Environmental Assessment of the Alaskan Continental Shelf

Volume 2

Principal Investigators' Reports
October–December 1976

VOLUME 1. RECEPTORS (BIOTA):
MARINE MAMMALS; MARINE BIRDS; MICROBIOLOGY

VOLUME 2. RECEPTORS (BIOTA):
FISH; PLANKTON; BENTHOS; LITTORAL

VOLUME 3. EFFECTS; CONTAMINANT BASELINES; TRANSPORT

VOLUME 4. HAZARDS; DATA MANAGEMENT

Environmental Assessment of the Alaskan Continental Shelf

October-December 1976 quarterly reports from Principal Investigators participating in a multi-year program of environmental assessment related to petroleum development of the Alaskan Continental Shelf. The program is directed by the National Oceanic and Atmospheric Administration under funding from and for use by the Bureau of Land Management.

ENVIRONMENTAL RESEARCH LABORATORIES
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Quarterly Report

Contract #03-5-022-56
Research Unit #5
Task Order #15
Reporting Period 10/1 - 12/31/76
Number of Pages 4

THE DISTRIBUTION, ABUNDANCE, DIVERSITY AND PRODUCTIVITY OF BENTHIC ORGANISMS IN THE BERING SEA

Dr. Howard M. Feder
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

January 1, 1977

I. Task Objectives

A. Qualitative and quantitative census of dominant species within oil lease sites.

B. Description of seasonal and spatial distribution patterns, with emphasis on assessing patchiness and correlation with microhabitat.

C. Comparison of species distribution with physical, chemical and geological factors.

D. Observations of biological interrelationships in benthic biota of the study area.

II. Field and Laboratory Activities

A. No cruise was scheduled during the last quarter.

B. A continuation of the analysis of grab and trawl samples taken in the past year is in progress at the Marine Sorting Center and the biological laboratory of the Institute of Marine Science. All data is being keypunched as it becomes available. Refinement of computer programs developed for the Gulf of Alaska studies is in progress. The methods used in Cluster Analysis are outlined in the Annual Report for the Gulf of Alaska (Feder, et al., 1976, *The Distribution, Abundance, Diversity and Productivity of Benthic Organisms in the Bering Sea*).

GRAB PROGRAM

III. Results

1. A selected set of stations from the cruise of the *R/V Discoverer* in 1975 have been processed by the Marine Sorting Center. This data has been keypunched, and analysis, inclusive of cluster analysis, will take place when 60 selected stations on the MB grid have been completely processed.

2. The samples listed below have been processed by the Marine Sorting Center during the past quarter (up to 12/20/76). It is anticipated that analysis of the entire grid (comprised of at least 60 stations) will begin in mid-January.

Station (MB Number)	Replicate Grabs	Station (MB Number)	Replicate Grabs
1	1-5	20	1-5
2	1, 2, 3	23	1-5
3	1-5	24	1, 2, 5
4	1, 2, 3	27	1-5
6	1-5	28	1, 2, 4, 5, 6
8	2-6	35	1, 2, 3, 5
10	2-6	39	1-5
11	2-6	42	1-5
12	1, 2, 4, 5	43	2-5
19	2-6	59	3-6

An additional series of stations from the 1975 *Discoverer* cruise and selected stations from the 1976 *Miller Freeman* cruises have been given to the Marine Sorting Center to broaden overall coverage. Mr. Karl Huflinger, graduate student on the program, is now actively involved in processing of infaunal material to directly aid in the expansion of coverage of the shelf.

3. Refinement of computer programs used in the Gulf of Alaska benthic investigation has progressed. One set of the Clustering Programs has been modified to accept the increased number of stations involved in the grid in the Bering Sea.

4. All grab programs have been modified to accept the 12-digit species code decided upon by the Marine Sorting Center and NOAA.

5. Pipe dredge material taken in Leg III of the *Miller Freeman* Bering Sea cruise of 1976 is now being rough sorted. Major groups and species will be separated. Clam species will be very carefully sorted to enable growth and mortality studies on Bering Sea species to commence. Genera and species to be particulary carefully sorted are *Nuculana spp; Yoldia spp., Muscula spp., Clinocardium spp., Cyclocardia spp.,* and *Tellina lutea.* Preliminary comparisons with Grab Data and Stomach Analytical Data from the same stations will be made.

IV. Preliminary Interpretation of Results

No preliminary interpretations of the grab available as yet. It is anticipated that additional stations will be given to the Sorting Center for processing in the coming quarter. It is currently projected that numerical analysis will be initiated by mid-January 1977.

Coordination between the Gulf of Alaska and the Bering Sea projects has been initiated to facilitate programming compatability, and it is anticipated that cluster analysis will proceed smoothly once initiated in January.

V. Problems Encountered

The nature of the substrate in many of the stations sampled in the Bering Sea is such that considerable time is needed to process each grab sample for each station. Thus, the cost per sample in the Bering Sea is higher than originally anticipated. A careful selection of stations to be processed has been made, and these stations are double checked as they are completed to avoid processing of extra samples. The end result of this unexpected problem is a slower completion rate of samples in the Bering Sea as compared to the Gulf of Alaska. In addition, a reduced grid of stations will be processed as compared to the extensive coverage originally anticipated. It is anticipated that a continuing problem in the sorting of materials will ensue; thus, it is probable that a full second-year coverage will not be possible. Instead, only a limited number of selected stations will be processed for comparison over a wide area on the Bering Sea grid.

TRAWL PROGRAM

III. Results

A. Benthic invertebrates obtained on Legs I, II, and III of the *Miller Freeman* in 1975 have been processed, all field notes verified, data key punched, and printed out in detail by station.

B. Benthic invertebrates obtained on Legs I and II of the *Miller Freeman* in 1976 have been processed, field notes verified, data key punched, and printed out in detail by station. Verification of Leg III data is completed, key punched, and preliminary printouts produced. The latter printouts will be checked and completed in the next quarter.

C. A cumulative species list for both summer's trawling activities is no being verified to include Leg III 1976 data.

D. All stomach analyses recorded in the field on Leg III 1976 are being verified and organized to enable us to begin examining Bering Sea food webs. Literature on food habits of Bering Sea benthos will be analyzed in the next quarter, and preliminary food webs developed.

E. A document similar to these are produced for the epifauna of the Gulf of Alaska (see Quarterly Report for the Gulf of Alaska) is now being developed. It is anticipated that this document, a preliminary to the final report, will be well on the way to completion by the end of the next quarter.

IV. Preliminary Interpretation of Results

No interpretations at this time, however, it should be indicated that the two-summer (1975-76) trawl survey will give a rather complete coverage of the shelf epifauna, and the report in progress should give an excellent picture of the shelf epifauna in the survey area.

V. Problems Encountered

No basic problems, however, the initial decisions that (1) our survey should be primarily one of assessment of distribution and abundance of invertebrata, (2) our survey should not examine crab stomachs, and (3) the fish stomach survey by Dr. Ron Smith should have minimal and limited funding, are now proving to be seriously in error. If it had not been directly suggested that we not look at stomachs as we progressed in our assessment program (and time was available as was our desire to collect this data), we would now have a good and sound basis for benthic food webs. I would strongly suggest that we be allowed to participate, on a limited basis, in the summer of 1977 on the *Miller Freeman* cruises to obtain some of this stomach data. We will suggest this in a short proposal to be submitted shortly.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 15 R.U. NUMBER: 5/303

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		
Discoverer Leg I #808	5/15/75	5/30/75	*	None		
Discoverer Leg II #808	6/2/75	6/19/75	*	None		
Miller Freeman	8/16/75	10/20/75	(a)	submitted		
Miller Freeman	3/76	6/76	(a)	(a)		

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

(a) These materials will be archived. Selected samples will be processed in FY '77, providing project is funded.

* That portion of cruise 808 grabs sorted, were submitted. The remainder will receive top priority in FY '77 providing projest is funded.

QUARTERLY REPORT

Contract No. 03-5-022-68, Task Order 5
Research Unit #6
Reporting Period: 1 October - 30 December 1976

The distribution, abundance, diversity and productivity of the western Beaufort Sea benthos.

Andrew G. Carey, Jr., Principal Investigator
School of Oceanography
Oregon State University
Corvallis, Oregon 97331

December 24, 1976

John J. Dickinson

I. Task Objectives

A. General nature and scope of the problem

The distribution, abundance and natural variability of benthic macrofauna will be described on the southwestern Beaufort Sea continental shelf. Patterns of faunal distributions will be described and characterized using suitable bio-indices and multivariate techniques. Seasonal changes in the structure of benthic populations will be studied by sampling four times within a single year.

B. Specific Objectives

We propose to describe the benthic infauna of the western Beaufort Sea continental shelf including studies of both geographic and seasonal variability. Data are to be obtained on the faunal composition and abundance to form baselines to which potential future changes can be compared.

Specific objectives include the continuation of studies and analyses to:

1. Describe the distribution, species composition, numerical density, and biomass of the benthos in the area of interest.
2. Describe the spatial and seasonal variability of faunal distributions and abundances.
3. Describe the benthic communities present and delineate their geographical and environmental extent.
4. Describe the effect of seasons on population size and reproductivity activity of dominant species.
5. Determine the degree of correlation of species distributions and of various bio-indices with features of the benthic environment.

II. Research Activities

A. Field Activities - OCS-6

1. Ship schedule

During the period 27 October - 14 November, the sixth seasonal Arctic field trip (OCS-6) was staged out of the Naval Arctic Research Laboratory, Barrow, Alaska.

2. Scientific Party

James Gish	O.S.U.	Party Chief
Dr. John Dickinson	O.S.U.	Research Associate
Gail Erskine	O.S.U.	Research Assistant
Frank Ratti	O.S.U.	Graduate Student

3. Methods

Benthic sampling of the Pitt Point Transect was accomplished by using a NOAA UH-1H helicopter to fly from Barrow to the stations. The station locations were determined utilizing the on-Track Navigation System available on the helicopter. This method was an improvement over the range and bearing techniques previously employed. The actual benthic sampling involved cutting a 4' X 4' hole in the ice, and lowering a Smith-MacIntyre grab to the sea floor. The details of the sampling procedure have been discussed in previous reports. Ice conditions during this field trip were close to optimal since it was usually possible to find a freshly frozen lead adjacent to thicker ice upon which the helicopter could safely be landed.

After sampling was completed each day, the party flew back to NARL for gear maintenance and sample processing. The biological samples were washed with a Cascading Multiple Sieve System using a high water capacity pump. The sample washing was done in a heated hydro hut off the beach at NARL. The washed samples were preserved in buffered formalin and shipped back to Oregon for laboratory analysis.

4. Sample Localities

All stations occupied during OCS-6 were located on the Pitt Point Transect. Despite limited daylight and poor weather, four of the five stations were sampled. Closing in of the Arctic night prevented sampling of PPB-40.

5. Four stations (PPB-25, PPB-55, PPB-70 and PPB-100) were successfully sampled with five biological samples and one sediment sample taken at each station. Table 1 summarizes the data collected during OCS-6.

C. Laboratory Activities

1. Personnel

a. Andrew G. Carey, Jr. Principal Investigator
Associate Professor

Responsibilities: coordination, evaluation, analysis, and reporting.

b. John J. Dickinson Research Associate Postdoctoral

Responsibilities: direction of laboratory personnel, gammarid Amphipod systematics, sample processing, data compilation and analysis, and field collection.

Table 1. List of Stations, Cruise OCS-6.

Station Number	Date (1976)	Position	Depth (meters)	Number of Samples
PPB-25	11 Nov.	71°12.0N 152°49.0W	30	6
PPB-55	4 Nov.	71°17.6N 152°43.4W	53	6
PPB-70	2 Nov.	71°20.3N 152°37.8W	66	6
PPB-100	3 NOv.	71°21.9N 152°33.4W	99	6

c. R. Eugene Ruff Research Assistant

Responsibilities: species list compilation, bottom photo analysis, and reporting.

d. James B. Gish Research Assistant

Responsibilities: data management, statistical analysis, and field collection.

e. Paul Montagna Research Assistant

Responsibilities: sample processing, biomass, and Harpacticoid Copepod systematics.

f. Paul Scott Research Assistant

Responsibilities: sample processing, and Mollusc systematics.

Terminated: 30 November 1976

g. Gail Erskine Research Assistant

Responsibilities: Arctic bibliography, sample processing, and field collection.

Terminated: 30 November 1976

2. Methods

The techniques for sample processing have not been altered this quarter. New methods of data management have recently been implemented to speed up the transfer of data to computer format. Identification of the gammarid amphipods has been initiated this quarter utilizing standard techniques for this animal group as described by J.L. Barnard (1969) in Bulletin 271 of U.S. National Museum.

3. Data Analyzed

Eighty-six Smith-McIntyre grab samples from OCS-1, OCS-2 and OCS-3 have been sorted to phyla. Determinations of animal density and biomass have also been completed for the first three field trips.

Ninety-five grab samples from OCS-4, OCS-5 and OCS-6 remain to be sorted to phyla.

The gammarid amphipods from OCS-1 have been identified to species. Systematic studies of molluscs have been initiated this quarter. The Pelecypods and Gastropods are being sorted to family as a preliminary step to species identification.

III. Results

A. Field Activities

The benthic sampling conducted during OCS-6 was the fifth seasonal sampling of the Pitt Point Transect within a year. This sample set will form the basis of a study of seasonal variability of the benthos on the Beaufort Sea continental shelf.

B. Laboratory Results

1. Biomass

Wet weights for all OCS-3 samples have been determined this quarter using methods described previously. Animals of six major phyla and one group of miscellaneous phyla have been weighed for each sample (Table 2).

2. Faunal Density

Animal densities have been dtermined for all OCS-1, OCS-2 and OCS-3 samples (Tables 3-15). Animal numbers are reported for each phyla and totaled for each grab. Since the Smith-McIntyre grab samples 0.1 m^2 of the sea floor, the densities reported can be converted to a m^2 basis using a multiplicative factor of ten.

Table 2. OCS-[illegible] Wet Weights in Grams. Pitt Point Transect.

Station and grab number	Anthozoa	Sipuncula	Annelida	Arthropoda	Mollusca	Echinodermata	Misc. Phyla
PPB-25							
1141			4.61± (1.81)	0.39	2.07		0.02
1142			0.10	0.32	0.39		0.01
1143			1.14	0.06	0.18		0.02
1144*			0.57	0.05	0.01		+
1145*			0.59	0.05	0.10		7.90± (0.05)
1146	0.02	0.02	0.01	0.03	0.24		0.03
1147*			0.03	0.02			
1149*			3.17	0.08	0.05		0.02
1150			0.84	0.25	0.10		
PPB-40							
1182			1.33	0.06	0.19	0.16	0.24
1187	0.02		3.30	0.10	14.90± (2.23)	4.14	0.02
1188	0.01	0.01	3.04	0.03	1.27	0.44	0.08
1190	0.01		3.28	0.21	1.35	0.01	0.03
PPB-55							
1151	0.09	0.01	0.63	0.58	3.13± (0.34)	0.01	0.06
1155	0.19	0.07	0.51	1.07	4.73± (1.18)	0.01	0.07
1156	0.20	0.03	0.43	0.97	0.23	0.03	0.22
1158	0.43	0.04	0.88	1.52	1.06	0.02	0.09
1159	0.19	0.06	0.74	0.86	9.46± (1.00)		0.13
1160*	0.05	0.04	0.71	1.47	9.07± (1.19)	0.01	0.08
PPB-70							
1171	0.01	0.47	2.13	1.57	0.44	0.22	0.25
1173	0.02	0.36	2.24	1.16	1.88± (0.56)	0.48	0.10
1174	0.07	0.04	2.14	1.52	0.60	3.30	0.34
1178	0.06	0.28	6.88± (2.57)	0.58	0.30	2.39	0.02
1180	0.04	0.10	1.14	0.79	1.97	1.58	0.04
PPB-100							
1161	0.21	0.09	2.09	1.00	32.53± (0.62)	3.85	0.1
1162	0.40	0.49	4.41	1.42	4.66± (0.67)	7.64	0.23
1166	0.15	0.10	2.28	0.82	4.75± (1.26)	0.01	0.12
1168	0.26	0.25	3.80	0.81	0.25	0.30	0.26
1169	0.14	0.02	10.16± (4.01)	0.80	9.11± (1.01)	0.01	0.12

* = Non quantitative grabs

\+ = Present but weighs less 0.01 g.

± = Biomass biased by rare large specimen, number in parenthesis is weight excluding large organism.

Table 3. Animal Densities for Station PPB-25 (OCS-1) collected on 22 October 1975.

	Grab Number					
Phylum: Class: Order	1082	1083	1084	1085	1087	Total
Protozoa: Rhizopodea: Foraminifera	+	+	+	+	+	+
Cnidaria: Hydrozoa	+	+	+	+	+	+
Nematoda	17			3	7	27
Nemertinea	2				1	3
Annelida: Polychaeta	110	66	88	52	47	363
Sipuncula	2					2
Arthropoda: Crustacea: Amphipoda	10	9	4	1	17	41
Isopoda	3	3	1			7
Ostracoda	5	1		1	2	9
Tanaidacea	10	1	1		4	16
Cumacea	7	2	1	1		11
Mollusca: Bivalvia	64	56	51	12	27	210
Gastropoda	5	1	2			8
Echinodermata: Holothuroidea	1					1
TOTAL	236	139	148	70	105	698

+ = Colonial forms, no count

Table 4. Animal densities for Station PPB-55 (OCS-1) collected on 29 October 1975.

Phylum: Class: Order	Grab Number 1088	1089	1090	1091	1092	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+
Porifera	3				2	5
Cnidaria: Hydrozoa	+	+	+	+	+	+
Anthozoa	6	3	11	7	4	31
Nematoda	67	23	24	72	46	232
Nemertinea	9	5	4	6	1	25
Annelida: Polychaeta	247	116	179	116	96	754
Sipuncula	5	6	2	4	7	24
Echiura	11	4	6	4		25
Arthropod: Crustacea: Amphipoda	182	40	76	175	85	558
Cirripedia	3					3
Harpacticoida	4	1			3	8
Decapoda	1	1				2
Isopoda	4	1	1	3	1	10
Ostracoda	141	53	71	134	67	466
Tanaidacea	26	8	9	31	5	79
Cumacea	29	9	20	19	13	90
Pycnogonida					1	1
Mollusca: Bivalvia	35	15	29	33	18	130
Gastropoda	5		3	3	4	15
Aplacophora				1	1	2
Bryozoa	+	+	+	+	+	+
Brachiopoda	1			1	1	3
Echinodermata: Holothuroidea	2	1				3
Ophiuroidea	3	2		2		7
Hemichordata		1				1
TOTAL	784	289	435	611	355	2,474

+ = Colonial forms, no count

Table 5. Animal Densities for Station PPB-100 (OCS-1) collected on 30 October 1976.

Phylum: Class: Order	Grab Number 1093	1094*	1095	1096	1097	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+
Porifer	3			1		4
Cnidaria: Hydrozoa	+	+	+	+	+	+
Anthozoa	7		2	2		11
Nematoda	604	13	244	68	10	939
Nemertinea	5		5	2		12
Annelid: Polychaeta	204	20	192	244	40	760
Sipuncula	7		4	3	1	15
Priapulida	3		2			5
Arthropoda: Cructacea: Amphipoda	117	6	51	36	15	225
Cirripedia	1					1
Harpactidoida	75		4	2		81
Isopoda	43		2	10		55
Ostracoda	290	22	48	94	2	456
Tanaidacea	9		2			11
Cumacea	36	1	13	12		62
Nebaliacea			1			1
Pycnogonida	1					1
Mollusca: Bivalvia	34	6	24	7	1	72
Gastropoda	7		2	2		11
Aplacophora	1		1	1		3
Polyplacophora	1					1
Bryozoa	+	+	+	+	+	+
Brachiopoda	2			4		6
Echinodermata: Ophiuroidea	31	2	2	2		37
TOTAL	1,481	70	599	490	69	2,709

+ = Colonial forms, no count

* = Non-quantitative grab

Table 6. Animal densities for station PPB-25 (OCS-2) collected on 12 March 1976.

	Grab Number										
Phylum: Class: Order	1098	1099	1100	1101	1102	1103	1104	1105	1106*	1107	Total
Protozoa: Rhizopodea: Foraminiferida		+			+	+		+			+
Porifera		+									+
Cnidaria: Hydrozoa				+	+		+	+			+
Nematoda		1			1			2	2	9	15
Nemertinea	2	1	1		2		1	3	2	4	16
Annelida: Polychaeta	76	106	58	56	155	40	116	155	88	107	957
Arthropod: Crustacea: Amphipoda	13	3	3	1	8		2	3	5	2	40
Harpacticoida					1		1			1	3
Isopoda	3	2			3				1	2	11
Ostracoda					2						2
Tanaidacea				1	2	1	1	2		2	9
Cumacea	1	1			3			1			6
Mollusca: Bivalvia	37	14	7	7	20	1	24	11	2	8	131
Gastropoda	3							3			6
Bryozoa					+		+	+		+	+
Echinodermata: Ophiuroidea	1										1
TOTAL	136	128	69	65	197	42	145	180	100	135	1,197

+ = Colonial forms, no count

* = Non-quantitative grab

Table 7. Animal densities for station PPB-40 (OCS-2) collected on 15 March 1976.

	Grab Number						
Phylum: Class: Order	1115	1116	1117	1118	1119	1120	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+	+
Cnidaria: Hydrozoa	+	+	+		+		+
Anthozoa	1				1	2	4
Nematoda	34	5	26	1	4	5	75
Memertinea	9	4			1	3	17
Annelida: Polychaeta	65	29	27	7	23	26	177
Sipuncula			1			2	3
Arthropoda: Crustacea: Amphipoda	20	9	6	4	9	11	59
Harpacticoida	1						1
Isopoda					1		1
Ostracoda	2	9			1		12
Tanaidacea	2	1			1	1	5
Cumacea	9	4	1		2	6	22
Mollusca: Bivalvia	5	3	1	1		11	21
Gastropoda		2					2
Bryozoa	+	+	+	+		+	+
Echinodermata: Ophiuroidea	2		1				3
Chordata: Ascidacea						1	1
TOTAL	150	66	63	13	43	68	403

+ = Colonial forms, no count

Table 8. Animal densities for station PPB-44 (OCS-2) collected on 18 March 1976.

	Grab Number										
Phylum: Class: Order	1121	1122	1123	1124*	1125	1126	1127*	1128	1129*	1130	Total
Protozoa: Rhizopoda, Foraminiferida	+	+	+	+	+	+	+	+	+	+	+
Cnidaria: Hydrozoa	+	+	+	+	+	+	+	+	+	+	+
Anthozoa		2	2		1	3			1	2	11
Nematoda	35	20	81	1	3	14	8	2	3	35	202
Nemertinea	2	14	25	1	2	2	2			4	52
Annelida: Polychaeta	109	118	127	16	17	92	38	32	43	123	715
Sipuncula	5	3	16	1	2	9	1	6	1	8	52
Echiura	1		1								2
Arthropoda: Crustacea: Amphipoda	115	112	148	9	9	55	9	13	8	95	573
Cirripedia	1		2								3
Harpacticoida	5	1	5			2				4	17
Isopoda	2		5								7
Ostracoda	116	126	241	4	7	88	29	8	9	139	767
Tanidacea	24	13	51	2	5	22	5	5	13	27	167
Cumacea	40	26	20			8				2	96
Pycnogonida	2	1	2								5
Mollusca: Bivalvia	59	34	42		4	22	11	1	7	24	204
Gastropoda	13	5	3			1					22
Aplacophora		1									1
Bryozoa	+	+	+	+		+	+	+	+	+	+
Brachiopoda			3								3
Echinodermata: Ophiuroidea	5	1					1				7
Crinoidea										1	1
Hemichordata		1	1			1			1		4
Chordata: Ascidacea			1				3			1	5
TOTAL	534	478	776	34	50	319	107	67	86	465	2,916

+ = Colonial forms, no count

* = Non-quantitative grab

Table 9. Animal densities for station PPB-70 (OCS-2) collected on 13 March 1976.

Phylum: Class: Order	Grab Number 1108	1109	1110	1111	1114	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+
Porifera			2	1	1	4
Cnidaria: Hydrozoa	+	+	+	+	+	+
Anthozoa		5	2	2	4	13
Nematoda	7	14	9	28	6	64
Nemertinea	3	5	1	4	1	14
Annelida: Polychaeta	186	292	93	226	127	924
Sipuncula	68	140	10	50	15	283
Echiura	12	13		8	1	34
Arthropoda: Crustacea: Amphipoda	156	412	105	219	237	1,129
Cirrepedia	1	1				2
Harpacticoida	1	9		1	1	12
Isopoda	4	23	5	6	1	39
Ostracoda	166	685	122	173	128	1,274
Tanaidacea	21	103	5	17	16	162
Cumacea	24	62	19	33	34	172
Pycnogonida		2	1	2		5
Mollusca: Bivalvia	32	49	28	33	24	166
Gastropoda	2	5	10	2	2	21
Bryozoa	+	+	+	+	+	+
Phoronida					1	1
Brachiopoda			1			1
Echinodermata: Ophiuroidea	4	4	2	5	3	18
Chordata: Ascidacea	1					1
TOTAL	688	1,824	415	810	602	4,339

+ = Colonial forms, no count

Table 10. Animal densities for station PPB-100 (OCS-2) collected on 19 March 1976.

Phylum: Class: Order	Grab Number 1131	1132	1133	1134	1135	1136*	1137	1138	1139	1140	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+	+	+	+	+	+
Porifera	1	1				1	2		3		8
Cnidaria: Hydrozoa	+	+	+	+	+	+	+	+	+	+	+
Anthozoa	5	6	2	2	1	5	11	3	7	4	46
Nematoda	155	36	56	7	20	36	138	29	40	18	535
Nemertinea	22	14	3	2	3	2	12	1	3	3	65
Annelida: Polychaeta	217	131	96	37	60	87	270	103	140	94	1,235
Sipuncula	8	5	4		4	1	8	2	6		38
Echiura			1		1				1		3
Arthropoda: Crustacea: Amphipoda	124	69	94	10	31	47	176	82	166	39	838
Cirrepedia	1										1
Harpacticoida	11	1			1	1	8	3	1	3	29
Isopoda	23	2	5		1	1	16	6	4	2	60
Ostracoda	266	71	117	13	32	31	230	54	104	62	980
Tanaidacea	44	18	4	1	10	13	47	7	12	3	159
Cumacea	47	16	29	5	11	9	48	11	26	10	212
Pycnogonida		2			6	1	1				10
Mollusca: Bivalvia	30	10	17	7	7	11	18	14	14	16	144
Gastropoda	5		3				7		1	3	19
Aplacophora	1							1	1		3
Polyplacophora	1						1		1		3
Bryozoa	+	+	+	+	+	+	+	+	+	+	+
Brachiopoda	2	1	1	1		1	10	1	2		19
Echinodermata: Ophiuroidea	18	3	21	1	1	1	1	1	3	3	53
Hemichordata								1			1
Chordata: Ascidacea	3						2				5
TOTAL	984	386	453	86	189	248	1,006	319	535	260	4,466

+ = Colonial forms, no count

* = Non-quantitative grab

Table 11. Animal densities for station PPB-25 (OCS-3) collected on 17 May 1976.

Phylum: Class: Order	Grab Number 1141	1142	1143	1144*	1145*	1146	1147*	1149*	1150	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+	+	+	+	+
Cnidaria: Hydrozoa	+	+		+	+	+	+			+
Anthozoa	1	1				1		1		4
Nematoda	8	2	7	1		1				19
Nemertinea	4	1			1	3		1		10
Annelida: Polychaeta	125	15	30	15	29	58	4	85	10	371
Sipuncula						2				2
Acathpopoda: Crustacea: Amphipoda	5	5	3	6	1	1	1	4	3	29
Cirrapedia		3								3
Harpacticoida				2						2
Isopoda	3	1								4
Ostracoda	1	2	8	3						14
Tanaidacea	5	1	7	2		8		2		25
Cumacea	6	2	1			3		1	1	14
Mollusca: Bivalvia	13	13	4	1	1	5		1	1	39
Gastropoda	1					1			1	3
Bryozoa		+	+						+	+
Echinodermata: Ophiuroidea						1				1
TOTAL	172	46	62	28	32	84	5	95	16	540

+ = Colonial forms, no count

* = Non-quantitative grab

Table 12. Animal densities for station PPB-40 (OCS-3) collected on 27 May 1976.

Phylum: Class: Order	Grab Number 1182	1187	1188	1189	1190	Total
Protozoa: Rhizopodea: Foraminiferida				+	+	+
Cnidaria: Hydrozoa		+		+		+
Anthrozoa		2		2	1	5
Nematoda	39	24	9	112	32	216
Nemertinea	3	3	4	6	3	19
Annelida: Polychaeta	41	71	50	52	48	262
Sipuncula				1		1
Arthropoda: Crustacea: Amphipoda	8	7	4	7	10	36
Harpacticoida				2	2	4
Nebaliacea	1					1
Ostracoda		1	2	5	3	11
Tanaidacea	3	2	4	26	3	38
Cumacea	8	8	2	7	7	32
Mollusca: Bivalvia	2	8	6	8	8	32
Gastropoda	3	3	3	2	5	16
Aplacophora			1		2	3
Bryozoa	+	+	+	+	+	+
Echinodermata: Ophiuroidea	2		3	2	1	8
Asteroidea		1				1
TOTAL	110	130	88	232	125	685

+ = Colonial forms, no count

Table 13. Animal densities for PPB-55 (OCS-3) collected on 20 May 1976.

Phylum: Class: Order	Grab Number 1151*	1155	1156	1158	1159	1160	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+	+
Porifera			6			5	11
Cnidaria: Hydrozoa	+	+	+	+	+	+	+
Anthozoa	6	7	4	16	12	8	53
Nematoda	91	77	93	321	191	140	913
Nemertinea	5	6	7	10	8	16	52
Annelida: Polychaeta	90	142	167	176	150	211	936
Sipuncula	3	7	7	8	13	15	53
Arthropoda: Crustacea: Amphipoda	101	114	174	250	141	189	969
Cirripedia						1	1
Harpactidoida	6	1	3	18	14	11	53
Isopoda		1		12	6	17	36
Ostracoda	73	98	121	834	378	317	1,821
Tanaidacea	25	20	16	79	30	31	201
Cumacea	22	24	38	47	26	40	197
Decapoda		1		1			2
Pycnogonida				2			2
Arachnida: Acarina			3		3	6	12
Mollusca: Bivalvia	31	47	36	56	77	80	327
Gastropoda	10	1	7	4	12	13	47
Aplacophora	1			3			4
Bryozoa	+	+	+	+	+	+	+
Brachiopoda		1	2		5	3	11
Echinodermata: Ophiuroidea	1	1	2	5		1	10
Chordata: Ascidacea			4		1	5	10
TOTAL	465	548	690	1,842	1,067	1,109	5,721

+ = Colonial forms, no count

* = Non-quantitative grab

Table 14. Animal densities for PPB-70 (OCS-3) collected on 26 May 1976.

Phylum: Class: Order	Grab Number 1171	1173	1174	1178	1180	Total
Protozoa: Rhizoporea: Foraminiferida	+	+	+	+	+	+
Porifera	1	+	3	+	3	7
Cnidaria: Hydrozoa	+	+	+	+	+	+
Nematoda	39	44	24	27	43	177
Nemertinea	5	4	1	3	5	18
Annelida: Polychaeta	68	119	90	89	191	557
Sipuncula	40	44	7	19	18	128
Arthropoda: Crustacea: Amphipoda	158	266	152	135	113	824
Harpacticoida	1	6	1			8
Isopoda	2	2	4	2	3	13
Ostracoda	181	700	247	142	265	1,535
Tanaidacea	29	49	9	21	15	123
Cumacea	34	48	21	34	31	168
Pycnogonida		2			2	4
Mollusca: Bivalvia	44	59	32	32	47	214
Gastropoda	4	16	3	5	6	54
Aplacophera	1					1
Bryozoa	+	+	+	+	+	+
Brachiopoda	1	2	1		1	5
Echinodermata: Holothuroidea				1		1
Ophiuroidea	1	4	7	3	7	22
Hemichordata		1			1	2
Chordata: Ascidacea	7	8	1	1	2	19
TOTAL	619	1,374	607	517	756	3,875

+ = Colonial forms, no count

Table 15. Animal densities for PPB-100 (OCS-3) collected on 21 May 1976.

Phylum: Class: Order	Grab Number 1161	1162	1166	1168	1169	Total
Protozoa: Rhizopodea: Foraminiferida	+	+	+	+	+	+
Porifera		4	4	1		9
Cndaria: Hydrozoa	+	+	+	+	+	+
Anthozoa	8	11	10	7	6	42
Nematoda	475	567	548	602	570	2,762
Nemertinea	12	18	12	2	6	50
Annelida: Polychaeta	327	381	273	177	381	1,539
Sipuncula	6	30	10	18	10	74
Arthropoda: Crustacea: Amphipoda	243	301	154	122	193	1,013
Harpacticoida	4	13	5	10	9	41
Isopoda	36	32	17	9	18	112
Ostracoda	361	386	192	259	354	1,552
Tanaidacea	56	46	28	32	31	193
Cumacean	65	78	66	33	43	285
Pycnogonida	1	1		2	1	5
Arachnida: Acarina		1	1		1	3
Mollusca: Bivalvia	33	48	55	19	65	218
Gastropoda	5	7	6	3	2	23
Aplacophora	2	1		1		4
Polyplacophora	1	1				2
Bryozoa	+	+	+	+	+	+
Brachiopoda	8	7	2	6	8	31
Echinodermata: Holothuroidea					3	3
Ophiuroidea	9	17	2	1	2	31
Chordata: Ascidacea		7	7	1		15
TOTAL	1,652	1,957	1,392	1,305	1,701	8,007

+ = Colonial forms, no count

3. Gammarid Amphipods

All the gammarid amphipods from OCS-1 have been identified to species (Tables 16-18). Sixty-one species including representatives of seventeen families were found in these collections. The amphipods from OCS-2 are now being identified, and will be completed next quarter.

IV. Preliminary Results

It would be premature to discuss interpretations of the results available at present.

V. Problems Encountered

No major difficulties developed this quarter in either field work or laboratory analysis.

Table 16. The gammarid amphipods from PPB-25 collected OCS-1. Twelve species were represented in the 31 specimens.

Family	mean number/.1 m^2	Frequency	Rank
Ampeliscidae			
Ampelisca eschricti	0.4	1/5	3
Byblis gaimardi	0.4	1/5	3
Haploops sibirica	0.2	1/5	4
Haploops tubicola	0.8	2/5	1
Corophiidae			
Goesia depressa	0.2	1/5	4
Eusiridae			
Pontogeneia sp. AA	0.6	3/5	2
Gammaridae			
Gammarus sp. AA	0.6	2/5	2
Lysianasidae			
Tryphosella sarsi	0.2	1/5	4
Oedicerotidae			
Aceroides latipes	0.6	2/5	2
Arrhis phyllonyx	0.8	2/5	1
Monoculodes tuberculatus	0.2	1/5	4
Stenothidae			
Metopa spinicoxa	0.2	1/5	4
Metopa sp.	1.0	2/5	-

Table 17. The gammarid amphipods from PPB-55 collected during OCS-1. Thirty-eight species were represented in the 350 specimens.

Family	mean number/.1 m^2	Frequency	Rank
Acanthonotozomatidae			
Odius kelleri	0.2	1/5	18
Ampeliscidae			
Ampelisca birulai	1.2	2/5	13
Ampelisca eschricti	1.8	4/5	11
Byblis affinis	3.2	5/5	8
Byblis gaimardi	0.4	1/5	17
Byblis sp. BB	0.8	2/5	15
Haploops laevis	1.0	3/5	14
Haploops sibirica	0.6	2/5	16
Haploops setosa	7.0	1/5	4
Calliopiidae			
Apherusa glacialis	0.4	2/5	17
Corophiidae			
Corophium clarencense	0.6	2/5	16
Goesia depressa	3.8	3/5	6
Photis rheinhardi	2.0	5/5	10
Photis vinogradova	32.6	5/5	1
Podoceropsis lindhaldi	2.2	2/5	9
Protomedeia fasciata	2.0	2/5	10
Unciola leucopis	7.8	5/5	2
Dexaminidae			
Guernea nordenskioldi	3.2	5/5	8
Eusiridae			
Pontogeneia sp. AA	0.6	1/5	16
Rhachotropis aculeta	0.2	1/5	18
Gammaridae			
Gammarus sp. AA	0.6	3/5	16
Maera danae	0.4	2/5	17
Melita dentata	0.6	1/5	16
Ischyroceridae			
Ischyrocerus commensalis	1.4	3/5	12
Lysianassidae			
Anonyx sp. AA	0.2	1/5	18
Anonyx nugax	0.2	1/5	18

Table 17 (cont.)

Oedicerotidae			
Aceroides latipes	0.2	1/5	18
Arrhis phyllanyx	0.2	1/5	18
Bathymedon obtusifrons	0.4	2/5	17
Monoculodes borealis	0.2	1/5	18
Monoculodes tuberculatus	0.2	1/5	18
Monoculodes tesselatus	0.2	1/5	18
Westwoodilla megalops	1.8	3/5	11
Pardaliscidae			
Halics sp. AA	0.2	1/5	18
Pardaliscella lavrovi	0.2	1/5	18
Phoxocephalidae			
Harpinia serrata	5.4	5/5	5
Harpinia kobjakovae	0.2	1/5	18
Paraphoxus oculatus	3.4	5/5	7
Pleustidae			
Pleusymtes karianus	0.2	1/5	18
Podoceridae			
Paradulichia typica	0.4	2/5	17
Stenothidae			
Metopa spinicoxa	0.2	1/5	18
Metopa sp.	1.2	4/5	-
Metopella nasuta	1.2	1/5	13
Synopiidae			
Tiron spinifera	7.2	5/5	3

Table 18. The gammarid amphipods from PPB-100 collected during OCS-1. Twenty-three species were represented in the 197 specimens.

Family	mean number/0.1 m^2	Frequency	Rank
Ampeliscidae			
Byblis gaimardi	0.2	1/5	11
Haploops sibirica	5.0	2/5	1
Calliopiidae			
Apherusa glacialis	0.6	1/5	9
Corophiidae			
Photis sp.	0.4	1/5	10
Protomedeia fasciata	0.4	1/5	10
Uniciola leucopis	3.4	4/5	4
Dexaminidae			
Guernea nordenskioldi	3.0	2/5	5
Eusiridae			
Pontogeneia sp. AA	2.4	3/5	7
Gammaridae			
Gammarus sp. AA	0.4	1/5	10
Haustoridae			
Pontoporeia femorata	1.0	4/5	8
Lysianassidae			
Anonyx sp. AA	0.4	2/5	10
Anonyx nugax	2.8	1/5	6
Hippomedon abyssi	3.6	4/5	3
Tryphosites sp. AA	0.4	2/5	10
Oedicerotidae			
Bathymedon obtusifrons	2.8	4/5	6
Monoculodes diamesus	0.2	1/5	11
Monoculodes latimanus	0.6	1/5	9
Monoculodes schneideri	0.2	1/5	11
Pardaliscidae			
Pardalisca cuspidata	0.2	1/5	11
Pardaliscella lavrovi	0.4	2/5	10
Phoxocephalidae			
Harpinia kobjakovae	0.2	1/5	11
Harpinia serrata	4.6	4/5	2
Paraphoxus oculatus	3.4	3/5	4
Stenothidae			
Metopa sp.	1.0	3/5	-
Synopiidae			
Tiron spiniferum	0.2	1/5	11

Quarterly Report

R.U. 19
October 1 - December 31
Three pages

SPAWNING HERRING SURVEYS IN THE BERING SEA AND FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

Principal Investigator

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December 31, 1976

I. Task Objectives

The objectives of these research units are to:

1) Determine the spatial and temporal distribution, species composition and relative abundance of finfishes in the coastal waters of Norton Sound and Kotzebue Sound east of 166 Degrees West Longitude.

2) Determine the timing and routes of juvenile salmon migrations as well as examine age and growth, relative maturity and food habits of important species in Norton Sound and Kotzebue Sound east of 166 Degrees West Longitude.

3) Determine the spatial and temporal distribution and relative abundance of spawning populations of herring and capelin from Unimak Pass to Point Hope.

4) Monitor egg density, distribution and development and document types of spawning substrates of herring and capelin.

5) Monitor the subsistence utilization of fishery resources to local residents.

II. Field Activities

Activities during this quarter (October-December) for R.U. 19 included a continuation of data summary and analysis. All Data Management forms were completed, recorded on disketts and submitted to the Juneau Project Office for archiving with NODC. Summary and analysis of data included:

1) Analysis of aerial photographs for determining the relative abundance of herring and capelin populations.

2) Tabulation of length and age frequencies.

3) Fecundity analysis.

4) Preparation of Figures and Tables from analysis of EDS forms illustrating the spatial and temporal distribution of forage fish.

5) Construction of maps depicting spawn deposition, density and substrate-types by area.

6) Analysis of herring subsistence to local residents as well as other species.

7) Processing photographs for inclusion in report.

A first draft of the project completion report was constructed and is in the editing process for submission to the Juneau Project Office by April 1, 1977.

Activities associated with R.U. 19E involved a continuation of data summary and analysis. All Data Management forms were completed, recorded on disketts and submitted for archiving with NODC. Summary and analysis of data included:

1) Analysis of fishery resources for subsistence to local residents.

2) Analysis of herring scales for age determinations.

3) Tabulation of length frequencies.

4) Tabulation of pelagic fish catches by species, gear type, time and location.

5) Processing photographs for inclusion in the annual report due April 1, 1977.

In addition to the above, Leg II of the R/V MILLER FREEMAN cruise was completed. Results from this survey is also being summarized.

III. Results and Preliminary Interpretation

There are no changes in the results and preliminary interpretation of results as described in the quarterly report submitted for the period July through September 30, 1976, for both Research Units. No new material is submitted in this quarterly report for either Research Unit and any such data will be included in the project completion report due April 1, 1977 (R.U. 19) and the annual report due April 1, 1977 (R.U. 19E).

IV. Problems/Changes

Problems encountered this past quarter have been associated with R.U. 19. A delay in previously agreed upon funding levels imposed severe budgetary constraints on operations (i.e., termination of key personnel, elimination of originally planned computer analysis and compromises in final preparation of graphic and pictoral materials). It is hoped the budgetary restraints will not affect the quality of the final project completion report. This project has essentially been operating on a no-cost extension since October 1, 1976.

