (1973) and Feder and Mueller (1975).

Species No.		Feeding Type
	<u>Group I</u>	
46	Crustacea Harpacticoida	S(?), G
54	Crustacea Amphipoda *Haploops tubicula*	S
20	Polychaeta Maldanidae *Maldane glebifex*	DF
55	Crustacea Amphipoda *Harpinia* sp.	S
21	Polychaeta Maldanidae *Notoproctus pacificus*	DF
35	Mollusca Pelecypoda *Dacrydium* sp.	SF
12	Polychaeta Paraonidae *Aricidea jeffreysii*	DF
57	Sipunculida *Golfingia magaretacea*	DF
49	Crustacea Isopoda *Gnathia* sp.	Parasite on fishes
6	Polychaeta syllidae *Langerhansia cornuta*	P
56	Crustacea Amphipoda *Harpiniopsis sandpedroensis*	S
5	Polychaeta Polyodontidae *Peisidice aspera*	S
36	Mollusca Pelecypoda *Cyclopecten randolphi*	SF
19	Polychaeta Maldanidae *Asychis similis*	DF
	Group II	
52	Crustacea Amphipoda *Byblis* sp.	S
60	Brachiopoda Articulata *Terebratulina unguicula*	SF
53	Crustacea Amphipoda *Byblis crassicornis*	S
51	Crustacea Amphipoda *Ampelisca macrocephala*	S
58	Bryozoa *Clavopora occidentalis*	SF
42	Mollusca Pelecypoda *Clinocardium fucanum*	SF
38	Mollusca Pelecypoda *Astarte montegui*	SF
34	Mollusca Pelecypoda *Crenella dessucata*	SF
	Group III	
1	Sponges	SF
59	Brachiopoda	SF
37	Mollusca Pelecypoda *Astarte* sp.	SF(?)
62	Echinoderm Echinoidea *Brisaster townsendii*	DF
	Group IV	
29	Mollusca Pelecypoda *Nucula tenuis*	DF, SF
43	Mollusca Pelecypoda *Psephidia lordi*	SF
14	Polychaeta Spionidae *Spiophanes cirrata*	DF
30	Mollusca Pelecypoda *Nuculana pernula*	DF, SF
11	Polychaeta Lumbrineridae *Lumbrineris similabris*	DF
15	Polychaeta Magelonidae *Magelona japonica*	DF
	Group V	
24	Polychaeta Oweniidae *Myriochele heeri*	DF, SF
65	Echinoderm Ophiuridae *Ophiura sarsi*	P
50	Crustacea Amphipoda (mixed species)	S

Table 10b. Continued

Species No.		Feeding Type
40	Mollusca Pelecypoda *Axinopsida serricata*	SF
10	Polychaeta Onuphidae *Onuphis geophiliformis*	DF
17	Polychaeta Sternaspidae *Sternaspis scutata*	DF
	Group VI	
32	Mollusca Pelecypoda *Portlandia arctica*	DF, SF
61	EC. AS. Porcellanasteridae *Ctenodiscus crispatus*	DF
3	Cnidaria Anthozoa Sea Pen	SF
	Group VII	
44	Mollusca Pelecypoda *Macoma calcarea*	DF, SF
66	Echinoderm Holothurcoidea *Molpadia* sp.	DF
48	Cr Cumacea Leuconidae *Eudorella emarginata*	DF
9	Polychaeta Glyceridae *Glycera capitata*	P
18	Polychaeta Capitellidae *Heteromastus filiformis*	DF
25	Polychaeta Ampharetidae *Melinna cristata*	DF
26	Polychaeta Terebeliidae *Terrebellides stroemi*	DF
16	Polychaeta Cirratalidae *Tharyx* sp.	DF
22	Polychaeta Maldanidae *Praxillella gracilis*	DF
45	Mollusca Scaphopoda *Dentalium* sp.	DF
4	*Nemerteans (Rhynchocoela)*	P
	Group VIII	
28	Mollusca Aplacophora *Chaetoderma robusta*	DF
31	Mollusca Pelecypoda *Nuculana minuta*	DF
41	Mollusca Pelecypoda *Thyasira flexuosa*	SF
8	Polychaeta Nepthydidae *Nepthys ferruginea*	P
	Group IX	
33	Mollusca Pelecypoda *Yoldia* sp.	DF, SF
63	Echinoderm Amphiuridae *Unioplus macraspis*	DF
7	Polychaeta Syllidae *Haplosyllis spongicola*	P
23	Polychaeta Oweniidae *Owenia fusiformis*	DF, SF(?)

Table 11. A list of species taken by trawl from the Northeast Gulf of Alaska (NEGOA) on board the National Marine Fisheries Service charter vessel M/V *NORTH PACIFIC*, 25 April - 7 August 1975.

- Phylum Porifera

- Phylum Cnidaria
  - Class Hydrozoa
  - Class Scyphozoa
    - Family Pelagiidae
      - *Chrysaora melanaster* Brandt
  - Class Anthozoa
    - Subclass Alcyonaria
      - *Eunephthya rubiformis* (Pallas)
      - Family Virgulariidae
        - *Stylatula gracile* (Gabb)
      - Family Pennatulidae
        - *Ptilosarcus gurneyi* (Gray)
      - Family Actiniidae
        - *Tealia crassicornis* (O. F. Müller)

- Phylum Annelida
  - Class Polychaeta
    - Family Polynoidae
      - *Arctonoe vittata* (Grube)
      - *Eunoe depressa* Moore
      - *Eunoe oerstedi* Malmgren
      - *Harmothoe multisetosa* Moore
      - *Hololepida magna* Moore
      - *Lepidonotus squamatus* (Linnaeus)
      - *Lepidonotus* sp.
      - *Polyeunoe tuta* (Grube)
    - Family Polynodontidae
      - *Peisidice aspera* Johnson
    - Family Euphrosinidae
      - *Euphrosine hortensis* Moore
    - Family Syllidae
    - Family Nereidae
      - *Ceratonereis paucidentata* (Moore)
      - *Ceratonereis* sp.
      - *Cheilonereis cyclurus* (Harrington)
      - *Nereis pelagica* Linnaeus
      - *Nereis vexillosa* Grube
      - *Nereis* sp.
    - Family Nephtyidae
    - Family Glyceridae
      - *Glycera* sp.
    - Family Eunicidae
      - *Eunice valens* (Chamberlin)
    - Family Lumbrineridae
      - *Lumbrineris similabris* (Treadwell)
    - Family Opheliidae
      - *Travisia pupa* Moore
    - Family Sabellariidae
      - *Idanthyrsus armatus* Kinberg
    - Family Terebellidae
      - *Amphitrite cirrate* O. F. Müller

- Family Sabellidae
  - *Euchone analis* (Kröyer)
- Family Serpulidae
  - *Crucigera irregularis* Bush
- Family Aphroditidae
  - *Aphrodita japonica* Marenzeller
  - *Aphrodita neglegens* Moore
  - *Aphrodita* sp.
- Class Hirudinae
  - *Notostomobdella* sp.

- Phylum Mollusca
  - Class Polyplacophora
    - Family Mopaliidae
  - Class Pelecypoda
    - Family Nuculanidae
      - *Nuculana fossa* Baird
    - Family mytilidae
      - *Mytilus edulis* Linnaeus
      - *Musculus niger* (Gray)
      - *Modiolus modiolus* (Linnaeus)
    - Family Pectinidae
      - *Chlamys hastata hericia* (Gould)
      - *Pecten caurinus* Gould
      - *Delectopecten randolphi* (Dall)
    - Family Astartidae
      - *Astarte polaris* Dall
    - Family Carditidae
      - *Cyclocardia ventricosa* (Gould)
    - Family Cardiidae
      - *Clinocardium ciliatum* (Fabricius)
      - *Clinocardium fucanum* (Dall)
      - *Serripes groenlandicus* (Bruguière)
    - Family Veneridae
      - *Compsomya subdiaphana* Carpenter
    - Family Mactridae
      - *Spisula polynyma* (Stimpson)
    - Family Myidae
    - Family Hiatellidae
      - *Hiatella arctica* (Linnaeus)
    - Family Teredinidae
      - *Bankia setacea* Tryon
    - Family Lyonsiidae
  - Class Gastropoda
    - Family Bathybembix
      - *Solariella obscura* (Couthouy)
      - *Lischkeia cidaris* (Carpenter)
    - Family Naticidae
      - *Natica clausa* Broderip and Sowerby
      - *Polinices monteronis* Dall
      - *Polinices lewisii* (Gould)
    - Family Cymatiidae
      - *Fusitriton oregonensis* (Redfield)
    - Family Muricidae
      - *Trophonopsis stuarti* (Smith)

Family Buccinidae
Buccinum plectrum Stimpson
Family Neptuneidae
Beringius kennicotti (Dall)
Colus halli (Dall)
Morrisonella pacifica (Dall)
Neptunea lyrata (Gmelin)
Neptunea pribiloffensis (Dall)
Plicifusus sp.
Pyrulofusus harpa (Mörch)
Volutopsius filosus Dall
Family Columbellidae
Mitrella gouldi (Carpenter)
Family Volutidae
Arctomelon stearnsii (Dall)
Family Turridae
Oenopota sp.
Leucosyrinx circinata (Dall)
Family Dorididae
Family Tritoniidae
Tritonia exsulans Bergh
Tochuina tetraquetra (Pallas)
Family Flabellinidae
Flabellinopsis sp.
Class Cephalopoda
Family Sepiolidae
Rossia pacifica Berry
Family Gonatidae
Gonatopsis borealis Sasaki
Gonatus magister Berry
Family Octopodidae
Octopus sp.

Phylum Arthropoda
Class Thoracica
Family Lepadidae
Lepas pectinata pacifica Henry
Family Balanidae
Balanus hesperius
Balanus rostratus Hoek
Balanus sp.
Class Isopoda
Family Aegidae
Rocinela augustata Richardson
Family Bopyridae
Argeia pugettensis Dana
Class Decapoda
Family Pandalidae
Pandalus borealis Kröyer
Pandalus jordani Rathbun
Pandalus montagui tridens Rathbun
Pandalus platyceros Brandt
Pandalus hypsinotus Brandt
Pandalopsis dispar Rathbun
Family Hippolytidae
Spirontocaris lamellicornis (Dana)

Spirontocaris arcuata Rathbun
Eualus barbata (Rathbun)
Eualus macrophthalma (Rathbun)
Eualus suckleyi (Stimpson)
Eualus pusiola (Kröyer)
Family Crangonidae
Crangon communis Rathbun
Argis sp.
Argis dentata (Rathbun)
Argis ovifer (Rathbun)
Argis alaskensis (Kingsley)
Paracrangon echinata Dana
Family Paguridae
Pagurus ochotensis (Benedict)
Pagurus aleuticus (Benedict)
Pagurus kennerlyi (Stimpson)
Pagurus confragosus (Benedict)
Elassochirus tenuimanus (Dana)
Elassochirus cavimanus (Miers)
Labidochirus splendescens (Owen)
Family Lithodidae
Acantholithodes hispidus (Stimpson)
Paralithodes camtschatica (Tilesius)
Lopholithodes foraminatus (Stimpson)
Rhinolithodes wosnessenskii Brandt
Family Galatheidae
Munida quadrispina Benedict
Family Majiidae
Oregonia gracilis Dana
Hyas lyratus Dana
Chionoecetes bairdi Rathbun
Chorilia longipes Dana
Family Cancridae
Cancer magister Dana
Cancer oregonensis (Dana)

Phylum Ectoprocta

Phylum Brachiopoda
Class Articulata
Family Cancellothridae
Terebratulina unguicula Carpenter
Terebratalia transversa (Sowerby)
Family Dallinidae
Laqueus californianus Koch

Phylum Echinodermata
Class Asteroidea
Family Asteropidae
Dermasterias imbricata (Grube)
Family Astropectinidae
Dipsacaster borealis Fisher
Family Benthopectinidae
Luidiaster dawsoni (Verrill)
Nearchaster pedicellaris (Fisher)

    - Family Goniasteridae
        - *Ceramaster patagonicus* (Sladen)
        - *Hippasterias spinosa* Verrill
        - *Mediaster aequalis* Stimpson
        - *Pseudarchaster parelii* (Düben and Koren)
    - Family Luiidae
        - *Luidia foliolata* Grube
    - Family Porcellanasteridae
        - *Ctenodiscus crispatus* (Retzius)
    - Family Echinasteridae
        - *Henricia aspera* Fisher
        - *Henricia* sp.
        - *Poraniopsis inflata* Fisher
    - Family Pterasteridae
        - *Diplopteraster multipes* (Sars)
        - *Pteraster tesselatus* Ives
    - Family Solasteridae
        - *Crossaster borealis* (Fisher)
        - *Crossaster papposus* (Linnaeus)
        - *Lophaster furcilliger* Fisher
        - *Lophaster furcilliger vexator* Fisher
        - *Solaster dawsoni* Verrill
    - Family Asteridae
        - *Leptasterias* sp.
        - *Lethasterias nanimensis* (Verrill)
        - *Stylasterias forreri* (de Loriol)
        - *Pycnopodia helianthoides* (Brandt)
- Class Echinoidea
    - Family Schizasteridae
        - *Brisaster townsendi*
    - Family Strongylocentrotidae
        - *Allocentrotus fragilis* (Jackson)
        - *Strongylocentrotus droebachiensis* (O. F. Müller)
- Class Ophiuroidae
    - Family Amphiuridae
        - *Unioplus macraspis* (Clark)
    - Family Gorgonocephalidae
        - *Gorgonocephalus caryi* (Lyman)
    - Family Ophiactidae
        - *Ophiopholis aculeata* (Linnaeus)
    - Family Ophiuridae
        - *Amphiophiura ponderosa* (Lyman)
        - *Ophiura sarsi* Lütkin
- Class Holothuroidea
    - Family Molpadiidae
        - *Molpadia* sp.
    - Family Cucumariidae
    - Family Psolidae
        - *Psolus chitinoides* H. L. Clark
- Class Crinoidea

Phylum Chordata
- Class Phlebobranchia
    - Family Rhodosomatiidae
        - *Chelyosoma columbianum* Huntsman
- Class Stolidobranchia
    - Family Pyuridae
        - *Halocynthia aurantium* Oka

- Class Chondrichthyes
  - Subclass Elasmobranchii
    - Order Squaliformes
      - Family Squalidae
        - *Squalus acanthias* Linnaeus
    - Order Rajiformes
      - Family Rajidae
        - *Raja binoculata* Girard
        - *Raja kincaidi* Garman
        - *Raja rhina* Jordon and Gilbert
        - *Raja stellulata* Jordon and Gilbert
- Class Osteichthyes
  - Subclass Teleostei
    - Order Salmoniformes
      - Family Osmeridae
        - *Thaleichthys pacificus* (Richardson)
    - Order Gadiformes
      - Family Gadidae
        - *Gadus macrocephalus* Tilesius
        - *Microgadus proximus* (Girard)
        - *Theragra chalcogramma* (Pallas)
      - Family Zoarcidae
        - *Lycodes brevipes* Bean
        - *Lycodes palearis* Gilbert
    - Order Scorpaeniformes
      - Family Scorpaenidae
        - *Sebastes aleutianus* (Jordon and Everman)
        - *Sebastes alutus* (Gilbert)
        - *Sebastes babcocki* (Thompson)
        - *Sebastes brevispinis* (Bean)
        - *Sebastes entomelas* (Jordon and Gilbert)
        - *Sebastes flavidus* (Ayres)
        - *Sebastes variegatus* Quast
        - *Sebastolobus alascanus* Bean
      - Family Hexagrammidae
        - *Ophiodon elongatus* Girard
      - Family Anoplopomatidae
        - *Anoplopoma fimbria* (Pallas)
      - Family Cottidae
        - *Dasycottus setiger* Bean
        - *Hemilepidotus jordani* Bean
        - *Ulca bolini* (Myers)
      - Family Agonidae
        - *Agonus acipenserinus* Tilesius
    - Order Perciformes
      - Family Bathymasteridae
        - *Bathymaster signatus* Cope
      - Family Stichaeidae
        - *Lumpenus sagitta* Wilimovsky
    - Order Pleuronectiformes
      - Family Pleuronectidae
        - *Atheresthes stomias* (Jordon and Gilbert)
        - *Glyptocephalus zachirus* Lockington
        - *Hippoglossoides elassodon* Jordon and Gilbert
        - *Hippoglossus stenolepis* Schmidt
        - *Isopsetta isolepis* (Lockington)
        - *Lepidopsetta bilineata* (Ayres)
        - *Microstomus pacificus* (Lockington)

Parophrys vetulus Girard
Platichthys stellatus (Pallas)
Family Cryptacanthodidae
Delolepis gigantea Kittlitz

Table 12. The invertebrate phyla and the number and percentage of species of each phylum collected by commercial trawl in the northeast Gulf of Alaska (NEGOA) on the M/V *North Pacific*. Collection made May-August 1975.

Phylum	Number of species	% of species
Mollusca	47	28.0
Arthropoda (Crustacea)	42	25.0
Echinodermata	36	21.4
Annelida	30	17.8
Cnidaria	6	3.6
Brachiopoda	3	1.8
Chordata (Tunicata)	2	1.2
Ectoprocta	1	0.6
Porifera	1	0.6
TOTAL	168	100.0%

Table 13. The number and percentage of species of subgroups of Mollusca, Arthropoda and Echinodermata collected by commercial trawl in the northeast Gulf of Alaska (NEGOA) on the M/V *North Pacific*. Collections made May-August, 1975.

Phylum	Subgroup	No. of Species	% of Species
Mollusca	Gastropoda (snails, nudibranchs)	24	51.1
	Pelecypoda (clams, scallops)	18	38.3
	Cephalopoda (ootopus, squid)	4	8.5
	Polyplacophora (chitons)	1	2.1
	TOTAL	47	100.0%
Arthropoda	Decapoda (crabs, shrimp)	36	85.7
	Thoracica (barnacles)	4	9.5
	Isopoda	2	4.8
	TOTAL	42	100.0%
Echinodermata	Asteroidea (sea stars)	24	66.7
	Ophiuroidea (brittle stars)	5	13.9
	Echinoidea (sea urchins)	3	8.3
	Holothuroidea (sea cucumbers)	3	8.3
	Crinoidea (feather star)	1	2.8
	TOTAL	36	100.0%

dominated in species representation with 47 and 42 species taken respectively. Molluscs were represented by 28 families; the Family Neptuneidae was most common with *Colus halli, Neptunea lyrata* and *Pyrulofusus harpa* dominant. The greatest abundance of *Neptunea lyrata* was found at Station 89-A (Fig. 3; also see Annual Report for Demersal Resources) with 32.4 kg (71 pounds) taken per hour. The gastropod *Arctomelon stearnsii*, which is considered rare in museum collections (Rice, 1973), was relatively common at the Gulf of Alaska stations occupied. The scallop *Pecten caurinus* was generally present in the nearshore stations from Kayak Island to Icy Bay. Station 83-E provided the largest total catch of scallops with 116 kg (226 pounds) taken per hour. Among the decapod crustacean representatives, the families Pandalidae, Crangonidae, Paguridae and Majidae were most abundant. *Chionoecetes bairdi* of the family Majidae normally comprised a considerable portion of the invertebrate biomass, e.g. as much as 1342.8 kg (2960 pounds) taken per hour. The pink shrimp *Pandalus borealis* also consistently made up an important segment of the invertebrate biomass, e.g. as much as 167.7 kg (370 pounds) taken per hour. The asteroids made up a conspicuous portion of the echinoderm benthic fauna of the area under discussion.

The stations showed a considerable diversity of species (up to 22 species at one station), and generally a small number of individuals of each species. The sea star *Ctenodiscus crispatus* was an abundant and widely distributed sea star. The greatest density of this small asteroid (average weight of 10 grams) was found at stations 73-D and 80-B with 55 kg (121 pounds) and 5581 specimens taken per hour. This sea star was normally found on muddy bottoms with its stomach full of mud. *Pycnopodia helianthoides* was another widely distributed sea star. One hundred and ninety (190) of these large sea stars (average weight of 0.453 kg or 1 pound) were taken at station 93-C. Several of the stomachs of these sea stars were examined, and it was determined that *Ctenodiscus crispatus* and the brittle star *Ophiura sarsi* were the most frequently occurring food items. Other food items of lesser importance used by *P. helianthoides* in order of diminishing frequence of occurrence are the gastropods *Colus halli*, *Mitrella gouldi*, *Solariella obscura*, *Oenopota* sp., and *Natica clausa*, and the pelecypods *Serripes groenlandicus* and *Clinocardium ciliatum*.

Another dominant echinoderm in the trawl catch was the brittle star *Ophiura sarsi*. This echinoderm was found throughout much of the surveyed area; it was most abundant at station 81-D. At the latter station, an estimated 125,000 specimens (57.7 kg or 127 pounds) were taken in a one hour drag.

C. Cod Stomach Contents

The dominant means of sampling fish stomachs was from king crab pots during the 1972, 1973, and 1974 ADF&G King Crab-Snow Crab Indexing Studies. During this time, 2019 Pacific cod were examined from a sample of 8302. Cottids and miscellaneous fish stomachs were also inventoried. For comparison of diets between trawl-caught and pot-caught cod, a sample of 59 Pacific cod was obtained from the bottomfish trawl.

The diversity of the diet of the various fishes examined were identified as belonging to nine phyla, 14 classes, four orders, 19 families and 49 genera. Molluscs, crustaceans and fishes were the dominant food of all fishes. All phyla were arranged in phylogenetic order according to Hyman (1949, 1951) (Table 14).

Table 14. Frequency and percent of occurrence of specific food items in stomachs of *Gadus macrocephalus* (Pacific cod) as related to Alaska Department of Fish and Game Indexing Studies: 1972, 1973 and 1974. N=stomachs examined.

Food Items	1972:N=147		1973:N=689		1974:N-1183	
	Number	Percent	Number	Percent	Number	Percen
Coelenterata						
Hydrozoa (hydroids)	-	-	2	0.2	-	-
Anthozoa (anemones)	-	-	5	0.7	3	0.3
Mollusca[1]						
Amphineura (chitons)	1	0.6	-	-	1	0.1
Pelecypoda (clams, mussels, cockles)						
Cardita crassidens	-	-	1	0.1	1	0.1
Clinocardium sp.	-	-	1	0.1	-	-
Glycymeris subobsoleta	-	-	1	0.1	-	-
Hiatella arctica	-	-	1	0.1	-	-
Macoma expansa	-	-	1	0.1	-	-
Macoma sp.	-	-	1	0.1	1	0.1
Musculus olivaceus	-	-	1	0.1	1	0.1
Nucula tenuis	-	-	1	0.1	-	-
Nuculana fossa	-	-	7	1.0	43	3.6
Panomya ampla	-	-	1	0.1	-	-
Psephidia lordi	-	-	1	0.1	-	-
Velutina velutina	-	-	1	0.1	-	-
Yoldia beringiana	-	-	2	0.2	-	-
Yoldia spp.	-	-	28	4.0	6	0.6
Unidentified	13	8.8	15	2.1	27	2.3
Gastropoda (snails)						
Amphissa columbiana	-	-	1	0.1	-	-
Buccinum sp.	-	-	1	0.1	-	-
Cylichna alba	-	-	1	0.1	-	-
Fusitriton sp.	-	-	1	0.1	-	-
Natica aleutica	-	-	1	0.1	2	0.2
Neptunea sp.	-	-	1	0.1	-	-
Polinices sp.	-	-	2	0.2	1	0.1
Trichotropis cancellata	-	-	1	0.1	1	0.1
Turridae	-	-	1	0.1	-	-
Unidentified gastropods	5	3.4	6	0.8	26	2.2
Cephalopoda						
Octopus - squid	11	7.4	53	7.6	109	9.2
Annelida						
Polychaeta						
(segmented worms)	8	5.4	15	2.1	63	5.3

Table 14. Continued

Food Items	1972:N=147		1973:N=689		1974:N-1183	
	Number	Percent	Number	Percent	Number	Percent
Arthropoda						
Crustacea						
Malacostraca						
Euphausiacea (krill)	1	0.6	20	2.9	34	2.9
Isopoda (pill bugs)	-	-	3	0.4	4	0.3
Amphipoda (sand fleas)	30	20.6	192	27.8	195	16.5
Decapoda						
Pandalidae (shrimp)	4	2.7	67	9.7	118	10.0
Crangonidae (shrimp)	1	0.6	77	11.1	95	8.0
Unidentified shrimp	55	37.4	131	19.0	82	6.9
Lithodidae (crabs)						
Paralithodes camtschatica	-	-	2	0.2	9	0.8
Paguridae (hermit crabs)	5	3.4	24	3.4	21	1.8
Cancridae (crabs)						
Cancer oregonensis	1	0.6	4	0.5	1	0.1
Telmessus cheiragonus	-	-	1	0.1	-	-
Pinnotheridae (pea crabs)						
Pinnixa occidentalis	1	0.6	5	0.7	36	3.0
Majidae (spider crabs)						
Chionoecetes bairdi	49	33.3	281	40.7	428	36.2
Hyas lyratus	5	3.4	13	1.8	44	3.7
Oregonia gracilis	4	2.7	-	-	3	0.3
Unidentified crabs	2	1.3	12	1.7	3	0.3
Echinodermata						
Asteroidea (starfish)	-	-	1	0.1	2	0.2
Echinoidea (sea urchins)	-	-	1	0.1	-	-
Holothuroidea (sea cucumbers)	1	0.6	2	0.2	5	0.4
Ophiuroidea (brittle stars)	-	-	-	-	3	0.3
Chordata						
Urochordata	1	0.6	-	-	-	-
Vertebrata						
Osteichthyes						
Clupeidae (herring)						
Clupea harengus pallasi	5	1.7	6	0.8	1	0.1
Osmeridae (smelts)	-	-	3	0.4	2	0.2
Gadidae						
Theragra chalcogramma	1	0.6	7	1.0	13	0.9
Gadus macrocephalus	1	0.6	12	1.7	32	2.7
Zoarcidae (eelpouts)	5	3.4	29	4.2	9	0.8
Scorpaenidae (rockfish)	-	-	1	0.1	1	0.1
Cottidae (sculpins)	1	0.6	8	1.1	27	2.3
Cyclopteridae (lumpsuckers)	-	-	1	0.1	1	0.1
Pleuronectidae (flatfishes)	4	2.7	22	3.1	21	1.8

Table 14. Continued

Food Items	1972:N=147 Number	 Percent	1973:N=689 Number	 Percent	1974:N-1183 Number	 Percen
Vertebrata						
Osteichthyes						
Ammodytidae (sand lance)						
Ammodytes hexapterus	-	-	20	2.9	20	1.7
Stichaeidae (pricklebacks)	-	-	14	2.0	-	-
Crypacanthodidae (wrymouth)						
Lyconectes aleutensis	4	2.7	9	1.3	4	0.3
Unidentified fish	22	14.9	256	37.1	476	40.2
Stomachs empty	6	4.0	39	7.6	59	5.0

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[1] All mollusc identifications were verified by Mr. Rae Baxter, Alaska Department of Fish and Game, Box 96, Bethel, Alaska.

To determine the frequency of occurrence of food items, the number of individual samples were recorded in which each kind of food item was found. The results have been expressed as the number and percent of stomachs containing various food items from the total number of stomachs analyzed.

During the 1972 Indexing Charter, 135 stations were fished by the M/V *Peggy Jo*; 1326 cod were landed, and 147 were examined. Food items which occurred most frequently in this sample were shrimp, snow crabs, amphipods and unidentifiable fish (Table 14).

While fishing at 236 stations in 1973, 1833 cod were caught of which 689 were examined.

In 1974, 172 stations yielded 5143 cod of which 1183 were examined.

In order of decreasing importance, snow crabs, fishes, amphipods, and shrimp were the organisms most frequently occurring in cod stomachs (Table 14). Molluscs were commonly found in stomachs. Identification of molluscs were made to genus and species in 1973 and 1974. The number of genera that were identified as pelecypods and gastropods was 12 and 8 respectively.

Although polychaetes were not an abundant food item, their percentage of occurrence declined by one-half in 1973.

Crustaceans were unquestionably a major food of codfish. Euphausids and amphipods increased in frequency of occurrence in 1973. During this year more shrimp were identified to the families Pandalidae and Crangonidae yielding a decline in the percentage of unidentified shrimp.

Crabs such as the king crab, *Paralithodes camtschatica*, and crabs belonging to the families Cancridae and Pinnotheridae were an uncommon article of food of the Pacific cod. Of the crabs belonging to the family Majidae, only the snow crab *Chionoecetes bairdi* was frequently consumed.

Eleven families of fishes were represented in cod stomach contents. Among the fishes, eelpouts (Zoarcidae) and flatfishes (Pleuronectidae) were the most abundant. Fishes which remained unidentified in 1972, 1973 and 1974 ranked highest at 14.9, 37.1 and 40.2 percent respectively.

All cod were caught between 11 and 230 meters with the highest catch per unit of effort occurring between 191 to 210 meters. The general trend was for cod to increase in size with increasing depth. The depths between 65 to 82 meters was most heavily fished with the deeper water, 191 to 210 meters, receiving the least effort.

Because the 1973 and 1974 Indexing Charter resulted in the most extensive data, special attention has been focused on these data. Codfish were divided into three size groups (30 to 49 cm, 50 to 69 cm, and 70 to 89 cm) and the percentage of occurrence of food items were enumerated within each group. Feeding trends which are characteristic of most gadiformes were found here. Fishes, echinoderms, crabs, shrimps, molluscs, cephalopods, and empty stomachs increased in frequency per stomach with increasing cod size. Euphausids and amphipods decreased in percentage of occurrence with increasing fish size. Isopods and annelids showed little change with cod size.

The trawl-caught cod yielded some interesting results. Nematodes were often found in the lower region of the stomach, yet not always recorded in pot-caught cod. The fact that nematodes were often located at the junction of the stomach and intestine made recognition difficult upon evisceration. Also due to the fact that nematodes are parasites, the examiners did not deem them worthwhile to record.

The fifty-nine cod stomachs which were obtained by the R/V *John N. Cobb* south of Kodiak Island were closely examined for the presence of nematodes. All fifty-nine stomachs contained from three to twelve nematodes per stomach. This small sample with 100 percent infestation may indicate some degree of parasitism in *Gadus macrocephalus*.

While the degree of infestation of nematodes was high in the R/V *John N. Cobb* sample, amphipods were only present in 5 percent of the cod examined. Paulsen (1918) reports that amphipods are often the primary host of nematodes. It is assumed that infestation of cod occurs when cod are smaller and feeding more intensively on amphipods.

Among the organisms which increased in percentage of occurrence in trawl-caught cod were octopus and shrimp. Amphipods were the outstanding food item which declined in trawl-caught cod. The item in which the percentage of occurrence remained similar to pot-caught cod was the snow crab *Chionoecetes bairdi*.

VII. DISCUSSION

A. Performance of the 0.1 m^2 van Veen Grab

The van Veen grab was a suitable instrument for sampling the soft sediments characteristic of the shallow shelf of the Gulf of Alaska; the grab typically collected large volumes of sediment. Volumes of 12 to 18 ℓ are indicative that the instrument is penetrating the surface sufficiently to obtain a good proportion of the infauna. Lie (1968) indicates that 1 cm penetration of the 0.1 m^2 van Veen grab will collect 1 ℓ of sediment, and states that a digging depth of at least 4 cm should be attained to assure a good representation of the fauna. He was able to accomplish this on all muddy bottoms; a situation that was also true for our grab sampling activities in the Gulf of Alaska. Sufficient penetration occurred on all of our stations except three -- station 30, with sandy bottom, and stations 26 and 29, with sand-gravel bottoms. The compact nature of the sediment at the former station resulted in 1 to 2 ℓ samples on several tries in the July 1974 cruise (cruise 193), and the station was ultimately abandoned with only 1 grab retained for qualitative analysis. Further sampling at this station in February 1975 resulted in somewhat larger samples, but most of the grab volumes were not over 3 ℓ. Six replicates were taken at this time. The replicability of species composition and numbers at each grab suggest that station 30 will be useful for quantitative analysis despite the small volumes taken at each grab. Most certainly station 30 will be valuable for species composition assessment over a time course (see Feder and Mueller, 1975; data on magnetic tape for current year of investigation).

B. Number of Grab Samples Per Station

One of the primary objectives of the first year of study concerned a qualitative inventory and census of dominant species. In view of projected limited ship time, it was decided to restrict the number of replicate samples to three to ensure maximum coverage of the study area. Three replicates were adequate to sample the most abundant species in similar soft sediments in Port Valdez, recruitment of numbers of individuals in subsequent samples represented members of less abundant species (Feder *et al.*, 1973). The general applicability of the Port Valdez analysis to the Gulf of Alaska was tested in the second year by taking 8 to 10 replicates at a variable number of selected stations. This data is to be analyzed by the grab-sampling simulation program developed by Feder *et al.* (1973). In addition, replicates at each station will be examined for variance about mean values (numbers of individuals of each species) as a further check on the number of replicates needed to describe a station. The latter check is essential in view of the patchiness of the fauna detected at most stations. This analysis will be presented in the Final Report for the 1975-76 contract period.

Five replicate samples per station have been suggested by Longhurst (1964) and Lie (1968) and further corroborated by the investigations of Feder *et al.* (1973). Thus, initiation of five grabs per station was begun on the cruise of May, 1975; this number of replicates was taken on all subsequent cruises, and will be continued until analysis of optimum replicate values is completed this year.

C. Station Coverage

The intensive grab-sampling program now in progress over the shelf from Yakatat Bay to Resurrection Bay and from lower Cook Inlet to Unamak Pass is the most comprehensive one carried out by an American research group to date. A somewhat parallel study by the Soviet Union, extending from the southern terminus of the Kenai Peninsula to Cape Spencer, is available from an earlier period for comparative purposes (Semenov, 1965). Although the latter study is broad, the bases for calculations used by the author (i.e. the station data -- number of replicate samples per station, the species taken per replicate, the number of individuals of each species taken per replicate, and the biomass for each species per replicate) are lacking. Thus, precise quantitative comparisons will not be possible. Preliminary review of Semenov (1965) and other published work from the Gulf of Alaska will ultimately be available at the end of the next study year (Feder, 1975). Specific benthic data for a restricted area around two potential oil-drilling sites are available in Bakus and Chamberlain (1975).

Since grab station coverage was only as intensive as allotted ship time, weather conditions, and sample workup in the laboratory would permit, it is recognized that vast unsampled areas exist in the study areas. It is possible that some unsampled regions support significant populations of hitherto uncollected benthic species, but our experience of the past two years in the Gulf suggests that most, if not all, of the common infaunal species may have been taken at the occupied stations (based on qualitative assessment of Appendix Table III in Feder and Mueller, 1975 and current year's data on magnetic tape). Nevertheless, additional stations will be occupied whenever ship time and weather permit. Additional coverage was accomplished with two new stations (68 and 69) established off Montague Island and stations 37, 60, 61, 62, 63 occupied.

The trawl program permitted further coverage of the lease area, and made it possible to collect the more motile, as well as the larger, epifaunal species. The integrated trawl program (demersal fish, benthic invertebrates, fish stomach analysis, meristic analysis of fish species, trace metal, and hydrocarbon programs) represents a significant supplement to the data collected in early the first year by way of grab samples only, and should broaden the data base ultimately to be used to understand the shelf ecosystem.

The major limitations of the survey were those imposed by the selectivity of the other trawl used, and the seasonal movements of certain species taken. Otter trawls of the type used can be fished only on relatively smooth bottom that are free. Thus, rocky-bottom areas were never sampled.

It is impossible to return all invertebrates to the laboratory for verification, therefore, it is difficult to get total numbers and weights of every species found especially those species that are very similar. However, by careful development of conversion factors in the laboratory, it has been possible to make total numbers and weights available for all stations occupied.

The intensity of the demersal fish program, the necessary on-board lower priority given to invertebrate weighing and counting activities, and the multiple role occupied by the benthic biologist on the vessel (i.e. identify, count, weigh as many invertebrates as possible per station, collect -- in cooperation with the biologists of the demersal fish program -- many species of fishes for stomach and meristic analyses, sample specific species for both the hydrocarbon and trace metal programs) made it difficult for him to do much more than collect species distribution and density data. Weight data were obtained, but this was initially spotty and only accomplished on a time-as-available basis (Appendix Table VIII in Feder and Mueller, 1975, and Appendix Table III). Little effort (in fact little time was available) was devoted to collection of sizable invertebrate samples for recruitment, growth age and feeding studies. It should be emphasized that support of a demersal fish trawling program is essential if a total, integrated understanding of the trophic-dynamics of the benthos is to be gained. Lack of additional trawl time will distinctly narrow the scope of the overall benthic program, and will hamper the development of an offshore monitoring plan.

D. Species Composition of the Stations

Species have been added in the second year by way of additional field and laboratory activity. The general distribution of benthic species in the projected lease area is now well documented (present investigation and Semenov, 1965) (see Feder and Mueller, 1975 Appendix Tables I, II, III, VII, and VIII, and data on magnetic tape from the current year of investigation). A variety of infaunal groups contribute to the biomass at stations sampled by grab (Appendix Table V in Feder and Mueller, 1975 and current data on magnetic tape). Members of the major marine phyla were collected in both investigations. Polychaetous annelids were the most important infaunal group collected by the grab-sampling program (Table 3 and Appendix Table IV in Feder and Mueller, 1975; current data on magnetic tape); similar results are also reported for Port Valdez, Prince William Sound (an embayment of the Gulf of Alaska with similar fine sediments in its fjords and bays) (Feder *et al.*, 1973). The molluscs and crustaceans were the major epifaunal invertebrate groups taken by trawl in our investigation. Sizable biomasses of echinoderms, especially sea stars, were typical of most of the trawl station samples, and many of the species were sufficiently abundant to represent suitable organisms for in-depth investigations of their biology. Availability of sufficient numbers of the latter types of organisms are a preliminary requirement for development of satisfactory monitoring schemes and acquisition of suitable predictive capabilities for stressed benthic systems.

Qualitative examination of the species composition at various grab stations by way of such listings as are included in the Results section of Feder and Mueller (1975) and data on magnetic tape for this year's program suggests distinct regional differences in species and biomass. However, widely dispersed or ubiquitous species are also apparent. Perhaps one of the obvious features of most stations is the patchiness of the infauna. Examination of infaunal species composition at stations occupied on separate sampling dates (e.g. stations 42, 44, 50, 52, and 55) indicates species common to each series of grabs, but also demonstrates omissions or addition of certain species on the two dates. As suggested in the section entitled, Number of Grab Samples Per Station, some of this patchiness of station variance will be damped out with more intensive sampling at each station. In addition, utilization of quantitative techniques to demonstrate the presence of species aggregates during the past year have already clarified some station differences; such an approach is to be pursued further during the balance of the year (see Feder *et al.*, 1973 for use of a Cluster Analysis technique to delineate groups of benthic species in Port Valdez), and is further discussed below.

E. Diversity Indices

It is generally accepted that an altered environment will result in changes in numbers of species and the population densities of these species (Pearson *et al.*, 1967). Thus, examination of species diversity can often serve as a basis for comparison in the future. In order to avoid subjective appraisal, a quantitative measure of diversity must be used. Such a measure should typically consider the number of species present, as well as the density of each species. Various diversity indices are available and at least two different types should be used to give the greatest insight into the faunal conditions present (Lloyd *et al.*, 1968). The indices included in this report, are complementary since the Simpson Index reflects dominance of a few species and the Shannon and Brillouin indices are weighted in favor of rare species. Values included in this report tend to reflect these weightings. However, the calculated indices should be interpreted with caution, and no comparisons made until more data is available for each station. Although in most cases, samples taken at stations on separate occasions have approximately the same indices for the sampling periods, there are exceptions. Presumably differences in indices with time reflect the general problem of patchiness of infauna; however, the possibility of changes in species composition over the sampling time period cannot be overlooked. An in depth interpretation of diversity and evenness values calculated from Gulf stations will be included in the Final Report for 1975-1976.

F. Biologically Important Taxa

As suggested by Lie (1968), "Most animal communities are so complex and rich in species that it is necessary to make a choice of the species that supposedly are most important to the communities and subject them to detailed analysis". Such species have been variously termed "characterizing species" (Thorson, 1957), and "ecologically significant species" (Ellis, 1969). The criteria used for selection of such species vary; criteria used in this investigation for distinguishing infaunal taxa of biological importance are listed in the section on Methods. See Appendix Table II for compilation of all of the species designated as Biologically Important, and Feder *et al.* (1973) for further discussion on the application of this concept to species in Port Valdez.

The initial printout of taxa of biological importance is a large one. Additional assessment of this list may prove necessary in order to pare the number of taxa to a size that will be workable in computations essential to quantitative assessment of species groupings at benthic stations. Nevertheless, it is apparent that a large number of species occupying diverse ecological niches are available to monitor once industrial activity in the Gulf becomes a reality.

G. Feeding Methods

Initial information was presented by Feder and Mueller (1975) for the feeding methods used by the majority of the infaunal species collected. This information is basically a literature compilation, but some unpublished data are included as well. The fact that most of the food data presented in Appendix Table VI in the above report is based on literature extrapolations from related species or the same species from other areas emphasizes the paucity of data on the feeding biology of Gulf fauna. This lack of basic data also dictates the urgency of immediate support of food studies and experimental work on selected species from the benthos and elsewhere in the waters of the Gulf.

Some insights into feeding biology can be gleaned from food analyses on collected and presently archived grab material. Particular attention should be paid to brittle stars and sea stars, two taxa occurring in great density in some areas (see Appendix Table VIII in Feder and Mueller, 1975 and data on magnetic tape for current project).

Two other echinoderm species of considerable interest are the sea star *Ctenodiscus crispatus* and the large sea cucumber *Molpadia* sp. Both of these species are non-selective deposit feeders, and pass large amounts of unsorted bottom material through their digestive tracts. The former species ingests surface deposits, but the latter species is continually reworking deeper deposits. Thus, both species are probably important in their particular areas in terms of recycling nutrients and petroleum hydrocarbons that might otherwise be trapped in the sediments.

In a bottom trawling survey of the northeast Gulf of Alaska, Hitz and Rathjen (1965), reports that the deposit-feeding heart urchin, *Brisaster townsendi* accounted for about 50 percent of the invertebrate catch, i.e. as high as 534 kg (1177 pounds) per hour. *Brisaster townsendi* that were collected by the M/V *North Pacific* was also found in the same areas as reported by Hitz and Rathjen (1965), i.e. in Kayak Canyon, Icy Canyon and in particular

Yakutat Canyon. Station 97-C yielded the largest catch of this urchin at 212.7 kg (469 pounds) per hour or 21,272 urchins per hour. As a canyon dweller they can take fullest advantage of deposit feeding by living in an area where food particles are more readily carried and deposited by prevailing currents.

Some preliminary information on feeding habits of fishes was obtained in the trawl survey on the M/V *North Pacific* at several stations. Stations 94-A and 94-B (Fig. 3) were noteworthy for their large abundance of two species of fishes and the near-absence of invertebrate; this was especially true for the latter station. The starry flounder, *Platichthys stellatus*, dominated these two stations with 94-B yielding 3549 kg (7824 pounds) of these fishes per hour (average weights 2 kg). Preliminary examination of stomach contents in *P. stellatus* revealed three lamellibranchs, *Yoldia seminuda, Siliqua sloati* and *Macoma* sp. Lamellibranchs were the only food item found in the 35 stomachs examined. All stomachs were full. There appears to be a definite seasonal trend in feeding intensity for *Platichtyhs stellatus* (Miller, MS 1965). Around January (month of the lowest bottom temperature) feeding stops and does not begin again until about June. The fullness of the stomachs of the starry flounder on 3 June in the Gulf of Alaska may be evidence of a recently terminated fasting period. In view of the large population of this potentially important commercial species that feeds predominantly on clams (Orcutt, 1950; Miller, MS, 1965; our study for the Gulf of Alaska) in the vicinity of stations 94-A and 94-B, it seems reasonable that the areas in the vicinity of these stations with their abundant clam populations might play a vital role in the trophic dynamics of *P. stellatus*.

A second species of interest was the large catch of juvenile (approximately 10 cm long) Walleye Pollock, *Theragra chalcogramma*. Station 94-B yielded approximately 544 kg (1199 pounds) per hour. Thus, this area may be ecologically important in terms of supporting another potentially commercial species or as a developmental area for a species which is known to be an important trophic link in the North Pacific (Chang, 1974; Kamba, 1974; Takashi and Yamaguchi, 1972).

The data from station 74-C is also of considerable interest. At this station was wide diversity of invertebrates and a high abundance of Pacific Halibut, *Hippoglossus stenolepis*. Of the 47 species of invertebrates that were found, 85% of the species were Molluscs (13 species), Crustaceans (14 species) and echinoderms (13 species). The biomass of the ascidian, *Halocynthia aurantium*, was 419.8 kg (925 pounds) per hour. The halibut occurred at the rate of 1398.8 kg (3084 pounds) per hour. Each fish average 18.5 kg or 41 pounds. Regrettably, stomachs were not obtained at this station so it is not known what organism(s) they are feeding on.

H. Food Habits of the Cod

Preliminary analysis indicated that the relative importance of various items of food changed with size of cod.

The principal food group for cod at all sizes were fishes, crustaceans, and molluscs. There were some small quantities (less than 10% of the total occurrence) of coelenterates (= cnidarians), annelids, euphausids, isopods and echinoderms.

This study has resulted in findings similar to other studies on gadiformes, i.e., fishes are less likely to occur in abundance as food in small cod and as the cod size increases so does its diet toward fishes. During the 1973 and 1974 ADF&G Indexing Study, the frequency of occurrence of fish in 30-49 cm cod was 32 percent. At 50-69 cm length, the percentage of occurrence had risen to 54 and finally the frequency in the 70-89 cm cod size was 65. Clearly this shows that as cod increases in size, its need for food must be met in the most efficient way, i.e., larger organisms rather than a large quantity of smaller organisms.

Larger crustaceans of crab and shrimp increased as a food item in the same manner as fishes. Although the percentage of occurrence of shrimp increased with increasing cod size, the percent increase from the smallest size, 30-49 cm, to the largest size, 70-89 cm, was less than 10 percent. Similarly, the percentage of occurrence increased in crabs from 50-69 cm to 70-89 cm at less than three percent. The greatest increase in percentage of occurrence of crabs as a food item is seen from the smallest size, 30-49 cm, to the intermediate size group of 50-69 cm. Here is found an increase from 39 to 49 percent respectively. The commercially important crab, *Chionoecetes bairdi* was by far an important food item for the cod.

Smaller crustaceans such as euphausids, isopods and especially amphipods decreased in percentage of occurrence with increasing cod size. Only nine cod stomachs out of 192, at the 70-89 cm size group, contained amphipods as opposed to 207 stomachs out of 537 at the 30-49 cm size group.

Upon examining 1500 haddock from Georges Bank, Clapp (1912) found 68 species of molluscs. During the 1973 and 1974 indexing study many species of molluscs were also found such as the pelecypods *Yoldia* spp. and *Nuculana fossa*. These two genera are remarkably similar in size and appearance. All summers also yielded relatively high percentage of occurrence of octopus. Generally, the octopus itself had been digested completely and the beak was the only identifiable part which remained. Occasionally squid beaks were found.

In comparison of food between cod, sculpins and miscellaneous fishes (Jewett, unpublished data), it can be generally stated that the cod is the most voracious species. It is interesting to note that cod and cottids are cannibalistic, i.e., among foodfish they feed occasionally upon their own kind. Sculpins were also found to seek out non-commercial crabs more frequently than did cod or other miscellaneous fishes. Numerous species of molluscs were also found in bullhead stomachs as well as cod from the 1973-1974 sample. The food items which were found to be most frequent in sculpins were amphipods and secondly crabs, chiefly *C. bairdi*.

Information pertaining to food of miscellaneous fishes was difficult to assess. Fishes seemed to be dominant forage item. However, often as fish were ascending in the pots and while on the deck, they would regurgitate part or all of their stomach contents thus making it difficult to enumerate food items.

Upon analysis of food with regards to sex, Homans and Vladykov (1954) reported there was no significant difference in the feeding rate between sexes of haddock on the offshore Nova Scotian banks. Also observations by Wigley (1956) of several hundred haddock from Georges Bank did not disclose any obvious differences between sexes in stomach-content volume. Powles (1958) found no appreciable difference between the diets of small male and female cod (*Gadus callarias L.*). Wigley and Theroux (1965) also arrived at the same conclusions, that there were no statistically significant differences between sexes in stomach-content weight of haddock. Similarily, data of the present study also did not lend itself to any major differences in feeding habits between sexes of *Gadus macrocephalus*.

I. Computerized Data Output

The major goals set for data management have been achieved. All infaunal taxa were given a code number according to the 10 digit VIMS code (Mueller, 1975; Swartz *et al.*, 1972), data for all species from the July, October, November, February, and May cruises have been key punched, a printout has been generated that lists all species, and an additional printout with all available data on numbers and weights of collected species has been generated. The speed necessary to complete the OCS Annual Report deadline resulted in some minor errors in the final computer printout, but these errors do not retract from the value of the printout as a preliminary document.

J. Cluster Analysis of Grab Data

While it should be emphasized that the results of the preliminary cluster analyses are based on an incomplete coverage of the study area, and have not been subjected to intense scrutiny as yet, certain trends can be discerned. First, there is a fairly close similarity between the station groups formed using three different classification schemes (Figs. 44, 48, and 50). In each of these cases, three basic groups are distinguished; Group I which is characterized by a group of stations primarily south of Prince William Sound, Group II, generally a pair of stations close to shore, and Group III, stations which are at or near the shelf break. As we progress from a classification scheme using the Sørensen coefficient and average linkage sorting (Figs. 43 and 44) through one using the Motyka coefficient, single linkage (Figs. 47 and 48) to one using the Motyka coefficient using average linkage sorting (Figs. 49 and 50) there is an increase in the sensitivity of the classification as well as rearrangement of the station groups. For example, station 57 is included in Group III in the Sørensen, average linkage classification (Figs. 43 and 44) but splits out of this group and doesn't cluster in the other two classifications (Figs. 48 and 50). Examination of the species which characterize this station (Table 10) indicate that there are distinct differences between it and the stations in Group III and it appears to occupy a transition area between Group I and Group III. In addition, the Motyka, average linkage classification, (Fig. 50) spilts Group I of the Sørensen, average linkage classification (Fig. 44) and the Motyka single linkage classification, (Fig. 48) into the groups, I and V.

An examination of the two way coincidence table of station groups *vs* species groups determined by normal and inverse analysis using the Motyka coefficient and, average linkage sorting (Table 10) indicates that:

1. Station Group III, which is composed of 4 stations near the shelf break (Fig. 48) is characterized by large number of individuals in species Group I (Table 10) and species Group V (Table 10).
2. Station Group IV (station 57) appears to be characterized by species Groups II and IV (Table 10). Station 57 contains many species in common with station Group III (shelf break stations) and station Groups I and V which form a clump of stations just south of Prince William Sound. However, those species that characterize station Group III (i.e. species Group I) are found in smaller numbers in station 57. This may indicate that they are existing near the limits of their environmental tolerances.
3. Species in species Groups I, II, III and IV are almost exclusively restricted to station Groups III and IV which obviously indicates

that there are some favorable conditions existing at these stations not present elsewhere; thereby, enabling these species to become more abundant in these areas.

4. Stations Group II is characterized primarily by high numbers of species Groups IV and V. Station Group II is similar to station Groups I and V except that station Group II (station 41 and 42) contains fewer species and individuals per species in species Groups VI, VII and VIII.
5. The primary difference between station Groups I and V (which overlap geographically) appears to be that station Group V contains fewer species and fewer individuals per species in species Groups IV through VIII.

As a result of weather conditions and the unsuitability of R/V *Acona* for grab sampling in the Gulf of Alaska, samples taken over the period July 1974 through February 1975 had to be pooled to increase coverage of the study area for purposes of analysis. Thus, several stations (i.e. 42, 44, 50, 52, and 55) included in the cluster analyses were sampled at two different periods of time. These stations often did not cluster together (Figs. 49 and 50), either due to temporal variations in the species assemblages or inadequate sampling of the station. Results of the grab simulation program (see Feder *et al.*, 1973) and calculation of confidence limits for 10 grab samples (to be available at the end of the project period), should provide some insight into the sampling variance. Hailstone (1972) quoted in Stephenson *et al.* (1972) surveyed the sublittoral fauna at the mouth of the Brisbane River at monthly intervals and delineated site groups and species groups through classification and two way coincidence tables.

Hailstone found that both site groups and species group changed from month to month. Williams and Stephenson (1973) developed a method for analyzing three dimensional matrices (sites x species x times). Since their matrices were based on an analysis of variance model, they were able to partition the variance into that due to site/species, times/species and sites/times interactions. This allowed them to give relative "importance" values to the matrices of site/species, times/species, and sites/times as well as being able to classify these interactions by cluster analysis (see Clifford and Stephenson, 1975; Stephenson *et al.*, 1972 for a discussion of this method). Such an approach is planned for the available grab data, and preliminary analysis may be available at the end of the project period.