No problems have been encountered this past quarter with work conducted under R.U. 19E.

V. Estimate of Funds Expended

Verbal approval has been received for an additional $25,000 to fund final data analysis and preparation of project completion reports for two Research Units. A portion of this monies was for R.U. 19 with the remainder for R.U. 24 (RAZOR CLAM DISTRIBUTION AND POPULATION ASSESSMENT STUDY). These funds have not yet been received and the present budget is zero dollars.

Research Unit 19E was refunded for FY 77 in the amount of $150,825. An additional $100,000 for large vessel work is expected. The following figures show the FY 77 allocation and resulting balance from FY 76 carry-over monies.

	(10/1/76) FY 77 Allocation	(12/1/76) Balance 1/
Salaries	83,721	73,971
Travel & Subsistence	5,365	2,635
Contractual Services	19,580	30,680
Commodities	20,800	20,133
Equipment	8,412	9,044
10% Overhead	12,947	-
Total	150,825	136,464 2/

1/ Balance as of 12/1/76 including FY 76 carry-over.

2/ Does not include a 10% overhead charge. Operating costs and salaries only are shown.

QUARTERLY REPORT

Contract No. : 03-5-022-69
Research Unit No.: 24
Reporting Period: Oct. 1 - Dec. 31, 1976
No. of pages: 14

Razor Clam (*Siliqua patula*, Dixon) Distribution and Population Assessment Study

Rodney J. Kaiser

Daniel Konigsberg

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December 31, 1976

INTRODUCTION

This study originated to develop baseline data for open surf-swept sandy beach habitat. The initial objective was to study a target specie *Siliqua patula* (Pacific razor clam) within this habitat type. A redefining of goals by OCSEAP planners in March 1976 expanded project planning to a "reconnaissance and assessment" of all bivalves and other invertebrates present within this single habitat type.

Project goals were set to supplement ongoing NMFS studies of intertidal rocky and muddy habitats. Prominant exposure of organisms inhabitating open and relatively flat sandy beaches to oil-related effects demonstrated a need for information.

I TASK OBJECTIVES

Project objectives of this study are to determine invertebrate organisms occurring, their density and distribution within the tide levels of the low tide terrace, and substrate characteristics (composition and size) in which they live.

Various phases of other OCSEAP projects interface with this study such as the low level aerial reconnaissance photography of intertidal habitats, their location, specific slope, cover and makeup area. This will aid in exact definition of the amount of habitat available. Additionally, data gathered will correlate with field groups from Auke Bay Fisheries Laboratory (Juneau) studying organisms inhabiting muddy or rocky substrates.

Specific objectives are to gather information on bivalve density, distribution, age and growth (razor clams only), and habitat on beaches from Yakutat Bay at 139° west longitude to Unimak Bight on the Alaska Peninsula. Specific goals are:

1. Investigate selected sandy beach areas and identify each organism's location with regard to the extent of the specie's existance, density, and habitat.

2. Collect and identify all bivalves at each location and assess density, length and age composition (razor clams only) of each tide level for the entire low tide terrace.

3. Collect core samples of the substrate by tide level at each beach site to investigate substrate composition and grain size.

4. Combine past and current razor clam data for the Gulf of Alaska areas to assist in formulating the biological parameters of this baseline study.

Secondary objectives include collection of incidentally captured invertebrates, investigation of razor clam samples for levels of paralytic shellfish poisoning (PSP) and recording of environmental parameters at each study site.

II PERSONNEL

Personnel involved in laboratory and data analysis were:

1. Rodney Kaiser, principal investigator, ADF&G, Kodiak.
2. Daniel Konigsberg , project leader, ADF&G, Kodiak.
3. Christopher Phillips, fisheries technician, NMFS, Auke Bay, Juneau.

4. Jesus Briones, fisheries technician, ADF&G, Kodiak.
5. Gayle Forrest, fisheries biologist, ADF&G, Kodiak.
6. Claudia Mauro, fisheries technician, ADF&G, Kodiak.

III LABORATORY METHODS

The fourth quarter activities (October 1-December 31) were concerned with laboratory analysis of data collected during the 1976 field season. A total of 14 beaches were studied in the Kodiak area South of the latitude of Cape Douglas (58°52' N. Lat.) and east of the longitude of Kilokak Rocks, (156°19'25") on the Alaskan Peninsula (Figure 1).

1. Invertebrates

All organisms collected with the subsample screening (seiving) were preserved at the beach in a 10% solution of formaldehyde. Systematic identification was done in the lab by Christopher Phillips and a voucher collection was verified by George Mueller at the University of Alaska.

2. Beach Mapping

Each beach was "mapped" for specific characteristics of exposure to the ocean, estimated habitat of the primary species *Siliqua*, length, width, and slope. Drawings, to scale, and location of stations of each beach will appear in the annual report.(FY 75-76) As aids in determining these characteristics, U.S.G.S. survey maps, foot surveys, and rangematic distance finders to locate prominent landmarks were used in the mapping process. Photographs were systematically taken at each beach to further document beach characteristics, transect location and substrate character.

3. Substrate Analysis

Ninty eight core samples for substrate grain size and composition were collected by tide level by station at each beach studied during the field season. Each core was 20 cm in length and .51 cm in width. The resulting core samples were air dried in the laboratory on large plastic plates. A Tyler mechanical sieve shaker was used to sift each sample utilizing the following U.S.A. Standard sieves.

ASTM E 11 Specification #	Opening in mm	Corresponding Φ grain size retained in sieve	Definition of particle size
5	4.00	< -2	pebble
10	2.00	-2 to -1	granule
18	1.00	-1 to 0	very coarse sand
35	.50	0 to 1	coarse sand
60	.25	1 to 2	medium sand
120	.125	2 to 3	fine sand
230	.063	3 to 4	very fine sand
bottom pan	-	> 4	silt

4. Age Analysis

Age analysis performed on the shells of *Siliqua patula* only. In the field, all the meat was scraped off the valves and after they were dry, both valves were identically numbered to aid in matching them up later. In the lab, shells were soaked overnight in a 50% solution of chlorox to remove periostracum. The shells were then rinsed in water and soaked for four hours in a dark solution of Alizarin Red dye. This solution stained the entire shell a dark purple. The shells were then briefly brushed in a 10% solution of nitric acid which left the annuli white against a purple background. The annular rings which correspond to the yearly period of slow winter growth were than measured with calipers. Measurements were taken at the center of the anterior end of the particular annuli to the center of the posterior end. All shells from a particular beach were aged collectively. Of the 1310 speciments of *Siliqua patula* captured in the field, 1182 specimens were aged.

IV RESULTS

1. Beach Mapping

Detailed drawings were made of each beach studied. These will be appendixed in the annual report (FY 75-76). Certain prominent physical aspects for each beach appear in Table 1. Slope and profile measurements (at station) indicated Kashvik Beach had the flatest profile while Ocean Bay Beach was the steepest. (Figure 2).

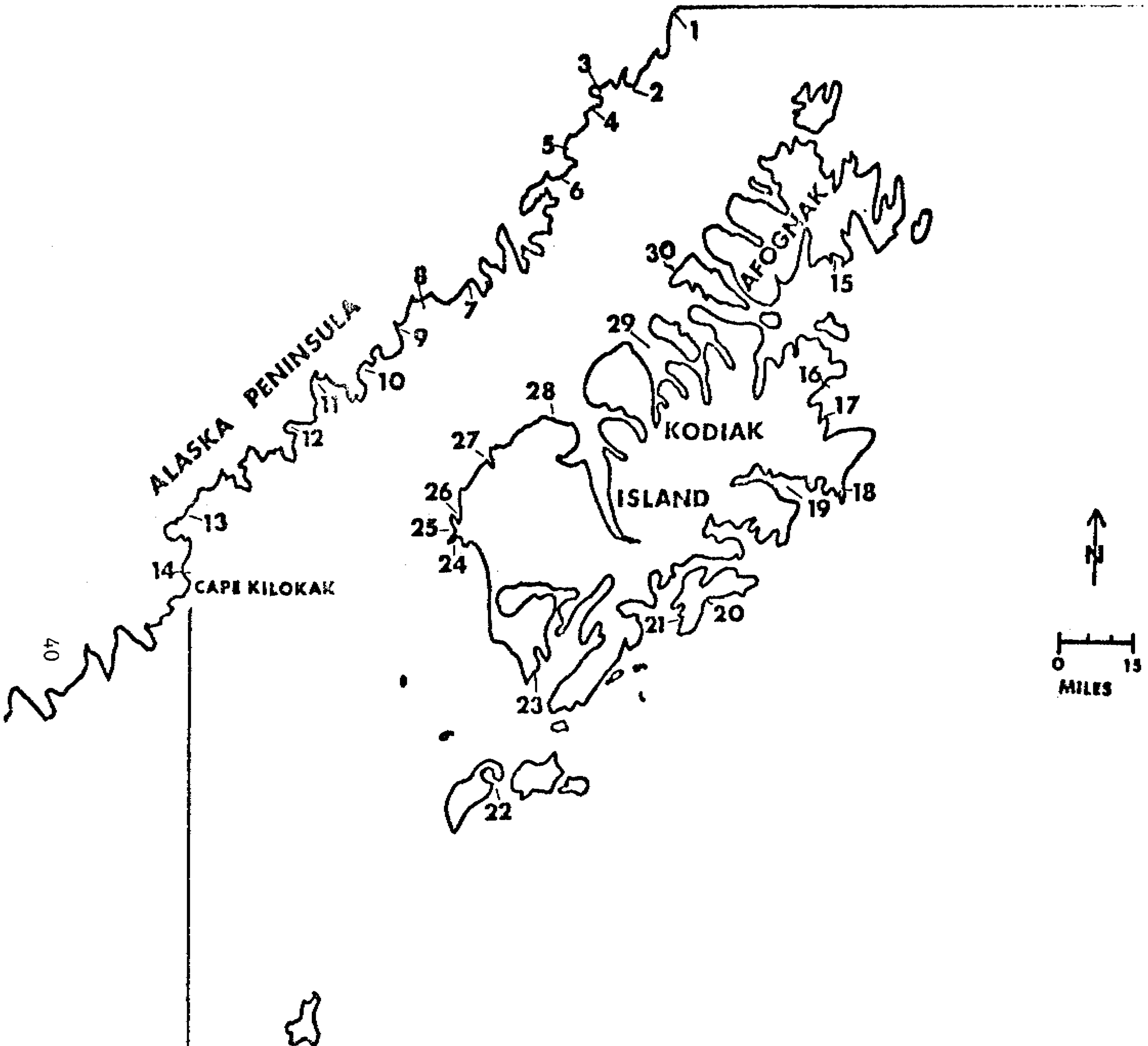
2. Invertebrates

All collected invertebrates were identified and their abundance noted. Of primary interest was the major grouping of bivalve mollusks. Sixteen species were identified by beaches and are shown in table 2. Other invertebrates were grouped and identified. Twelve species of polychaetes and nemeridians were identified (table 3).

The most nummerous bivalve encountered was the Pacific razor clam (*Siliqua patula*). This species is of considerable importance both commercially and as a recreational fishery. Its occurance is recorded by beach and by tidelevel (tables 4 and 5). A closely related specie (*Siliqua alta*) was also found in abundance at some beaches (tables 6 and 7).

3. Substrate Analysis

Results of the substrate grain size analysis (mean size per tide level) are shown in table 8. Complete grain size analysis is being prepared for inclusion in the annual report.



1. Unnamed bay due south of Cape Douglas
2. Swikshak Beach*
3. Big River Beach*
4. Village Beach*
5. Hallo Bay*
6. Kukak Bay*
7. Dakavak Bay*
8. Katmai Bay*
9. Kashvik Bay*
10. Alinchak Bay*
11. Puale Bay
12. Dry Bay
13. Wide Bay
14. Imuya Bay
15. Duck Bay
16. Buskin Beach
17. Middle Bay
18. Narrow Cape
19. Ugak Bay
    a) Portage Bay
    b) Saltrey Cove
20. Ocean Bay*
21. Rolling Bay
22. Tugidak Island*
23. Tanner Head*
24. Bumble Bay*
25. Gurney Bay
26. Halibut Bay*
27. Sturgeon Head
28. Seven Mile Beach
29. Uganik Bay
30. Driver Bay

Figure 1 Beaches with known populations of Pacific razor clams within zone B. (* Denotes those beaches surveyed during the 1976 field season.)

Table I Location of station and some physical characteristics of fourteen Alaska Peninsula and Kodiak Island area sandy beaches studied May 13 - August 30, 1976.

Beach	Station #	Approximate Lat - Long	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)[1]	Slope distance from +1 to -1 foot tide level (m)
Ocean Bay	B1	57°06'40" N 153°10'00" W	148°	7.08	91.20 (-1)	23.79
Tanner Head	B2	56°52'50" N 154°13'20" W	114°	3.70	155.55 (-3)	22.88
Halibut Bay	B3	57°21'35" N 154°45'40" W	32°	7.61	114.38 (-1.7)	28.98
Swikshak[2]	B4	58°36'35" N 153°43'10" W	181°	7.24(-2)	201.91 (-2)	62.83
Village[3]	B5	58°34'10" N 153°50'30" W	102°	6.92(-4)	383.39 (-4)	234.24
Big River	B6	58°35'40" N 153°52'10" W	76°	3.22	900 (-4)	131.83
Hallo Bay[4]	B7	58°20'10" N 154°04'15" W	64°	6.84	676.66 (-3)	172.52
Kukak[5]	B8	58°21'20" N 154°06'10" W	90°	1.28	598.93 (-2)	51.82
Bumble Bay	B9	57°16'50" N 154°40'30" W	201°	1.61	108.97 (-1)	26.67

[1] Beach width measured from high tide swash to the low tide level indicated in feet within parenthesis.
[2] Measurements refer to that area of Swikshak beach from the mouth of the Swikshak River northeast to the first prominent rocky bluff.
[3] Steep embankment and rock cobble begins just above the zero (0.00') mean low water level.
[4] The beach studied and measured is that beach area between Hallo Creek and Hook Creek.
[5] Only one beach within an un-named bay within the Kukak Bay system was investigated.

Table 1 Cont.

Beach	Station #	Approximate Lat - Long	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)[1]	Slope distance from +1 to -1 foot tide level (m)
Tugidak	B10	56°30'40" N 154°28'40" W	153°	?[6]	73.15 (-1)	23.62
Dakavak[7]	B11	58°03'40" N 154°41"10" W	150°	2.4	179.07 (-2)	20.57
Katmai[8]	B12	58°01'10" N 154°54'58" W	146°	4.02	-	-
Kashvik	B13	57°56'40" N 155°05'35" W	108°	2.01	1798.92 (-1)	917.75
Alinchak[9]	B14	57°49'50" N 155°20'10" W	106°	1.61	735.79 (-1)	156.06

[6] Extent of razor clam habitat is unknown.
[7] Measurements refer to the beach west of the major river in Dakavak Bay.
[8] No transect was established at Katmai Bay. Measurements refer to beach east of the Katmai river.
[9] Measurements refer to the northern most beach within Alinchak Bay.

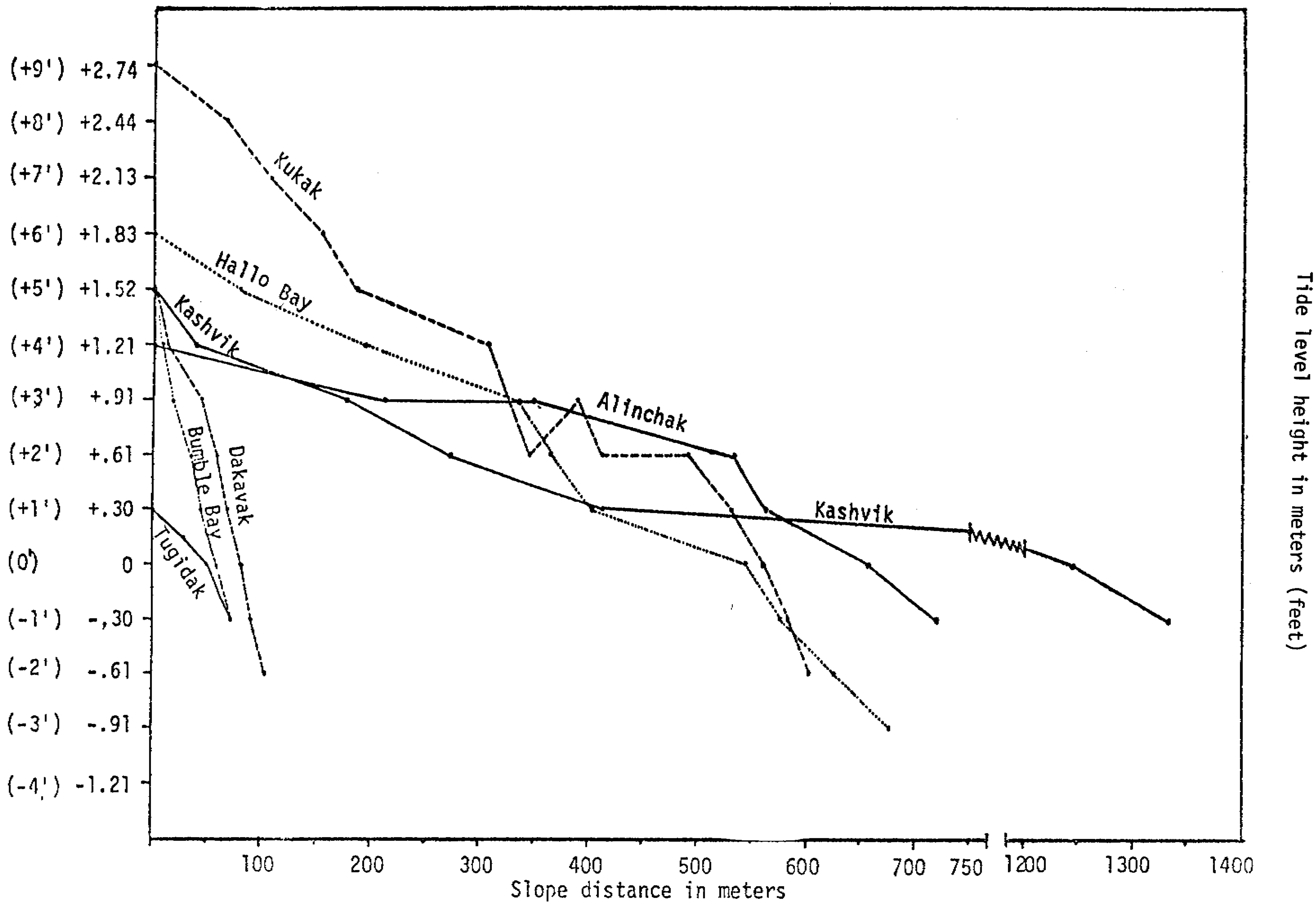


Figure 2. Slope and profile for seven beaches as determined at station site during July-August, 1976 on the Alaska Peninsula and Kodiak Island.

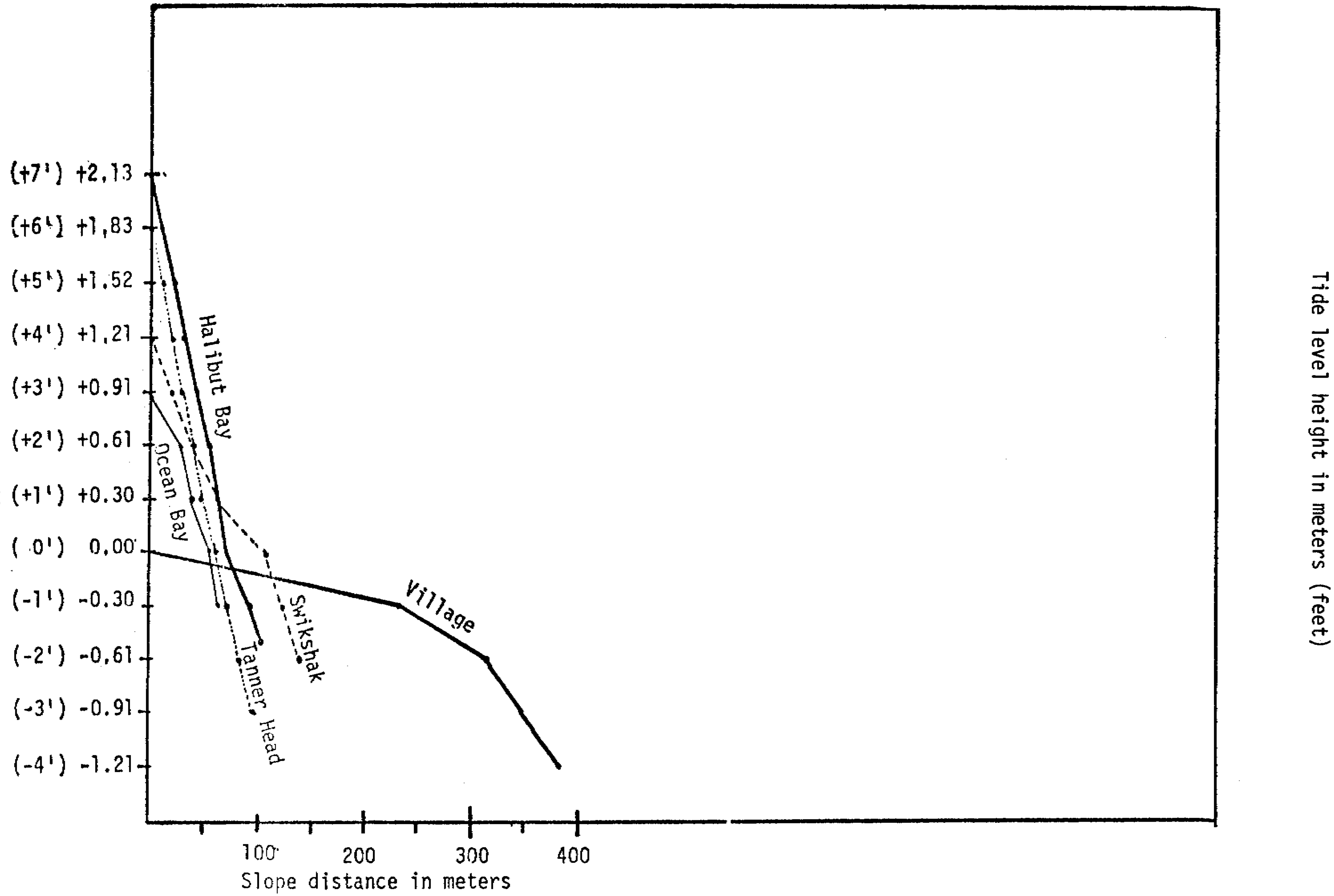


Figure 2 Slope and profile for five beaches as determined at station site during May - June, 1976 on the Alaska Peninsula and Kodiak Island.

Table 2 Identification and total numbers of bivalve molluscs by beach May 13-August 30, 1976 on the Alaska Peninsula and Kodiak Island.

Beach	# of tide level stations examined	*Siliqua patula*	*Siliqua alta*	*Spisula polynyma*	*Clinocardiom nuttallii*	*Macoma lama*	*Macoma balthica*	*Macoma calcarea*	*Macoma loveni*	*Macoma nasuta*	*Macoma yoldiformis*	*Littorina sitkana*	*Mya arenaria*	*Protothaca staminae*	*Tellina lutea alternidenta*	*Tellina nucleoides*	*Tressus capax*
Tanner Head	7	25	0	10	4	0	0	0	0	1	0	1	0	0	0	0	0
Halibut Bay	10	268	3	7	3	1	0	0	0	0	0	0	0	0	1	0	1
Swikshak	6	121	3	17	0	11	0	0	0	1	0	0	0	0	0	1	0
Village	5	208	26	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Big River	5	211	2	11	2	11	0	0	0	0	0	0	0	0	3	0	0
Hallo Bay	8	63	3	21	5	64	16	1	2	0	0	0	20	0	2	0	0
Kukak Bay	10	123	28	37	16	150	3	0	0	0	3	0	0	1	2	0	0
Bumble Bay	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugidak	5	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dakavak	7	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kashvik	7	120	0	4	0	19	11	0	0	0	0	0	0	0	0	0	0
Alinchak	4	85	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 3 Identification and total numbers of invertebrates (*polychaetes and nemeridians*) captured May 13 - August 30, 1976 on the Alaska Peninsula and Kodiak Island.

Beach	Volume of sand sieved in thousands of liters	*Scolelepis squamatus*	*Haploscoloplos elongatus*	*Ophelia assimilis*	*Anaites groenlandica*	*Eteone longa*	*Glycinde picta*	*Cistenides brevicoma*	*Nephtys caeca*	*Nephtys californiensis*	*Nephtys ciliata*	*Nemertea*	*Cerebratulus californiensis*
Tanner Head	2.1	137	0	14	0	0	0	0	20	0	0	0	0
Halibut Bay	2.1	231	29	13	0	2	4	0	11	17	0	5	0
Swikshak	1.8	359	18	0	0	7	0	0	20	13	3	0	1
Village	1.2	248	30	1	0	0	0	2	28	19	0	0	3
Big River	1.5	157	44	9	0	0	0	0	7	2	0	0	1
Hallo Bay	1.8	264	14	0	6	0	0	2	57	0	0	1	4
Kukak	3.0	912	16	0	4	1	1	0	80	1	0	5	3
Bumble Bay	.2	3	0	4	0	0	0	0	1	0	0	0	0
Tugidak	1.4	0	9	4	0	2	7	0	0	7	0	0	0
Dakavak	1.5	24	1	111	2	1	0	0	0	104	0	3	1
Kashvik	1.7	270	24	9	0	5	2	0	23	21	0	0	0
Alinchak	1.1	496	0	0	0	0	0	0	13	9	0	0	0

Table 4 Number of *Siliqua patula* dug from each tide level station plot, May 13 - August 30, 1976.

Beach	Tide level in feet (meters)												
	-4 (1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (1.22)	+5 (+1.52)	+6 (+1.83)	+7 (+2.14)	+8 (+2.44)
Tanner Head	-*	-	-	7	10	5	0[1]	1	1	-	0	-	-
Halibut Bay	-	-	-	34	53	32	73	27	21	26	0	-	0[2]
Swikshak	-	-	-	32	34	13	12	17	3	-	-	-	-
Village	34	58	67	33	14	-	-	-	-	-	-	-	-
Big River	-	-	60	52	43	41	-	10	-	-	-	-	-
Hallo Bay	-	10	5	20	9	13	0	0	0	0	-	-	-
Kukak	-	-	-	6	4	10	19	23	26	9	0	0	0
Tugidak	-	-	-	8	12	1	-	-	-	-	-	-	-
Dakavak	-	-	-	4	12	16	11	5	1	0	-	-	-
Kashvik	-	-	-	43	36	26	2	0	0	0	-	-	-
Alinchak	-	-	-	-	-	29	51	0	-	-	-	-	-
Bumble Bay	-	-	-	-	1	2	1	0	0	0	-	-	-

*Dash indicates tide level not examined'

[1]Poor weather conditions kept bivalves from "showing."

[2]The +9' tide level station was also examined. No bivalves were found.

Table 5 Mean length in mm of *Siliqua patula* dug from each tide level station plot, May 13 - August 30, 1976.

Beach	-4 (-1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)
	Tide level in feet (meters)									
Tanner Head	-*	-	-	122	126	118	0	63	117	-
Halibut Bay	-	-	-	120	119	112	99	101	110	93
Swikshak	-	-	-	85	93	102	101	97	66	-
Village	133	140	140	132	130	-	-	-	-	-
Big River	-	-	142	143	157	124	-	129	-	-
Hallo Bay	-	128	131	110	127	125	-	-	-	-
Kukak	-	-	-	133	147	106	117	120	116	90
Bumble Bay	-	-	-	-	99	125	121	-	-	-
Tugidak	-	-	-	110	118	122	-	-	-	-
Dakavak	-	-	-	127	134	131	132	123	120	-
Kashvik	-	-	-	117	112	107	97	-	-	-
Alinchak	-	-	-	-	-	28	98	-	-	-

*Dash(-) Indicates tide level was not examined

Table 6 Number of all *Siliqua alta* dug from each tide level station plot, May 13 - August 30, 1976.

Beach*	Tide level in feet (meters)												
	-4 (-1.22)	-3 (-0.91)	-2 (-0.61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)	+6 (+1.83)	+7 (+2.14)	+8 (+2.44)
Swikshak	-	-	-	2	0	0	0	0	0	-	-	-	-
Village	24	0	1	1	0	-	-	-	-	-	-	-	-
Big River	-	-	1	0	1	0	-	0	-	-	-	-	-
Kukak	-	-	-	0	3	1	4	3	4	1	1	0	0
Alinchak	-	-	-	-	-	0	2	0	-	-	-	-	-

*No *Siliqua alta* found in tide level station plots at Tanner Head, Halibut Bay, Hallo Bay, Bumble Bay, Tugidak, Dakavak, Kashvik.

Table 7 Mean length in mm of all *Siliqua alta* dug from each tide level station plot, May 13 - August 30, 1976

Beach	Tide level in feet (meters)										
	-4 (-1.22)	-3 (-0.91)	-2 (-).61)	-1 (-0.30)	0 (0.00)	+1 (+0.30)	+2 (+0.61)	+3 (+0.91)	+4 (+1.22)	+5 (+1.52)	+6 (+1.83)
Swikshak	-	-	-	63	0	0	0	0	0	-	-
Village	49	0	104	99	0	-	-	-	-	-	-
Big River	-	-	12	0	51	0	-	0	-	-	-
Kukak	-	-	-	21	20	29	27	56	16	31	-
Alinchak	-	-	-	-	-	0	17	0	-	-	-

Dash (-) indicates tide level was not examined.

Table 8 Mean sand grain diameter (mm) for each tide level investigated on 12 Alaska Peninsula and Kodiak Island area beaches.

Beach	Tide Level -4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
Tanner Head*			.20	.20	.28	.30	.42	.47	.21	.20	.31	.19	.18	.18
Swikshak			.21	.24	.23	.20	.21	.22	.26					
Village	.20	.19	.23	.21	.21	.36	.39	.36	.37					
Big River		.24	.26	.25										
Halibut Bay*			.18	.19	.19	.20	.24	.23	.21	.21	.20	.22	.21	.20
Bumble Bay				.59	.52	.53	.59	.56	.64	.74				
Tugidak				.21	.23	.25								
Hallo Bay		.47	.42	.38	.34	.38	.28	.46						
Kukak			.25	.23	.22	.22	.22	.27	.22	.24	.23	.27	.31	.30
Dakavak			.24	.23	.25	.23	.27	.31	.28	.35				
Kashvik			.23	.25	.39	.58	.25	.43	.45	.64				
Alinchak					.35	.31	.30	.35						

*Not all standard seive sizes were available for sediment analysis.

RU# 27

NO REPORT WAS RECEIVED

A final report is expected next quarter

NOAA 03-5-022-67
Research Unit #58
October 1 - December 31, 1976

Quarterly Report

A Description and Numerical Analysis of the Factors Affecting the Processes of Production in the Gulf of Alaska

George C. Anderson

Ronald K. Lam

Beatrice Booth

University of Washington

Seattle, Washington 98195

December 20, 1976

Quarterly Report

I. Subtask a. Objective: To conduct a search and present a compilation of available baseline biological and associated physical and chemical data from the Gulf of Alaska (planktonic realm).

With the completion of Tape 2 (Phytoplankton Data), Subtask a is essentially accomplished.

II. Subtask b. Objective: To use the compiled data for a description of the temporal and geographic variation in phytoplankton standing stock (and species), production, and related physical and chemical factors.

A. Analysis of Variance

The ANOVA program was run on all 15 variables without transformation. The descriptive statistics (range, mean, standard deviation) are being transcribed on to maps, one map for each variable at each season in each depth range. Even though significant differences between years have been found, years were averaged to produce the maps. A second run of the ANOVA program will be made using the appropriate transformation for each variable. Chlorophyll a, oxygen, and primary productivity are still a problem. By eliminating coastal variations, we hope to find transformations for oceanic values that will allow us to make statistical tests. Within the oceanic realm, we will test the difference between zones, between years and between seasons.

B. Results

Very tentative results have emerged from preliminary analysis. The coastal regime (as indicated by large chlorophyll a variation) seems to extend out well beyond the shelf break, especially south of the Aleutian chain. In the oceanic regime, significant differences between years may indicate that phytoplankton standing stock is not as uniformly low as previous studies have shown.

III. Subtask c. Objective: To use the data from Station P in a model of phytoplankton productivity and to test the sensitivity of the model to changes in physiological constants and external parameters.

The standard run and variations were complete by October. Nothing new has been done with regard to the model. In January, a last run of the model will be made to simulate possible effects of an oil spill in an oceanic regime. The physiological constants to be changed are phytoplankton growth rate and the grazing coefficient. The external parameter to be changed is radiation.

VI. Estimate of funds expended through December 31, 1976:

Salaries	$25,892
Employee Benefits	3,455
Equipment	963
Materials and Services	13,928
Travel and Per Diem	368
Indirect Costs	12,217
	$56,813

RU# 64

NO REPORT WAS RECEIVED

A final report is expected next quarter

In addition a final report for RU# 354 is expected for next quarter

RU # 78/79

BASELINE/RECONNAISSANCE CHARACTERIZATION

LITTORAL BIOTA, GULF OF ALASKA AND BERING SEA

By

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Submitted as part of the Quarterly Report for
Contract R7120801 Research Units 78/79
OUTER CONTINENTAL SHELF ENERGY ASSESSMENT PROGRAM
Sponsored by
U.S. Department of the Interior
Bureau of Land Management

January 1, 1977

I. Task Objectives

There are two objectives in this study: to determine the distribution of the major habitat types (sandy, muddy, rocky, etc.) along the coastline; and to determine the densities and distribution of biotic populations within these habitat types.

There are several phases to each objective. The distribution of habitat types has been determined using visual reconnaissance methods from fixed wing aircraft. This plane was completed in July, 1976 and survey data are included with this report. Additional information utilizing aerial photography and multispectral scanning methods is being produced in cooperation with NASA and the Environmental Research Institute of Michigan.

The distribution of organisms within habitat types is being determined by field parties from the Auke Bay Fisheries Laboratory (ABFL), with logistical assistance from the Pacific Marine Center. Additional projects include, a study of the accumulation of biotic debris in the "drift zone," which was completed in July 1976, the estimation of variability between sampling areas, and more intensive studies at a few sites which may receive major impact from oil exploration in the eastern Gulf of Alaska.

II. Field or Laboratory Activities

No field work or laboratory research occurred during the October-December quarter.

III. Results

Much of our recent work has been devoted to summarizing observations and preparing a major report on the Kodiak Basin. Several sections are included here.

The completed report is not yet available because the discussion section is not finished and also because the data section, which includes tabular arrays of data and statistical summaries is several hundred pages long and is of marginal value in this quarterly report. We anticipate completion of the Kodiak report in the first quarter of 1977.

The data included here are arranged in three sections: aerial, intertidal, and subtidal. The aerial data section contains a short summary of methodology and accuracy and contains the atlas plates which were used to depict the Kodiak intertidal habitats. The intertidal data section includes a summary section on the dominant intertidal biota and zonation of rocky shores along with several species lists and additional figures indicating the abundance of dominant organisms at quantitative study sites. The subtidal section discusses the distribution and abundance of subtidal kelp communities.

THE ALASKA INTERTIDAL SURVEY

Part 1. The Kodiak Island Area

Howard S. Sears
Steven T. Zimmerman

National Marine Fisheries Service
Auke Bay Fisheries Laboratory

PREFACE

The plates contained in this report represent the first completed section of our survey on the Alaskan Intertidal zone. The survey, which extends from Yakutat in the eastern Gulf of Alaska to Cape Prince of Wales in the northern Bering Sea, has been divided into approximately seven sections. These include:

1. Eastern Gulf (Yakutat to Cook Inlet)
2. Western Gulf (Cook Inlet to Unimak Pass)
3. Kodiak (Barren Islands to Chirikof Island)
4. Aleutian Islands (Unimak Pass to Islands of Four Mountains)
5. Bristol Bay (Unimak Pass to Cape Newenham and the Pribilof Islands)
6. Central Bering Sea (Cape Newenham to Pastol Bay)
7. Norton Sound (Pastol Bay to Cape Prince of Wales)

The sections are being completed on a schedule which is tied to the production of timely impact statements for specific areas. Thus, the Kodiak section was given highest priority. The Bristol Bay section, which includes the St. George Basin area, was given second priority and is over half completed at the time of this writing.

Anyone who has been buffeted about in a samll plane flying along the Alaska coastline can imagine how much effort went into compiling this extensive survey. The achievement is more remarkable because Howards Sears had to survive a plane crash and the loss of much of his data before the work was finished. Few men would have accepted such a difficult and dangerous assignment. Fewer still would have gone back to complete the job after having to swim out of a crashed airplane. I am grateful we had a man like Howard Sears to call on.

STZ, December, 1976

Aerial Survey of the Kodiak Area

INTRODUCTION

During the first three weeks of May, 1976, the entire Kodiak coastline was surveyed from a small amphibious aircraft flying at 100-300 foot altitudes. The survey, made by NMFS biologist Howard Sears, extended from the Barren Islands northeast of Kodiak, to Chichagof Island southwest of Kodiak. This work was done as part of a larger study which was describing the distribution of beach types and littoral habitats from the eastern Gulf of Alaska to the northern Bering Sea.

The aerial survey data were later used to choose sites for further biological investigations. Several habitat types were located using aerial data and were then investigated by helicopter reconnaissance and on foot. By actually investigating selected areas we were able to verify the accuracy of the aerial survey.

METHODS AND MATERIALS

A. Aerial

Aerial observations were made primarily to provide information on three littoral parameters: beach slope, substrate composition, and biological cover. The categories used to describe each parameter included:

<u>Substrate</u>

Bedrock
Boulder
  a. boulders > 2 ft. sq.
  b. boulders < 2 ft. sq.
  c. combination of a & b
Gravel
Sand
Mud

<u>Slope of Exposed Beach</u>

Vertical
Steep
Moderate
Flat

<u>Biological cover or substrate</u>

Bare
Light
Medium
Heavy

Coastline resolution for these factors was at approximately 1/8 mile intervals, i.e. beach types which extended for 1/8 mile or more were noted on survey charts.

Several other phenomena were also noted whenever they occurred. These included the locations of sea bird rookeries, sea animal haul out areas, swimming sea mammals, dead sea mammals, eagle sightings, land animals on beaches, large concentrations of surf grasses, and offshore kelp beds. All data were recorded on USGS topographic quadrangle sheets (1:63,360) during flights.

B. Cartographic Methods

A photo-mechanical transfer (PMT) process was used to transform USGS quadrangle sheets into a usable background format. The resulting black and white plates were exact copies of the quadrangles except for size and color. In some cases, portions of as many as three different quadrangles were combined to make a single plate. Differences in background clarity often resulted due to the different colors on separate quadrangles.

To each of these background plates the survey data, as well as information on latitude, and longitude, and sequencing were added. Substrate was portrayed using different patterns of ZIPPATONE drafting screen which were cut into narrow bands paralleling the coast. Sixteen categories of circular symbols were drafted to portray the possible combinations of cover and slope.

The alignment and margins of the plates were constructed so they could be bound at the top. When bound together in this manner it is possible to use them in a plane or helicopter without interferring with the pilot or controls.

Fifty four plates were used to describe the Kodiak coastline. The arrangement of these plates is shown on an index map which precedes the actual survey plates. The plates are numbered K1 through K54, with each number corresponding to its position on the index map. Although most of the plates in our atlas series will be arranged in an order which follows the coastline in an unbroken numerical sequence, the shape of Kodiak and the deeply cleaved coastline made this impossible.

Results

The Kodiak area coastline is estimated to be approximately 2500 miles long (Table 1). This figure is partially dependent on subjective factors, however, as it is difficult to determine where marine influence ends in the many bays and estuaries which penetrate deeply into the land mass.

Over half the coastline is composed of bedrock or large boulder beaches (Table 1) and the exposed coastline on the Gulf side is overwhelmingly dominated by these substrates. Gravel and sand beaches make up much of the remaining area. Gravel beaches seem to be infrequent on the outer coasts except near river mouths. Muddy substrates are uncommon and make up less than 1% of the Kodiak coastline.

Table 1. Number of miles and percentage of major substrate types in the Kodiak area.

	Kodiak	Barren Islands	Trinity Islands	Chirikof Island	Total	Percentage
Bedrock	1078	56	9.5	16.5	116.0	47.58
Boulder	297.5	1.5	3.5	2	304.5	12.49
Gravel	740.5	1.5	34		776	31.83
Sand	79	4	94	14.5	191.5	7.8
Mud	5.75				5.75	.2
Totals	2200.75	63	141	33	2437.75	99.9

C. Level of Accuracy

In May and July 1976, several types of habitat were investigated while making biological surveys. The preliminary selection of a general area was usually based on data from the aerial survey. After selection of a specific site was completed, notes were made on the actual slope, cover, and substrate. These were later compared with the aerial records.

No major discrepancies were found between the aerial survey and the ground level verification (Table 2). Although occasional differences were found between interpretations of moderate or flat slopes, or between moderate and heavy cover, these were not deemed to be major differences. Thus, our data indicate that the aerial survey is accurate and can be used to predict the occurrence of substrate, slope, and cover with high reliability.

Three general types of error may occur when the plates are compared with field observations, however. These are:

1. Seasonal. Uunconsolidated beaches may vary in composition and profile with seasonal changes. A flat sand beach in summer may become a sloping gravel beach following periods of heavy winter surf.

Likewise, changes in temperature, daylight, and turbulence may change the amount of biological cover present. Offshore kelp beds which are striking features in the summer may be absent in the winter. Migrations of marine mammals and birds will change haul-out and breeding concentrations. Thus, the observations portrayed on the aerial plates, which were made in May 1976, may not correspond to observations made at a different time.

2. Tidal differences. All flights were made during low tide periods. Because the height of low tide changes constantly, however, it was not possible to view all points during maximum low water. Further, because flights began 2 hours before and ended 2 hours after low tide, some areas were observed at quite different tidal stages.

The lowest predicted tide during the Kodiak survey period was -2.6 feet. The highest low tide was +1 foot (1976 NOAA West Coast Tide Tables pg.129). Tidal heights 2 hours before and 2 hours after the latter tide would have been approximately +4 feet. Thus, a maximum water level difference of slightly less than 7 feet was possible between the most divergent observations.

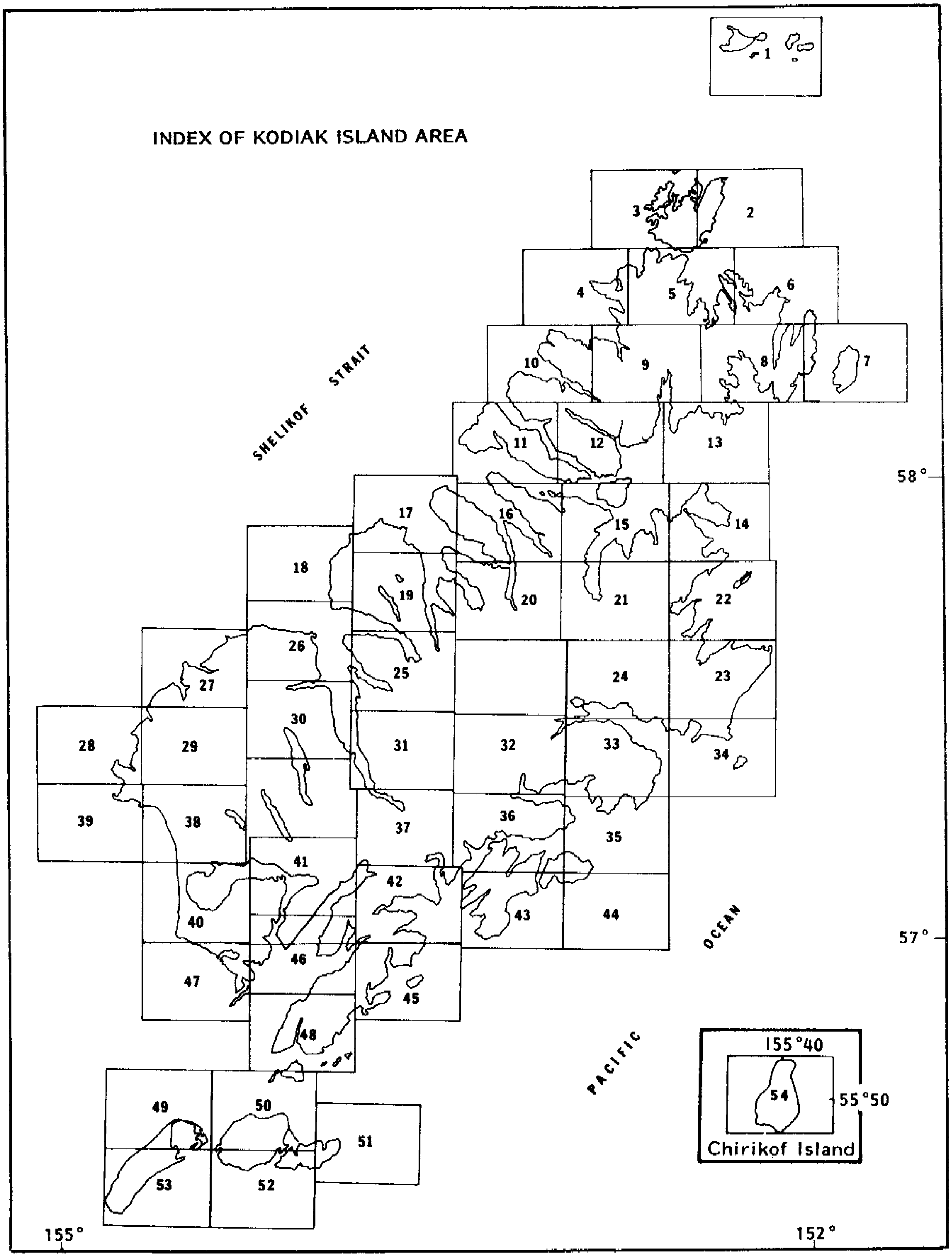
In some cases this source of error appeared to be significant. At Cape Sitkinak, for instance, the mid and upper littoral zones are composed of boulders. At lower levels, however, wide and flat bedrock reefs are exposed. Because of the extensive area they occupy and their heavy biological cover, the reefs are probably the dominant feature. Their presence could be missed on a plus tide.

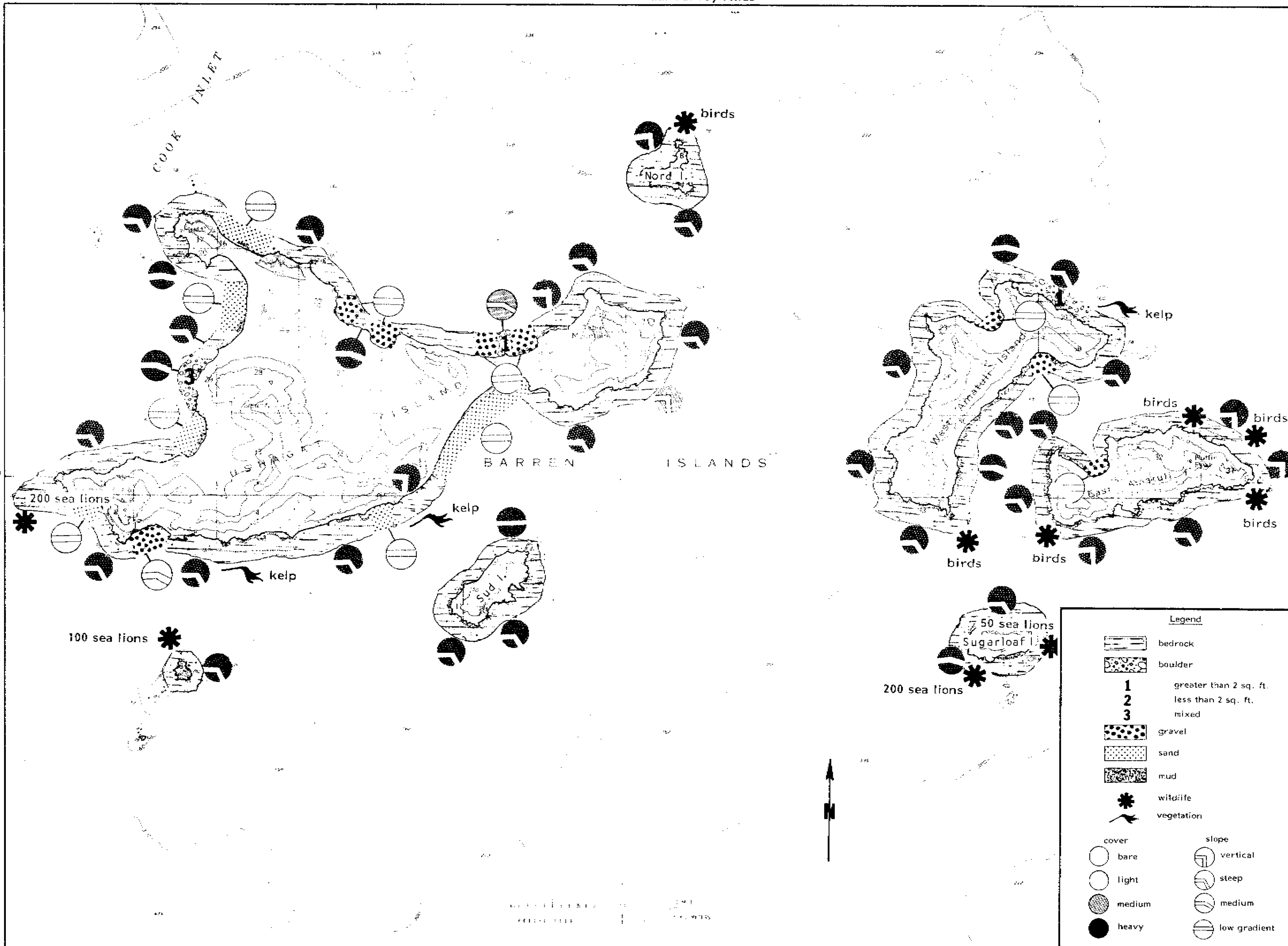
3. Subjective differences. The Kodiak coastline is highly variable. Many features are less than 1/8 mile long and all cannot be listed. The small pocket sand beaches which dot Spruce Island are an example. Also, when several short segments of different beach types occur in close proximity a subjective decision must be made as to which is the dominant feature. A similar problem arises when the upper part of the beach varies from the lower part.

It is also sometimes difficult to determine from the air whether certain beaches should be called sand or mud, or others should be called sand or travel. In many cases either description could be appropriate. These and similar problems can lead to slight differences in interpretations between observers.

Table 2. Comparison of substrate, slope, and cover data made by aerial or ground observations in the Kodiak area.

Location	Method	Substrate	Slope	Cover
Spruce Island	aerial	bedrock	flat	heavy
	ground	bedrock	moderate	heavy
Otter Island	aerial	bedrock	moderate	heavy
	ground	bedrock	moderate	heavy
Geese Islands	aerial	bedrock	flat	heavy
	ground	bedrock	flat	heavy
St. Paul Harbor	aerial	bedrock	moderate	medium
	ground	bedrock	flat	heavy
Narrow Cape	aerial	bedrock	flat	medium
	ground	bedrock	flat	medium
Sundstrom Island	aerial	bedrock	flat	heavy
	ground	bedrock & boulder	moderate	heavy
Lagoon Point	aerial	large boulder	flat	medium
	ground	large boulder	moderate	heavy
Cape Kaguyak	aerial	large boulder	moderate	heavy
	ground	large boulder	moderate	heavy
Piller Cape	aerial	mixed boulder	moderate	medium
	ground	mixed boulder	moderate	medium
Touki Bay	aerial	mixed boulder	moderate	medium
	ground	mixed boulder	moderate	medium
Whale Island	aerial	small boulder	moderate	medium
	ground	small boulder	moderate	medium
Low Cape	aerial	small boulder	flat	light
	ground	small boulder	flat	light
W. Dolina Point	aerial	small boulder	flat	light
	ground	small boulder (high) bedrock (low)	flat	light, moderate
W. Lagoon Point	aerial	gravel	moderate	light
	ground	gravel	moderate	light
Whirlpool Point	aerial	gravel	flat	none
	ground	gravel	moderate	none
Ocean Bay	aerial	mud	flat	none
	ground	sand	flat	none
S. Sitkaldak Lagoon	aerial	mud	flat	light
	ground	mud	flat	light


INDEX OF KODIAK ISLAND AREA
SHELIKOF STRAIT
PACIFIC OCEAN
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
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
155°40
55°50
Chirikof Island
58°
57°
155°
152°



BARREN ISLANDS

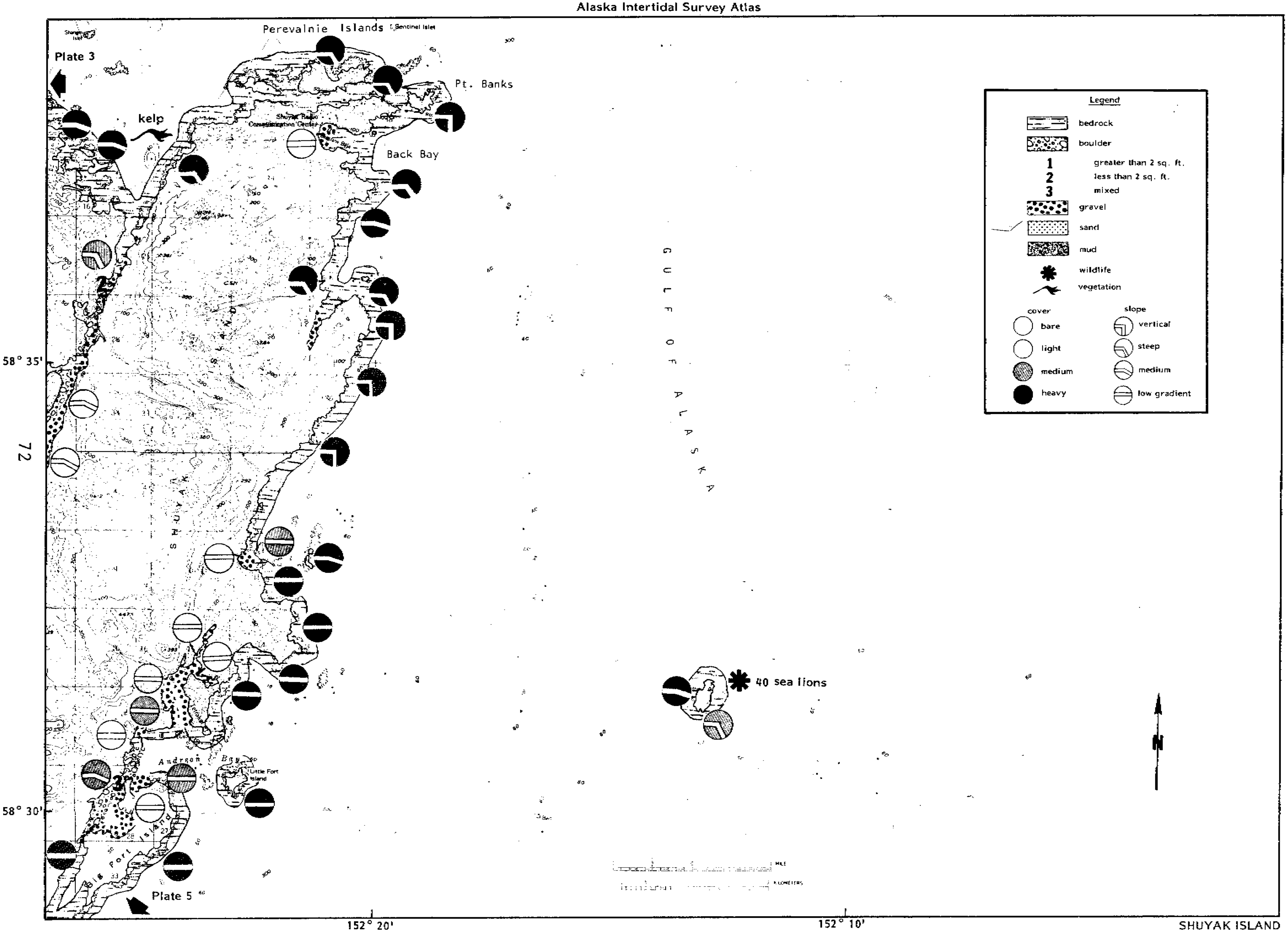
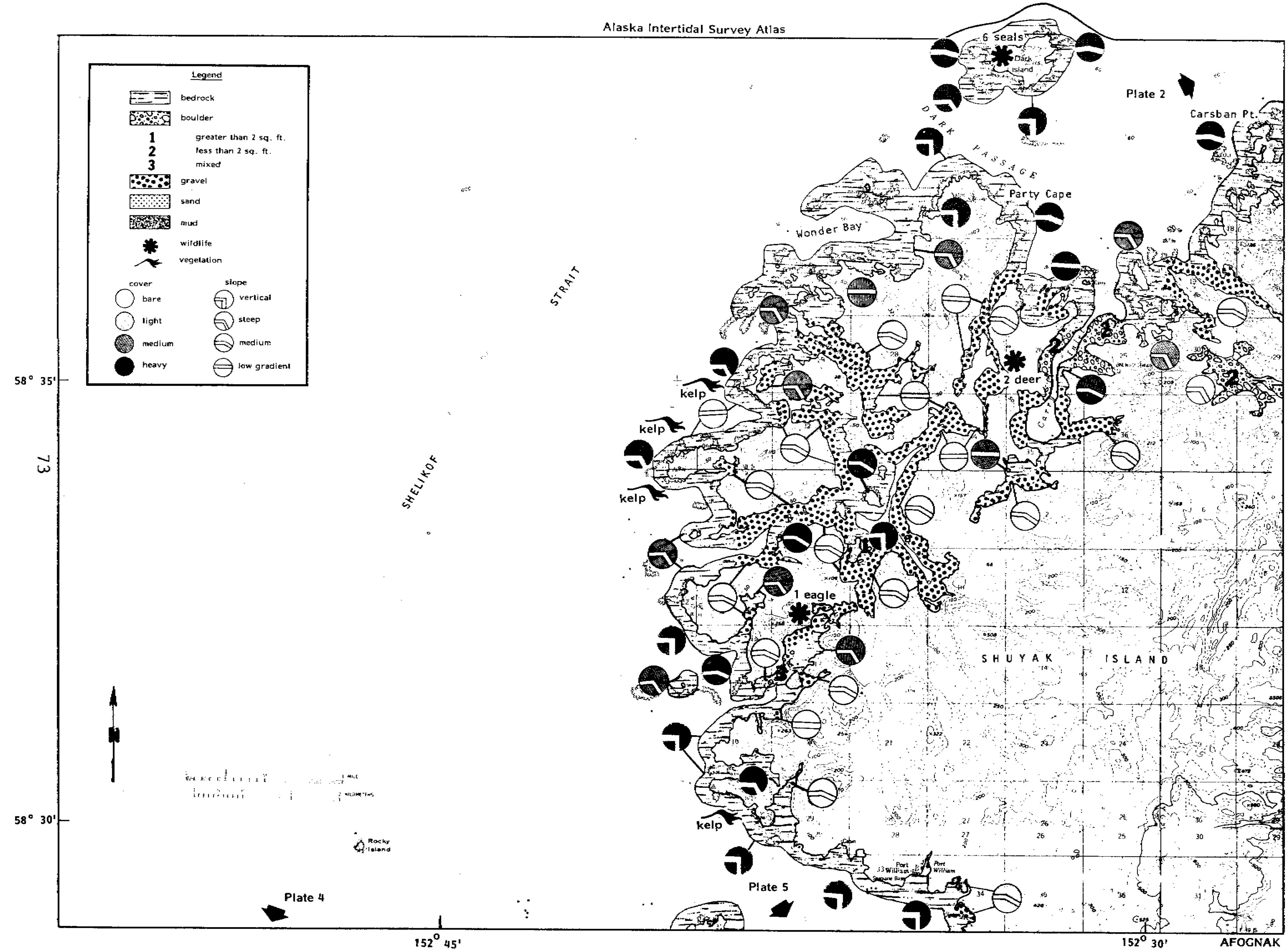
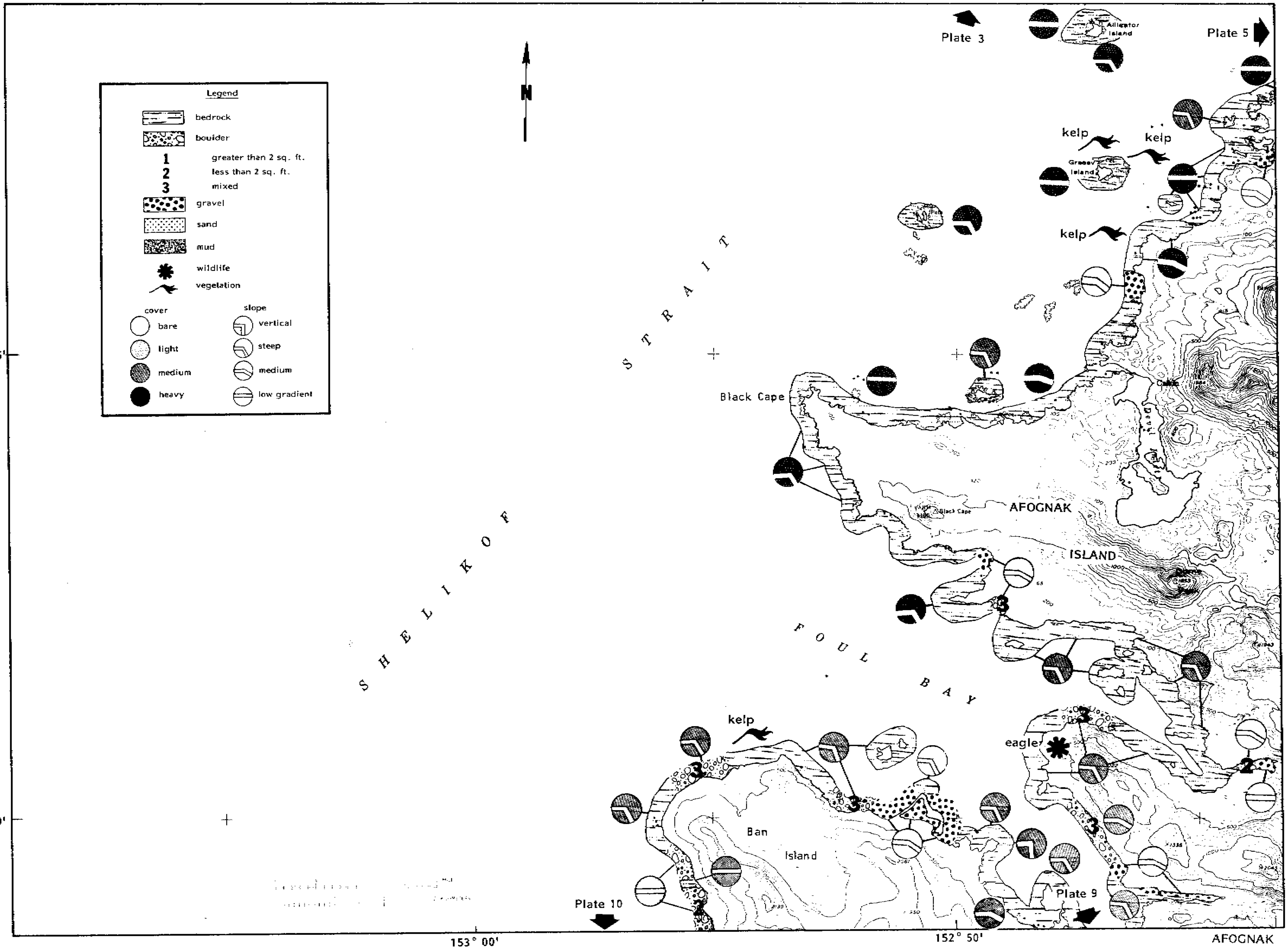


Plate 3
Perevalnie Islands
Sentinel Islet
Pt. Banks
kelp
Shuyak Radio Communication Center
Back Bay
G U L F O F A L A S K A
58° 35'
58° 30'
40 sea lions
Andrson Bay
Little Fort Island
Big Fort Island
Plate 5
152° 20'
152° 10'
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
6 seals
Dark Island
DARK PASSAGE
Plate 2
Carsban Pt.
Party Cape
Wonder Bay
STRAIT
SHELIKOF
2 deer
kelp
kelp
kelp
1 eagle
SHUYAK ISLAND
kelp
Rocky Island
Port William
Plate 4
Plate 5
58° 35'
58° 30'
152° 45'
152° 30'
AFOGNAK


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Plate 3
Plate 5
Plate 10
Plate 9
Alligator Island
kelp
kelp
kelp
kelp
eagle
Black Cape
SHELIKOF STRAIT
FOUL BAY
AFOGNAK
ISLAND
Ban
Island
58° 25'
58° 20'
153° 00'
152° 50'
AFOGNAK

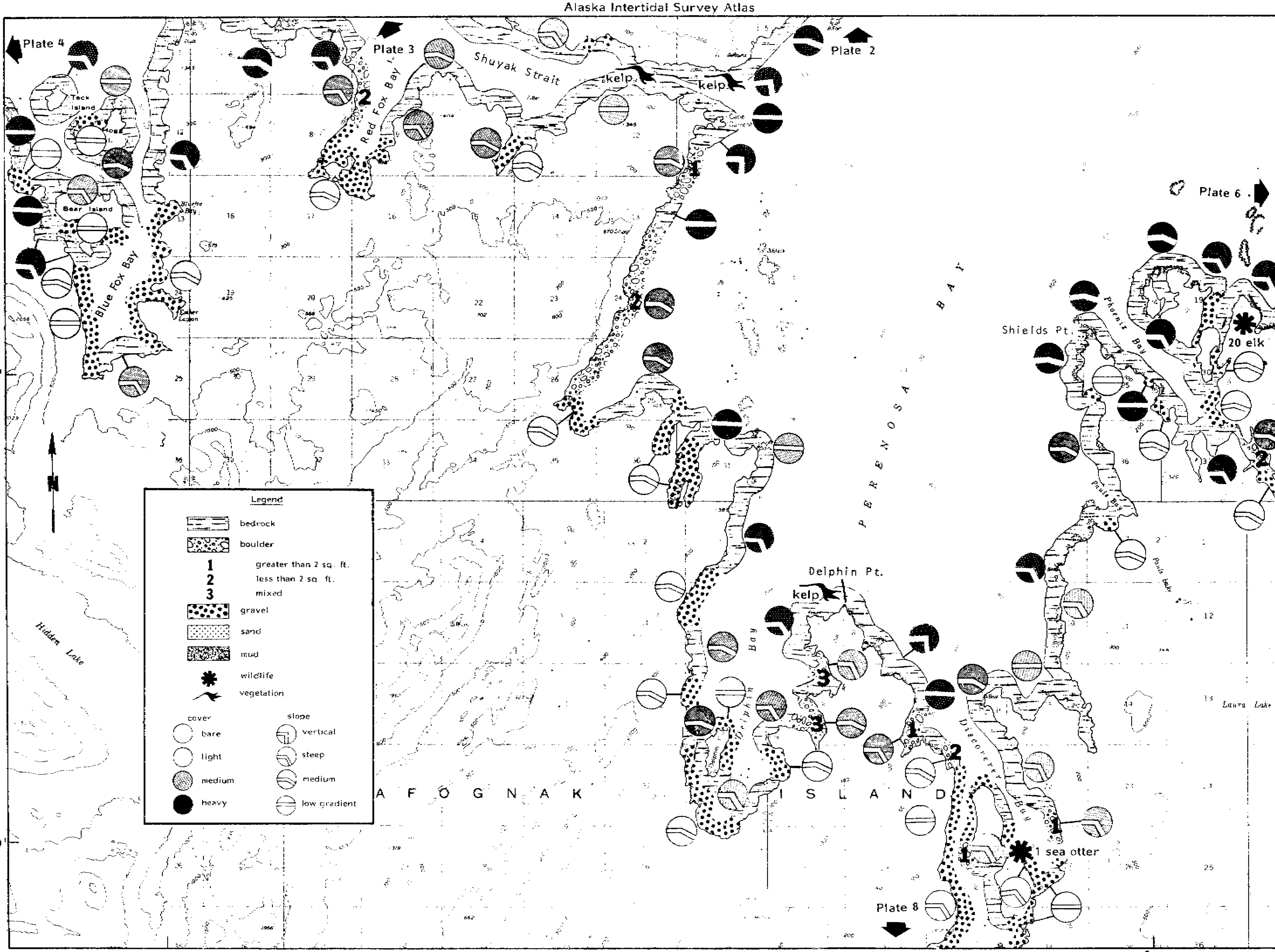
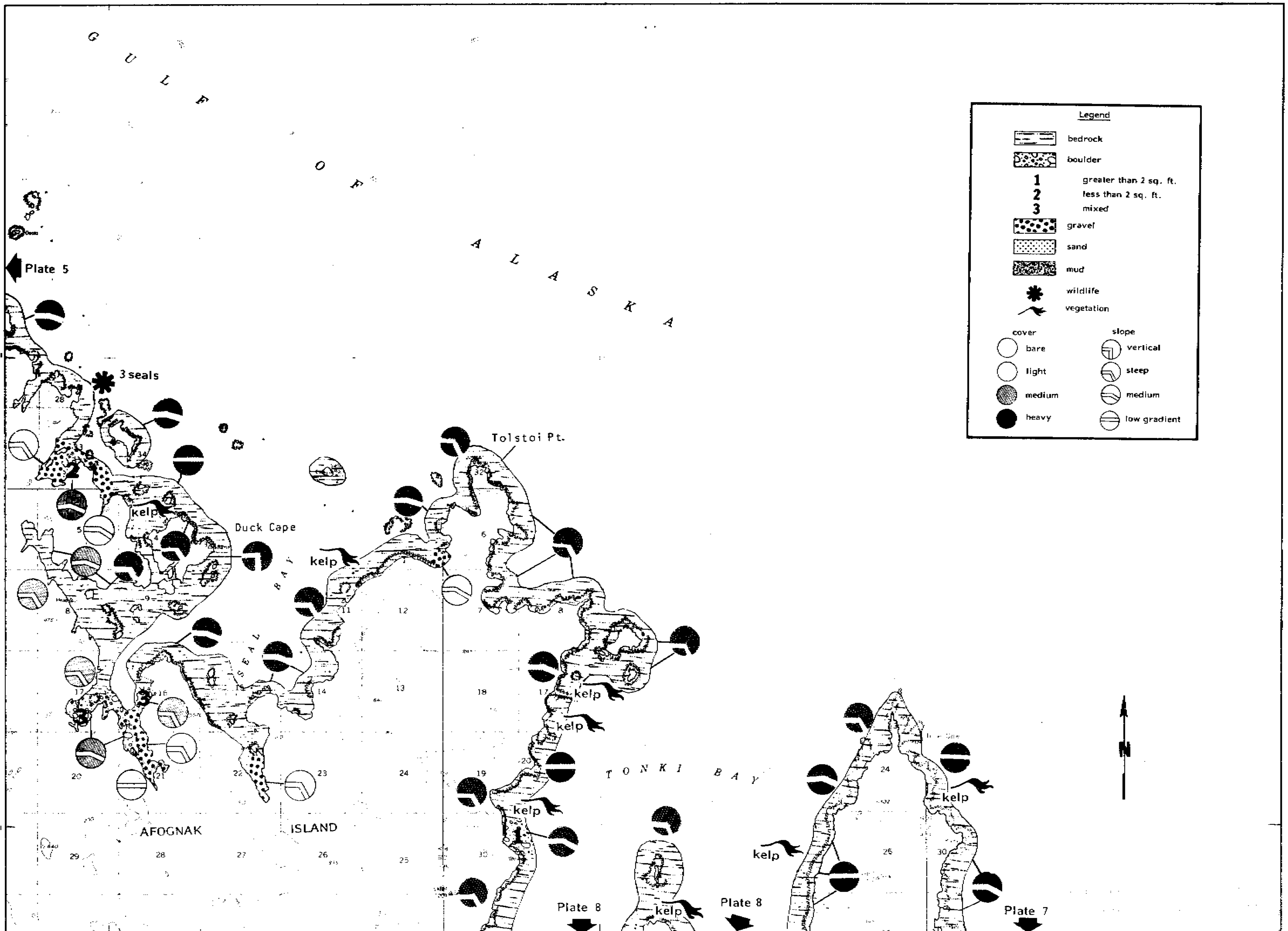
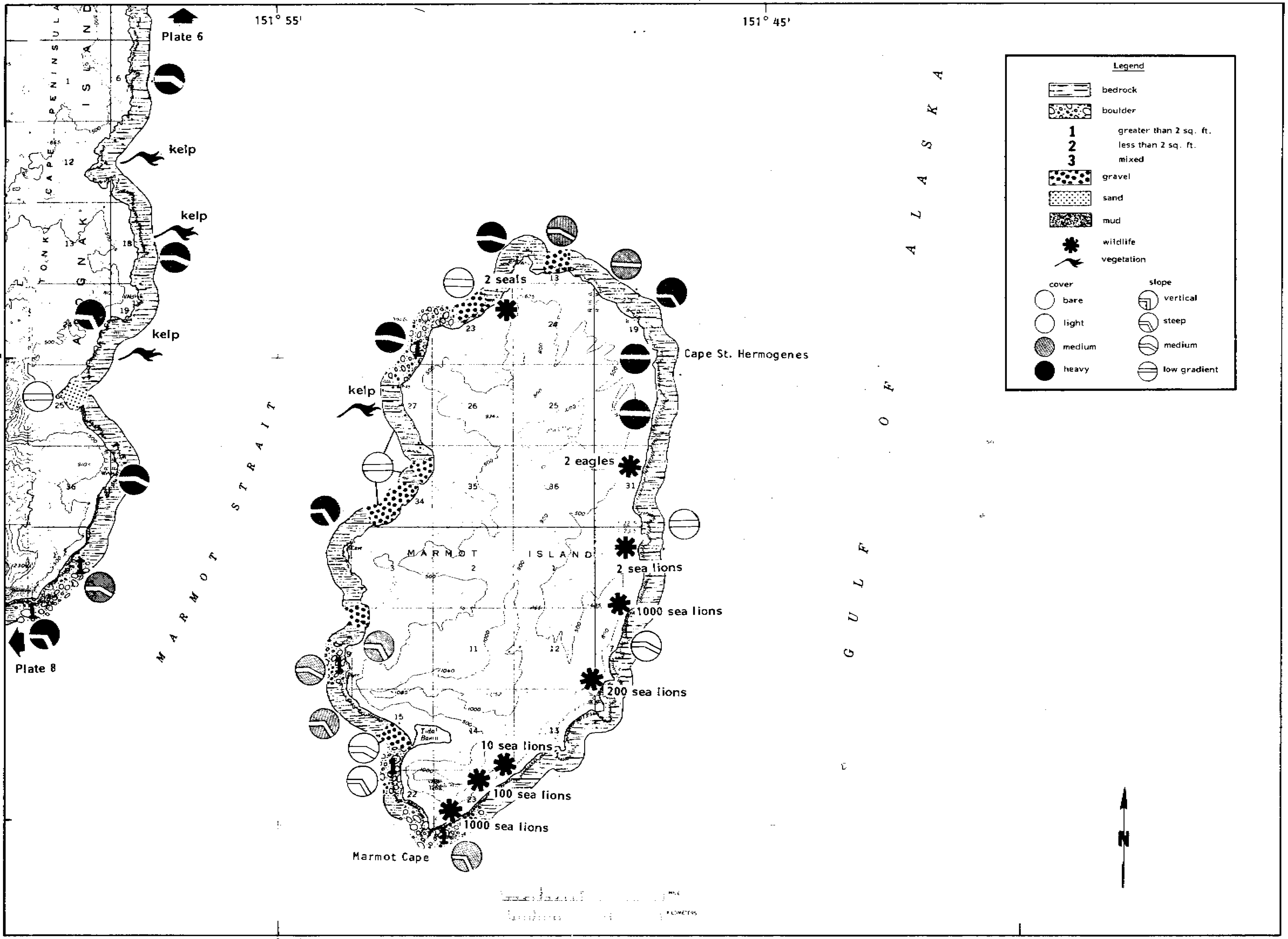


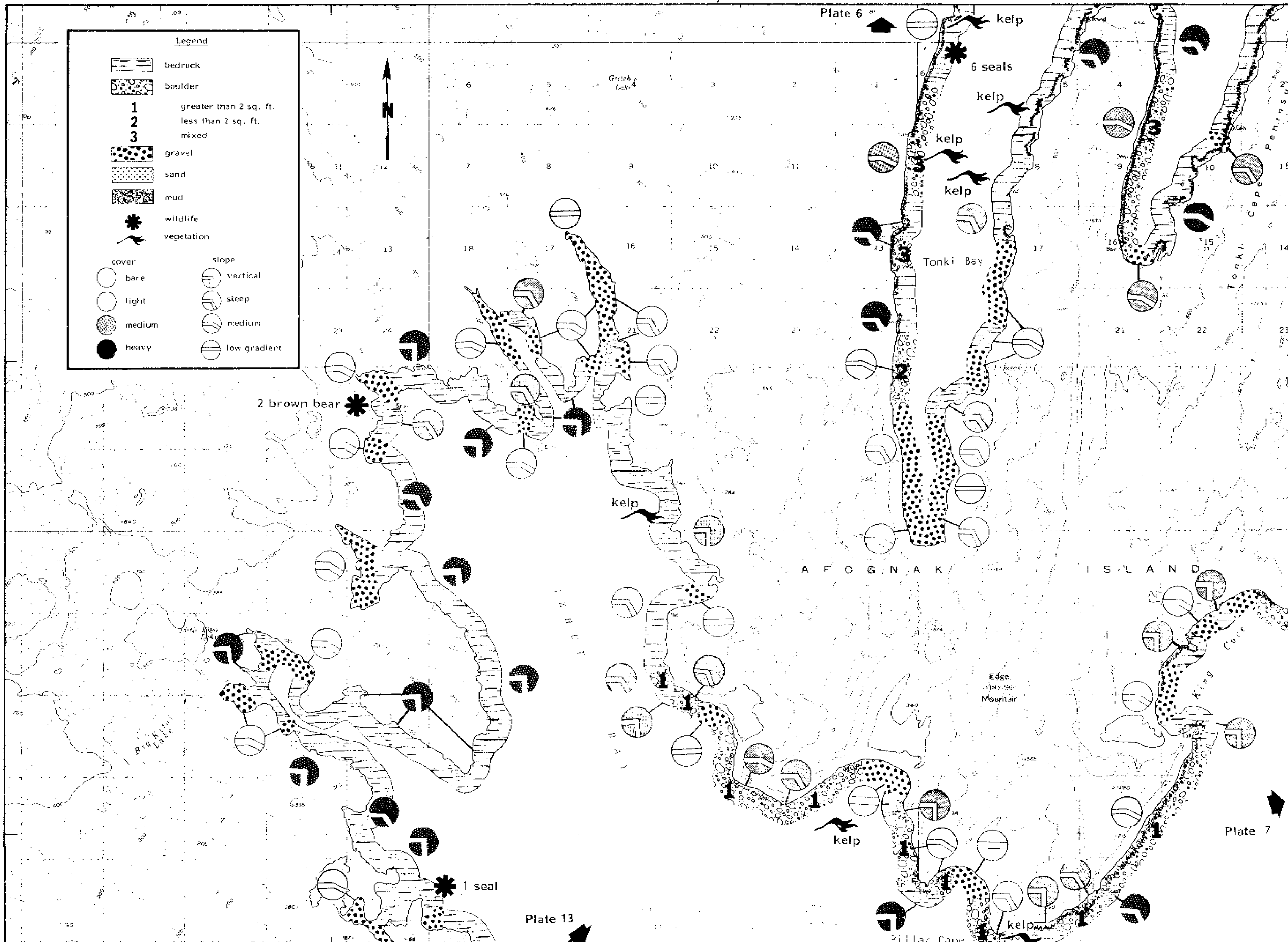
Plate 4
Plate 3
Plate 2
Plate 6
Plate 8
Shuyak Strait
kelp
kelp
Red Fox Bay
Tack Island
Bear Island
Blue Fox Bay
Shields Pt.
Phoenix Bay
20 elk
PERENOSA BAY
Delphin Pt.
kelp
Delphin Bay
Discovery Bay
1 sea otter
AFOGNAK ISLAND
Hidden Lake
Laura Lake
58° 25'
58° 20'
152° 40'
152° 20'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient


GULF OF ALASKA
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
Plate 5
58° 25'
3 seals
Tolstoi Pt.
Duck Cape
kelp
SEAL BAY
TONKI BAY
N
AFOGNAK
ISLAND
58° 20'
Plate 8
Plate 8
Plate 7
152° 15'
152° 05'

AFOGNAK



MARMOT ISLAND


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Plate 6
kelp
6 seals
kelp
kelp
kelp
Tonki Bay
Tonki Cape Peninsula
2 brown bear
kelp
A F O G N A K I S L A N D
King Cove
Edge Mountain
kelp
Plate 7
1 seal
Plate 13
kelp
Pillar Cape
58° 15'
58° 10'
152° 20'
152° 05'
AFOGNAK