Pollutants were recorded on the first two legs of the M/V *North Pacific* cruise which covered an area from Montague Island to Yakutat Bay. Thirty-three (33) stations out of 58 (57%) contained trash which consisted primarily of plastic materials such as brown and green trash bags, pieces of clear plastic (bait wrappers), and plastic straps which are used as a binding material. Numerous plastics had Japanese or Korean identification on them. A variety of other pollutants consisted of tarred paper, bottles, a steel cable, rubber gloves, a rubber tire and two derelict snow crab pots. This high frequency of occurrence of pollutants within the surveyed area may give some feeling to the amount of pollution throughout the North Pacific.

VIII. CONCLUSIONS

Forty-two widely dispersed permanent stations have been established in the northeastern Gulf in conjunction with the physical, chemical, heavy metals and hydrocarbon programs. These stations represent a reasonable nucleus around which a monitoring program can be developed.

Twenty-nine widely dispersed stations were established in the northwestern Gulf in conjunction with other programs there. Although substrate characteristics (e.g. compact sand, gravel, rock) of this part of the shelf of the Gulf made it impossible to occupy all planned stations and difficult to quantitatively occupy many of the stations sampled, sufficient information was obtained about the bottom and the fauna to enable us to plan a monitoring program there. However, further sampling with other types of gear is definitely indicated in the northwestern Gulf to finalize such a monitoring program.

The sampling device chosen, the van Veen grab, functioned effectively, in all weather and adequately sampled the infauna at most stations in the northeastern Gulf. Penetration was excellent in the soft sediments characteristic of the majority of stations; poor penetration occurred at a few stations where substratum was sandy or gravelly. Problems concerned with sampling in the northwest Gulf are considered above.

General patchiness of many components of the fauna at the quantitative stations suggests that at least five replicates be taken per station. Quantitative field testing for the optimum number of replicates per station has been accomplished; these samples are being processed at the Marine Sorting Center.

There is now a satisfactory feeling, on a station basis for grab data, for invertebrate species (infauna and epifauna) present and general species distribution on the shelf in the northeast Gulf study area. Three hundred and eleven (311) species have been identified to date. Fourteen marine phyla are represented in the collections. The important groups, in terms of species, in descending order of importance are the polychaetous annelids, molluscs, arthropod crustaceans, and echinoderms. It is probable that all species with numerical and biomass importance have been collected by way of the intensive sampling schedule of the past two years and that only rare species will be added to the list in the future.

Little data is currently available to test for seasonal fluctuations in species by station; no comments can be made at this time. Insufficient ship time was a contributing factor to the inability to occupy stations seasonally.

The diversity indices included in this report, Simpson, Brillouin, and Shannon are complementary to each other since the former reflects dominance of a few species and the latter two are weighted in favor of rare species. Values calculated in this report, in general, reflect these weightings. A preliminary examination of the two measures of evenness (or equitability) indicates a reasonable relationship to the calculated diversity values. In general, as examination of Table 3 indicates, high measures of evenness show numerical codominance of many species (with low Simpson index and high Shannon and Brillouin indices) while low evenness measures imply marked dominance of a few species (high Simpson index and low Shannon and Brillouin indices). All of these indices and measures must still be interpreted with considerable caution until more data is available, and further detailed assessment of the meaning of the calculated values can be made.

Criteria established for Biologically Important Taxa (BIT) for the grab data have delineated 95 species. These species have been subjected to detailed analysis in an attempt to comprehend station species aggregations or communities. Representative members of the BIT will be the organisms most intensively studied for their general biology.

Information on feeding biology of most species has been compiled. Most of this information is from literature source material; it is suggested that experimental work on feeding biology for selected species be encouraged.

Although all of the station data has not been available up to the time of this report and the results of the various types of cluster analysis presented have not as yet been examined in depth, clustering techniques have supplied us with valuable preliminary insights into species distributions on the shelf of the Gulf of Alaska. Using more complete data sets in future calculations should clarify the ecological positions of some of the stations not clustering with other stations on the shelf. The preliminary grouping of stations by three different classification schemes has delineated three basic clusters -- Group I, which is characterized by a group of stations south of Prince William Sound; Group II, which generally consists of a pair of stations close to shore; and Group III, composed of stations that are at or near the shelf break. Further insight into the meaning of stations clustered by our analysis is gained by means of the two-way coincidence table of station groups *vs* species groups. Specific groupings of species can be related to station clusters, and intermediate positions of stations (or clusters) can be determined by the particular groupings of species they have in common.

The joint National Marine Fisheries Service trawl charter for investigation of demersal fishes and epifaunal benthos was effective and maximum spatial coverage was achieved. Integration of this information with the infaunal benthic data will enhance our understanding of the shelf ecosystem.

To date the NEGOA study represents the first intensive taxonomic study of epibenthic invertebrates in the Gulf of Alaska. Although this is not the only data base for epifaunal invertebrates of the Gulf (Hitz and Rathjen, 1965), our work does result in more thorough and more complete numerical and weight determinations.

Preliminary analysis of the data indicates that the commercially important crab, *Chionoecetes bairdi* clearly dominates the invertebrate biomass. Further, stomach analysis of the Pacific cod *Gadus macrocephalus* on the Kodiak shelf area, reveals that *C. bairdi* is a dominant food item. Here we find a non-commercial species which has potential commercial importance, preying intensively on a species of great commercial significance.

In conclusion, it can be stated that sampling by means of grabs, trawls and/or dredges as well as stomach analysis of demersal fishes is necessary in order to fully comprehend trophic interactions in the benthic environment in the North Pacific.

Initial qualitative assessment of data printouts (to be stored on magnetic tape at the National Environmental Data Center) indicates that (1) sufficient station uniqueness exists to permit development of an adequate monitoring program based on species composition at selected stations and (2) adequate numbers of unique, abundant and/or large species are available to ultimately permit nomination of likely monitoring candidates.

IX. NEEDS FOR FURTHER STUDY

1. Although the van Veen grab is satisfactory for the soft sediments characteristic of the shallow shelf of the northeastern portion of the Gulf of Alaska, it is not the instrument of choice for the shelf of the

northwestern Gulf. Additional sampling in the latter area is indicated; a variety of sampling devices must be tested to determine the optimum device.

2. The number of grab stations occupied was dictated by available shiptime and funding essential to complete processing of the samples. Thus, a relatively small number of stations were occupied on the extensive shelf of the Gulf. It is possible that some areas of significant biological importance were omitted. Additional stations should be occupied in the future to develop some baseline data for some of the larger unsampled areas.

3. All samples taken on a semi-seasonal basis in the northeast Gulf should be processed, and all data made available to the general program of study of the benthic stations for the area. Analysis of all archived samples will make it possible to develop better feelings for seasonality of benthic infauna.

4. Selected members of the Biologically Important Taxa (BIT) should be chosen for intensive study as soon as possible so that basic information will be available to a monitoring program. Specific biological parameters that should be examined are reproduction, recruitment, growth, age, feeding biology, and trophic interactions with other invertebrates and vertebrates.

5. The advantage of the cluster analysis technique is that it provides a method for delineating station groups that can be used as a basis for developing monitoring schemes and delimiting areas that can be used for intensive studies of food-web interactions. It is obvious that food webs will vary in areas encompassing differing species assemblages. An inaccurate or even erroneous description of the shelf ecosystem could occur if trophic data collected on species from one station cluster (with its complement of species) is loosely applied to another area encompassing a totally different

station cluster (with its differing complement of species). Thus, continuing development of clustering and other multivariate techniques should be pursued to refine methods to be certain the best methodology is available to the projected offshore monitoring program.

6. It appears that the temporal change in species groups at stations will lead to confusion in the interpretation of station groups if stations are always pooled in time. Williams and Stephensen's (1973) technique (species x time x sites) provides an excellent solution to this problem, but it requires that a study area be completely sampled at least three times per year. Therefore, it is suggested that a suitable research vessel ultimately be made available for such sampling needs. In addition, it should be recognized that funds must then be available to workup the samples and data from these cruises.

7. The extensive trawl program in conjunction with the National Marine Fisheries Service permitted complete coverage of the benthos for invertebrate organisms. Considerable effort is still needed to complete this program in the current contract period, and the following is needed: maps of distribution and abundance for selected species, calculations of Diversity Indices, derivation of a list of Biologically Important Taxa, application of cluster analysis techniques to groups of species and stations, and continuation of cod stomach analyses. The needs for the future are development of a monitoring plan, additional trawl data on a seasonal basis, completion of Pacific cod food study to include workup of all existing cod data (1972-1975; all data available from notes of S. Jewett), and further trawl sampling in the Kodiak area.

X. SUMMARY OF 4th QUARTER OPERATIONS

A. Ship or Laboratory Activities

1. No ship activity
2. Scientific party - not applicable
3. Methods

    a. sediment samples from each station are being analyzed by Dr. A. S. Naidu.

    b. Laboratory analysis of samples from previous cruises are in progress at the Marine Sorting Center. Forty five (45) samples were completed in this quarter.

    c. After extensive examination of the current literature on cluster analysis of benthic invertebrate survey data, two approachs are being tested to determine their capabilities in determining species groups and areal patterns of species groups for data collected during the first year of the benthic biology study for the Gulf of Alaska OCS project. A hierarchial agglomerative cluster analysis adaptable to single linkage (nearest neighbor) and group average sorting strategies has been obtained from Ivan Frohne (computer center). This program will be used with a subprogram that will create similarity matrix using Czekanowski's coefficient and Spatz's quantitative modification of the Jaccard coefficient. The above technique is similar to that used by field and his co-workers (i.e. Field, 1971) except for the use of Spatz coefficient. The coefficient should be more powerful in distinquishing between quantitatively similar samples that show qualitative differences. The above techniques will also be applied to data collected from Port Valdez (Feder *et al.*, 1973) so that it can be compared with the results of the previous cluster analysis performed on that data. In addition we shall utilize the divisive monothetic cluster analysis of Stephenson *et al.* (1970) to analyze the GOA, OCS data. A copy of the paper containing the Algorithms for this technique has been requested *via* interlibrary loan.

d. A bibliography of feeding behavior of polychaetous annelids and of feeding behavior and reproductive biology of selected echinoderms common in the Gulf of Alaska is being compiled.

4. Sample localities - not applicable

5. Data collected - not applicable. Data analyzed - preliminary processing is underway for all of the samples collected on previous cruises.

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APPENDIX TABLE 1.

A selected series of grab stations from the Gulf of Alaska. July 74 through May 1975. Showing species counts and wet weights. The complete data set is on magnetic tape at the National Environmental Data Center.

CRUISE 193 STATION 026 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
3200000000	SPONGES	07/07/74	0002	1	0.74	0.545	16.84	3	1.817	X X X X
3200000000	SPONGES	07/07/74	0002	1	0.74	0.010	0.31	3	0.033	X X X X
		SUBTOTAL		2	1.48	0.555	17.15	7	1.850	
4801010811	POLYCHAETA POLYNOIDAE HARMOTHOE LUNULATA	07/07/74	0002	1	0.74	0.001	0.03	3	0.003	
4801011103	POLYCHAETA POLYNOIDAE LEPIDONOTUS SQUAMATUS	07/07/74	0003	1	0.74	0.003	0.09	3	0.010	
4801120205	POLYCHAETA PHYLLODOCIDAE ETEONE LONGA	07/07/74	0002	1	0.74	0.001	0.03	3	0.003	
4801221001	POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA	07/07/74	0003	1	0.74	0.001	0.03	3	0.003	X
4801221201	POLYCHAETA SYLLIDAE HAPLOSYLLIS SPONGICOLA	07/07/74	0003	3	2.22	0.007	0.22	10	0.023	
4801221201	POLYCHAETA SYLLIDAE HAPLOSYLLIS SPONGICOLA	07/07/74	0002	1	0.74	0.001	0.03	3	0.003	
		SUBTOTAL		4	2.96	0.008	0.25	13	0.027	
4801230404	POLYCHAETA NEREIDAE NEREIS PROCERA	07/07/74	0002	1	0.74	0.005	0.15	3	0.017	
4801230404	POLYCHAETA NEREIDAE NEREIS PROCERA	07/07/74	0001	1	0.74	0.014	0.43	3	0.047	
		SUBTOTAL		2	1.48	0.019	0.59	7	0.063	
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	07/07/74	0001	1	0.74	0.010	0.31	3	0.033	X X
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	07/07/74	0003	1	0.74	0.002	0.06	3	0.007	X X
		SUBTOTAL		2	1.48	0.012	0.37	7	0.040	
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	07/07/74	0001	1	0.74	0.017	0.53	3	0.057	X X X X X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/07/74	0001	3	2.22	0.021	0.65	10	0.070	X X X X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/07/74	0003	1	0.74	0.012	0.37	3	0.040	X X X X
		SUBTOTAL		4	2.96	0.033	1.02	13	0.110	
4801400204	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII	07/07/74	0002	1	0.74	0.001	0.03	3	0.003	X
4801400400	POLYCHAETA PARAONIDAE CIRROPHORUS SP.	07/07/74	0003	1	0.74	0.001	0.03	3	0.003	
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	07/07/74	0003	2	1.48	0.001	0.03	7	0.003	
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	07/07/74	0001	1	0.74	0.001	0.03	3	0.003	
		SUBTOTAL		3	2.22	0.002	0.06	10	0.007	
4801560100	POLYCHAETA OPHELIIDAE AMMOTRYPANE SP.	07/07/74	0003	2	1.48	0.003	0.09	7	0.010	
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS	07/07/74	0003	5	3.70	0.007	0.22	17	0.023	X X
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS	07/07/74	0001	3	2.22	0.014	0.43	10	0.047	X X
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS	07/07/74	0002	7	5.19	0.012	0.37	23	0.040	X X
		SUBTOTAL		15	11.11	0.033	1.02	50	0.110	
4801620102	POLYCHAETA OWENIIDAE OWENIA FUSIFORMIS	07/07/74	0002	1	0.74	0.001	0.03	3	0.003	X
4801620102	POLYCHAETA OWENIIDAE OWENIA FUSIFORMIS	07/07/74	0003	4	2.96	0.005	0.15	13	0.017	X
		SUBTOTAL		5	3.70	0.006	0.19	17	0.020	

CRUISE 193 STATION 026 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT		WET WEIGHT		PER SQ METER		BIT CRITERIA				
				NO.	PCT	GRAMS	PCT	NO.	WWGT					
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	07/07/74	0003	3	2.22	0.005	0.15	10	0.017	X	X		X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	07/07/74	0002	1	0.74	0.002	0.06	3	0.007	X	X		X	
		SUBTOTAL		4	2.96	0.007	0.22	13	0.023					
4801650201	POLYCHAETA AMPHARETIDAE AMPHARETE ARCTICA	07/07/74	0003	2	1.48	0.003	0.09	7	0.010					
4801660702	POLYCHAETA TEREBELLIDAE PISTA FASCIATA	07/07/74	0003	1	0.74	0.001	0.03	3	0.003					
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/07/74	0003	3	2.22	0.010	0.31	10	0.033	X	X		X	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/07/74	0002	1	0.74	0.010	0.31	3	0.033	X	X		X	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/07/74	0001	2	1.48	0.003	0.09	7	0.010	X	X		X	
		SUBTOTAL		6	4.44	0.023	0.71	20	0.077					
4801680201	POLYCHAETA SABELLIDAE EUCHONE ANALIS	07/07/74	0003	1	0.74	0.001	0.03	3	0.003					
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	07/07/74	0001	2	1.48	0.005	0.15	7	0.017	X	X		X	
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	07/07/74	0003	2	1.48	0.003	0.09	7	0.010	X	X		X	
		SUBTOTAL		4	2.96	0.008	0.25	13	0.027					
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA	07/07/74	0002	3	2.22	0.050	1.54	10	0.167		X	X	X	X
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA	07/07/74	0001	1	0.74	0.020	0.62	3	0.067		X	X	X	X
		SUBTOTAL		4	2.96	0.070	2.16	13	0.233					
4904030500	MOLLUSCA PELECYPODA YOLDIA SP.	07/07/74	0003	2	1.48	0.002	0.06	7	0.007		X		X	
4904070201	MOLLUSCA PELECYPODA CRENELLA DESSUCATA	07/07/74	0002	1	0.74	0.005	0.15	3	0.017		X		X	
4904070201	MOLLUSCA PELECYPODA CRENELLA DESSUCATA	07/07/74	0003	2	1.48	0.011	0.34	7	0.037		X		X	
		SUBTOTAL		3	2.22	0.016	0.49	10	0.053					
4904070500	MOLLUSCA PELECYPODA DACRYDIUM SP.	07/07/74	0003	7	5.19	0.014	0.43	23	0.047				X	
4904070500	MOLLUSCA PELECYPODA DACRYDIUM SP.	07/07/74	0002	2	1.48	0.002	0.06	7	0.007				X	
4904070500	MOLLUSCA PELECYPODA DACRYDIUM SP.	07/07/74	0001	4	2.96	0.024	0.74	13	0.080				X	
		SUBTOTAL		13	9.63	0.040	1.24	43	0.133					
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/07/74	0001	7	5.19	0.007	0.22	23	0.023	X	X		X	
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/07/74	0003	4	2.96	0.009	0.28	13	0.030	X	X		X	
		SUBTOTAL		11	8.15	0.016	0.49	37	0.053					
4904200101	MOLLUSCA PELECYPODA CLINOCARDIUM CILIATUM	07/07/74	0002	1	0.74	0.020	0.62	3	0.067					
4904200101	MOLLUSCA PELECYPODA CLINOCARDIUM CILIATUM	07/07/74	0001	1	0.74	0.062	1.92	3	0.207					
		SUBTOTAL		2	1.48	0.082	2.53	7	0.273					
4904210501	MOLLUSCA PELECYPODA PSEPHIDIA LORDI	07/07/74	0002	1	0.74	0.001	0.03	3	0.003		X		X	
5328050100	CRUSTACEA CUMACEA DIASTYLIDAE DIASTYLIS SP	07/07/74	0002	1	0.74	0.002	0.06	3	0.007					
5328050100	CRUSTACEA CUMACEA DIASTYLIDAE DIASTYLIS SP	07/07/74	0001	1	0.74	0.003	0.09	3	0.010					
		SUBTOTAL		2	1.48	0.005	0.15	7	0.017					
5328070107	CR CUMACEA CAMPYLASPIDAE CAMPYLASPIS VERRUCOSA	07/07/74	0003	1	0.74	0.001	0.03	3	0.003					

CRUISE 193 STATION 026 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA				
5330110000	CRUSTACEA ISOPODA GNATHIA SP.	07/07/74	0002	1	0.74	0.001	0.03	3	0.003		X		X	
5331000000	CRUSTACEA AMPHIPODA	07/07/74	0001	1	0.74	0.001	0.03	3	0.003		X		X	
5331000000	CRUSTACEA AMPHIPODA	07/07/74	0001	2	1.48	0.003	0.09	7	0.010		X		X	
5331000000	CRUSTACEA AMPHIPODA	07/07/74	0002	3	2.22	0.094	2.90	10	0.313		X		X	
		SUBTOTAL		6	4.44	0.098	3.03	20	0.327					
5331220100	EOHAUSTORIUS SP.	07/07/74	0003	1	0.74	0.002	0.06	3	0.007					
5331420201	CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS	07/07/74	0003	1	0.74	0.002	0.06	3	0.007				X	
5331420201	CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS	07/07/74	0001	1	0.74	0.001	0.03	3	0.003				X	
		SUBTOTAL		2	1.48	0.003	0.09	7	0.010					
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	07/07/74	0001	5	3.70	0.003	0.09	17	0.010			X	X	X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	07/07/74	0003	2	1.48	0.005	0.15	7	0.017			X	X	X
		SUBTOTAL		7	5.19	0.008	0.25	23	0.027					
6600000000	ECTOPROCTA	07/07/74	0002	1	0.74	0.102	3.15	3	0.340		X		X	
6601080101	BRYOZOA MICROPORINA BOREALIS	07/07/74	0001	1	0.74	0.010	0.31	3	0.033					
6702030101	BRACHIOPODA ARTICULATA TEREBRATULINA UNGUICULA	07/07/74	0003	1	0.74	0.014	0.43	3	0.047			X	X	X
6801060101	EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS	07/07/74	0002	1	0.74	0.005	0.15	3	0.017	X	X	X	X	X
6803020801	ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS	07/07/74	0003	2	1.48	0.291	8.99	7	0.970		X	X	X	X
6803020801	ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS	07/07/74	0001	2	1.48	0.404	12.48	7	1.347		X	X	X	X
		SUBTOTAL		4	2.96	0.695	21.47	13	2.317					
6803090611	ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI	07/07/74	0003	1	0.74	0.503	15.54	3	1.677	X	X	X	X	X
6803090611	ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI	07/07/74	0002	1	0.74	0.790	24.41	3	2.633	X	X	X	X	X
		SUBTOTAL		2	1.48	1.293	39.94	7	4.310					
9999999999	UNIDENTIFIABLE	07/07/74	0001	1	0.74	0.019	0.59	3	0.063				X	
9999999999	UNIDENTIFIABLE	07/07/74	0003	1	0.74	0.011	0.34	3	0.037				X	
9999999999	UNIDENTIFIABLE	07/07/74	0003	1	0.74	0.001	0.03	3	0.003				X	
9999999999	UNIDENTIFIABLE	07/07/74	0003	2	1.48	0.003	0.09	7	0.010				X	
		SUBTOTAL		5	3.70	0.034	1.05	17	0.113					
		STATION TOTAL		135		3.237		450	10.790					

SIMPSON INDEX 0.039912 SHANNON DIVERSITY INDEX 3.384649

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CRUISE 193 STATION 048 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
3200000000	SPONGES	07/03/74	0003	1	0.52	7.765	48.84	3	25.883	X X X X
4000000000	NEMERTEANS RHYNCHOCOELA	07/03/74	0002	1	0.52	0.005	0.03	3	0.017	X
4801020101	POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA	07/03/74	0002	4	2.06	0.012	0.08	13	0.040	X X
4801050101	POLYCHAETA SIGALIONIDAE PHLOE MINUTA	07/03/74	0001	1	0.52	0.001	0.01	3	0.003	
4801120205	POLYCHAETA PHYLLODOCIDAE ETEONE LONGA	07/03/74	0001	1	0.52	0.004	0.03	3	0.013	
4801230000	POLYCHAETA NEREIDAE	07/03/74	0001	2	1.03	0.098	0.62	7	0.327	
4801230000	POLYCHAETA NEREIDAE	07/03/74	0002	1	0.52	0.015	0.09	3	0.050	
4801230000	POLYCHAETA NEREIDAE	07/03/74	0003	1	0.52	0.003	0.02	3	0.010	
		SUBTOTAL		4	2.06	0.116	0.73	13	0.387	
4801240105	POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA	07/03/74	0003	1	0.52	0.095	0.60	3	0.317	X
4801240105	POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA	07/03/74	0001	1	0.52	0.075	0.47	3	0.250	X
		SUBTOTAL		2	1.03	0.170	1.07	7	0.567	
4801240111	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA	07/03/74	0002	1	0.52	0.018	0.11	3	0.060	X X
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	07/03/74	0002	2	1.03	0.050	0.31	7	0.167	X X
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	07/03/74	0001	2	1.03	0.002	0.01	7	0.007	X X X X X
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	07/03/74	0002	2	1.03	0.041	0.26	7	0.137	X X X X X
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	07/03/74	0003	1	0.52	0.001	0.01	3	0.003	X X X X X
		SUBTOTAL		5	2.58	0.044	0.28	17	0.147	
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/03/74	0003	3	1.55	0.023	0.14	10	0.077	X X X X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/03/74	0001	1	0.52	0.095	0.60	3	0.317	X X X X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/03/74	0002	1	0.52	0.075	0.47	3	0.250	X X X X
		SUBTOTAL		5	2.58	0.193	1.21	17	0.643	
4801400204	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII	07/03/74	0001	3	1.55	0.018	0.11	10	0.060	X
4801400204	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII	07/03/74	0002	2	1.03	0.005	0.03	7	0.017	X
4801400204	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII	07/03/74	0003	5	2.58	0.032	0.20	17	0.107	X
		SUBTOTAL		10	5.15	0.055	0.35	33	0.183	
4801421001	POLYCHAETA NERINIDES SPIOPHANES BOMBYX	07/03/74	0002	2	1.03	0.046	0.29	7	0.153	
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA	07/03/74	0003	1	0.52	0.015	0.09	3	0.050	X X
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	07/03/74	0003	2	1.03	0.099	0.62	7	0.330	
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	07/03/74	0001	1	0.52	0.048	0.30	3	0.160	
		SUBTOTAL		3	1.55	0.147	0.92	10	0.490	
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS	07/03/74	0001	2	1.03	0.391	2.46	7	1.303	X X X
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS	07/03/74	0003	1	0.52	0.087	0.55	3	0.290	X X X
		SUBTOTAL		3	1.55	0.478	3.01	10	1.593	

CRUISE 193 STATION 048

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA				
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS	07/03/74	0003	1	0.52	0.059	0.37	3	0.197		X		X	
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS	07/03/74	0001	2	1.03	0.005	0.03	7	0.017		X		X	
		SUBTOTAL		3	1.55	0.064	0.40	10	0.213					
4801610901	POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS	07/03/74	0001	1	0.52	0.008	0.05	3	0.027				X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	07/03/74	0002	1	0.52	0.001	0.01	3	0.003	X	X		X	
4801630100	IDANTHYRSUS SP.	07/03/74	0002	1	0.52	0.011	0.07	3	0.037					
4801640300	PECTINARIA SP.	07/03/74	0001	1	0.52	0.067	0.42	3	0.223					
4801650306	POLYCHAETA AMPHARETIDAE AMPHICTEIS MACRONATA	07/03/74	0003	1	0.52	0.168	1.06	3	0.560					
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	07/03/74	0001	1	0.52	0.001	0.01	3	0.003				X	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/03/74	0002	1	0.52	0.001	0.01	3	0.003	X	X		X	
4801680101	POLYCHAETA SABELLIDAE CHONE GRACILIS	07/03/74	0002	2	1.03	0.026	0.16	7	0.087					
4801680102	POLYCHAETA SABELLIDAE CHONE INFUNDIBULIFORMIS	07/03/74	0003	2	1.03	0.041	0.26	7	0.137					
4801680201	POLYCHAETA SABELLIDAE EUCHONE ANALIS	07/03/74	0002	3	1.55	0.014	0.09	10	0.047					
4801680201	POLYCHAETA SABELLIDAE EUCHONE ANALIS	07/03/74	0001	1	0.52	0.005	0.03	3	0.017					
		SUBTOTAL		4	2.06	0.019	0.12	13	0.063					
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	07/03/74	0001	1	0.52	0.010	0.06	3	0.033	X	X		X	
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA	07/03/74	0002	1	0.52	0.010	0.06	3	0.033		X	X	X	X
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA	07/03/74	0003	1	0.52	0.062	0.39	3	0.207		X	X	X	X
		SUBTOTAL		2	1.03	0.072	0.45	7	0.240					
4904070201	MOLLUSCA PELECYPODA CRENELLA DESSUCATA	07/03/74	0003	2	1.03	0.010	0.06	7	0.033		X		X	
4904070201	MOLLUSCA PELECYPODA CRENELLA DESSUCATA	07/03/74	0001	2	1.03	0.006	0.04	7	0.020		X		X	
		SUBTOTAL		4	2.06	0.016	0.10	13	0.053					
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM	07/03/74	0001	2	1.03	0.008	0.05	7	0.027				X	
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM	07/03/74	0003	3	1.55	0.013	0.08	10	0.043				X	
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM	07/03/74	0002	2	1.03	0.007	0.04	7	0.023				X	
		SUBTOTAL		7	3.61	0.028	0.18	23	0.093					
4904080201	MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI	07/03/74	0002	2	1.03	0.001	0.01	7	0.003		X	X	X	
4904080201	MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI	07/03/74	0003	1	0.52	0.013	0.08	3	0.043		X	X	X	
4904080201	MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI	07/03/74	0001	1	0.52	0.005	0.03	3	0.017		X	X	X	
		SUBTOTAL		4	2.06	0.019	0.12	13	0.063					
4904110100	ASTARTE SP.	07/03/74	0001	1	0.52	0.006	0.04	3	0.020				X	
4904120101	MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA	07/03/74	0002	4	2.06	0.065	0.41	13	0.217		X	X	X	

CRUISE 193 STATION 048 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/03/74	0003	1	0.52	0.002	0.01	3	0.007	X X X
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/03/74	0001	3	1.55	0.008	0.05	10	0.027	X X X
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/03/74	0002	5	2.58	0.025	0.16	17	0.083	X X X
		SUBTOTAL		9	4.64	0.035	0.22	30	0.117	
4904240101	MOLLUSCA PELECYPODA MACOMA CALCAREA	07/03/74	0002	1	0.52	0.001	0.01	3	0.003	X X
4904370101	MOLLUSCA PELECYPODA CARDIOMYA PECTENATA	07/03/74	0002	1	0.52	0.016	0.10	3	0.053	
4904370101	MOLLUSCA PELECYPODA CARDIOMYA PECTENATA	07/03/74	0003	1	0.52	0.008	0.05	3	0.027	
		SUBTOTAL		2	1.03	0.024	0.15	7	0.080	
4906010100	MOLLUSCA SCAPHOPODA DENTALIUM SP	07/03/74	0001	1	0.52	0.004	0.03	3	0.013	X X
5200030300	CRUSTACEA AMPHIPODA HALOSOMA SP.	07/03/74	0003	1	0.52	0.002	0.01	3	0.007	
5307000000	CRUSTACEA PODACOPA	07/03/74	0002	2	1.03	0.002	0.01	7	0.007	
5330110000	CRUSTACEA ISOPODA GNATHIA SP.	07/03/74	0002	7	3.61	0.009	0.06	23	0.030	X X
5330110000	CRUSTACEA ISOPODA GNATHIA SP.	07/03/74	0001	16	8.25	0.013	0.08	53	0.043	X X
5330110000	CRUSTACEA ISOPODA GNATHIA SP.	07/03/74	0003	1	0.52	0.001	0.01	3	0.003	X X
		SUBTOTAL		24	12.37	0.023	0.14	80	0.077	
5331000000	CRUSTACEA AMPHIPODA	07/03/74	0002	7	3.61	0.076	0.48	23	0.253	X X
5331000000	CRUSTACEA AMPHIPODA	07/03/74	0002	1	0.52	0.001	0.01	3	0.003	X X
		SUBTOTAL		8	4.12	0.077	0.48	27	0.257	
5331020101	CRUSTACEA AMPHIPODA AMPELISCA MACROECEPHALA	07/03/74	0002	1	0.52	0.002	0.01	3	0.007	X
5331020200	BYBLIS SP.	07/03/74	0003	1	0.52	0.010	0.06	3	0.033	X
5331020200	BYBLIS SP.	07/03/74	0001	5	2.58	0.198	1.25	17	0.660	X
		SUBTOTAL		6	3.09	0.208	1.31	20	0.693	
5331020201	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS	07/03/74	0002	4	2.06	0.076	0.48	13	0.253	X
5331020201	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS	07/03/74	0002	4	2.06	0.076	0.48	13	0.253	X
		SUBTOTAL		8	4.12	0.152	0.96	27	0.507	
5331150301	CRUSTACEA AMPHIPODA ERICTHONIUS HUNTERI	07/03/74	0003	1	0.52	0.001	0.01	3	0.003	
5331420100	HARPINIA SP.	07/03/74	0003	3	1.55	0.010	0.06	10	0.033	X
5331420201	CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS	07/03/74	0002	1	0.52	0.004	0.03	3	0.013	X
5331980000	CRUSTACEA AMPHIPODA CAPRELLIDAE	07/03/74	0001	1	0.52	0.001	0.01	3	0.003	
5331980722	CRUSTACEA AMPHIPODA CAPRELLA STRIATA	07/03/74	0003	1	0.52	0.003	0.02	3	0.010	
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	07/03/74	0003	1	0.52	0.033	0.21	3	0.110	X X X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	07/03/74	0002	5	2.58	0.177	1.11	17	0.590	X X X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	07/03/74	0001	4	2.06	0.013	0.08	13	0.043	X X X
		SUBTOTAL		10	5.15	0.223	1.40	33	0.743	

CRUISE 193 STATION 055

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT		WET WEIGHT		PER SQ METER		BIT CRITERIA			
				NO.	PCT	GRAMS	PCT	NO.	WWGT				
4000000000	NEMERTEANS RHYNCHOCOELA	07/02/74	0002	1	0.78	0.007	0.01	3	0.023	X			
4801000000	POLYCHAETA	07/02/74	0001	1	0.78	0.089	0.14	3	0.297				
4801230000	POLYCHAETA NEREIDAE	07/02/74	0002	1	0.78	0.006	0.01	3	0.020				
4801230000	POLYCHAETA NEREIDAE	07/02/74	0003	1	0.78	0.001	0.00	3	0.003				
		SUBTOTAL		2	1.56	0.007	0.01	7	0.023				
4801240105	POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA	07/02/74	0002	2	1.56	0.418	0.67	7	1.393				X
4801240111	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA	07/02/74	0001	2	1.56	0.182	0.29	7	0.607		X		X
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	07/02/74	0001	1	0.78	0.083	0.13	3	0.277	X			X
4801280100	POLYCHAETA ONUPHIDAE ONUPHIS SP.	07/02/74	0002	1	0.78	0.096	0.15	3	0.320				
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/02/74	0002	10	7.81	0.035	0.06	33	0.117	X	X	X	X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/02/74	0001	7	5.47	0.012	0.02	23	0.040	X	X	X	X
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	07/02/74	0003	14	10.94	0.156	0.25	47	0.520	X	X	X	X
		SUBTOTAL		31	24.22	0.203	0.33	103	0.677				
4801400301	POLYCHAETA PARAONIDAE PARAONIS GRACILIS	07/02/74	0002	2	1.56	0.001	0.00	7	0.003				
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA	07/02/74	0003	2	1.56	0.004	0.01	7	0.013		X		X
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA	07/02/74	0002	1	0.78	0.004	0.01	3	0.013		X		X
		SUBTOTAL		3	2.34	0.008	0.01	10	0.027				
4801490200	POLYCHAETA CIRRATULIDAE CAULLERIELLA SP	07/02/74	0001	3	2.34	0.003	0.00	10	0.010				X
4801490200	POLYCHAETA CIRRATULIDAE CAULLERIELLA SP	07/02/74	0003	4	3.13	0.005	0.01	13	0.017				X
		SUBTOTAL		7	5.47	0.008	0.01	23	0.027				
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	07/02/74	0001	1	0.78	0.006	0.01	3	0.020	X	X	X	X
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	07/02/74	0002	3	2.34	0.558	0.90	10	1.860	X	X	X	X
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	07/02/74	0003	2	1.56	0.459	0.74	7	1.530	X	X	X	X
		SUBTOTAL		6	4.69	1.023	1.64	20	3.410				
4801610000	POLYCHAETA MALDANIDAE	07/02/74	0001	1	0.78	0.004	0.01	3	0.013	X	X	X	X
4801610802	POLYCHAETA MALDANIDAE AXIOTHELLA RUBROCINCTA	07/02/74	0001	1	0.78	0.005	0.01	3	0.017				
4801610901	POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS	07/02/74	0002	1	0.78	0.196	0.31	3	0.653				X
4801610901	POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS	07/02/74	0003	2	1.56	0.212	0.34	7	0.707				X
		SUBTOTAL		3	2.34	0.408	0.65	10	1.360				
4801611001	POLYCHAETA MALDANIDAE RHODINE BITORQUATA	07/02/74	0003	1	0.78	0.012	0.02	3	0.040				
4801611001	POLYCHAETA MALDANIDAE RHODINE BITORQUATA	07/02/74	0002	1	0.78	0.017	0.03	3	0.057				
		SUBTOTAL		2	1.56	0.029	0.05	7	0.097				
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	07/02/74	0002	1	0.78	0.015	0.02	3	0.050				X

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CRUISE 193 STATION 055 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA				
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/02/74	0002	2	1.56	0.037	0.06	7	0.123	X	X		X	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/02/74	0001	1	0.78	0.013	0.02	3	0.043	X	X		X	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	07/02/74	0003	2	1.56	0.098	0.16	7	0.327	X	X		X	
		SUBTOTAL		5	3.91	0.148	0.24	17	0.493					
4801670201	PO TRICHOBRANCHIDAE TRICHOBRANCHUS GLACIALIS	07/02/74	0003	1	0.78	0.006	0.01	3	0.020					
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	07/02/74	0002	1	0.78	0.001	0.00	3	0.003	X	X		X	
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA	07/02/74	0001	6	4.69	0.015	0.02	20	0.050		X	X	X	X
4904030202	MOLLUSCA PELECYPODA NUCULANA MINUTA	07/02/74	0002	5	3.91	0.034	0.05	17	0.113				X	
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/02/74	0001	16	12.50	0.010	0.02	53	0.033	X	X		X	
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	07/02/74	0003	3	2.34	0.002	0.00	10	0.007	X	X		X	
		SUBTOTAL		19	14.84	0.012	0.02	63	0.040					
4904150301	MOLLUSCA PELECYPODA THYASIRA FLEXUOSA	07/02/74	0001	4	3.13	0.163	0.26	13	0.543				X	
4904150301	MOLLUSCA PELECYPODA THYASIRA FLEXUOSA	07/02/74	0002	1	0.78	0.010	0.02	3	0.033				X	
		SUBTOTAL		5	3.91	0.173	0.28	17	0.577					
4904240101	MOLLUSCA PELECYPODA MACOMA CALCAREA	07/02/74	0002	2	1.56	0.027	0.04	7	0.090			X		X
4904240101	MOLLUSCA PELECYPODA MACOMA CALCAREA	07/02/74	0003	1	0.78	0.123	0.20	3	0.410			X		X
		SUBTOTAL		3	2.34	0.150	0.24	10	0.500					
4906010100	MOLLUSCA SCAPHOPODA DENTALIUM SP	07/02/74	0002	1	0.78	0.343	0.55	3	1.143		X		X	
4906010100	MOLLUSCA SCAPHOPODA DENTALIUM SP	07/02/74	0001	1	0.78	0.141	0.23	3	0.470		X		X	
		SUBTOTAL		2	1.56	0.484	0.78	7	1.613					
5328040201	CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA	07/02/74	0001	1	0.78	0.003	0.00	3	0.010		X		X	
5328040201	CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA	07/02/74	0002	2	1.56	0.001	0.00	7	0.003		X		X	
5328040201	CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA	07/02/74	0003	1	0.78	0.001	0.00	3	0.003		X		X	
		SUBTOTAL		4	3.13	0.005	0.01	13	0.017					
5331000000	CRUSTACEA AMPHIPODA	07/02/74	0002	2	1.56	0.002	0.00	7	0.007		X		X	
5331000000	CRUSTACEA AMPHIPODA	07/02/74	0001	2	1.56	0.002	0.00	7	0.007		X		X	
		SUBTOTAL		4	3.13	0.004	0.01	13	0.013					
5331420101	CRUSTACEA AMPHIPODA HARPINIA EMERYI	07/02/74	0003	2	1.56	0.005	0.01	7	0.017					
6801060101	EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS	07/02/74	0001	1	0.78	7.879	12.65	3	26.263	X	X	X	X	X
6804050100	ECHINODERM HOLOTHUROIDEA MOLPADIA SP.	07/02/74	0001	1	0.78	7.533	12.09	3	25.110			X	X	X
6804050100	ECHINODERM HOLOTHUROIDEA MOLPADIA SP.	07/02/74	0003	1	0.78	43.269	69.44	3	144.230			X	X	X
		SUBTOTAL		2	1.56	50.802	81.53	7	169.340					
9999999999	UNIDENTIFIABLE	07/02/74	0003	1	0.78	0.003	0.00	3	0.010				X	
		STATION TOTAL		128		62.307		427	207.690					

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SIMPSON INDEX 0.091781 SHANNON DIVERSITY INDEX 2.369763

CRUISE 200 STATION 057

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
3200000000	SPONGES	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	x x x x
3200000000	SPONGES	10/09/74	0002	1	0.27	0.006	0.01	3	0.020	x x x x
		SUBTOTAL		2	0.54	0.007	0.02	7	0.023	
3303010000	CNIDARIA ANTHOZOA SEA PEN	10/09/74	0003	1	0.27	9.938	22.46	3	33.127	x x x
4000000000	NEMERTEANS RHYNCHOCOELA	10/09/74	0003	1	0.27	0.007	0.02	3	0.023	x
4801010806	POLYCHAETA POLYNOIDAE HARMOTHOE IMBRICATA	10/08/74	0001	1	0.27	0.009	0.02	3	0.030	
4801011701	POLYCHAETA POLYNOIDAE HESPERONOE COMPLANATA	10/09/74	0002	1	0.27	0.315	0.71	3	1.050	
4801020101	POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA	10/08/74	0001	2	0.54	0.015	0.03	7	0.050	x x
4801020101	POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA	10/09/74	0003	3	0.82	0.002	0.00	10	0.007	x x
		SUBTOTAL		5	1.36	0.017	0.04	17	0.057	
4801050101	POLYCHAETA SIGALIONIDAE PHLOE MINUTA	10/09/74	0002	1	0.27	0.002	0.00	3	0.007	
4801120205	POLYCHAETA PHYLLODOCIDAE ETEONE LONGA	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	
4801120307	POLYCHAETA PHYLLODOCIDAE EULALIA NIGROMACULATA	10/09/74	0002	1	0.27	0.001	0.00	3	0.003	
4801220700	POLYCHAETA SYLLIDAE EXOGONE SP.	10/09/74	0002	1	0.27	0.001	0.00	3	0.003	
4801220700	POLYCHAETA SYLLIDAE EXOGONE SP.	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	
		SUBTOTAL		2	0.54	0.002	0.00	7	0.007	
4801221001	POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA	10/09/74	0003	2	0.54	0.011	0.02	7	0.037	x
4801221001	POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA	10/09/74	0002	1	0.27	0.001	0.00	3	0.003	x
		SUBTOTAL		3	0.82	0.012	0.03	10	0.040	
4801230000	POLYCHAETA NEREIDAE	10/09/74	0003	3	0.82	0.008	0.02	10	0.027	
4801240103	POLYCHAETA NEPHTYIDAE NEPHTYS COECA	10/09/74	0003	1	0.27	0.004	0.01	3	0.013	
4801240105	POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA	10/08/74	0001	1	0.27	0.194	0.44	3	0.647	x
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	10/09/74	0002	2	0.54	0.079	0.18	7	0.263	x x
4801270201	POLYCHAETA GONIADIDAE GONIADA ANNULATA	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	x
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	10/09/74	0003	15	4.08	0.348	0.79	50	1.160	x x x x
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	10/09/74	0002	12	3.26	0.209	0.47	40	0.697	x x x x
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	10/08/74	0001	5	1.36	1.253	2.83	17	4.177	x x x x
		SUBTOTAL		32	8.70	1.810	4.09	107	6.033	
4801400301	POLYCHAETA PARAONIDAE PARAONIS GRACILIS	10/08/74	0001	1	0.27	0.001	0.00	3	0.003	
4801420201	POLYCHAETA SPIONIDAE LAONICE CIRRATA	10/09/74	0003	1	0.27	0.018	0.04	3	0.060	

CRUISE 200 STATION 057 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA	10/09/74	0002	2	0.54	0.009	0.02	7	0.030	X X
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	10/09/74	0002	1	0.27	0.002	0.00	3	0.007	
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	10/08/74	0001	2	0.54	0.002	0.00	7	0.007	
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.	10/09/74	0003	6	1.63	0.006	0.01	20	0.020	
		SUBTOTAL		9	2.45	0.010	0.02	30	0.033	
4801550101	POLYCHAETA SCALIBREGMIDAE SCALIBREGMA INFLATUM	10/09/74	0002	3	0.82	0.014	0.03	10	0.047	
4801580201	POLYCHAETA CAPITELLIDAE HETEROMASTUS FILIFORMIS	10/09/74	0003	1	0.27	0.003	0.01	3	0.010	X
4801610000	POLYCHAETA MALDANIDAE	10/08/74	0001	1	0.27	0.011	0.02	3	0.037	X X X X
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS	10/08/74	0001	3	0.82	1.460	3.30	10	4.867	X X X
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS	10/09/74	0002	1	0.27	0.017	0.04	3	0.057	X X X
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS	10/09/74	0003	1	0.27	0.382	0.86	3	1.273	X X X
		SUBTOTAL		5	1.36	1.859	4.20	17	6.197	
4801610302	POLYCHAETA MALDANIDAE MALDANE GLEBIFEX	10/08/74	0001	3	0.82	0.013	0.03	10	0.043	X X
4801611001	POLYCHAETA MALDANIDAE RHODINE BITORQUATA	10/08/74	0001	1	0.27	0.012	0.03	3	0.040	
4801611001	POLYCHAETA MALDANIDAE RHODINE BITORQUATA	10/09/74	0003	1	0.27	0.006	0.01	3	0.020	
		SUBTOTAL		2	0.54	0.018	0.04	7	0.060	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	X X X
4801630102	POLYCHAETA SABELLARIIDAE IDANTHYRSUS ARMATUS	10/08/74	0001	1	0.27	0.010	0.02	3	0.033	
4801630102	POLYCHAETA SABELLARIIDAE IDANTHYRSUS ARMATUS	10/09/74	0002	1	0.27	0.002	0.00	3	0.007	
		SUBTOTAL		2	0.54	0.012	0.03	7	0.040	
4801650000	POLYCHAETA AMPHARETIDAE	10/09/74	0002	2	0.54	0.006	0.01	7	0.020	
4801650000	POLYCHAETA AMPHARETIDAE	10/09/74	0002	2	0.54	0.005	0.01	7	0.017	
		SUBTOTAL		4	1.09	0.011	0.02	13	0.037	
4801650207	POLYCHAETA AMPHARETIDAE AMPHARETE GOESI	10/09/74	0003	5	1.36	0.022	0.05	17	0.073	
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	10/09/74	0003	3	0.82	0.020	0.05	10	0.067	X
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	10/09/74	0002	1	0.27	0.009	0.02	3	0.030	X
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	10/08/74	0001	3	0.82	0.010	0.02	10	0.033	X
		SUBTOTAL		7	1.90	0.039	0.09	23	0.130	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	10/08/74	0001	2	0.54	0.008	0.02	7	0.027	X X X
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	10/09/74	0003	1	0.27	0.001	0.00	3	0.003	X X X
		SUBTOTAL		3	0.82	0.009	0.02	10	0.030	
4801680102	POLYCHAETA SABELLIDAE CHONE INFUNDIBULIFORMIS	10/09/74	0003	3	0.82	0.011	0.02	10	0.037	
4801680201	POLYCHAETA SABELLIDAE EUCHONE ANALIS	10/09/74	0002	1	0.27	0.002	0.00	3	0.007	

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 CRUISE 200       STATION 057                                  PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

                                                               SAMPLE   SAMP     COUNT       WET WEIGHT    PER SQ METER
 TAXON CODE               TAXON NAME                            DATE     NO.   NO.   PCT    GRAMS   PCT    NO.   WWGT    BIT CRITERIA

 4903020302  MOLLUSCA POLYPLACOPHRA ISCHNOCHITON ALBUS        10/09/74 0003    1  0.27    0.019  0.04     3   0.063

 4904000000  MOLLUSCA PELECYPODA                              10/09/74 0002    1  0.27    0.027  0.06     3   0.090

 4904020201  MOLLUSCA PELECYPODA NUCULA TENUIS                10/08/74 0001    1  0.27    0.012  0.03     3   0.040   X X   X

 4904030201  MOLLUSCA PELECYPODA NUCULANA PERNULA             10/09/74 0003    2  0.54    0.099  0.22     7   0.330     X X X X

 4904070201  MOLLUSCA PELECYPODA CRENELLA DESSUCATA           10/09/74 0003   12  3.26    0.082  0.19    40   0.273     X   X
 4904070201  MOLLUSCA PELECYPODA CRENELLA DESSUCATA           10/08/74 0001   14  3.80    0.173  0.39    47   0.577     X   X
 4904070201  MOLLUSCA PELECYPODA CRENELLA DESSUCATA           10/09/74 0002   19  5.16    0.188  0.42    63   0.627     X   X
                                                                 SUBTOTAL     45 12.23    0.443  1.00   150   1.477

 4904070500  MOLLUSCA PELECYPODA DACRYDIUM SP.                10/09/74 0003    1  0.27    0.009  0.02     3   0.030         X

 4904070601  MOLLUSCA PELECYPODA MODIOLUS MODIOLUS            10/09/74 0003    1  0.27    0.018  0.04     3   0.060
 4904070601  MOLLUSCA PELECYPODA MODIOLUS MODIOLUS            10/09/74 0002    2  0.54    0.250  0.56     7   0.833
                                                                 SUBTOTAL      3  0.82    0.268  0.61    10   0.893

 4904080201  MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI        10/09/74 0002    1  0.27    0.003  0.01     3   0.010     X X X
 4904080201  MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI        10/08/74 0001    2  0.54    0.043  0.10     7   0.143     X X X
 4904080201  MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI        10/09/74 0003    2  0.54    0.019  0.04     7   0.063     X X X
                                                                 SUBTOTAL      5  1.36    0.065  0.15    17   0.217

 4904110103  MOLLUSCA PELECYPODA ASTARTE MONTEGUI             10/09/74 0003    1  0.27    0.016  0.04     3   0.053       X X X
 4904110103  MOLLUSCA PELECYPODA ASTARTE MONTEGUI             10/08/74 0001    4  1.09    1.872  4.23    13   6.240       X X X
 4904110103  MOLLUSCA PELECYPODA ASTARTE MONTEGUI             10/09/74 0002    4  1.09    0.952  2.15    13   3.173       X X X
                                                                 SUBTOTAL      9  2.45    2.840  6.42    30   9.467

 4904120101  MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA       10/09/74 0002    2  0.54    0.072  0.16     7   0.240     X X X
 4904120101  MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA       10/08/74 0001    3  0.82    0.161  0.36    10   0.537     X X X
 4904120101  MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA       10/09/74 0003    2  0.54    0.200  0.45     7   0.667     X X X
                                                                 SUBTOTAL      7  1.90    0.433  0.98    23   1.443

 4904150201  MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA         10/09/74 0003    5  1.36    0.097  0.22    17   0.323   X X   X
 4904150201  MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA         10/08/74 0001    3  0.82    0.051  0.12    10   0.170   X X   X
 4904150201  MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA         10/09/74 0002    1  0.27    0.024  0.05     3   0.080   X X   X
                                                                 SUBTOTAL      9  2.45    0.172  0.39    30   0.573

 4904200103  MOLLUSCA PELECYPODA CLINOCARDIUM FUCANUM         10/09/74 0002    7  1.90    1.630  3.68    23   5.433         X
 4904200103  MOLLUSCA PELECYPODA CLINOCARDIUM FUCANUM         10/08/74 0001    1  0.27    0.724  1.64     3   2.413         X
 4904200103  MOLLUSCA PELECYPODA CLINOCARDIUM FUCANUM         10/09/74 0003    5  1.36    0.419  0.95    17   1.397         X
                                                                 SUBTOTAL     13  3.53    2.773  6.27    43   9.243