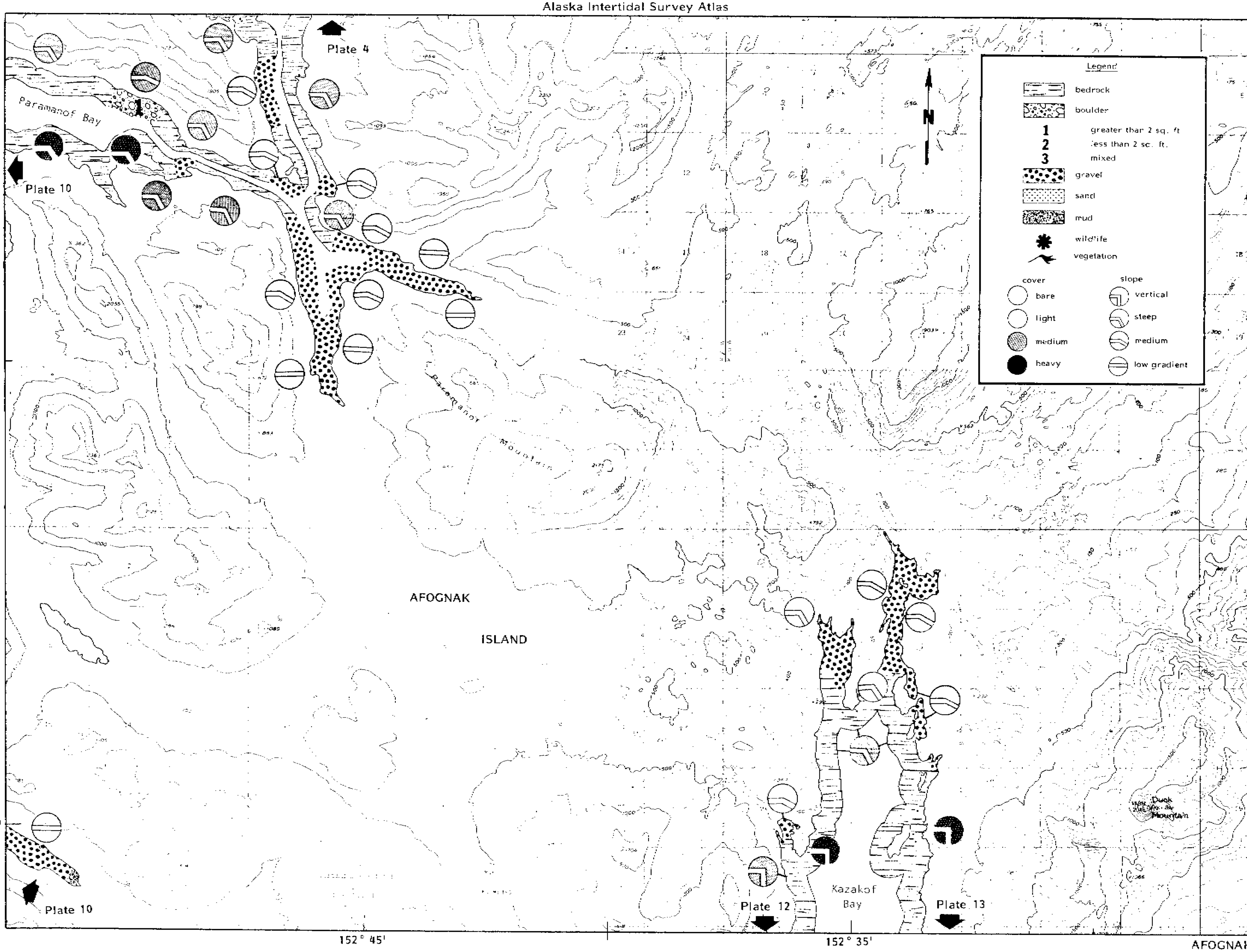
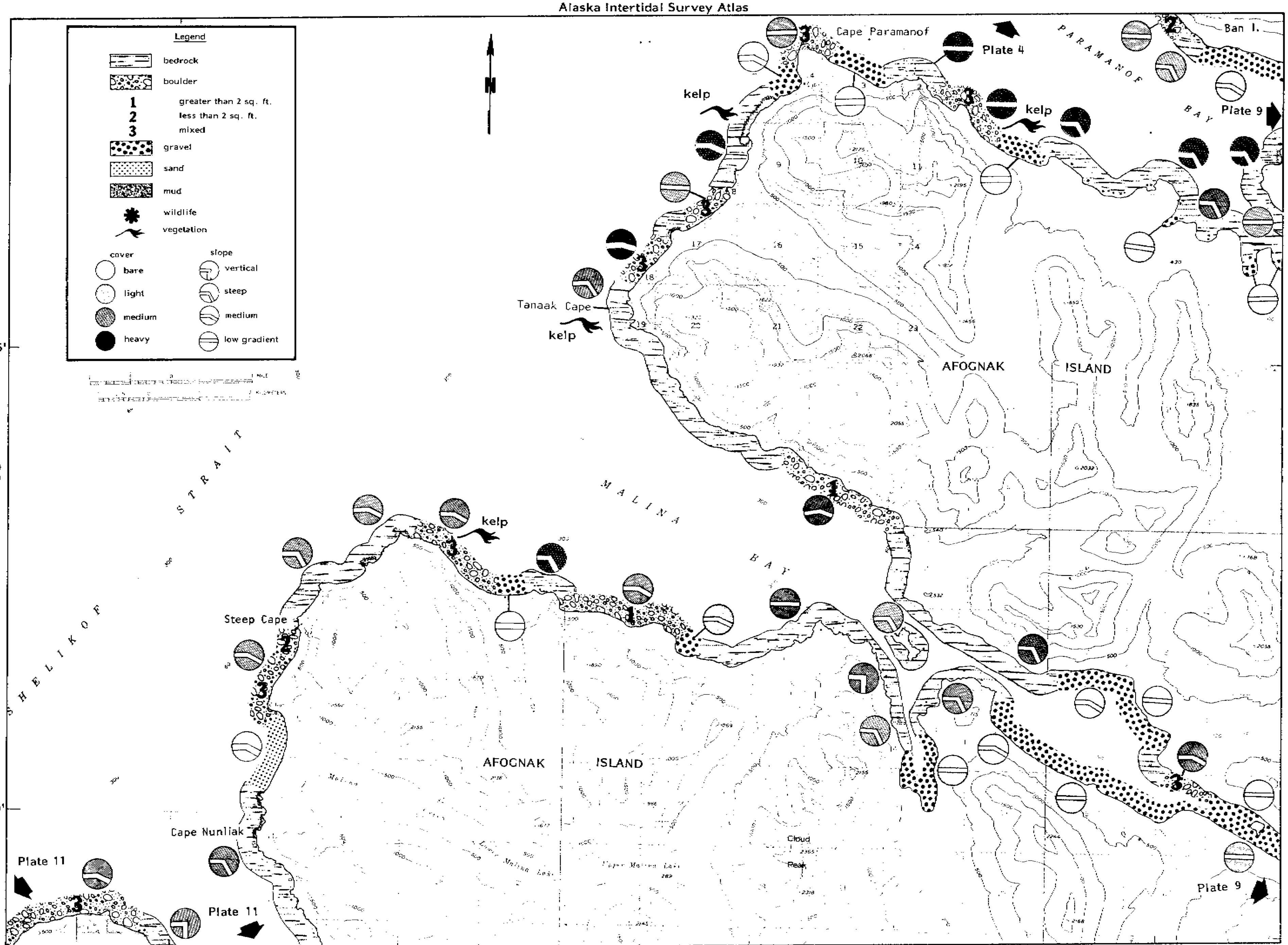


Plate 4
Paramanof Bay
Plate 10
Legend
bedrock
boulder
1 greater than 2 sq. ft
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
58° 15'
Paramanof Mountain
AFOGNAK
ISLAND
58° 10'
Duck Mountain
Plate 10
Plate 12
Kazakof Bay
Plate 13
152° 45'
152° 35'
AFOGNAK


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Cape Paramanof
Plate 4
PARAMANOF BAY
Ban I.
Plate 9
kelp
kelp
kelp
kelp
Tanaak Cape
AFOGNAK ISLAND
MALINA BAY
SHELIKOF STRAIT
Steep Cape
Cape Nunliak
AFOGNAK ISLAND
Cloud Peak
Plate 11
Plate 11
Plate 9
58° 15'
58° 10'
153° 15'
152° 55'
AFOGNAK
08

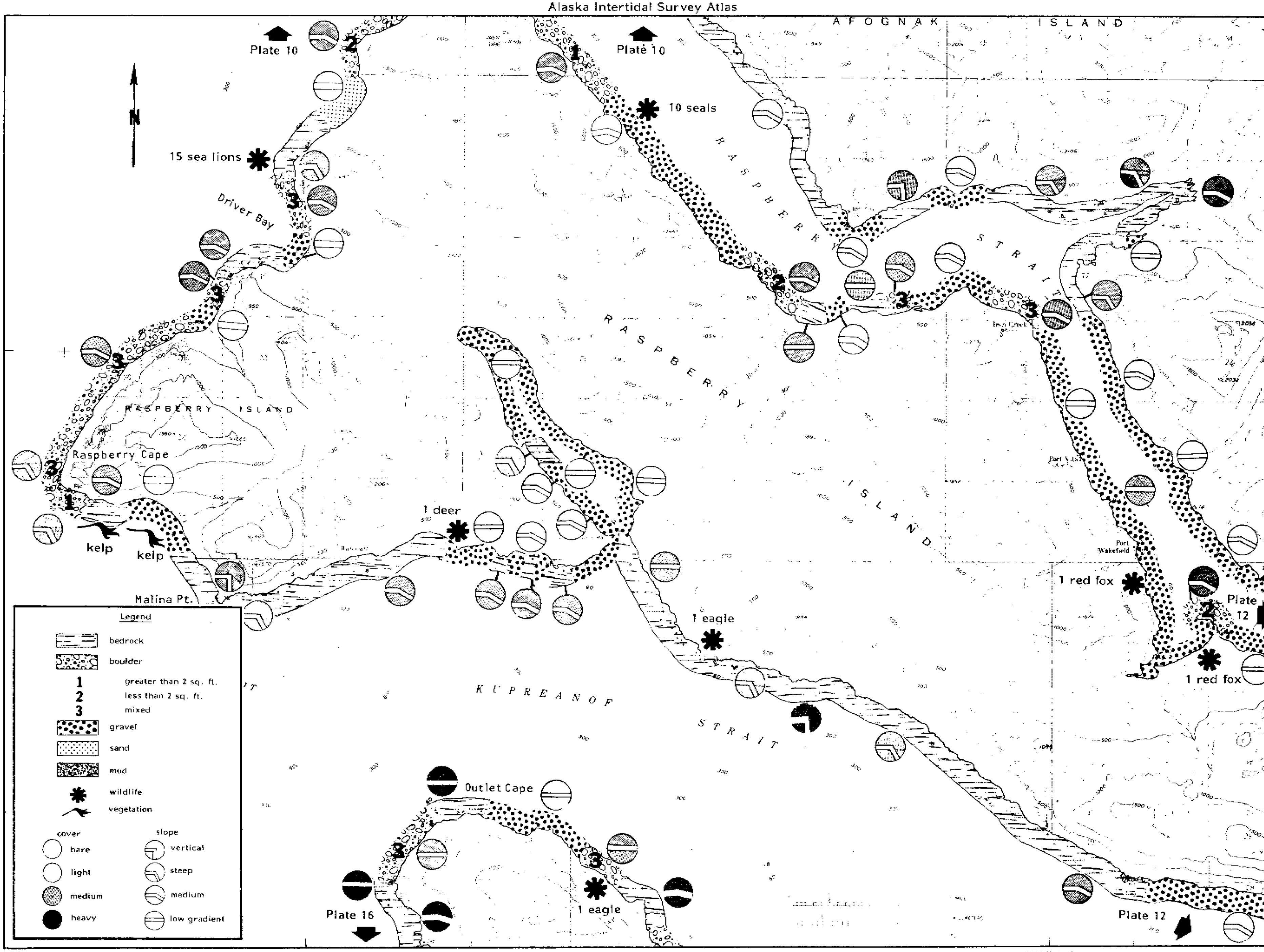
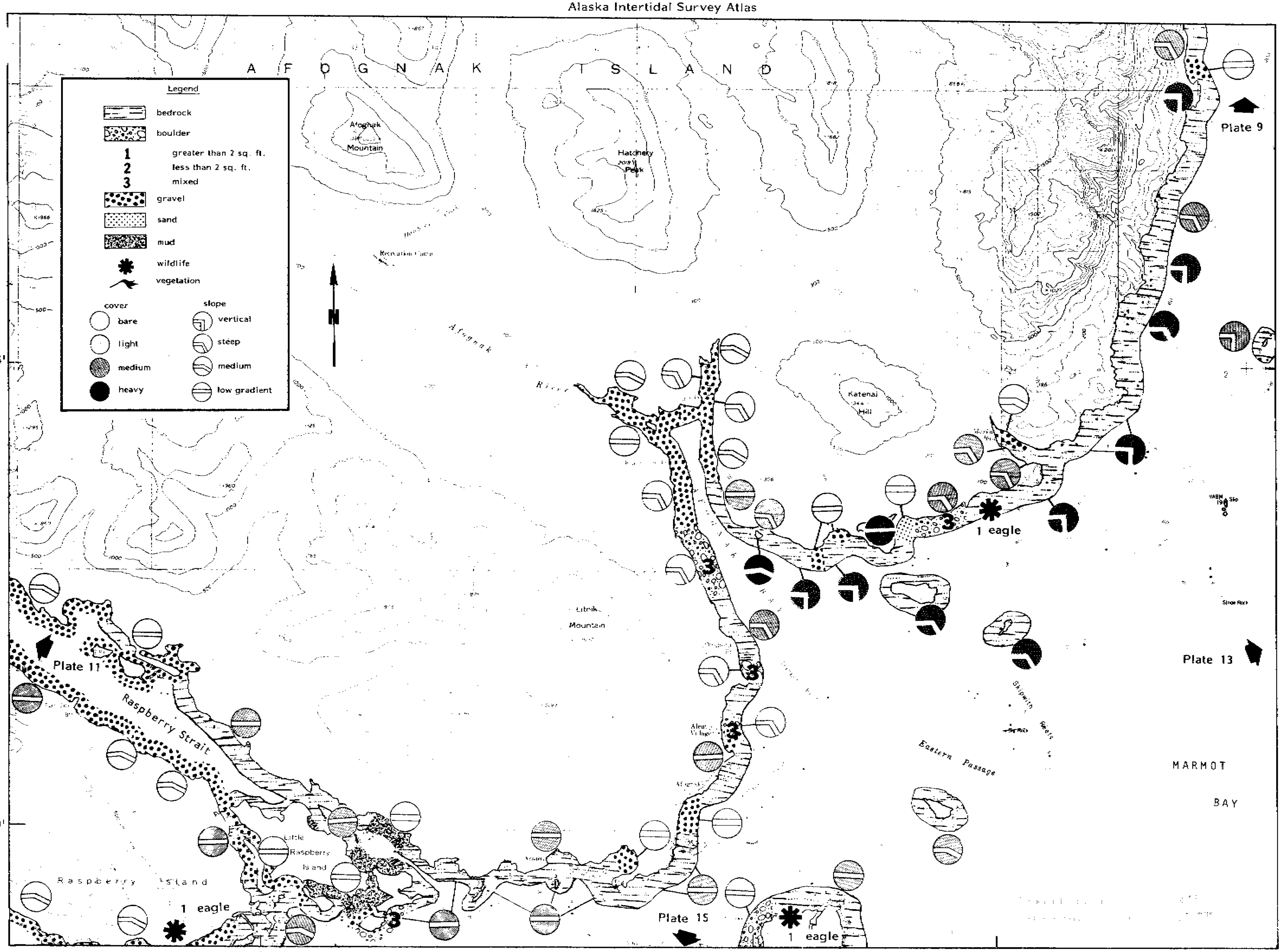


Plate 10
Plate 10
AFOGNAK ISLAND
N
10 seals
15 sea lions
Driver Bay
RASPBERRY STRAIT
RASPBERRY ISLAND
RASPBERRY ISLAND
58° 05'
Raspberry Cape
1 deer
kelp
kelp
Malina Pt.
1 eagle
1 red fox
1 red fox
Plate 12
KUPREANOF STRAIT
Outlet Cape
1 eagle
Plate 16
Plate 12
153° 20'
153° 05'
AFOGNAK
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient

18


A F O G N A K I S L A N D
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Afognak Mountain
Hatchery Peak
Katenai Hill
Litnik Mountain
Afognak River
Plate 9
Plate 11
Plate 13
Plate 15
Raspberry Strait
Little Raspberry Island
Raspberry Island
1 eagle
1 eagle
1 eagle
Eastern Passage
MARMOT BAY
58° 05'
58° 00'
152° 55'
152° 40'
82
KODIAK ISLAND

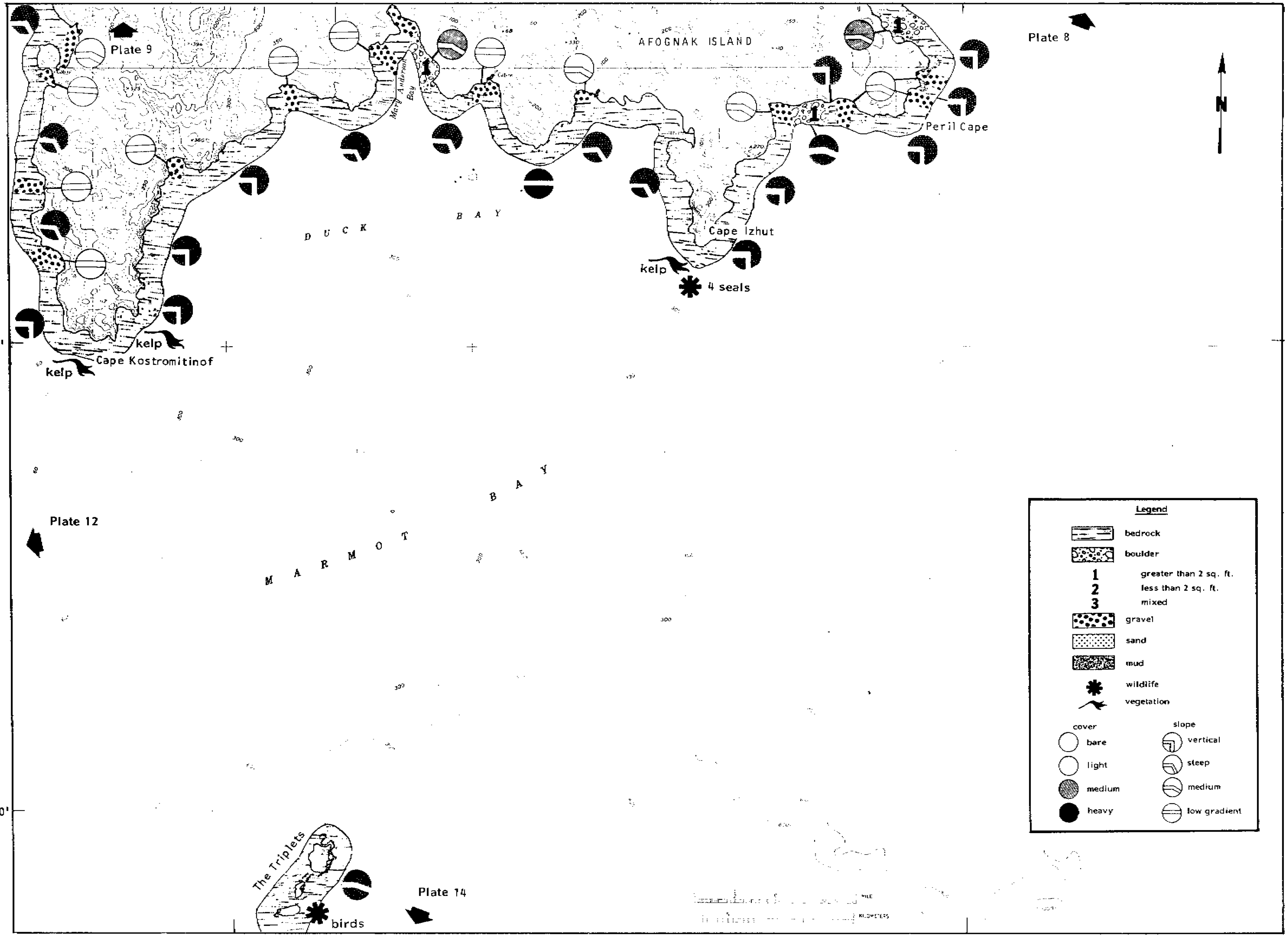


Plate 9
AFOGNAK ISLAND
Plate 8
N
Mary Anderson Bay
Peril Cape
DUCK BAY
Cape Izhut
kelp
4 seals
kelp
Cape Kostromitinof
kelp
58° 05'
MARMOT BAY
Plate 12
58° 00'
The Triplets
birds
Plate 14
152° 30'
152° 15'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient

AFOGNAK

84

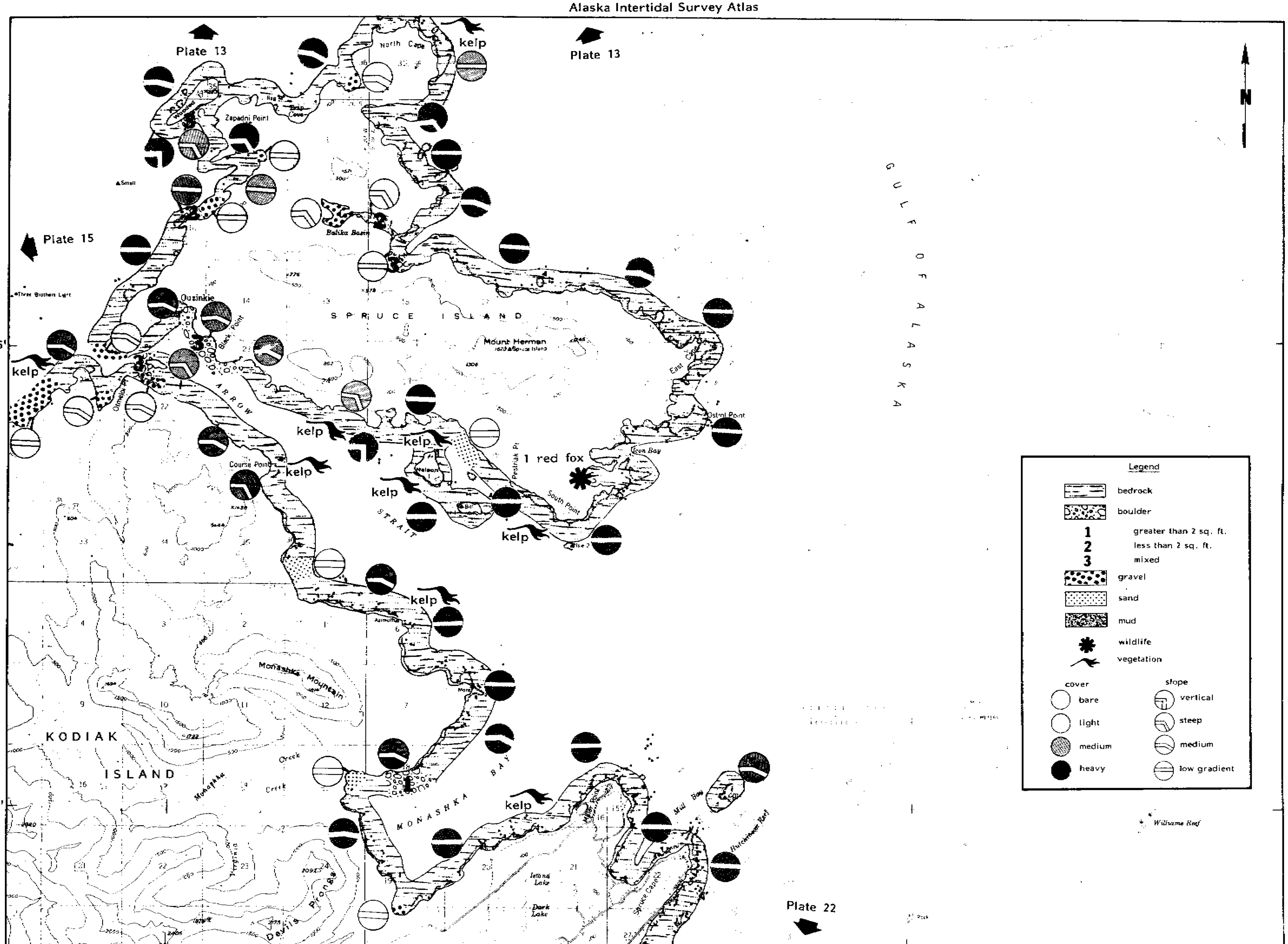
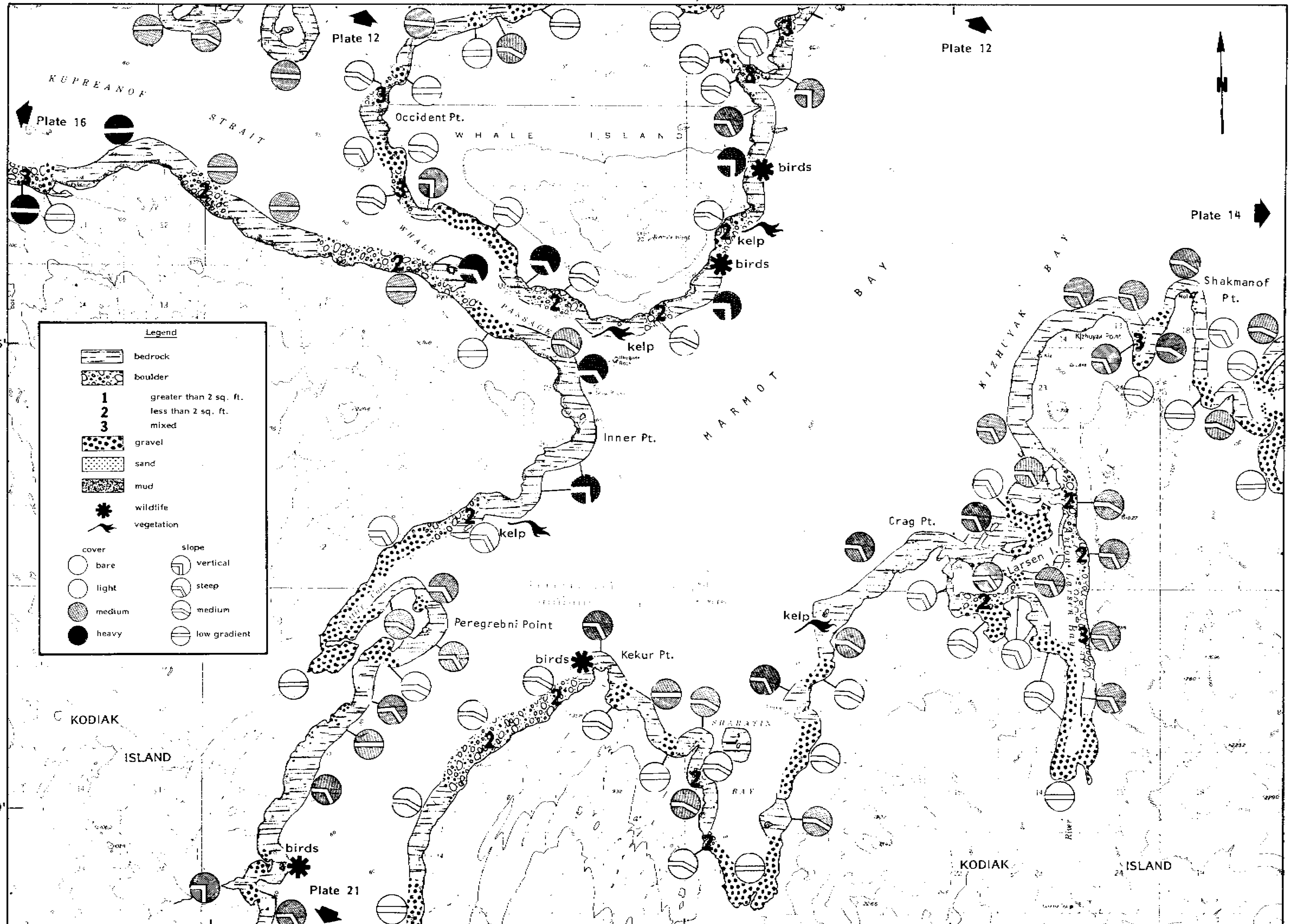


Plate 13
Plate 13
Plate 15
Plate 22
kelp
North Cape
Zapadni Point
Ouzinkie
SPRUCE ISLAND
Mount Herman
GULF OF ALASKA
Ostrol Point
1 red fox
Icon Bay
South Point
Course Point
ARROW
STRAIT
Monashka Mountain
KODIAK ISLAND
MONASHKA BAY
Mill Bay
57° 55'
57° 50'
152° 30'
152° 15'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient



KODIAK ISLAND

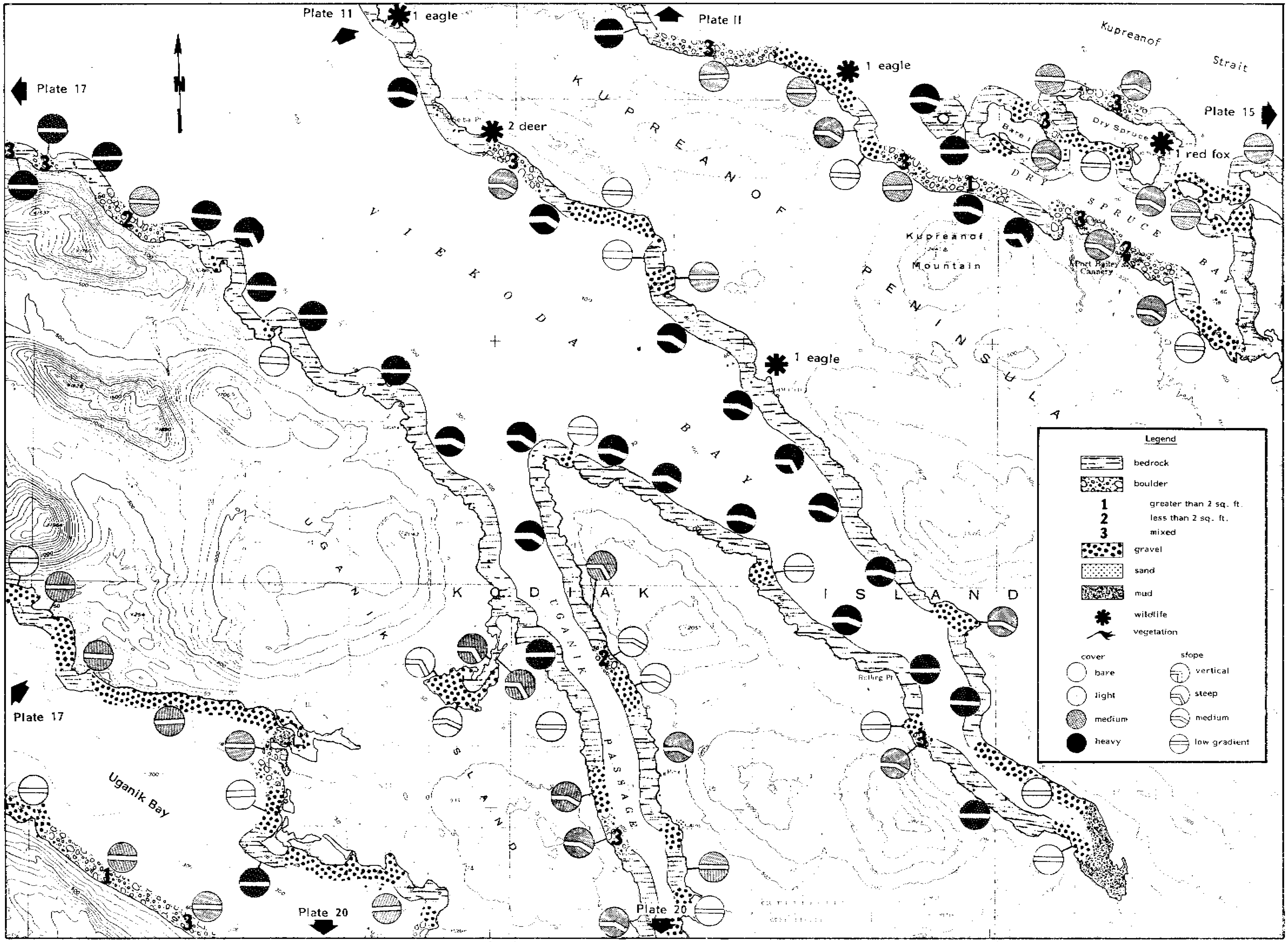
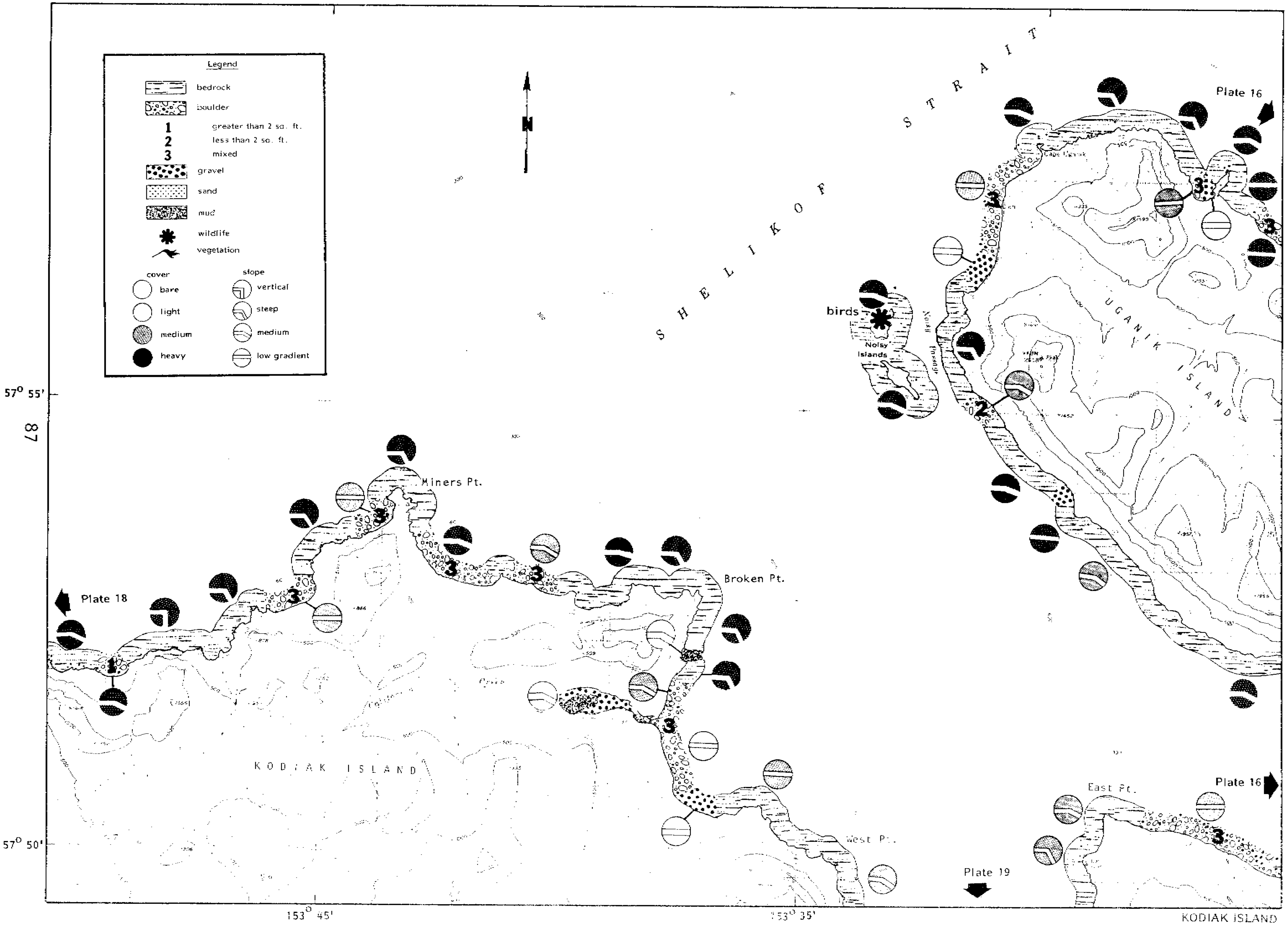


Plate 11
1 eagle
Plate II
Kupreanof
Strait
Plate 17
N
2 deer
K U P R E A N O F
1 eagle
3
Plate 15
1 red fox
Dry Spruce
D R Y S P R U C E B A Y
Kupreanof Mountain
P E N I N S U L A
Port Bailey Cannery
V I E K O D A
B A Y
57° 55'
1 eagle
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
U G A N I K
K O D I A K
I S L A N D
U G A N I K
P A S S A G E
I S L A N D
Plate 17
Uganik Bay
57° 50'
Plate 20
Plate 20
153° 15'
153° 05'
KODIAK ISLAND


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
SHELIKOF STRAIT
Plate 16
Plate 18
Plate 19
Plate 16
birds
Noisy Islands
UGANIK ISLAND
Miners Pt.
Broken Pt.
KODIAK ISLAND
East Pt.
West Pt.
57° 55'
57° 50'
153° 45'
153° 35'
KODIAK ISLAND

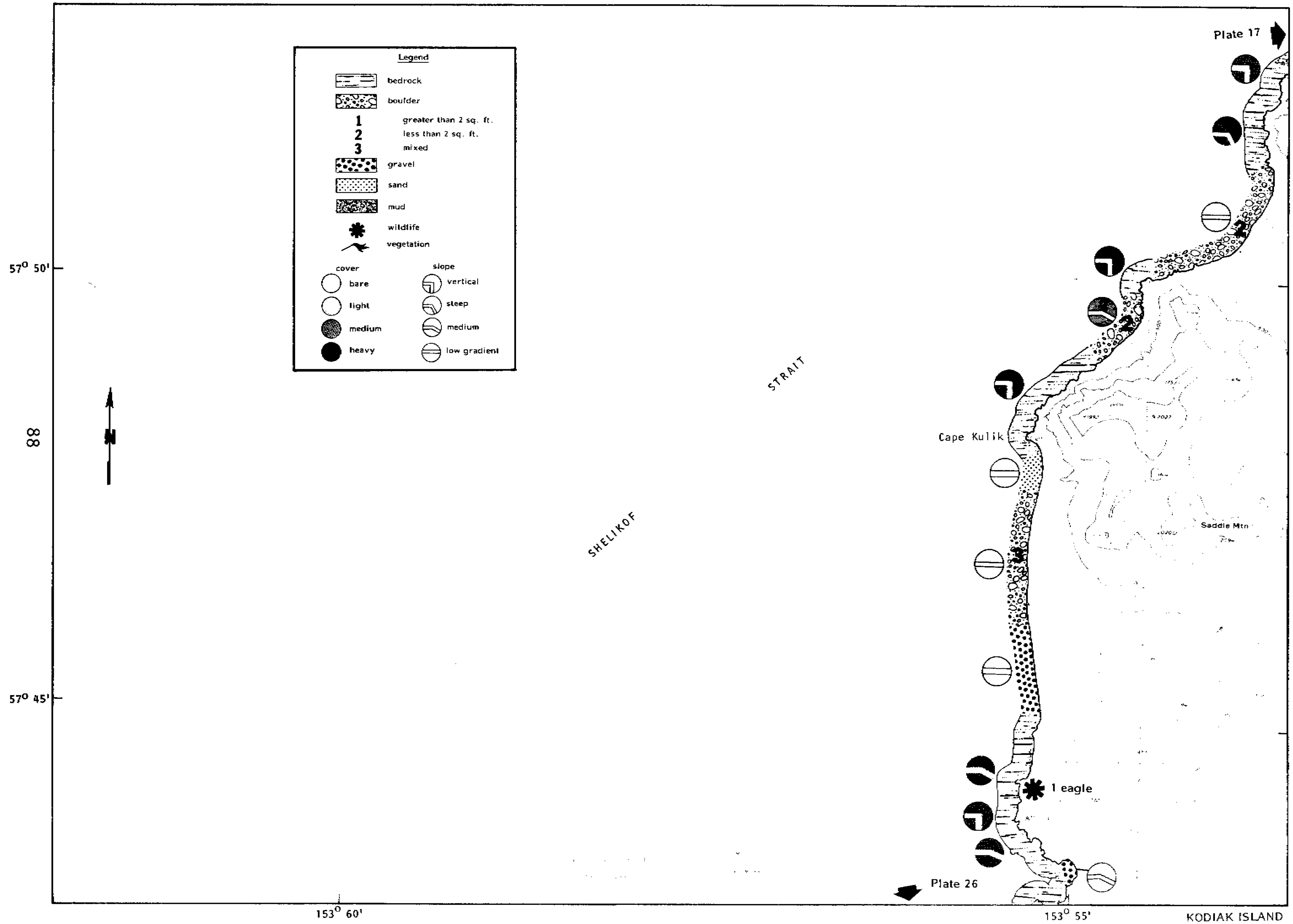
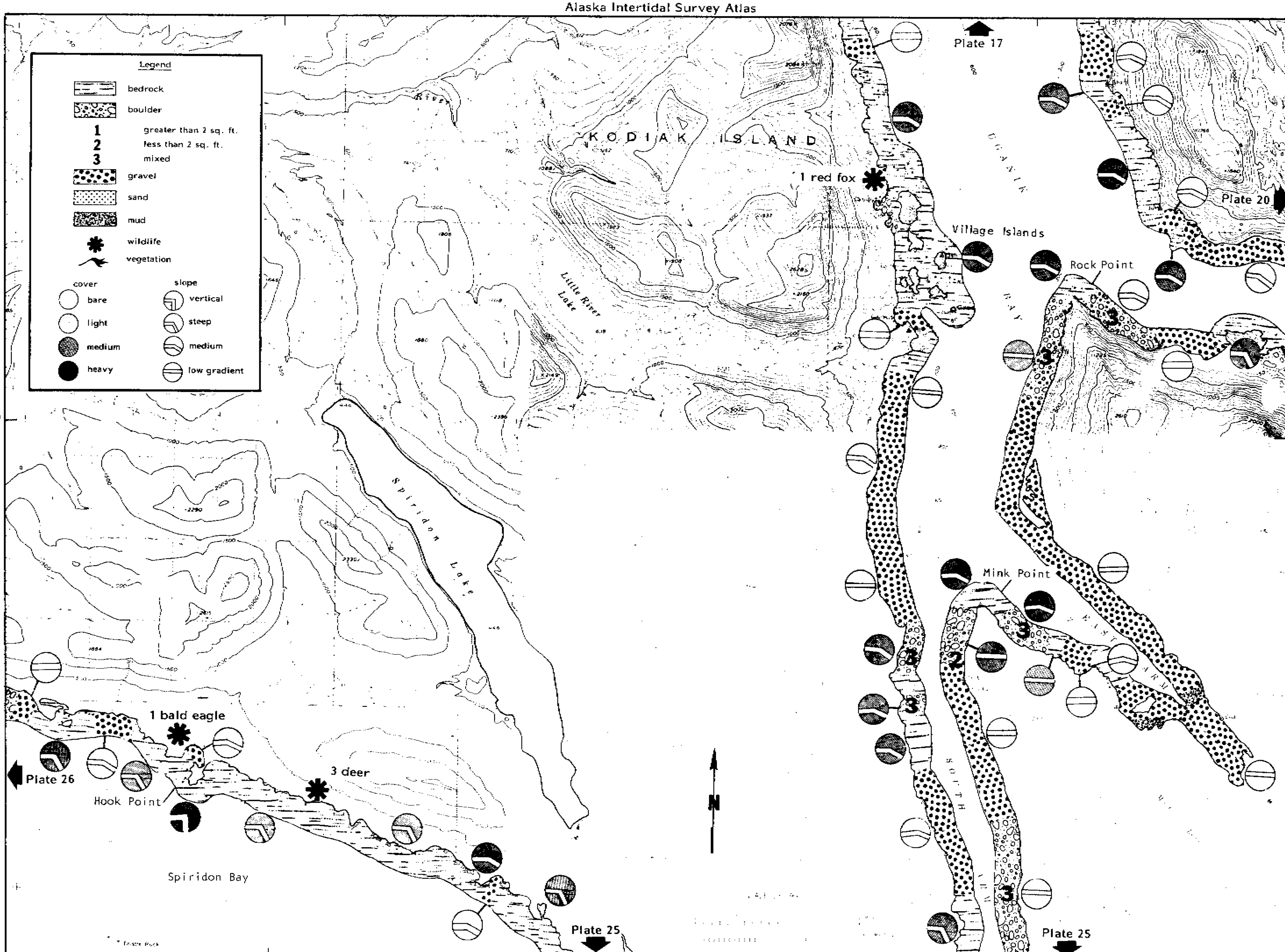


Plate 17
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
57° 50'
57° 45'
88
STRAIT
SHELIKOF
Cape Kulik
Saddle Mtn
1 eagle
Plate 26
153° 60'
153° 55'
KODIAK ISLAND



Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
KODIAK ISLAND
1 red fox
Plate 17
Plate 20
Village Islands
Rock Point
Little River Lake
Spiridon Lake
57° 45'
Mink Point
1 bald eagle
3 deer
Plate 26
Hook Point
Spiridon Bay
Plate 25
Plate 25
N
153° 45'