 4904210501  MOLLUSCA PELECYPODA PSEPHIDIA LORDI              10/09/74 0003    7  1.90    0.052  0.12    23   0.173     X   X
 4904210501  MOLLUSCA PELECYPODA PSEPHIDIA LORDI              10/08/74 0001   10  2.72    0.072  0.16    33   0.240     X   X
 4904210501  MOLLUSCA PELECYPODA PSEPHIDIA LORDI              10/09/74 0002    9  2.45    0.119  0.27    30   0.397     X   X
                                                                 SUBTOTAL     26  7.07    0.243  0.55    87   0.810
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CRUISE 200 STATION 057 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA	
4904290201	MOLLUSCA PELECYPODA HIATELLA ARCTICA	10/09/74	0002	1	0.27	0.024	0.05	3	0.080		
4904330202	MOLLUSCA PELECYPODA LYONSIA PUGETTENSIS	10/09/74	0002	1	0.27	0.307	0.69	3	1.023		
4905050201	MOLLUSCA GASTROPODA LEPETA CAECA	10/09/74	0002	1	0.27	0.009	0.02	3	0.030		
4905050201	MOLLUSCA GASTROPODA LEPETA CAECA	10/08/74	0001	1	0.27	0.004	0.01	3	0.013		
4905050201	MOLLUSCA GASTROPODA LEPETA CAECA	10/09/74	0003	5	1.36	0.055	0.12	17	0.183		
		SUBTOTAL		7	1.90	0.068	0.15	23	0.227		
4905270209	MOLLUSCA GASTROPODA VELUTINA LAEVIGATA	10/08/74	0001	1	0.27	0.032	0.07	3	0.107		
4905340101	MOLLUSCA GASTROPODA AMPHISSA COLUMBIANA	10/09/74	0003	1	0.27	0.094	0.21	3	0.313		X
5328020101	CRUSTACEA CUMACEA LAMPROPIDAE LAMPROPS FUSCATA	10/09/74	0003	2	0.54	0.003	0.01	7	0.010		
5328020101	CRUSTACEA CUMACEA LAMPROPIDAE LAMPROPS FUSCATA	10/08/74	0001	2	0.54	0.006	0.01	7	0.020		
5328020101	CRUSTACEA CUMACEA LAMPROPIDAE LAMPROPS FUSCATA	10/09/74	0002	1	0.27	0.006	0.01	3	0.020		
		SUBTOTAL		5	1.36	0.015	0.03	17	0.050		
5328040201	CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA	10/09/74	0002	1	0.27	0.006	0.01	3	0.020	X	X
5328040301	CR CUMACEA LEUCONIDAE EUDORELLOPSIS INTEGRA	10/09/74	0002	1	0.27	0.001	0.00	3	0.003		
5328040301	CR CUMACEA LEUCONIDAE EUDORELLOPSIS INTEGRA	10/08/74	0001	2	0.54	0.001	0.00	7	0.003		
		SUBTOTAL		3	0.82	0.002	0.00	10	0.007		
5330120000	CRUSTACEA ISOPODA ANTHURIDAE HYSSURA SP.	10/09/74	0003	1	0.27	0.001	0.00	3	0.003		
5331000000	CRUSTACEA AMPHIPODA	10/09/74	0003	18	4.89	0.112	0.25	60	0.373	X	X
5331000000	CRUSTACEA AMPHIPODA	10/09/74	0003	2	0.54	0.001	0.00	7	0.003	X	X
5331000000	CRUSTACEA AMPHIPODA	10/08/74	0001	15	4.08	0.079	0.18	50	0.263	X	X
5331000000	CRUSTACEA AMPHIPODA	10/09/74	0002	3	0.82	0.034	0.08	10	0.113	X	X
		SUBTOTAL		38	10.33	0.226	0.51	127	0.753		
5331020101	CRUSTACEA AMPHIPODA AMPELISCA MACROECEPHALA	10/08/74	0001	9	2.45	0.067	0.15	30	0.223		X
5331020101	CRUSTACEA AMPHIPODA AMPELISCA MACROECEPHALA	10/09/74	0003	9	2.45	0.070	0.16	30	0.233		X
		SUBTOTAL		18	4.89	0.137	0.31	60	0.457		
5331020201	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS	10/09/74	0003	2	0.54	0.027	0.06	7	0.090		X
5331020201	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS	10/09/74	0002	1	0.27	0.004	0.01	3	0.013		X
		SUBTOTAL		3	0.82	0.031	0.07	10	0.103		
5331020301	CRUSTACEA AMPHIPODA HAPLOOPS TUBICULA	10/09/74	0003	1	0.27	0.005	0.01	3	0.017		X
5331420701	CRUSTACEA AMPHIPODA PARAPHOXUS ROBUSTUS	10/09/74	0002	1	0.27	0.014	0.03	3	0.047		
5331420702	CRUSTACEA AMPHIPODA PARAPHOXUS SIMPLEX	10/09/74	0003	4	1.09	0.030	0.07	13	0.100		
5331980722	CRUSTACEA AMPHIPODA CAPRELLA STRIATA	10/09/74	0003	2	0.54	0.003	0.01	7	0.010		
5331980722	CRUSTACEA AMPHIPODA CAPRELLA STRIATA	10/08/74	0001	1	0.27	0.001	0.00	3	0.003		
		SUBTOTAL		3	0.82	0.004	0.01	10	0.013		

CRUISE 200 STATION 057

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	10/08/74	0001	1	0.27	5.512	12.46	3	18.373	X X X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	10/08/74	0001	3	0.82	0.102	0.23	10	0.340	X X X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	10/09/74	0003	4	1.09	7.698	17.40	13	25.660	X X X
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA	10/09/74	0002	4	1.09	0.929	2.10	13	3.097	X X X
		SUBTOTAL		12	3.26	14.241	32.18	40	47.470	
6600000000	ECTOPROCTA	10/08/74	0001	1	0.27	0.145	0.33	3	0.483	X X
6600000000	ECTOPROCTA	10/08/74	0001	1	0.27	0.104	0.24	3	0.347	X X
		SUBTOTAL		2	0.54	0.249	0.56	7	0.830	
6603060101	BRYOZOA CLAVOPORA OCCIDENTALIS	10/08/74	0001	2	0.54	0.004	0.01	7	0.013	X
6603060101	BRYOZOA CLAVOPORA OCCIDENTALIS	10/09/74	0002	8	2.17	0.021	0.05	27	0.070	X
6603060101	BRYOZOA CLAVOPORA OCCIDENTALIS	10/09/74	0003	7	1.90	0.020	0.05	23	0.067	X
		SUBTOTAL		17	4.62	0.045	0.10	57	0.150	
6700000000	BRACHIOPODA	10/09/74	0003	1	0.27	0.646	1.46	3	2.153	X
6700000000	BRACHIOPODA	10/09/74	0003	1	0.27	4.197	9.48	3	13.990	X
		SUBTOTAL		2	0.54	4.843	10.94	7	16.143	
6802030101	ECHINODERM ECHINOIDEA BRIASTER TOWNSENDI	10/09/74	0003	1	0.27	0.012	0.03	3	0.040	X X X X
6803000000	ECHINODERM OPHIUROIDEA	10/09/74	0002	1	0.27	0.007	0.02	3	0.023	X
6803000000	ECHINODERM OPHIUROIDEA	10/08/74	0001	1	0.27	0.005	0.01	3	0.017	X
		SUBTOTAL		2	0.54	0.012	0.03	7	0.040	
6803090503	EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA VACINA	10/09/74	0003	1	0.27	0.042	0.09	3	0.140	
7200000000	TUNICATA	10/09/74	0003	2	0.54	0.162	0.37	7	0.540	
7200000000	TUNICATA	10/09/74	0002	2	0.54	1.264	2.86	7	4.213	
		SUBTOTAL		4	1.09	1.426	3.22	13	4.753	
9999999999	UNIDENTIFIABLE	10/08/74	0001	1	0.27	0.019	0.04	3	0.063	X
9999999999	UNIDENTIFIABLE	10/09/74	0003	1	0.27	0.494	1.12	3	1.647	X
		SUBTOTAL		2	0.54	0.513	1.16	7	1.710	
		STATION TOTAL		368		44.252		1227	147.507	

SIMPSON INDEX 0.047788 SHANNON DIVERSITY INDEX 3.533722

CRUISE 202 STATION 001 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801000000	POLYCHAETA	11/18/74	0001	1	5.00	0.150	0.84	3	0.500	
4801240111	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA	11/18/74	0001	1	5.00	0.040	0.22	3	0.133	X X
4801240111	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA	11/18/74	0003	1	5.00	0.080	0.45	3	0.267	X X
		SUBTOTAL		2	10.00	0.120	0.67	7	0.400	
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	11/18/74	0002	1	5.00	0.246	1.37	3	0.820	X X X X X
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	11/18/74	0002	1	5.00	0.087	0.49	3	0.290	X X X X
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	11/18/74	0003	2	10.00	0.020	0.11	7	0.067	X X X X
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	11/18/74	0001	3	15.00	0.201	1.12	10	0.670	X X X X
		SUBTOTAL		6	30.00	0.308	1.72	20	1.027	
4801610000	POLYCHAETA MALDANIDAE	11/18/74	0002	1	5.00	0.114	0.64	3	0.380	X X X X
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA	11/18/74	0003	1	5.00	0.132	0.74	3	0.440	X
4901030101	MOLLUSCA APLACOPHORA CHAETODERMA ROBUSTA	11/18/74	0003	1	5.00	0.007	0.04	3	0.023	X X
4901030101	MOLLUSCA APLACOPHORA CHAETODERMA ROBUSTA	11/18/74	0001	2	10.00	0.030	0.17	7	0.100	X X
		SUBTOTAL		3	15.00	0.037	0.21	10	0.123	
4904000000	MOLLUSCA PELECYPODA	11/18/74	0003	1	5.00	0.003	0.02	3	0.010	
4906010100	MOLLUSCA SCAPHOPODA DENTALIUM SP	11/18/74	0001	1	5.00	0.141	0.79	3	0.470	X X
6802030101	ECHINODERM ECHINOIDEA BRIASTER TOWNSENDI	11/18/74	0003	1	5.00	11.000	61.43	3	36.667	X X X X
6802030101	ECHINODERM ECHINOIDEA BRIASTER TOWNSENDI	11/18/74	0002	1	5.00	5.606	31.31	3	18.687	X X X X
		SUBTOTAL		2	10.00	16.606	92.73	7	55.353	
6803000000	ECHINODERM OPHIUROIDEA	11/18/74	0001	1	5.00	0.050	0.28	3	0.167	X
		STATION TOTAL		20		17.907		67	59.690	

SIMPSON INDEX 0.105263 SHANNON DIVERSITY INDEX 2.154783

CRUISE 805 STATION 040 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA				
4000000000	NEMERTEANS RHYNCHOCOELA	02/28/75	0004	1	0.81	0.112	0.23	3	0.280	X				
4801000000	POLYCHAETA	02/28/75	0001	1	0.81	0.025	0.05	3	0.063					
4801000000	POLYCHAETA	02/28/75	0002	1	0.81	0.028	0.06	3	0.070					
		SUBTOTAL		2	1.63	0.053	0.11	5	0.133					
4801120205	POLYCHAETA PHYLLODOCIDAE ETEONE LONGA	02/28/75	0004	1	0.81	0.025	0.05	3	0.063					
4801240105	POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA	02/28/75	0004	1	0.81	0.285	0.58	3	0.713				X	
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	02/28/75	0003	2	1.63	0.088	0.18	5	0.220	X			X	
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	02/28/75	0004	2	1.63	0.018	0.04	5	0.045	X			X	
		SUBTOTAL		4	3.25	0.106	0.22	10	0.265					
4801270201	POLYCHAETA GONIADIDAE GONIADA ANNULATA	02/28/75	0001	2	1.63	0.079	0.16	5	0.198		X			
4801270201	POLYCHAETA GONIADIDAE GONIADA ANNULATA	02/28/75	0004	1	0.81	0.023	0.05	3	0.058		X			
		SUBTOTAL		3	2.44	0.102	0.21	8	0.255					
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	02/28/75	0004	2	1.63	0.020	0.04	5	0.050	X	X	X	X	X
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	02/28/75	0003	1	0.81	0.074	0.15	3	0.185	X	X	X	X	X
		SUBTOTAL		3	2.44	0.094	0.19	8	0.235					
4801300100	LUMBRINERIS SP.	02/28/75	0004	1	0.81	0.106	0.22	3	0.265					
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	02/28/75	0003	1	0.81	0.047	0.10	3	0.118	X	X	X	X	
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	02/28/75	0004	3	2.44	0.115	0.23	8	0.288	X	X	X	X	
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	02/28/75	0001	1	0.81	0.046	0.09	3	0.115	X	X	X	X	
		SUBTOTAL		5	4.07	0.208	0.42	13	0.520					
4801400201	POLYCHAETA PARAONIDAE ARICIDEA SUECICA	02/28/75	0002	1	0.81	0.001	0.00	3	0.003					
4801420701	POLYCHAETA SPIONIDAE SPIO FILICORNIS	02/28/75	0003	1	0.81	0.007	0.01	3	0.018		X		X	
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA	02/28/75	0001	1	0.81	0.024	0.05	3	0.060		X		X	
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	02/28/75	0003	3	2.44	0.338	0.69	8	0.845	X	X	X	X	
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	02/28/75	0004	4	3.25	0.161	0.33	10	0.403	X	X	X	X	
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	02/28/75	0001	1	0.81	0.060	0.12	3	0.150	X	X	X	X	
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	02/28/75	0002	2	1.63	0.384	0.78	5	0.960	X	X	X	X	
		SUBTOTAL		10	8.13	0.943	1.92	25	2.358					
4801610000	POLYCHAETA MALDANIDAE	02/28/75	0004	1	0.81	0.027	0.05	3	0.068	X	X	X	X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	02/28/75	0003	1	0.81	0.048	0.10	3	0.120	X	X		X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	02/28/75	0002	1	0.81	0.053	0.11	3	0.133	X	X		X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	02/28/75	0001	1	0.81	0.005	0.01	3	0.013	X	X		X	
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	02/28/75	0004	1	0.81	0.057	0.12	3	0.143	X	X		X	
		SUBTOTAL		4	3.25	0.163	0.33	10	0.408					

CRUISE 805 STATION 040 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801660701	POLYCHAETA TEREBELLIDAE PISTA CRISTATA	02/28/75	0003	1	0.81	0.090	0.18	3	0.225	x
4801661201	POLYCHAETA SPINOSHAERA ARTECAMA CONIFERA	02/28/75	0004	1	0.81	0.229	0.47	3	0.573	
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	02/28/75	0004	1	0.81	0.024	0.05	3	0.060	x x x
4801680601	POLYCHAETA SABELLIDAE POTAMILLA NEGLECTA	02/28/75	0001	1	0.81	0.006	0.01	3	0.015	
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	02/28/75	0004	4	3.25	0.023	0.05	10	0.058	x x x
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	02/28/75	0003	1	0.81	0.011	0.02	3	0.028	x x x
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	02/28/75	0002	4	3.25	0.032	0.07	10	0.080	x x x
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	02/28/75	0001	1	0.81	0.002	0.00	3	0.005	x x x
		SUBTOTAL		10	8.13	0.068	0.14	25	0.170	
4904030301	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA	02/28/75	0003	4	3.25	0.037	0.08	10	0.093	x x
4904030301	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA	02/28/75	0002	6	4.88	0.132	0.27	15	0.330	x x
4904030301	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA	02/28/75	0004	4	3.25	0.269	0.55	10	0.673	x x
4904030301	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA	02/28/75	0001	2	1.63	0.006	0.01	5	0.015	x x
		SUBTOTAL		16	13.01	0.444	0.90	40	1.110	
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM	02/28/75	0001	4	3.25	0.007	0.01	10	0.018	x
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM	02/28/75	0004	1	0.81	0.001	0.00	3	0.003	x
		SUBTOTAL		5	4.07	0.008	0.02	13	0.020	
4904120101	MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA	02/28/75	0002	1	0.81	0.271	0.55	3	0.678	x x x
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	02/28/75	0003	3	2.44	0.022	0.04	8	0.055	x x x
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	02/28/75	0004	4	3.25	0.007	0.01	10	0.018	x x x
		SUBTOTAL		7	5.69	0.029	0.06	18	0.073	
4904210501	MOLLUSCA PELECYPODA PSEPHIDIA LORDI	02/28/75	0001	3	2.44	0.010	0.02	8	0.025	x x
4906020100	MOLLUSCA SCAPHOPODA CADALUS SP	02/28/75	0003	3	2.44	0.118	0.24	8	0.295	x x
4906020100	MOLLUSCA SCAPHOPODA CADALUS SP	02/28/75	0002	1	0.81	0.040	0.08	3	0.100	x x
4906020100	MOLLUSCA SCAPHOPODA CADALUS SP	02/28/75	0001	3	2.44	0.115	0.23	8	0.288	x x
4906020100	MOLLUSCA SCAPHOPODA CADALUS SP	02/28/75	0004	3	2.44	0.105	0.21	8	0.263	x x
		SUBTOTAL		10	8.13	0.378	0.77	25	0.945	
5330050203	CRUSTACEA ISOPODA ROCINELA AUGUSTATA	02/28/75	0001	1	0.81	0.111	0.23	3	0.278	
5331341405	CRUSTACEA AMPHIPODA HIPPOMEDON PROPINQUUS	02/28/75	0004	3	2.44	0.023	0.05	8	0.058	
5331420100	HARPINIA SP.	02/28/75	0003	1	0.81	0.003	0.01	3	0.008	x
5331420301	C AMPHIPODA PHOXOCEPHALIDAE HETEROPHOXUS OCULATU	02/28/75	0003	1	0.81	0.010	0.02	3	0.025	
6801060101	EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS	02/28/75	0003	2	1.63	3.806	7.74	5	9.515	x x x x x
6801060101	EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS	02/28/75	0002	1	0.81	2.296	4.67	3	5.740	x x x x x
		SUBTOTAL		3	2.44	6.102	12.40	8	15.255	

CRUISE 805 STATION 040 PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
6803020801	ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS	02/28/75	0003	1	0.81	0.170	0.35	3	0.425	X X X X
6803020801	ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS	02/28/75	0002	3	2.44	0.647	1.32	8	1.618	X X X X
		SUBTOTAL		4	3.25	0.817	1.66	10	2.043	
6803090501	EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA DISACANTHA	02/28/75	0003	1	0.81	0.105	0.21	3	0.263	
6803090501	EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA DISACANTHA	02/28/75	0001	1	0.81	0.038	0.08	3	0.095	
6803090501	EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA DISACANTHA	02/28/75	0002	1	0.81	0.024	0.05	3	0.060	
		SUBTOTAL		3	2.44	0.167	0.34	8	0.418	
6803090611	ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI	02/28/75	0003	2	1.63	2.950	6.00	5	7.375	X X X X X
6803090611	ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI	02/28/75	0002	4	3.25	0.178	0.36	10	0.445	X X X X X
6803090611	ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI	02/28/75	0001	2	1.63	1.898	3.86	5	4.745	X X X X X
		SUBTOTAL		8	6.50	5.026	10.22	20	12.565	
6804050100	ECHINODERM HOLOTHUROIDEA MOLPADIA SP.	02/28/75	0001	1	0.81	6.832	13.89	3	17.080	X X X
6804050100	ECHINODERM HOLOTHUROIDEA MOLPADIA SP.	02/28/75	0003	2	1.63	12.762	25.94	5	31.905	X X X
6804050100	ECHINODERM HOLOTHUROIDEA MOLPADIA SP.	02/28/75	0002	1	0.81	13.528	27.50	3	33.820	X X X
		SUBTOTAL		4	3.25	33.122	67.33	10	82.805	
		STATION TOTAL		123		49.194		308	122.985	

SIMPSON INDEX 0.048914 SHANNON DIVERSITY INDEX 3.160702

APPENDIX TABLE 2.

Gulf of Alaska Benthos. List of all taxonomic groups found on cruises from July 74 through May 75. Listing of all Biologically Important Species (BIT) and BIT Criteria.

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 LIST OF ALL TAXONOMIC GROUPS FOUND

 CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS          CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
 CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION      CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION
 CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION

TAXON CODE                TAXON NAME                                 CRIT1  CRIT2  CRIT3  CRIT4  CRIT5      STA OCC

3104000000   PROTOZOA SARCODINA RHIZOPEDIA                                   X             X                  4
3200000000   SPONGES                                                         X      X      X      X          12
3301000000   CNIDARIA HYDROZOA                                                                                1
3303000000   CNIDARIA ANTHOZOA                                               X      X      X      X           7
3303010000   CNIDARIA ANTHOZOA SEA PEN                                              X      X      X           5
3303480101   CNIDARIA ANTHOZOA LEIOPTILUS GUERNEYI                                                            1
4000000000   NEMERTEANS RHYNCHOCOELA                                  X                                      22
4801000000   POLYCHAETA                                                                                      16
4801010000   POLYCHAETA POLYNOIDAE                                                                            1
4801010300   POLYCHAETA POLYNOIDAE ARCTEOBIA                                                                  1
4801010602   POLYCHAETA POLYNOIDAE GATTYANA CILIATA                                                           2
4801010606   POLYCHAETA POLYNOIDAE GATTYANA TREADWELLI                                                        2
4801010806   POLYCHAETA POLYNOIDAE HARMOTHOE IMBRICATA                                                        4
4801010811   POLYCHAETA POLYNOIDAE HARMOTHOE LUNULATA                                                         1
4801011103   POLYCHAETA POLYNOIDAE LEPIDONOTUS SQUAMATUS                                                      2
4801011502   POLYCHAETA POLYNOIDAE POLYNOE GRACILIS                                                           1
4801011701   POLYCHAETA POLYNOIDAE HESPERONOE COMPLANATA                                                      3
4801020101   POLYCHAETA POLYODONTIDAE PEISIDICE ASPERA                       X             X                  7
4801050101   POLYCHAETA SIGALIONIDAE PHLOE MINUTA                                                             9
4801120102   POLYCHAETA PHYLLODOCIDAE PHYLLODOCE GROENLANDICA                                                 2
4801120104   POLYCHAETA PHYLLODOCIDAE ARAITIDES MUCOSA                                                        2
4801120203   POLYCHAETA PHYLLODOCIDAE ETEONE PACIFICA                                                         1
4801120205   POLYCHAETA PHYLLODOCIDAE ETEONE LONGA                                                            8
4801120307   POLYCHAETA PHYLLODOCIDAE EULALIA NIGROMACULATA                                                   1
4801120700   POLYCHAETA PHYLLODOCIDAE PHYLLODOCE SP.                                                          1
4801200401   POLYCHAETA HESIONIDAE OPHIODROMUS PUGENTTENSIS                                                   1
4801220000   POLYCHAETA SYLLIDAE                                                                              1
4801220300   POLYCHAETA SYLLIDAE SYLLIS SP                                                                    2
4801220304   POLYCHAETA SYLLIDAE SYLLIS SCLEROLEMA                                                            2
4801220501   POLYCHAETA SYLLIDAE TYPOSYLLIS ALTERNATA                                                         1
4801220502   POLYCHAETA SYLLIDAE SYLLIS ARMARILLIS                                                            1
4801220504   POLYCHAETA SYLLIDAE SYLLIS ELONGATA                                                              0
4801220602   POLYCHAETA SYLLIDAE EUSYLLIS BLOOMSTRANDI                                                        2
4801220700   POLYCHAETA SYLLIDAE EXOGONE SP.                                                                  4
4801220804   POLYCHAETA SYLLIDAE SPHAEROSYLLIS MIRUSATA                                                       1
4801221001   POLYCHAETA SYLLIDAE LANGERHANSIA CORNUTA                                      X                  7
4801221201   POLYCHAETA SYLLIDAE HAPLOSYLLIS SPONGICOLA                                                       3
4801230000   POLYCHAETA NEREIDAE                                                                              8
4801230101   POLYCHAETA NEREIDAE CERATONEREIS PAUCIDENTATA                                                    5
4801230400   NEREIS SP.                                                                                       2
4801230403   POLYCHAETA NEREIDAE NEREIS PELAGICA                                                              1
4801230404   POLYCHAETA NEREIDAE NEREIS PROCERA                                                               1
4801230407   POLYCHAETA NEREIDAE NEREIS GRUBEI                                                                1
4801240000   POLYCHAETA NEPHTYIDAE                                                                            4
4801240100   NEPTHYS SP.                                                                                      5
4801240102   POLYCHAETA NEPHTYIDAE NEPHTYS CILIATA                                                            2
4801240103   POLYCHAETA NEPHTYIDAE NEPHTYS COECA                                                              6
4801240105   POLYCHAETA NEPHTYIDAE NEPHTYS PUNCTATA                                        X                 20
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LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
4801240109	POLYCHAETA NEPTHYIDAE NEPTHYS LONGASETOSA						7
4801240111	POLYCHAETA NEPHTYIDAE NEPHTYS FERRUGINEA		X		X		6
4801260101	POLYCHAETA GLYCERIDAE GLYCERA CAPITATA	X			X		27
4801270100	POLYCHAETA GONIADIDAE GLYCINDE SP						1
4801270101	POLYCHAETA GONIADIDAE GLYCINDE PICTA						1
4801270201	POLYCHAETA GONIADIDAE GONIADA ANNULATA		X				17
4801270202	POLYCHAETA GONIADIDAE GONIADA MACULATA						2
4801280100	POLYCHAETA ONUPHIDAE ONUPHIS SP.						1
4801280102	POLYCHAETA ONUPHIDAE ONUPHIS GEOPHILIFORMIS	X	X	X	X	X	27
4801280103	POLYCHAETA ONUPHIDAE ONUPHIS IRIDESCENS						1
4801290000	POLYCHAETA EUNICIDAE						1
4801290100	POLYCHAETA EUNICIDAE EUNICE SP						3
4801290102	POLYCHAETA EUNICIDAE EUNICE BIANNULATA						1
4801290103	POLYCHAETA EUNICIDAE EUNICE BIANNULATA						1
4801290104	POLYCHAETA EUNICIDAE EUNICE KOB[illegible]NSIS						1
4801300000	POLYCHAETA LUBRINERIDAE						1
4801300100	LUMBRINERIS SP.						5
4801300105	POLYCHAETA LUBRINERIDAE LUMBRINERIS SIMILABRIS	X	X	X	X		39
4801390101	POLYCHAETA ORBINIIDAE HAPLOSCOLOPLOS [illegible]MENSIS						5
4801400200	POLYCHAETA PARAONIDEE ARICIDEA SP						1
4801400201	POLYCHAETA PARAONIDAE ARICIDEA SUECICA						5
4801400202	POLYCHAETA PARAONIDAE ARICIDEA USHAKOWI						1
4801400204	POLYCHAETA PARAONIDAE ARICIDEA JEFFREYSII				X		4
4801400301	POLYCHAETA PARAONIDAE PARAONIS GRACILIS						4
4801400400	POLYCHAETA PARAONIDAE CIRROPHORUS SP.						1
4801420000	POLYCHAETA SPIONIDAE						2
4801420201	POLYCHAETA SPIONIDAE LAONICE CIRRATA						2
4801420400	POLYCHAETA SPIONIDAE POLYDURA SP						1
4801420501	POLYCHAETA SPIONIDAE PRIONOSPIO MALMGRENI						1
4801420701	POLYCHAETA SPIONIDAE SPIO FILICORNIS		X		X		7
4801421001	POLYCHAETA NERINIDES SPIOPHANES BOMBYX						1
4801421003	POLYCHAETA SPIONIDAE SPIOPHANES CIRRATA		X		X		16
4801430101	POLYCHAETA MAGELONIDAE MAGELONA JAPONICA		X		X		3
4801480302	PCHAETA CHAETOPTERIDAE SPIOCHAETOPTERUS **COSTARUM**						2
4801490200	POLYCHAETA CIRRATULIDAE CAULLERIELLA SP				X		1
4801490300	POLYCHAETA CIRRATULIDAE THARYX SP.						19
4801520301	PO FLABELLIGERIDAE STYLARIOIDES PAPILLATA						1
4801520302	POLYCHAETA FLABELLIGERIDAE STY. PLUMOSA						1
4801550101	POLYCHAETA SCALIBREGMIDAE SCALIBREGMA INFLATUM						4
4801560100	POLYCHAETA OPHELIIDAE AMMOTRYPANE SP.						1
4801560400	POLYCHAETA SCALIBREGMIDAE TRAVISTA SP						1
4801560401	POLYCHAETA OPHELIIDAE TRAVISIA BREVIS						1
4801560403	POLYCHAETA SCALIBREGMIDAE TRAVISTA PUPA						1
4801570101	POLYCHAETA STERNASPIDAE STERNASPIS SCUTATA	X	X	X	X		26
4801580000	POLYCHAETA CAPITELLIDAE		X		X		1
4801580101	POLYCHAETA CAPITELLIDAE CAPITELLA CAPITATA						5
4801580201	POLYCHAETA CAPITELLIDAE HETEROMASTUS FILIFORMIS				X		7
4801610000	POLYCHAETA MALDANIDAE	X	X	X	X		25

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LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
4801610100	ASYSCHIS SP.						1
4801610102	POLYCHAETA MALDANIDAE ASYCHIS SIMILIS			X	X	X	5
4801610301	POLYCHAETA MALDANIDAE MALDANE SARSI						5
4801610302	POLYCHAETA MALDANIDAE MALDANE GLEBIFEX			X	X		6
4801610500	POLYCHAETA MALDANIDAE NICOMACHE SP						1
4801610501	POLYCHAETA MALDANIDAE NICOMACHE LUMBRICALIS						1
4801610502	POLYCHAETA MALDANIDAE NICOMACHE PERSONATA						1
4801610601	POLYCHAETA MALDANIDAE NOTOPROCTUS PACIFICUS		X		X		5
4801610802	POLYCHAETA MALDANIDAE AXIOTHELLA RUBROCINCTA						1
4801610900	PRAXILLELLA SP.						4
4801610901	POLYCHAETA MALDANIDAE PRAXILLELLA GRACILIS				X		15
4801610903	POLYCHAETA MALDANIDAE PRAXILLELLA AFFINIS						1
4801611001	POLYCHAETA MALDANIDAE RHODINE BITORQUATA						6
4801620102	POLYCHAETA OWENIIDAE OWENIA FUSIFORMIS				X		3
4801620201	POLYCHAETA OWENIIDAE MYRIOCHELE HEERI	X	X		X		36
4801630000	POLYCHAETA SABELLARIIDAE						1
4801630100	IDANTHYRSUS SP.						1
4801630102	POLYCHAETA SABELLARIIDAE IDANTHYRSUS ARMATUS						2
4801640300	PECTINARIA SP.						1
4801650000	POLYCHAETA AMPHARETIDAE						3
4801650200	AMPHARETE SP.						1
4801650201	POLYCHAETA AMPHARETIDAE AMPHARETE ARCTICA						8
4801650207	POLYCHAETA AMPHARETIDAE AMPHARETE GOESI						4
4801650303	POLYCHAETA AMPHARETIDAE AMPHICTEIS GUNNERI						1
4801650306	POLYCHAETA AMPHARETIDAE AMPHICTEIS MACRONATA						1
4801650501	POLYCHAETA AMPHARETIDAE MELINNA CRISTATA				X		14
4801660000	POLYCHAETA TEREBELLIDAE						2
4801660700	POLYCHAETA TEREBELLIDAE PISTA SP						1
4801660701	POLYCHAETA TEREBELLIDAE PISTA CRISTATA				X		13
4801660702	POLYCHAETA TEREBELLIDAE PISTA FASCIATA						4
4801661201	POLYCHAETA SPINOSHAERA ARTECAMA CONIFERA						2
4801661901	POLYCHAETA TEREBELLIDAE PROCLEA EMMI						2
4801670101	POLYCHAETA TEREBELLIDAE TEREBELLIDES STROEMI	X	X		X		22
4801670201	PO TRICHOBRANCHIDAE TRICHOBRANCHUS GLACIALIS						1
4801680000	POLYCHAETA SABELLIDAE						3
4801680101	POLYCHAETA SABELLIDAE CHONE GRACILIS						2
4801680102	POLYCHAETA SABELLIDAE CHONE INFUNDIBULIFORMIS						5
4801680201	POLYCHAETA SABELLIDAE EUCHONE ANALIS						4
4801680401	POLYCHAETA SABELLIDAE MEGALOMMA SPLENDIDA					X	1
4801680601	POLYCHAETA SABELLIDAE POTAMILLA NEGLECTA						4
4801700200	POLYCHAETA SERPIDULAE CRUCIGERA SP						1
4801700900	POLYCHAETA SERPULIDAE APOMATUS SP						1
4801740103	POLYCHAETA APHRODITIDAE APHRODITA PARVA						1
4802000000	OLIGICHAETA				X		1
4900000000	MOLLUSCA						1
4901030101	MOLLUSCA APLACOPHORA CHAETODERMA ROBUSTA		X		X		20
4903020302	MOLLUSCA POLYPLACOPHRA ISCHNOCHITON ALBUS						5
4903050400	MOLLUSCA POLYPLACOPHRA MOPALIA SP.			X		X	2

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
4903080100	MOLLUSCA POLYPLACOPHORA HANLEYA SP						2
4903080101	MOLLUSCA POLYPLACOPHORA HANLEYA HANLEYI						1
4904000000	MOLLUSCA PELECYPODA						3
4904020201	MOLLUSCA PELECYPODA NUCULA TENUIS	X	X		X		34
4904030101	MOLLUSCA PELECYPODA MALLETIA CUNEATA						3
4904030201	MOLLUSCA PELECYPODA NUCULANA PERNULA		X	X	X	X	21
4904030202	MOLLUSCA PELECYPODA NUCULANA MINUTA				X		4
4904030301	MOLLUSCA PELECYPODA PORTLANDIA ARCTICA		X		X		14
4904030500	MOLLUSCA PELECYPODA YOLDIA SP.		X		X		3
4904030501	MOLLUSCA PELECYPODA YOLDIA AMYGDAIEA				X		2
4904070201	MOLLUSCA PELECYPODA CRENELLA DESSUCATA		X		X		7
4904070301	MOLLUSCA PELECYPODA MEGACRENELLA COLUMBIANA						2
4904070402	MOLLUSCA PELECYPODA MUSCULUS DISCORS						1
4904070500	MOLLUSCA PELECYPODA DACRYDIUM SP.				X		7
4904070501	MOLLUSCA PELECYPODA DACRYDIUM PACIFICUM				X		9
4904070601	MOLLUSCA PELECYPODA MODIOLUS MODIOLUS						1
4904080201	MOLLUSCA PELECYPODA CYCLOPECTEN RANDOLPHI		X	X	X		5
4904090101	MOLLUSCA PELECYPODA LIMA SABAURICULATA						1
4904110100	ASTARTE SP.				X		5
4904110103	MOLLUSCA PELECYPODA ASTARTE MONTEGUI			X	X	X	4
4904110104	MOLLUSCA PELECYPODA ASTARTE POLARIS		X	X	X	X	6
4904110108	MOLLUSCA PELECYPODA ASTARTE ESQUIMAULTI						2
4904120101	MOLLUSCA PELECYPODA CYCLOCARDIA VENTRICOSA		X	X	X		13
4904150201	MOLLUSCA PELECYPODA AXINOPSIDA SERRICATA	X	X		X		28
4904150300	MOLLUSCA PELECYPODA THYASIRA SP		X		X		1
4904150301	MOLLUSCA PELECYPODA THYASIRA FLEXUOSA				X		15
4904180101	MOLLUSCA PELECYPODA MYSELLA COMRESSA						1
4904180201	MOLLUSCA PELECYPODA ODONTOGENIA BOREALIS		X		X		7
4904200101	MOLLUSCA PELECYPODA CLINOCARDIUM CILIATUM						2
4904200103	MOLLUSCA PELECYPODA CLINOCARDIUM FUCANUM				X		1
4904210501	MOLLUSCA PELECYPODA PSEPHIDIA LORDI		X		X		20
4904240101	MOLLUSCA PELECYPODA MACOMA CALCAREA			X		X	6
4904290200	MOLLUSCA PELECYPODA HIATELLA SP.						1
4904290201	MOLLUSCA PELECYPODA HIATELLA ARCTICA						2
4904320104	MOLLUSCA PELECYPODA PANDORA GRANDIS						1
4904330200	MOLLUSCA PELECYPODA LYONSIA SP.						0
4904330202	MOLLUSCA PELECYPODA LYONSIA PUGETTENSIS						1
4904350205	MOLLUSCA PELECYPODA THRACIA BERINGI						1
4904370100	CARDIOMYA SP.						0
4904370101	MOLLUSCA PELECYPODA CARDIOMYA PECTENATA						9
4904370103	MOLLUSCA PELECYPODA CARDIOMYA OLDROYDI						1
4905000000	MOLLUSCA GASTROPODA						1
4905030200	MOLLUSCA GASTROPODA PUNCTURELLA SP						1
4905030201	MOLLUSCA GASTROPODA PUNCTURELLA GALEATA						1
4905050201	MOLLUSCA GASTROPODA LEPETA CAECA						2
4905060300	MOLLUSCA GASTROPODA MARGARITES SP.						1
4905060402	MOLLUSCA GASTROPODA SOLARIELLA OBSCURA						1
4905060404	MOLLUSCA GASTROPODA SOLARIELLA LEWISAI						2

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
4905090100	MOLLUSCA GASTROPODA LITTORINA SP.						1
4905250201	MOLLUSCA GASTROPODA NATICA CLAUSA						1
4905250402	MOLLUSCA GASTROPODA POLINICES PALLIDA						1
4905270209	MOLLUSCA GASTROPODA VELUTINA LAEVIGATA						1
4905300416	MOLLUSCA GASTROPODA TROPHONOPSIS LASIUS						1
4905310102	MOLLUSCA GASTROPODA NUCELLA LAMELLOSA						1
4905330300	MOLLUSCA GASTROPODA COLUS						1
4905340101	MOLLUSCA GASTROPODA AMPHISSA COLUMBIANA				X		3
4905340102	MOLLUSCA GASTROPODA AMPHISSA RETACULATA				X		3
4905340200	MITRELLA SP.						1
4905340204	MOLLUSCA GASTROPODA MITRELLA GOULDI						1
4905410000	MOLLUSCA GASTROPODA TURRIDAE						1
4905410400	MOLLUSCA GASTROPODA OENOPOTA SP.						2
4905420100	MOLLUSCA GASTROPODA ODOSTOMIA SP.						1
4905490203	MOLLUSCA GASTROPODA CYLICHNA ALBA						2
4906010100	MOLLUSCA SCAPHOPODA DENTALIUM SP		X		X		18
4906020100	MOLLUSCA SCAPHOPODA CADALUS SP		X		X		9
5200030300	CRUSTACEA AMPHIPODA HALOSOMA SP.						2
5200030301	PYCNOGONIDA HALOSOMA VIRIDINTESTINALIS						1
5307000000	CRUSTACEA PODACOPA						1
5311000000	CRUSTACEA HARPACTICOIDA				X		1
5318010000	CRUSTACEA THORACICA LEPADIDAE						0
5318010201	CR THORACICA LEPADIDAE SCALPELLUM COLUMBIANA			X		X	1
5318020111	CRUSTACEA THORACICA LEPADIDAE BALANUS ROSTRATUS				X		1
5328000000	CRUSTACEA CUMACEA						4
5328020101	CRUSTACEA CUMACEA LAMPROPIDAE LAMPROPS FUSCATA						3
5328040101	CRUSTACEA CUMACEA LEUCONIDAE LEUCON NASICA						4
5328040106	CRUSTACEA CUMACEA LEUCONIDAE LEUCON ACUTIROSTRIS						2
5328040201	CR CUMACEA LEUCONIDAE EUDORELLA EMARGINATA		X		X		13
5328040202	CRUSTACEA CUMACEA LEUCONIDAE EUDORELLA PACIFICA						1
5328040301	CR CUMACEA LEUCONIDAE EUDORELLOPSIS INTEGRA						2
5328050100	CRUSTACEA CUMACEA DIASTYLIDAE DIASTYLIS SP						4
5328050110	CRUSTACEA CUMACEA DIASTYLIDAE DIASTYLIS LUCIFERA						1
5328050112	CRUSTACEA CUMACEA DIASTYLIS KOREANA						1
5328050124	CRUSTACEA CUMACEA DIASTYLIDAE DIASTYLIS HIRSATA						4
5328070101	CRUSTACEA CUMACEA CAMPYLASPIS RUFA						1
5328070107	CR CUMACEA CAMPYLASPIDAE CAMPYLASPIS VERRUCOSA						1
5328080102	CRUSTACEA CUMACEA NANNASTACIDAE CUMELLA VULGARIS						1
5330000000	CRUSTACEA ISOPODA						1
5330010301	CRUSTACEA ISOPODA ANTHURIDAE CALATHURA BRANCHIAT				X		1
5330050203	CRUSTACEA ISOPODA ROCINELA AUGUSTATA						1
5330110000	CRUSTACEA ISOPODA GNATHIA SP.		X		X		7
5330110100	CRUSTACEA ISOPODA GNATHIA SP						2
5330120000	CRUSTACEA ISOPODA ANTHURIDAE HYSSURA SP.						2
5331000000	CRUSTACEA AMPHIPODA		X		X		20
5331010101	CRUSTACEA AMPHIPODA ACANTHONATOZOMA INFLATUM						2
5331020000	AMPELISCIDAE						3
5331020101	CRUSTACEA AMPHIPODA AMPELISCA MACROECEPHALA				X		7

LIST OF ALL TAXONOMIC GROUPS FOUND

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CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
5331020102	CRUSTACEA AMPHIPODA AMPELISCIDA BIRULAI						2
5331020200	BYBLIS SP.				X		1
5331020201	CRUSTACEA AMPHIPODA BYBLIS CRASSICORNIS				X		5
5331020202	CRUSTACEA AMPHIPODA BYBLIS EAIMANDI				X		3
5331020300	HAPLOOPS SP						1
5331020301	CRUSTACEA AMPHIPODA HAPLOOPS TUBICULA				X		3
5331150000	COROPHIDAE						1
5331150301	CRUSTACEA AMPHIPODA ERICTHONIUS HUNTERI						3
5331210000	CRUSTACEA AMPHIPODA GAMMARIDAE						1
5331220100	EOHAUSTORIUS SP.						1
5331220400	CRUSTACEA AMPHIPODA UROCHOE SP						1
5331220401	CRUSTACEA AMPHIPODA UROTHOE ELEGANS						1
5331260201	CRUSTACEA AMPHIPODA PHOTIS BREVIPES						0
5331340301	CRUSTACEA AMPHIPODA ANONYX OCHOTICUS						3
5331341405	CRUSTACEA AMPHIPODA HIPPOMEDON PROPINQUUS						2
5331370200	CRUSTACEA AMPHIPODA ACEROIDES SP.						1
5331420000	CRUSTACEA AMPHIPODA PHOXOCEPHALIDAE						1
5331420100	HARPINIA SP.				X		8
5331420101	CRUSTACEA AMPHIPODA HARPINIA EMERYI						3
5331420102	CRUSTACEA AMPHIPODA HARPINIA KOBJAKOVAE						1
5331420201	CRUSTACEA AMPHIPODA HARPINIOPSIS SANDPEDROENSIS				X		9
5331420301	C AMPHIPODA PHOXOCEPHALIDAE HETEROPHOXUS OCULATU						6
5331420401	CRUSTACEA AMPHIPODA HETEROPHOXUS OCULATUS						0
5331420701	CRUSTACEA AMPHIPODA PARAPHOXUS ROBUSTUS						3
5331420702	CRUSTACEA AMPHIPODA PARAPHOXUS SIMPLEX						4
5331420800	CRUSTACEA AMPHIPODA PHOXOCEPHALUS SP.						3
5331980000	CRUSTACEA AMPHIPODA CAPRELLIDAE						1
5331980722	CRUSTACEA AMPHIPODA CAPRELLA STRIATA						4
5333000000	CRUSTACEA DECAPODA						2
5333090000	CRUSTACEA DECAPODA MAJIIDAE						0
5333110200	CRUSTACEA DECAPODA PAGURUS SP						1
5333130000	CRUSTACEA DECAPODA PINNOTHERIDAE						0
5333170302	CRUSTACEA DECAPODA MAJIIDAE CHIONOECETES BAIRDI						1
5333210300	CRUSTACEA DECAPODA XANTHIDAE PINNIXA SP						2
5333210303	CR DECAPODA PINNOTHERIDAE PINNIXA OCCIDENTALIS						3
5900000000	SIPUNCULIDA			X			7
5901010101	SIPUNCULIDA GOLFINGIA MARGARITACEA			X	X	X	14
6000000000	ECHIUROIDEA						1
6101010100	PRIAPULIDA HALICRYPTUS SP						1
6101010202	PRIAPULIDA PRIAPULUS CAUDATUS						1
6600000000	ECTOPROCTA		X		X		11
6601080101	BRYOZOA MICROPORINA BOREALIS						4
6603060101	BRYOZOA CLAVOPORA OCCIDENTALIS				X		3
6700000000	BRACHIOPODA			X			2
6702000000	BRACHIOPODA ARTICULATA						1
6702030100	TEREBRATULINA SP.						1
6702030101	BRACHIOPODA ARTICULATA TEREBRATULINA UNGUICULA			X	X	X	4
6702030103	BRACHIOPODA ARTICULATA TEREBRATULINA CROSSEI				X		2

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[redacted]LF [redacted]LAS[redacted]ENT[redacted] - [redacted]RAB[redacted]KEN[redacted]Y 7[redacted]ROU[redacted]AY 7[redacted] [redacted] [redacted] [redacted] [redacted] [redacted]/12[redacted] [redacted]AGE[redacted]8 [redacted]

 LIST OF ALL TAXONOMIC GROUPS FOUND

 CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS             CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
 CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION         CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION
 CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION

TAXON CODE              TAXON NAME                                CRIT1  CRIT2  CRIT3  CRIT4  CRIT5     STA OCC

6702030104   BRACHIOPODA ARTICULATA TEREBRATULINA SPINDENT                                                 1
6702050101   BRACHIOPODA ARTICULATA DEISTOTHYRIS FRONTALIS                      X             X            1
6702050301   BRACHIOPODA ARTICULATA LAQUEUS CALIFORNIANUS                       X             X            2
6702050401   BRACHIPODA ARTICULATA TENEBRATATA TRANSVERSA                                                  1
6801060100   CTENODISCUS SP.                                                                               1
6801060101   EC AS PORCELLANASTERIDAE CTENODISCUS CRISPATUS      X      X      X      X      X            22
6801110103   ECHINODERM ASTEROIDEA CROSSASTER PAPPOSUS                                                     1
6802000000   ECHINODERM ECHINOIDEA                                      X      X             X            2
6802030101   ECHINODERM ECHINOIDEA BRIASTER TOWNSENDI                   X      X      X      X            5
6803000000   ECHINODERM OPHIUROIDEA                                                   X                  14
6803020101   ECHINODERM OPHIUROIDEA AMPHIODA EVRYASPIS                                                     1
6803020201   ECHINODERM AMPHIURIDAE AMPHIPHOLUS PUGETANA                                                   1
6803020301   ECHINODERM AMPHIURIDAE DIAMPHIODIA CRATERODMETA                                               2
6803020303   ECHINODERM AMPHIURIDAE DIAMPHIODIA PERIERCTA                                                  2
6803020501   OPHIUROIDEA AMPHIURIDAE NULLAMPIURA PSILOPHORA                                                1
6803020701   ECHINODERM AMPHIURIDAE PANDELLIA CARCHARA                                X                    1
6803020801   ECHINODERM AMPHIURIDAE UNIOPLUS MACRASPIS                  X      X      X      X           15
6803060101   ECHINODERM OPHIUROIDEA OPHINOPHOLUS ACULEATA                                                  1
6803090000   ECHINODERM OPHIUROIDEA OPHIURIDAE                                                             3
6803090501   EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA DISACANTHA                                               5
6803090503   EC OPHIUROIDEA OPHIURIDAE OPHIOPENIA VACINA                                                   1
6803090600   OPHIURA SP.                                                       X                           1
6803090611   ECHINODERM OPHIUROIDEA OPHIURIDAE OPHIURA SARSI     X      X      X      X      X           23
6804000000   HOLOTHUROIDEA                                                                                 2
6804050100   ECHINODERM HOLOTHUROIDEA MOLPADIA SP.                             X      X      X           10
6804080000   ECHINODERM HOLOTHUROIDEA DEIMATIDAE                               X             X            1
6804120200   ECHINODERM PSOLUS SP.                                                    X                    2
6805000000   ECHINODERM CRINOID FRAGMENTS                                                                  2
7200000000   TUNICATA                                                                                      3
7202050103   UROCHORDATA CHELYOSOMA COLUMBIANUM                                                            1
9999999999   UNIDENTIFIABLE                                                           X                   19

 TOTAL NUMBER OF TAXONS = 311
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APPENDIX TABLE 3.

A sample of trawl data collected by commercial trawl in the Northeast Gulf of Alaska (NEGOA) on the M/V *North Pacific*. Collection made May - August 1975.

BENTHIC TRAWL DATA

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Mo	Day	Start Time	Start Lat Deg	Min	Start Long Deg	Min
10917	742	14	078	75	05	02	1400	59°	57.0'	146°	45.0'
1 2 3 4 5	6 7 8 9	10 11 12 13	14 15 16	17 18	19 20	21 22	23 24 25 26	27 28	29 30 31	32 33 34	35 36 37

Date Finish Year	Mo	Day	Finish Time	Finish Lat Deg	Min	Finish Long Deg	Min	Q L	Time Zone	Distance Fished (Km)	Depth Fished (M)		% Samp		Card
75	05	03	1415	59°	50.0'	146°	42.0'		09	4.44	63.7	67.3	50		H

Comments: Weights of hermit crabs include their shells; this tow contains many small round rock (4cm in diameter); Weights of some ascidians include some small rocks to which the ascidian are attached.

Collector: JEWETT

	TAXON	COMMON NAME	SPECIES CODE 14–23	Count 24–28	Wet "Weight" (Kg.) 29–34	Wet "Weight" (lbs) 35–39	Code 78	Last 79	Card 80
1	Porifera	sponge	32	3	1.350		A		P
2	Ptilosarcus gurneyi	sea pen	3303480101	23	1.380		"		P
3	Actiniidae	anemone	330355	6	1.200		"		P
4	Clinocardium fucanum	clam	4904200103	1	.004		"		P
5	Lischkeia cidaris	gastropod	4905060701	75	.900		"		P
6	Pyrolofusus harpa	"	4905331001	2	.200		"		P
7	Buccinum plectrum	"	4905320128	20	.400		"		P
8	Modiolus modiolus	mussel	4904070601	10	1.100		"		P
9	Pecten caurinus	scallop	4904080401	6	.660		"		P
10	Astarte polaris	clam	4904110104	4	.040		"		P
11	Serripes groenlandicus	clam	4904200201	2	.400		"		P
12	Fusitriton oregonensis	gastropod	4905290101	130	9.970		"		P
13	Neptunea lyrata	"	4905330201	15	2.720		"		P
14	Chlamys hastata hericia	scallop	4904020101	200	1.600		"		P
15	Tochuina tetraquetra	nudibranch	4905660201	2	.300		"		P
16	Tritoniidae	"	490566	2	.300		"		P
17	Hyas lyratus	crab	5333170201	10	1.810		"		P
18	Pandalus montagui tridens	shrimp	5333040104	6	.048		"		P
19	Pagurus ochotensis	hermit crab	5333110202	75	6.800		"		P
20	Pagurus kennerlyi	"	5333110207	20	2.260		"		P
21	Elassochirus tenuimanus	"	5533110301	20	2.260		A		P

(Record additional comments on reverse side)

(Continued)

060176
IMSUAWBK

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BENTHIC TRAWL DATA (Continued)

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Date Start Mo	Date Start Day	Start Time	Start Lat Deg	Start Lat Min	Start Long Deg	Start Long Min
	749	14									

Date Finish Year	Date Finish Mo	Date Finish Day	Finish Time	Finish Lat Deg	Finish Lat Min	Finish Long Deg	Finish Long Min	Q L	Time Zone	Distance Fished (Km)	Depth Fished (M)	% Samp		Card
														H

Comments:

Collector:

	TAXON	COMMON NAME	SPECIES CODE	Count	Wet "Weight" (Kg.)	Wet "Weight" (lbs)		Code	Last	Card
1	Elassochirus cavimanus	hermit crab	5333110302	19	2.260			A		P
2	Cancer oregonensis	Crab	5333180106	12	.070					P
3	Oregonia gracilis	"	5333170101	7	1.260					P
4	Rhinolithodes wosnessenski	"	5333121201	8	1.440					P
5	Lopholithodes foraminatus	"	5333121002	1	.420					P
6	Labidochirus splendescens	hermit crab	5333110401	12	.600					P
	Pagurus aleuticus	"	5333110203	6	.660					P
8	Balanus sp.	Barnacles	53180201	151	4.530					P
9	Paracrangon echinata	shrimp	5333060401	12	.084					P
10	Terebratulina unguicula	Brachiopods	6702030101	432	3.020					P
11	Terebratalina transversa	"	6702050401	432	3.020					P
12	Laqueus californianus	"	6702050301	432	3.020					P
13	Strongylocentrotus droebachiensis	urchin	6802040201	248	7.440					P
14	Ophiura sarsi	Brittle star	6803090611	12	.070					P
15	Lethasterias nanimensis	sea star	6801120901	10	2.000					P
16	Solaster dawsoni	"	6801110301	12	2.400					P
17	Henricia aspera	"	6801080101	6	.600					P
18	Stylasterias forreri	"	6801121101	8	.320					P
19	Pteraster tesselatus	"	6801100306	45	9.900					P
20	Crossaster papposus	"	6801110103	22	1.760					P
21	Poraniopsis inflata	"	6801080201	3	.660			A		P

(Record additional comments on reverse side)

039178
IMSUAWBK

(Continued)

BENTHIC TRAWL DATA (Continued)

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Mo	Day	Start Time:	Start Lat Deg	Min	Start Long Deg	Min
	74C	14						°	. ′	°	. ′

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37

Date Finish Year	Mo	Day	Finish Time	Finish Lat Deg	Min	Finish Long Deg	Min	Q L	Time Zone	Distance Fished (Km)	Depth Fished (M)	% Samp		Card
				°	. ′	°	. ′			.	. – .			H

38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Comments:

Collector:

	TAXON	COMMON NAME	SPECIES CODE 14–23	Count 24–28	Wet "Weight" (Kg.) 29–34	Wet "Weight" (lbs) 35–39		Code 78	79	Card 80
1	Ceramaster Patagonicus	Sea star	6801040104	7	.490			A		P
2	Henricia sp.	"	68010801	25	1.750			A		P
3	Cucumariidae	Sea cucumber	680410	18	6.120			A		P
4	Halocynthia aurantium	Ascidian	7203030402	612	122.470			A		P
5	Gorgonocephalus cargi	Basket star	6803040201	6	.240			A		P
6										P
7	Hippoglossus stenolepis	halibut	7917020701	22	408.240			B		P
8	Bathymaster signatus	Searcher	7916090103		32.430			B		P
9	Lepidopsetta bilineata	Rock sole	7917020901		18.590			B		P
10										P
11										P
12										P
13										P
14										P
15										P
16										P
17										P
18										P
19										P
20										P
21										P

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 78 79 80

(Record additional comments on reverse side)

030178
IMSUAWBK

BENTHIC TRAWL DATA

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Mo	Day	Start Time:	Start Lat Deg	Min	Start Long Deg	Min
N0817	768	15	078	75	05	10	1055	60°	10.0'	145°	14.0'
1 2 3 4 5	6 7 8 9	10 11 12 13	14 15 16	17 18	19 20	21 22	23 24 25 26	27 28	29 30 31	32 33 34	35 36 37

Date Finish Year	Mo	Day	Finish Time	Finish Lat Deg	Min	Finish Long Deg	Min	Q L	Time Zone	Distance Fished Km	Depth Fished (M)		% Samp		Card
75	05	10	1155	60°	10.0	146°	20.0'		09	5.2	72.2	83.7	100		H
38 39	40 41	42 43	44 45 46 47	48 49	50 51 52	53 54 55	56 57 58	59	60 61	62 63 64 65	66 67 68 69	70 71 72 73	74 75 76	77 78 79	80

Comments: Weights of hermit crab include their shells; One rubber glove found.