89

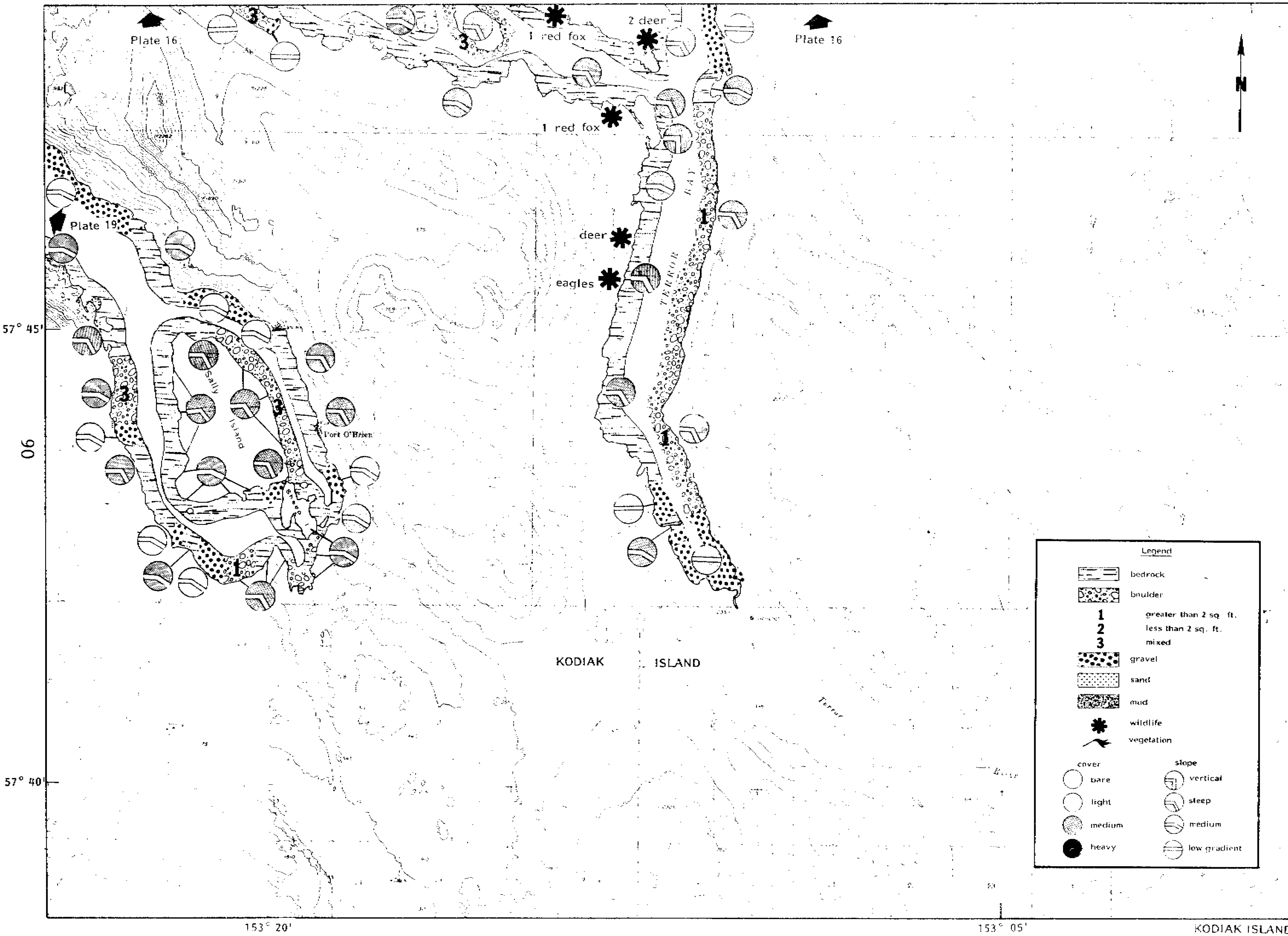


Plate 16
2 deer
1 red fox
Plate 16
1 red fox
Plate 19
deer
eagles
57° 45'
Sally Island
Port O'Brien
TERROR BAY
KODIAK ISLAND
57° 40'
153° 20'
153° 05'
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient

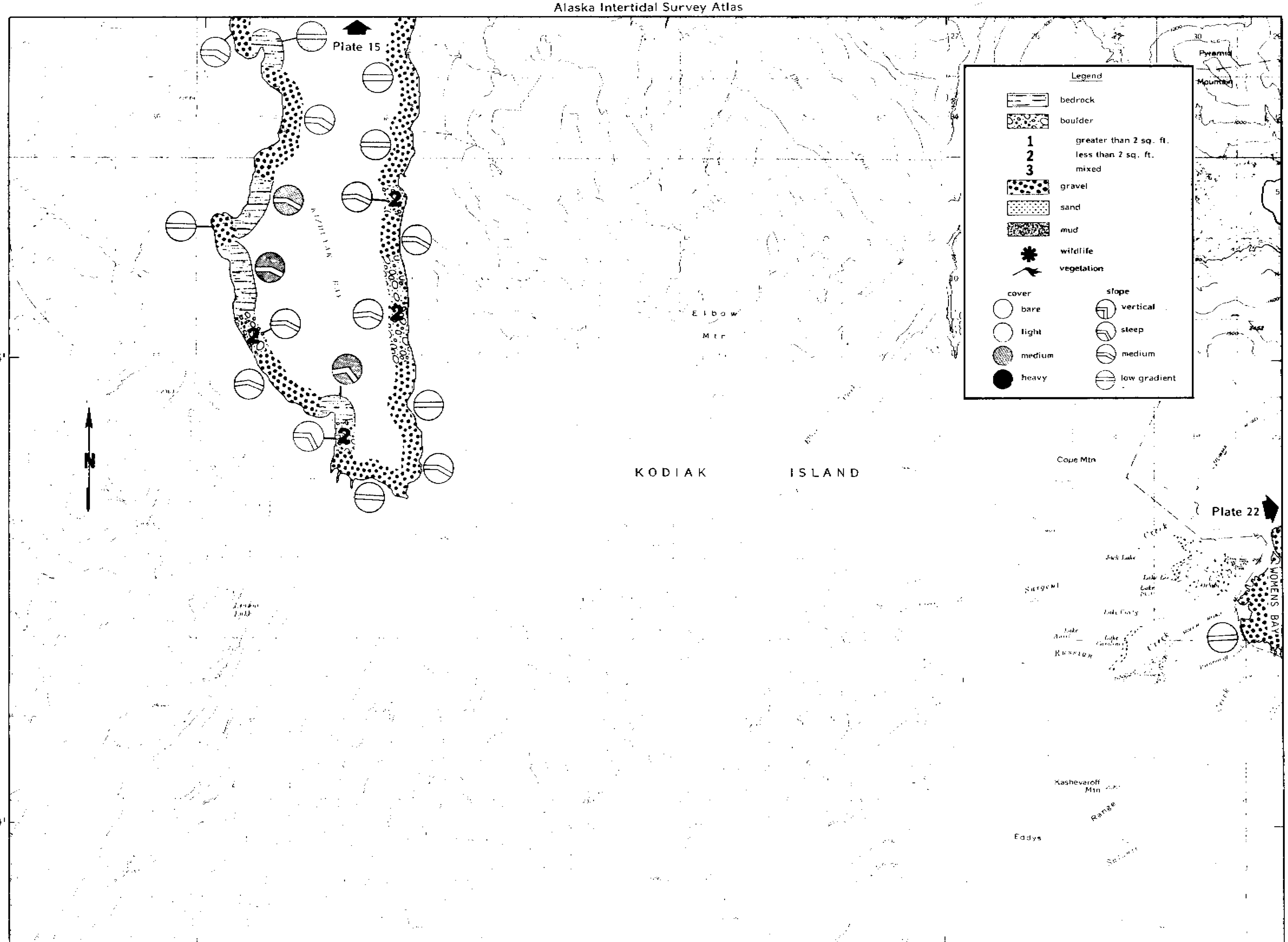


Plate 15
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
Pyramid Mountain
Elbow Mtn
KODIAK ISLAND
Cope Mtn
Plate 22
WOMENS BAY
Kashevaroff Mtn
Range
Eddys
57° 45'
57° 40'
152° 55'
152° 40'
N
16

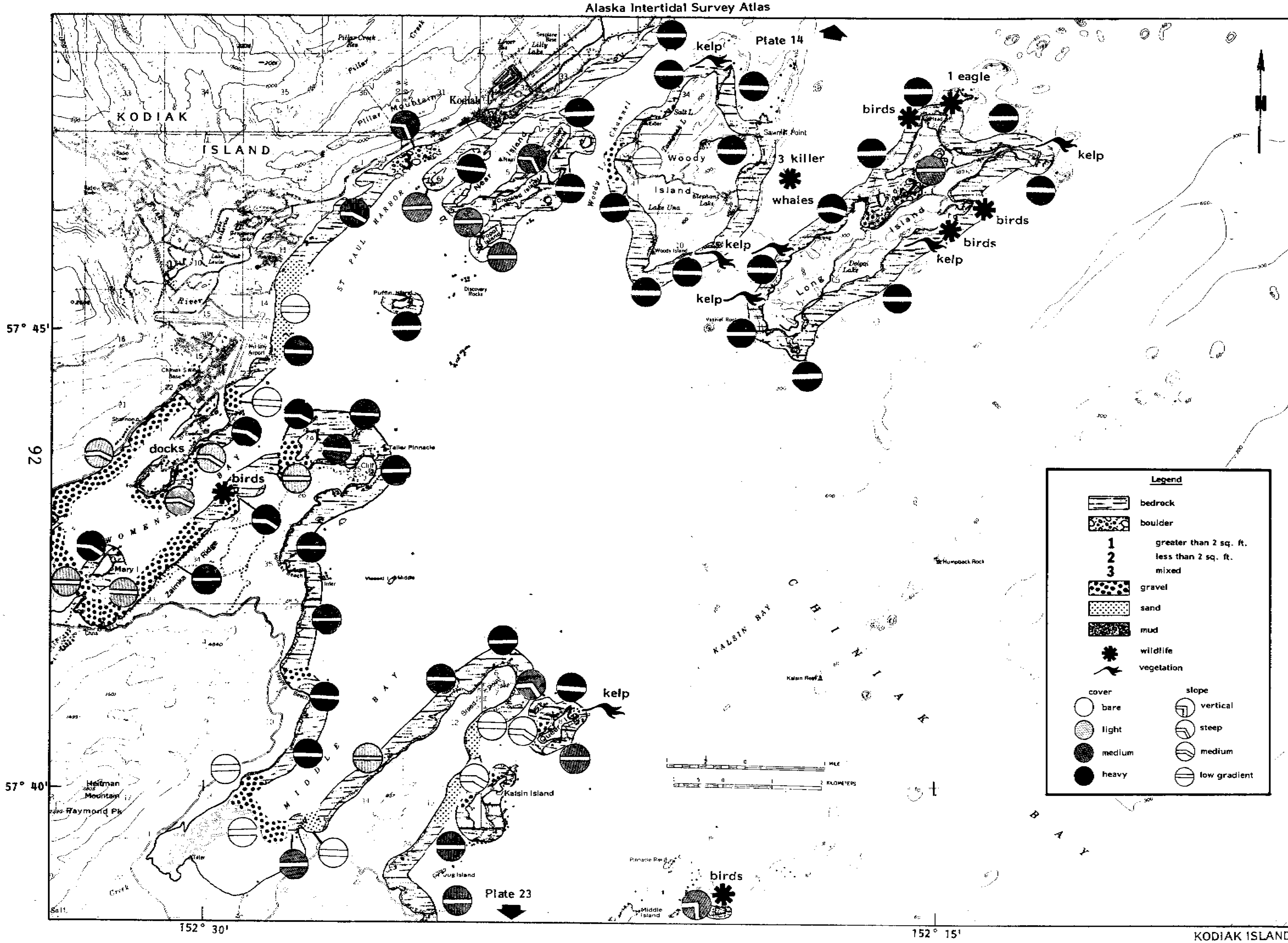


Plate 14
kelp
1 eagle
birds
kelp
3 killer
whales
birds
birds
kelp
kelp
kelp
KODIAK
ISLAND
Woody
Island
Long Island
ST PAUL HARBOR
docks
birds
WOMENS BAY
Mary I
Zaimka Ridge
MIDDLE BAY
kelp
Kalsin Island
Jug Island
Plate 23
birds
Middle Island
KALSIN BAY
CHINIAK BAY
Humpback Rock
Kalsin Reef
Teller Pinnacle
Puffin Island
Discovery Rocks
Heitman Mountain
Raymond Pk
57° 45'
57° 40'
152° 30'
152° 15'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
1 MILE
2 KILOMETERS
KODIAK ISLAND

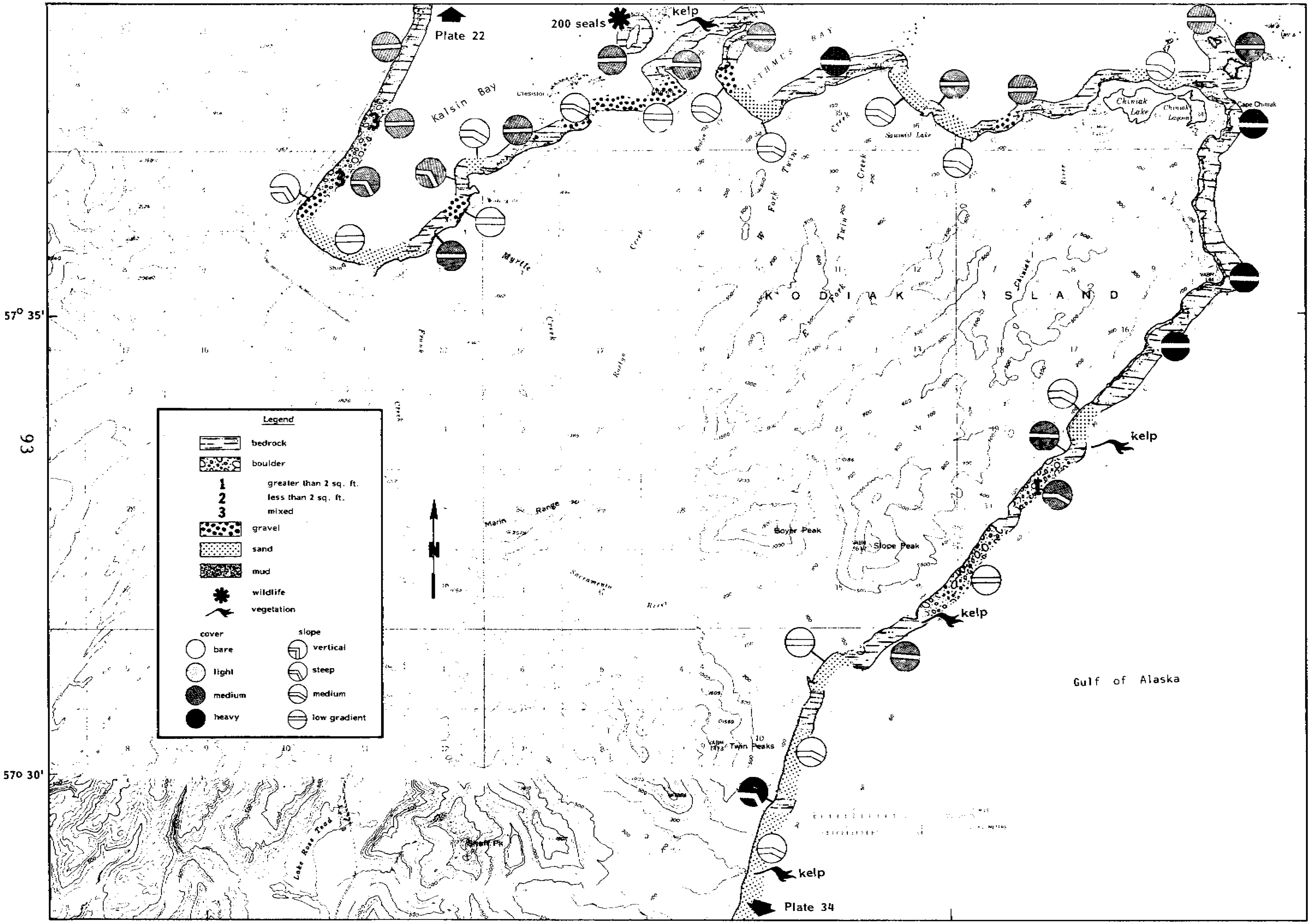
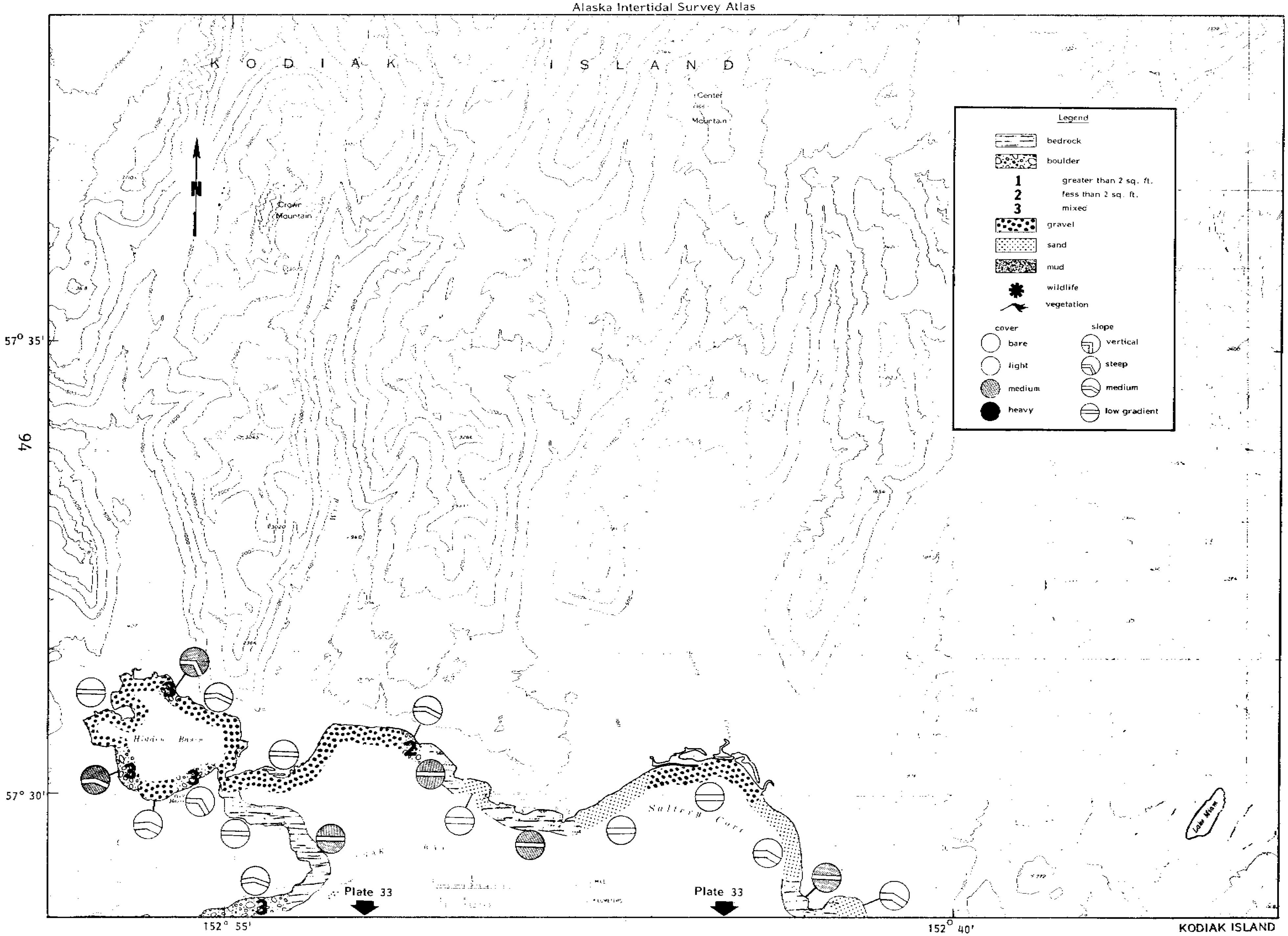


Plate 22
200 seals
kelp
Kalsin Bay
Isthmus Bay
Chiniak Lake
Chiniak Lagoon
Cape Chiniak
Saltery Lake
Myrtle
Creek
W Fork
Twin Creek
E Fork
KODIAK ISLAND
Marin Range
Sacramento River
Boyer Peak
Slope Peak
Twin Peaks
Lake Rose Tead
Gulf of Alaska
kelp
kelp
kelp
Plate 34
57° 35'
57° 30'
152° 30'
152° 15'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N


K O D I A K I S L A N D
Center Mountain
Crown Mountain
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
57° 35'
57° 30'
152° 55'
152° 40'
Plate 33
Plate 33
Hidden Basin
Saltery Cove
KODIAK ISLAND

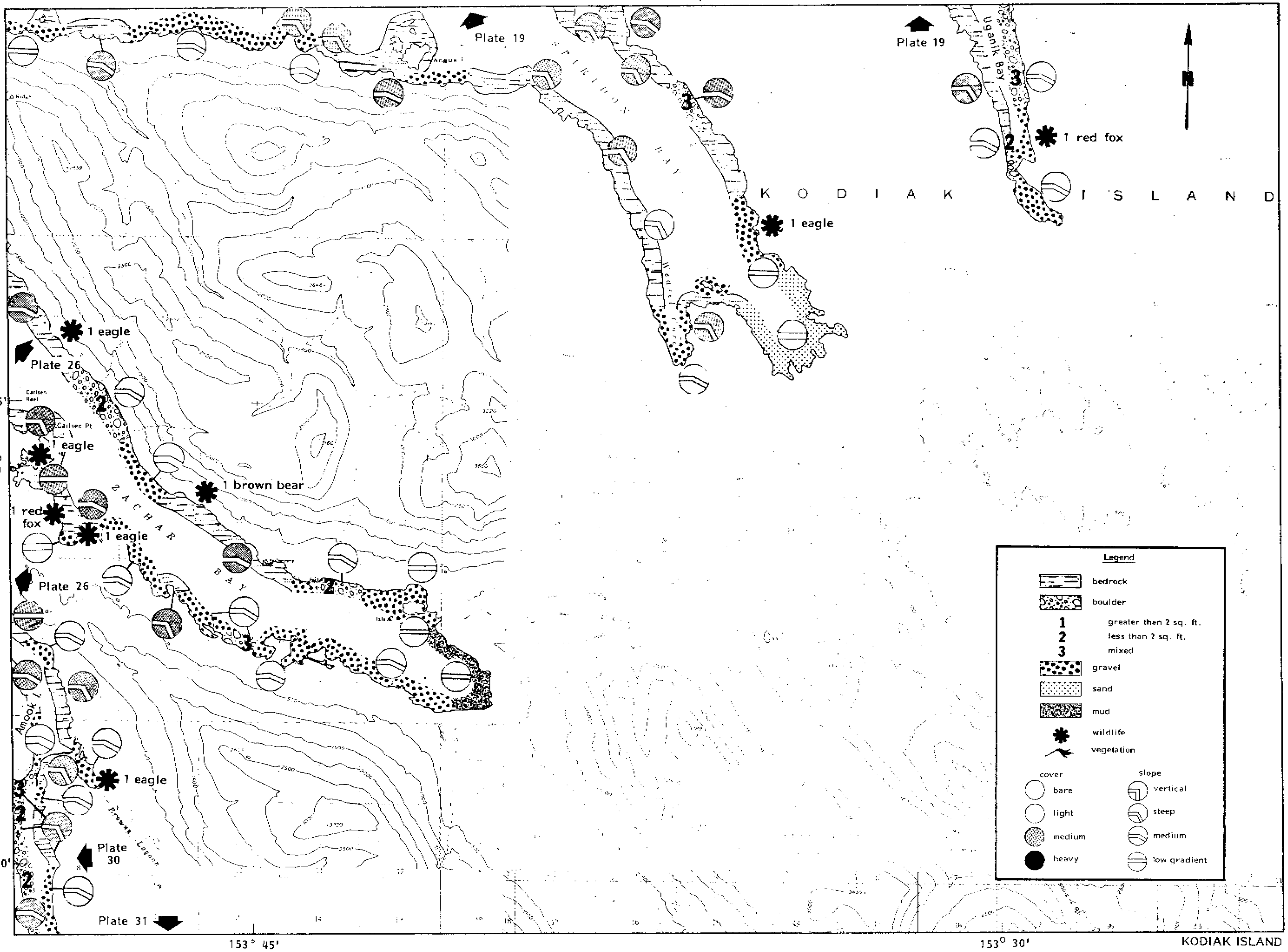


Plate 19
Plate 19
Uganik Bay
N
1 red fox
K O D I A K I S L A N D
1 eagle
1 eagle
Plate 26
57° 35'
Carlsen Reef
Carlsen Pt
1 eagle
1 brown bear
1 red fox
1 eagle
Z A C H A R B A Y
Plate 26
Amook I
1 eagle
Plate 30
57° 30'
Plate 31
153° 45'
153° 30'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
KODIAK ISLAND

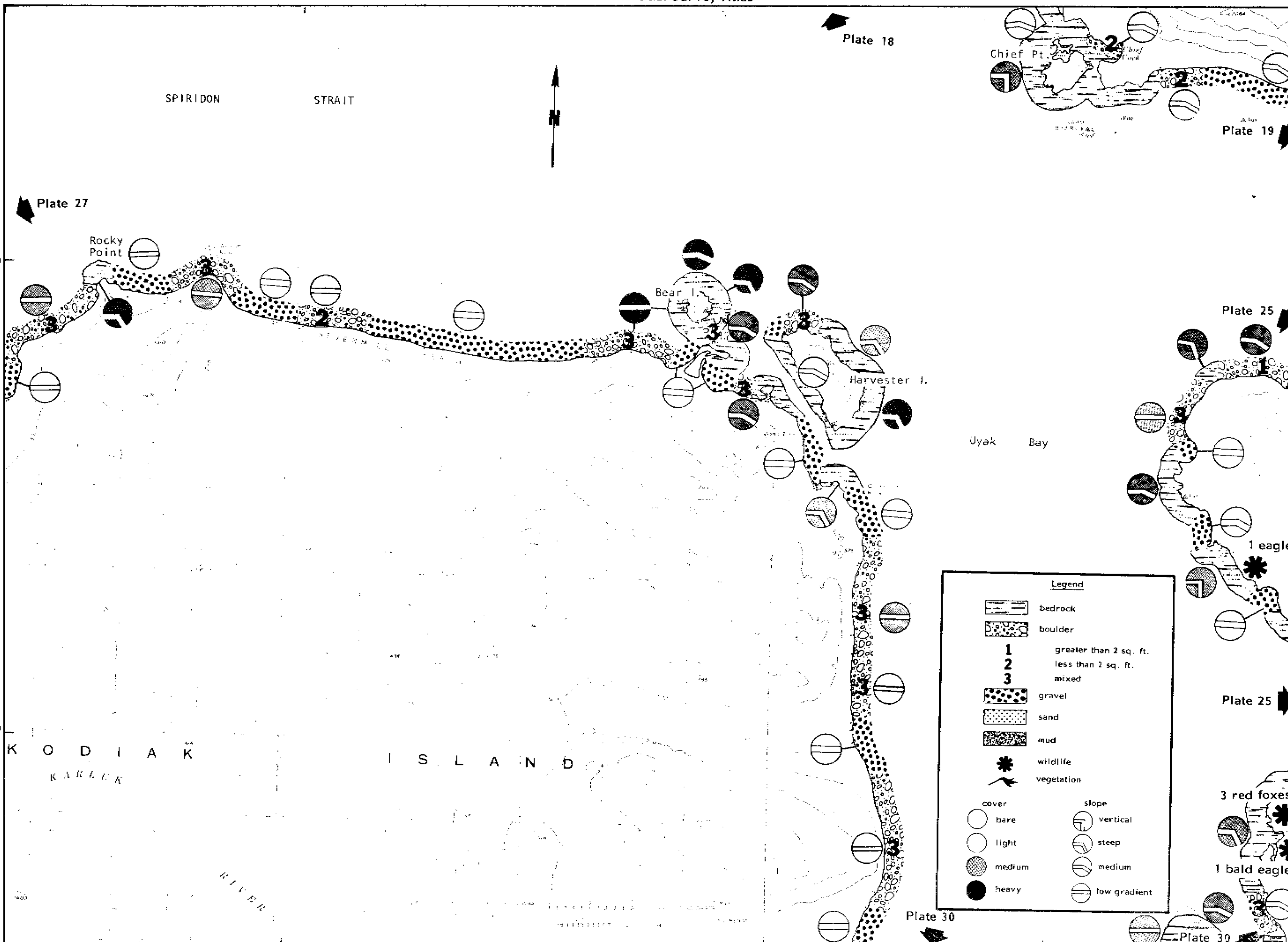


Plate 18
Chief Pt.
Plate 19
SPIRIDON STRAIT
N
Plate 27
Rocky Point
57° 40'
Bear I.
Harvester I.
Plate 25
Uyak Bay
1 eagle
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
Plate 25
57° 35'
K O D I A K I S L A N D
KARLUK
RIVER
3 red foxes
1 bald eagle
Plate 30
Plate 30
154° 10'
153° 55'

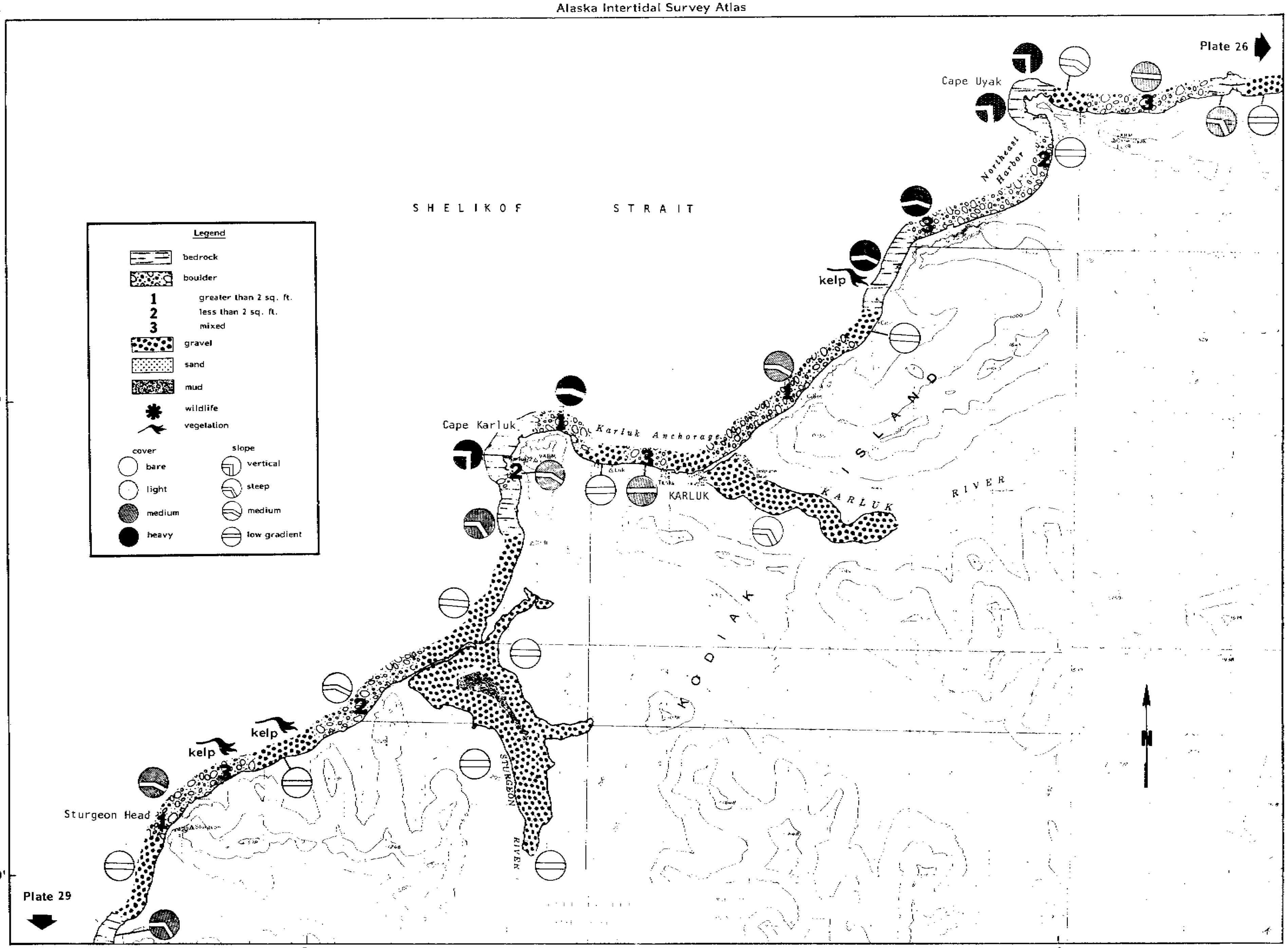
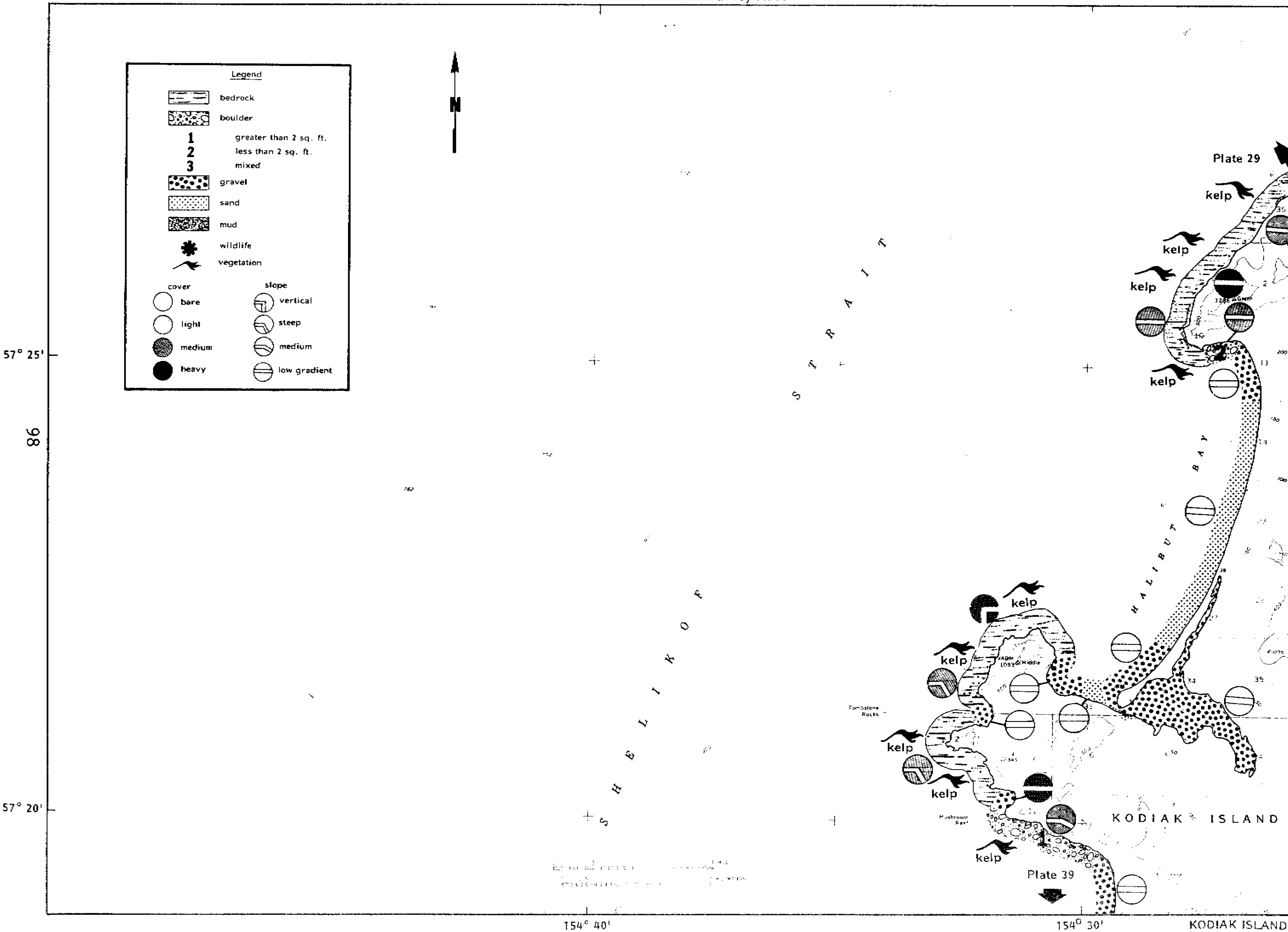


Plate 26
Cape Uyak
Northeast Harbor
SHELIKOF STRAIT
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
kelp
57° 35'
Cape Karluk
Karluk Anchorage
KARLUK
KARLUK RIVER
KODIAK ISLAND
STURGEON RIVER
Sturgeon Head
57° 30'
Plate 29
154° 35'
154° 20'
N

97


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Plate 29
kelp
57° 25'
86
S T R A I T
S H E L I K O F
H A L I B U T B A Y
Tombstone Rocks
Plate 39
57° 20'
K O D I A K I S L A N D
154° 40'
154° 30'
KODIAK ISLAND

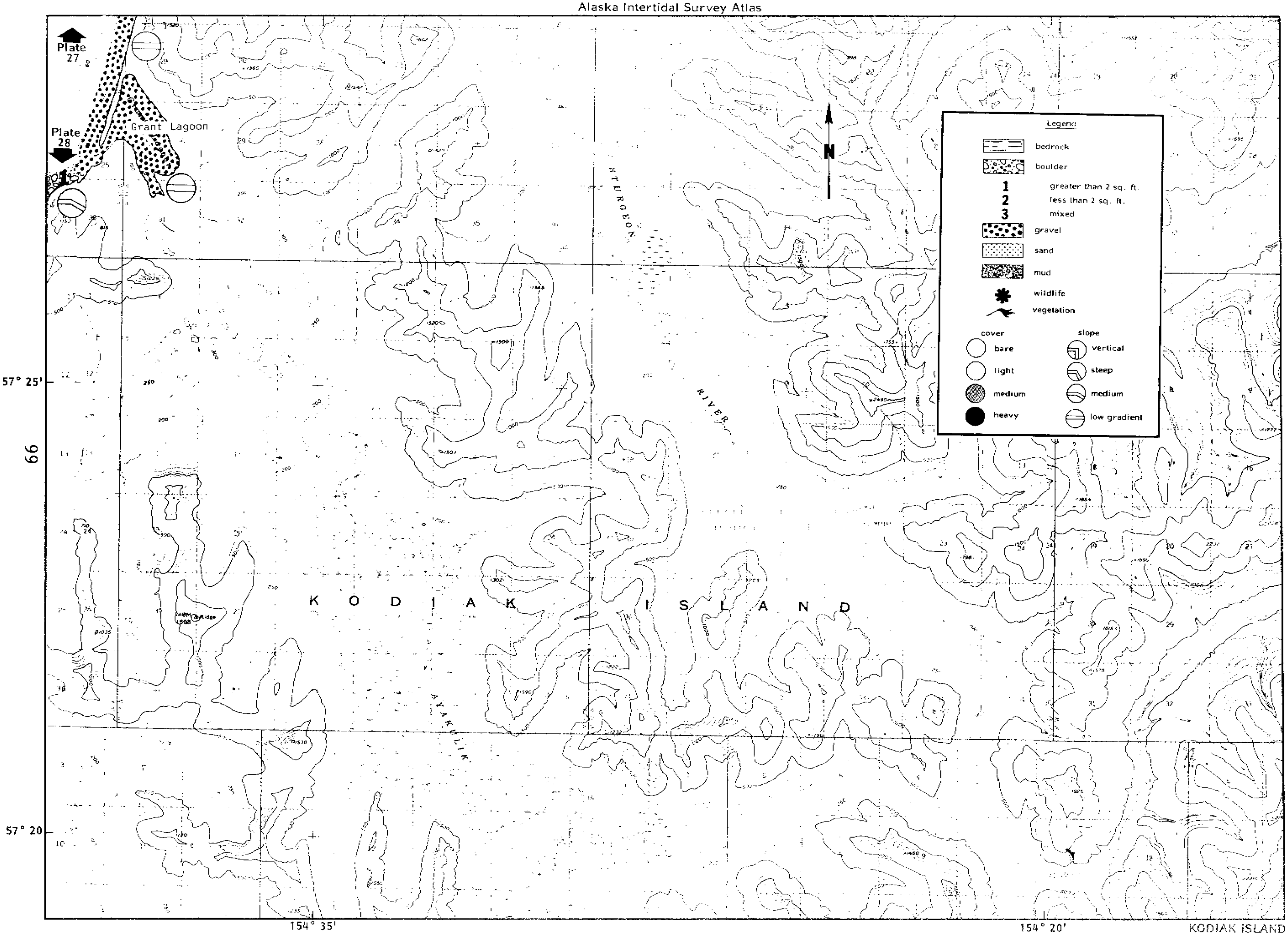
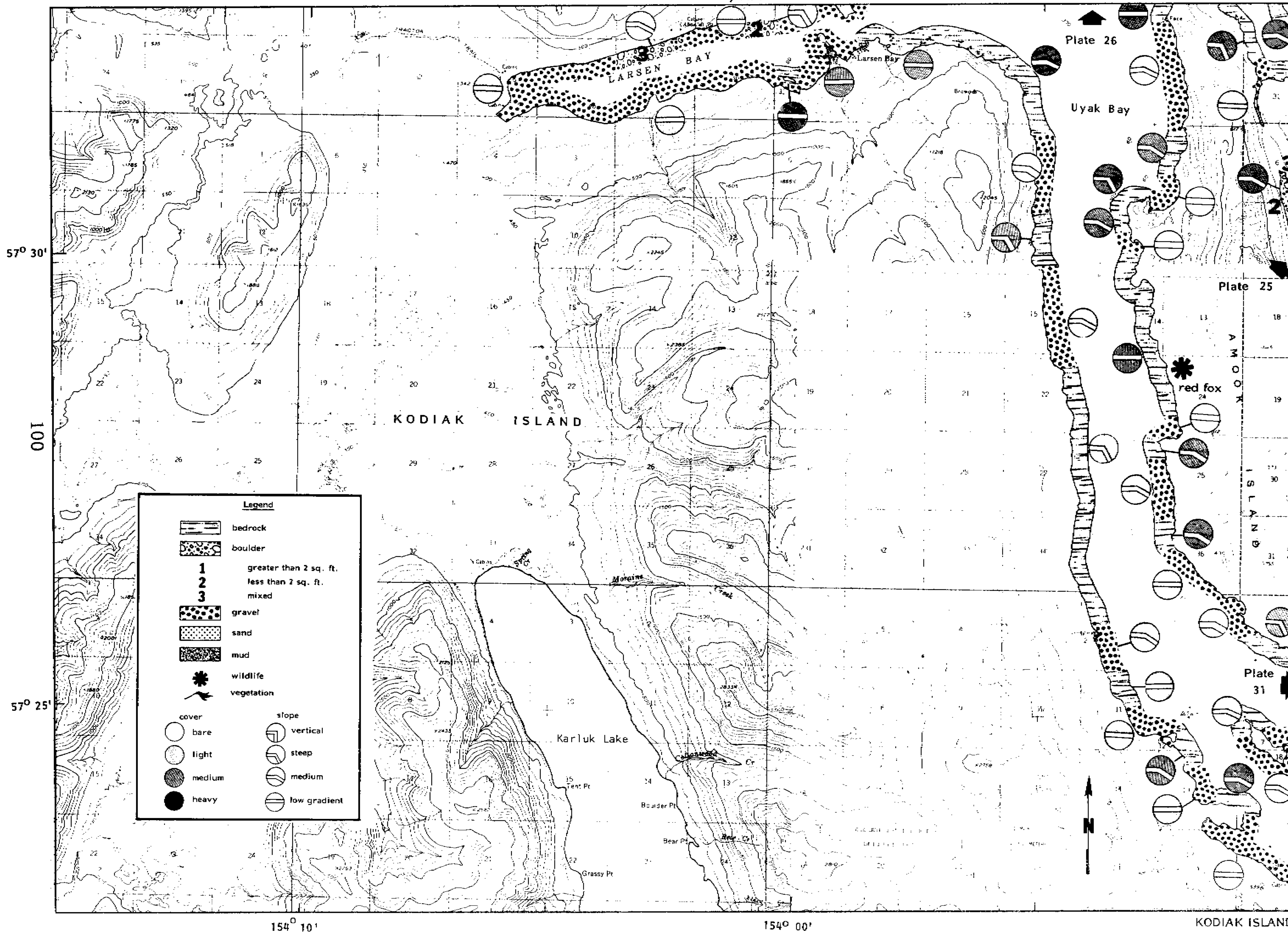