Collector: JEWETT

	TAXON	COMMON NAME	SPECIES CODE 14–23	Count 24–28	Wet "Weight" (Kg.) 29–34	Wet "Weight" (lbs) 35–39	Code 78	Last 79	Card 80
1	Tealia crassicornis	Anemone	3303550201	18	3.600		A		P
2	Pecten caurinus	scallop	4904080401	3	1.050				P
3	Fusitriton oregonensis	gastropod	4905290101	26	2.600				P
4	Buccinum plectrum	"	4905320128	12	.240				P
5	Neptunea lyrata	"	4905330801	18	3.240				P
6	Modiolus modiolus	muscle	4904070601	3	.330				P
7	Pyrulofusus harpa	gastropod	4905331001	2	.200				P
8	Tochuina tetraquetra	nudibranch	4905660201	5	.750				P
9	Tritoniidae	"	490566	7	1.050				P
10	Dorididae	"	490557	2	.300				P
11	Hyas lyratus	Crab	5333170201	29	5.220				P
12	Lopholithodes foraminatus	"	5333121002	1	.420				P
13	Rocinela angustata	isopod	5330050203	1	.001				P
14	Pandalus borealis	pink shrimp	5333040101	113	.900				P
15	Pandalus montagui tridens	shrimp	5333040104	28	.220				P
16	Chionoecetes bairdi	snow crab	5333170302	187	84.820				P
17	Pagurus aleutensis	hermit crab	5333110202	4	.360				P
18	Elassochirus cavimanus	"	5333110302	2	.240				P
19	Labidochirus splendescens	"	5333110401	5	.600				P
20	Pagurus confragosus	"	5333110216	5	.550				P
21	Hippolytidae	Shrimp	533305	1	.007		A		P

(Record additional comments on reverse side)

(Continued)

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BENTHIC TRAWL DATA (Continued)

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Mo	Day	Start Time:	Start Lat Deg	Min	Start Long Deg	Min
	766	15						°	ʹ	°	ʹ

Date Finish Year	Mo	Day	Finish Time	Finish Lat Deg	Min	Finish Long Deg	Min	O L	Time Zone	Distance Fished/Km	Depth Fished (M)	% Samp		Card
				°	ʹ	°	ʹ							H

Comments:

Collector:

	TAXON	COMMON NAME	SPECIES CODE	Count	Wet "Weight" (Kg.)	Wet "Weight" (lbs)		Code	Last	Card
			14–23	24–28	29–34	35–39		72	73	80
1	Pandalopsis dispar	sidestripe shrimp	5333040204	12	.120			1		P
2	Terebratalia transversa	Brachiopod	6702050401	250	1.750					P
3	Laqueus californianus	"	6702050301	138	.960					P
4	Terebratulina unguicula	"	6702030101	33	.230					P
5	Cucumariidae	Sea cucumber	680410	19	6.460					P
6	Strongylocentrotus droebachiensis	urchin	6802040201	40	1.200					P
7	Gorgonocephalus caryi	Basket star	6803040201	455	172.820					P
8	Ctenodiscus crispatus	Mud star	6801060101	1	.010					P
9	Mediaster aequalis	Sea star	6801040501	6	.660					P
10	Solaster dawsoni	"	6801110301	12	2.400					P
11	Lethasterias nanimensis	"	6801120901	8	1.600			A		P
12										P
13	Hippoglossus stenolepis	halibut	7917020791		29.930			3		P
14	Atheresthes stomias	Turbot	7917020102		17.010			5		P
15										P
16										P
17										P
18										P
19										P
20										P
21										P

(Record additional comments on reverse side)

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439

BENTHIC TRAWL DATA

Cruise Number	Station Number	Tow Number	Gear Code	Date Start Year	Date Start Mo	Date Start Day	Start Time:	Start Lat Deg	Start Lat Min	Start Long Deg	Start Long Min
1 2 3 4 5	6 7 8 9	10 11 12 13	14 15 16	17 18	19 20	21 22	23 24 25 26	27 28	29 30 31	32 33 34	35 36 37
R0917	76A	16	0T3	75	05	10	1335	60°	12.0'	146°	10.0'

Date Finish Year	Date Finish Mo	Date Finish Day	Finish Time	Finish Lat Deg	Finish Lat Min	Finish Long Deg	Finish Long Min	O I	Time Zone	Distance Fished (Km)	Depth Fished (M)	% Samp		Card
38 39	40 41	42 43	44 45 46 47	48 49	50 51 52	53 54 55	56 57 58	59	60 61	62 63 64 65	66 67 68 69 70 71 72 73	74 75 76	77 78 79	80
75	05	10	1425	60°	12.0'	146°	11.0'		07	5.92	105.5 107.3	100		H

Comments:

Collector: JEWETT

	TAXON	COMMON NAME	SPECIES CODE	Count	Wet "Weight" (Kg.)	Wet "Weight" (lbs)		Code	Last	Card
			14 15 16 17 18 19 20 21 22 23	24 25 26 27 28	29 30 31 32 33 34	35 36 37 38 39		78	79	80
1	Pandalus borealis	Pink shrimp	5333040101	170	1.360			A		P
2	Chionoecetes bairdi	snow crab	5333170302	217	98.430			A		P
3	Ctenodiscus crispatus	mud star	6801060101	136	1.360			A		P
4										P
5	Theragra chalcogramma	Pollock	7909020701		23.810			B		P
6	Hippoglossoides elassodon	Flathead sole	7917020601		21.096			B		P
7	Atheresthes stomias	Turbot	7917020102		14.960			B		P
8										P
9										P
10										P
11										P
12										P
13										P
14										P
15										P
16										P
17										P
18										P
19										P
20										P
21										P
			14 15 16 17 18 19 20 21 22 23	24 25 26 27 28	29 30 31 32 33 34	35 36 37 38 39		78	79	80

(Record additional comments on reverse side)

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IMSUAWBK

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 20

PRINCIPAL INVESTIGATOR: Dr. Howard M. Feder

Period July 1, 1975 - March 31, 1976* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	63,564.00	20,504.30	43,059.70
Staff Benefits	10,806.00	3,432.75	7,373.25
Equipment	4,000.00	3,211.02	788.98
Travel	5,200.00	3,740.97	1,459.03
Other	95,700.00	23,455.32	72,244.68
Total Direct	179,270.00	54,344.36	124,925.64
Indirect	36,359.00	11,728.45	24,630.55
Task Order Total	215,629.00	66,072.81	149,556.19

* Preliminary cost data, not yet fully processed.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 20 R.U. NUMBER: 281

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]	
	From	To	Batch 1	2
Silas Bent Leg I #811	8/31/75	9/14/75	6/30/76	None
Discoverer Leg IV #812	10/8/75	10/16/75	6/30/76	None
North Pacific	4/25/75	8/7/75	None	5/15/76
Discoverer #816	11/23/75	12/2/75	9/30/76	None
Contract #03-5-022-34	Last	Year	4/20/76	

Note: [1] Data Management Plan and Data Formats have been approved and are considered contractual.

Following is part 2 of the quarterly report R.U.# 281 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

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NEGOA

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RU 281

Project Title:	The Distribution, Abundance, Diversity, and Productivity of Benthic Organisms in the Gulf of Alaska
Contract Number:	03-5-022-56
Task Order Number:	20
Principal Investigator:	Dr. Howard M. Feder

I. Task Objectives

A. Inventory and census of dominant species.

B. Description of spatial and seasonal distribution patterns of selected species.

C. Provide comparison of dominant species distribution with physical, chemical and geological factors.

D. Provide preliminary observations of biological interrelationships between selected segments of benthic marine communities.

II. Field and Laboratory Activities

A. Grab Program

1. Ship schedules and names of vessels

a. 8 - 16 October 1975, NOAA ship Discoverer

b. 23 November - 8 December, 1975, NOAA ship Discoverer

2. Scientific Party

a. Dr. Howard M. Feder (Professor of Marine Science)

b. Grant E. M. Matheke, (Research Assistant and Graduate Student)

c. William Kopplin (Marine Technician)

3. Methods

a. $0.1M^2$ Van Veen grab was used on all stations. Five replicate grabs were taken on all stations except stations 25, 48, 55 where 10 grabs were taken in order to determine the number of grabs required for adequate statistical precision. During the Discoverer cruise, 8 - 16 October, 1975, in the Western Gulf of Alaska, substrate conditions often prevented adequate penetration of the grab and qualitative samples only were collected at stations 120, 137, 146, 157, 158, and 160. No samples could be collected from stations 136, 145, 147, 148 and 156. During Discoverer cruise, 23 November - 8 December, 1975, only qualitative samples could be obtained at stations 109 and 110 and no samples could be collected from stations 106, 107 and 108 due to substrate conditions.

b. A separate sediment sample was taken from one grab of each successful station for sediment size analysis.

c. Laboratory analysis at the Marine Sorting Center, University of Alaska, has not been completed for samples collected.

d. After extensive examination of the current literature on cluster analysis of benthic-invertebrate survey data, two approaches are being tested to determine their capabilities in determining species groups and areal patterns of species groups. The techinques will initially be applied to the data collected during the first year of the benthic biological study of the Northeastern Gulf of Alaska. A hierarchical agglomerative cluster analysis adaptable to single linkage (nearest neighbor) and group average sorting strategies will be used. Similarity matrices will be constructed using Czekanowski's co-efficient and Spatz's quantitative modification of the Jaccard co-efficient.

4. Sample Localities

a. Discoverer cruise of 8 - 16 October, 1975

The following stations were taken on a grid constructed to cover the Northwestern Gulf of Alaska (see enclosed table): Station numbers 101, 102, 103, 104, 105, 119, 120, 121, 123, 124, 133, 134, 135, 136, 137, 145, 146, 147, 148, 156, 157, 158, 159, and 160.

b. Discoverer cruise of 23 November - 8 December, 1975

The following stations, on the standard station grid of the Gulf of Alaska Lease Area, were taken: Station numbers 7, 25, 26, 39, 44, 48, 54, 55, 59A, 60, 61 62, and 63. Two new stations were occupied in order to get increased areal coverage - station number 68, Lat. 59° 38.2'N, Long. 147° 36.5'W and station number 69, Lat. 59° 20.0' N, Long. 147° 32.0' W. Finally, five stations in the Northwestern Gulf of Alaska grid, which were not occupied during Discoverer cruise of 8 - 16 October, 1975, were taken: station numbers 106, 107, 108, 109 and 110.

B. Trawl Program

1. Ship schedules and names of vessels.

   a. None this period.

2. Scientific party.

   a. Not applicable.

3. Methods.

   a. Field sampling.

   One hour tows were made at predetermined station locations using a 400 mesh Eastern otter trawl. Invertebrate samples were sorted, weighed and/or counted, identified or assigned a type number, and preserved for later examination.

   b. Laboratory analysis.

   Samples were returned for examination to the Marine Sorting Center, University of Alaska. Maps to show species distribution in the study area are in the final planning stage.

4. Sample locations.

   a. Stations occupied (see Fig. 1, NEGOA F/V North Pacific)

   b. Station Numbers (F/V North Pacific)

   70 A-F; 71 B-D; 72 D-I; 73 A-E, H, I; 74 A-D, F-I; 75 A-C, G; 76 A-C; 77 A, B, E, F, H, I; 78 A-C, E, F, H; 79 A-C, E-G; 80 A-F; 81 A-G; 82 A-F; 83 B, C, E-G; 84 B, C; 85 A; 86 B-D; 87 D; 88 A, B, D; 89 A-E; 90 B, C; 91 A-D; 92 C. D; 93 A-F; 94 A-G; 95 C-E; 96 A-G; 97 A-D; 98 A-D; 99 B-E; 100 B-D.

III. Results

A. Grab samples have been turned over to the Marine Sorting Center for laboratory analysis.

B. Maps showing species distribution in the study area are being prepared.

C. Trawl invertebrates have been identified and assigned a species code number.

IV. Preliminary Interpretation of Results

Not available.

V. Problems Encountered, Recommended Changes

A. More samples are available than present funding will permit us to process. Selected stations will be examined for species content and biomass. It will be necessary to archive all other samples pending additional funds. Such a procedure will necessarily reduce the seasonal and spatial coverage.

B. Substratum differences encountered in the Northwestern Gulf sampling grid indicate that a quantitative bottom survey might not be possible. Considerable additional time will be needed to develop a program in this area, if such type of data is essential. Possible alternatives are qualitative surveys with underwater cameras or t.v. in conjunction with dredges or trawls.

GULF OF ALASKA
SHELF STUDY

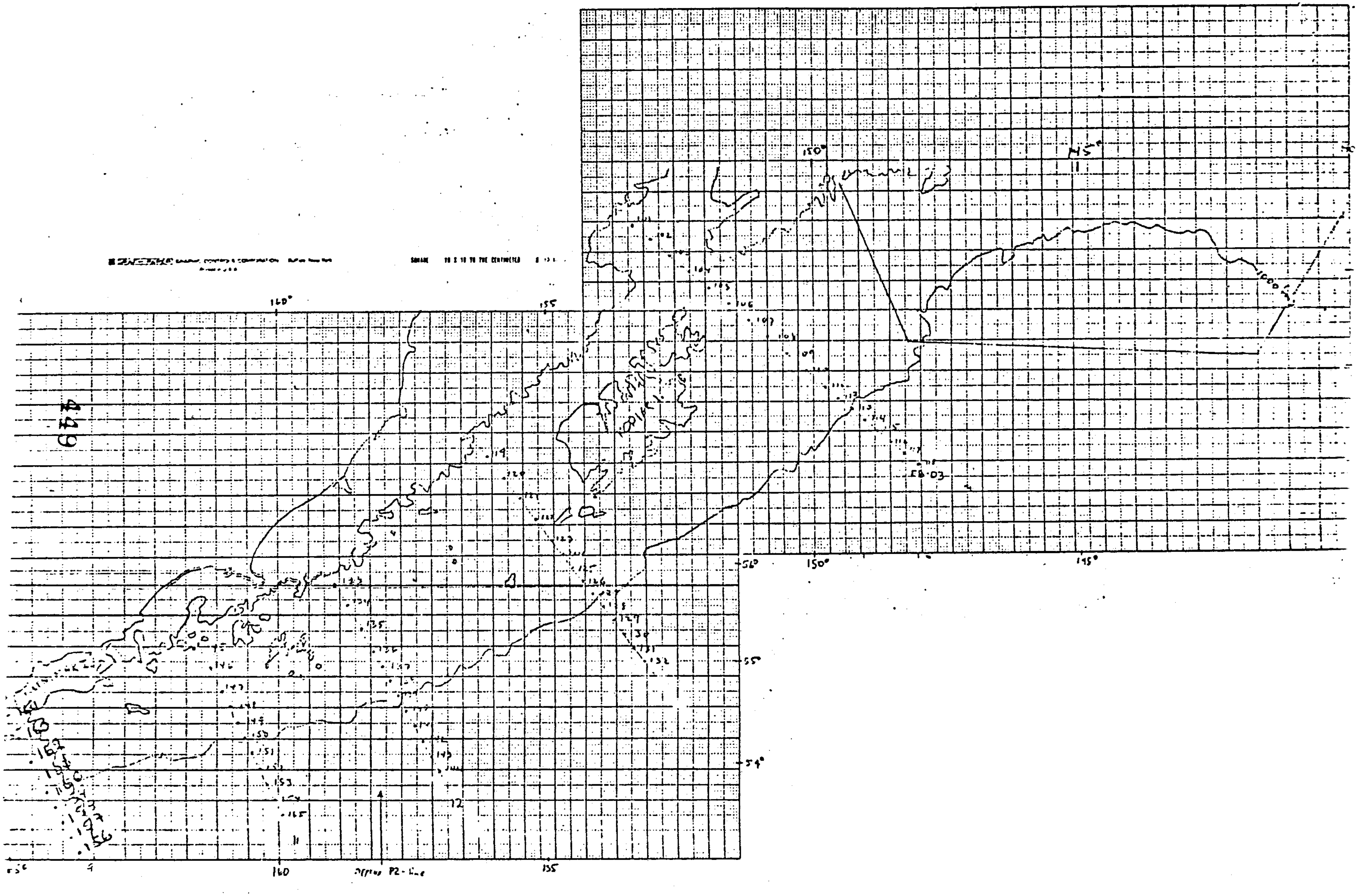
CRUISE NO. ________

GAS STATION NUMBER	POSITION LATITUDE (N)	POSITION LONGITURE (W)	APPROX. DEPTH (m)	ACTIVITIES
✓101	59 19.8	152 24.1	170	G
✓102	59 09.9	152 04.1	101	G
✓103	59 00.0	151 45.1	96	G
✓104	58 50.0	151 26.4	100	G
✓105	58 39.9	151 07.1	160	G
✓106	58 28.1	150 47.7	86	G
✓107	58 18.6	150 28.0	53	G
✓108	58 09.1	150 09.1	57	G
✓109	58 02.5	149 56.3	176	G
✓110	57 55.8	149 43.4	180	G
111	57 48.2	149 30.0	580	
112	57 41.6	149 17.1	1710	
113	57 34.8	149 03.9	2542	
114	57 27.0	148 51.3	2940	
115	57 20.6	148 38.7	4075	
116	57 14.0	148 25.5	4978	
117	57 05.5	148 12.7	4925	
118	57 00.0	148 00.0	4700	
✓119	57 06.9	156 00.0	250	G
✓120	56 55.0	155 44.1	294	G
✓121	56 43.2	155 27.9	238	G
✓122	56 31.3	155 12.0	42	G
✓123	56 19.1	154 55.1	12	G
✓124	56 07.1	154 39.4	107	G
125	55 58.9	154 28.5	565	
126	55 50.9	154 18.1	700	
127	55 43.1	154 07.4	540	
128	55 35.3	153 56.7	2385	
129	55 27.2	153 46.8	3804	
130	55 18.9	153 36.0	5460	
131	55 10.7	153 25.7	5150	
132	55 02.6	153 15.0	4545	
✓133	55 46.3	158 51.0	68	G
✓134	55 33.4	158 38.3	152	G
✓135	55 20.3	158 25.1	145	G
✓136	55 07.5	158 12.4	144	G
137	54 54.3	157 59.0	102	G
138	54 45.7	157 50.6	340	
139	54 36.9	157 42.2	1183	
140	54 28.2	157 33.7	1913	
141	54 19.3	157 25.2	4198	
142	54 10.5	157 15.6	5315	
143	54 02.0	157 07.8	5676	
144	53 52.8	156 59.6	5023	
✓145	55 03.1	161 24.4	70	G
✓146	54 49.4	161 12.5	67	G
✓147	54 36.2	161 00.7	105	G
✓148	54 23.5	160 49.1	109	G
149	54 13.4	160 41.2	777	
150	54 04.4	160 33.2	1645	
151	53 55.3	160 25.4	2910	
152	53 46.1	160 17.8	3907	
153	53 37.0	160 09.9	5641	
154	53 27.6	160 02.1	5938	
155	53 18.8	159 54.6	5165	

GULF OF ALASKA
SHELF STUDY

CRUISE NO. ______

GAS STATION NUMBER	POSITION LATITUDE (N)	LONGITUDE (W)	APPROX. DEPTH (m)	ACTIVITIES
✓156	54 29.2	165 11.3	98	G
✓157	54 17.0	164 58.8	65	G
✓158	54 04.5	164 46.2	101	G
✓159	53 51.9	164 34.0	100	G
✓160	53 43.3	164 25.6	195	G
161	53 34.7	164 17.0	2050	
162	53 26.0	164 08.7	3207	
163	53 17.2	164 00.7	3305	
164	53 08.7	163 52.0	4301	


SQUARE 10 X 10 TO THE CENTIMETER
150°
145°
160°
155°
56°
55°
54°
1000
EB-03
.102
.104
.106
.107
.113
.114
.119
.123
.124
.127
.130
.131
.132
.135
.136
.137
.145
.146
.147
.150
.151
.153
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.162
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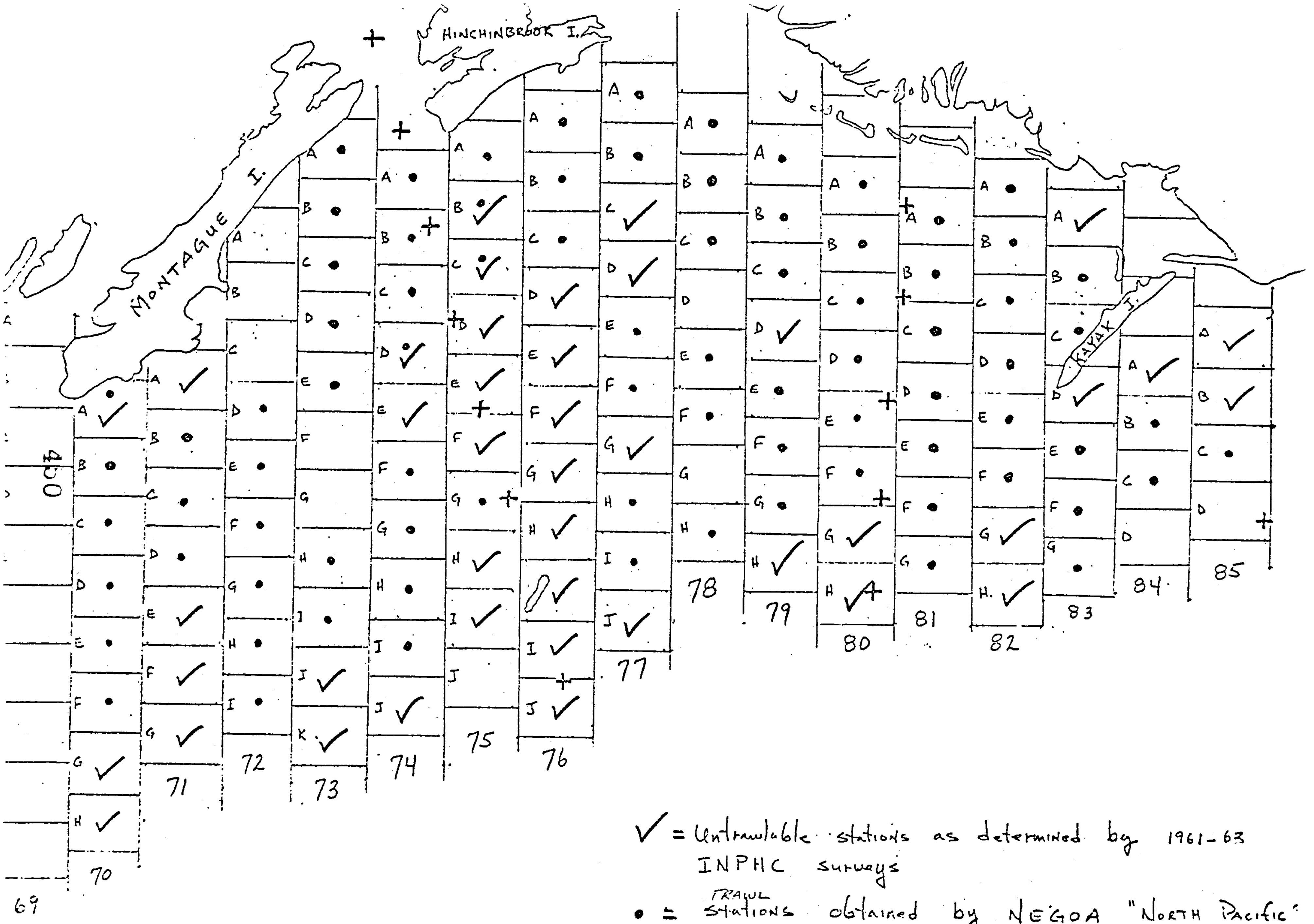
11
12
160
155
Offset P2-line



✓ = Untrawlable stations as determined by 1961-63 INPHC surveys

● = TRAWL Stations obtained by NEGOA "NORTH PACIFIC"

+ = Grab stations obtained by NEGOA "Oceanographer

Fig. 1 NEGOA Trawl stations obtained by
[illegible]

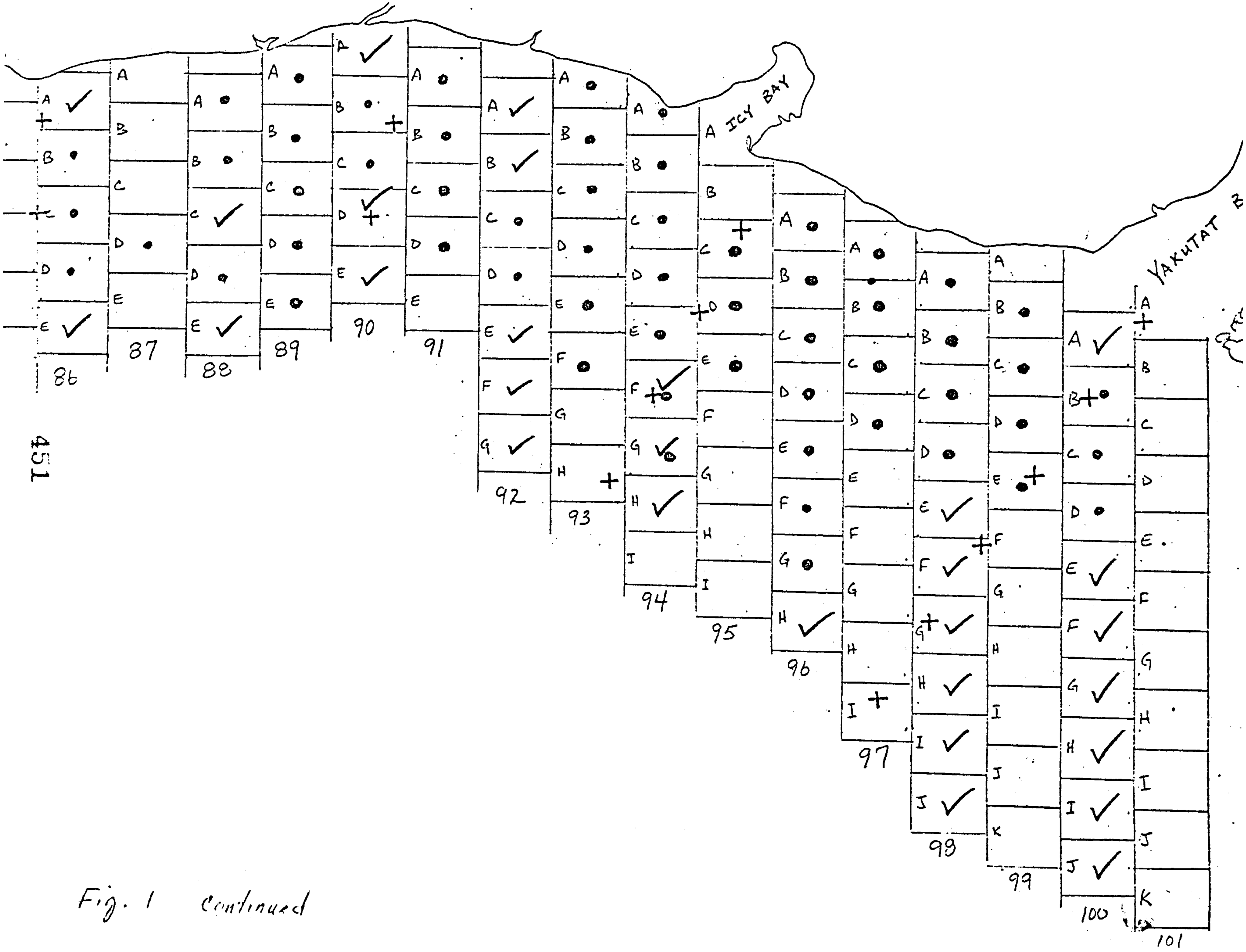


Fig. 1 continued

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 20 R.U. NUMBER: 281

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates (1)		
	From	To	Batch 1	2	
Silas Bent Leg I #811	8/31/75	9/14/75	6/30/76	None	
Discoverer Leg IV #812	10/8/75	10/16/75	6/30/76	None	
North Pacific	4/25/75	8/7/75	None	3/31/76	
Discoverer #816	11/23/75	12/2/75	9/30/76	None	
Contract #03-5-022-34	Last	Year	3/31/76		

Note: (1) Estimated submission dates are contingent upon final approval of data management plan submitted in draft form Oct. 9, 1975 and University of Alaska approved form Nov. 20, 1975 to NOAA. Also, final agreement by all parties on the data format is necessary.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE:	December 31, 1975
CONTRACT NUMBER:	03-5-022-56
TASK ORDER NUMBER:	20
PRINCIPAL INVESTIGATOR:	Dr. Howard M. Feder

Period July 1 -- December 31, 1975 * (6 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	63,564.00	21,951.31	41,612.69
Staff Benefits	10,806.00	3,666.86	7,139.14
Equipment	4,000.00	3,211.02	788.98
Travel	5,200.00	2,926.39	2,273.61
Other	95,700.00	20,271.50	75,428.50
Total Direct	179,270.00	52,027.08	127,242.92
Indirect	36,359.00	12,556.15	23,802.85
Task Order Total	215,629.00	64,583.23	151,045.77

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract # 03-5-022-56
Research Unit # 282/301
Reporting Period 4/1/75-3/31/76
Number of Pages 10

SUMMARIZATION OF EXISTING LITERATURE AND UNPUBLISHED DATA ON THE DISTRIBUTION, ABUNDANCE AND PRODUCTIVITY OF BENTHIC ORGANISMS OF THE GULF OF ALASKA AND BERING SEA

DR. HOWARD M. FEDER
Institute of Marine Science

University of Alaska

March 31, 1976

1. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

Objectives: (1) To summarize the existing literature on the systematics, abundance and feeding biology on Gulf of Alaska and Bering Sea marine organisms. (2) To locate unpublished data and archived biological samples available for analysis. (3) Where practical, to convert to digital form on magnetic tape pertinent data on the density, distribution and ecology of benthic organisms.

This information will provide a historical perspective of the abundance and distribution of benthic animals and establish the current state of knowledge on the biology of these organisms. With this histroical perspective current OCS projects looking at the current distribution and biology of marine organisms can be interpreted in a larger time frame. In addition, gaps in information not currently funded under OCS or not possible to understand in the time frame of the OCS funding period can be elucidated.

II. Introduction

See Section I

III. Current State of Knowledge

N.A.

IV. Study Area Gulf of Alaska and Bering Sea

V. Sources, Methods and Rationale of Data Collection

Standard Library Research Techniques

VI. Results

Objective 1: To summarize the existing literature on systematics, abundance and feeding biology using a key format.

Some 1500 references pertaining to North Pacific and Bering Sea have been punched on computer cards and an alphabetical listing will be available within a few weeks. Key words are being prepared and punched as well. This objective should be completed by the end of the next quarter.

Objective 2: To locate unpublished biological data and archived biological samples for analysis.

The sources queried and from those responding the materials available have summarized in Addendum I.

VII. Discussion

Substantially larger amounts of published material is available than was anticipated. Much of this information is of a nature not amendable to conversion to digitable data, (See Sec. IX).

VIII. Conclusions

N.A.

IX. Needs for further study

1.) Much of the information available is not transferable to magnetic tape. For example, mos of the Russian literature describes biocoenosis with out quantitative information by locality. Another example is general range information by species. Both of these types of data are much more ameniable to mapping than to conversion to magnetic tape.

2.) In view of the geographical limitations i.e., Gulf of Alaska and

Bering Sea, biological information such as breeding biology, feeding strategy and distribution of organisms in relationship to environmental factors from other areas is not being made available. This type of information will be extremely useful in interpreting relationships of organisms to petroleum impact.

3.) Preliminary information to develop food web diagrams and to document other biological interactions need to be developed. This information would provide a predictive base to aid in the understanding of the effects of petroleum on all levels of the food web.

X. Summary of 4th Quarter Activities

Covered above of N.A.

ADDENDUM

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Center
2725 Montlake Blvd. E.
Seattle, Washington 98112

-Unpublished data, Shellfish and Ground Fish abundance from Gulf of Alaska, Bering Sea and Chukchi Sea on ADP cards.

-Archived samples from the Chukchi Sea.

State of Alaska
Department of Fish and Game
Division of Commercial Fisheries
P.O. Box 686
Kodiak, Alaska 99615

-Types of unpublished data and biological material on file in the Westward Region are as follows:

1. Commercial fishery catch statistics by statistical area, species, vessels, gear and landings: These data for the most part are grossly summarized in the Alaska Department of Fish and Game annual and statistical leaflet "Alaska Catch and Production".

2. Commercial fishery biological samples for age-length-weight-sex and condition: These data exist for nearly all commercially utilized species of salmon, crab, shrimp, herring and clams.

3. Research cruise data: Extensive research cruises to assess and predict the abundance of Tanner crab, king crab and shrimp are undertaken annually and cover commercially important areas from Kodiak Island to and including the Aleutian Islands. Crab abundance is indexed using pots and shrimp are indexed with trawls. Extensive biological observations are made in the field and laboratory. Records of some incidental species are kept.

4. Tagging information: Extensive tagging and recapture information exists for king crab and Tanner crab primarily for the Gulf of Alaska and Aleutian Island water. Some unpublished data on salmon also exists and covers Gulf of Alaska and Bering Sea.

5. Pre-emergent salmon fry: Alevin densities are assessed annually on Kodiak Island, Shumagin Islands, and Alaska Peninsula.

6. Salmon spawning escapements: Weir counts and aerial survey records of escapements for major salmon producing systems throughout the Westward Region.

7. SCUBA observations: Recorded diver observations of benthic invert-

ebrates.

8. Reference collections: Keyed out collections of primarily mollusks.

Most of this material is key punched and/or summarized in internal Alaska Department of Fish and Game reports or printouts.

International Pacific Halibut Commission
P.O. Box 5009
University Station
Seattle, Washington 98105

-No unpublished data nor archived Biological samples
-Sent several reports (published)

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 1668
Juneau, Alaska 99801

- No information- referred us to NOAA- Auke Bay Laboratory

United States Department of the Interior
Geological Survey
Alaskan Geology Branch
345 Middlefield Road
Menlo Park, California 94025

-No information-referred us to Mr. Harry Hulsing and Dr. A. "Gus" Armstrong

U.S. Department of Commerce
NOAA National Marine Fisheries Service
Northwest Fisheries Center
Kodiak, Alaska

-Archived Biological samples- 165 lots of Invertebrates in position of Marine Sorting Center, I.M.S., University of Alaska

Dr. Hans Nelson
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

-Archived Material- In position of Sam Stoker, Institute of Marine Science, University of Alaska

J.M. Armentrout
Mobil Oil Company
Denver, Colorado

-Archived material- Gulf of Alaska, Benthic material available for cost of work up.

Sam Stoker
Institute of Marine Science
University of Alaska
Fairbanks, Alaska

-Unpublished data- Bering And Chukchi Sea- Benthic organisms abundance data used for thesis.
-Archived material- In position of Marine Sorting Center

Dr. Donald J. Reish
Department of Biology
Long Beach State College
Long Beach, California 90840

-Referred to Dr. John L. Mohr

Mr. Lloyd F. Lowry
1300 College Road
Fairbanks, Alaska 99701

-Biological material-Seal stomach contents and Fishes.

Dr. John L. Mohr
Department of Biology
University of Southern California 90007

No response

Alaska Department of Fish and Game
333 Rasberry Road
Anchorage, Alaska 99501

No response

Dr. Patsy A. McLaughlin
School of Marine & Atmospheric Science
Miami, Florida 33149

No response

J.J. Burns
Alaska Department of Fish & Game
1300 College Road
Fairbanks, Alaska 99701

No response

Geological Survey
310 First Street
Fairbanks, Alaska 99701

Department of Oceanography
University of Washington
Seattle, Washington 98105

No response

University of Washington
College of Fisheries
Seattle, Washington 98195

-No information- referred us to Dr. Ken Chew

Alaska Department of Fish and Game
Nome, Alaska 99762

-No response

Alaska Department of Fish & Game
Homer, Alaska 99603

-No response

Fisheries Research Institute
College of Fisheries
260 Fisheries Center
Seattle, Washington 98105

-No response

National Marine Fisheries
P.O. Box 1638
Kodiak, Alaska 99165

-No response

Environmental Protection Agency
401 "M" Street S.W.
Washington, D.C. 20460

No response

Alaska Department of Environmental Conservation
St. Anne's Center
Pouch "O"
Juneau, Alaska 99801

No response

Mr. Harry Hulsing, District Chief
Water Resources Division
Room 304 Skyline Building
218 "E" Street
Anchorage, Alaska 99501

No response

Dr. A. "Gus" Armstrong
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

No response

Dr. Ken Chew
College of Fisheries
University of Washington
Seattle, Washington 98195

No response

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 10 R.U. NUMBER: 282/301

PRINCIPAL INVESTIGATOR Dr. H. M. Feder

Progress on this study has indicated that there is little data in a form suitable for submission using available EDS Format (Benthic Organisms). As indicated in this report, much information of utility is available, and this information would best be presented in media other than magnetic tape. It is suggested that the following information products be accepted; (1) key word bibliography (available in next quarter); (2) distribution maps, which would be available as they are produced; however, the total applicable information available could not be converted into this media prior to December 1976.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 10

PRINCIPAL INVESTIGATOR: Dr. Howard M. Feder

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	51,046.00	14,945.68	36,100.32
Staff Benefits	8,625.00	2,274.89	6,350.11
Equipment	-0-	-0-	-0-
Travel	3,750.00	234.70	3,515.30
Other	5,200.00	1,432.16	3,767.84
Total Direct	68,621.00	18,887.43	49,733.57
Indirect	29,198.00	8,548.93	20,649.07
Task Order Total	97,819.00	27,436.36	70,382.64

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 282/301 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

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OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Fed R.U. 28? 301

Project Title: Summarizing of Existing Literature and Unpublished Data on the Distribution, Abundance and Productivity of Benthic Organisms of the Gulf of Alaska and Bering Sea.

Contract Number: 03-5-022-56

Task Order Number: 10

Principal Investigator: Dr. Howard M. Feder

I. Task Objectives

A. A summary of existing data, published and unpublished, for the Gulf of Alaska and the Bering Sea.

B. Access to and loan of archived material from both of the above areas.

C. Workup of archived data and material.

II. Field and Laboratory Activities

Methods:

1. Literature survey using standard library search techniques has been undertaken. Plans under way to utilize literature searching organizations; some correspondence will be initiated.

2. Correspondence will be initiated to locate archived data and material.

III. Results

A. 1500 references pertaining to North Pacific and Bering Sea have been located. From these some 500 have references to distribution and/or biology of Benthic organisms in the study area. These references are being accumulated, key words and data content are being extracted or noted.

B. Approximately 30 letters have been sent to various federal and state agencies inquiring about archived data and/or biological material. Material has been received as follows:

1. Archived data from National Marine Fisheries Center - Seattle, relating to Gulf of Alaska trawl surveys.

2. Archived material from United States Geological Survey in Menlo Park.
3. Archived material from Gulf of Alaska is available from J. M. Armentrout, Mobil Oil Company.
4. Archived material from Walrus Feeding Studies in the Bering Sea has been received.
5. Archived material from Northwest Fisheries Center - Kodiak, has been received and contains 165 lots of material.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 10 R.U. NUMBER: 282/301

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates(1)			
	From	To				
Marine Fisheries Data (2)	----	----				
U.S.G.S. Data (2)	----	----				
Mobil Oil Data (3)	----	----				
Walrus Data (3)	----	----				
M.F.C. - Kodiak Data (2)	----	----				

Notes: (1) Estimated submission dates are contingent upon final approval of data management plan submitted in draft form Oct. 9, 1975 and University of Alaska approved form November 20, 1975 to NOAA. Also, final agreement by all parties on the data format is necessary.

(2) Identified operations refer to data received, see Results.

(3) Identified operations refer to archived material, see Results. No dates are given for submission due to lack of funds for working up data.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 10

PRINCIPAL INVESTIGATOR: Dr. Howard M. Feder

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	51,046.00	2,870.00	48,176.00
Staff Benefits	8,625.00	488.01	8,136.99
Equipment	-0-	-0-	-0-
Travel	3,750.00	-0-	3,750.00
Other	5,200.00	-0-	5,200.00
Total Direct	68,621.00	3,358.01	65,262.99
Indirect	29,198.00	1,641.64	27,556.36
Task Order Total	97,819.00	4,999.65	92,819.35

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract # 03-5-022-56

Research Unit # 284

Reporting Period 7/1/75-3/31/76

Number of Pages 32

FOOD AND FEEDING RELATIONSHIPS IN THE BENTHIC AND DEMERSAL FISHES OF THE GULF OF ALASKA AND BERING SEA

Ronald L. Smith
Alan C. Paulson
John R. Rose

Institute of Marine Science

University of Alaska

March 31, 1976

I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS

The objectives of this first year's study were to:

1) generate a bibliography pertinent to fish trophic relationships in the study areas,

2) amass a collection of guts from the benthic and demersal fishes within the study areas,

3) present preliminary food analyses for two fish species from the Gulf of Alaska and two species from the Bering.

Our ultimate goal is to construct a detailed picture of the food and feeding relationships of the fishes in these two study areas. This will (or should) include analyses of predator size vs. prey composition; bottom type, temperature and location vs. prey composition; prey composition in diets vs. prey abundance; prey composition vs. season. The rationale behind this study is to develop an ability to predict the impact of oil development activities on the fishes in these two areas. Clearly, for example, activities which affect benthic invertebrates will directly affect those fish species which feed on them. This study, coupled with others designed to study acute and chronic toxic effects on the fish populations, will establish the predictive base necessary to make management decisions. It is already known that certain specific geographic areas are fairly critical as overwintering areas or feeding areas for some of the fishes. Exploration and drilling activity could have a much greater impact in these areas than in others. Again, one of the ultimate goals of this study is to elucidate some of these area effects.

II. INTRODUCTION

A. General Nature and Scope of Study

This study is, in this first year, very limited in scope. Our collections have been limited as have our preliminary analyses. It is the nature of this study to develop a picture of the food and feeding relationships of most, if not all, of the fishes present in the study area.

B. Specific Objectives

This study is charged with making a collection of stomachs, with curating them and with performing preliminary analyses on several species each from the Gulf of Alaska and the Bering Sea.

C. Relevance to Problems of Petroleum Development

The fishing industry is the most important economically in the state of Alaska. Commercial fishing in Alaskan waters contributes heavily to the landings of at least three other countries: Japan, Russia, and Korea. To an unknown extent, oil exploration and development on the outer continental shelf will impact these fisheries. Impacts other than economic will also occur but will be difficult to access. The relevance of this project is to add to the total fund of information available on the *risks* of oil development. Other information will be provided, hopefully, on *the benefits* of development. This is the strength of scientific investigation, to clarify the *risks* and *benefits* which will come out of a particular course of action. Then, the politicians will have some firm ground on which to base their decisions.

III. CURRENT STATE OF KNOWLEDGE

Knowledge about the food, feeding and trophic relationships of fishes from the Gulf of Alaska and Bering Sea is scattered widely through the literature and includes papers in English, Russian and Japanese. Other works with pertinent information on congeneric species are even more prevalent in the scientific literature. These latter papers deal with food and feeding of *Hippoglossus, Limanda, Glyptocephalus, Gadus* and other relevant genera from the Atlantic and also from east Asia. We have not attempted to summarize the existing knowledge on these congenerics but have briefly discussed what is known of four of the fish species common to the study area. The four are the flathead sole, rock sole, Pacific Ocean perch, and Pacific halibut. Similar summaries are possible on several other species common in the area. However, the vast majority of fishes from the study area are very poorly studied. Summaries of the four species follow.

A. Flathead Sole *Hippoglossoides elassodon*

A survey of available information on this species seems to indicate that studies have been largely restricted to the Bering Sea and Washington coast.

In the Bering, feeding intensity varies seasonally and geographically. This species does feed during the winter but much less intensely than during the summer months. On the basis of percentages of fish with empty stomachs, feeding is more intensive in the southeast Bering, least intensive in the central Bering. A ranking of food items according to % frequency of occurrence is ophiuroids > shrimps > amphipods > fish remains > molluscs. As *H. elassodon* migrates from southern wintering grounds in the Bering its diet shifts from predominantly echinoderms and *Pandalus borealis.* The shrimp is replaced by hyperiids, euphausiids and chaetognaths, while the echinoderms drop out entirely.

Studies from Washington state indicate this species ingests both benthic and pelagic food organisms. Changes in diet with age are evident, the smallest fish feeding primarily on mysids, larger fishes beginning to eat shrimps and then fishes. Mature fishes have the highest percentage of empty stomachs at the peak of spawning. Other food items reported from this area include clams and worms.

Food, feeding and basic life history information from the Gulf of Alaska is apparently nonexistent. This present study will partially fill the void, and, hopefully, add to existing knowledge of this species in the Bering. It would seem that the southeast Bering in the summer is a sensitive period in the life of this species from the viewpoint of food and feeding. This summary was drawn from the following: Smith, 1936; Minerva, 1968; Skalkin, 1968; Miller, 1970.

B. Rock Sole *Lepidosetta bilineata*

As with the flathead sole, there seems to be little information on this species from the Gulf of Alaska, yet quite a bit from the Bering Sea. Like several other fishes in this region, the rock sole exhibits feeding and distributional changes over the course of a year.

Little or no feeding occurs on the wintering grounds in the Bering with slight feeding activity beginning in April. Most intensive feeding occurs in June and July. One report lists summer diets consisting mainly of polychaeta, 62%F; molluscs, 37%; crustacea (mostly shrimps) 14% and some fishes and echinoderms. Diets apparently differ from one region to another.

Although *L. bilineata* is found all over the southern half of the Bering, two major concentrations have been delineated for purposes of commercial exploitation. One is located just north of Unimak and the other in central Bristol Bay. These concentrations move in the spring as indicated by the Figure below. Dense schools are reported to form during both the winter and summer.

Food items reported from Washington and California include clams, clam siphons, polychaetes, shrimps, small crabs, ophiuroids and *Ammodytes* (Forrester and Thomson, 1969; Roedel, 1948). Other references used above are Skalkin, 1968; Shubnikov and Lisovenko, 1968.

The two centrations mentioned above are important and would be particularly vulnerable during the intensive feeding period. Impacts affecting their major food organisms, the polychaetes, could also have a major impact on the Rock Sole.

C. Pacific Ocean Perch *Sebastes alutus*

Marked seasonal shifts are evident in this species with respect to both geographic distribution and feeding habits. In the Bering from January to May densest concentrations of adult fishes are found in Bristol Bay and south of the Pribilofs. During the rest of the year they extend well into the central Bering. In the Gulf of Alaska during the periods from May through September, concentrations occur near Unimak Pass, near the Shumagins, Kodiak, and Yakutat (see Fig. 1). Vertical segregation according to size is suggested by catch data; larger sized fish being caught at greater depth (see Fig. 2).

Existing information on food habits indicate that in the Gulf juveniles feed on planktonic crustacea. Benthic juveniles feed very heavily

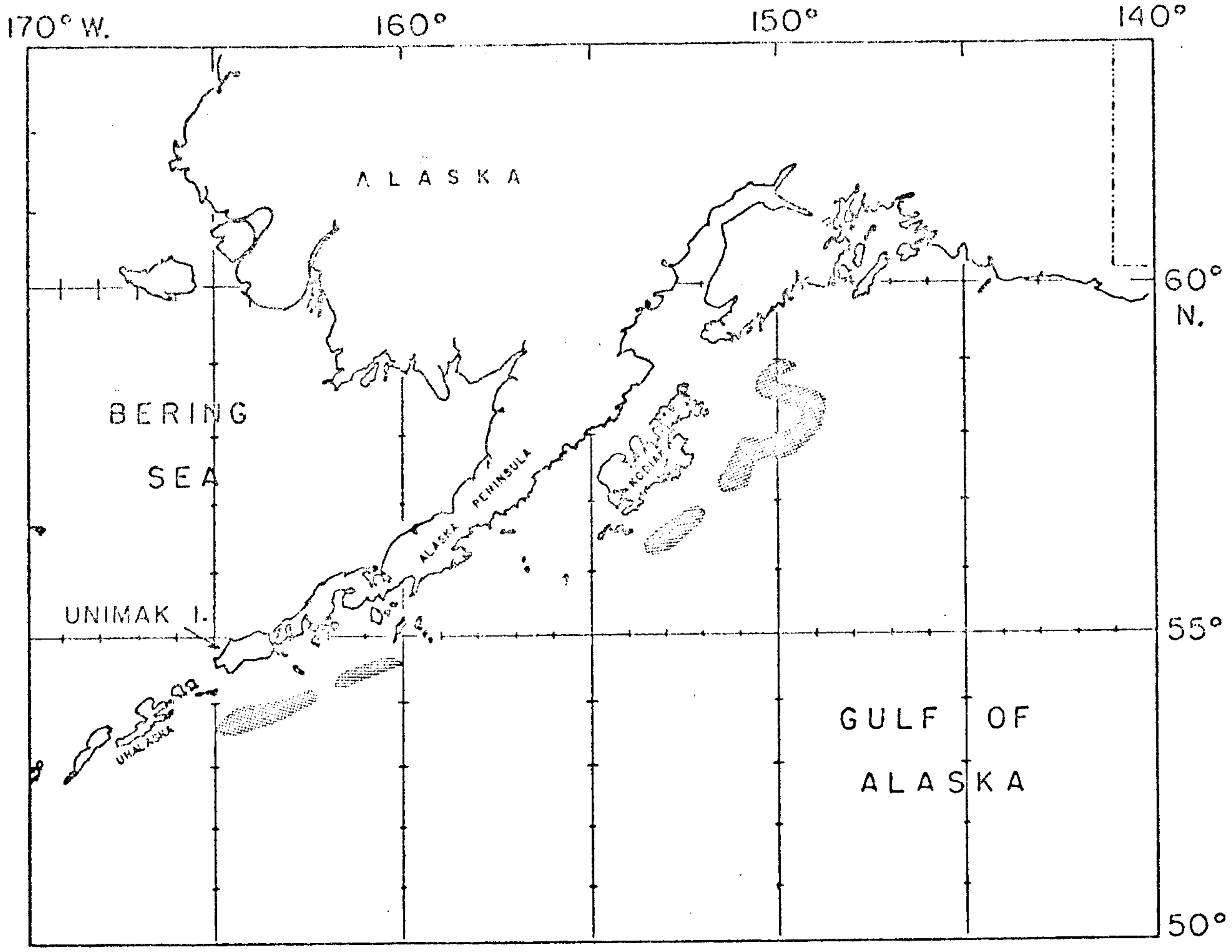

Figure 1. Distribution of Pacific ocean perch in the Gulf of Alaska during the principal feeding period (from Lyubimova, 1965).

on euphausiids and pandalid shrimps. Adult stomach contents contained 75% crustacea (again euphausiids and pandalids, primarily), 15% squids and 6-7% fishes. In the Bering relative importance of food items varies with both depth and size. On the shelf *S. alutus* feeds mainly on calanids while at 200-300m on euphausiids, and on mysids and squids below 300m.