Plate 27
Plate 28
Grant Lagoon
STURGEON
RIVER
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
K O D I A K
I S L A N D
AYAKULIK
57° 25'
57° 20
154° 35'
154° 20'
KODIAK ISLAND



KODIAK ISLAND

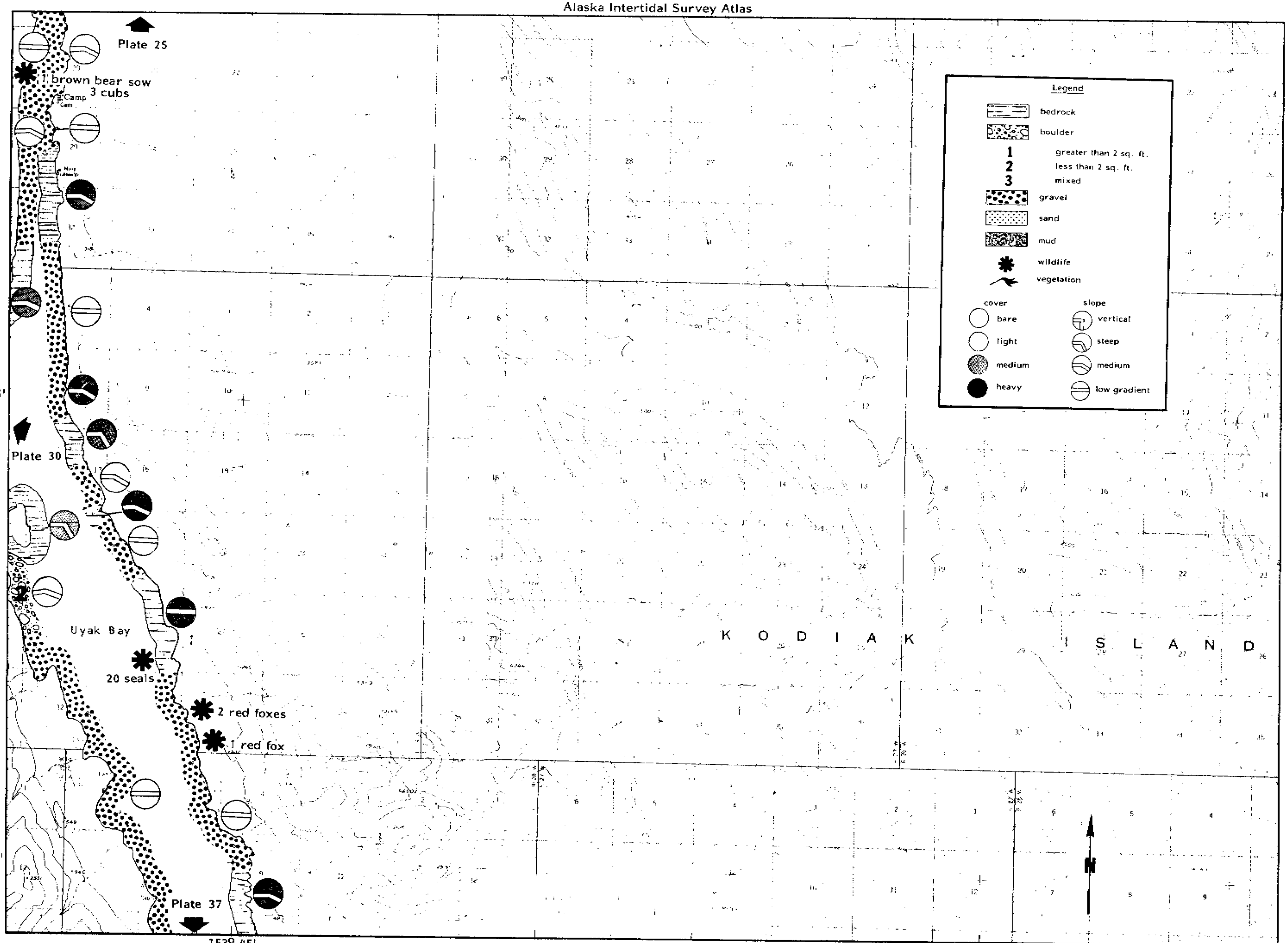
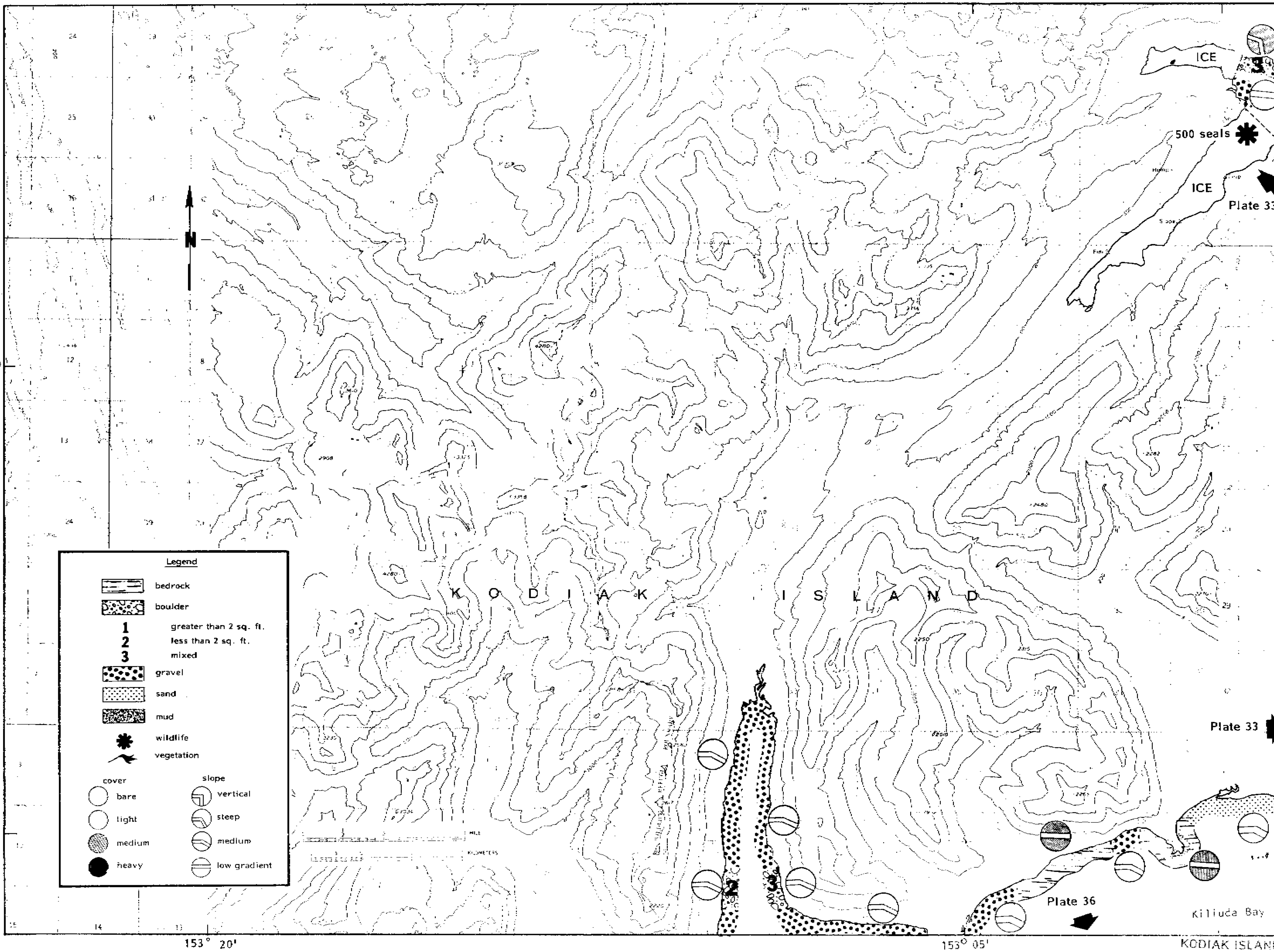


Plate 25
1 brown bear sow
3 cubs
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
57° 25'
101
Plate 30
Uyak Bay
20 seals
2 red foxes
1 red fox
K O D I A K I S L A N D
57° 20'
Plate 37
153° 45'
153° 30'


ICE
500 seals
ICE
Plate 33
57° 25'
K O D I A K I S L A N D
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
Plate 33
57° 20'
2
3
Plate 36
Kiliuda Bay
153° 20'
153° 05'
KODIAK ISLAND

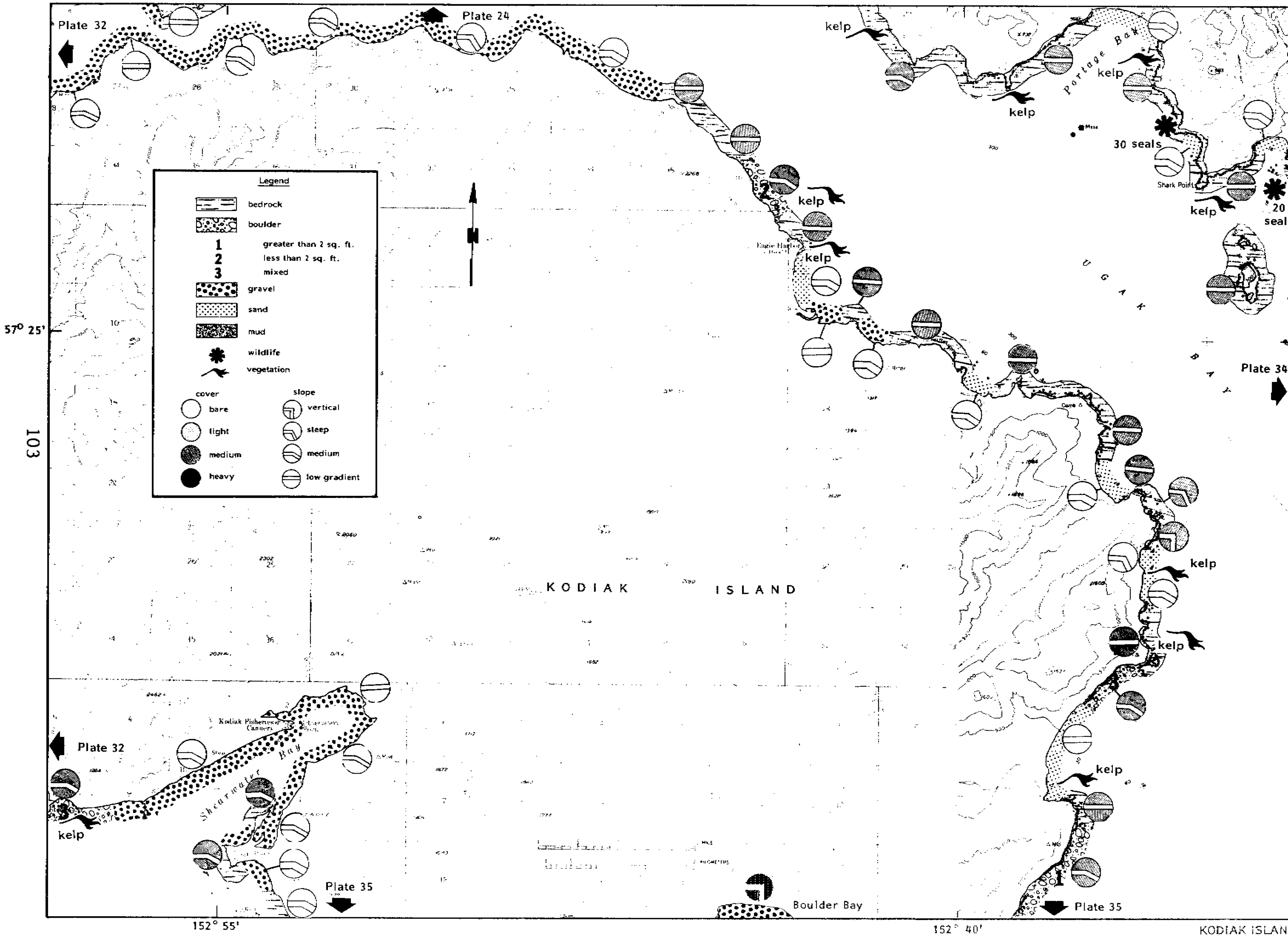


Plate 32
Plate 24
Plate 34
Plate 35
Plate 32
Plate 35
kelp
kelp
kelp
kelp
kelp
kelp
kelp
kelp
kelp
kelp
Portage Bay
30 seals
20 seals
Shark Point
UGAK BAY
KODIAK ISLAND
Shearwater Bay
Kodiak Fisheries Cannery
Boulder Bay
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
57° 25'
152° 55'
152° 40'

103

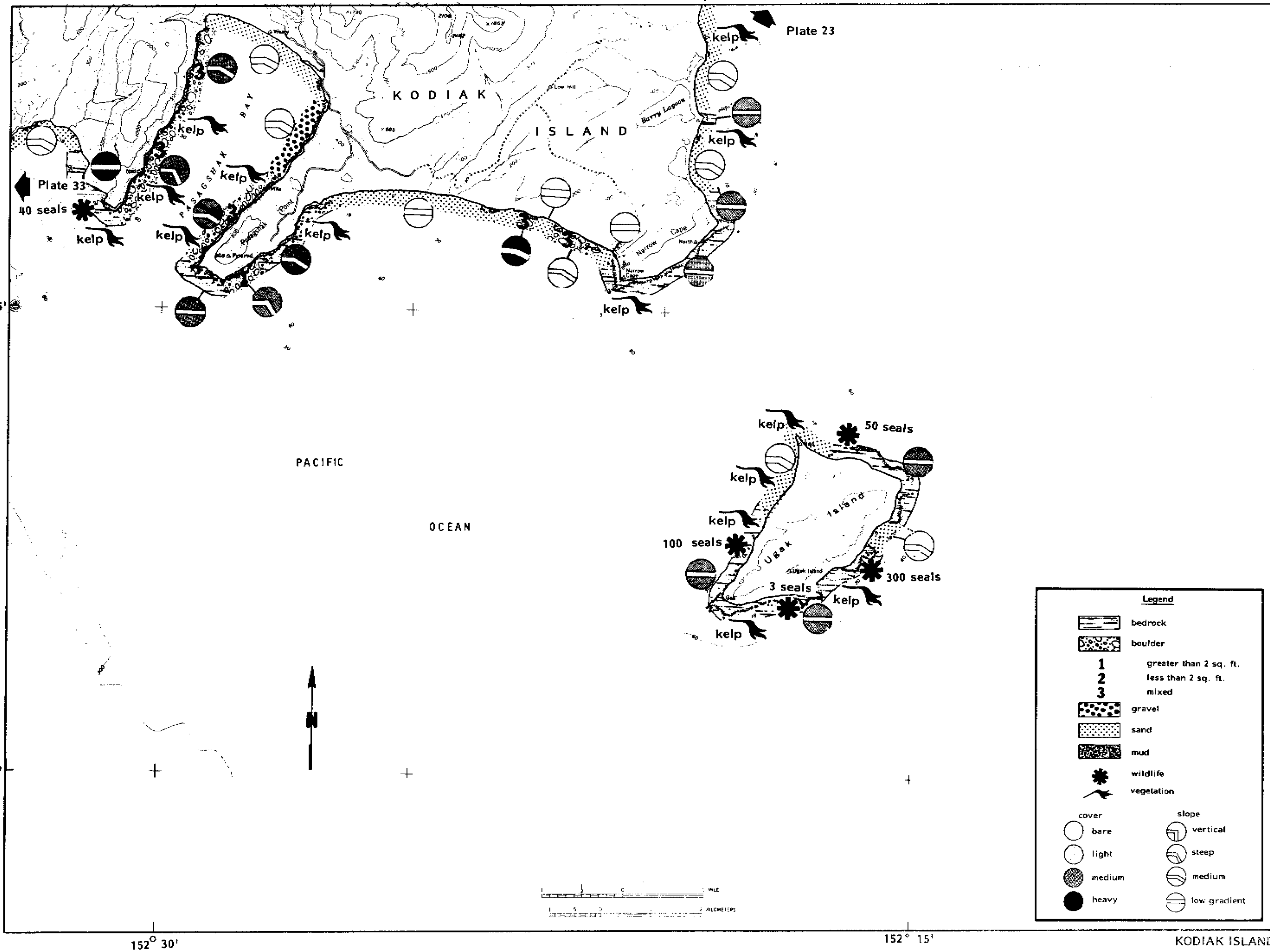


Plate 23
Plate 33
KODIAK
ISLAND
PASAGSHAK
BAY
Barry Lagoon
Narrow Cape
kelp
40 seals
57° 25'
57° 20'
PACIFIC
OCEAN
Ugak Island
50 seals
100 seals
300 seals
3 seals
152° 30'
152° 15'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
KODIAK ISLAND

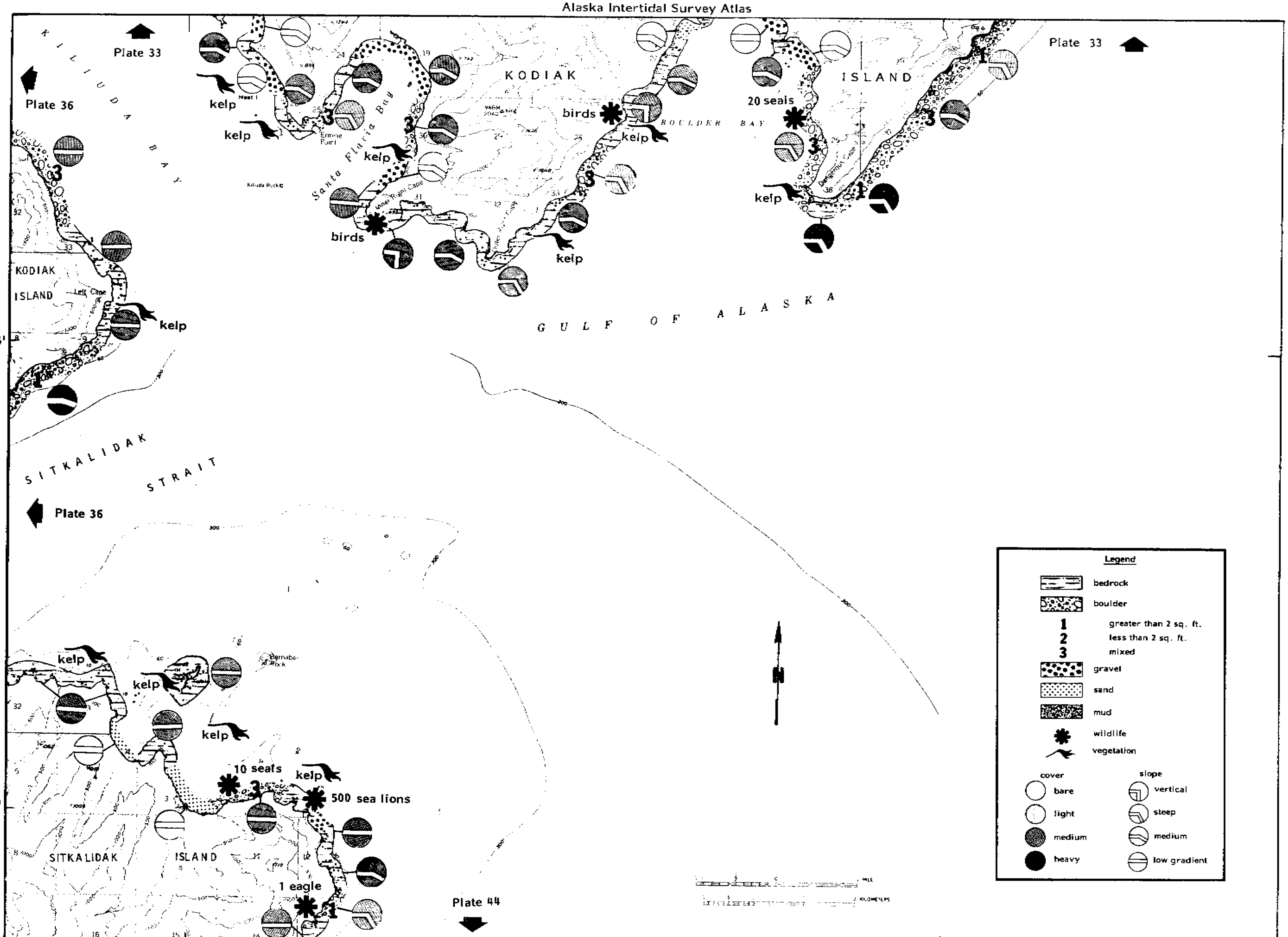
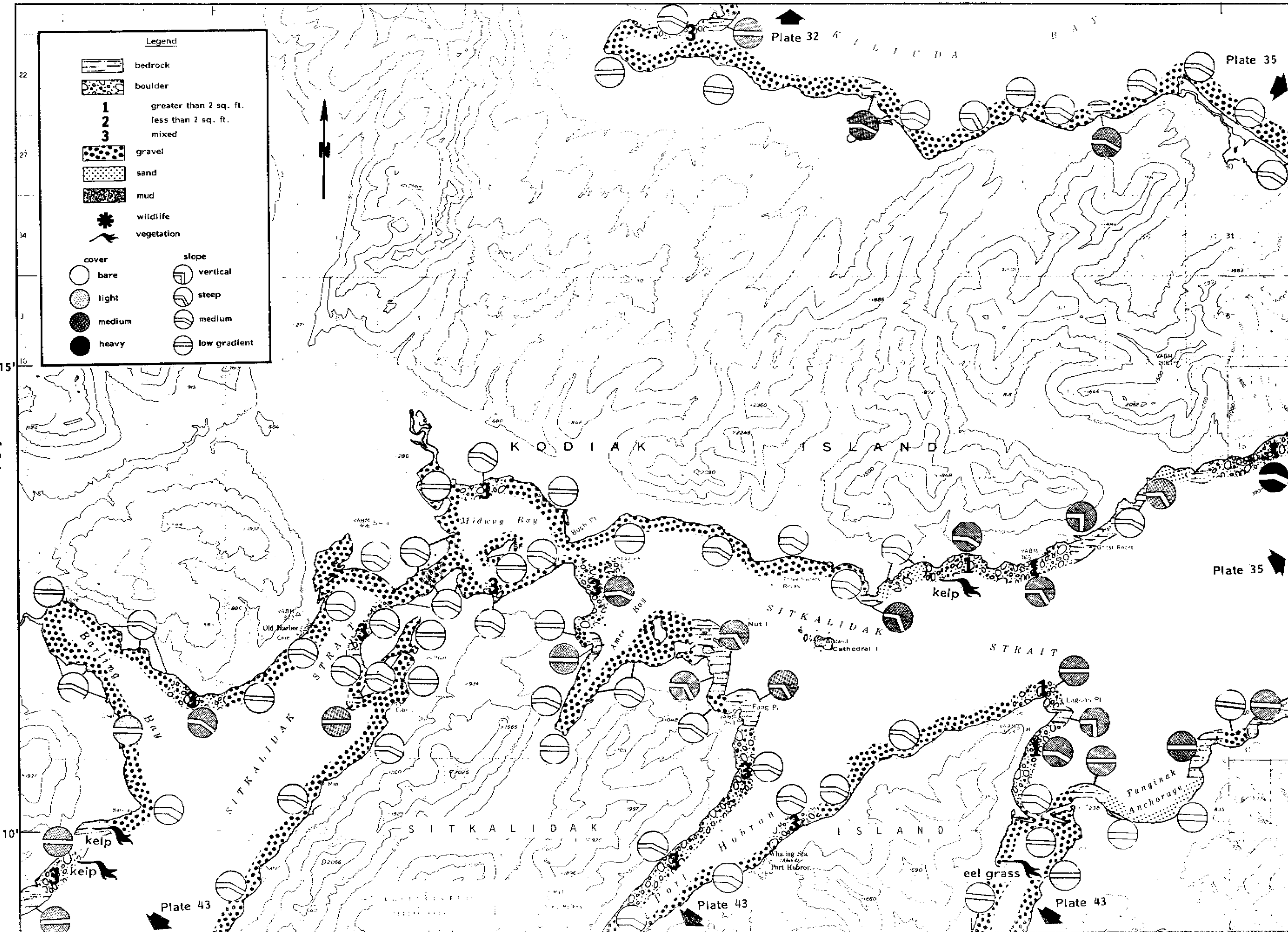
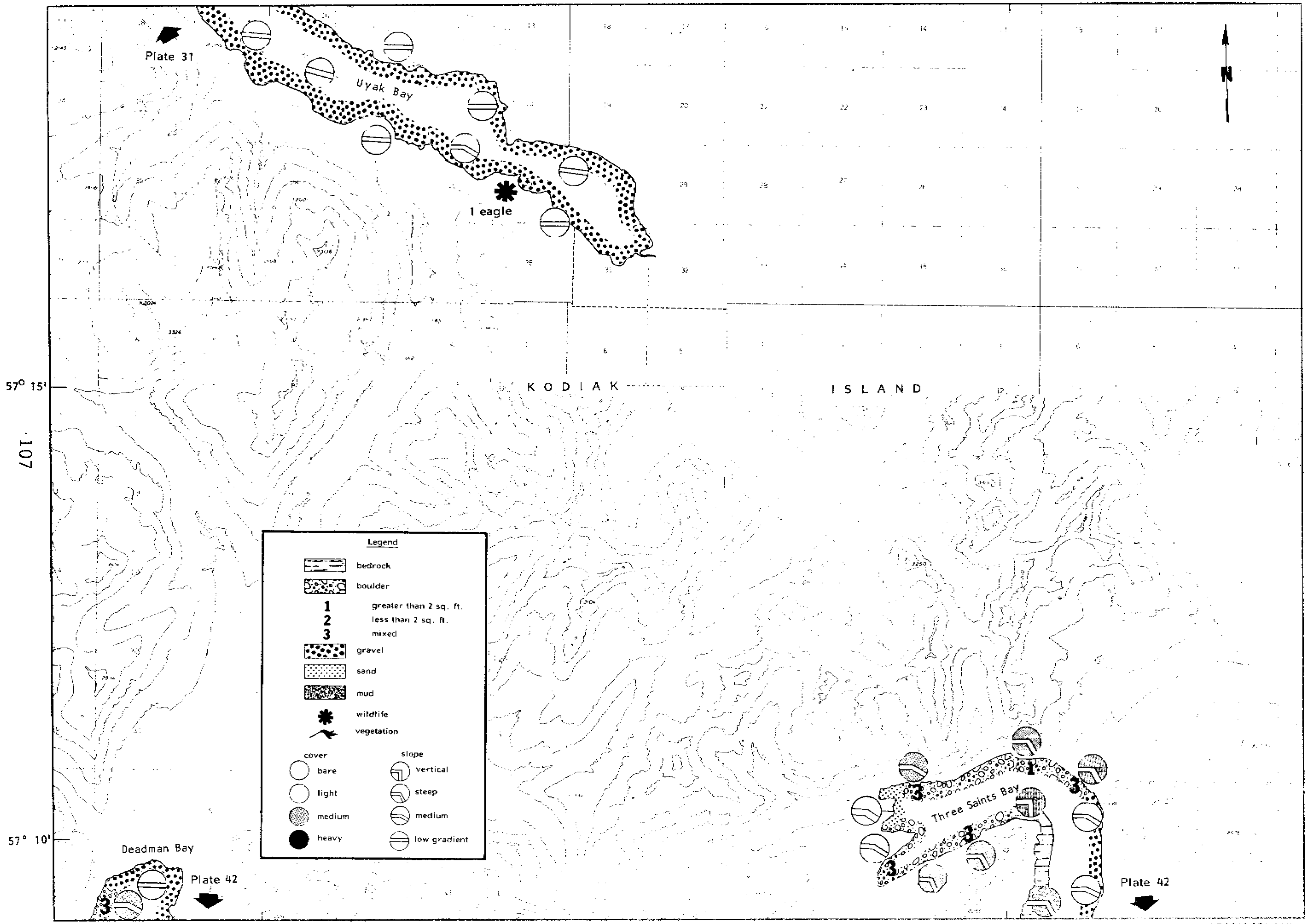


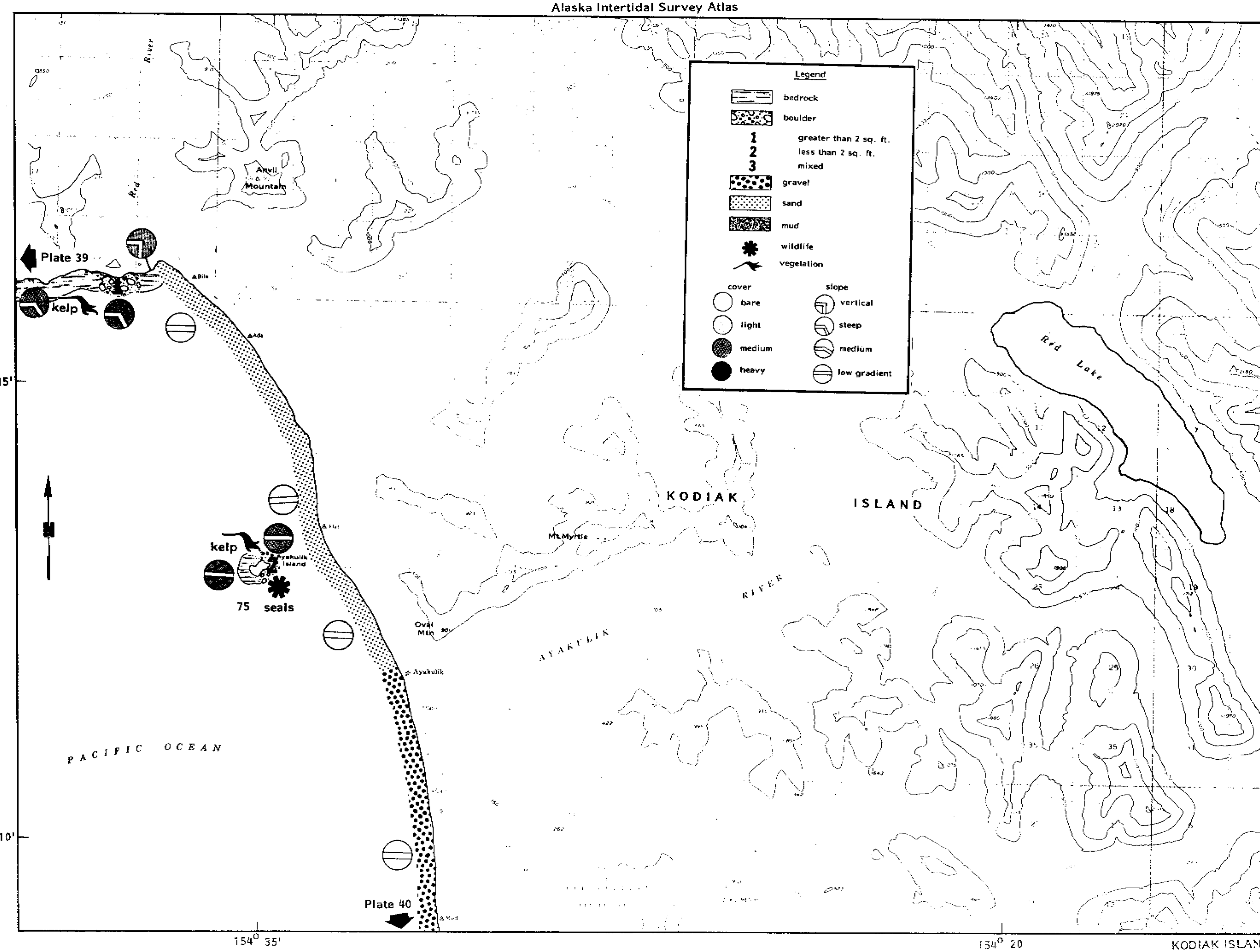
Plate 33
Plate 36
KILIUDA BAY
kelp
Santa Flavia Bay
birds
KODIAK
BOULDER BAY
20 seals
ISLAND
Plate 33
KODIAK
ISLAND
Left Cape
57° 15'
GULF OF ALASKA
SITKALIDAK STRAIT
Plate 36
10 seals
500 sea lions
1 eagle
Barnabas Rock
57° 10'
SITKALIDAK
ISLAND
Plate 44
152° 55'
152° 40'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N

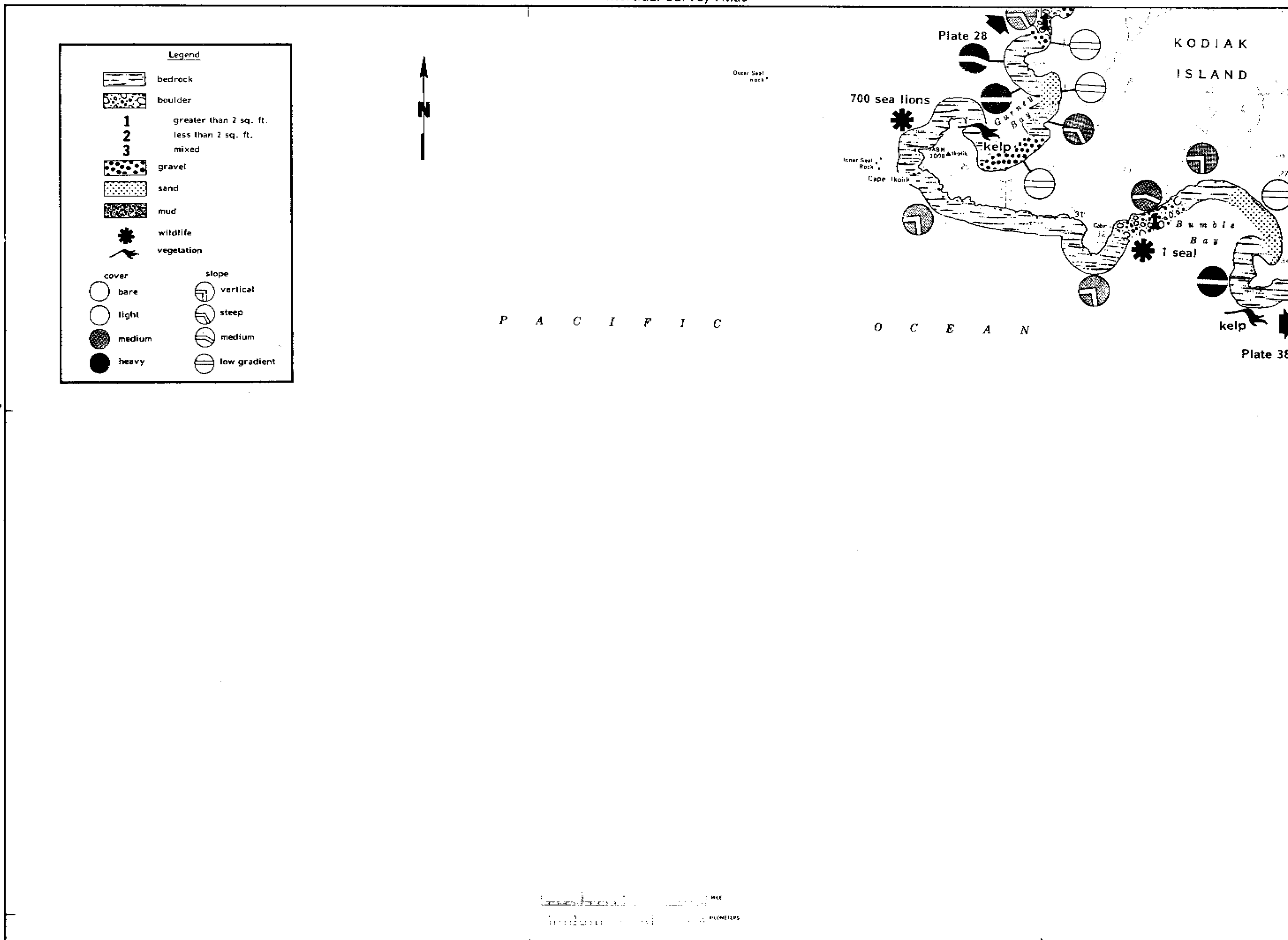

Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Plate 32
Plate 35
Plate 35
Plate 43
Plate 43
Plate 43
KODIAK ISLAND
SITKALIDAK STRAIT
SITKALIDAK ISLAND
Midway Bay
Barling Bay
Port Hobron
Tanginak Anchorage
kelp
kelp
kelp
eel grass
57° 15'
57° 10'
153° 20'
153° 05'

106



KODIAK ISLAND


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
Plate 39
kelp
kelp
75 seals
Anvil Mountain
Red River
KODIAK ISLAND
Red Lake
Mt Myrtle
Oval Mtn
AYAKULIK RIVER
Ayakulik
Ayakulik Island
PACIFIC OCEAN
Plate 40
57° 15'
57° 10'
154° 35'
154° 20
KODIAK ISLAND


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Plate 28
700 sea lions
KODIAK ISLAND
Gurney Bay
kelp
Cape Ikolik
Bumble Bay
1 seal
P A C I F I C O C E A N
kelp
Plate 38
57° 15'
57° 10'
154° 40'
154° 30'