Summer populations in the Gulf of Alaska appear to be foraging aggregations. Some of the Russian work suggests that mature fish do not feed during the rest of the year (October through April) (see Fig. 3).

From the standpoint of impact from oil exploration and development, the concentrations in Bristol Bay in the spring and the summer concentrations present in the Gulf would be important. Information on this important but declining species was gathered from Lyubimova, 1968; Skalkin, 1968; Quast, 1969; Major and Shippen, 1970 and Isakson *et al.*, 1971. Additional information on feeding habits and seasons in the Bering Sea would be very useful in determining the most sensitive periods and geographical areas for Pacific Ocean Perch.

D. Pacific Halibut *Hippoglossus stenolepis*

This species continues to be an important fish from a commercial standpoint. Impacts felt farther down in the food chain will certainly have an effect on this large carnivore.

Young halibut become established on the bottom after 6-7 months of pelagic larval existence. The earliest juveniles occur in water shallower than 100m. During ontogeny individuals tend to move offshore to deeper water. Immature halibut are relatively nonmigratory while adults from the Gulf of Alaska are known to migrate rather long distances, up to 700 miles in some cases.

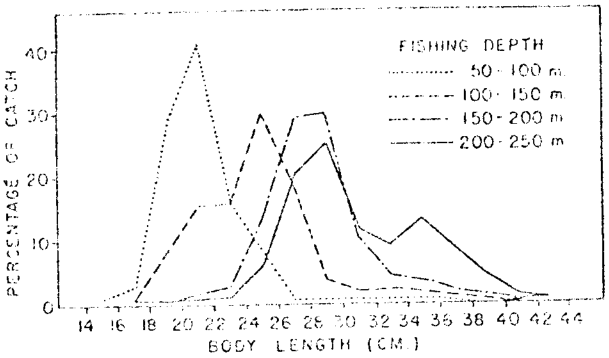

Figure 2. Body lengths of Pacific ocean perch taken in the Gulf of Alaska at various depths (from Lyubimova, 1964).

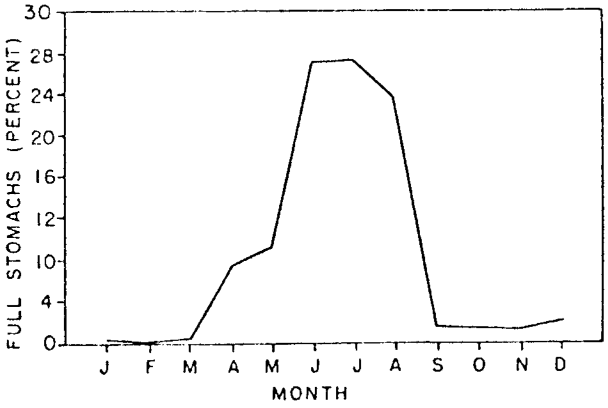

Figure 3. Percentage of full stomachs in samples of Pacific ocean perch taken each month in the Gulf of Alaska (from Lyubimova, 1963).

Feeding habits from the Gulf are apparently not available. Novikov (1968) has reported on the food habits from the southeastern Bering Sea. Small halibut (30cm or less) fed primarily on crustaceans (89%F) while medium sized fishes (30-60cm) shift to a largely fish diet (61%F). Flatfishes, smelt, capelin, pollock and sand lances are included while crustaceans appear in 33% of the stomachs. Fishes larger than 60 cm fed predominantly on fishes, especially the yellowfin sole. Feeding intensity was greater in summer than in winter. Marked seasonal movements of halibut in the southeast Bering have been reported (see Fig. 4).

Information for this species was abstracted from Gray, 1964; Hart, 1973; and Novikov, 1968.

IV. STUDY AREA

The study area includes the Gulf of Alaska, primarily the area bounded by Yakutat on the east and Resurrection Bay on the west. The Bering Sea study area lies principally in the southeast. Almost all collections come from stations south of Nunivak Island. Collections will include fishes from Bristol Bay, the vicinity of the Pribilof Islands and along the continental slope. We also hope to get collections from the vicinity of Unimak Island.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

A. Fish Stomachs

Sources we have and will draw upon:

North Pacific charter, summer 1975, Gulf of Alaska

Miller Freeman fall 1975, spring 1976 Bering Sea

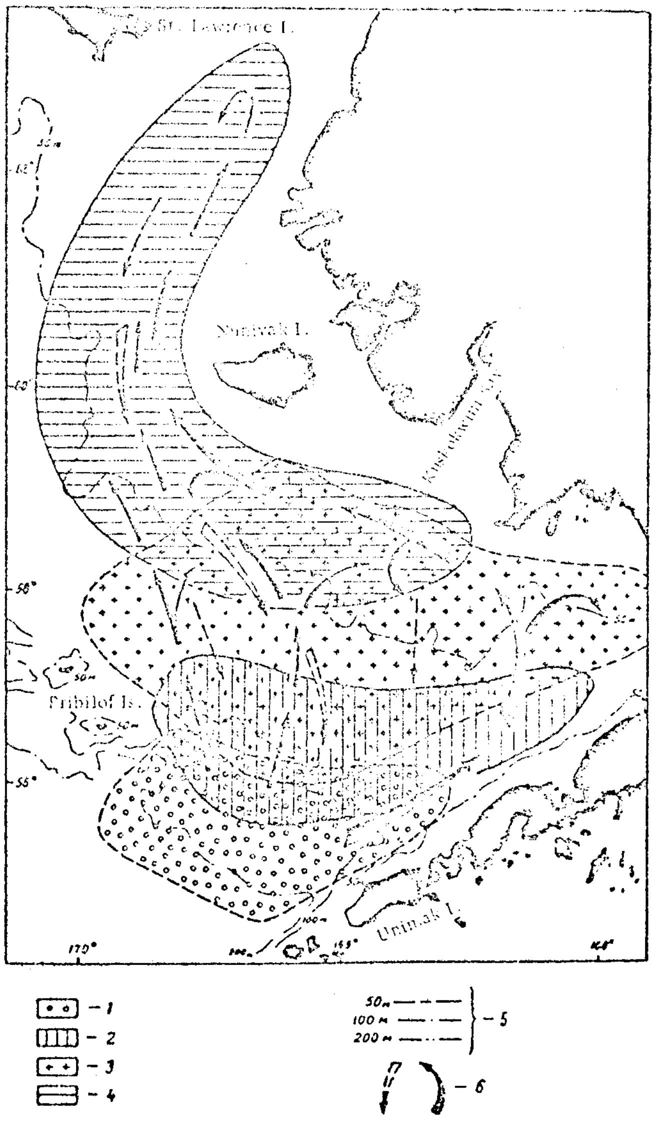

Figure 4. Diagram of the seasonal distribution and migration of the halibut in the southeastern Bering Sea:

1-January-April; 2-May; 3-June; 4-June-September; 5-isobaths; 6-direction of migrations

Surveyor spring 1976, Bering Sea

Alpha Helix 1970, 1971, 1972, Bering Sea

NMFS charter, spring or summer, 1976 Bering Sea

Halibut Commission charter, summer, 1976, Gulf of Alaska

Methods employed in obtaining stomachs:

capture: otter trawl

selection of individuals to be retained: unknown, but undoubtedly depended on what was in catch

disposition of samples: various, dependent largely on personal bias of collectors. Some fishes were preserved whole others had stomachs removed and placed in cloth bags, still others were preserved as anterior halves of fishes only

Rationale for collections:

original concept was to obtain a representative sampling of fish guts from a variety of bottom types, locations and times or the year. These collections were to be made simultaneously with benthic invert collections (trawls and grabs) so that the effects of invert abundance and fish selectivity could also be studied. Relatively few of our stations correlate with grab stations and few station samples were adequate. We don't know if our samples are representative. The chief problem lies in the fact that collections have been made, when made at all, by personnel whose primary interests have been elsewhere.

B. Stomach Analyses

Methods employed in analysis:

Methods are those outlined in the work statement. If stomachs only are present we sort the prey items to the lowest taxonomic level possible, complete the identifications we can and retain the organisms preserved in vials awaiting final identification. When intact fishes are processed we record data on standard length, sex, gonadal maturity and stomach fullness.

Rationale for analytical procedures:

Only preliminary data are being amassed since we do not have budgeted funds to pay the Marine Sorting Center for the identifications we need.

VI. RESULTS

A major outcome of this project to date has been to amass a list of references dealing with fish feeding. These references include those specifically about the study area as well as those concerning relevant species and genera outside the bounds of our study area. A bibliography with annotations on many of the cited works is included below.

To date we have accumulated preliminary feeding data on three species of fishes, the rex sole, arrowtooth flounder and pollock. All samples examined thus far have been from the Gulf of Alaska. Bear in mind, these are preliminary findings based on rather small sample sizes.

We have performed a preliminary sort of stomach contents from the rex sole, *Glyptocephalus zachirus* ranging from 11.0 to 34.0 cm standard length (n=80). Polychaetes were the most important food number both in terms of frequency occurrence (%F) and by volume (%V). Small crabs with carapaces only several mm across were the next most frequent prey, but the volumetric contribution was negligible. Euphausiids were the next most frequent prey item, but appeared to be the second most important item by volume. Cumaceans and pandalid shrimps (*Pandalus borealis*) were also taken frequently. Other invertebrates were consumed, but represent a small volumetric input into the diet. Fishes were rarely taken.

Table 1. Food of rex sole from Gulf of Alaska

Prey Item	Frequency of Occurrence (%F)
Polychaetes	66%
Crabs	55%
Unidentifiable Animal Matter	33%
Euphausids	28%
Pandalid Shrimp	25%
Cumaceans	22%
Amphipods	5%
Pelecypods	3%
Ophiuroids	2%
Teleost Fishes	2%

To date the stomachs of 151 specimens of *Atheresthes stomias* have been examined for contents. The specimens ranged in size from 82 mm to 680 mm, standard length. Of the 151 stomachs examined, 78 were found to have contents, the other 73 were empty. The breakdown of the contents can be seen below (Table 2) in frequency of occurrence. On considering the volumetric measurements of the various prey groups, the teleost fishes probably constitute 65% to 75% of the total volume of prey consumed.

Table 2. Food of arrowtooth flounder from gulf of Alaska

Stomach Contents	Frequency of Occurrence %F
Teleostei	40%
Pleuronectiformes	1%
Pollock	1%
Arrowtooth flounder	1%
Herring	1%
Zoarchids	3%
Capelin	4%
Unidentified Teleosts	29%
Euphausiids	36%
Decapods	24%
Pelecypods	1%
Ophiuroids	1%
Unidentified Animal Matter	10%

A total of 84 stomachs from the pollock, *Theragra chalcogrammus*, have been examined. Individuals were drawn from a size range of 26.2 cm to 56.0 cm S.L. Five percent of the stomachs were empty. Data in frequency of occurrence are presented in Table 3. In terms of volumetric composition the euphausiids were most important followed by fishes, shrimps and cephalopods.

Table 3. Food of pollock from Gulf of Alaska

Stomach Contents	Frequency of Occurrence %F
Euphausiids	90%
Amphipods	19%
Fishes	17%
Crab megalops	11%
Shrimp	8%
Cephalopods	2%
Pelecypods	2%
Copepods	2%
Gastropods	1%
Polychaetes	1%
Unidentified material	31%

VII. DISCUSSION

As stated in previous quarterly reports and in the work statement itself, a larger budget will be required for FY 1977. The backlog of fishes to be examined and prey organisms to be positively identified will necessitate a greater effort than was possible under present budgetary constraints.

Sources of information on feeding relationships of fishes from the study area are scattered and often anecdotal. Some information exists on feeding of pertinent species but in areas outside the present study area. More peripheral information exists for related species from other northerly areas, expecially the northeast Atlantic.

Literature has been summarized on four species and our own data on three more. Very preliminary indications are that the halibut, rock role, flathead sole and rex sole are predominantly benthic feeders. The pollock, arrowtooth flounder and Pacific Ocean perch largely feed off the bottom on pelagic organisms. Activities which impact the benthic environment and its invertebrate fauna will have impact on the former species. Activities which primarily affect the pelagic environment will have effects on the latter species rather quickly. However, since the benthic fauna is ultimately dependent on primary production in the pelagic environment, it too will be affected, as will the fishes feeding on the benthos.

From the little information at hand on seasonal variation in distribution and feeding, a number of critical areas can be suggested. In the Bering, winter concentrations of halibut, yellowfin sole, rock sole and perhaps flathead sole as well are all found just to the northwest of Unimak Island. Pacific Ocean perch concentrate just south of the Pribilofs and in Bristol Bay. Although feeding is not intense at this time, large numbers of fishes could be affected in a very few locations. In the Gulf, Pacific Ocean perch would be particularly vulnerable to effects of development during the feeding season when dense feeding aggregations apparently form south of Unimak, southeast of the Shumagins, and east and south of Kodiak.

Much more data is needed on the feeding habits and seasonality of feeding within the fish fauna. This is especially true of the Gulf of Alaska, which has not come under as much intensive scrutiny by the Russian workers. Much information will be supplied by this present study but seasonal information for the Gulf of Alaska will still be largely unavailable.

VIII. CONCLUSIONS

See discussion section

IX. NEEDS FOR FURTHER STUDY

a. More information on trophic relationships is needed on the continental slope in the Bering and at the proposed lease sites in both Bering and Gulf of Alaska.

b. Seasonality of feeding has been shown to be very important. Further work on seasonality of feeding is critical, especially in the Gulf of Alaska.

c. More complete information is needed on the relationship between fish size and food habits.

d. A critical area for further study is the relationship between occurrence of prey organisms in the diet and prey availability. This seems most feasible in benthic feeders and involves close coordination with Dr. Feder's benthic studies.

e. All needs mentioned above are contingent on additional funding to permit identification of archived materials to the species level. Any real understanding of trophic relationships will require a large additional expenditure of funds. These identifications are <u>absolutely crucial</u>.

X. SUMMARY OF 3rd QUARTER OPERATONS

A. Ship and Laboratory Activities

1. Ship or field work schedule:

   The following arrangements have been solidified during this quarter. Fish stomach samples will be collected on legs I, III and possibly II of the *Miller Freeman* spring cruise in the Bering. I will have part of one man on leg I and a man on leg III. Fishes will also be collected on the *Surveyor* spring cruise in the Bering (Leg I, at least and possibly Leg II). The latter is through the kind cooperation of Dr. John Burns, Alaska Dept. of Fish and Game. We have arranged for fishes to be sampled on the charter trawler of the Pacific Halibut Commission in the Gulf of Alaska.

2. Scientific party involved in project:

   R. L. Smith, IMS, Principal Investigator
   A. C. Paulson, IMS, Biological Technician
   J. R. Rose, IMS, Research Assistant
   M. Hoberg, IMS, part-time Biological Technician

3. Methods:

   same as previous methods.

4. Sample localities:

   Station locations depend on other investigators since our operation is simply worked into the field program at the convenience of other investigators. We will, hopefully, receive station locations and station data at the conclusion of the spring cruises.

5. Data analyzed:

   Of the total preliminary sorts refered to earlier, the following were performed this quarter:

Arrowtooth flounder	151
Pollock	84
Rex Sole	80

B. Problems Encountered

The major problem encountered was the confusion over supplies we arranged to have delivered to Northwest Fisheries Center for use on board the *Miller Freeman.* We ordered 30 gal of formaldehyde and it was apparently lost after delivery to the *Miller Freeman.* Such a loss, considering our very limited (and exhausted) budget, is very unfortunate. I might mention that exactly the same thing happened last summer when 120-5 gal buckets were delivered to the *Miller Freeman* and disappeared. These buckets have never been found.

ANNOTATED BIBLIOGRAPHY OF SELECTED LITERATURE

I. Order *Pleuronectiformes (Heterosomata)*

Andriyashev, A. P. 1964. Fishes of the northern seas of the U.S.S.R. Isr. Prog. Sci. Trans. TT63-11160. 617 pp.

This book was the first attempt to synthesize all soviet literature on arctic fish species. In all, 237 species representing 54 families are discussed in terms of taxonomy, distribution, life history (including limited feeding habits information), and commercial importance. Families of interest include Rajidae, Clupeidae, Salmonidae, Osmeridae, Gadidae, Zoarcidae, Ammodytidae, Scorpaenidae, Hexagrammidae, Cottidae, Agonidae, Liparidae, Bothidae, and Pleuronectidae.

Arntz, V. W. E. 1971. Die Nahrung der Kliesche (*Limanda limanda* [L.]) in der Kieler Bucht. Ber. dt. wiss. komm. Meeresforsch 22:129-183.

The gut contents of 1551 dabs were taken over a one year period from six study areas. Annual cycles of food composition and diurnal rhythms of food intake were examined. Data were used to estimate food consumption by different size groups of dab per day and per year. The author then calculated the total consumption of macrobenthos during the same period. Annual averages of food consumption were: Polychaetes 31%, crustaceans 26%, molluscs 24%, fish waste (mainly intestines thrown overboard by cod fisherman) 11%, echinoderms 4%, and priapulids 4%. Diets were shown to change with the size of the dab as well as with season. Echinoderms were preferred in winter while crustaceans and polychaetes were preferred in the summer. In many cases no correlation could be established between food abundance and seasonal food preference. The daily feeding rate was lower than in the plaice. The dab consumes about 3% of its body weight per day. So in a year, the dab consumes 10 to 11.5 times its own initial weight. The ratio of consumption to production of the dab was: 1:25 for the total macrobenthos; and 1:14 for main food items. The author felt these figures were baised by an underestimation of the macrobenthos biomass.

Cunningham, J. T. 1890. A treatise on the common sole. Mar. Biol. Ass., Plymouth. 147 pp.

Solea vulgaris, S. lascaris, S. variegata, S. lutea, and *S. greeni* are discussed in terms of the morphology of the skeleton, musculature, digestive system, reproductive system, nervous system, and the skin. Distribution, feeding habits, behavior, development, and taxonomy are examined. Aspects of the fishery also receive attention.

Dando, P. R. 1971. Lactate dehydrogenase polymorphism in the flatfish (Heterostomata). Int. Council Expl. Sea Rapp. Proc. verb Reun. 161:130-133.

Seventeen species of flatfishes were studied. Unlike many flatfishes, some species (especially the soles), appear to have at least two catalytically distinct isoenzymes in heart and muscle tissue which show tissue-specific patterns. The value of this polymorphism as a tool of stock identification is discussed. The common and scientific names are listed for the European species of flatfishes.

de Groot, S. J. 1971. On the interrelationships between morphology of the alimentary tract, food and feeding behavior in flatfishes (Pisces: Pleuronectiformes). Netherlands J. Sea Res. 5(2):121-196.

The feeding habits literature of the flatfishes of the world is reviewed. Diurnal activity patterns are discussed. Sensory and morphological relationships to feeding habits are examined.

Forrester, C. R. and J. A. Thomson. 1969. Population studies on the rock sole *Lepidopsetta bilineata* of Northern Hecate Strait, British Columbia. Fish. Res. Bd. Canada Tech. Rep. 108. 104pp.

Gray, G. W. 1964. Halibut preying on large Crustacea. Copeia. 1964(3):590.

Kohler, A. C. 1967. Size at maturity, spawning season and food of the Atlantic halibut. J. Fish. Res. Bd. Canada 24(1):53-66.

Most males of *Hippoglossus hippoglossus* mature at 96 to 100 cm. Halibut up to 30 cm long ate invertebrates, halibut from 30 to 80 cm ate invertebrates and fishes, and halibut over 80 cm ate fish almost exclusively.

Miller, B. S. 1965. Food and feeding studies on adults of two species of pleuronectids (*Platichthys stellatus* and *Psettichthys melanostictus*) in East Sound, Orcas Island, Washington. M.S. Thesis, Univ. of Washington. 131 pp.

There is no overlap in the food and feeding habits of starry flounders and sand soles except that they both are diurnal feeders. While starry flounders completely ceased feeding in the winter the sand sole exhibited only a slight decrease in feeding activity. Starry flounders fed primarily on priapulids, nemerteans, polychaetes, and lamellibranchs. Brittle stars and sea crabs were of secondary importance. Sand soles fed mainly on fish, especially herrings. Mysids were quite important while shrimps and squids were of secondary importance. Starry flounders use their stomachs primarily as holding organs for their food while sand soles use their stomachs for digestive purposes. Starry flounders emptied their stomachs in about nine hours. Sand soles retained fish in their stomachs for over 24 hours, but cycled mysids through in a maximum of 11 hours. Feeding habits are reflected in morphological differences in mouth size, dentition, and gill rakers.

Miller, B. S. 1967. Stomach contents of adult starry flounder and sand sole in East Sound, Orcas Island, Washington. J. Fish. Res. Bd. Canada 24: 2515-2526.

The starry flounder fed primarily on priapulids, nemerteans, polychaetes, and lamellibranchs. Data is given in percent volume (%V) and percent frequency (%F). Feeding ceased during the months of lowest temperature so the commercial fishery takes fish when they are in their poorest physical condition. The sand sole fed primarily on fish, mysids, shrimps and squids. There was little reduction in feeding during the cold water months.

Miller, B. S. 1970. Food of the flathead sole (*Hippoglossoides elassodon*) in East Sound, Orcas Island, Washington. J. Fish. Res. Bd. Canada 27: 1661-1665.

The flathead sole fed both on benthic organisms (clams, polychaetes, and pea crabs) and on nektonic organisms (mysids, fishes, and shrimps). The smallest sole (40 to 179 mm total length) ate primarily mysids. With an increase in size, they began to utilize first shrimps and then fishes (mainly herring). All but the largest (320 to 440 mm) continued to feed heavily on mysids. Fishes over 320 mm exhibited the greatest proportion of empty stomachs in the warmer months, while smaller soles had the highest number of empty stomachs during the colder months. In mature fishes, the highest frequency of empty stomachs occurred during the peak of spawning.

Minerva, T. A. 1968. On the biology of some flatfishes in the eastern Bering Sea. *In* Sov. Fish. Inv. N. Poc. Pt. II. Isr. Prog. Sci. Trans. TT67-51204. 289 pp.

Six species of flatfishes were studied: The yellowfin sole *Limanda aspera*, the rock sole *Lepidopsetta bilineata*, the flathead sole *Hippoglossoides elassodon*, the Alaska plaice *Platessa quadrituberculata*, the rex sole *Glyptocephalus zachirus*, and the snout sole *Limanda punctatissima*. The stomach fullness of the flathead sole (i.e. % fish with empty guts) showed that feeding was most intensive in the southeast Bering Sea and was least intensive in the central Bering. In order of importance (%F), flathead soles ate ophiuroids, shrimps, amphipods, fish remains, and molluscs. The flathead does feed in the winter but less than in the warmer months. The Alaska plaice fed mainly on molluscs and worms, and to a lesser extent on amphipods and ophiuroids.

Moiseev, P. A. 1953. Cod and flounders of the far eastern seas. (In Russian.) Vladivostok, Izv. Tikh. Nauchn. Issled. Rybn. Khoz. i Okeongr. No. 40. (Fish. Res. Bd. Canada Transl. Ser. 119:463-490.)

Mulicki, Z. 1974. The food and feeding habits of the flounder (*Pleuronectes flesus* L.) in the Gulf of Gdansk. (In Russian.) Arch. Hydrobiol. i Rybactwa (Gdynia) 13. (Transl. OTS 60-21490(1963):87-115.)

Mulkana, M. S. 1966. The growth and feeding habits of juvenile fishes in two Rhode Island estuaries. Gulf Res. Rept. 2(2):97-167.

Juvenile fishes of 41 species were studied with reference to importance of estuarine systems as nursery areas. Growth and feeding habits were emphasized. The discussion emphasized *Menidia menidia*, *Pseudopleuronectes americanus*, *Brevoortia tyrannus*, *Glugea hertwigi*, and *Osmerus mordax*.

Neiman, A. A. 1968a. Age of bivalve molluscs and utilization of benthos by flatfishes in the southeastern Bering Sea. *In* Sov. Fish. Inv. N. Pac. Pt. III. Isr. Prog. Sci. Transl. TT67-51205. 338 pp.

Flatfishes exploit very little of the food benthos in the zone where the residual winter-cooled water layer touches the bottom. This was concluded from an analysis of the flatfish distribution in different hydrological conditions, and is confirmed by studies of the distribution of different age groups of bivalve molluscs. The actual amount of food benthos reserve available to flatfishes is therefore smaller than that extrapolated from charts of the quantitative distribution of the food benthos.

Neiman, A. A. 1968b. Quantitative distributions of benthos and food supply of demersal fish in the eastern part of the Bering Sea. *In* Sov. Fish. Inv. N. Pac. Pt. I. Isr. Prog. Sci. Trans. TT67-51203. 333 pp.

Composition and distribution of benthic communities of the eastern Bering are discussed. Zoogeographic and trophic relationships are examined, and the quantitative distribution of benthic invertebrates is discussed as it relates to fish feeding. The availability of food for three major trophic groups (filter feeders, browsers, and non-selective feeders) increases from the southeastern to the northwestern Bering Sea. Thus both the numbers and biomass of predators and prey increase accordingly in this same direction.

Nikol'skaya, N. G. and I. A. Verigina. 1974. Structural characteristics of the organs of feeding and digestion in three White Sea flounder species in relation to food consumed. J. Ichthyol. 14(1):99-108.

The structure of feeding and digestive organs were studied in *Platichthysus flesus*, *Liopsetta glacialis*, and *Limanda limanda*. Differences in the structure of jaws, the pharyngeal apparatus, relative gut length, and the histology of the stomach were related to feeding habits.

Novikov, N. P. 1968. Basic elements of the biology of the Pacific halibut (*Hippoglossus hippoglossus stenolepis* Schmidt) in the Bering Sea. *In* Sov. Fish. Inv. N. Pac. Pt. II. Isr. Prog. Sci. Transl. TT67-51204. 289 pp.

Length and weight, age and growth, reproduction, diet, distribution and migration, and management considerations are discussed. Prior to this study there was no feeding data from the southeastern Bering Sea except a statement of the Int. Pac. Halibut Comm. stating that small halibut (19 to 63 cm) feed exclusively on shrimps. Novikov found that small halibut (up to 30 cm) fed mainly on crustaceans, which occurred in 89% of the stomachs examined. The most abundant crustaceans were shrimps (78%F). Medium halibut (30 to 60 cm) shift to a diet comprised largely of fishes. Flatfishes, smelt, capelin, pollock, and sand lances total 61%F, while crustaceans (especially shrimps and hermit crabs) comprised 33%F. The role of molluscs and other invertebrates was insignificant. Large halibut (60 to 90 cm) ate mainly flatfishes, particularly yellowfin sole. Next in dietary importance were pollock, smelts, capelin, sea poachers, eelpouts, gobies, sand lances, and others. Crustaceans only occurred in 13% of the stomachs, and the take of molluscs was negligable. Very large halibut (over 90 cm) ate fishes, especially flatfishes (87%F). There was a significant reduction of crustaceans in the diet while more molluscs (11%F) were taken. All halibut sizes fed all year, but feeding was less active in the winter.

Olla, B. I., C. E. Samet and A. L. Studholme. 1972. Activity and feeding behavior of the summer flounder (*Paralichthys dentatus*) under controlled laboratory conditions. Fish. Bull. 70(4):1127-1136.

Feeding by the summer flounder can occur equally well on the bottom or in the water column, much like the turbot, *Scophthalmus maximus*. Both these fishes are principally day feeders depending on sight. Some feeding does, however, occur at night. The behavioral literature of other flatfishes is reviewed.

Olla, B. I., R. Wicklund and S. Wilk. 1969. Behavior of winter flounder in a natural habitat. Trans. Am. Fish. Soc. 98:717-720.

The feeding posture is described: The head is raised off the substrate with the first 12 to 17 rays of the dorsal fin. The flounder fed mainly on bivalves and molluscs. Also eaten, in order of decreasing importance were: algae, annelids, crustaceans, and sea anemones. Sight was critical for feeding of adults and juveniles, so this species mainly fed during the day. Stomach evacuation time was 7 to 9 hours for juveniles and 7 to 11 hours for adults.

Orcutt, H. G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Fish Game Bull. 78:64 pp.

Pandian, T. J. 1970. Intake and conversion of food in the fish *Limanda limanda* exposed to different temperatures. Mar. Biol. 5:1-17.

Rae, B. B. 1956. The food and feeding of the lemon sole. Mar. Res. 1956(3):1-32.

Rae, B. B. 1963. The food of the megrim. Mar. Res. 1963(3):1-23.

Rae, B. B. 1969. The food of the witch. Scotland Dept. Agr. Fish. Mar. Res. 2:1-21.

The feeding habits of *Glyptocephalus cynoglossus* were given in %F, with prey organisms identified to genus or species. Dramatic seasonal feeding differences were shown, with peak feeding in June and July, a decline in feeding from August to November, and minimum feeding in December. Polychaetes were the most important food (81%) followed by small crustaceans (60%), chiefly amphipods and cumaceans. Other food items included molluscs (14%), echinoderms (4%), anthozoans (6%), gephyreans (2%), nemerteans (2%), and fishes (1%). Anthozoans, gephyreans, and fishes can be of greater value to larger fishes in certain areas. Feeding habits of the witch were compared to the megrim and the lemon sole, concluding there are few prey species common between predators.

Ryland, J. S. 1964. The feeding of plaice and sand-eel larvae in the southern North Sea. J. Mar. Biol. Ass. U.K. 44:343-364.

Large numbers of sand-eel (*Ammodytes marinus*) appeared 2 to 4 weeks after the peak hatch of plaice (*Pleuronectes platessa*) eggs. At this time they outnumbered plaice young by 60 to 1. The food of the sand-eel consisted mainly of copepod nauplii and appendicularians while plaice fed mainly on the latter. Both larvae fed only during the day at 2 to 6 fathoms. The competition for food was discussed.

Shubnikov, D. A. and L. A. Lisovenko. 1968. Data on the biology of rock sole of the southeastern Bering Sea. *In* Sov. Fish. Inv. N. Pac. Pt. II. Isr. Prog. Sci. Transl. TT67-51204. 289 pp.

The mean weight of individual *Lepidopsetta bilineata* was greater from the west coast of Kamchatka than from the southeastern Bering Sea. The rock sole's diet included polychaetes (62%F), molluscs (37%), crustaceans - mainly shrimps (14%), and fishes and echinoderms were occassionally taken. Little feeding occurs in the winter and early spring, and the most intensive feeding is in June and July. The rock sole has a unique style of oviposition on the bottom off Kamchatka in 100 to 200 m of water. This taken place from mid-February to mid-April. Sexual maturity is attained at 5 to 7 years of age. The main commercial areas are northwest of Unimak and in central Bristol Bay. This species forms dense schools in the winter.

Skalkin, V. A. 1959. Feeding and feeding interrelationships of flatfishes in the shallows of Ilinsk. (In Russian.) Izv. tikhookean. nauchno., Inst. ryb. Khoz. Okeanogr. 47:62-75.

Skalkin, V. A. 1968. Diet of flatfishes in the southeastern Bering Sea. *In* Sov. Fish. Inv. N. Pac. Pt. I. Isr. Prog. Sci. Transl. TT67-51203. 333 pp.

Summer diets were examined in the yellowfin sole, rock sole and the Alaska plaice, showing that most food predominantly came from certain groups. Diet did sometimes differ from one region to another. The yellowfin sole ate primarily mysids, euphausids, *Pandalus borealis*, *Serripes groenlandicus*, and several other molluscs. The rock sole fed mainly on polychaetes and some molluscs, and the Alaska plaice principally took molluscs and a few polychaetes. Flathead sole ate ophiuroids and some crustaceans. The best yellowfin feeding grounds were in water less than 60 m deep. The apparent similarity of feeding by Alaska paice with the rock sole, and the Alaska plaice with yellowfin sole may have been largely due to difficulties in identifying the polychaetes.

Suyerhiro, Y. 1941. A study of the digestive system and feeding habits of fish (Pleuronectidae). Jap. J. Zool. 10:224-233.

Suyerhiro, Y. 1942a. A study of the digestive system and the feeding habit of the important fishes of the North Pacific. II. The plaice, *Lepidopsetta mochigarei* (Snyder) and the halibut *Hippoglossus elassodon* (Jordan and Snyder). (In Japanese). Bull. Jap. Soc. Scient. Fish. 3:65-72.

Suyerhiro, Y. 1942b. A study on the digestive system and feeding habits of fish. Jap. J. Zool. 10(1):1-303.

One hundred and fifty species of northwestern Pacific fishes from 88 families are discussed in terms of feeding habits and related morphology. Families of interest to Alaskan problems include Hexagrammidae, Cottidae, Pleuronectidae, and Gadidae.

Todd, R. A. 1915. Report on the food of the plaice. Fish. Inv. London 2(3): 1-31.

Pleuronectes platessa had 58 to 92% empty stomachs from November through February, with only 1 to 7% from March through October. In the winter they fed mainly on polychaetes while in the summer the frequency of worms drops dramatically occompanied by a large increase in the importance of molluscs. Changes in feeding between 10 cm size groups was demonstrated. As the plaice grow, molluscs become more important. Polychaetes become more important until the plaice attains a length of 30 cm, thereafter their importance declines. The importance of crustacea declines steadily. Echinoderms decrease until the plaice attain 40 cm, thereafter their importance increases. The feeding habits of the plaice is compared with the haddock, dab, and sole suggesting that most competition was over molluscs and polychaetes. Haddock were the strongest competitors.

Villadolid, D. V. 1927. The flatfishes (Heterosomata) of the Pacific coast of the United States. PhD. Dissertation. Standford University. 332 pp.

II. Remaining Orders

Anon, -- -. 1967. The food of the cod. Scott. Fish. Bull. 28:27.

Armstrong, R. H. and P. C. Winslow. 1968. An incidence of walleye pollock feeding on salmon young. Trans. Am. Fish. Soc. 97:202-203.

Bainbridge, V. and B. J. McKay. No Date. The feeding of cod and redfish larvae. Int. Comm. N. W. Atl. Fish. Dartmouth Spec. Publ. 7:187-217.

The cod *Gadus morhua* and the redfish *Sebastes spp*. were studied in the Greenland area. Upon hatching, redfish larvae fed heavily on eggs of the copepod *Calanus*. Later in the summer mainly nauplii and copepodites of *Calanus* were taken. Cod larvae also fed heavily on these early stages of *Calanus*. In Icelandic waters, however, the cod larvae took a wider variety of prey including early stages of *Calanus*, *Temora*, *Evadne*, and euphausids. Generally the cod select larger food organisms than redfish larvae of the same length. Both larvae were diurnal feeders, with the volume of gut contents reaching a minimum just before dawn. Geographical differences in the feeding of both species was demonstrated.

Brawn, V. M. 1969. What's on the codfish's menu today? New Scient. 41(639): 509--511.

Brunel, P. 1963. Recherces sur l'alimentation et les migrations verticales de la morue. Rapp. Sta. Biol. Mar. Grando-Riviere 1963(1964):45-50.

Research on the feeding and vertical migrations of the cod.

Brunel, P. 1965. Food as a factor or indicator of vertical migrations of cod in the western Gulf of St. Lawrence. Spec. Publs. int. Comm. N.W. Atlantic Fish. 6(1965):439-448.

Gotshall, D. W., J. G. Smith and A. Holbert. 1965. Food of the blue rockfish *Sebastodes mystinus*. Bull. Calif. Fish Game 51:147-162.

The stomachs of 806 rockfish were examined yeilding 223 empty stomachs. The following major food items were recorded: crustaceans (37%F, 3%V), tunicates (28%F, 44%V), scyphozoids (21%F, 12%V), algae (20%F, 17%V), fishes (8%F, 12%V), hydroids (4%F, 1%V), and miscellaneous (25%F, 12%V). Differences in feeding habits of rockfishes were demonstrated by geographic area, water depth, predator size, and season.

Hart, J. L. 1949. Food of fish of the cod family. Fish. Res. Bd. Can. Poc. Progr. Rept. 79:35-36.

Horstead, S. A. and E. Smidt. 1965. Remarks on effect of food animals on cod behavior. Spec. Publs. int. Comm. N.W. Atlant. Fish. 6(1965): 435-437.

Jolicoeur, P. and P. Brunel. 1966. Application du diagramme hexagonal a l'etude de la selection de ses proies par la morue. Vie Milieu 17B:419-433.

On the food preferences of *Gadus*.

Kamba, M. 1974. Food and feeding habits of walleye pollock, *Theregra chalcogramma* (Pallas) in Funka Bay. M.S. Thesis, Hokkaido Univ. 35 pp.

Distribution, behavior, and feeding habits of larval and juvenile pollock were described from Uchiura Bay, Hokkaido. The eggs and larvae of pollock were widely distributed in the mouth of the bay during March and April. The larvae were most abundant at 20 m, but extended from the surface to about 50 m. The copepod *Pseudodocalanus minatus* was the dominant food item. Copepod nauplii were most important for yolk-bearing larvae, while copepodite and adult copepods were utilized as the pollock grew. Seasonal feeding differences were demonstrated in the feeding of juvenile pollock.

Kariya, T. 1969. The relationship of food intake to the amount of stomach contents in mebaru, *Sebastes inermis*. (In Japanese.) Bull. Jap. Soc. Sci. Fish. 35(6):533-536.

A stomach capacity of 6.5 to 7.5% of body weight was demonstrated for S. inermis. The emptying rate of the stomach varied with temperature from 70 hours at 14°C to 140 hours at 7°C. At a temperature of 4.5°C food intake was reduced to 1.4% of the body weight.

Ketchen, K. S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. J. Fish. Res. Bd. Canada 18(4):513-558.

Distribution, age and growth, and reproduction are discussed. These warmer water fish display an earlier maturity, lower fecundity, and shorter life span than stocks of colder regions.

Kudersky, L. A. 1966. Change in the feeding of the White Sea cod (*Gadus morhua maris-albi* Derjugin) depending on their size in connection with interspecific food relations. (In Russian.) Vop. Ikhtiol. 6:346-352.

Lambert, D. G. 1960. The food of the redfish *Sebastes marinus* (L.) in the Newfoundland area. J. Fish. Res. Bd. Canada 17:235-243.

Major, R. L. and H. H. Shippen. 1970. Synopsis of biological data on Pacific Ocean perch, *Sebastodes alutus*. U.S. Dept. Commerce, NOAA circular 347:1-38.

Discussion includes the species description, distribution, bionomics, life history, population biology, and the fishery. Pelagic juveniles fed on planktonic crustaceans while benthic juveniles are euphausids and pandalids. Adults fed on euphausids, pandalids, squids, and fishes. One author cited suggests that immature fishes feed mostly on Calanoids while mature fish feed mainly on euphausids.

Mikulich, L. V. 1965. Feeding of Asiatic greenling (*Pleurogrammas azonus* Jordan et Metz) in the northern Sea of Japan. (In Russian.) Vop. Ikhtiol. 5:680-694.

Mito, K. 1974. Food relation in demersal fishing community in the Bering Sea walleye pollock fishing in October and November 1972. (In Japanese.) M.S. Thesis. Hokkaido Univ. 86 pp.

Nakamura, R. 1971. Food of two cohabiting tide-pool Cottidae. J. Fish. Res. Bd. Canada 28:928-932.

Oligocottus maculosus and *Oligocottus snyderi* were studied on Vancouver Island. Most foods were common to both species including amphipods, isopods, copepods, decapods, ostracods, caprellids, annelid worms, and molluscs. Relative importance of prey items differed between sculpins slightly.

Naumov, V. M. 1958. The feeding of cod in the Baltic Sea. (In Russian.) Inst. morsk. ryb. Khoz Okeanogr. 34:127-132.

Novikova, N. S. 1963. Some data on the food relations of cod and haddock from the Barents Sea. Dokl. Akad. Nauk. SSSR. (Transl.) Biol. Sci. Sect. 146:1182-1184.

Novikova, N. S. 1966. On the problem of the dependence of the daily way of feeding of the Barents Sea cod *Gadus morhua morhua* L. upon tide phenomena. (In Russian.) Vop. Ikhtiol. 6(1966):91-97.

Outram, D. N. and C. Haegele. 1972. Food of the Pacific Hake (*Merluccius productus*) on an offshore bank southwest of Vancouver Island, British Columbia. J. Fish. Res. Bd. Canada 29:1792-1795.

The feeding habits are given in frequency of occurrence (%F) euphausids 94%; sand lances 26%; Pacific herring 5%; eulachons 5%, lanternfishes, young rockfishes, northern anchovies, and pandalid shrimps each comprised 3% of less. Fresh or near fresh prey occurred in only 9% of stomachs taken during daylight, plus a high incidence (52%) of empty or near empty stomachs suggest that there is little feeding during daylight.

Pereyra, W. T., W. G. Pearcy, and F. E. Carvey, Jr. 1969. *Sebastodes flavidus*, a shelf rockfish feeding on mesopelagic fauan, with consideration of the ecological implications. J. Fish. Res. Bd. Canada 26:2211-2215.

The yellowtail rockfish aggregated along the southern edge of Astoria Canyon, probably in response to the increased availability of mesopelagic food. The mytophid *Stenbrachius leucopsarus* was the dominant food organism, followed by crustaceans, squids, and other invertebrates.

Popova, O. A. 1962. Some data on feeding of cod in the Newfoundland area of the N.W. Atlantic. *In* Sov. Fish. Invest. N.W. Atlantic, Moscow 1962: 235-252. (See also Isr. Prog. Sci. Transl. 1963:228-248.)

Prince, E. D. 1975. Pinnixid crabs in the diet of young-of-the-year copper rockfish (*Sebastes caurinus*). Trans. Am. Fish. Soc. 1975(3):539-540.

Quast, J. C. 1969. The Pacific cod, systematic relationships, biology, and fishery. Rapp. 13 Geo-Economie de la Morue:245-254.

Quast, J. C. 1971. Observations on the food of kelp bed fishes. *In* W. J. North (ed). Biology of giant kelps. Beiheft zur Nova Hedwiga 32:541-600.

The feeding habits of kelp bed fishes are discussed by predator species. A table of relative food usage is constructed for 38 categories of food items. The five most significant groups in decreasing importance were amphipods, crabs, algae, shrimps, and polychaetes.

Rae, B. B. 1967. The food of cod in the North Sea and on west of Scotland grounds. Mar. Res. 1967(1):1-68.

Rae, B. B. 1968. The food of cod in Icelandic waters. Mar. Res. 6:1-19.

Rass, T. S., (ed.). 1970. Greenlings, taxonomy, biology, interoceanic transplantation. Isr. Prog. Sci. Transl. TT69-55097. 208 pp.

Roedel, P. M. 1948. Common marine fishes of California. Calif. Game Fish. Bull. 68:150 pp.

Shubnikov, D. A. 1968. Data on the biology of sablefish of the Bering Sea. *In* Sov. Fish. Inv. N.E. Pac. Part I. Isr. Prog. Sci. Transl. TT67-51203. 287-296 pp.

Fish form the major part of the sablefish diet in early spring and autumn. During the summer months the sablefish switch to a diet including shrimp, ctenophores, and some benthic invertebrates.

Sidorenko, I. N. 1963. Feeding of cod in west Greenland waters. *In* Sov. Fish. Inv. N.W. Atlantic. Isr. Prog. Sci. Transl. 1963:249-255.

Simenstad, C. A. 1971. Feeding ecology of the rock greenling, *Hexagrammos lagocephalus*, in the inshore waters of Amchitka Island, Alaska. M.S. Thesis, Univ. of Washington. 131 pp.

Skalkin, V. A. 1968. Diet of rockfish in the Bering Sea. *In* Sov. Fish. Invest. N.E. Pac. Part II. Isr. Prog. Sci. Transl. TT67-51204. 159-179 pp.

The major food items are euphausids and calanids. Relative importance of food items varies with both depth and size of the rockfish. The rockfish apparently rise up the slope to above 200 m at night to feed on euphausids. By morning the fish have returned to deeper water, and little feeding occurs. On the shelf, the Pacific rockfish (*Sebastodes alutus*) feeds mainly on calanids, at depths of 200 to 300 m on euphausids, and on mysids and squids beyond 300 m. Juvenile specimens (up to 32 cm long) ate calanids while larger rockfish ate calanids and euphausids. Some data is also given for *Sebastodes polyspinus*.

Smith, R. T. 1936. Report on the Puget Sound otter trawl investigations. Wash. Dep. Fish. Biol. Rep. 36B:1-61.

Suyehiro, Y. 1934. Studies on the digestive system and the feeding habits of the important fishes of the North Pacific. I. The cods *Gadus macrocephalus* Tilesius and *Theregra chalcogrammus* (Pallas). (In Japanese.) Bull. Jap. Soc. Sci. Fish. 3:8-16.

In Bristol Bay, *G. macrocephalus* ate crabs, polychaetes, and several species of flatfishes, and pollock. *T. chalcogrammus* fed upon smaller invertebrates especially copepods and shrimps. Morphological correlates to feeding habits are discussed.

Templeman, W. 1965. Some instances of cod and haddock behavior and concentrations in the Newfoundland and Labrador areas in relation to food. Spec. Publs. int. Comm. N. W. Atl. Fish 1955(6):449-461.

The cod *Gadus morhua* from the commercial catch fed mainly on capelin from mid-June to early August in 13 to 38 m of water. From mid-August until November they fed mainly on bottom invertebrates, especially crustacea in water 55 to 130 m deep. Over 80% of the crustacea were spider crabs. The haddock *Melanogrammus aeglefinius* fed on capelin eggs in July and August while the cod fed on adult capelin. Larger haddock fed more heavily on adult capelin than on their eggs.

Tripolskaya, V. N. and L. O. Andrievskaya. 1967. Feeding of cod in Avachin Bay. (In Russian.) Izv. tikhooken. nauchno. issled., Inst. ryb. Khoz. Okeanogr. 57:122-134.

Westrheim, S. J. 1958. On the biology of the Pacific Ocean perch (*Sebastodes alutus*) (Gilbert). M.S. Thesis, Univ. of Washington. 106 pp.

Westrheim, S. J. and H. Tsuyuki. 1971. Taxonomy, distribution, and biology of the northern rockfish, *Sebastes polyspinis*. J. Fish. Res. Bd. Canada 28:1621-1627.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 21 R.U. NUMBER: 284

PRINCIPAL INVESTIGATOR: Dr. R. L. Smith

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1			
North Pacific	4/25/75	8/7/75	9/30/76			
Miller Freeman	8/16/75	10/20/75	9/30/76			

Note: [1] Data Management Plan has been approved and made contractual. We await receipt and approval, by all parties, of necessary Data Format.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 21

PRINCIPAL INVESTIGATOR: Dr. Ronald L. Smith

Period July 1, 1975 - March 31, 1976* (6 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	36,609.00	18,867.57	17,741.43
Staff Benefits	6,224.00	3,207.45	3,016.55
Equipment	490.00	-0-	490.00
Travel	1,500.00	352.81	1,147.19
Other	9,400.00	2,460.09	6,939.91
Total Direct	54,223.00	24,887.92	29,335.08
Indirect	20,940.00	10,792.25	10,147.75
Task Order Total	75,163.00	35,680.17	39,482.83

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 284 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

RECEIVED
JAN 19 1976

NEGOA

Fish
R.U. 284

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title: Food and Feeding Relationships in the Benthic and Demersal Fishes of the Gulf of Alaska and Bering Sea.

Contract Number: 03-5-022-56

Task Order Number: 21

Principal Investigator: Dr. Ronald L. Smith

I. Task Objectives

One major objective of this quarter was to complete collections of specimens from the Miller Freeman cruise in the Bering Sea. Another objective was to complete curation of fishes taken on the North Pacific in the summer, 1975. We also wanted to continue our literature search and to make arrangements for examining stomach contents of fishes caught by other agencies in the study areas.

II. Field and Laboratory Activities

Laboratory activities have centered around repacking of fish specimens obtained from the Gulf of Alaska. Each station's catch, usually packed in a single bucket, is sorted into its component species and repacked with identifying data. Specimens from the Bering were preserved in buffered formalin and will not be sorted at this time. Our next activity, already underway, is the removal of stomachs from one or two species, rough sorting of contents and running some preliminary samples through the Sorting Center for complete identifications.

III. Results

Leg III of the Miller Freeman cruise in the Bering netted the following samples:

83	cod (Pacific and saffron)
65	rock sole
96	Osmerus mordax
70	sturgeon poacher
59	yellowfin sole
73	long-nose dab
64	greenlings (primarily H. octogrammus)
30	pollock
33	Alaska plaice
45	Myoxocephalus sp.
37	unidentified sculpins

20	wattled eelpout
67	sandfish
10	halibut
15	arrowtooth flounder
10	flathead sole
4	starry flounder
9	unidentified poachers
6	herring

In addition to these specimens in hand, we have made arrangements for obtaining additional collections from the Bering Sea. NMFS, Kodiak, has frozen fish specimens from the Bering Sea. We have contacted John Paul Anderson and are arranging to have these specimens air freighted collect to Fairbanks. Once here, they will need to be properly curated. We do not know how many fish or which species are in the samples.

Another source of material from the Bering Sea has been located. Dr. John Burns, ADF&G, Fairbanks, has perhaps 200 gallons of preserved fish he caught on board the R/V *Alpha Helix*. Again, we do not know the species composition of the collection. This material is preserved in formalin and is presently located in Fairbanks. We are proceeding with arrangements to examine this material.

IV. Problems Encountered

One problem which I discussed with Jay Quast and Bob Meyer in October is the fact that many of the fish collected in the summer from the Gulf of Alaska were improperly preserved. A number of these specimens have been discarded.

The major problem, also mentioned in our October meeting, is that of funding. At this time, all non-salary funds for the entire year's budget have been committed. This means that we are faced with several tasks with no money to accomplish them. Specifically, we have no funds for getting personnel on board any additional cruises (our travel budget has been totally depleted), we have no funds to purchase additional preservative, buffer or containers (needed to curate NMFS and ADF&G material, as well as any fish collected on future cruises) and we do not have sufficient salary money to continue technician help through to September 30, 1976.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 21 R.U. NUMBER: 284

PRINCIPAL INVESTIGATOR: Dr. R. L. Smith

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates(1)			
	From	To	Batch 1			
North Pacific	4/25/75	8/7/75	9/30/76			
Miller Freeman	8/16/75	10/20/75	9/30/76			

Note: (1) Estimated submission dates are contingent upon final approval of data management plan submitted in draft form Oct. 9, 1975 and University of Alaska's approved form Nov. 20, 1975, to NOAA. Also, receipt and approval of data formats are necessary.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 21

PRINCIPAL INVESTIGATOR: Dr. Ronald L. Smith

Period July 1 -- December 31, 1975 * (6 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	36,609.00	14,339.65	22,269.35
Staff Benefits	6,224.00	2,437.71	3,786.29
Equipment	490.00	-0-	490.00
Travel	1,500.00	352.81	1,147.19
Other	9,400.00	2,049.67	7,350.33
Total Direct	54,223.00	19,179.84	35,043.16
Indirect	20,940.00	8,202.28	12,737.72
Task Order Total	75,163.00	27,382.12	47,780.88

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract #03-5-022-56
Research Unit #285
Reporting Period - 1 April 1975
31 Mar 1976

Preparation of Illustrated Keys to Skeletal Remains and Otoliths of Forage Fishes - Bering Sea and Gulf of Alaska

James E. Morrow

Principal Investigator

University of Alaska

31 March 1976

ANNUAL REPORT

I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

The objectives of this study are to prepare illustrated keys to skeletal remains and otoliths of forage fishes of the area. These will be used by principle investigators in other fields to determine the foods and trophic feeding levels of marine mammals, sea birds, and the larger demersal fishes. The implications with respect to OCS oil and gas development lie with these other studies rather than with the present project.

II. Introduction

Same as paragraph I.

III. Current state of knowledge

A fairly large number of papers has been published, notably by Frost in the late 1920's, in which the otoliths of major taxonomic groups (orders, families) have been broadly characterized. However, no detailed work exists by which the otoliths of particular species may be recognized. This is especially true of the fishes of the far north, which have been virtually unstudied from any aspect. The only work on skeletal parts that is of any consequence is that of Clothier (1950), who prepared a key to 163 species of southern California fishes.

IV. Study area

The study area for this portion of the keys is the Bering Sea and the Gulf of Alaska. Because of the limited number of species so far obtained from the Beaufort Sea, that material has been combined with the present.

V. Sources, methods and rationale of data collection

Study material was collected during the summer trawling cruises of 1975. Additional material from the Bering Sea is expected from the spring 1976 cruise of the MILLER FREEMAN. Some additional material has been derived from the University of Alaska Museum Fish Collection.

VI. Results

Skeletal material from 68 specimens of 35 species has been prepared and stored for future study. An additional 85 skeletons are in process.

Otoliths have been obtained from 278 specimens representing 64 species in 16 families (see list attached to quarterly report). Forty six of these species were obtained from the 1975 trawling cruises, the remaining 18 from the University of Alaska Museum Fish Collection.

On the basis of otoliths, working definitions of all 16 families have been prepared. We are currently working on a preliminary key to the families, genera and species represented in the collection. Copies of this key will be sent to principal investigators dealing with food habits of marine mammals, sea birds and demersal fishes.

These PI's will be asked to attempt to use the keys, test them and make suggestions for improvement. The preliminary key should be ready by June 1976.

Because many of the species are represented by only one or two specimens, the preliminary key may not be entirely reliable. However, we believe it will be satisfactory to the family level and in most cases to the generic level. The testing done by other principal investigators will indicate how accurate the key may be and where it needs improvement.

VII. Discussion

The preparation of skeletons from preserved material is extraordinarily time consuming. We have therefore devoted the major part of our efforts towards the otolith work. We feel confident of producing a working key to otoliths. However, even if suitable material were available for skeletal studies, it appears that such work would require far more time than is available to the project.

VIII. Conclusions - Not applicable

IX. Needs for further study

The work on otoliths should be continued and expanded, adding as many species as possible to the keys. This will not only provide broader covereage but will also increase the accuracy of identifications.

The work on the key to skeletal remains should be phased out of the present project, allowing the investigators to devote their entire time to the otolith studies. The skeletal remains key is a long-term project which will require several years to complete and should be treated as such.

X. Summary of 4th quarter operations.

A. Field or Laboratory Activities

1. Ship or field trip schedule - Not applicable

2. Scientific Party

Dr. James E. Morrow
University of Alaska
Principal Investigator

Mr. Sverre Pedersen
University of Alaska
Technician, ½ time

Mr. Edmond Murrell
University of Alaska
Technician, ½ time

3. Methods

Skeletons are prepared from material on hand, using the rotting method. This technique is the only one we have found which is at all effective on preserved material. It requires three weeks to three months to prepare a skeleton from formaldehyde preserved material. However, frozen specimens can be prepared in a matter of three or four days and the results are excellent. In these preparations, as much meat as possible is cut off the vertebral column and skull. The remains are then put in a jar of water and left until the flesh is soft enough to be removed with the fingers. The skeletal parts are carefully arranged on the bottom of a shallow cardboard box, allowed to dry and then stored in a special cabinet.

Otoliths are removed by making a medial incision through the skull with a sharp knife and carefully removing the otoliths with fine tweezers. The otoliths are cleaned of the surrounding saccular material, dried and mounted on frosted-end glass microscope slides, using Duco cement. The slides are stored in ordinary large slide boxes and cabinets.

4. Sample localities

Specimens were taken on trawling cruises in the Bering Sea and Gulf of Alaska.

5. Data collected or analysed

Otoliths have been taken from 278 specimens, representing 64 species in 16 families (see attached list). Forty six of these species were obtained from the trawling cruises, the remaining 18 taken from the University of Alaska Museum Fish Collection.

Skeletons have been prepared from 68 specimens of 35 species. An additional 85 skeletons are currently being prepared. The total of 153 represents 63 species.

B. Preliminary interpretation of results - Not applicable

C. Problems encountered/recommended changes

The skeletal work is extremely slow and time consuming. Mr. Ray Baxter, Alaska Department of Fish and Game, visited our laboratory recently. He told us that he had worked for Dr. Charles Clothier for a year during which Dr. Clothier was working on his key to skeletons of California fishes. According to Mr. Baxter, Dr. Clothier spent more than five years in the preparation of his key. Because of this and our own experience, we are devoting our major efforts to the otolith work. We recommend that the skeletal key be deleted from our project and made a separate, long-term project. This will enable us to devote all our time to the otolith work and to make the otolith key far more comprehensive than would otherwise be the case.

LIST OF SPECIES PREPARED FOR OTOLITH AND SKELETAL STUDIES

(B = species found also in the Beaufort Sea)

Family and species	Otoliths	Skeleton
Clupeidae		
Clupea harengus B	x	x
Salmonidae		
Oncorhynchus tshawytscha	x	
Osmeridae		
Hypomesus pretiosus	x	
Mallotus villosus B	x	
Thaleichthys pacificus	x	
Gadidae		
Boreogadus saida B	x	
Eleginus gracilis	x	
Gadus macrocephalus	x	x
Microgadus proximus	x	
Theragra chalcogramma	x	x
Zoarcidae		
Bothrocara molle	x	x
Lycodes brevipes	x	x
Lycodes palearis B	x	x
Lycodes turneri B	x	
Lycodes sp	x	
Trichodontidae		
Trichodon trichodon	x	x
Bathymasteridae		
Bathymaster signatus	x	x
Stichaeidae		
Lumpenella longirostris	x	x
Lumpenus sagitta	x	
Stichaeus punctatus B	x	x
Pholidae		
Pholis laeta		x
Cryptacanthodidae		
Delolepis gigantea	x	x
Ammodytidae		
Ammodytes hexapterus B	x	
Scorpaenidae		
Sebastes aleutianus	x	x
Sebastes alutus	x	

Family and species		Otoliths	Skeleton
Sebastes aurora (?)		x	x
Sebastes ciliatus		x	x
Sebastes crameri		x	
Sebastes entomelas		x	
Sebastes melanops		x	
Sebastes saxicola		x	
Sebastes variegatus		x	x
Sebastolobus alascanus		x	
Anoplopomatidae			
Anoplopoma fimbria		x	x
Hexagrammidae			
Hexagrammos lagocephalus		x	
Hexagrammos stelleri		x	x
Ophiodon elongatus		x	x
Pleurogrammus monopterygius		x	x
Cottidae			
Dasycottus setiger		x	x
Enophrys claviger		x	
Gymnocanthus galeatus		x	x
Gymnocanthus tricuspis	B	x	x
Hemilepidotus jordani		x	x
Hemilepidotus spinosus		x	x
Hemitripterus bolini		x	
Icelinus borealis		x	
Icelus spiniger		x	x
Leptocottus armatus		x	x
Malacocottus kincaidi		x	x
Myoxocephalus scorpius	B	x	
Psychrolutes paradoxus		x	
Triglops macellus		x	
Triglops pingeli		x	
Agonidae			
Agonus acipenserinus	B	x	x
Hypsagonus quadricornis		x	x
Pallasina barbata		x	x
Pleuronectidae			
Atheresthes stomias		x	
Glyptocephalus zachirus		x	
Hippoglossoides elassodon		x	x
Hippoglossoides robustus		x	
Hippoglossus stenolepis		x	
Isopsetta isolepis		x	x
Lepidopsetta bilineata		x	x
Limanda aspera		x	x
Microstomus pacificus		x	

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 22 R.U. NUMBER: 285

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 22

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period July 1, 1975 - March 31, 1976* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	24,318.00	9,247.71	15,070.29
Staff Benefits	4,134.00	1,560.41	2,573.59
Equipment	400.00	444.00	(44.00)
Travel	-0-	-0-	-0-
Other	1,200.00	275.86	924.14
Total Direct	30,052.00	11,527.98	18,524.02
Indirect	13,910.00	5,289.69	8,620.31
Task Order Total	43,962.00	16,817.67	27,144.33

Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 285 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title: Preparation of Illustrated Keys to Skeletal Remains and Otoliths of Forage Fishes

RU 285
Fish

Contract Number: 03-5-022-56

Task Order Number: 22

Principal Investigator: Dr. James E. Morrow

I. Task Objectives

To develop illustrated keys to skeletal materials and otoliths for forage fishes in the Gulf of Alaska and Bering Sea.

II. Field and Laboratory Activities

No additional material has been received since the last quarterly report. We have continued to prepare material from the first three cruises. A second part-time technician was hired in October.

III. Results

We currently have completed preparation of from one to ten sets of otoliths for 45 species and from one to three complete skeletons of 41 species.

IV. Problems Encountered

The greatest problem encountered is that of insufficient material. We received no specimens from the last trawling cruise. We are making what use we can of material collected for Dr. Ronald Smith's study of food habits. However, most of this material arrived in very poor condition, half rotted, cut into pieces, etc., so that identifications are difficult and the specimens are relatively useless for skeletons. The material, so far prepared, represents less than 10% of the species known to inhabit the Gulf and Bering. It is stipulated in our proposal and contract that the NMFS will provide frozen material, but, so far, we have received only about a dozen specimens in this condition. UNLESS ADDITIONAL MATERIAL, PROPERLY PREPARED, IS RECEIVED IN GOOD SEASON, IT WILL BE IMPOSSIBLE TO COMPLETE THIS PROJECT.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 22 R.U. NUMBER: 285

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable (1).

NOTE: (1) Data management plan was submitted to NOAA in draft form on October 9, 1975 and University of Alaska approval given on November 20, 1975. We await formal approval from NOAA.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 22

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period July 1 -- December 31, 1975 * (6 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	24,318.00	-0-	24,318.00
Staff Benefits	4,134.00	-0-	4,134.00
Equipment	400.00	444.00	(44.00)
Travel	-0-	-0-	-0-
Other	1,200.00	69.89	1,130.11
Total Direct	30,052.00	513.89	29,538.11
Indirect	13,910.00	-0-	13,910.00
Task Order Total	43,962.00	513.89	43,448.11

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract #03-5-022-56
Research Unit #318
Reporting Period - 1 April 1975
31 March 1976

Preparation of Illustrated Keys to Skeletal Remains and Otoliths of Forage Fishes - Beaufort Sea

James E. Morrow

Principal Investigator

University of Alaska

31 March 1976

ANNUAL REPORT

I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

The objectives of this study are to prepare illustrated keys to skeletal remains and otoliths of forage fishes of the area. These will be used by principle investigators in other fields to determine the foods and trophic feeding levels of marine mammals, sea birds, and the larger demersal fishes. The implications with respect to OCS oil and gas development lie with these other studies rather than with the present project.

II. Introduction

Same as paragraph I.

III. Current state of knowledge

A fairly large number of papers has been published, notably by Frost in the late 1920's, in which the otoliths of major taxonomic groups (orders, families) have been broadly characterized. However, no detailed work exists by which the otoliths of particular species may be recognized. This is especially true of the fishes of the far north, which have been virtually unstudied from any aspect. The only work on skeletal parts that is of any consequence is that of Clothier (1950), who prepared a key to 163 species of southern California fishes.

IV. Study area

The study area for this portion of the keys is the Beaufort Sea and closely adjoining waters.

V. Sources, methods and rationale of data collection

Study material was supposed to have been collected by several trawling cruises. However, for various reasons, the cruises were cancelled. Such material as we have been able to obtain has come from the University of Alaska Museum Fish Collection.

VI. Results

The Beaufort Sea material has been combined with specimens from the Bering Sea and Gulf of Alaska to prepare a key to otoliths. On the basis of this material, we have defined the families shown on the attached list. We are in the process of preparing a preliminary key to the otoliths. We plan to send copies of this key to principal investigators dealing with food habits of marine mammals, sea birds and demersal fishes and ask them to test it on their material and make suggestions for its improvement. The preliminary key should be ready to send out by June 1976.

Because many of the species are represented by only one or two specimens, the preliminary key may not be entirely reliable. However, we believe it will be satisfactory to the family level and in most cases to the generic level. The testing done by other principal investigators will tell how accurate the key may be and where it needs improvement. Skeletal material has been prepared and stored for future study.

VII. Discussion

The preparation of skeletons from preserved material is extraordinarily time consuming. We have therefore devoted the major part of our efforts towards the otolith work. We feel confident of producing a working key to otoliths. However, even if suitable material were available for skeletal studies, it appears that such work would require far more time than is available to the project.

VIII. Conclusions - Not applicable

IX. Needs for further study

The work on otoliths should be continued and expanded, adding as many species as possible to the keys. This will not only provide broader coverage but will also increase the accuracy of identifications.

The work on the key to skeletal remains should be phased out of the present project. This will allow the investigators to devote their entire time to the otolith studies. The skeletal remains key is a long-term project which will require several years to complete and should be treated as such.

X. Summary of 4th quarter operations

A. Field or Laboratory Activities

1. Ship or Field Trip Schedule - Not applicable

2. Scientific Party

Dr. James E. Morrow
University of Alaska
Principle Investigator

Mr. Sverre Pedersen
University of Alaska
Technician, ½ time

Mr. Edmond Murrell
University of Alaska
Technician, ½ time

3. Methods

Skeletons are prepared from material on hand, using the rotting method. This technique is the only one we have found which is at all effective on preserved material. It requires three weeks to three months to prepare a skeleton from formaldehyde preserved material. However, frozen specimens can be prepared in a matter of three or four days and the results are excellent. In these preparations, as much meat as possible is cut off the vertebral column and skull. The remains are then put in a jar of water and left until the flesh is soft enough to be removed with the fingers. The skeletal parts are carefully arranged on the bottom of a shallow cardboard box, allowed to dry and then stored in a special cabinet.

Otoliths are removed by making a medial incision through the skull with a sharp knife and carefully removing the otoliths with fine tweezers. The otoliths are cleaned of the surrounding saccular material, dried and mounted on frosted-end glass microscope slides, using Duco cement. The slides are stored in ordinary large slide boxes and cabinets.

4. Sample localities

   Beaufort Sea material has been obtained from the fish collection of the University of Alaska Museum.

5. Data collected or analysed

   We have obtained material representing 10 species known to occur in the Beaufort Sea. See attached list.

B. Preliminary interpretation of results - Not applicable

C. Problems encountered/recommended changes

The skeletal work is extremely slow and time consuming. Mr. Ray Baxter, Alaska Department of Fish and Game, Fairbanks, visited our laboratory recently. He told us that he had worked for Dr. Charles Clothier for a year during which Dr. Clothier was preparing his key to skeletons of California fishes. According to Mr. Baxter, Dr. Clothier spent more than five years in the preparation of his key. Because of this and our own experience, we are devoting our major efforts to the otolith work. We recommend that the skeletal key be deleted from our project and made a separate, long-term project. This will enable us to devote all our time to the otolith work and to make the otolith key far more complete than would otherwise be true.

LIST OF SPECIES PREPARED FOR OTOLITH AND SKELETAL STUDIES

(B = species found also in the Beaufort Sea)

Family and species	Otoliths	Skeleton
Clupeidae		
Clupea harengus B	x	x
Salmonidae		
Oncorhynchus tshawytscha	x	
Osmeridae		
Hypomesus pretiosus	x	
Mallotus villosus B	x	
Thaleichthys pacificus	x	
Gadidae		
Boreogadus saida B	x	
Eleginus gracilis	x	
Gadus macrocephalus	x	x
Microgadus proximus	x	
Theragra chalcogramma	x	x
Zoarcidae		
Bothrocara molle	x	x
Lycodes brevipes	x	x
Lycodes palearis B	x	x
Lycodes turneri B	x	
Lycodes sp	x	
Trichodontidae		
Trichodon trichodon	x	x
Bathymasteridae		
Bathymaster signatus	x	x
Stichaeidae		
Lumpenella longirostris	x	x
Lumpenus sagitta	x	
Stichaeus punctatus B	x	x
Pholidae		
Pholis laeta		x
Cryptacanthodidae		
Delolepis gigantea	x	x
Ammodytidae		
Ammodytes hexapterus B	x	
Scorpaenidae		
Sebastes aleutianus	x	x
Sebastes alutus	x	

Family and species	Otoliths	Skeleton
Sebastes aurora (?)	x	x
Sebastes ciliatus	x	x
Sebastes crameri	x	
Sebastes entomelas	x	
Sebastes melanops	x	
Sebastes saxicola	x	
Sebastes variegatus	x	x
Sebastolobus alascanus	x	
Anoplopomatidae		
Anoplopoma fimbria	x	x
Hexagrammidae		
Hexagrammos lagocephalus	x	
Hexagrammos stelleri	x	x
Ophiodon elongatus	x	x
Pleurogrammus monopterygius	x	x
Cottidae		
Dasycottus setiger	x	x
Enophrys claviger	x	
Gymnocanthus galeatus	x	x
Gymnocanthus tricuspis B	x	x
Hemilepidotus jordani	x	x
Hemilepidotus spinosus	x	x
Hemitripterus bolini	x	
Icelinus borealis	x	
Icelus spiniger	x	x
Leptocottus armatus	x	x
Malacocottus kincaidi	x	x
Myoxocephalus scorpius B	x	
Psychrolutes paradoxus	x	
Triglops macellus	x	
Triglops pingeli	x	
Agonidae		
Agonus acipenserinus B	x	x
Hypsagonus quadricornis	x	x
Pallasina barbata	x	x
Pleuronectidae		
Atheresthes stomias	x	
Glyptocephalus zachirus	x	
Hippoglossoides elassodon	x	x
Hippoglossoides robustus	x	
Hippoglossus stenolepis	x	
Isopsetta isolepis	x	x
Lepidopsetta bilineata	x	x
Limanda aspera	x	x
Microstomus pacificus	x	

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 9 R.U. NUMBER: 318

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 9

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	15,272.00	1,200.96	14,071.04
Staff Benefits	2,570.00	204.17	2,365.83
Equipment	-0-	-0-	-0-
Travel	750.00	-0-	750.00
Other	900.00	25.42	874.58
Total Direct	19,492.00	1,430.55	18,061.45
Indirect	8,734.00	686.95	8,047.05
Task Order Total	28,226.00	2,117.50	26,108.50

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 318 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

R.U. 318
[illegible]

Project Title: Preparation of Illustrated Keys to Skeletal Remains and Otoliths of Forage Fishes (Beaufort Sea)

Contract Number: 03-5-022-56

Task Order Number: 9

Principal Investigator: Dr. James E. Morrow

I. Task Objectives

To develop illustrated keys to skeletal remains and otoliths of forage fishes in the Beaufort Sea.

II. Field and Laboratory Activities

No material has been received.

III. Results

None

IV. Problems Encountered

Lack of material is created by no logistics in this area. Sample material was to be provided by programs taking trawl surveys.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56   T/O NUMBER: 9   R.U. NUMBER: 318

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable (1).

NOTE: (1) Data management plan was submitted to NOAA in draft form on October 9, 1975 and University of Alaska approval given on November 20, 1975. We await formal approval from NOAA.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 9

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	15,272.00	2,382.92	12,889.08
Staff Benefits	2,570.00	405.09	2,164.91
Equipment	-0-	-0-	-0-
Travel	750.00	-0-	750.00
Other	900.00	19.27	880.73
Total Direct	19,492.00	2,807.28	16,684.72
Indirect	8,734.00	1,363.03	7,370.97
Task Order Total	28,226.00	4,170.31	24,055.69

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract #03-5-022-56
Research Unit #348
Reporting Period - 1 April 1975
31 Mar 1976

Literature Search on the density and distribution of fishes of the Beaufort Sea

James E. Morrow

University of Alaska

31 March 1976

ANNUAL REPORT

I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development

The sole objective is to prepare an annotated bibliography on the density and distribution of the fishes of the Beaufort Sea. This bibliography will provide a data base for future research in the aquatic environment of the area.

II. Introduction

A. General nature and scope - See I.

B. Specific objectives - See I.

C. Relevance to problems of petroleum development - The Beaufort Sea is virtually unknown as far as fauna is concerned. Neither qualitative nor quantitative aspects have been determined. Data exist as published or unpublished papers and reports, ranging from the narratives of early polar explorers to modern, highly technical reports on narrow aspects of the ecological relationships in small parts of the sea. By bringing all this information together in one place, we will contribute to the ability of future workers to predict, ameliorate and even avoid altogether the adverse effects of petroleum exploration and production on the environment.

III. Current state of knowledge - The Beaufort Sea is virtually unknown as far as fauna is concerned.

IV. Study area - not applicable

V. Sources, methods and rationale of data collection

Sources are all libraries available to us, including the several libraries of the University of Alaska; the libraries of the Alaska Department of Fish and Game, Fairbanks; U. S. Fish and Wildlife Service, Anchorage; and Arctic Environmental Information and Data Center, Anchorage. In addition, we have been given access to files of unpublished data by the three latter organizations.

VI. Results

Almost 1,000 items have been searched, annotated and entered on file cards.

VII. Discussion - not applicable

VIII. Conclusions - not applicable

IX. Needs for further study

The project should continue until its expiration on 30 September 1976. Files and libraries at major centers in the southern part of the country should be searched. We plan to visit the libraries of the University of Washington College of Fisheries; the Department of Ichthyology of the California Academy of Sciences; and Scripps Institution of Oceanography.

X. Summary of 4th quarter activities

A. Field or laboratory activities

1. Ship or field trip schedule

   March 8 - 11, 1976, Mrs. Pfeifer travelled to Anchorage to consult pertinent sources in files made available by Mr. Eugene Buck, Arctic Environmental Information and Data Center, and by Mrs. Rosie Olsen, U. S. Fish and Wildlife Service. She also contacted Mr. Dave Spencer, Pipeline Division, U. S. Fish and Wildlife Service, who has promised to supply additional data.

2. Scientific party

   Dr. James E. Morrow
   University of Alaska
   Principal Investigator

   Mrs. Wilma E. Pfeifer
   University of Alaska
   Library Technician

3. Methods

   Standard library search methods are used throughout.

4. Sampling localities

   Data have been discovered in the Elmer E. Rasmuson Library, University of Alaska; Biomed Library, U of A; IMS Library, U of A; IAB Library, U of A; Alaska Dept. Fish and Game, Fairbanks; Arctic Environmental Data Center, Anchorage; and U. S. Fish and Wildlife Service, Anchorage.

5. Data collected

   Approximately 200 additional references have been discovered, annotated and entered on file cards. This brings the total to nearly 1,000 entries.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 16 R.U. NUMBER: 348

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 16

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period July 1, 1975 - March 31, 1976* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	10,851.00	5,542.72	5,308.28
Staff Benefits	1,844.00	835.51	1,008.49
Equipment	-0-	-0-	-0-
Travel	625.00	251.48	373.52
Other	475.00	62.16	412.84
Total Direct	13,795.00	6,691.87	7,103.13
Indirect	6,207.00	3,170.44	3,036.56
Task Order Total	20,002.00	9,862.31	10,139.69

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 348 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

348,
[illegible]

Project Title:	Literature Search on Density Distribution of Fishes of the Beaufort Sea
Contract Number:	03-5-022-56
Task Order Number:	16
Principal Investigator:	Dr. James E. Morrow

I. Task Objectives

To complete a literature search on the density distribution of fishes of the Beaufort Sea.

II. Field and Laboratory Activities

None.

III. Results

Mrs. Pfeiffer has located 540 pertinent references. Approximately 20% of these have been annotated. She has surveyed the Rasmuson Library, the libraries of the Institute of Marine Science and Institute of Arctic Biology, and is currently almost finished with Wildlife Research Library. She has communicated with Ms. Dorothy Lunsfor, ADF&G, Juneau; Ms. Patti Brommelsiek, AEIDC, Anchorage, and Mr. Gene Buck, AEIDC, Anchorage, requesting opportunity to search their libraries and reference files. She has also started working part-time for Mr. George Mueller, Curator of Aquatic Collections, University of Alaska, on his project, "Summarization of Existing Literature and Unpublished Data on the Distribution, Abundance and Productivity of Benthic Organisms of the Gulf of Alaska and the Bering Sea", an arrangement which is working out to mutual benefit. Mrs. Pfeiffer expects to visit Anchorage, Juneau and Seattle in February. At those places, she will search the libraries and files of AEIDC, ADF&G, NMFS and the Fisheries Oceanography Library of the University of Washington.

IV. Problems Encountered

None.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 16 R.U. NUMBER: 348

PRINCIPAL INVESTIGATOR: Dr. J. E. Morrow

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable(1)

NOTE: (1)Data management plan was submitted to NOAA in draft form on October 9, 1975 and University of Alaska approval given on November 20, 1975. We await formal approval from NOAA.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 16

PRINCIPAL INVESTIGATOR: Dr. James E. Morrow

Period July 1 -- December 31, 1975 * (6 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	10,851.00	2,480.60	8,370.40
Staff Benefits	1,844.00	421.70	1,422.30
Equipment	-0-	-0-	-0-
Travel	625.00	-0-	625.00
Other	475.00	58.10	416.90
Total Direct	13,795.00	2,960.40	10,834.60
Indirect	6,207.00	1,418.90	4,788.10
Task Order Total	20,002.00	4,379.30	15,622.70

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract #: 03-5-022-67-TA9 #4
Research Unit #: 349
Reporting Period: 1 Apr 1975 - 30 Mar 1976
Number of Pages: 35

Alaska Marine Ichthyoplankton Key

T. Saunders English
Department of Oceanography
University of Washington
Seattle, Washington 98195

1 April 1976

REF: A76-32

I. Task Objectives

The task of primary emphasis is A25b--to develop an ichthyoplankton key to aid identification of the ichthyoplankton occurring in Alaskan waters. Other objectives are to:

A. locate and describe archived specimens,

B. make recommendations for a field sampling program,

C. participate in sorting, identification, and analysis.

II. Field or Laboratory Activities

A preliminary key (Table 1) to the pelagic fish eggs of Alaskan waters has been constructed. The key is based on live material and covers 21 species of commercial or possible commercial value. Some species have been excluded because no information is available.

A list (Table 2) has been prepared of commercially valuable Alaskan species, including 48 species of fish, 2 species of shrimps, 3 species of crabs, 3 species of clams, 1 species of scallop, and 1 species of abalone. A list of references for these species is included.

A list (Table 3) has been prepared of Alaskan fishes with pelagic larvae. This list comprises 173 species from 37 families.

A bibliography has been prepared covering life history information on 15 fish species of commercial value. There are approximately 100-130 references dealing with pelagic life history studies of Alaskan commercial species although many of these species are also found elsewhere. There is little available information concerning fishes in the Beaufort Sea.

A bibliography of about 75 references to literature relating to ichthyoplankton and fisheries in Alaskan waters has been compiled.

Table 1. Preliminary Key to the Pelagic Fish Eggs of Alaskan Waters

1a.	Eggs spherical or nearly so	2a.
1b.	Eggs ellipsoidal.	*Engraulis mordax*
2a.	Eggs with oil globules	3a.
2b.	Eggs without oil globules.	7a.
3a.	Eggs with single oil globule.	4a.
3b.	Eggs with 5-6 oil globules, diminishing to 2-3 in late stages of development. Shell with reticulate network, diameter 1.19-1.81 mm.	*Theragra chalcogramma*
4a.	Oil globule larger than 0.30 mm.	*Merluccius productus*
4b.	Oil globule smaller than 0.30 mm	5a.
5a.	Perivitelline space wide	*Sardinops caerulea*
5b.	Perivitelline space narrow	6a.
6a.	Oil globule about 0.26 mm.	*Scomber japonicus*
6b.	Oil globule about 0.10 mm.	*Citharichthys sordidus* or *Citharichthys stigmaeus*
7a.	Eggs with large, wide perivitelline space	*Hippoglossoides elassodon*
7b.	Eggs with small, narrow perivitelline space	8a.

Table 1(cont).

8a. Eggs with diameter larger than 1.9 mm. . . . . 9a.

8b. Eggs with diameter smaller than 1.9 mm . . . . 12a.

9a. Shell punctured, honeycombed or wrinkled . . . . 10a.

9b. Shell smooth . . . . 11a.

10a. Shell punctured or with honeycomb appearance . . . . *Hippoglossus stenolepis*

10b. Shell wrinkled with a raised vermiculate pattern . . . . *Microstomus pacificus*

11a. Egg diameter greater than 3.0 mm . . . .*Reinhardtius hippoglossoides*

11b. Egg diameter smaller than 3.0 mm . . . . *Anoplopoma fimbria*

12a. Shell with hexagonal and/or pentagonal sculpturing . . . . 13a.

12b. Shell not sculptured . . . . 14a.

13a. Width of hexagon large, 0.042 mm . . . . *Pleuronichthys coenosus*

13b. Width of hexagon small, 0.037 mm . . . . . . *Pleuronichthys decurrens*

14a. Pigment spots present on late developing embryo . . . . . . 15a.

14b. Pigment spots absent on late developing embryo. .*Eopsetta jordani*

15a. Pigment spots on embryo and yolk . . . . 16a.

15b. Pigment spots on embryo only . . . . 18a.

Table 1(cont).

16a. Eggs larger than 1.4 mm. . . . . *Lyopsetta exilis*

16b. Eggs smaller than 1.4 mm . . . . 17a.

17a. Chromatophores yellow . . . . *Platichthys stellatus*

17b. Chromatophores tan or brown . . . . *Psettichthys melanostictus*

18a. Egg diameter larger than 0.9 mm . . . . 19a.

18b. Egg diameter smaller than 0.9 mm. . . . . *Limanda aspera*

19a. Egg shell smooth, diameter 1.07-1.25 mm . . . .*Glyptocephalus zachirus*

19b. Egg shell minutely wrinkled, diameter 0.87-1.05 mm. . . . . . . *Parophrys vetulus*

Note: The characteristics in this key apply mainly to live materials, but may also be applicable to some preserved materials. Several species of commercial value are not included in the key because of lack of information.

Table 2, Alaskan Commercial Species

Clupeidae:

Alossa sapidissima (Wilson)
Clupea harengus pallasi Valenciennes
Sardinops sagax caerulea (Girard)

Engraulidae:

Engraulis mordax (Girard)

Salmonidae:

Onchorhynchus gorhuscha (Walbaum)
Onchorhynchus kisutch (Walbaum)
Onchorhynchus keta (Walbaum)
Onchorhynchus tschawytscha (Walbaum)

Gadidae:

Gadus morhua macrocephalus Tilesius
Microgadus proximus (Girard)
Theragra chalcogramma (Pallas)

Merlucciidae:

Merluccius productus (Ayres)

Scombridae:

Scomber japonicus (Houtuyn)
Thunnus alalunga (Gmelin)
Thunnus thynnus (Linne)

Anoplopomatidae:

Anoplopoma fimbria (Pallas)

Bothidae:

Citharichthys sordidus Girard
Citharichthys stigmaeus Jordan and Gilbert

Pleuronectidae:

Atheresthes evermanni Jordan and Starks
Embassichthys bathybius (Gilbert)
Eopsetta jordani (Lockington)
Glyptocephalus zachirus Lockington
Hippoglossoides elassodon Jordan and Gilbert

Table 2 (cont.).

Pleuronectidae (cont.):

Hippoglossoides robustus Gill and Townsend
Hippoglossus stenolepis Schmidt
Isopsetta isolepis (Lockington)
Lepidopsetta bilineata (Ayres)
Limanda aspera (Pallas)
Limanda proboscidea Gilbert
Lyopsetta gracilis (Pallas)
Lyopsetta exilis (Jordan and Gilbert)
Microstomus pacificus (Lockington)
Parophrys vetulus Girard
Platichthys stellatus (Pallas)
Pleuronectes quadrituberculatus Pallas
Pleuronichthys coenosus Girard
Pleuronichthys decurrens Jordan and Gilbert
Psettichthys melanostictus Girard
Reinhardtius hippoglossoides (Walbaum)

Osmeridae:

Mallotus villosus socialis (Müller)

Scorpaenidae:

Sebastes alutus (Gilbert)
Sebastes sp.

Hexagrammidae:

Hexagrammos stelleri Tilesius
Hexagrammos decagrammus (Pallas)
Hexagrammos octogrammus (Pallas)
Hexagrammos lagocephalus (Pallas)
Pleurogrammus monopterygius (Pallas)
Ophiodon elongatus Girard

Crustacea:

Shrimp:	*Pandalus* sp. *Pandalopsis* sp.
King Crab:	*Paralithodes camtschatica* Tilesius
Tanner Crab:	*Chionoecetes* sp.
Dungeness Crab:	*Cancer magister* Dana

Table 2 (cont.).

Mollusca:

Butter clam:	*Saxidomus giganteus* (Deshayes)
Razor clam:	*Squila patula* (Dixon)
Cockle:	*Clinocardium nuttali* (Conrad)
Scallops:	*Pecten* sp.
Abalone:	*Haliotis kamtschatkana* Jonas

REFERENCES

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Buck, Eugene H. 1953. Alaska and the law of the sea. National patterns and trends of fishery development in the North Pacific. Arctic Environment Information and Data Center. University of Alaska, Anchorage, Alaska. 65 pp.

Wilimovsky, N. J. 1954. List of fishes of Alaska. Stanford Ichthyol. Bull. 4(5):279-294.

Wilimovsky, N. J. 1958. Provisional keys to the fishes of Alaska. U. S. Fish and Wildl. Serv., Fish. Res. Lab., Juneau, Alaska. 113 pp.

Wilimovsky, N. J. 1963. Inshore fish fauna of the Aleutian Archipelago. Proc. 14th Alaskan Sci. Conf.: 172-189.

Table 3. Alaskan Fishes with Pelagic Larvae

Notacanthidae--spiny eels:

Macdonaldia challengeri (Vaillant)
Polyacanthonotus altus (Gill and Townsend)
Polyacanthonotus challengeri (Vaillant)
Polyacanthonotus longus (Gill and Townsend)

Clupeidae--herrings:

Alosa sapidissima (Wilson)
Clupea harengus pallasii Valenciennes
Sardinops sagax caerulea (Jenyns)

Engraulidae--anchovies

Engraulis mordax Girard

Osmeridae--smelts:

Hypomesus olidus (Pallas)
Hypomesus pretiosus (Girard)
Mallotus villosus socialis (Müller)
Osmerus eperlanus (Linnaeus)
Spirinchus starksi (Fisk)
Spirinchus thaleichthys (Ayres)
Thaleichthys pacificus (Richardson)

Gadidae--codfishes:

Arctogadus borisovi Drjagin
Boreogadus saida (Lepechin)
Eleginus gracilis (Tilesius)
Gadus morhua macrocephalus Tilesius
Lota lota (Linnaeus)
Microgadus proximus (Girard)
Theragra chalcogramma (Pallas)

Merluciidae--hakes:

Merluccius productus (Ayres)

Ophidiidae--brotulas and cusk eels:

Brosmophycis marginata (Ayres)
Spectrunculus radcliffei Jordan and Thompson

Zoarcidae--eelpouts:

Bothrocara brunneum (Bean)
Bothrocara molle Bean
Bothrocara pusillum (Bean)

Table 3 (cont.).

Zoarcidae (cont.):

Embryx crotalina (Gilbert)
Gymnelis bilabrus Andriashev
Gymnelis hemifasciatus Andriashev
Gymnelis viridis (Fabricius)
Gymnelopsis stigma (Lay and Bennett)
Lycenchelys jordani (Evermann and Goldsborough)
Lycodalepis turneri (Bean)
Lycodapus extensus Gilbert
Lycodapus fierasfer Gilbert
Lycodapus grossidens Gilbert
Lycodapus mandibularis Gilbert
Lycodapus parviceps Gilbert
Lycodes agnostus Jensen
Lycodes breviceps Bean
Lycodes diapterus Gilbert
Lycodes digitatus Gill and Townsend
Lycodes mucosus Richardson
Lycodes palearis Gilbert
Lycodes polaris (Sabine)
Lycodes raridens Taranetz and Andriashev
Lycodes turneri Bean
Lycodes pacifica (Collett)
Nalbantichthys elongatus Schultz

Scomberesocidae--sauries:

Cololabis saira (Brevoort)

Melamphaeidae--Bigscales:

Melamphaes lugubris Gilbert
Poromitra crassiceps (Günther)
Scopeloberyx nycterinus (Gilbert)

Zeidae--dories:

Allocyttus verrucosus (Gilchrist)

Lampridae--opahs:

Lampris regius (Bonnaterre)

Trachipteridae--ribbonfishes:

Trachipterus altivelis Kner

Table 3 (cont.).

Aulorhynchidae--tubesnouts:

Aulorhynchus flavidus Gill

Scorpaenidae--rockfishes:

Sebastes aleutianus (Jordan and Evermann)
Sebastes alutus (Gilbert)
Sebastes auriculatus Girard
Sebastes babcocki (Thompson)
Sebastes brevispinis (Bean)
Sebastes borealis Barsukov
Sebastes caurinus Richardson
Sebastes ciliatus (Tilesius)
Sebastes crameri (Jordan)
Sebastes diploproa (Gilbert)
Sebastes elongatus Ayres
Sebastes emphaeus (Starks)
Sebastes entomelas (Jordan and Gilbert)
Sebastes flavidus Ayres
Sebastes helvomaculatus Ayres
Sebastes maliger (Jordan and Gilbert)
Sebastes melanops (Girard)
Sebastes melanostomus (Eigenmann and Eigenmann)
Sebastes nebulosus Ayres
Sebastes nigrocinctus Ayres
Sebastes paucispinus Ayres
Sebastes pinniger (Gill)
Sebastes polyspinis (Taranetz and Moiseev)
Sebastes proriger (Jordan and Gilbert)
Sebastes reedi (Westrheim and Tsuyuki)
Sebastes ruber Ayres
Sebastes ruberrimus (Cramer)
Sebastes saxicolo (Gilbert)
Sebastes variegatus Quast
Sebastes wilsoni (Gilbert)
Sebastes zacentrus (Gilbert)
Sebastolus alascanus Bean
Sebastolus altivelis Gilbert

Hexagrammidae--greenlings:

Hexagrammos decagrammus (Pallas)
Hexagrammos lagocephalus (Pallas)
Hexagrammos octogrammus (Pallas)
Hexagrammos stelleri Tilesius
Hexagrammos superciliosus (Pallas)
Ophiodon elongatus Girard
Pleurogrammus monopterygius (Pallas)

Table 3 (cont.).

Anaplopomatidae--sable fishes:

Anoplopoma fimbria (Pallas)
Erilepis zonifer (Lockington)

Carangidae--jacks, scads, and pompanos:

Trachurus symmetricus (Ayres)

Bramidae--pomfrets:

Brama japonica Hilgendorf

Sciaenidae--drums:

Cynoscion nobilis (Ayres)

Pentacerotidae--boarfishes:

Pseudopentaceros richardsoni (Smith)

Sphyraenidae--barracudas:

Sphyraena argentea Girard

Trichodontidae--sandfishes:

Arctoscopus japonicus (Steindachner)
Trichodon trichodon (Tilesius)

Anarhichadidae--wolffishes:

Anarhichas orientalis Pallas
Anarhichthys ocellatus Ayres

Stichaeidae--pricklebacks:

Acantholumpenus mackayi (Gilbert)
Alectridium aurantiacum Gilbert and Burke
Anisarchus medius Reinhardt
Anoplarchus insignis Gilbert and Burke
Anoplarchus purpurescens Gill
Bryostemma tarsodes Jordan and Snyder
Bryozoichthys lysimus (Jordan and Snyder)
Bryozoichthys marjoricus McPhail
Chirolophis nugator (Jordan and Williams)
Chirolophis polyactocephalus (Pallas)
Delolepis gigantea Kittlitz
Eumesogrammus praecisus (Krøyer)

Table 3 (cont.).

Stichaeidae (cont.):

Gymnoclinus cristulatus Gilbert and Burke
Leptoclinus maculatus (Fries)
Lumpenella longirostris (Evermann and Goldsborough)
Lumpenus fabricii (Valenciennes)
Lumpenus sagitta Wilimosky
Lyconectes aleutensis Gilbert
Phytichthys chirus (Jordan and Gilbert)
Poroclinus rothrocki Bean
Stichaeus punctatus (Fabricius)
Xiphister atropurpureus (Kittlitz)
Xiphister mucosus (Girard)

Ptilichthyidae--quillfishes:

Ptilichthys goodei Bean

Pholididae--gunnels:

Apodichthys flavidus Girard
Pholis dolichogaster (Pallas)
Pholis fasciata (Block and Schneider)
Pholis gilli Evermann and Goldsborough
Pholis laeta (Cope)
Pholis ornata (Girard)

Zaproridae--prowfishes:

Zaprora silenus Jordan

Icosteidae--ragfishes:

Icosteus aenigmaticus Lockington

Ammodytidae--sand lances:

Ammodytes hexapterus Pallas

Scombridae--mackerals and tunas:

Sarda chiliensis (Cuvier)
Scomber japonicus Houttuyn
Thunnus alalunga Bonnaterre)
Thunnus thynnus (Linnaeus)

Centrolophidae--rudder fishes:

Icichthys lockingtoni Jordan and Gilbert

Table 3 (cont.).

Bothidae--lefteye flounders:

Citharichthys sordidus (Girard)
Citharichthys stigmaeus Jordan and Gilbert

Pleuronectidae--righteye flounders:

Atheresthes evermanni Jordan and Starks
Embassichthys bathybius (Gilbert)
Eopsetta jordani (Lockington)
Glyptocephalus zachirus Lockington
Hippoglossoides elassodon Jordan and Gilbert
Hippoglossoides robustus Gill and Townsend
Hippoglossus stenolepis Schmidt
Isopsetta isolepis (Lockington)
Lepidopsetta bilineata (Ayres)
Limanda aspera (Pallas)
Limanda proboscidea Gilbert
Lyopsetta gracilis (Pallas)
Lyopsetta exilis (Jordan and Gilbert)
Microstomus pacificus (Lockington)
Parophrys vetulus Girard
Platichthys stellatus (Pallas)
Pleuronectes quadrituberculatus Pallas
Pleuronichthys coenosus Girard
Pleuronichthys decurrens Jordan and Gilbert
Psettichthys melanostictus Girard
Reinhardtius hippoglossoides (Walbaum)

Molidae--ocean sunfish:

Mola mola Linnaeus

Reference list of life history information on 15 species of commercial value

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Brock, V. E. 1940. Note on the young of the sablefish, *Anaplopoma fimbria*. Copeia 1940:263-270. (planktonic young)

Kobayashi, K. 1957. Larva and young of the sablefish, *Anapolopoma fimbria* (Pallas) from the sea near the Aleutian Islands. Bull. Jap. Soc. scient. Fish. 23(7, 8):376-382. (planktonic larvae and young, illustrations)

Thompson, W. F., Jr. 1941. A note on the spawning of the black cod (*Anaplopoma fimbria*). Copeia 1941:270. (unfertilized water hardened eggs and planktonic eggs)

Clupea harengus pallasii Valenciennes (herring)

Alderdice, D. F., and E. P. J. Velsen. 1971. Some effects of salinity and temperature on early development of Pacific herring (*Clupea pallasi*). J. Fish. Res. Board Can. 28:1545-1562. (salinity and temperature effects on development)

Barraclough, W. E. 1967. Occurrence of larval herring, *Clupea pallasii*, in the Strait of Georgia during July 1966. J. Fish. Res. Board Can. 24:2455-2460. (planktonic larvae)

Galking, L. A. 1962. Fertilization and development of eggs of the White Sea herring, *Clupea harengus pallasi*. [In Russian] Akad. Nauk SSSR, Dokl. 143:497-482. (not seen)

Hart, J. L., and A. L. Tester. 1934. Quantitative studies on herring spawning. Trans. Am. Fish. Soc. 64:307-312. (demersal eggs, spawning, survival, illustrations)

Katz, M., and D. W. Erickson. 1950. The fecundity of some herring from Seal Rock, Washington. Copeia 1950:176-181. (fecundity)

Stevenson, J. C. 1962. Distribution and survival of herring larvae (*Clupea pallasii* Valenciennes) in British Columbia waters. J. Fish. Res. Board Can. 19:735-810. (planktonic larvae)

Taylor, F. H. C. 1964. Life history and present status of British Columbia herring stocks. Fish. Res. Board Can. Bull. 143. 81 pp. (general life history, spawning, larval life, juvenile stages, illustrations)

Cololabis saira (Brevoort) (Saury)

Ahlstrom, E. H., and H. D. Casey. 1956. Saury distribution and abundance, Pacific Coast, 1950-55. U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish 190. 69 pp. (distribution)

Hatanaka, M. 1943. Biological studies on the population of the saury, *Cololabis saira* (Brevoort). I. Reproduction and growth. Tohoku J. agric. Res. 6:227-269. (planktonic eggs and larval distribution, growth)

Hatanaka, M., T. Watanabe, K. Sekino, M. Kosaka, and K. Kimura. *Cololabis saira* 1953. Studies on the reproduction of the saury, *Cololabis saira* (Brevoort), in adjacent water to Oki Islands. I. Spawning of the northward migrating saury in the spring of 1962. [In Japanese, English abstract] Bull. Jap. Soc. scient. Fish. 31:799-803. (demersal eggs, planktonic larvae, distribution)

Kitahara, T. 1894. On the eggs of Scomberesocidae. (Sanma-zoku no Tamago nitsuite). [In Japanese] Zool. Mag., Tokyo. (Dobutsugaku Zasshi) 6:435-437. (demersal eggs)

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Engraulis mordax Girard (northern anchovy)

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Hippoglossus stenolepis (Schmidt) (Pacific halibut)

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Sardinops sagax caerulea (Girard) (Pacific sardine)

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ANNUAL REPORT

LITTORAL SURVEY OF THE BEAUFORT SEA

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I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

The shallow edge of the Beaufort Sea provides habitats for populations of epibenthic crustaceans and previously unreported infaunal worms and is important during the Summers in the feeding of migratory shorebirds and geese. Progress is being made toward characterization of habitats and relationships between species in a region that is considered particularly sensitive to perturbation that might result from trapping floating materials along the shoreline.

II. Introduction

A. General Nature and Scope of the Study: This study is a survey of the edge of the Beaufort Sea designed to characterize habitats and ecological relationships of the Alaskan Arctic Ocean coastline between the U.S.-Canadian border (Demarcation Point) and Point Barrow sufficient to provide an immediate estimate of risks incurred in OCS oil and gas exploration and development and to furnish a base for planning further research.

B. Specific objectives: The specific objectives of the research are:

1. To characterize by biota and substrate type the habitats of the Beaufort Sea littoral zone.
2. To provide quantitative estimates of populations of the principal species of the Beaufort Sea littoral zone.
3. To describe trophic and other, ecological relationships that obtain within the study area.

C. Relevance to problems of petroleum development: The shoreline or sea-land interface is a region in which flotsam comes to rest and is, thus, unusually subject to perturbations that may result from blowout or various other, undesirable events that could accompany oil and gas exploration and development on the continental shelf. If, at the same time, the edge of the sea if of particular importance as a feeding zone or nursery area for marine animals or for birds or other terrestrial animals, disrupting influences that are trapped at the shoreline may affect ecosystems of both the land and the sea. When species to which the shoreline is important are migratory, these effects may be felt many miles away from the locale of the actual event. All of these considerations are pertinent to the shore of the Beaufort Sea, yet remarkably little information on populations that inhabit the very shallow water or the low beach has been available.

III. Current State of Knowledge

The benthic biota of the Beaufort Sea was known principally through the work of the MacGinities, Crane and Cooney, Carey *et al.*, and others. Almost all collections, however, have been made from depths in excess of two meters. Crane and Cooney state that "The shallow nearshore environment would seem unfit for any kind of biota; indeed the beaches surrounding the Colville estuarine complex bear out this contention as they are seemingly barren of macroscopic life....It is apparent that in the very shallow parts of the lagoon, ice scouring prevents organisms from establishing populations. No infaunal species were found in either Simpson Lagoon or Harrison Bay in the grab samples taken at depths of less than two meters. Only mobile epifaunal species occurred at these shallow depths."

IV. Study Area

Field teams were in the Alaskan Arctic from July 10 through September 12, 1975. An initial characterization of the coast based on observations made during flights from Point Barrow to the Canadian border was completed on July 21. Beginning on August 1 and ending on September 7, when new ice formed alongshore made continuation impossible, working teams established stations and sampled along selected beach transects in locations given in Table 1.

V. Sources, methods and rationale of data collected

At each station the following samples and measurements were made:

1. Beach profile (elevation and distance) from the clearly terrestrial vegetation on the landward side to a depth of two meters (or, if a boat was not available, the greatest depth possible by wading) on the seaward side.

2. Density, percent cover, and frequency of occurrence of beach vegetation; biomass samples of beach vegetation. (In some areas this vegetation is an important food of geese. In all it is subject to inundation during storms.)

3. Replicate (6) infaunal samples of benthic invertebrates taken at depths of 0 M (shoreline), 0.5 M, 1.0 M, 1.5 M, and 2.0 M as possible using a hand operated, pole-mounted Eckman grab. (All material retained on a 0.516 mm screen was retained. Larger stones were discarded in the field, and the rest of the sample preserved for later sorting and analysis.)

4. Replicate samples made by towing a sea-sled type, naturalist's dredge equipped with a 1.050 mm mesh net for 100 M at depths of 0.5 M and, if possible, 1.5 M.

5. Replicate seine samples made by operating a 10 M long seine of 10 mm stretched mesh webbing (openings 5 mm x 5 mm) for 100 M along beaches at a depth of 0.5 M.

6. Samples made with baited amphipod traps (similar to minnow traps); collections made with dip nets; other, various collecting methods; general observations.

Table 1: Sampling stations and number of samples taken in the Beaufort Sea Littoral Zone, August and September, 1975. Samples are mainly biological materials but include some taken for sediment analysis.

Station	West Long.	North Lat.	Type	No. of Samples Taken
B06	142°05'	69°50'	river delta	57
B18	142°18'	69°53'	lagoon shore (physical data only)	0
B21	142°21'	69°55'	barrier island	114
B22	142°39'	69°55'	barrier island	1
C37	143°37'	70°08'	lagoon beach and marsh	65
C38	143°38'	70°06'	lagoon beach and marsh	65
C39	143°39'	70°08'	sea beach	27
C40	143°40'	70°06'	lagoon beach	47
C41	143°41'	70°05'	mud flat	68
D00	143°59'	70°05'	barrier island	46
H08	148°08'	70°20'	river delta	13
H12	148°12'	70°20'	river delta	20
H19	148°19'	70°21'	bay	9
H20	148°19'	70°21'	bay	9
H22	148°32'	70°20'	bay	9
H28	148°28'	70°18'	marsh	13
H32	148°38'	70°22'	sea beach	20
H39	148°40'	70°24'	mud flat	21
H40	148°40'	70°24'	lagoon beach and marsh	19
I30	149°30'	70°33'	barrier island	16
I31	149°31'	70°33'	barrier island	17
I50	149°50'	70°30'	lagoon beach	14
I58	149°58'	70°28'	lagoon beach	17
J22	150°22'	70°26'	river delta	24
J24	150°24'	70°29'	delta	6
M10	153°10'	70°55'	sea beach	17
M11	153°11'	70°55'	mud flat	15
M14	153°14'	70°54'	lagoon beach	10
N42	154°42'	71°03'	sea beach	15
N43	154°43'	71°03'	sea beach	18
N44	154°44'	71°03'	lagoon	15
O39	155°39'	71°14'	barrier island	18
O40	155°40'	71°14'	barrier island	21
O42	155°42'	71°14'	barrier island	20
P30	156°30'	71°22'	lagoon beach	12
P33	156°33'	71°18'	mud flat	14
P34	156°34'	71°19'	lagoon beach	8
Other	various			43

7. Routine hydrographic and meteorological observations (salinity, water temperature, pH, dissolved oxygen, air temperature, wind speed and direction precipitation, and cloud cover).

   Data from sample types 1 and 7 have been reported to NODC. Data from sample types 2 - 6 currently are being analyzed. The date of acquisition of these data is defined in the contract as May 30, 1976.

VII. Results

Our samples so far sorted are from the Colville River delta, Oliktok Point, Simpson Lagoon, Pingok Island, Point McIntyre, Prudhoe Bay, the Sagavanirktok River delta, and Barter Island and vicinity. Prior to the completion of sorting and the accumulation of complete data, statistical inferences are, of course, meaningless, but most of our grab samples, almost all of which are from water of less than two meters deep, include infaunal species (polychaetes, oligochaetes, nematodes, harpacticoid copepods), as well as mobile, epifaunal forms (mainly mysids and amphipods). In general, the density of polychaete populations is greater in samples from depths of two meters or more (two such samples have 7,704 and 5,410 worms/M^2 and all so far sorted include at least several worms), but sometimes large numbers of individuals are found at lesser depths: 290 to 1,558/M^2 at a depth of 1.5 M; 952 to 1,255/M^2 at 1 M; and 1,428 to 5,107/M^2 at 0.5 M depth. These data are selected to demonstrate a point; that our grab samples from less than two meters' depth may sometimes contain large numbers of infaunal animals. The cited data do not establish norms. The indication currently is that distribution of infauna in the very shallow water is uneven and may be related to the presence of peat (disintegrating tundra vegetation) in the substrate.

We have found an unexpected number of oligochaete worms in our shallow water grab samples. One sample of 10,604 worms/M^2 from a mud flat is the current high, but other samples of several hundred worms/M^2 are common in depths of water of 0.5 M or less. We have found fewer oligochaetes in samples taken from water deeper than 0.5 M.

The principal epifaunal animals of the shallow Beaufort Sea are crustaceans,[2] and our data so far are in agreement with this finding of other investigators. Mysids and amphipods are abundant in our epitaunal samples, but the isopod, *Saduria entomon* (*Mesidotea entomon*), curiously is not.