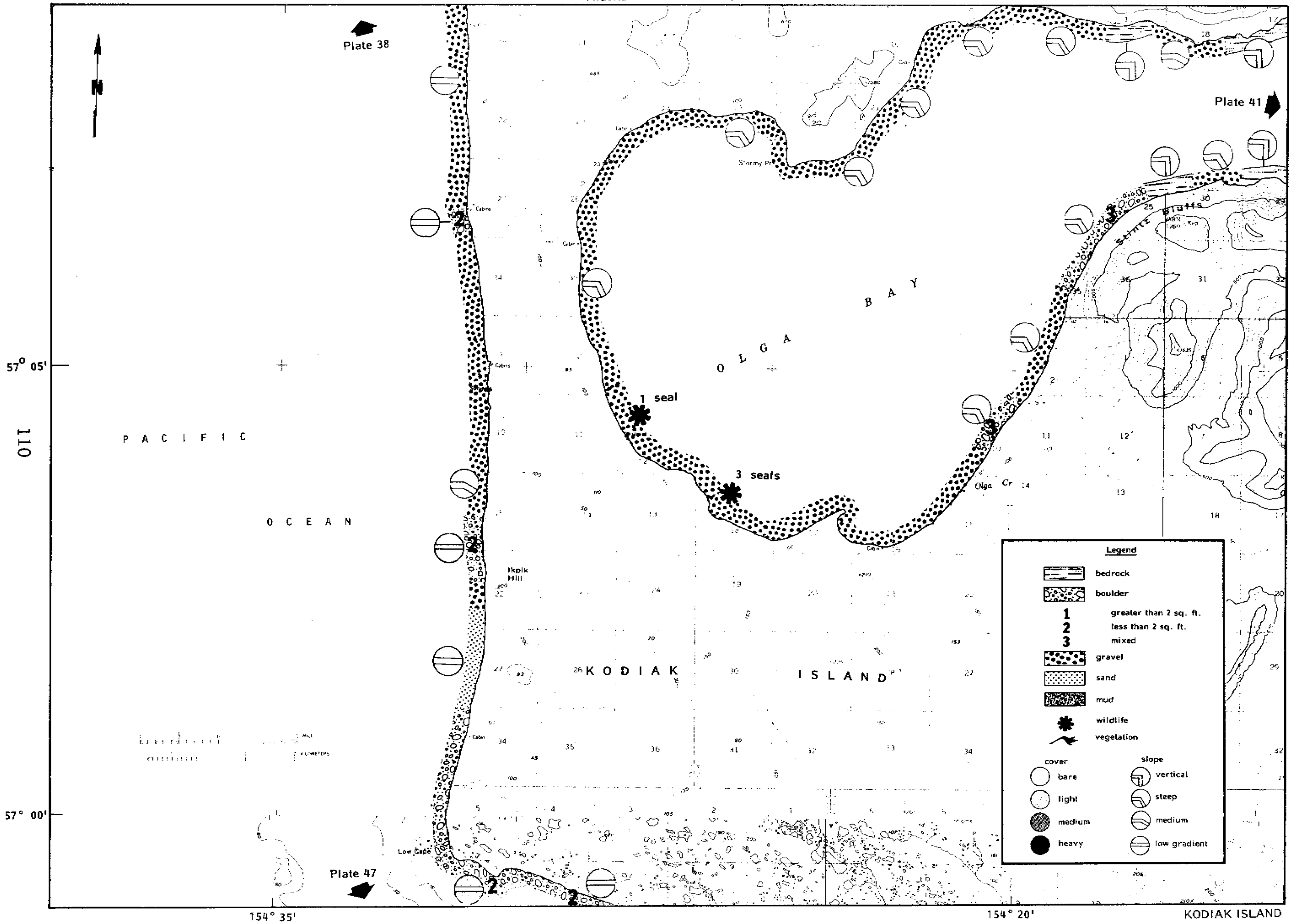
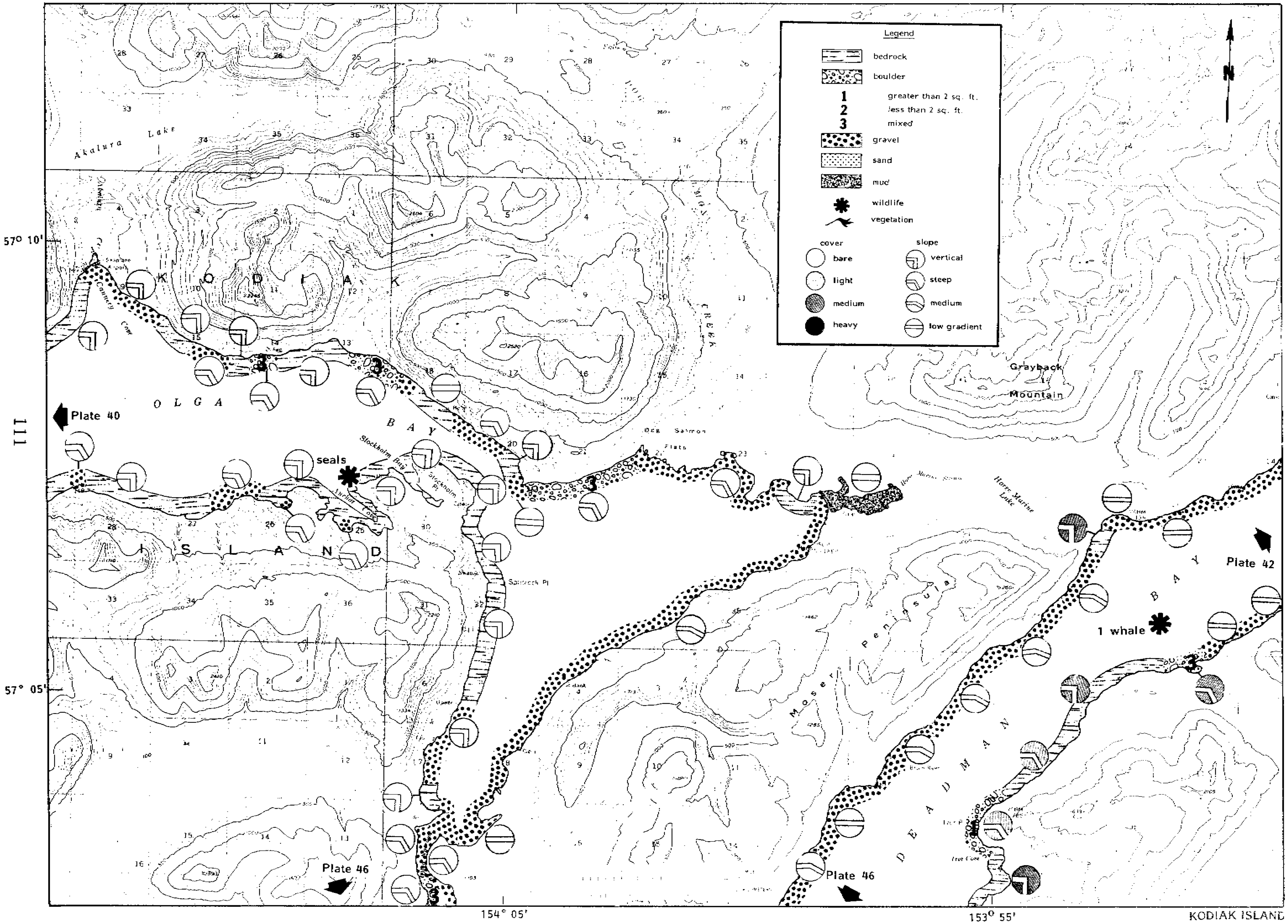
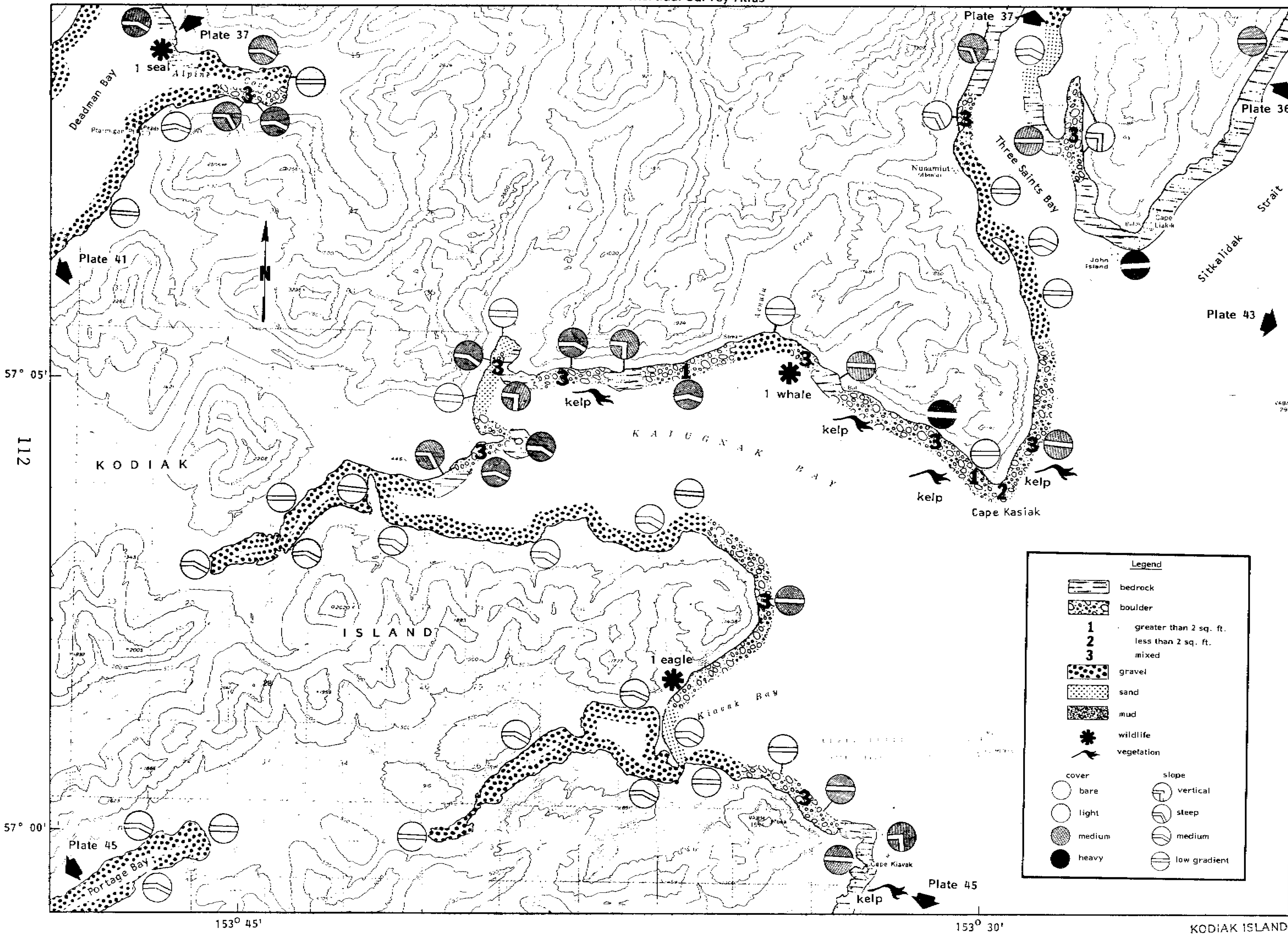


Plate 38
N
Plate 41
Stormy Pt
O L G A B A Y
Stintz Bluffs
1 seal
3 seals
Olga Cr
P A C I F I C
O C E A N
Ikpik Hill
K O D I A K I S L A N D
Low Cape
Plate 47
57° 05'
57° 00'
154° 35'
154° 20'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient

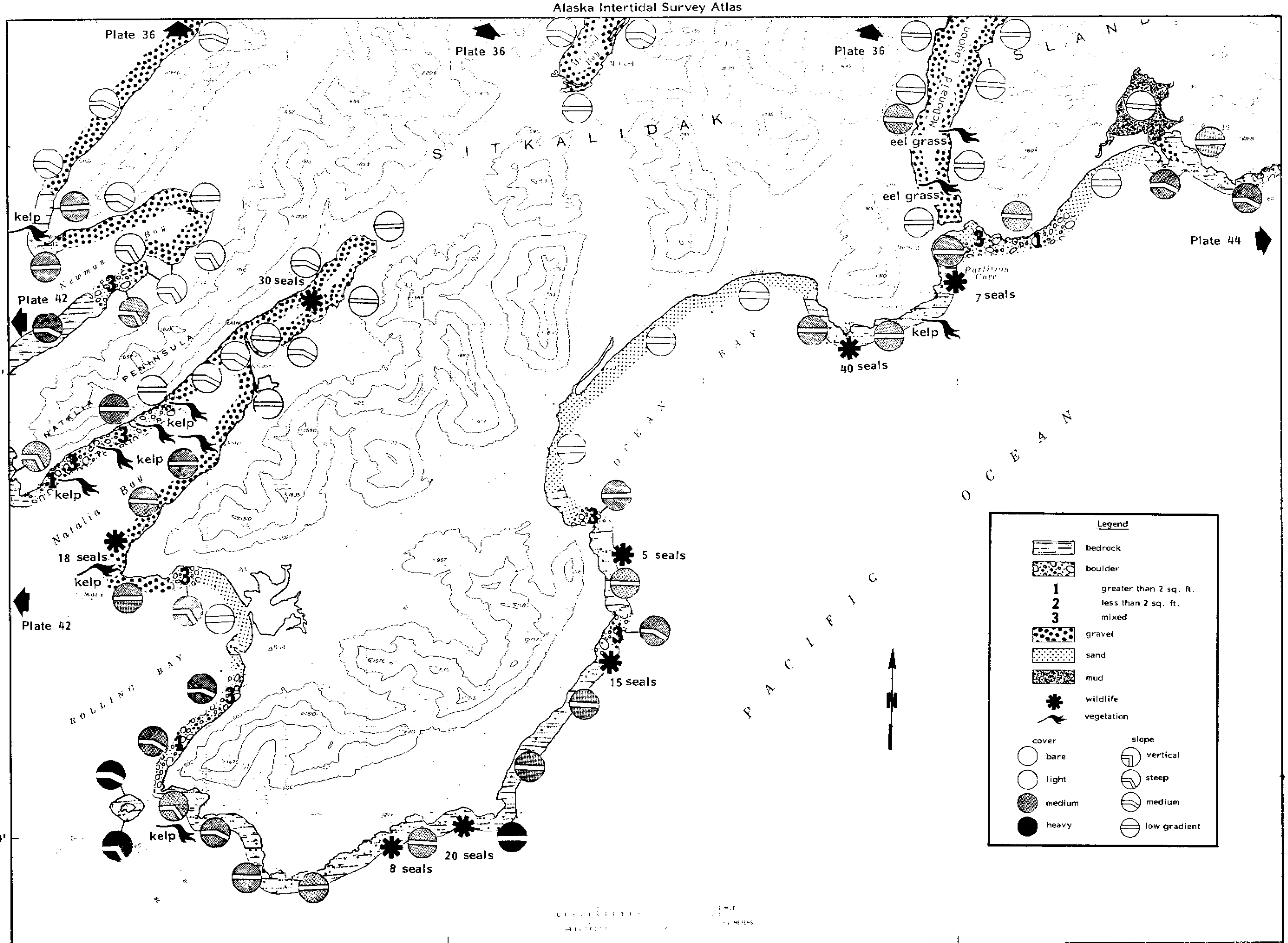
111



Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
Akalura Lake
KODIAK
OLGA BAY
ISLAND
Plate 40
seals
Stockholm Bay
Spiridon Pt
Dog Salmon Flats
CREEK
Graybeck Mountain
Moser Peninsula
DEADMAN BAY
1 whale
Plate 42
Plate 46
Plate 46
57° 10'
57° 05'
154° 05'
153° 55'
KODIAK ISLAND

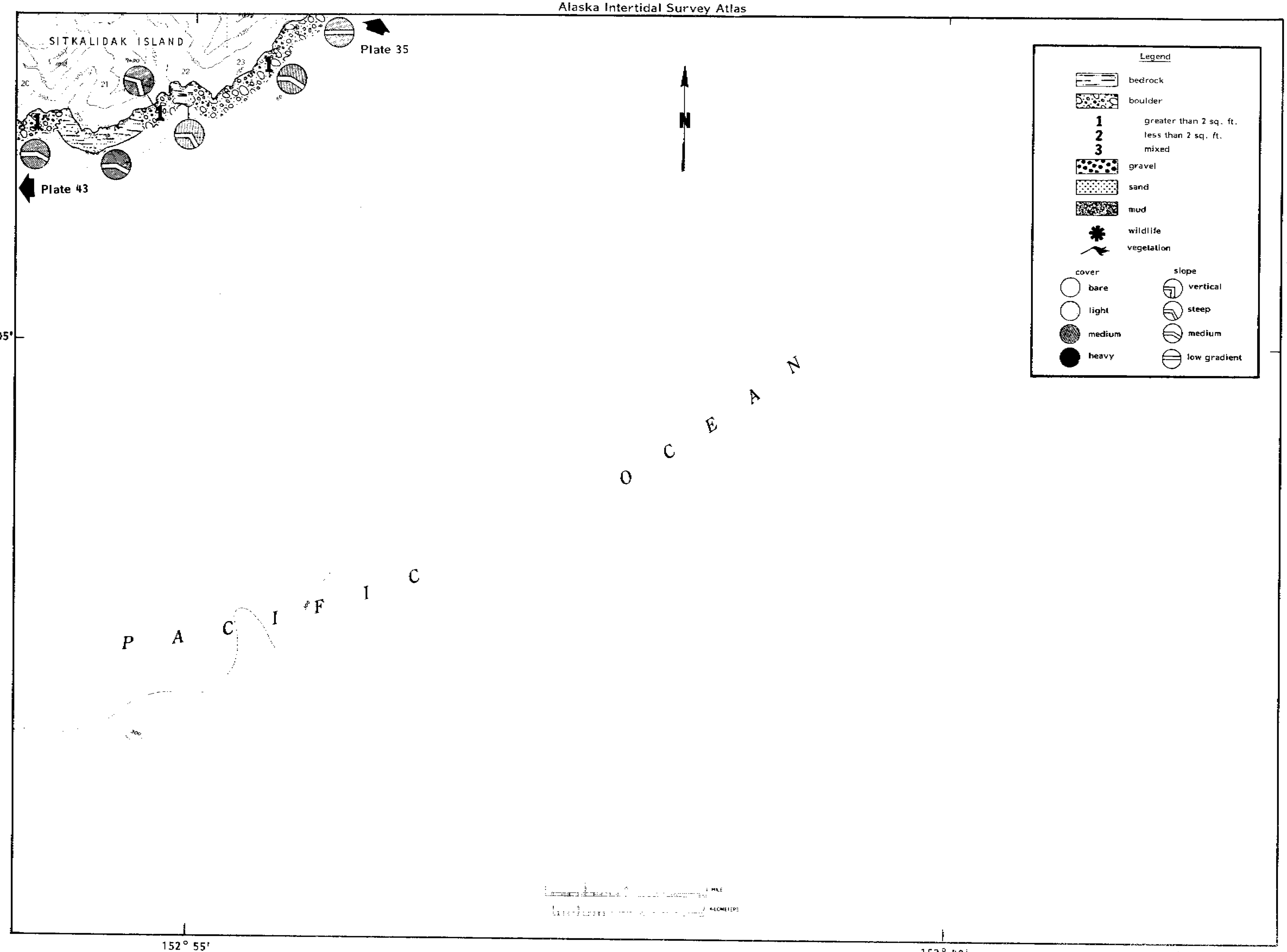


KODIAK ISLAND



KODIAK ISLAND

113


SITKALIDAK ISLAND
Plate 35
Plate 43
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
57° 05'
P A C I F I C
O C E A N
152° 55'
152° 40'

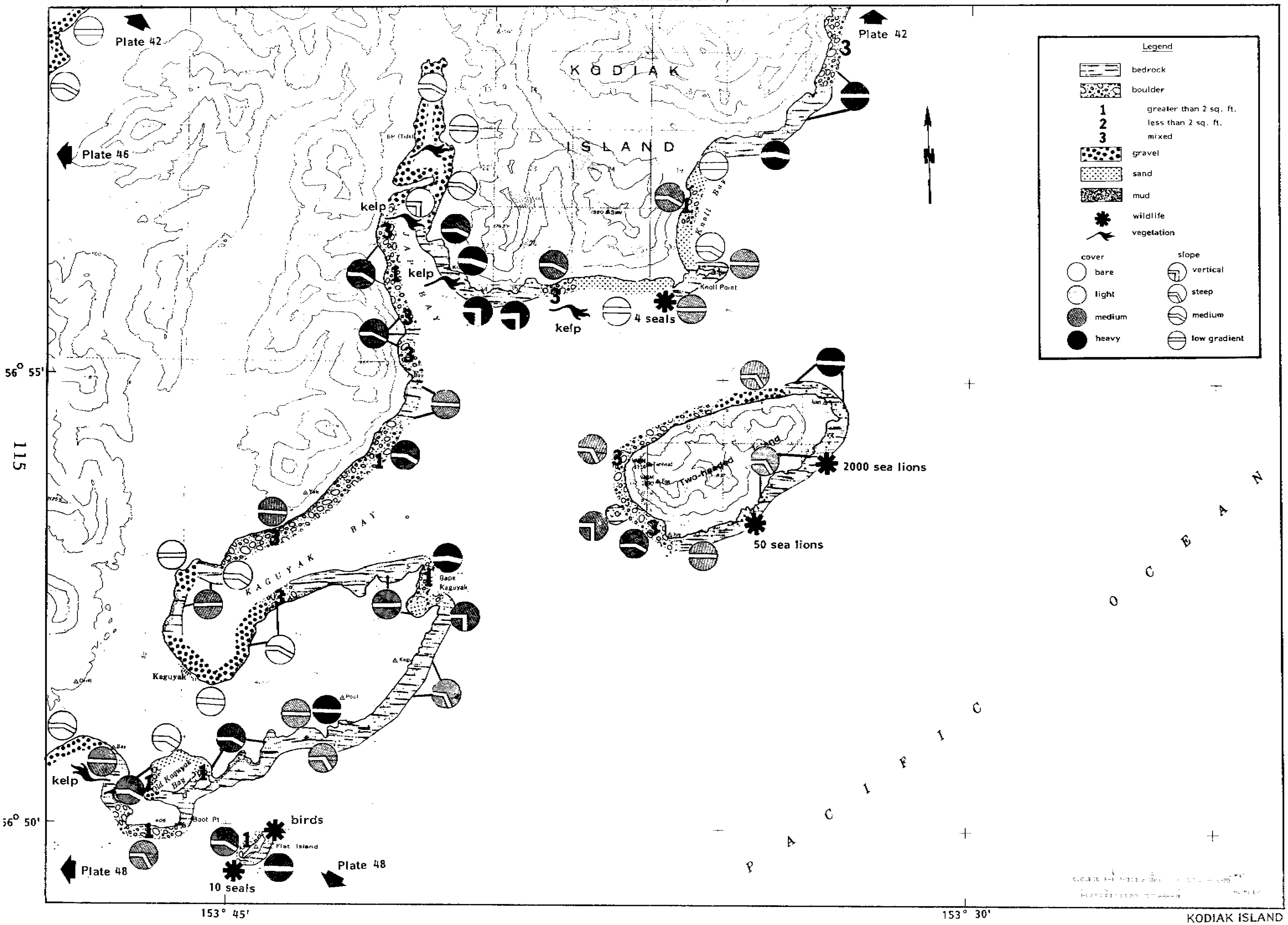
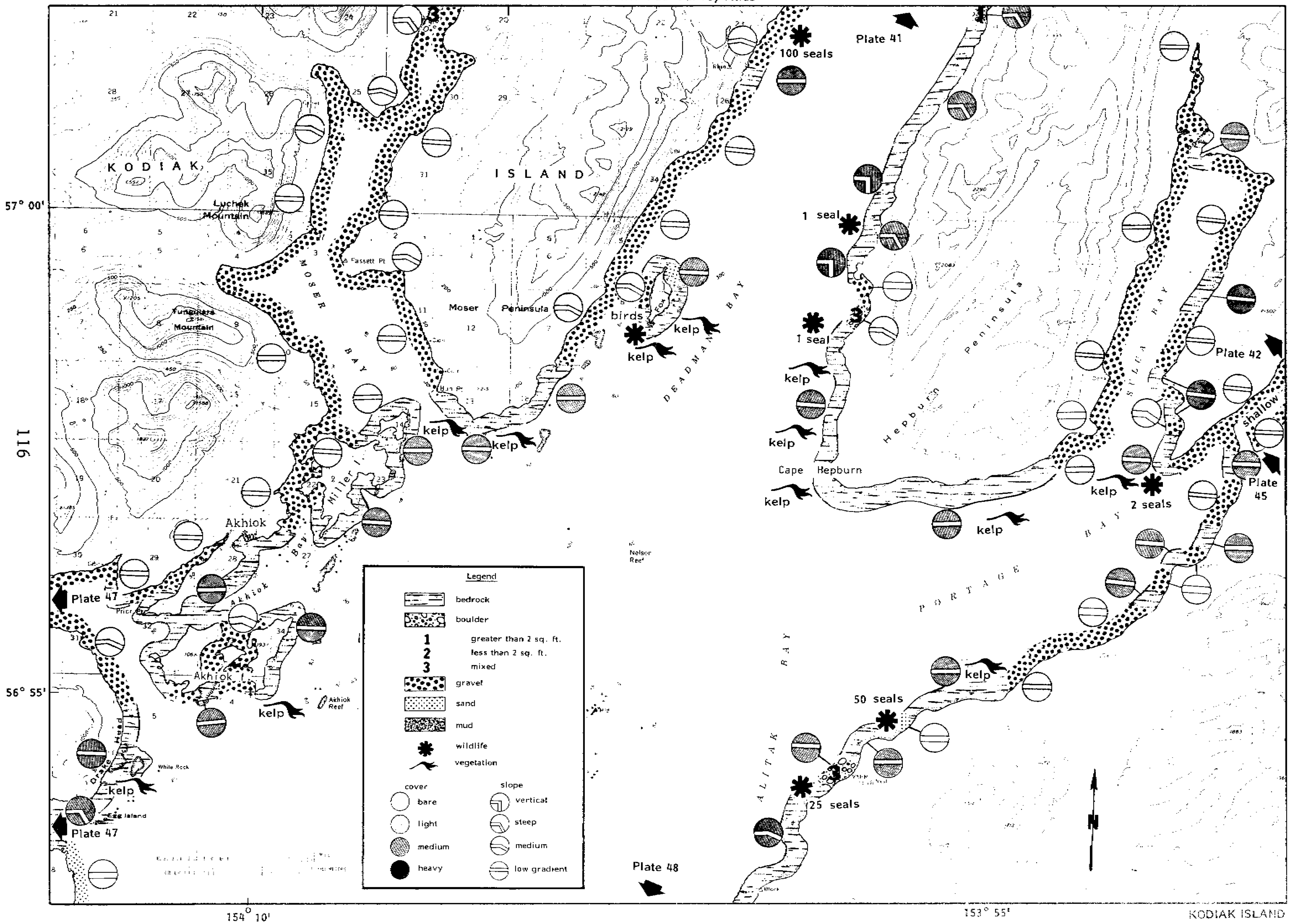
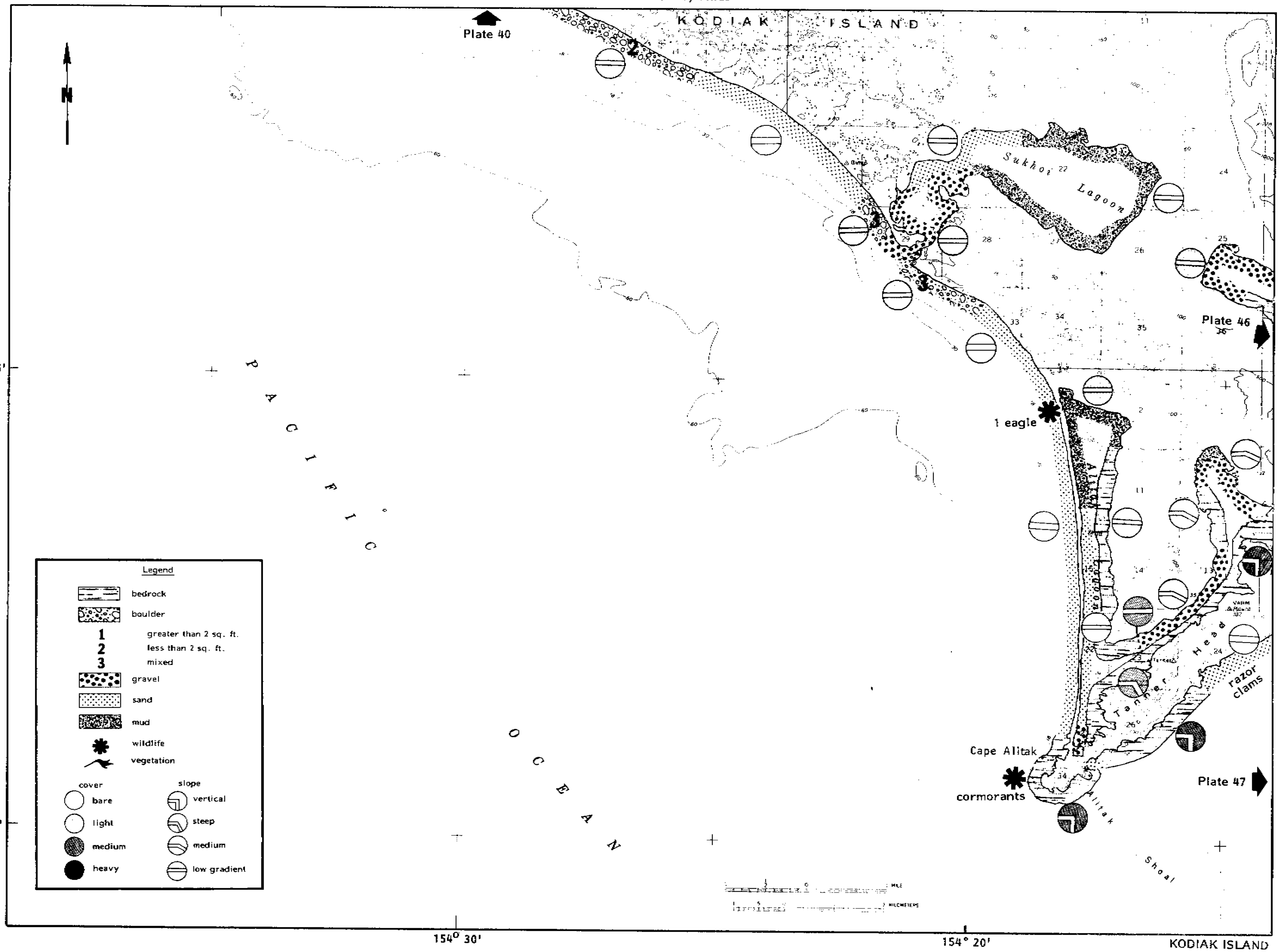


Plate 42
Plate 42
Plate 46
Plate 48
Plate 48
KODIAK
ISLAND
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
kelp
kelp
kelp
kelp
4 seals
2000 sea lions
50 sea lions
birds
10 seals
Knoll Point
Knoll Bay
Two-headed Island
KAGUYAK BAY
Cape Kaguyak
Kaguyak
Old Kaguyak Bay
Flat Island
PACIFIC OCEAN
56° 55'
56° 50'
153° 45'
153° 30'
KODIAK ISLAND

115


KODIAK
ISLAND
Luchak Mountain
Tunguara Mountain
57° 00'
56° 55'
116
154° 10'
153° 55'
MOSER BAY
Fassett Pt
Moser Peninsula
Miller I.
Akhiok
Akhiok Bay
Akhiok I.
Akhiok Reef
Plate 47
Plate 47
Plate 48
Plate 41
Plate 42
Plate 45
Egg Island
White Rock
Nelson Reef
DEADMAN BAY
birds
kelp
100 seals
1 seal
1 seal
50 seals
25 seals
2 seals
Cape Hepburn
Hepburn Peninsula
SITKALIDAK... BAY
PORTAGE BAY
ALITAK BAY
shallow
N
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
KODIAK ISLAND



KODIAK ISLAND
Plate 40
N
Sukhoi Lagoon
Plate 46
56° 55'
1 eagle
PACIFIC OCEAN
Cape Alitak
cormorants
Plate 47
Tanner Head
razor clams
Alitak Shoal
56° 50'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
154° 30'
154° 20'

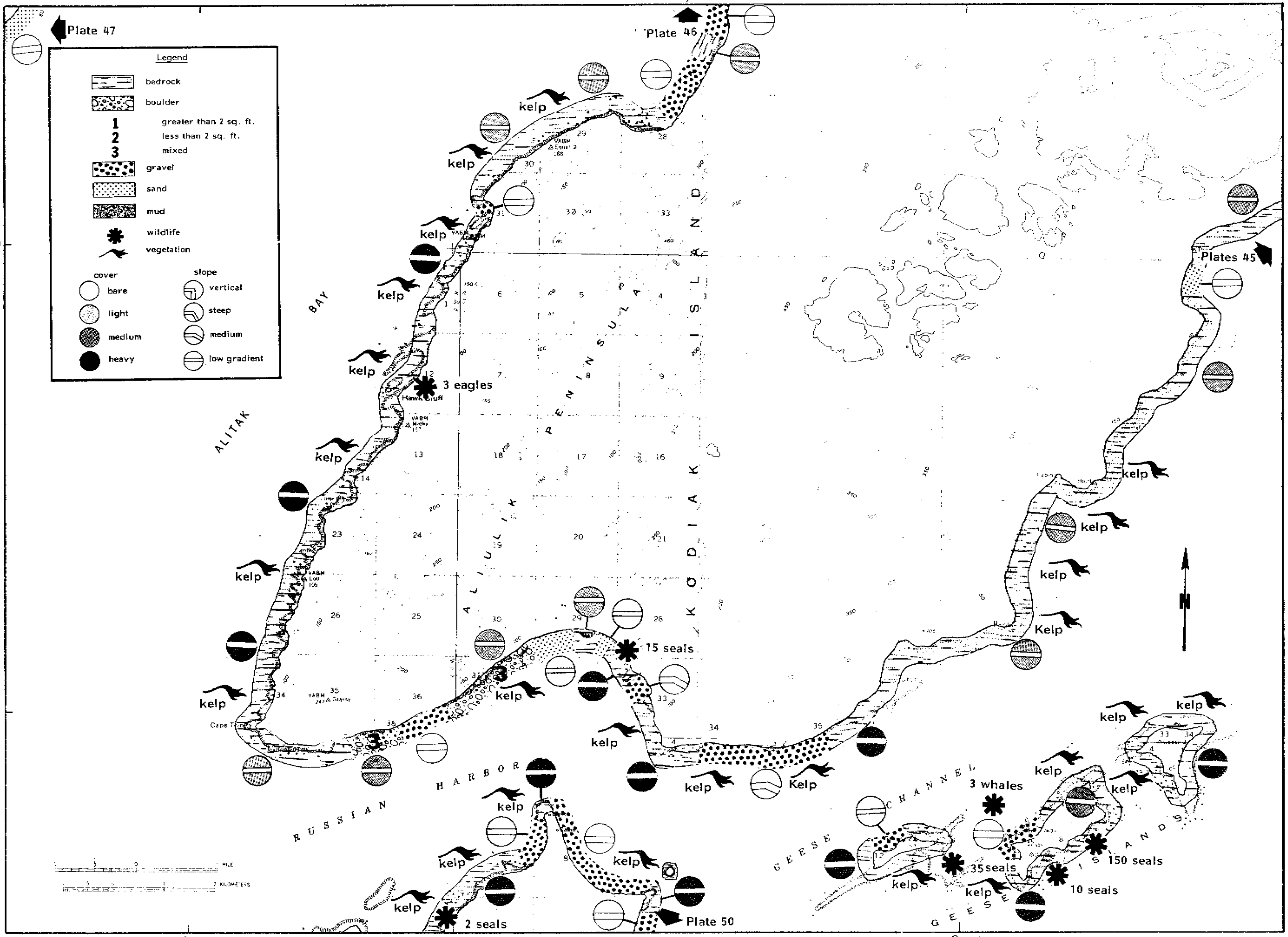
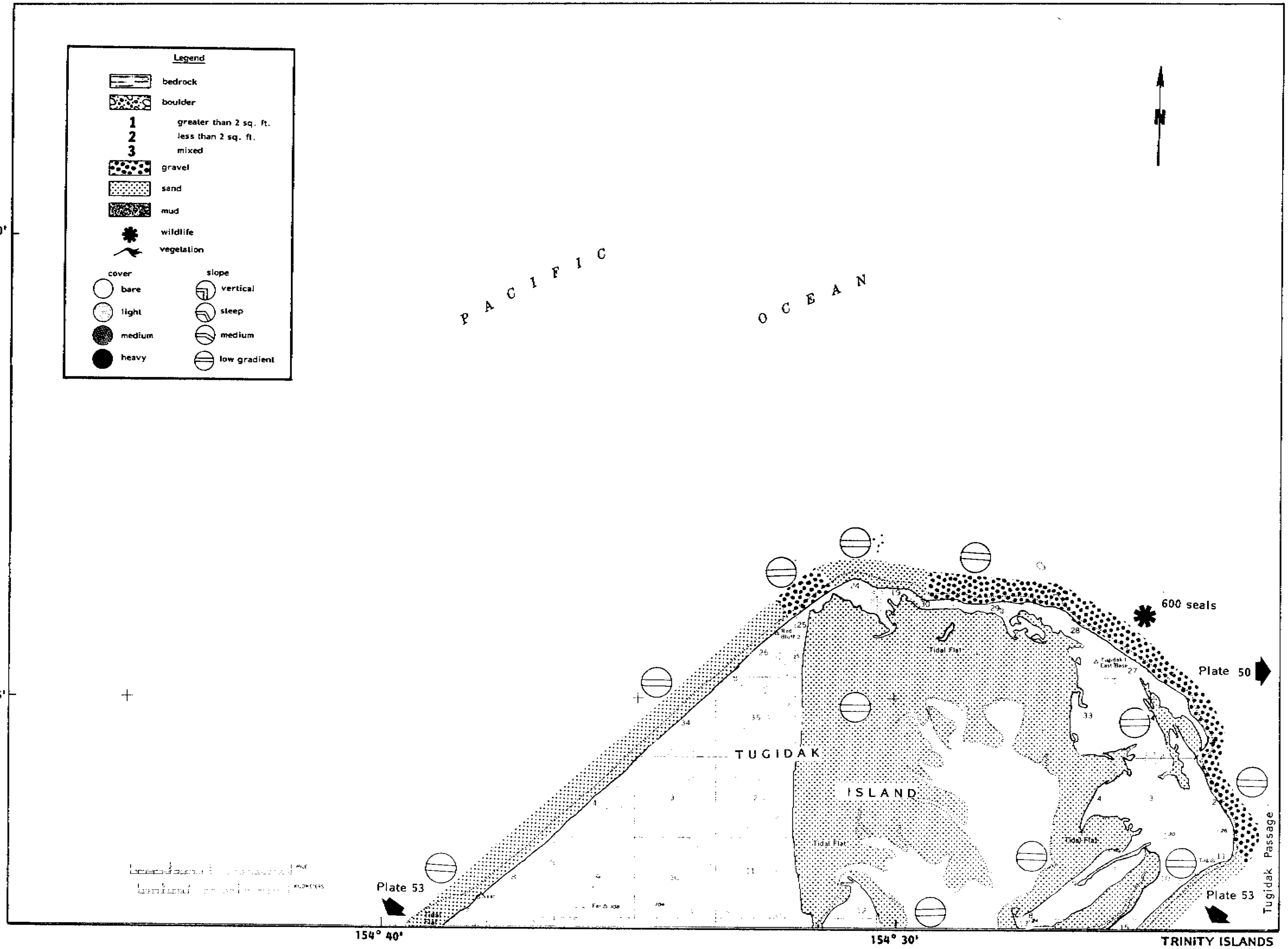
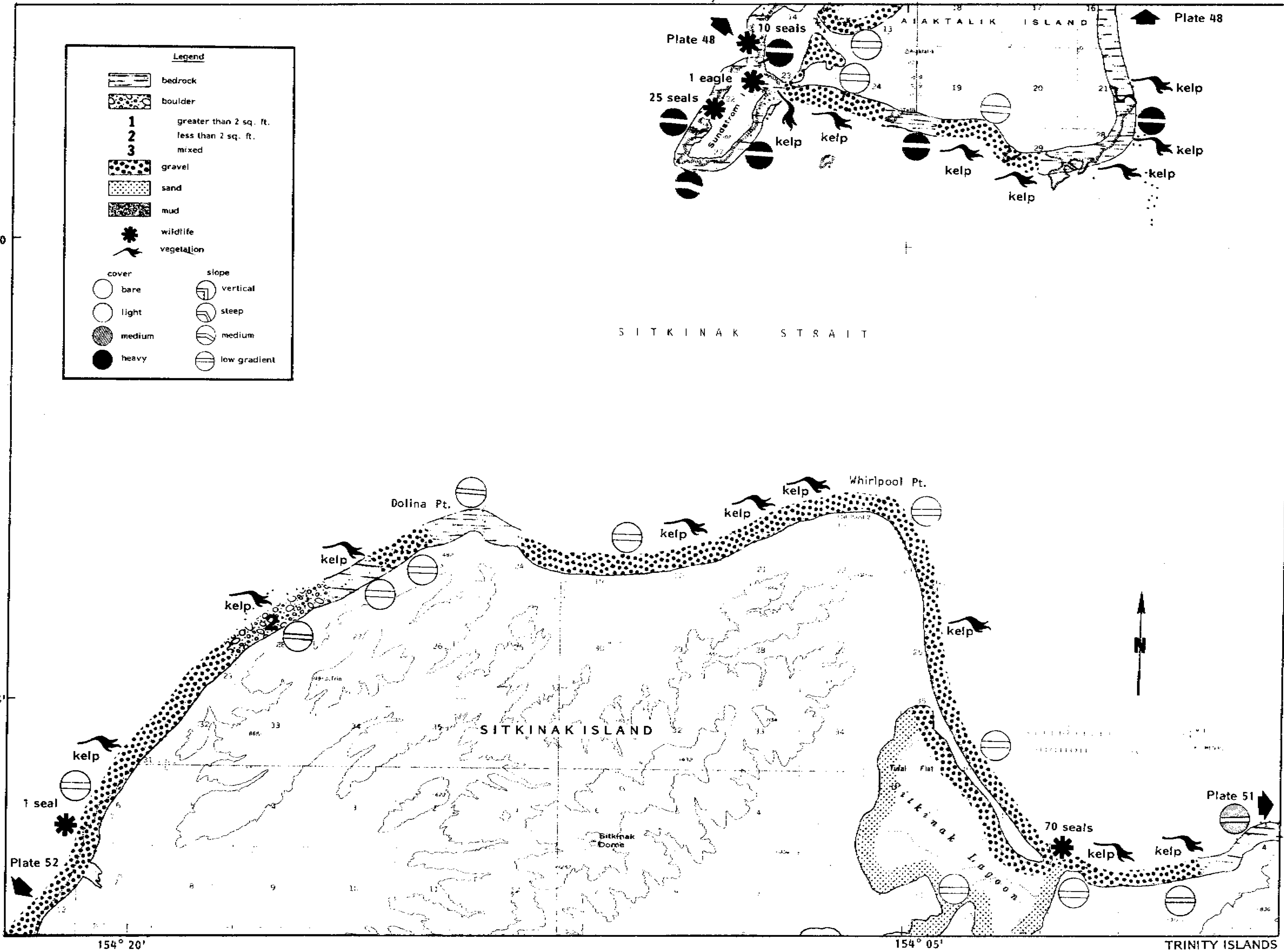
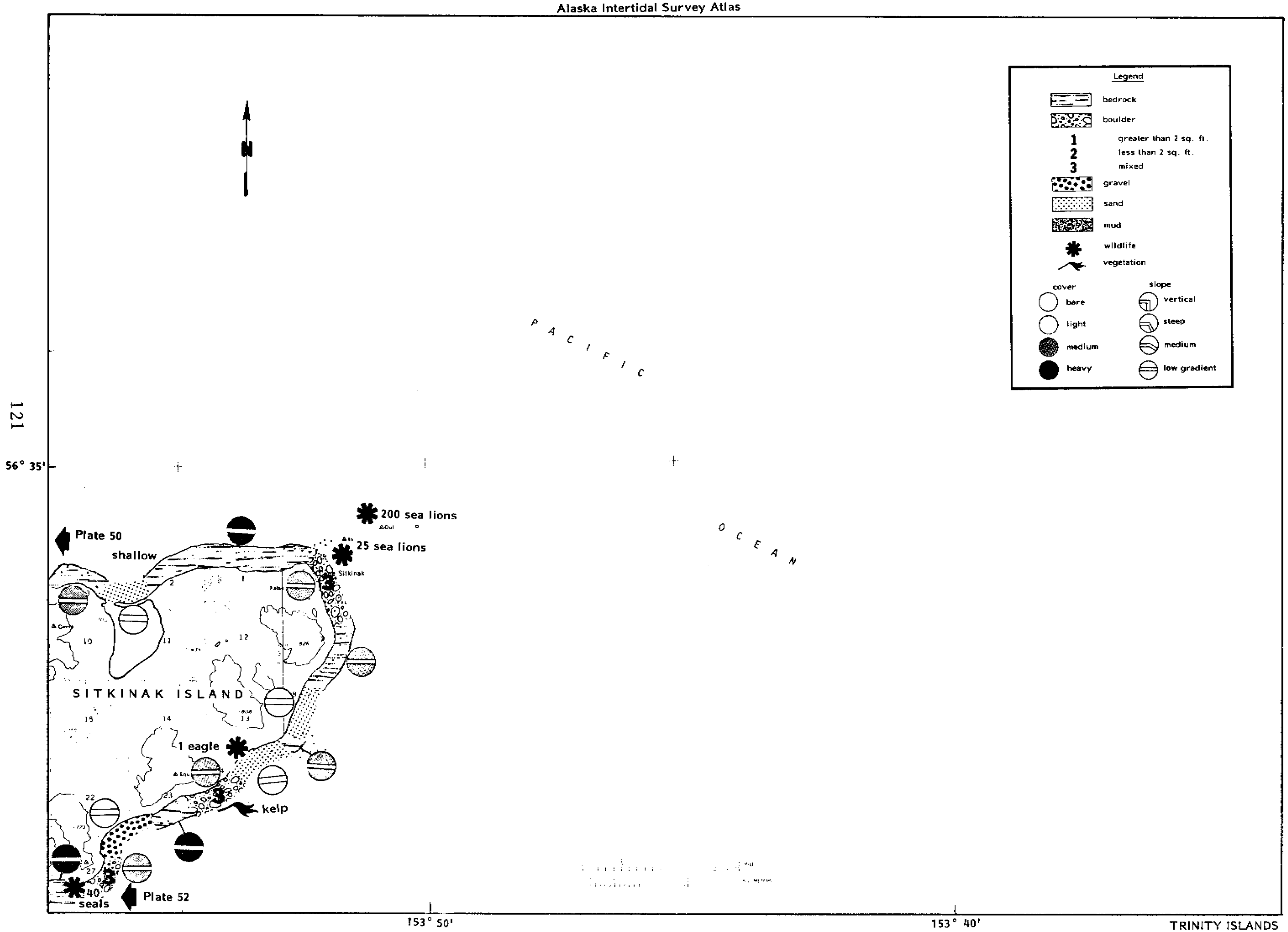