The principal infaunal animals of the shallow Beaufort Sea are mollusks and polychaetes.[2] Our samples, taken largely from very shallow water contain only a few mollusks.

Our observation of heavy utilization of the edge of the Beaufort Sea by feeding shorebirds (especially red phalaropes) and of the low marshes by geese, although neither new nor original, provides evidence of the importance of this zone to organisms other than thos directly sampled.

VIII. Conclusions

1. The very shallow (less than 2 M) sea bottom along the edge of the Beaufort Sea contains infaunal organisms not reported in literature.

2. The edge of the Beaufort Sea is important to the feeding of migratory shorebirds and geese.

References Cited

1. MacGinitie, G. and N. MacGinitie, 1955. Smithsonian Misc. Coll., 128; MacGinitie, N., 1959. Proc. U.S. Nat. Mus., 109. Pettibone, M., 1954. Proc. U. S. Nat. Mus., 103; Menzies, R. and J. Mohr, 1963. Crustaceana, 3; Given, R., 1965. Arctic, 18; Hulseman, K., 1962. The Veliger, 5; Hulseman, K. and J. Soule, 1962. Arctic, 15; Crane, J. and R. T. Cooney, 1974. In Alexander, V., *et al.*, Univ. of Alaska IMS Report 74-1; Carey, A. G., *et al.*, 1974. In Reed and Sater, *The Coast and Shelf of the Beaufort Sea*, The Arctic Inst., N. A., Arlington, Va.; Mueller, G. J., personal communications.

2. Crane, J., and R. T. Cooney, *l. c.* and Carey, A. G., *et al.*, *l.c.*

IX. Needs for Further Study

1. Our 1975 observations should be verified in 1976.

2. More samples of the benthos of the lagoons (taken at depths in excess of two meters) is needed.

3. Samples of benthos from the region between the shoreline and depths of 10 to 20 meters are important and are planned for 1976. This sampling program also will include locations at which shore-based sampling in 1975 was not feasible.

4. The present sampling protocol should be enlarged to include zooplankton.

X. Summary of the 4th Quarter

A. Ship or Laboratory Activities:

1. Ship or field trip schedule: None.

2. Scientific party:

   a. Principal Investigator:

      A. C. Broad -- not on salary to contract.

   b. Programmer:

      Greg Petrie -- January 1 to March 31, 8 hrs/week.

c. Lab Assistants:

Helmut Koch -- January 1 to March 31, 20 hrs/week
Mark Bertness -- January 1 to March 31, 25 hrs/week

d. Work-Study students

David Cormany)
Randall Beaver) -- Total cost to contract: $23.

3. Methods:

a. Laboratory analysis (sorting and identification) of samples collected last summer continued.

b. Work was begun on integrating our data management system and sampling procedures with those of Zimmerman (R. U. 79).

4. Sampling Localities -- not applicable.

5. Data collected or analyzed:

a. No data collected.

b. 168 samples analyzed.

c. No miles of trackline run.

Contract 03-5-022-81
Research Unit 356
January 1 to March 31, 1976
5 pages

QUARTERLY REPORT

LITTORAL SURVEY OF THE BEAUFORT SEA

Principal Investigator, A. C. Broad

Western Washington State College

March 29, 1976

I. TASK OBJECTIVES: During the quarter work continued on our work statement Task 5, Data analysis and identification of collected material. Hydrographic, beach profile, and other, physical data were submitted to NODC through the Project Data Manager on computer tape on March 4. By agreement with PDM, the data format previously approved and used in this submission will be replaced by the format of Zimmerman (R. U. 79), and these data will be resubmitted in the new format. On January 30, a revised work statement and budget, entitled "Reconnaisance characterization of the littoral biota, Beaufort and Chukchi Seas," was submitted to the Director, OCSEAP. The Principal Investigator attended an interdisciplinary workshop on Alaska's littoral zone in Seattle on January 13 and 14.

II. FIELD OR LABORATORY ACTIVITIES:

A. Ship or field trip schedule: None.

B. Scientific party:

1. Principal Investigator:

A. C. Broad -- not on salary to contract.

2. Programmer:

Greg Petrie -- January 1, to March 31, 8 hrs/week.

3. Lab assistants:

Helmut Koch -- January 1 to March 31, 20 hrs/week.

Mark Bertness -- January 1 to March 31, 25 hrs/week

4. Work-study students

David Cormany)
) -- total cost to contract: $23.
Randall Beaver)

C. Methods:

1. Laboratory analysis (sorting and identification) of samples collected last Summer continued.
2. Work was begun on integrating our data management system and sampling procedures with those of Zimmerman (R. U. 79).

D. Sampling localities -- not applicable.

E. Data collected or analyzed:

1. No data collected.
2. 168 samples analyzed.
3. No miles of trackline run.

III. RESULTS: Analysis of samples taken during the summer of 1975 was begun when they were received in Bellingham on October 10, 1975. The laboratory analysis includes sorting biological specimens from the substrate material retained on sieves or in nets (or completing sorting begun in the field), identification or tentative identification of specimens, counts by species, wet weight determinations, and preservation for storage. The number of samples analyzed by December 31, 1975, was 129 (of a total of 943), but, on the basis of bulk, this was estimated to be between 20 and 30 percent completion of our task 5. During the current quarter, 168 samples have been analyzed. On the basis of the number of samples alone, we have completed 32 percent of the total, but, on the basis of bulk of material to be sorted, we are around 40 percent through with task 5. We are slightly behind where we had hoped to be on this task at this time, and extra help will be required. In the contract, the date of acquisition of the data derived from these samples is May 30, 1976.

IV. PRELIMINARY INTERPRETATION OF RESULTS: The benthic biota of the Beaufort Sea was known principally through the work of the MacGinities, Crane and Cooney, Carey et al, and others.[1] Almost all collections, however, have been made from depths in excess of two meters. Crane and Cooney state that "The shallow nearshore environment would seem unfit for any kind of biota; indeed the beaches surrounding the Colville estuarine complex bear out this contention as they are seemingly barren of macroscopic life....It is apparent that in the very shallow parts of the lagoon, ice scouring prevents organisms from establishing populations. No infaunal species were found in either Simpson Lagoon or Harrison Bay in the grab samples taken at depths of less than two meters. Only mobile epifaunal species occurred at these shallow depths."

Our samples so far sorted are from the Colville River delta, Oliktok Point, Simpson Lagoon, Pingok Island, Point McIntyre, Prudhoe Bay, the Sagavanirktok River delta, and Barter Island and vicinity. Prior to the completion of sorting and the accumulation of complete data, statistical inferences are, of course, meaningless, but most of our grab samples, almost all of which are from water of less than two meters deep, include infaunal species (polychaetes, oligochaetes, nematodes, harpacticoid copepods) as well as mobile, epifaunal forms (mainly mysids and amphipods). In general, the density of polychaete populations is greater in samples from depths of two meters or more (two such samples have 7,704 and 5,410 worms/M^2 and all so far sorted include at least several worms), but sometimes large numbers of individuals are found at lesser depths: 290 to 1,558/M^2 at a depth of 1.5 M; 952 to 1,255/M^2 at 1 M; and 1,428 to 5,107/M^2 at 0.5 M depth. These data, I must stress are selected to demonstrate a point; that our grab samples from less than two meters' depth may sometimes contain large numbers of infaunal animals. These cited data do not establish norms. The indication currently is that distribution of infauna in the very shallow water is uneven and may be related to the presence of peat (disintegrating tundra vegetation) in the substrate.

We have found an unexpected number of oligochaete worms in our shallow water grab samples. One sample of 10,604 worms/M^2 from a mud flat is the current high, but other samples of several hundred worms/M^2 are common in depths of water of 0.5 M or less. We have found fewer oligochaetes in samples taken from water deeper than 0.5 M.

The principal epifaunal animals of the shallow Beaufort Sea are crustaceans,[2] and our data so far are in agreement with this finding of other investigators. Mysids and amphipods are abundant in our epifaunal samples, but the isopod, Saduria entomon (Mesidotea entomon), curiously is not.

The principal infaunal animals of the shallow Beaufort Sea are mollusks and polychaetes.[2] Our samples, taken largely from very shallow water contain only a few mollusks.

References Cited

1. MacGinitie, G. and N. MacGinitie, 1955. Smithsonian Misc. Coll., 128; MacGinitie, N., 1959. Proc. U.S. Nat. Mus., 109. Pettibone, M., 1954. Proc. U. S. Nat. Mus., 103; Menzies, R. and J. Mohr, 1963. Crustaceana, 3; Given, R., 1965. Arctic, 18; Hulseman, K., 1962. The Veliger, 5; Hulseman, K. and J. Soule, 1962. Arctic, 15; Crane, J. and R. T. Cooney, 1974. In Alexander, V., et al., Univ. of Alaska IMS Report

74-1; Carey, A. G., *et al.*, 1974. In Reed and Sater, *The Coast and Shelf of the Beaufort Sea*, The Arctic Inst. N.A., Arlington, Va.; Mueller, G. J., personal communications.

2. Crane, J. and R. T. Cooney, *l.c.* and Carey, A. G., *et al.*, *l.c.*

V. PROBLEMS ENCOUNTERED: The principal problem encountered this quarter has been the time required to sort through samples that contain large amounts of peat. This, clearly, was unanticipated in planning prior to the first field season. The immediate (and perhaps only) solution will be to employ more sorters, but we also hope, during our second field season, to do a better job of sorting samples in the Arctic.

Note also problems mentioned in the last quarterly report and those inherent in working toward a common data reporting and management format with Zimmerman.

VI. ESTIMATE OF FUNDS EXPENDED:

Budget category	Amount budgeted	Amount spent	Amount remaining
Salary, Principal	$14,065	$ 4,617	$ 9,448
Salary, Associates	21,463	8,290	13,173
Salary, other	31,000	17,748	13,252
Student work-study	--	29	- 29
Fringe	8,875	3,447[1]	5,428[1]
Travel	9,000	6,249[2]	2,751
Card punch	600	--	600
Supply	--	605	- 605
Overhead	8,500	4,500[1]	4,000[1]
Totals	$93,503	$45,485	$48,018

[1] These figures are estimates of current obligations and unobligated funds. The College accounting currently shows more in the "amount remaining" column.

[2] Includes some freight charges not originally anticipated.

ANNUAL REPORT

Contract #: 03-5-022-67-TA2 #4
Research Unit #: 359
Reporting Period: 1 Apr 1975 - 30 Mar 1976
Number of Pages: 29

Beaufort Sea Plankton Studies

T. Saunders English
Rita A. Horner

Department of Oceanography
University of Washington
Seattle, Washington 98195

1 April 1976

REF: A76-34

I. Task Objectives

The two tasks of primary emphasis are A-23 and A-24: to determine seasonal density distribution and environmental requirements of principal species of phytoplankton, zooplankton, and ichthyoplankton, and to determine seasonal indices of phytoplankton production, including the sea ice flora. The task of secondary emphasis will be to summarize the existing literature, unpublished data, and archived samples.

II. Field or laboratory Activities

A. Ship or Field Trip Schedule

1. Barrow to Prudhoe Bay; 1 Aug - 2 Oct 1975
   USGS Beaver airplane on floats; NARL Boston whaler

B. Scientific Party

Rita Horner, Associate Investigator, 1-15 Aug
Mike Macaulay, Graduate Student, 4-18 Aug
Rich McKinney, Research Aide, 4 Aug - 3 Sep
Debbie White, Assistant Oceanographer, 1 Aug - 2 Oct

All personnel are associated with the Department of Oceanography, University of Washington, Seattle, Washington 98195.

C. Methods

1. Field Sampling

Water samples for phytoplankton standing stock, primary productivity, chlorophyll a, and nutrients were collected with a modified van Dorn (Scott-Richards) bottle. These samples were returned to the shore laboratory in 4-1 polyethylene bottles for processing.

Acoustic measurements were made with a Ross 200A Fineline echosounder.

2. Laboratory Methods

Phytoplankton standing stock samples were preserved with 5-10 ml of 4% formalin buffered with sodium acetate. Cell counts and species identifications are being made using a Zeiss phase-contrast inverted microscope following the method of Utermöhl (1931).

One or two liters of each water sample were filtered through 0.45 μm Millipore filters and the filters frozen. In Seattle, the filters were ground, the chlorophyll extracted in 90% acetone, and the chlorophyll a determined using a Turner fluorometer (Strickland and Parsons 1968).

Primary productivity experiments were run following the method of Steeman Nielsen (1952). Filters containing the radioactive phytoplankton were returned to Seattle where they were analyzed using a Packard Tri-Carb Liquid Scintillation Spectrometer with Aquasol (New England Nuclear) as the scintillation cocktail.

Millipore-filtered seawater was frozen in 125 ml polyethylene bottles and returned to Seattle for nutrient analyses. Autoanalyzer methods (Strickland and Parsons 1968) were used to determine nutrient concentrations.

Filtered seawater was also used to determine salinity. These samples, in 250 ml polyethylene bottles, were taken to NARL, Barrow, and analyzed using a Beckman RS 7B induction salinometer.

D. Sample localities are given in Figs. 1 and 2.

E. Data Collected and Analyzed

1. Data Collected

Type	Number
Phytoplankton standing stock samples	86
Chlorophyll a	84
Primary productivity	168
Nutrients (PO_4, Si, NO_3, NO_2, NH_4)	61
Temperature	87
Salinity	84
Ross echosounder traces	9

2. Data Analyzed

Type	Number
Phytoplankton standing stock	43
Chlorophyll a	84
Primary productivity	100
Nutrients (PO_4, Si, NO_3, NO_2, NH_4)	61
Temperature	87
Salinity	84
Ross traces	0

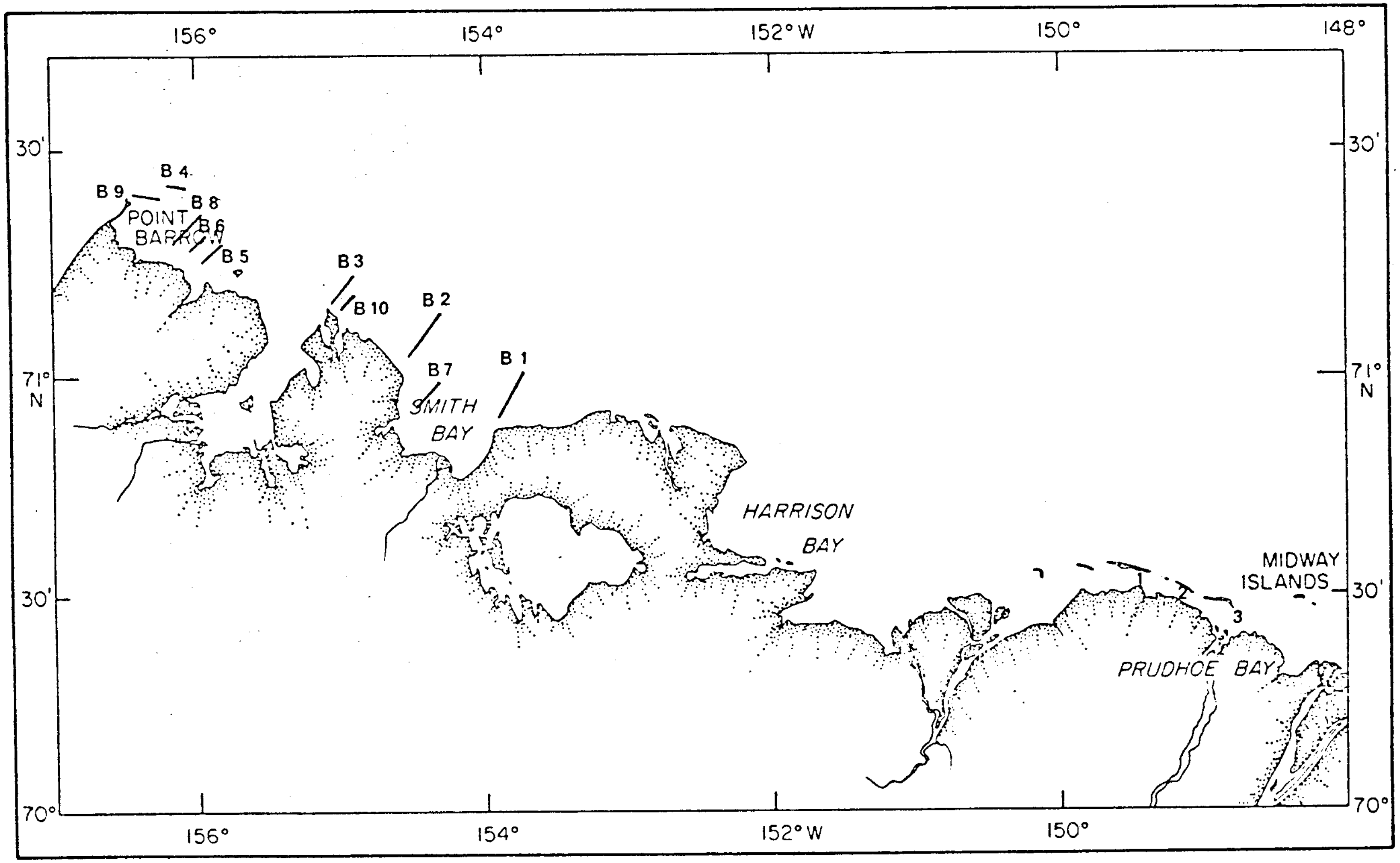

Fig. 1. Transects, August 1975, Prudhoe Bay stations 1-3

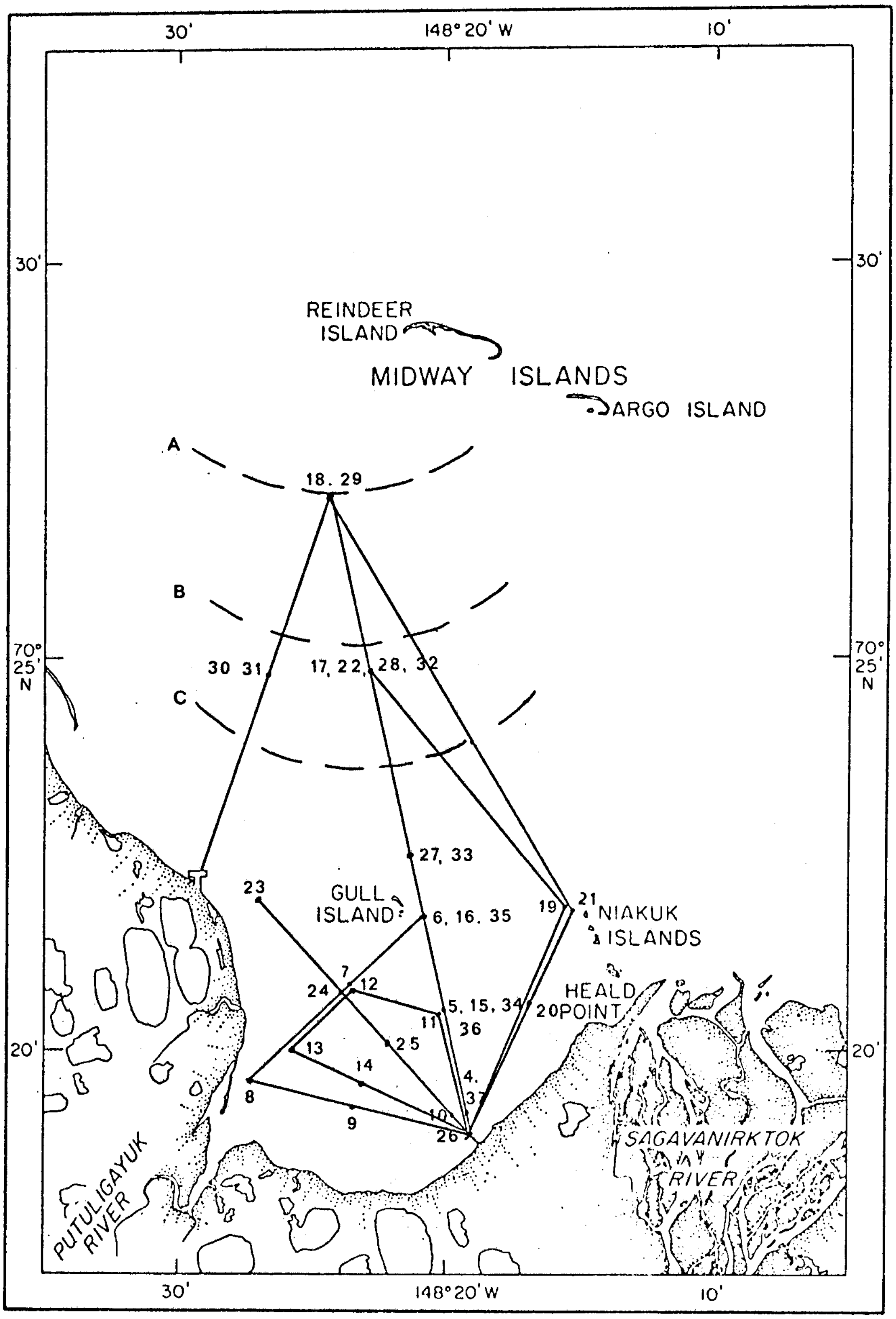

Fig. 2. Station locations, Prudhoe Bay, September 1975. A is ice edge 10 Sep; B is ice edge 11 Sep; C is ice edge 14 Sep.

III. Results

Inside Prudhoe Bay, small species of the diatom genus *Chaetoceros*, especially *Ch. furcellatus* Bailey, were dominant. Pennate diatoms, mostly unidentified, were also present, but usually not in large numbers. At station 33, slightly north of Gull Island, at 15 m, small flagellates were abundant along with *Chaetoceros* spp. Small flagellates were also abundant at the surface at station 30. Ciliates were abundant at stations 6, 14, 15, 16, 23, 24, and 31.

Chlorophyll a concentrations were generally below 1 mg/m^3, except for near-bottom samples at stations 24, 27, and 30 where the concentrations were 2-3 mg/m^3. At stations 30-15, pennate diatoms were most abundant, but at station 24-7, *Chaetoceros furcellatus* was most abundant.

Temperature ranged from -1.0 - +3.0° C with the lowest and highest temperatures at the surface. Salinity ranged from 11.648 - 24.959 °/oo with higher salinities generally being in deeper water.

Phosphate concentrations ranged from 0.03 - 1.31 μg at/l, generally being below 0.60 μg at/l; silicate concentrations ranged from 4.72 - 20.95 μg at/l. The lowest concentration was at station 10 and the highest at station 4, both located inside the bay near the east dock. The samples were collected one day apart and few diatoms were present at either station. Nitrate concentrations ranged from 0.03 - 1.19 μg at/l; nitrite ranged from 0.00 - 0.57 μg at/l; ammonia ranged from 0.60 - 2.57 μg at/l.

Primary productivity values have not been calculated.

Summary station sheets are in Appendix 1.

IV. Preliminary Interpretation of Results

Chaetoceros furcellatus is usually considered to be a spring diatom. It occurs with spores in the Barrow area at the edge of the ice. The *Thalassiosira* species present are also spring forms. Many of the pennate diatoms, while not identified to species, appear to be diatoms that usually live in sea ice in spring. It appears that the phytoplankton community sampled in September 1975 consisted primarily of species characteristic of the spring bloom that usually occurs about the time the ice breaks up. This is consistent with ice conditions in the Prudhoe Bay area in 1975.

Average nutrient concentrations were higher than those reported by Horner et al. (1974) for August 1972. The average nitrate + nitrite concentration was about twice that of 1972 while ammonia was only slightly higher. This could also indicate that the phytoplankton bloom was taking place during early September.

I. Task Objectives

The basic objective of the biological oceanographic program at AIDJEX main camp, Big Bear, was to collect information on standing stocks and seasonal changes in the environment under pack ice, including primary production and the response of herbivores to production. This information, with data from past biological investigations at Fletcher's Ice Island, T-3, will be used as the basis for a descriptive model characterizing the planktonic ecosystem and its relationship to the overlying ice cover.

II. Field Activities

A. The field investigation was conducted from 1 June to 30 September, 1975, at the AIDJEX main camp, Big Bear.

B. Scientific Party

Clarence Pautzke, Party Chief, 30 May - 2 Oct
Jerry Hornoff, Marine Technician, 30 May - 18 Sep
Kevin Wyman, Marine Technician, 30 May - 24 Aug
Maureen McCrea, Graduate Student Helper, 18 Sep - 2 Oct

All personnel are associated with the Department of Oceanography, University of Washington, Seattle, Washington 98195.

C. Methods

1. Field Sampling

Zooplankton samples were taken with overlapping depth-to-surface net hauls using a non-closing conical 1-m diameter ring net with 73μm mesh. Samples were preserved in 4% buffered formalin or frozen for later analysis in Seattle.

Water samples for phytoplankton standing stock, primary productivity, chlorophyll _a_, and nutrients were collected with a modified von Dorn (Scott-Richards) bottle.

2. Laboratory Methods

Primary productivity was measured following the method in Strickland and Parsons (1968).

Chlorophyll _a_ concentrations were measured by filtering four liters of seawater onto Type A, Gelman glass fiber filters. The filters were frozen and taken to Seattle, where they were ground, the chlorophyll extracted with 90% acetone, and the extract analyzed with a Turner fluorometer (Strickland and Parsons 1968).

Phytoplankton standing stock samples were preserved with 8% formalin buffered with sodium acetate and borate to give a final concentration of 2% formalin.

Nitrate analysis was done according to Strickland and Parsons (1968).

Water samples to be analyzed for particulate carbon were filtered onto Reeve Angel 934 AH filters and frozen.

Incoming solar radiation was recorded daily at the ice surface using a LI-COR-185 quantum meter.

D. The drift track of the AIDJEX main camp is shown in Fig. 3.

E. Data Collected or Analyzed

1. Data Collected

Type	Number
Net zooplankton	994
Phytoplankton standing stock	209
Chlorophyll a	1096
Primary productivity	2941
Nitrates	272
Particulate carbon	44

2. Data Analyzed

Type	Number	Display
Net zooplankton	12	Table 6; Figs. 6-9
Phytoplankton standing stock	0	
Chlorophyll a	825	Tables 2-5; Figs 4,5
Primary productivity	1394	
Nitrates	272	Table 1
Particulate carbon	0	

3. Miles of Trackline

The AIDJEX main camp drifted approximately 870 km from 1 June - 30 September 1975.

III. Results

A. Nitrates: No nitrate replicates were made; at the 1 μg at/l level, the correct value is ± 0.05 μg at/l of the measured value (Strickland and Parsons 1968). There was no measurable nitrate in the upper 40 m throughout the summer (Table 1). Measurable nitrate remained absent in the upper 50 m until near the end of August when small amounts (< 1 μg at/l) appeared at depths less than 50 m. By

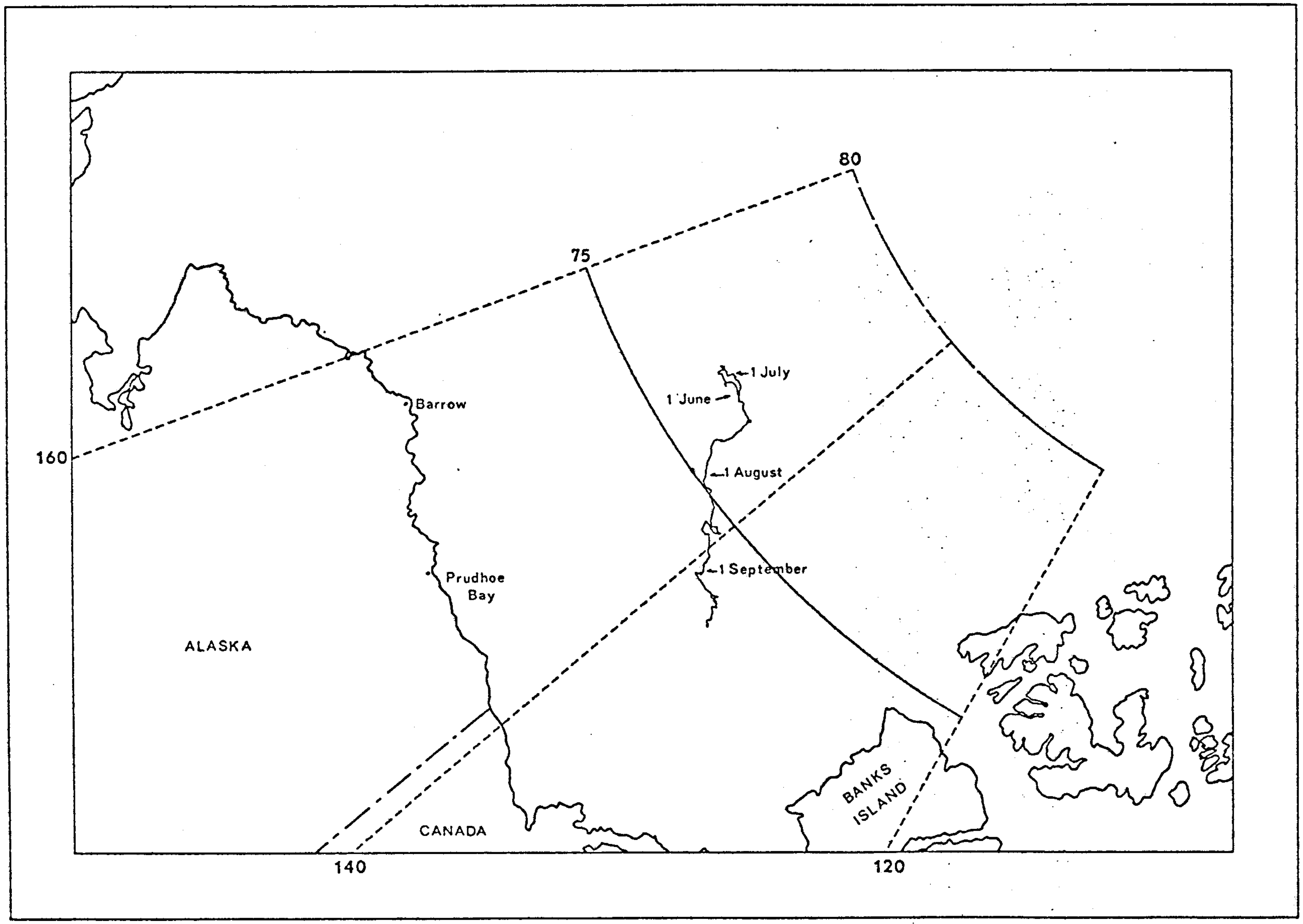

Fig. 3. Drift track of AIDJEX main camp, Big Bear, 1 June to 30 September 1975

Table 1. Nitrate Concentrations (µg A/l) Measured at AIDJEX Main Camp Big Bear during Summer 1975

Date (1975)

Depth (m)	June					July						August						September			
	11	17	20	23	29	5	7	11	17	23	29	4	10	16	22	28	30	6	12	22	27
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42																	0.0	0.0	0.0	0.1	0.1
44																	0.0	0.0	0.0	0.0	0.2
46		0.0							0.0				0.0				0.0	0.0	0.4	0.4	0.7
48									0.0				0.0				0.2	0.0	0.4	0.4	1.1
50		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.8	1.0	1.9
52								0.0	0.0				0.3				1.2	0.2	1.3	1.4	3.0
54								0.1	0.2				0.5				1.9	0.3	1.8	2.1	3.3
56						0.0	0.1	0.2	0.4	0.0	0.0	0.0	0.8				2.6	0.9	1.9	2.4	3.6
58									0.4				1.2				2.4	1.3	2.1	2.1	4.3
60		1.3	0.2	0.6	1.3	0.0	0.3	0.4	1.1	0.2	0.1	2.4	0.9	0.5	1.2	1.7	3.0	1.9	2.1	3.4	5.6
62									0.9				1.9				3.4	3.7	3.4	5.0	5.4
64						0.3	0.6	2.4	1.4				2.4				3.7	5.8	2.8	4.4	6.4
70		6.3			3.5	2.8	2.6	4.7	4.5	2.4	4.0	6.6	3.6			3.0	5.8	6.5			
80					7.4		5.8	8.4	6.6				7.0				10.1	10.2	10.2	9.6	10.8
100					11.0				10.5				12.2				13.5	14.8	14.3		13.3

late September there was measurable nitrate at 42 m. At the bottom of the mixed layer (55-65 m), concentrations were low but increased slowly with depth. At 100 m, nitrate concentrations were over 10.0 μg at/l.

B. Chlorophyll *a*: The 825 samples that were analyzed (Tables 2-5) comprised the depth series to 100 m. Estimates of precision will be made after the remaining 271 samples are analyzed.

In the upper 40-45 m (Fig. 4 a-k) peak chlorophyll *a* concentrations of 0.09 - 0.10 mg/m^3 were found in early June. A secondary small increase occurred in mid-to-late September. By late June, concentrations had decreased in the upper 40 m to less than 0.03 mg/m^3 and remained low through August.

The major summer increase in chlorophyll *a* occurred at 58-64 m (Fig. 4 l, 5) during July and August. Concentrations above 0.25 mg/m^3 were recorded at 60 m on 23 July, and at 62 m on 1 August. Concentrations at these depths in general decreased after mid-August on. At 80 m (Tables 2-5), concentrations increased in July to 0.07 mg/m^3 and 0.08 mg/m^3 in early August, thereafter declining. Concentrations at 100 m remained at or below 0.05 mg/m^3 throughout the summer.

Chlorophyll *a* integrated to 100 m (Fig. 4 m) dropped to a minimum in late June and early July, the period between increased concentrations in the upper 40 m and the increased concentrations at 58-64 m. Except for this period, the integrated chlorophyll *a* remained between 5.0 and 7.0 mg/m^2 throughout the summer, declining in late September.

C. Primary Productivity: Results will be presented in the next quarterly report after the analysis of the radiocarbon standards and the prevailing light levels during incubation have been calculated.

D. Zooplankton: Three of the larger, more abundant copepod species *Calanus hyperboreus*, *C. glacialis*, and *Euchaeta glacialis* were counted and identified to developmental stage for 12 samples. Total numbers (Table 6 and Figs. 6-9) have not been adjusted to mouth opening or filtration efficiency (i.e., 100% filtration is assumed).

C. hyperboreus females, stages V and IV (Fig. 6), show maximum abundance in July. Stages III and II appear in late August and in September. No stage I juveniles were found. The total of individuals exhibits a maximum in mid-September.

C. glacialis females and stage V (Fig. 7) are abundant from 15 June through mid-August. Few stage IV's were found throughout the summer. Stage I's appeared during the second week in July and stage II's appeared about mid-August. Stage III's appeared only at the end of September. Total individuals had a mid-August maximum.

TABLE 2. CHLOROPHYLL A (MG/M^3) MEASURED AT AIDJEX MAIN CAMP.

CHLOROPHYLL A (MG/M^3) FOR JUNE 1975

DEPTH (M)	2	5	8	11	14	17	20	23	26	29 DAY
3	.09	.10	.09	.08	.05	.07	.03	.04	.03	.02
5	.10	.10	.10	.08	.06	.06	.04	.04	.02	.01
10	.11	.09	.10	.08	.06	.05	.03	.02	.02	.01
15	.11	.11	.09	.09	.06	.07	.03	.03	.02	.01
20	.10	.11	.08	.08	.06	.05	.03	.03	.02	.01
25	.08	.09	.11	.07	.07	.05	.03	.03	.02	.01
30	.09	.10	.08	.07	.06	.04	.03	.02	.02	.01
35	.08	.11	.06	.07	.07	.05	.04	.03	.02	.01
40	.06	.08	.08	.07	.07	.04	.04	.03	.02	.02
45	.06	.08	.09	.08	.06	.05	.05	.03	.03	.02
46				.07		.06				.02
48				.09		.05				.03
50	.07	.10	.08	.07	.06	.06	.06	.03	.03	.03
52				.06		.08				.03
54				.05		.09				.04
56				.05		.11				.04
58				.04		.08				.08
60		.06	.04	.04	.06	.05	.08	.05	.05	.07
62				.04		.06				.05
64				.04		.04				.03
80				.02		.00				.01
100				.00		.00				.00

TABLE 3. CHLOROPHYLL A (MG/M^3) MEASURED AT AIDJEX MAIN CAMP.

CHLOROPHYLL A (MG/M^3) FOR JULY 1975

DEPTH (M)	2	5	8	11	14	17	20	23	26	29 DAY
3	.02	.03	.01	.03	.01	.01	.01	.01	.01	.01
5	.02	.03	.01	.03	.01	.01	.01	.01	.01	.01
10	.01	.02	.01	.03	.01	.01	.01	.01	.01	.02
15	.01	.03	.01	.03	.02	.01	.01	.01	.01	.01
20	.03	.03	.01	.03	.02	.01	.01	.01	.01	.02
25	.03	.03	.01	.04	.02	.01	.02	.02	.01	.03
30	.01	.03	.01	.03	.02	.02	.02	.02	.01	.03
35	.02	.04	.02	.03	.03	.02	.02	.02	.02	.03
40	.04	.04	.04	.03	.03	.03	.03	.02	.02	.03
45	.04	.06	.05	.04	.04	.05	.04	.03	.02	.04
46		.10		.04		.06				.02
48		.11		.06		.07				.02
50	.04	.11	.08	.06	.05	.09	.05	.04	.03	.02
52		.11		.09		.10				.02
54		.13		.09		.10				.04
56		.12		.11		.13				.07
58		.11		.08		.12				.12
60	.11	.11	.12	.09	.08	.12	.14	.26	.19	.13
62		.12		.10		.13				.13
64		.12		.09		.14				.10
80		.03		.04		.05				.07
100		.01		.01		.02				.03

TABLE 4. CHLOROPHYLL A (MG/M^3) MEASURED AT AIDJEX MAIN CAMP.

CHLOROPHYLL A (MG/M^3) FOR AUGUST 1975

DEPTH (M)	1	4	7	10	13	16	19	22	25	28	31 DAY
3	.01	.02	.02	.03	.02	.03	.01	.03	.02	.03	.02
5	.02	.02	.01	.03	.02	.02	.02	.02	.02	.03	.02
10	.01	.01	.01	.04	.02	.03	.01	.02	.02		.02
15	.01	.02	.03	.03	.02	.05	.02	.02	.02	.03	.04
20	.02	.03	.06	.03	.03	.04	.02	.04	.02	.03	.04
25	.03	.02	.04	.04	.03	.04	.02	.04	.03	.03	.03
30	.02	.02	.03	.03	.04	.04	.03	.03	.03	.04	.04
35	.03	.03	.04	.03	.06	.07	.03	.03	.03	.05	.04
40	.04	.04	.04	.04	.09	.05	.05	.04	.05	.05	.06
45	.06	.08	.06	.05	.19	.06	.10	.07	.07	.06	.12
46	.04		.06	.07	.19	.08	.07	.05	.08	.10	.07
48	.07		.06	.10	.14	.07	.10	.09	.08	.12	.09
50	.06	.09	.08	.11	.17	.10	.13	.12	.09	.11	.10
52	.08		.12	.10	.17	.10	.16	.14		.12	.11
54	.07		.12	.10	.14	.11	.16	.14	.12	.10	.18
56	.11		.10	.10	.14	.18	.15	.14	.14	.08	.17
58	.14		.14	.08	.09	.14	.10	.11	.12	.09	.14
60	.17	.20	.16	.09	.08	.13	.08	.11	.12	.11	.14
62	.26		.15	.09	.07	.14	.08	.10	.10	.09	.11
64	.24		.14	.10	.06	.12	.06	.10	.10	.07	.08
80	.05		.08	.06	.04	.06	.04	.04	.04	.05	.05
100	.03		.05	.04	.02	.04	.03	.03	.03	.02	.02

TABLE 5. CHLOROPHYLL A (MG/M^3) MEASURED AT AIDJEX MAIN CAMP.

CHLOROPHYLL A (MG/M^3) FOR SEPTEMBER 1975

DEPTH (M)	3	6	9	12	15	18	21	24	27	30 DAY
3	.03	.02	.04	.05	.06	.05	.04	.05	.04	.04
5		.03	.05	.05	.04	.06	.05	.05	.04	.04
10	.03	.03	.04	.06	.04	.04	.05	.05	.04	.04
15	.05	.03	.04	.04	.03	.04	.05	.05	.04	.04
20	.05	.02	.04	.04	.04	.02	.05	.05	.04	.04
25	.03	.04	.03	.04	.03	.03	.05	.05	.04	.04
30	.04	.04	.03	.04	.04	.04	.05	.05	.04	.04
35	.04	.04	.04	.04	.05	.04	.05	.06	.04	.04
40	.04	.04	.04	.06	.08	.05	.05	.06	.05	.06
45	.05	.05	.06	.09	.12	.05	.07	.07	.06	.06
46	.05	.06	.06	.10	.08		.07	.08	.06	.06
48	.04	.07	.07	.08	.08		.07	.08	.07	.06
50	.06	.07	.07	.10	.08	.09	.08	.07	.06	.05
52	.10	.08	.08	.12	.08		.08	.06	.05	.05
54	.10	.09	.08	.12	.08		.07	.07	.05	.05
56	.12	.11	.09	.11	.08		.08	.05	.05	.06
58	.11	.12	.10	.11	.08		.07	.05	.05	.04
60	.12	.12	.09	.10	.08	.08	.07	.05	.05	.06
62	.12	.12	.07	.10	.07		.06	.04	.04	.05
64	.12	.11	.08	.09	.06		.06	.04	.03	.04
80	.03	.04	.04	.04	.05		.03	.02	.02	.02
100	.02	.02	.02	.02	.03		.02	.01	.02	.02

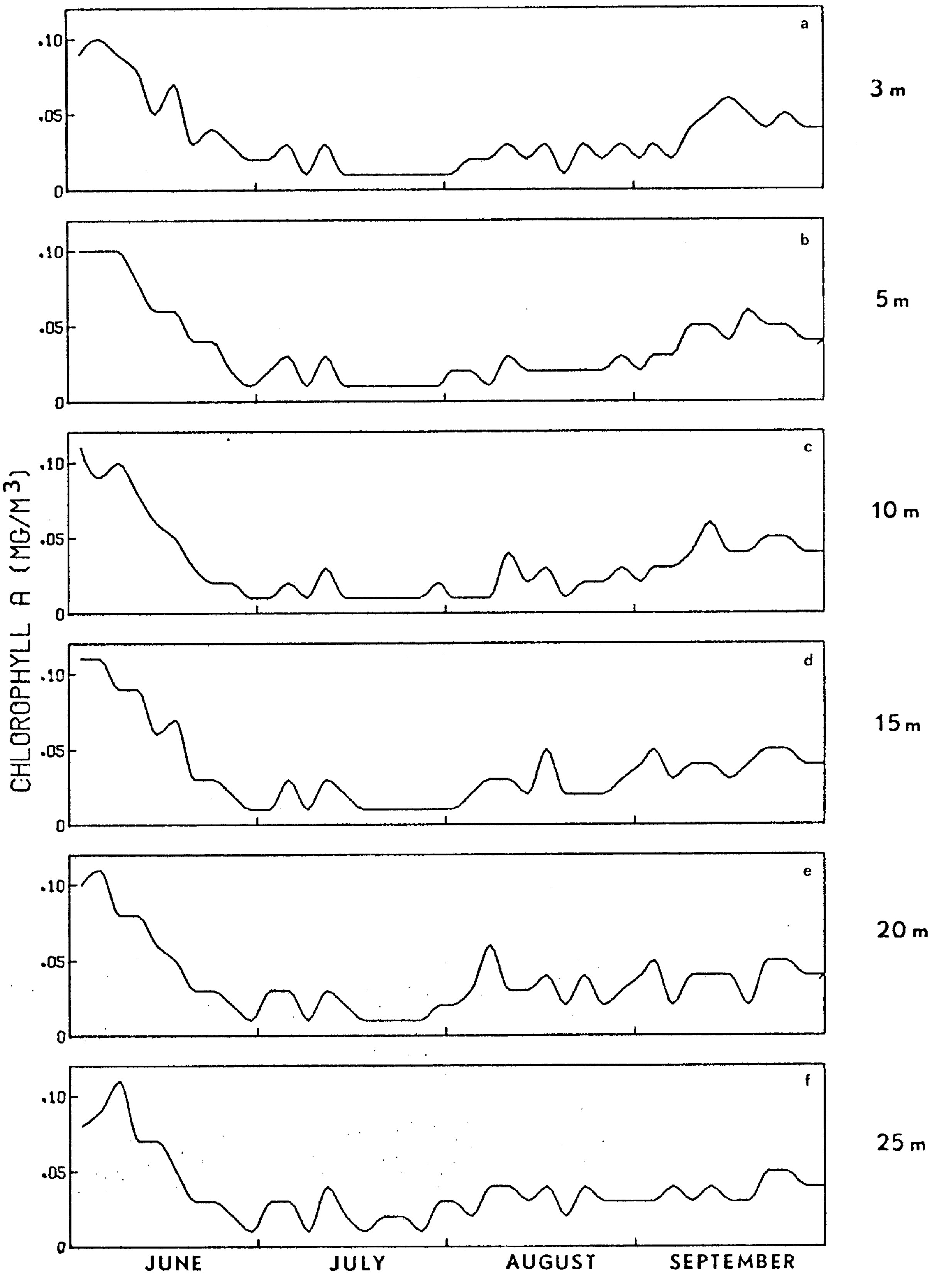

Fig. 4. Chlorophyll a (mg/m^3) measured at depths indicated during summer of 1975. (m) Chlorophyll a (mg/m^2) integrated over the upper 100 m.

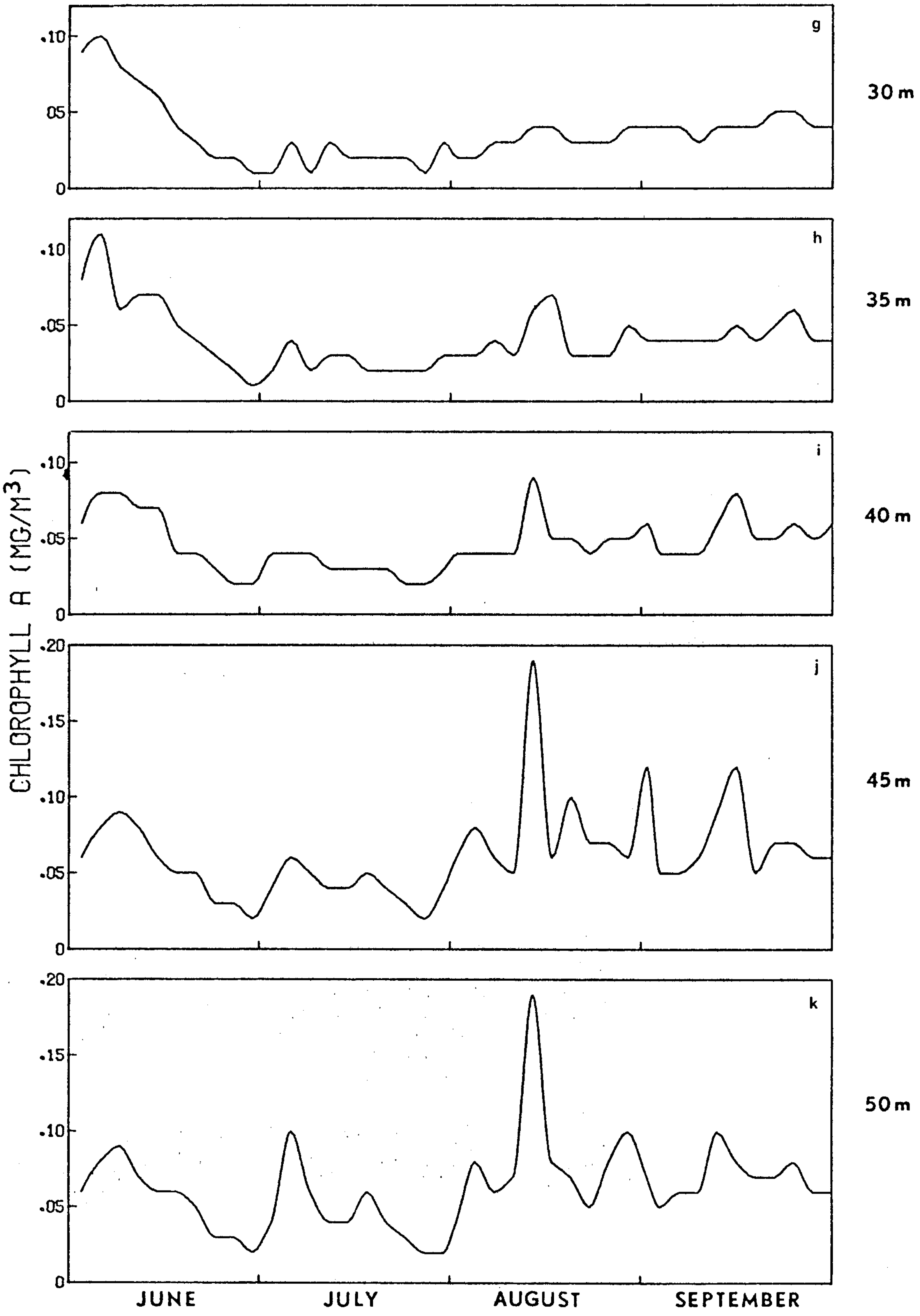
g
30 m
h
35 m
i
40 m
j
45 m
k
50 m
CHLOROPHYLL A (MG/M^3)
.10
05
0
.10
.05
0
.10
.05
0
.20
.15
.10
.05
0
.20
.15
.10
.05
0
JUNE
JULY
AUGUST
SEPTEMBER

Fig 4 (cont.)

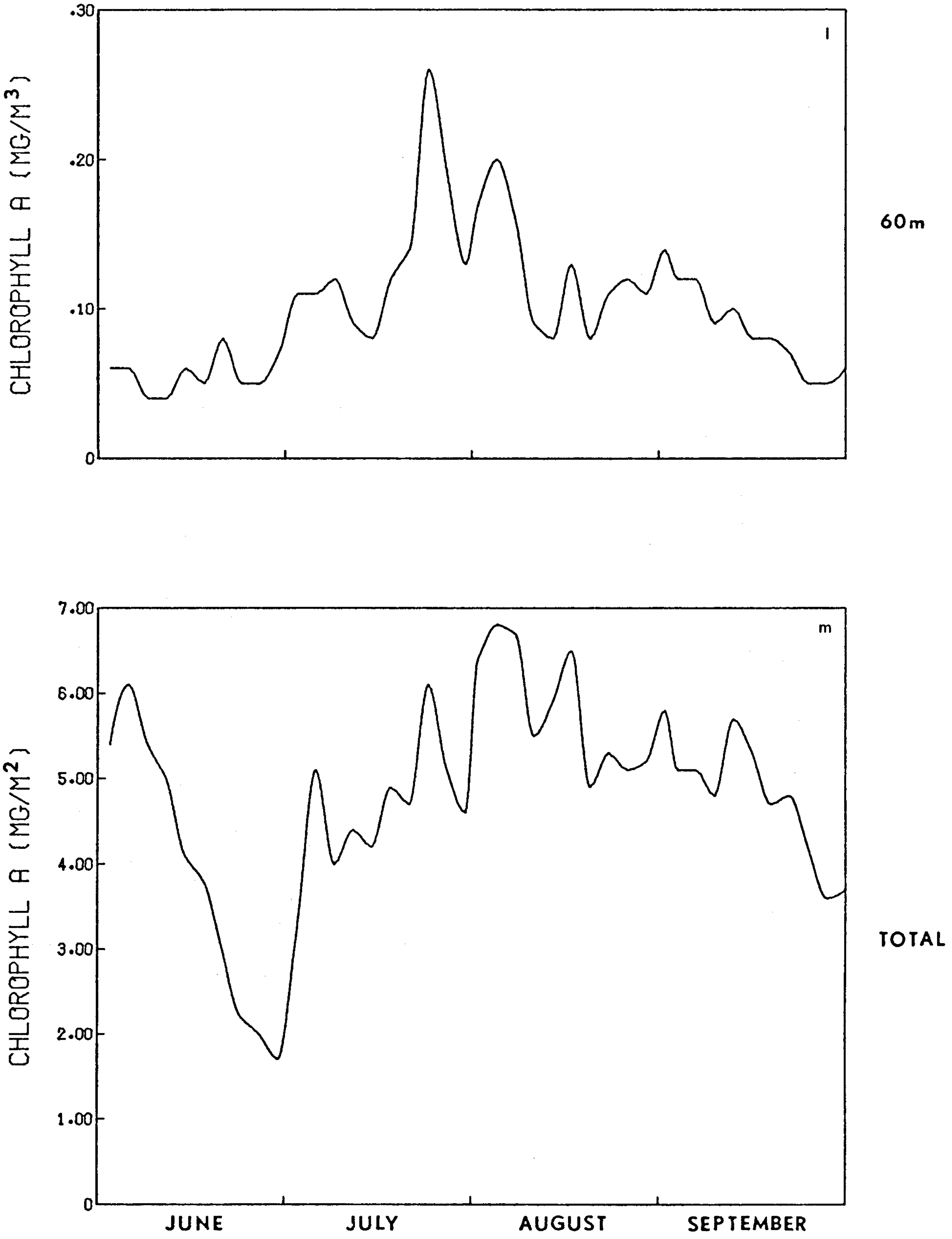
.30
.20
.10
0
CHLOROPHYLL A (MG/M^3)
l
60m
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
CHLOROPHYLL A (MG/M^2)
m
TOTAL
JUNE
JULY
AUGUST
SEPTEMBER

Fig. 4 (cont.).

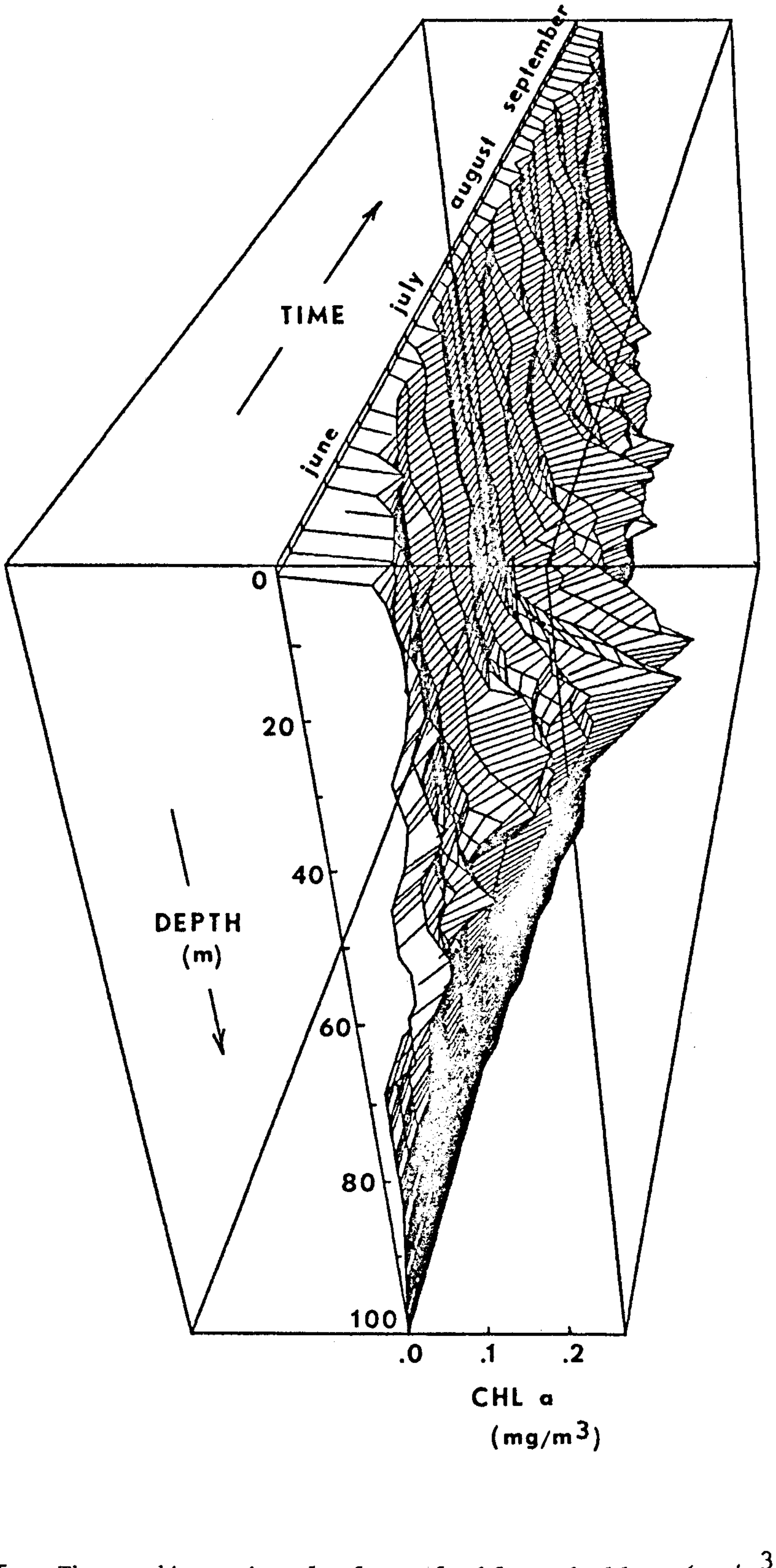

Fig. 5. Three dimensional plot of chlorophyll a (mg/m^3), 0-100 m, 1 June to 30 September 1975

TABLE 6. NUMBERS OF ADULT FEMALES AND JUVENILE STAGES I-V FOR *CALANUS HYPERBOREUS*, *C. GLACIALIS*, AND *EUCHAETA GLACIALIS* AS SAMPLED WITH 50-0 M NET HAULS 12 TIMES DURING THE SUMMER 1975.

	JUNE			JULY				AUGUST			SEPTEMBER	
Date / Stage	7	15	24	3	12	21	30	8	16	26	13	28
CALANUS HYPERBOREUS												
Females	8	24	26	52	48	6	8	38	16	26	37	18
V	35	40	24	76	38	31	19	28	13	18	26	8
IV	21	16	21	27	13	10	10	15	9	10	34	39
III	1	0	0	0	0	0	0	0	33	80	327	74
II	0	0	0	0	0	0	0	0	29	23	23	0
I	0	0	0	0	0	0	0	0	0	0	0	0
CALANUS GLACIALIS												
Females	3	15	11	26	27	23	23	34	24	9	10	3
V	1	9	5	14	15	13	15	3	4	2	4	3
IV	0	2	1	0	1	0	0	0	0	0	0	0
III	0	0	0	0	0	0	0	0	0	0	1	14
II	0	0	0	0	0	0	0	0	49	26	21	9
I	0	0	0	0	49	29	30	0	69	19	28	8
EUCHAETA GLACIALIS												
Females	0	0	0	0	2	0	0	0	1	3	3	0
V	1	0	1	1	3	0	0	2	4	4	0	5
IV	0	1	1	0	0	0	0	0	0	0	0	0
III	0	0	1	0	0	2	20	10	4	4	0	0
II	11	0	0	2	1	0	0	2	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0	0	0

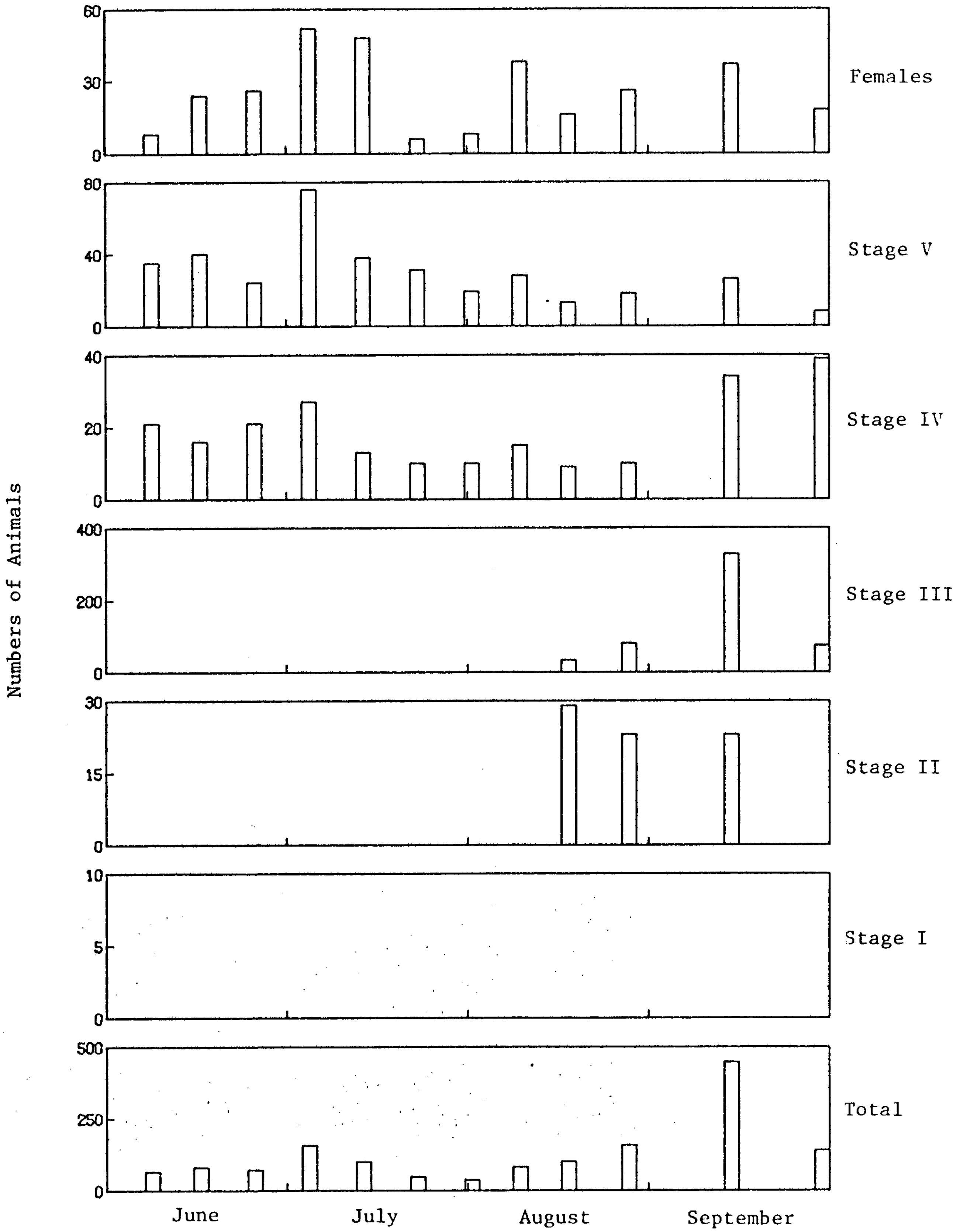

Fig. 6. Number of adult females, stages I-V, and total animals of *Calanus hyperboreus* sampled 12 times during the summer of 1975

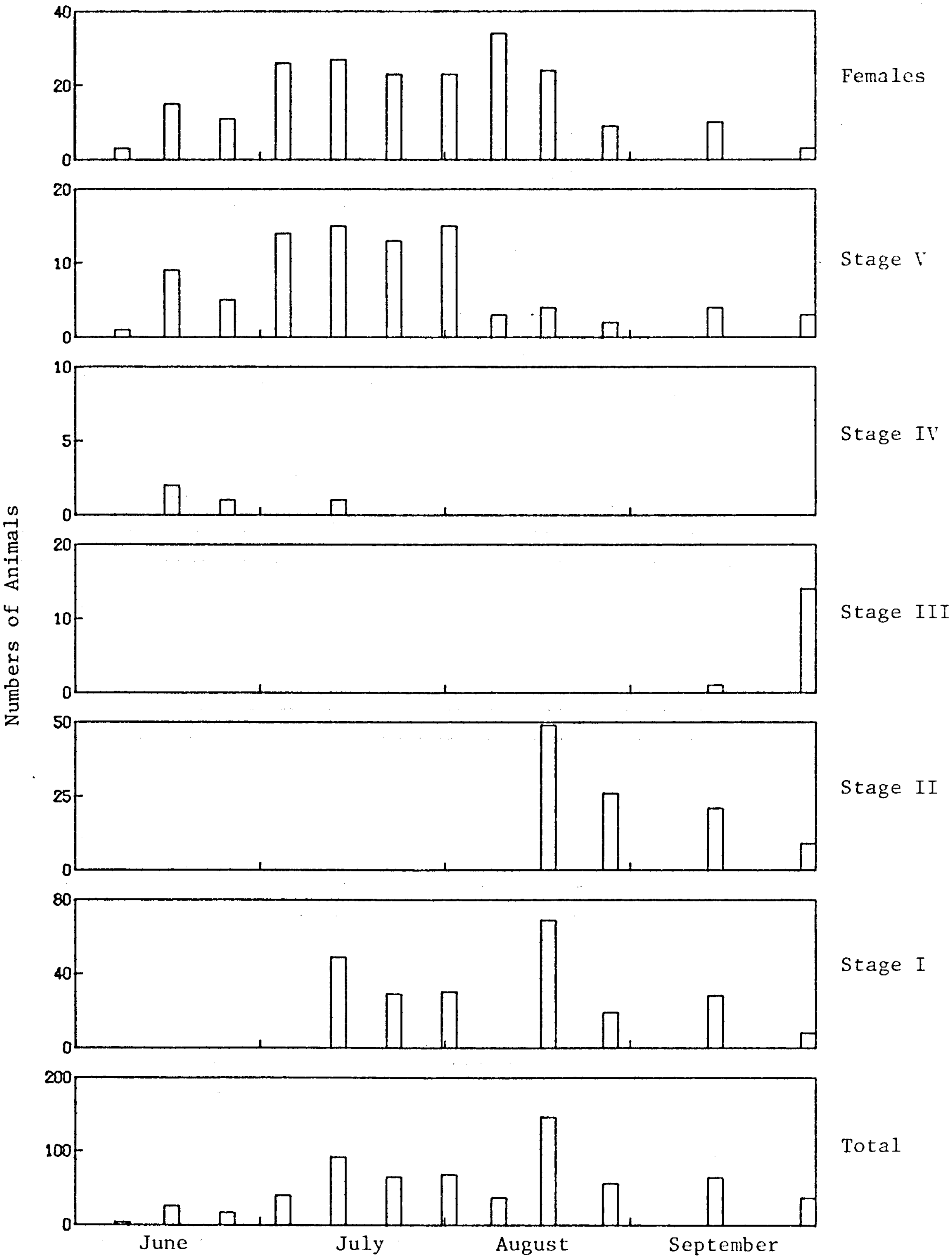

Fig. 7. Number of adult females, stages I-V, and total animals of *Calanus glacialis* sampled 12 times during the summer of 1975

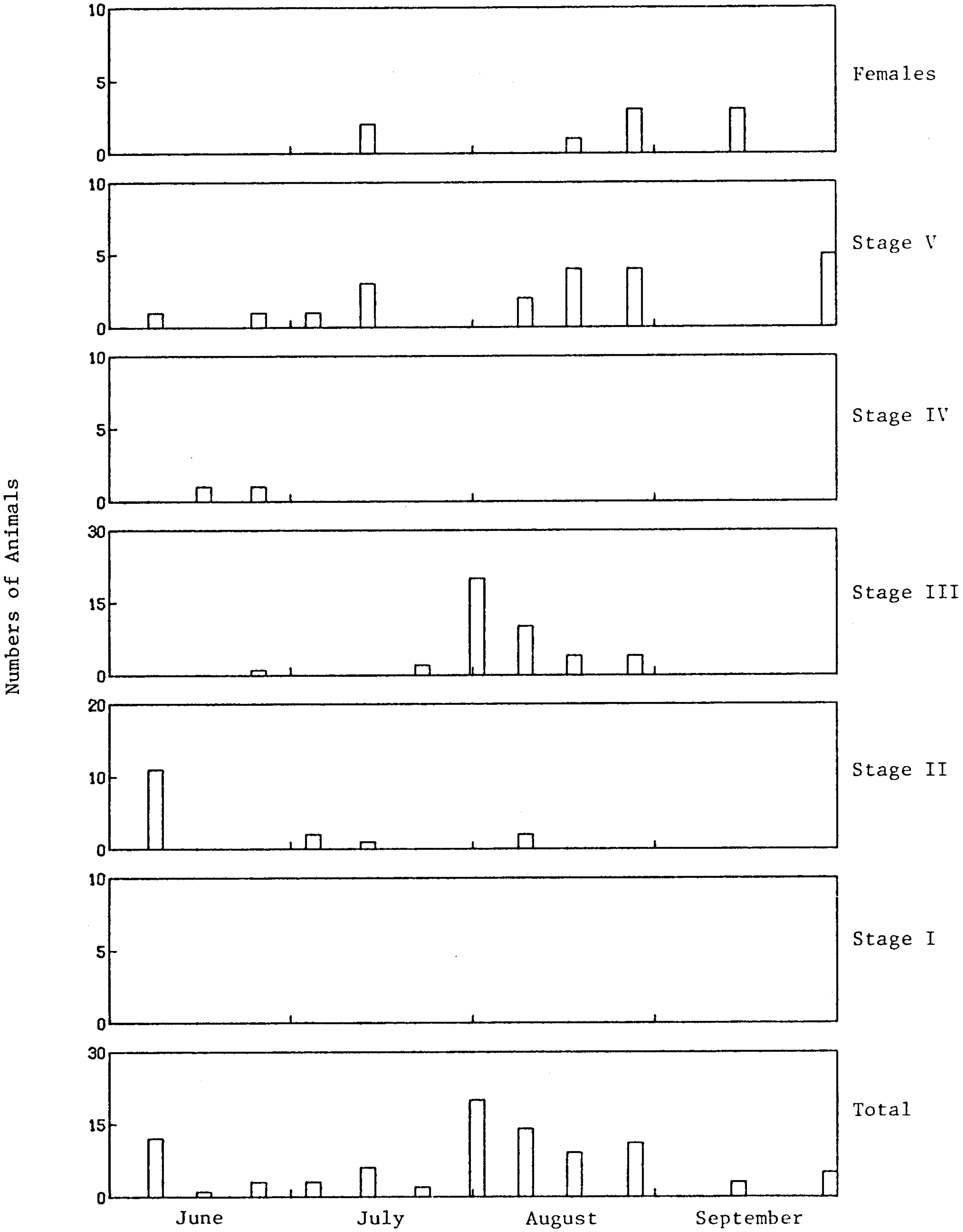

Fig. 8. Number of adult females, stages I-V, and total animals of *Euchaeta glacialis* sampled 12 times during the summer of 1975

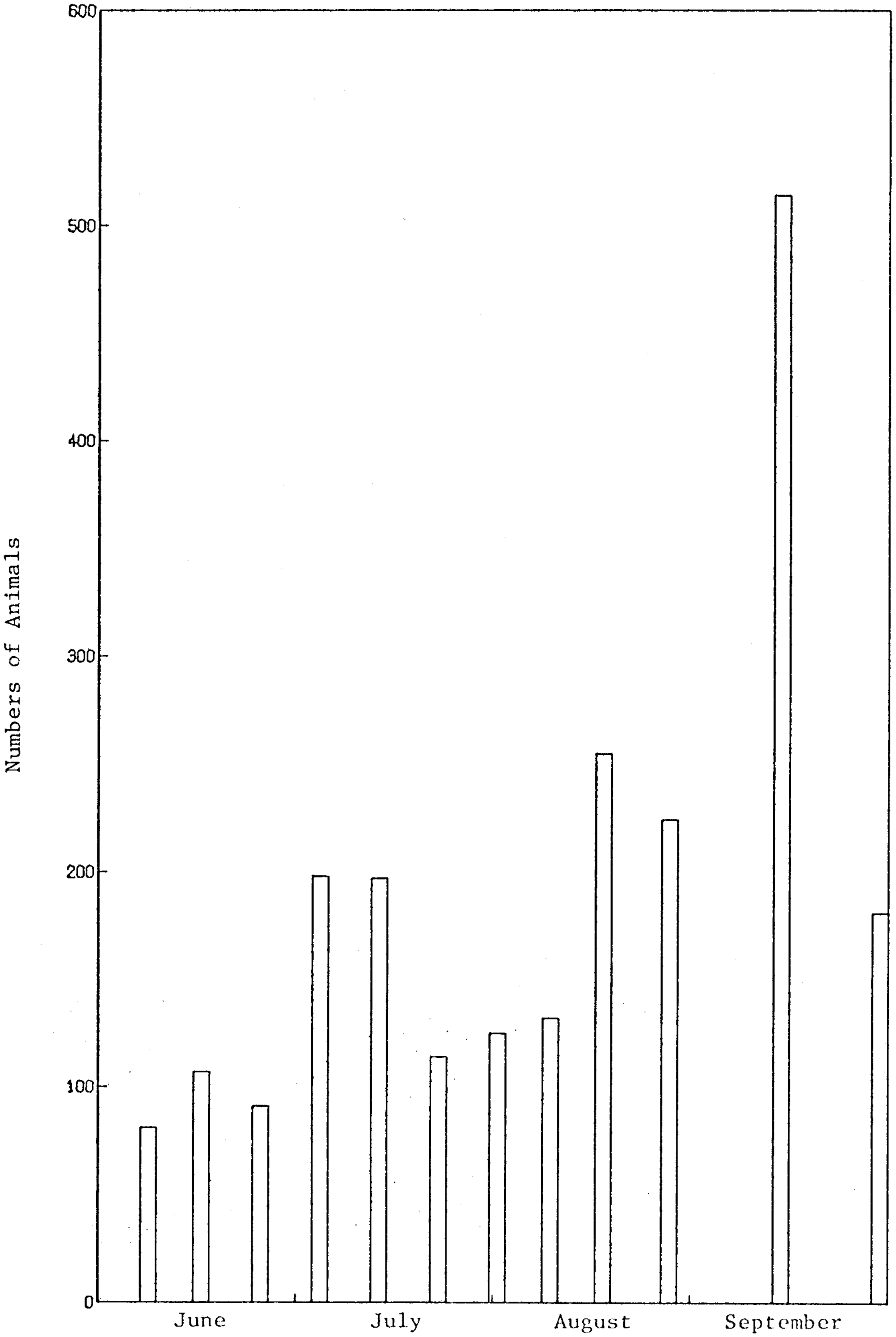

Fig. 9. Total numbers of *Calanus hyperboreus*, *Calanus glacialis*, and *Euchaeta glacialis* sampled 12 times during the summer of 1975

E. glacialis was present in low numbers for all stages and females (Fig. 8). Maximum numbers appeared in early August and these were largely stage III's.

Total numbers (Fig. 9) of these three species attained a secondary maximum in abundance during the first two weeks of July, composed mainly of *C. hyperboreus* and *C. glacialis* stage V's and females. The greatest abundance is found in the last half of August and first part of September and is composed principally of Stage III *C. hyperboreus* and stages I and II *C. glacialis*.

IV. Preliminary Interpretation of Results

The chlorophyll concentrations of the upper 50 m mixed layer have been observed from Fletcher's Ice Island, T-3, to increase in late June or early July after the spring snow cover has decayed and melt water accumulates on the ice surface. Chlorophyll remains abundant until mid or late August snow storms obliterate melt ponds and cover the ice surface with a highly reflective, almost opaque cover. This typical single pulse of primary production is constrained by the timing of the spring melt and the lasting autumn accumulation of snow. During the summer, growth of the phytoplankton may be modified by temporary changes in the ice cover such as intermittent snow storms. Neither grazing by herbivores nor nutrient limitation has been verified as causing the late summer decline in plant standing crop.

Chlorophyll concentrations during the summer of 1975 (Figs. 4 a-m, 5) show the possible consequences of nutrient limitation in the mixed layer. Nitrate, the only nutrient measured, was not detected in the upper 40 m during the summer (Table 1). Other nitrogen sources and nutrients such as phosphate and silicate were not measured, so it cannot be stated unequivocally that nitrogen was limiting to plant growth, although that seems probable. The relatively high chlorophyll values recorded in early June in the upper 40 m may be the end of an earlier spring bloom that exhausted the nutrient supply in the mixed layer.

The seasonal pattern of submarine light may be deduced from changes in the ice cover recorded from June to September, 1975. Eight periods can be delineated roughly:

June 1-22: pre-melt, crusty, snowy, bright white surface
June 22-July 1: heavy melting, melt ponds increase, intermittent rains
July 2-9: maximum meltwater (40-60%), intermittent snows
July 10-15: pond drainage, increased leads, intermittent snow
July 16-25: little change, grey ice, ponds skimmed, some snow
July 26 - Aug 19: heavy snow accumulation, ponds drifted over, bare ice snow covered
Aug 20-29: brief rainy, warm melt period, grey ice, slight regeneration of ponds

Aug 30 - Sep 30: final snow build up, ponds and bare ice all snow covered

Submarine light increased with the rains and warming temperatures in late June. Optimal light conditions prevailed until late July when snow drifted over many melt ponds. The slight warming in late August temporarily increased submarine light, but that effect was minimized by low sun elevations.

The phytoplankton at 60-64 m responded to the optimal light conditions in July with an increase which reached its maximum in late July and early August. The subsurface chlorophyll maximum may have effectively stopped nutrient transfer into the mixed layer from below the pycrocline. Aside from a brief recovery in late August, the 60-64 m chlorophyll concentration declined through August and September concomitant with the decreasing light. Low chlorophyll concentrations at the bottom of the mixed layer toward the end of September are associated with an increase in nitrate in the 42-50 m layer where, until then, none was detected. A slight increase in chlorophyll in the upper 40 m was evident at this time.

V. Unpublished Data and Archived Samples

We are beginning to acquire unpublished data and archived samples. In particular, we are analyzing WEBSEC (Western Beaufort Sea Ecological Cruises, sponsored by the U. S. Coast Guard) data and samples collected in 1972 and 1973.

We have acquired zooplankton samples collected by National Marine Fisheries, Auke Bay Laboratory, personnel in 1972 and have begun processing them. No fish eggs have been found in seven Isaacs-Kidd mid-water trawl samples that have been sorted. Fish larvae have been found at two stations (Table 7).

Table 7. Number of fish larvae found in two WEBSEC-72 Isaacs-Kidd mid-water trawl samples

Station	Date	Depth (m)	Sample	Fish Larvae
009	7 Aug 72	0	AB 72-157	29
(70°30.8'N,		40	-159	15
144°27.0'W)		20	-160	0
010	7 Aug 72	20	-163	26
(70°19.3'N,		15	-164	38
144°46.5'W)		10	-165	59
		0	-166	272

Sixty vertical net hauls have been examined for fish larvae and fish eggs; only 2 eggs and 1 fish larva have been found in these samples (Table 8).

Table 8, Fish eggs and larvae from two vertical net hauls

Station	Date	Depth (m)	Sample	Fish Larvae	Fish Eggs
005 (70°51.7'N, 143°45.4'W)	5 Aug 72	500	AB 72-137	0	1
		800	-138	0	1
010 (70°19.3'N, 144°46,5'W)	7 Aug 72	30	-161	1	0

Copepods have been separated and identified from two WEBSEC-72 vertical net hauls (Tables 9, 10).

Table 9. Copepods sorted from station 005, AB 72-132, (70°51,7'N, 143°45.4'W), 5 Aug 1972, 50 m. The total number of copepods was 1742.

Species	Stage	% Total
Calanus hyperboreus	VI ♀	38.80
	V	19.17
	IV	2.46
	III	0.40
	I	0.11
Calanus glacialis	VI ♀	14.12
	V	3.32
	IV	0.74
	III	1.32
	II	0.74
	I	0,11
Metridia longa	VI ♀	4.53
	VI ♂	1.03
	V ♀	2.58
	V ♂	0.80
	IV ♀	0.92
	IV ♂	0,45
Euchaeta glacialis	VI ♀	0.86
	V ♀	0.63
	V ♂	0.63
	IV ♀	0.11
	IV ♂	0.11
	III	0.06
	II	0.23
	I	0.05
Pseudocalanus minatus	VI ♀	3.20

Table 9 (cont.).

Species	Stage	% Total
Scaphocalanus magnus	VI ♀	0.28
	V ♀	0.17
	V ♂	0.06
	IV ♀	0.06
Heterorhabdus norvegicus	VI ♀	0.46
	VI ♂	0.22
Gaidius tenuispinus	VI ♀	0.11
	VI ♂	0.11
	V ♀	0.17
	V ♂	0.11
	IV ♀	0.06
Aetideopsis rostrata	VI ♀	0.29
Limnocalanus grimaldii	VI ♀	0.11
	VI ♂	0.06
	V ♀	0.06
	V ♂	0.06

Table 10. Copepods sorted from station 019, AB 72-199, 71°09.0'N, 146°29.0'W, 11 Aug 1972, 250 m. The total number of copepods was 265.

Species	Stage	% Total
Calanus hyperboreus	VI ♀	2.64
	V	4.15
	IV	0.75
	III	0.75
Calanus glacialis	VI ♀	4.15
	VI ♂	0.38
	V	3.01
	IV	9.81
	III	35.09
	II	8.30
	I	0.38
Metridia longa	VI ♀	3.01
	V ♀	7.17
	V ♂	7.92
Euchaeta glacialis	VI ♂	0.38
	V ♀	0.38
	IV ♀	0.38
	IV ♂	0.38
	III	0.38

Table 10 (cont.).

Species	Stage	% Total
Pseudocalanus minutus	VI♀	12.83
	V	0.75
Scaphocalanus magnus	VI♀	0.38

Reference slides have been prepared for the following copepod species including adult forms and copepodid stages:

Calanus hyperboreus (VI♀, V, IV, III, I)
Calanus glacialis (VI♀, VI♂, V, IV, III, II, I)
Metridia longa (VI♀, VI♂, V♀, V♂, IV♀, IV♂)
Euchaeta (Paraeuchaeta) glacialis (VI♀, VI♂, V♀, V♂, IV♀, IV♂, III, II, I)
Pseudocalanus minutus (VI♀, V♀)
Scaphocalanus magnus (VI♀, V♀, V♂, IV♀)
Heterorhabdus norvegicus (VI♀, VI♂)
Gaidius tenuispinus (VI♀, VI♂, V♀, V♂, IV♀)
Aetideopsis rostrata (VI♀)
Limnocalanus grimaldii (VI♀, VI♂, V♀, V♂)

Data from phytoplankton standing stock and chlorophyll *a* samples collected during WEBSEC-73 and previously analyzed, are being examined in terms of species present, standing stock, chlorophyll *a* concentrations, depth, and geographic distributions.

VI. Literature Review: Zooplankton and Phytoplankton

The literature review for Beaufort Sea zooplankton and phytoplankton is continuing. Approximately 615 references pertinent to Arctic zooplankton have been obtained. Of these, approximately 80 are not in the University of Washington library system. These are being ordered on Interlibrary Loan and copies will be placed in the Fisheries-Oceanography Library of the UW system.

Approximately 125 Arctic phytoplankton references have been obtained. Most of these are in the UW library system or will be made available for permanent placement in the library.

Many of the references are taxonomic in nature and not restricted to the Arctic. The literature search has been designed to include references for the whole Arctic Ocean and peripheral waters including the northern Bering Sea, Norwegian Sea, Denmark Strait, Baffin Bay, and Davis Strait because it is not possible to separate the Beaufort Sea biologically from the rest of the Arctic and Subarctic.

The search for ichthyoplankton literature for the Beaufort Sea is continuing.

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Appendix 1. Station Summary Sheets for the Barrow Transects (B-1-10) and the Prudhoe Bay Stations (PB-1, P-1-37).

Station Location and Number: PB-1 Prudhoe Bay Date: 8/12/75 Time: 1600

Air temperature: 10° Secchi disc depth: -- Water depth: 15'

Local weather and wind conditions: sunny, clear, wind 0-5 kts; station taken from Beaver airplane on floats

			Nutrients (μg-at/ℓ)						
Depth	T	$S^{\circ}/_{\circ\circ}$	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	4.5	26.776	--	--	--	--	--	0.170	
9	4.5	26.550	--	--	--	--	--	0.355	

Station Location and Number: B-1 Drew Pt. Date: 8/15/75 Time: 1500

Air temperature: 4.5 Secchi disc depth: -- Water depth: 4'

Local weather and wind conditions:

Depth	T	S°/∘∘	PO_4	Si	Nutrients (μg-at/ℓ) NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	∿3.0	16.130	0.38	6.82	0.00	0.03	0.00	0.417	

Station Location and Number: B-2 Cape Simpson

Date: 8/15/75

Time: 1530

Air temperature: 4.5

Secchi disc depth: --

Water depth: 4'

Local weather and wind conditions:

					Nutrients (μg-at/ℓ)				
Depth	T	$S^{\circ}/_{\circ\circ}$	PO_4	Si	NO_3	NO_2	NH_4	Chl. a (mg/m^3)	Prim. Prod. (mg C/m^2·hr)
0	3.0	23.539	0.18	2.89	0.02	0.03	1.06	0.430	

Station Location and Number: B-3 Tangent Point Date: 8/15/75 Time: 1600

Air temperature: 4.5 Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions:

Depth	T	S°/₀₀	Nutrients (µg-at/ℓ)					Chl. *a* (mg/m^3)	Prim. Prod. $(mg\ C/m^2 \cdot hr)$
			PO_4	Si	NO_3	NO_2	NH_4		
0	3.0	30.283	0.33	5.50	0.01	0.02	0.21	0.212	

Station Location and Number: B-4 off Scott Point (lead)　Date: 8/15/75　Time: 1700

Air temperature: 4.5　Secchi disc depth: --　Water depth: 3'

Local weather and wind conditions:

					Nutrients (μg-at/ℓ)				
Depth	T	S°/°°	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	3.0	12.854	0.82	14.78	2.17	0.10	0.63	0.456	

Station Location and Number: B-5 Ross Point

Date: 8/27/75

Time: 1526

Air temperature: 1.2°

Secchi disc depth: --

Water depth: 5'

Local weather and wind conditions: clear; wind 10-18 kts.

					Nutrients (μg-at/ℓ)			Chl. a	Prim. Prod.
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
S	0°	13.072	0.35	3.55	0.12	0.08	0.63	0.290	
E	0°	26.850	0.24	2.45	0.16	0.07	0.63	0.298	

Station Location and Number: B-6 Ross Point Date: 8/27/75 Time: 1547

Air temperature: 1.2° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: clear, wind 10-18 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
S	-.2	20.826	0.43	4.89	0.05	0.01	1.06	0.116	
E	-.2	--	0.39	4.95	0.04	0.02	0.21	0.350	

Station Location and Number: B-7 Cape Simpson Date: 8/27/75 Time: 1810

Air temperature: 4° Secchi disc depth: -- Water depth: 4'

Local weather and wind conditions: clear, wind 10-18 kts.

Depth	T	S°/oo			Nutrients (μg-at/ℓ)			Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
			PO_4	Si	NO_3	NO_2	NH_4		
S	3°	24.937	--	--	--	--	--	2.028	
E	3°	24.490	--	--	--	--	--	--	

Station Location and Number: B-8 Scott Point

Date: 8/27/75

Time: 1905

Air temperature: 2.5

Secchi disc depth: --

Water depth: 3'

Local weather and wind conditions: clear, wind 10-18 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. a (mg/m^3)	Prim. Prod. (mg C/m^3-hr)
(S	Samples not taken at start of transect)								
E	-.5	31.791	0.40	5.00	0.10	0.02	0.63	0.363	

Station Location and Number: B-9 Pt. Barrow Date: 8/27/75 Time: 1930

Air temperature: 2.5° Secchi disc depth: -- Water depth: 4'

Local weather and wind conditions: clear, wind 10-18 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	$S^\circ/_{\circ\circ}$	PO_4	Si	NO_3	NO_2	NH_4	Chl. a (mg/m^3)	Prim. Prod. (mg C/m^2·hr)
S	.5	22.564	0.17	2.01	0.19	0.01	0.21	0.223	
E	.5	25.914	0.27	3.49	0.10	0.04	1.06	0.241	

Station Location and Number: B-10 Tangent Point Date: 8/29/75 Time: 1230

Air temperature: .5° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions:

						Nutrients (μg-at/ℓ)				
	Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. ($mg\ C/m^3 \cdot hr$)
S	0	1.8	24.870	0.26	1.41	0.06	0.05	0.84	0.443	
	15	1.8	25.447	0.27	2.16	0.15	0.07	1.50	0.702	

No end sample taken here due to plane trouble.

Station Location and Number: P-1 Milne Point Date: 9/5/75 Time: 1430

Air temperature: 0° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: overcast, fog, snow, wind 0-5 kts.

					Nutrients (μg-at/ℓ)			Chl. α	Prim. Prod.
Depth	T	$S^{\circ}/_{\circ\circ}$	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\,C/m^3 \cdot hr$)
0	-1.0	12.844	0.36	16.60	0.20	0.12	0.86	0.845	

Station Location and Number: P-2 Beechey Point Date: 9/5/75 Time: 1500

Air temperature: 0° Secchi disc depth: -- Water depth: 6'

Local weather and wind conditions: overcast, fog, snow, wind 0-5 kts.

					Nutrients (μg-at/ℓ)			Chl. a	Prim. Prod.
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg $C/m^3 \cdot hr$)
0	-1.0	20.208	0.52	10.14	0.35	0.24	0.80	1.284	

Station Location and Number: P-3 Egg Island Date: 9/5/75 Time: 1600

Air temperature: 0° Secchi disc depth: -- Water depth: 3'

Local weather and wind conditions: overcast, fog, snow, wind 0-5 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	-1.0	22.126	0.71	8.00	1.19	0.06	1.86	.777	

Station Location and Number: P-4 Prudhoe Bay Date: 9/7/75 Time: 1040

Air temperature: 4.3° Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: overcast; seas ∿ 2'; wind 10 kts.; grease ice on bay

			Nutrients (μg-at/ℓ)					Chl. *a*	Prim. Prod.
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	.2	13.168	0.94	20.95	0.27	0.10	0.52	0.879	
7	1.2	12.642	0.95	20.64	1.15	0.10	1.08	0.811	

Station Location and Number: P-5 Prudhoe Bay Date: 9/7/75 Time: 1100

Air temperature: 4.3° Secchi disc depth: -- Water depth: 8'

Local weather and wind conditions: overcast; seas ∿ 2'; 10 kts winds; grease ice on bay

					Nutrients (μg-at/ℓ)				
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg $C/m^3 \cdot hr$)
0	-.8	14.054	0.73	19.21	0.16	0.13	0.94	0.714	
8	-.4	18.948	0.36	12.47	0.85	0.21	1.62	1.048	

Station Location and Number: P-6 Prudhoe Bay Date: 9/7/75 Time: 1130

Air temperature: 4.3 Secchi disc depth: -- Water depth: 3'

Local weather and wind conditions: overcast; seas ∿ 2'; wind 10 kts; grease ice on bay

			Nutrients (μg-at/ℓ)					Chl. a	Prim. Prod.
Depth	T	$S^\circ/_{\circ\circ}$	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	-.8	17.317	0.57	11.21	0.37	0.17	1.29	0.545	
3	-1.5		(No bottom samples taken here)						

Station Location and Number: P-7 Prudhoe Bay Date: 9/7/75 Time: 1145

Air temperature: 4.3 Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: overcast; seas ∿ 2'; wind 10 kts; grease ice on bay

					Nutrients (μg-at/ℓ)				
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	-.8	16.107	0.52	14.16	0.92	0.21	1.90	0.642	
5	-1.2	19.497	0.58	7.91	0.24	0.39	0.60	0.946	

Station Location and Number: P-8 Prudhoe Bay Date: 9/7/75 Time: 1215

Air temperature: 4.3° Secchi disc depth: -- Water depth: 2'

Local weather and wind conditions: overcast; seas ∿ 2'; winds 10 kts; grease ice on bay

			Nutrients (µg-at/ℓ)					Chl. *a*	Prim. Prod.
Depth	T	S°/°°	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\ C/m^2 \cdot hr$)
0	-1	20.579	1.28	10.38	0.08	0.57	0.88	1.169	
2	-1		(no bottom samples taken here)						

Station Location and Number: P-9 Prudhoe Bay

Date: 9/7/75

Time: 1230

Air temperature: 4.3°

Secchi disc depth: --

Water depth: 7'

Local weather and wind conditions: overcast; seas ∿ 2'; wind 10 kts; grease ice on bay

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. ($mg\ C/m^3 \cdot hr$)
0	-1	14.778	0.48	14.65	0.58	0.42	2.01	0.777	
7	-1	12.317	0.43	20.92	0.08	0.30	1.09	0.533	

Station Location and Number: P-10 Prudhoe Bay Date: 9/8/75 Time: 1000

Air temperature: 4.0° Secchi disc depth: -- Water depth: 6'

Local weather and wind conditions: clear; wind 0-5 kts; light ice on bay

Depth	T	S°/₀₀	PO$_4$	Si	Nutrients (μg-at/ℓ) NO$_3$	NO$_2$	NH$_4$	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	.8	17.186	0.22	4.72	0.20	0.05	0.85	0.879	
6	.8	13.405	0.29	5.65	0.35	0.05	0.84	0.630	

Station Location and Number: P-11 Prudhoe Bay Date: 9/8/75 Time: 1015

Air temperature: 4.0° Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: clear; wind 0-5 kts; light ice on bay

					Nutrients (µg-at/ℓ)			Chl. *a*	Prim. Prod.
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\ C/m^3 \cdot hr$)
0	-.8	12.570	0.47	20.20	1.19	0.11	1.82	0.436	
7	-.4	19.148	0.36	10.91	0.24	0.06	0.62	0.787	

Station Location and Number: P-12 Prudhoe Bay Date: 9/8/75 Time: 1030

Air temperature: 4.0° Secchi disc depth: -- Water depth: 8'

Local weather and wind conditions: clear; wind 0-5 kts; light ice on bay

			Nutrients (µg-at/ℓ)						
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	-.5	12.456	0.45	15.91	1.15	0.11	1.15	0.472	
8	-.2	19.416	0.63	8.92	0.15	0.05	1.04	1.220	

Station Location and Number: P-13 Prudhoe Bay Date: 9/8/75 Time: 1045

Air temperature: 4.0° Secchi disc depth: -- Water depth: 6'

Local weather and wind conditions: clear; wind 0-5 kts; light ice on bay

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	-.4	12.522	0.49	20.71	0.86	0.13	1.70	0.521	
6	-.2	16.811	0.36	14.48	0.40	0.10	1.39	0.606	

Station Location and Number: P-14 Prudhoe Bay Date: 9/8/75 Time: 1115

Air temperature: 4.0° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: clear; wind 0-5 kts; light ice on bay

Depth	T	S‰	Nutrients (µg-at/ℓ)					Chl. a (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
			PO_4	Si	NO_3	NO_2	NH_4		
0	-1	11.648	0.28	20.22	0.92	0.09	2.03	0.351	
5	-.5	17.687	0.38	8.33	0.23	0.01	0.74	0.845	

Station Location and Number: P-15 Prudhoe Bay

Date: 9/10/75

Time: 1030

Air temperature: 3.8°

Secchi disc depth: --

Water depth: 5'

Local weather and wind conditions: clear; wind 0-3 kts.

			Nutrients (μg-at/ℓ)					Chl. a	Prim. Prod.
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m$^3\cdot$hr)
0	.5	16.067	0.17	14.35	0.11	0.00	1.03	0.557	
5	.2	17.675	0.40	15.45	0.59	0.28	2.17	0.946	

Station Location and Number: P-16 Prudhoe Bay

Date: 9/10/75

Time: 1100

Air temperature: 3.8

Secchi disc depth: --

Water depth: 4'

Local weather and wind conditions: clear; wind 0-3 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	1.0	17.572	0.27	15.61	0.10	0.07	1.26	0.424	
4	.8	18.031	0.51	14.15	0.15	0.09	2.65	0.823	

Station Location and Number: P-17 Prudhoe Bay Date: 9/10/75 Time: 1200

Air temperature: 3.8° Secchi disc depth: -- Water depth: 23'

Local weather and wind conditions: clear; wind 0-3 kts.

			Nutrients (μg-at/ℓ)					Chl. *a*	Prim. Prod.
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	.8	22.618	0.53	14.22	0.27	0.12	2.57	0.460	
23	.5	23.091	0.72	11.80	0.56	0.09	1.23	0.606	

Station Location and Number: P-18 Prudhoe Bay Date: 9/10/75 Time: 1300

Air temperature: 3.8° Secchi disc depth: -- Water depth: 30'

Local weather and wind conditions: clear; wind 0-3 kts.

Depth	T	S°/°°	PO_4	Si	Nutrients (μg-at/ℓ) NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	1.2	23.366	0.50	11.47	0.14	0.07	0.93	0.279	
30	.5	24.959	0.70	10.17	0.82	0.10	1.47	0.465	

Station Location and Number: P-19 Prudhoe Bay Date: 9/10/75 Time: 1330

Air temperature: 3.8° Secchi disc depth: -- Water depth: 11'

Local weather and wind conditions: clear; wind 0-3 kts.

					Nutrients (μg-at/ℓ)			Chl. *a*	Prim. Prod.
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	1.2	21.462	0.45	12.17	0.42	0.14	1.17	0.254	
11	1.0	22.134	0.61	12.49	0.33	0.08	1.30	0.509	

Station Location and Number: P-20 Prudhoe Bay Date: 9/11/75 Time: 1330

Air temperature: 3° Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: cloudy with fog; wind 2 kts; ice cover in morning, cleared by 1300

Depth	T	$S^{\circ}/_{\circ\circ}$	Nutrients (μg-at/ℓ)					Chl. a (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
			PO_4	Si	NO_3	NO_2	NH_4		
0	1.5	15.494	--	--	--	--	--	0.855	
7	1.2	18.356	--	--	--	--	--	1.790	

Station Location and Number: P-21 Prudhoe Bay Date: 9/11/75 Time: 1400

Air temperature: 3° Secchi disc depth: -- Water depth: 8'

Local weather and wind conditions: cloudy with fog; wind 2 kts; ice cover in morning, clear by 1300

Depth	T	S°/∘∘			Nutrients (µg-at/ℓ)			Chl. *a*	Prim. Prod.
			PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	$(mg C/m^3 \cdot hr)$
0	1.2	16.227	--	--	--	--	--	0.823	
8	1.2	17.708	--	--	--	--	--	0.799	

Station Location and Number: P-22 Prudhoe Bay Date: 9/11/75 Time: 1430

Air temperature: 3° Secchi disc depth: -- Water depth: 19'

Local weather and wind conditions: cloudy with fog; wind 2 kts.; ice cover in morning, clear by 1300.

			Nutrients (μg-at/ℓ)					Chl. *a*	Prim. Prod.
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\,C/m^3 \cdot hr$)
0	1.2	23.166	--	--	--	--	--	0.606	
19	1.2	23.186	--	--	--	--	--	0.545	

Station Location and Number: P-23 Prudhoe Bay Date: 9/13/75 Time: 0945

Air temperature: 5.5° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: overcast; SW wind 2-5 kts.

					Nutrients (μg-at/ℓ)			Chl. *a*	Prim. Prod.
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\ C/m^3 \cdot hr$)
0	2.5	19.660	0.47	9.64	0.13	0.26	2.52	0.472	
5	2.3	20.002	0.46	8.97	0.26	0.46	2.40	1.217	

Station Location and Number: P-24 Prudhoe Bay Date: 9/13/75 Time: 1000

Air temperature: 5.5° Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: overcast; wind SW 2-5 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. $(mg\ C/m^3 \cdot hr)$
0	2.2	20.491	0.45	10.77	0.54	0.28	1.03	0.799	
7	2.2	20.832	0.47	10.33	0.15	0.29	0.67	2.907	

Station Location and Number: P-25 Prudhoe Bay Date: 9/13/75 Time: 1030

Air temperature: 5.5° Secchi disc depth: -- Water depth: 8'

Local weather and wind conditions: overcast; SW winds 2-5 kts.

					Nutrients (μg-at/ℓ)			Chl. *a*	Prim. Prod.
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	1.9	19.571	0.21	11.26	0.80	0.80	1.25	0.799	
8	2.2	20.693	0.29	10.42	0.38	1.10	0.94	0.690	

Station Location and Number: P-26 Prudhoe Bay Date: 9/13/75 Time: 1130

Air temperature: 5.5° Secchi disc depth: -- Water depth: 6'

Local weather and wind conditions: overcast; SW wind 2-5 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	S°/oo	PO$_4$	Si	NO$_3$	NO$_2$	NH$_4$	Chl. a (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	1.8	17.010	0.19	8.24	0.05	0.07	1.06	0.642	
6	1.8	18.895	0.28	11.03	0.32	1.05	1.01	0.690	

Station Location and Number: P-27 Prudhoe Bay Date: 9/14/75 Time: 1030

Air temperature: 4.4° Secchi disc depth: -- Water depth: 5'

Local weather and wind conditions: clear, calm, wind 0-2 kts.

					Nutrients (μg-at/ℓ)				
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	2.2	17.489	0.03	13.01	0.09	0.13	2.18	0.339	
5	1.8	21.055	0.56	11.25	0.03	0.09	0.21	2.260	

Station Location and Number: P-28 Prudhoe Bay
Date: 9/14/75
Time: 1130
Air temperature: 4.4°
Secchi disc depth: --
Water depth: 20'
Local weather and wind conditions: clear, calm, wind 0-2 kts.

			Nutrients (µg-at/ℓ)					Chl. *a*	Prim. Prod.
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	$(mg\ C/m^3 \cdot hr)$
0	1.5	19.314	0.16	12.64	0.03	0.13	0.21	1.048	
20	.3	23.530	1.09	11.20	0.28	0.27	0.21	0.744	

Station Location and Number: P-29 Prudhoe Bay Date: 9/14/75 Time: 1200

Air temperature: 4.4° Secchi disc depth: -- Water depth: 19'

Local weather and wind conditions: clear, calm, wind 0-2 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. ($mg\ C/m^3 \cdot hr$)
0	.3	21.759	0.45	9.96	0.12	0.15	--	0.246	
19	0	23.587	1.31	11.25	0.21	0.36	--	0.777	

Station Location and Number: P-30 Prudhoe Bay

Date: 9/14/75

Time: 1300

Air temperature: 4.4°

Secchi disc depth: --

Water depth: 15'

Local weather and wind conditions: clear, calm, wind 0-2 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	Chl. a (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	1.9	17.261	0.33	13.83	0.04	0.18	--	0.173	
15	.6	22.801	--	--	--	--	--	2.330	

Station Location and Number: P-31 Prudhoe Bay

Date: 9/16/75

Time: 1015

Air temperature: 3.0

Secchi disc depth: --

Water depth: 15'

Local weather and wind conditions: partly cloudy, swells, wind 5-10 kts.

Depth	T	S°/∘∘	PO_4	Si	Nutrients (μg-at/ℓ) NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	2.2	17.600	--	--	--	--	--	0.642	
15	1.4	20.872	--	--	--	--	--	0.744	

Station Location and Number: P-32 Prudhoe Bay Date: 9/16/75 Time: 1030

Air temperature: 3.0° Secchi disc depth: -- Water depth: 20'

Local weather and wind conditions: partly cloudy, swells, winds 5-10 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	1.2	22.217	--	--	--	--	--	1.180	
20	1.1	22.258	--	--	--	--	--	0.702	

Station Location and Number: P-33 Prudhoe Bay

Date: 9/16/75

Time: 1100

Air temperature: 3.0

Secchi disc depth: --

Water depth: 15'

Local weather and wind conditions: partly cloudy, swells, wind 5-10 kts.

Depth	T	S°/₀₀	Nutrients (μg-at/ℓ)					Chl. *a*	Prim. Prod.
			PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	($mg\ C/m^3 \cdot hr$)
0	1.9	20.767	--	--	--	--	--	0.363	
15	1.5	21.274	--	--	--	--	--	0.744	

Station Location and Number: P-34 Prudhoe Bay Date: 9/16/75 Time: 1130

Air temperature: 3.0° Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: partly cloudy, swells, winds 5-10 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/oo	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	2.0	14.567	--	--	--	--	--	0.630	
7	3.0	18.690	--	--	--	--	--	0.879	

Station Location and Number: P-35 Prudhoe Bay Date: 9/16/25 Time: 1400

Air temperature: 3.0° Secchi disc depth: -- Water depth: 6'

Local weather and wind conditions: partly cloudy, swells, wind 5-10 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	2.1	20.067	--	--	--	--	--	0.702	
6	2.0	20.094	--	--	--	--	--	0.879	

Station Location and Number: P-36 Prudhoe Bay Date: 9/16/75 Time: 1430

Air temperature: 3.0 Secchi disc depth: -- Water depth: 7'

Local weather and wind conditions: partly cloudy, swells, winds 5-10 kts.

			Nutrients (μg-at/ℓ)						
Depth	T	S°/∘∘	PO_4	Si	NO_3	NO_2	NH_4	Chl. *a* (mg/m^3)	Prim. Prod. (mg C/m^3·hr)
0	2.0	20.071	--	--	--	--	--	0.375	
7	1.7	20.097	--	--	--	--	--	0.545	

Station Location and Number: P-37 Prudhoe Bay

Date: 9/16/75

Time: 1500

Air temperature: 3.0

Secchi disc depth: --

Water depth: 5'

Local weather and wind conditions: partly cloudy, swells, wind 5-10 kts.

					Nutrients (μg-at/ℓ)			Chl. *a*	Prim. Prod.
Depth	T	S°/₀₀	PO_4	Si	NO_3	NO_2	NH_4	(mg/m^3)	(mg C/m^3·hr)
0	2.0	19.916	--	--	--	--	--	0.744	
5	2.0	19.930	--	--	--	--	--	0.507	

* U.S. Government Printing Office: 1976-679-559/454 Region 8