Plate 47
Plate 46
Plates 45
Plate 50
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
56° 50'
56° 45'
154° 10'
153° 55'
ALITAK BAY
ALIULIK PENINSULA
KODIAK ISLAND
RUSSIAN HARBOR
GEESE CHANNEL
GEESE ISLANDS
3 eagles
15 seals
3 whales
35 seals
150 seals
10 seals
2 seals
kelp
Kelp
Hawk Bluff
Cape
N
KODIAK ISLAND

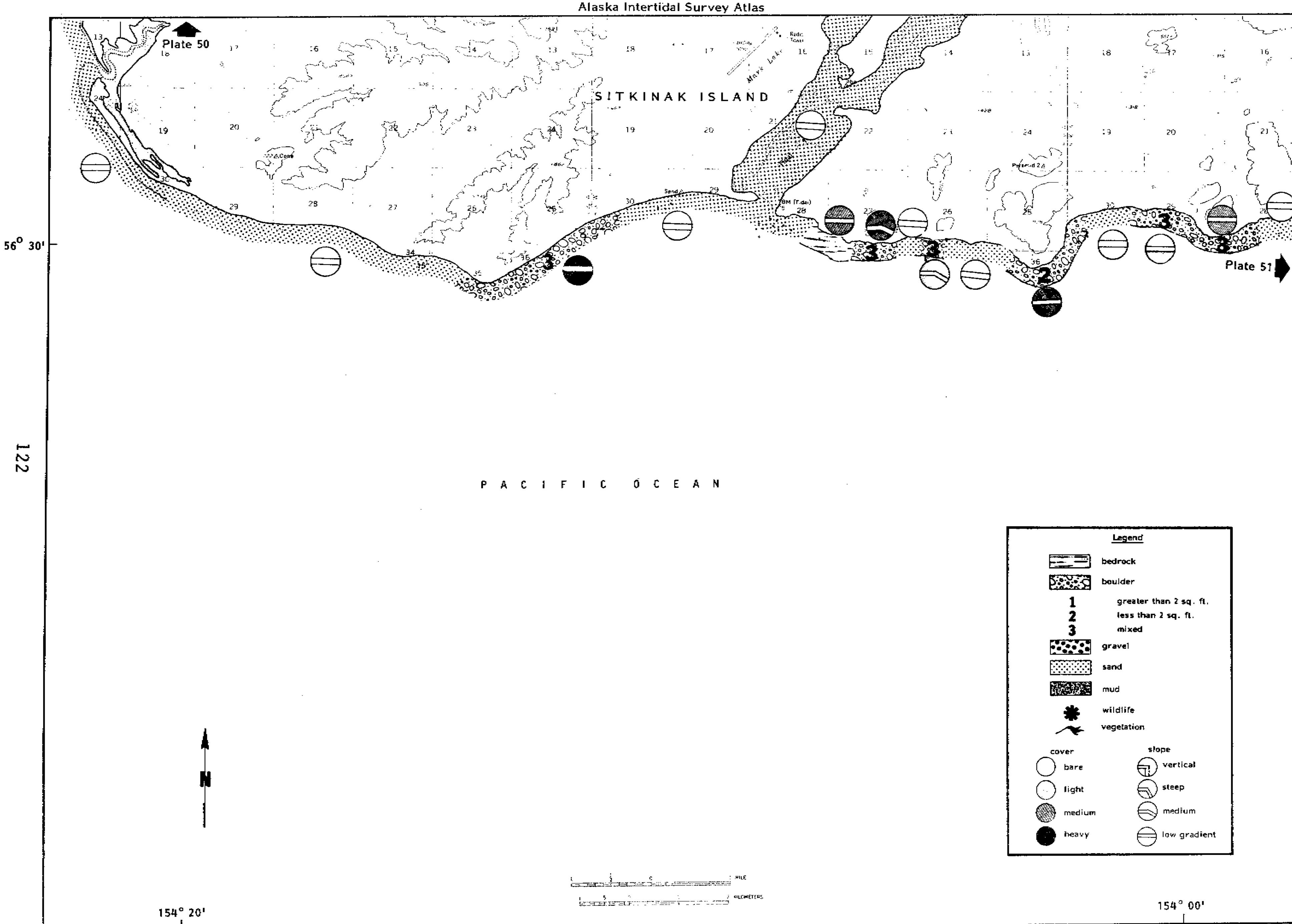

Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
N
56° 30'
56° 25'
PACIFIC
OCEAN
600 seals
Plate 50
Plate 53
Plate 53
TUGIDAK
ISLAND
Tidal Flat
Tidal Flat
Tidal Flat
Tugidak Passage
154° 40'
154° 30'
TRINITY ISLANDS


Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient
56° 40
56° 35'
154° 20'
154° 05'
Plate 48
Plate 48
10 seals
1 eagle
25 seals
AIAKTALIK ISLAND
Sundstrom I.
kelp
SITKINAK STRAIT
Dolina Pt.
Whirlpool Pt.
SITKINAK ISLAND
Sitkinak Dome
Tidal Flat
Sitkinak Lagoon
70 seals
1 seal
Plate 51
Plate 52
N
TRINITY ISLANDS

120



TRINITY ISLANDS



TRINITY ISLANDS

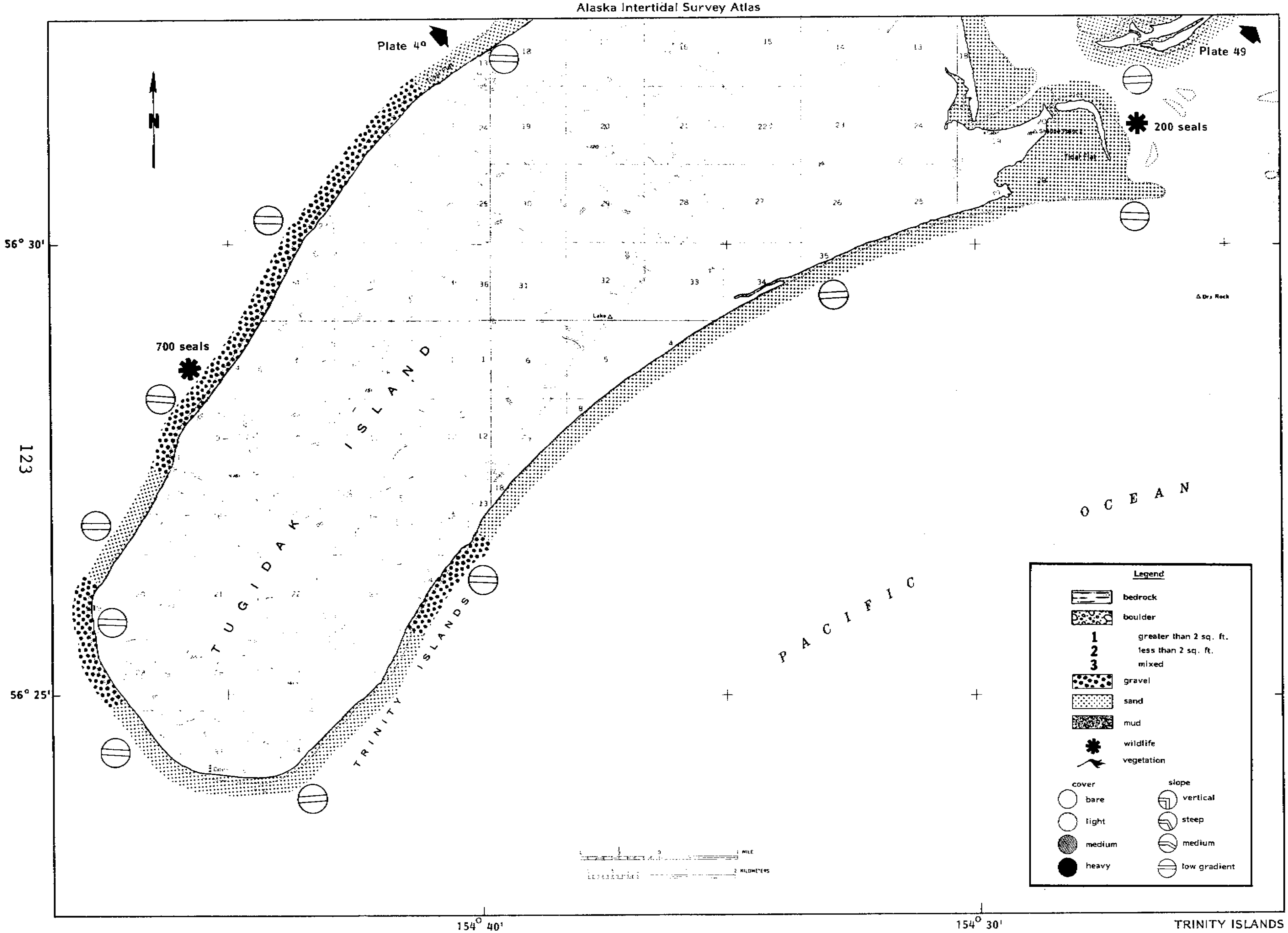
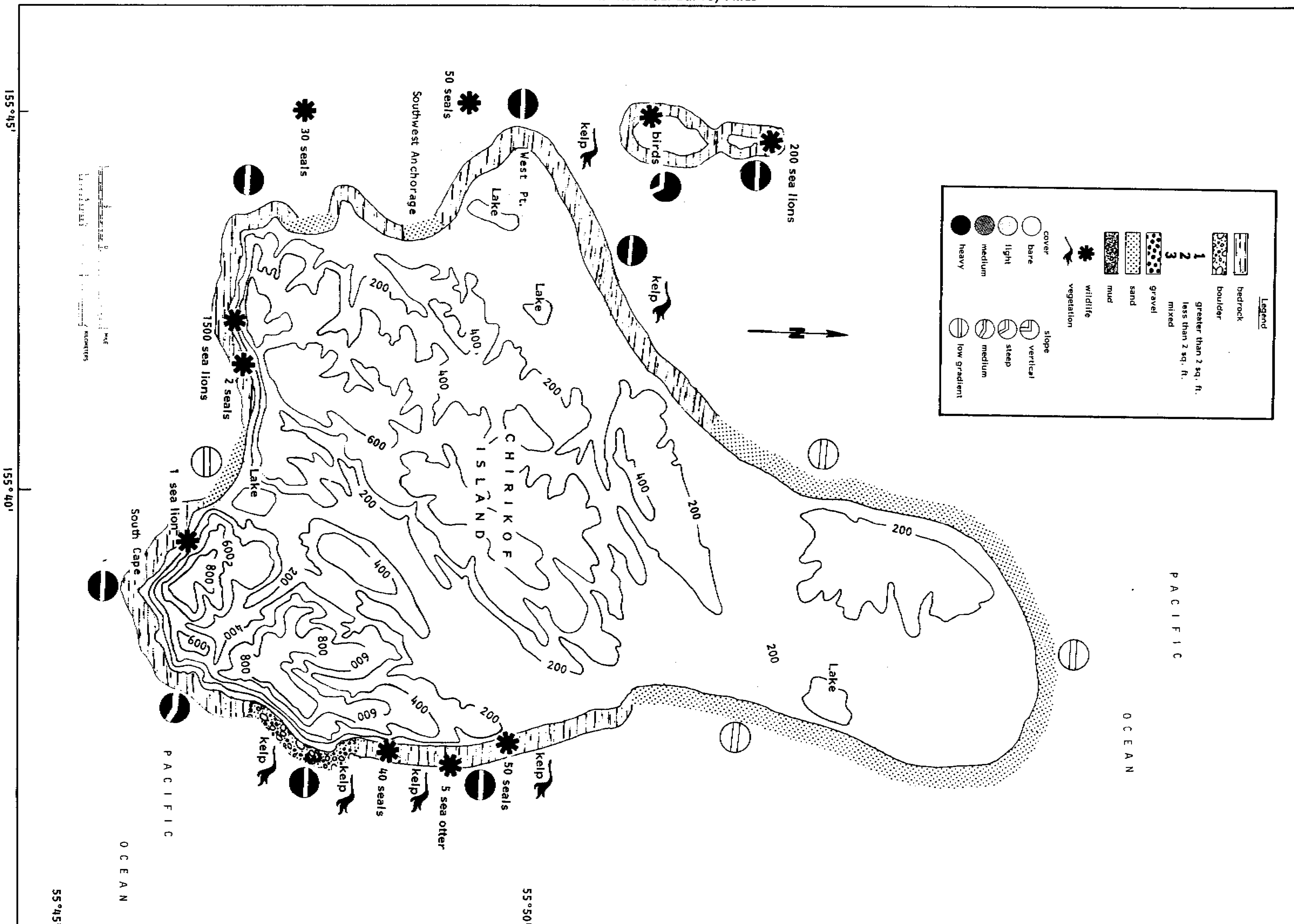
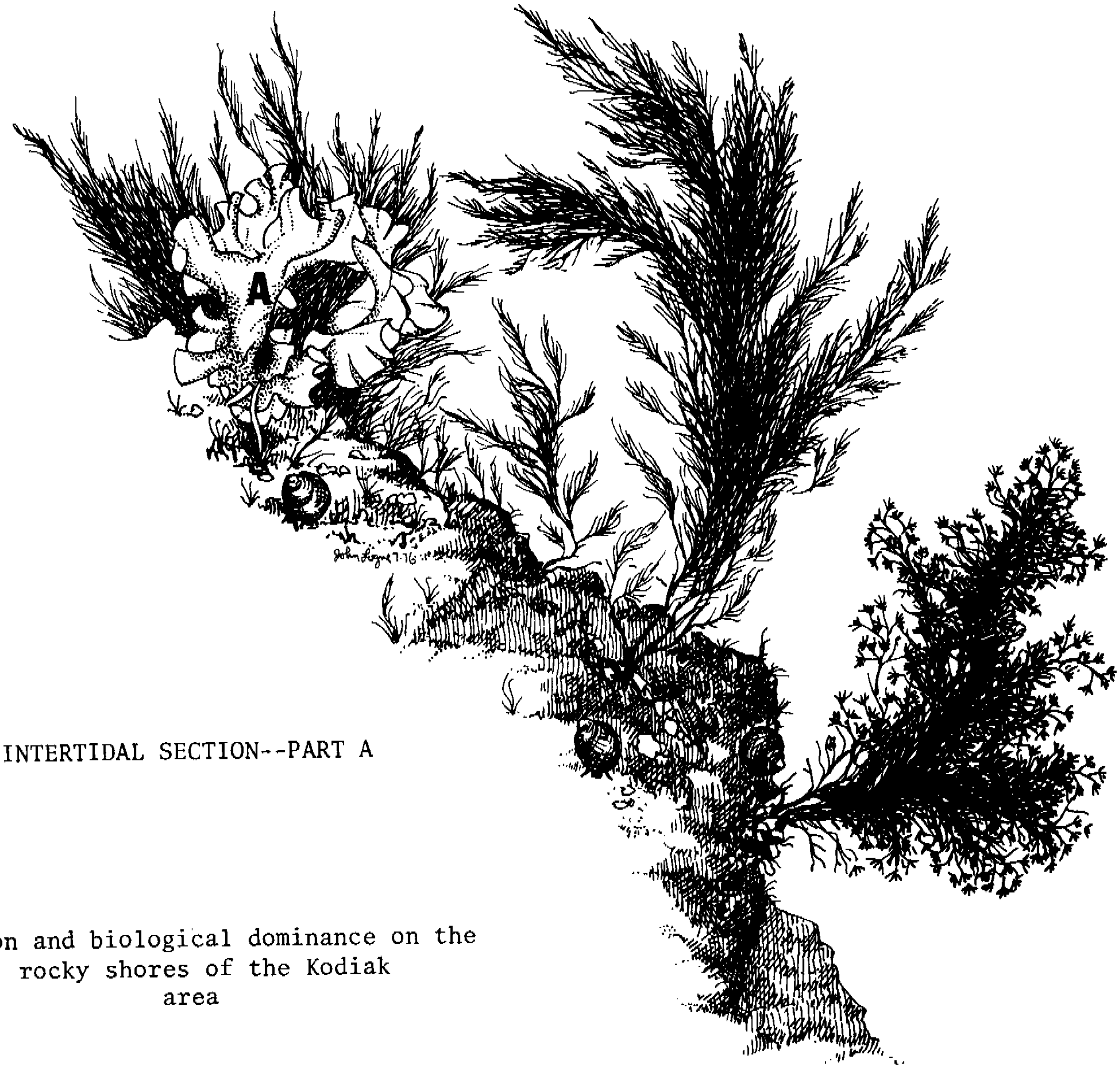


Plate 49
Plate 49
N
700 seals
200 seals
TUGIDAK ISLAND
TRINITY ISLANDS
PACIFIC OCEAN
56° 30'
56° 25'
154° 40'
154° 30'
Legend
bedrock
boulder
1 greater than 2 sq. ft.
2 less than 2 sq. ft.
3 mixed
gravel
sand
mud
wildlife
vegetation
cover
bare
light
medium
heavy
slope
vertical
steep
medium
low gradient

124



CHIRIKOF ISLAND



INTERTIDAL SECTION--PART A

Zonation and biological dominance on the rocky shores of the Kodiak area

I. Introduction

It is an unfortunate fact of life, for those who would generalize, that no two rocky shores are exactly similar. In fact, the communities are hardly ever predictable. Many factors (Dawson, 1966, Table 1) contribute to the extreme variability found intertidally. Such differences as the type and slope of the rock, occurrence of crevices, amount of standing water, exposure to waves, winds, sand and ice and the presence of a myriad of different competitors and predators will all combine to affect the success of each species. Since many of the major factors are not predictable without several seasons of research at a specific site, the communities encountered at a new station are often a surprise. The intertidal zone, then, is a patchy collection of populations which vary in dominance from site to site.

Within this heterogeneity, however, certain species will be found to be more common than others. In order to provide a basic format for reference, a generalized scheme of species zonation will be described here. More specific occurrences and quantitative relationships will be discussed later in the final report.

Tidal Range. On the west coast of North America the zero (0.0) tide level is the mean height of the lower of the two low tides which occur each day (MLLW). All tidal heights are referenced to MLLW In this report.

The heights of the tides, and therefore the extent of the littoral zone, vary from site to site in the Kodiak area. It is generally true that tidal amplitudes are greater on the northern part of the island group and tend to diminish slightly in the southern areas. Table 2 shows the differences between four of our sampling sites. Tonki Bay on Afognak Island and Three Saints Bay on southern Kodiak Island illustrate

Table 1.---A list of the factors known to affect the density and distribution of intertidal algae (From Dawson, 1966).

A. Physical factors
  1. light
    a. intensity (varying with latitude, tidal exposure, cloud cover, shore shading, biological overshadowing)
    b. quality (varying with water depth, transparency, tidal amplitude)
    c. periodicity (daily; seasonal)
  2. substrate
    a. solidarity (bedrock, cobble, gravel, sand, mud)
    b. texture (penetrability or suitability for attachment)
    c. porosity (water-holding capacity)
    d. position
      a'. with regard to water availability (tidal flooding, wave wash, splash, spray, seepage, tidepool retention)
      b'. with regard to wave shock or disturbance
      c'. with regard to ice action or cobble scour
    e. solubility and erosibility
    f. color (with regard to intertidal heat absorption, radiation and reflection)
    g. chemical composition
  3. temperature
    a. seawater temperature
      a'. annual variation
      b'. duration of maximum and minimum
      c'. diurnal variation
      d'. stratification; thermocline position with respect to tides, mixing of nutrients, etc.
    b. air temperature during intertidal exposure
      a'. annual variation
      b'. duration of maximum and minumum
    c. direct heat of insolation (complete exposure; tidepool exposure)
  4. relative humidity (with respect to algae subject to exposure)
    a. seasonal variation in conjunction with exposure
    b. duration of minimum coincident with maximum exposure temperature
  5. rain
    a. seasonal extent coincident with tidal exposure
    b. maximum duration
  6. pressure (mainly significant with regard to effect of tidal amplitude on attached seaweeds bearing air vesicles)
B. Chemical factors
  1. salinity
    a. annual variation from runoff
    b. tidal fluctuation of the halocline
    c. maximum concentration from evaporation during exposure
  2. availability of dissolved oxygen during dark-hour respiration
  3. availability of nitrogen, phosphorus and other essential metabolic substances
  4. availability of free carbon dioxide for photosynthesis
  5. pH (mainly significant in confined pools subject to marked increases during active photosynthesis)
  6. pollution
    a. by natural marine organisms
    b. by waste products of human activity

Table 1. (continued)

C. Dynamic factors
  1. water movement
     a. surf
     b. ocean currents
     c. tidal fluctuation and currents
     d. maximum severity of annual storms or hurricanes
     e. upwelling
     f. extent of surface chop vs. calm
  2. tidal exposure (period and amplitude)
  3. tidal rhythem (with respect to release of reproductive bodies)
  4. wind (with respect to coincidence with exposure)

D. Biological factors
  1. grazing pressure
  2. fungal and microbial activity
  3. competition for substrate
  4. protective cover against desiccation during exposure
  5. light restriction by overgrowth (either by mactoscopic or microscopic forms)
  6. availability of host plants or animals for obligately epiphytic, endophytic, epizootic, endozootic, and parasitic algae.

Table 2.---Comparison of tidal heights at four sites in the Kodiak area. Data are from the 1976 Tide Tables.

	Ushagat Islands[1]	Tonki Bay	Three Saints Bay	Sitkinak Lagoon
Mean Higher High Water (MHHW)	14.1	11.4	8.6	7.9
Mean High Water (MHW)	12.9	10.3	7.7	6.9
Mean Tide Level (MTL)	7.2	5.8	4.4	4.1
Mean Low Water (MLW)	1.5	1.3	1.1	1.3
Mean Lower Low Water (MLLW)[2]	0.3	0.2	0.2	0.3

[1] These data apply to our Sud Island site, which, like Ushagat Island lies in the Barren Island group.

[2] MLLW is usually referred to as the zero (0.0) tide level. When mean ranges are calculated using tidal summaries, however, some small differences occur.

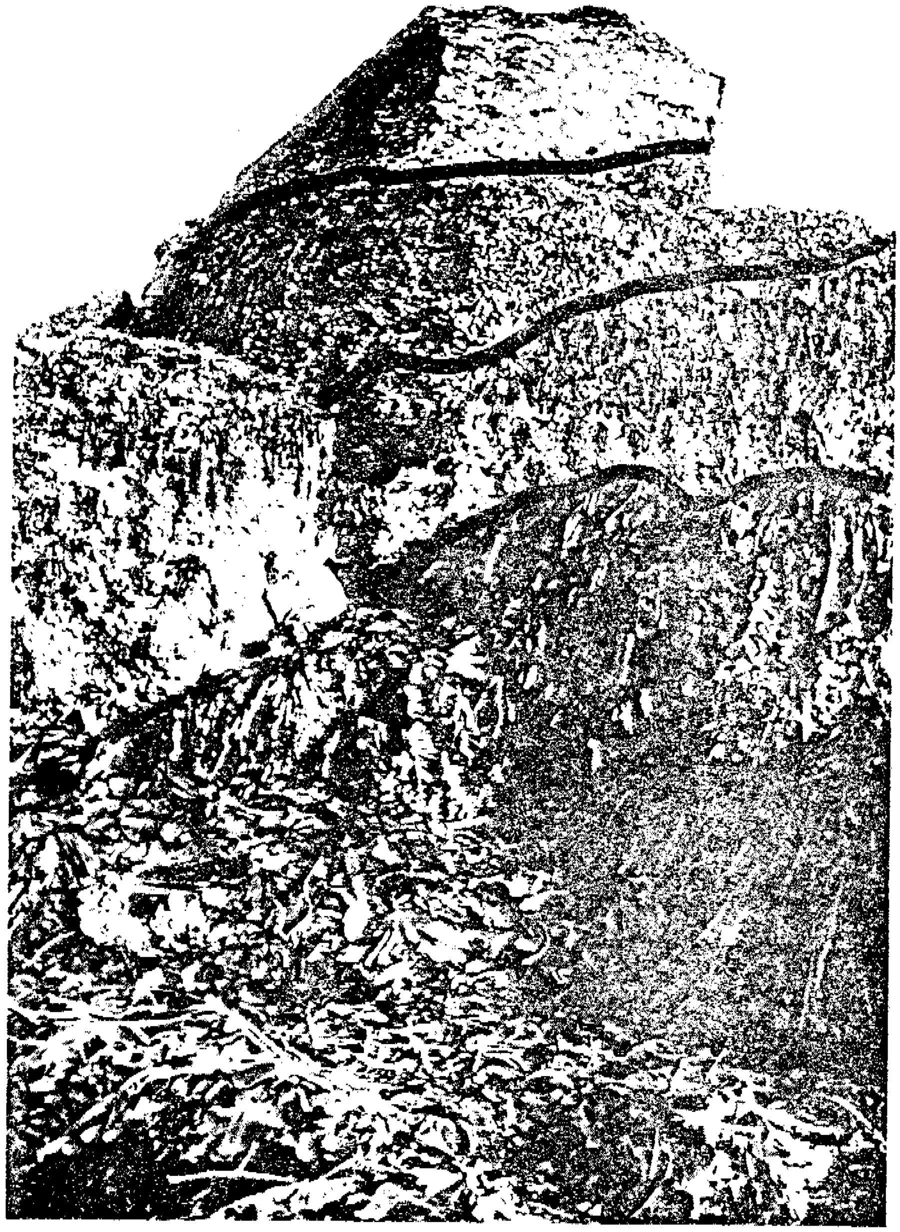


Figure 1. Vertical zonation of intertidal species on Spruce Island near Kodiak.
Zone 1 = Balanus glandula, Endocladia muricata
Zone 2 = Fucus distichus
Zone 3 = Odonthalia floccosa, Balanus cariosus
Zone 4 = Alaria spp.

the general range in the Kodiak area. Ushagat Island, near our Sud Island site in the Barren Islands shows the most extreme range at our Kodiak sites. Sitkinak Lagoon near our Cape Sitkinak site shows the minimal range encountered.

Within these tidal ranges two algal species dominate at almost all sites. In the middle part of the two intertidal, to (28)* Fucus distichus (Fig 2A) is dominant. In the lower areas (2to 2') at least one species of Alaria (Fig 5A) is dominant. Several invertebrate species also occur commonly, but only the barnacle Balanus cariosus (Fig 5B) is almost always present. It occures throughout the vertical range inhabited by Fucus and Alaria, although the greatest biomass is usually found at lower (04') elevations.

Several other species also occur frequently and make major contributions. Those which occur in bands at different elevations have often been seperated into descriptive biotic zones by scientists. Appropriate reviews of littoral zonation schemes, with emphasis on Alaska, are found in Weineman (1969) and Nybakken (1969).

After comparing our data on vertical distributions with classical concepts of intertidal zonation, it appeared that the Stephensontype system (Stephenson & Stephenson, 1972) most accurately represented the zonation patterns in the Kodiak area. This system recognized three littoral zones: the Supralittoral or splash zone; the Littoral zone; and the Infralittoral Fringe or upper sublittoral zone. Because this system is meant to be "universal" the three zones are not further subdivided.

Within any littoral area, however, several subzones can usually be found. Some authors elevate these to full zonal status. Others do not.

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* The heights used in this section are generalized in order to indicate areas of relative dominance. Fucus, for instance, was colloected from -13 feet to +10 feet, but tends to produce its greatest by mass in the 2-8 foot range.

The decision usually rests on the spatial extent of each subzonal unit.

In the Kodiak area we found several subzones at each site. Some of these were dominant at one site and then absent at the next. The mussel (Mytilus edulis) for instance, often formed a dominant band on large rocks in protected areas. In more exposed locations, however, it was often either a small part of the Fucus zone, or absent entirely.

Based on the most common occurrences at all of our Kodiak sites we have divided the lower two Stephenson zones into several subzones which are described in following sections. It should be emphasized, however, that this is done for general descriptive purposes and not all of these subzones will be found at all of the sites. This scheme (Table 3) represents a generalized picture of the vertical distributions of the most dominant organisms we encountered.

II. Vertical Distribution of Dominant Organisms

ZONE 1

This zone, the supralittoral fringe or "splash zone" is seldom, if ever, covered by tides. Often the rocks are bare, with only small populations of snails or amphipods indicating the marine influence. In areas that are either directly exposed to spray or are very well protected from desiccation, however, algal species may be found. These can form distinct bands, each composed of a single species (Doty, 1946---p 321). In the Kodiak area the range of this zone is approximately ten to fifteen feet above MLLW. The absolute height varies, however, with the amount of surf. In more protected areas where surf and spray do not occur as high the organisms will inhabit a relatively lower level.

Prasiola meridionalis. The algal species which often occurs highest above the water line is Prasiola meridionalis. It is by no means ubiquitous, occurring only in areas that have bird droppings. When found, it is almost unmistakable, forming a dense green layer over the otherwise bare or guano covered rocks. On Sundstrom Island it seems to grow in association with another alga, Schizogonium murale. We found dense Prasiola growths at Sundstrom and also at Sea Otter Island near bird colonies at a level 12-15 feet above MLLW.

Porphyra sp. Although the algal genus Porphyra (Frontispiece-A) produces its largest individuals in the mid-littoral zone, occasional heavy growths will be found on rocks a few feet above the highest tides. The species, which is difficult to identify at this time, grows in thin reddish sheets, one to four inches long, which may appear iridescent. It probably reaches greatest development in winter and spring, and by mid-summer desiccation and bleaching will usually have killed off most of the plants.

Littorina sp. Littorine snails are one of the most ubiquitous groups of animals found on the Alaska coast. We found at least a few individuals at every sampling site. Several species occur in Alaska; Littorina sitkana (Fig. 1B) is the most common. It was often found aggregated into very dense groups containing several thousand individuals per square meter. On flat surfaces the aggregations were quite thick with individuals piled several deep. Although most common at the highest tidal levels, individuals can move down into the upper intertidal areas to feed and lay eggs. Small, recently hatched or settled juvenile stages may also be found low intertidally.

ZONE 2

This zone, the true littoral zone, is the first which is covered by tides on a predictable basis. It lies between the splash zone and the levels dominated by kelps. The upper area often begins with almost bare rocks and grades into

Table 3.---Generalized Zonation scheme for the Kodiak rocky intertidal area.

Physical zone		Approximate range	Approximate height (ft)	Biological name	Characteristic organisms
Zone 1 Supralittoral Fringe		Highest reach of spray MHHW	10-15	Porphyra-Prasiola Zone =Littorina Zone-Stephenson (1974, p 20) =Littorina-Verrucaria Zone Lewis (1964, p 82)	Prasiola meridionalis Porphyra cp Littorina sitkana
Zone 2 Littoral Zone	Subzone 2A	MHHW MHW	8-10	Barnacle-Endocladia Zone =Barnacle Zone-Nybakken (1969, p 75) =Upper Barnacle Zone Lewis (1964)	Littorina sitkana Cthamalus dalli Balanus glandula Acmea digitalis Diatom Colonies Endocladia muricata sterile Fucus distichus
	Subzone 2B	MHW MTL	4-8	Fucus Zone =Fucus Zone-Nybakken (1969 p 22) =Fucus Zone-Stephenson (1972, p 123) Balanus, Patella, Fucus Zone Lewis (1964 p 82) Upper Midlittoral Zone Kozloff (1973 p 124)	fertile Fucus distichus Halosaccion glandi forme Balanus cariosus Mytilus edulis Nucella lima and lamellosa Odonthalia floccosa
	Subzone 2C	MTL MLLW	0-4	Rhodymenia Zone =Red Algae Belt-Lewis (1964, p 82) =Rhodyphyceae Zone-Lewis (1964, p 78)	Rhodymenia palmata Ulva-Monostroma Balanus cariosus Katherina tunicata Cucumeria pseudocurata

Table 3. (continued)

Physical zone		Approximate range	Approximate height (ft)	Biological name	Characteristic organisms
Zone 3 Infra-Littoral Fringe	Subzone 3A	MLLW Lowest Low Water	-2-0	Alaria Zone* =Alaria Zone-Weinmann (1969, p 29)	*Alaria spp* *Lithothamnion sp* *Ptilota filicina* *Crisia*, *Filicrisia* *Halichondria panicea* *Tonicella lineata*
	Subzone 3B		-2	Laminaria Zone*	*Laminaria spp* *Laminaria dentigera* *Lithothamnion sp* *Corrallina sp* *Acmea mitra*

* Most authors do not distinguish tow zones in the sublittoral fringe the entire sublittoral fringe is usually referred to as the Laminaria Zone. The Zone of Alaria Dominance may be placed in the Littoral Zone (Weinmann) or the Laminaria Zone (Lewis).

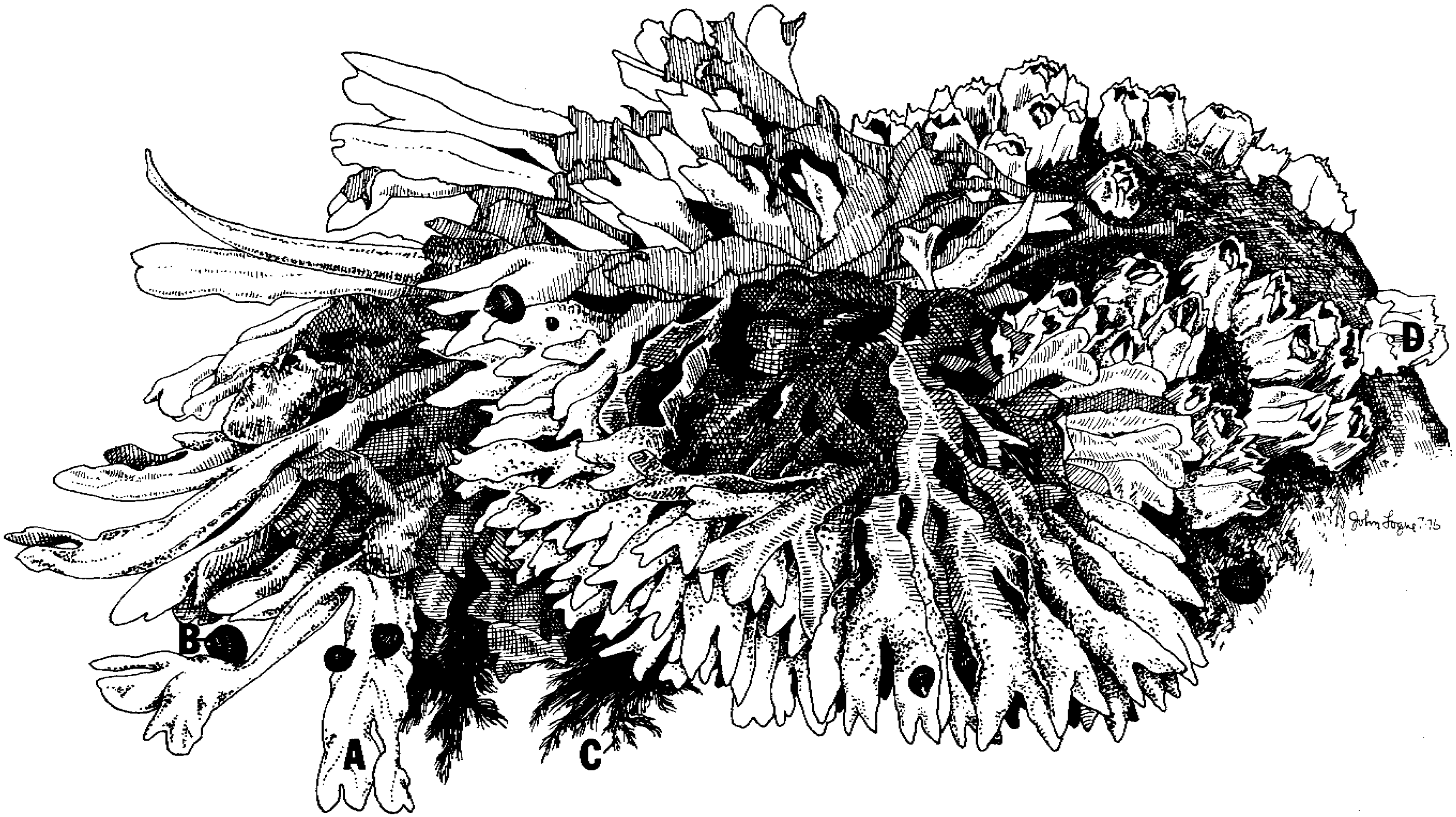

Figure 2. Characteristic species of the upper and middle intertidal zones. A. Fucus distichus B. Littorina sitkana C. Odonthalia floccosa D. Balanus glandula

areas which are densely covered by living organisms. The overall zone is dominated by the alga Fucus distichus.

We have divided zone 2 into three subzones. The uppermost is dominated by barnacles and small tufts of algae, the middle by Fucus and Mytilus, and the lower by red algae-predominantly Rhodymenia palmata. The three subzones are found at many, but not all of our Kodiak intertidal sites. They are grouped because the boundries are often indistinct and some organisms occur in all three areas. As mentioned above, the vertical range of each subzone will differ with the range of the tide and the extent of surf and biological interactions.

Subzone 2A. Patchy growths of small barnacles and tufts of Endocladia and sterile Fucus characterized this subzone which occured at the 7 to 10 foot levels. These organisms, are covered by tides for only short periods each day. Growths are not extensive and much of the rock is bare. Motile organisms tend to aggregate under rocks, in crevices, or under patches of algae.

Endocladia muricata. The upper part of Subzone 2A often contains sparse growths, one to two inches in diameter, of a small, brush-like alga which looks dark brown or black in color. These are Endocladia muricata which occur quite commonly although they may be inconspicuous in the spring and early summer.

Fucus distichus. In the lower part of this subzone Fucus distichus may grow quite abundantly, covering rocks with short (1-2") yellowish-brown plants. The species reaches its fullest growth lower in the intertidal, however, and the fertile plants with their characteristic swollen tips do not usually occur in subzone 2A.

Cthamalus dalli and Balanus glandula. Two species of barnacles are common in this area. They may completely cover the rocks in the lower part.

Cthamalus dalli is a small, brownish form that does not exceed 4-6mm in diameter (Kozloff, 1973). Balanus glandula is a whitish barnacle, often larger than 6mm, that reaches its greatest biomass lower in the intertidal (Fig 2D). These species may be found growing in close proximity and can be distinguished by the different arrangement of plates*. We found B. glandula to be the more common form.

Collisella digitalis. The highest occurring limpet is Collisella (= Acmaea) digitalis. The adults have a restricted vertical range and when found, are an indicator of the higher zones. The species is seldom very abundant. It can be distinguished from other limpets by its strong, often knobby ribs and the fact that the apex is almost in line with the anterior edge of the shell. Like other limpets, it feeds by scraping algae from the rocks.

Collisella pelta. This is a highly variable species. Specimens from Subzone 2A are usually small, swollen, ribbed, and have a high apex which does not extend to the anterior edge of the shell. Specimens from lower in the intertidal are usually less strongly ribbed and have a lower apex and less swollen form (Fig 3B). Collisella pelta is probably the most common intertidal limpet.

Subzone 2B. Plants and animals living in this subzone are covered by tides twice each day. Organisms in the lower part are probably covered about half the time. Little bare rock is seen as algal and invertebrate cover is almost complete.

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* Photographic examples and a discussion of the differences can be found in Kozloff (1973, p 122).

This subzone is often elevated to zonal status and in the literature described by its principal component, Fucus distichus (Fig 2A). Indeed, the entire range of zone 2 can be covered almost completely by either sterile or fertile Fucus plants. Thus, it may be somewhat artificaial to delineate an area within zone 2 and designate it as a "Fucus" subzone. On the other hand, this subzone includes the area of real Fucus dominance. Subzones above do not contain the well-developed plants which structure the community by providing a moist shaded habitat. Subzones below often find Fucus being replaced by red algae.

Halosaccion glandiforme. Dense patches of olive to reddish-brown Halosaccion glandiforme are often found in the Fucus subzone. The plants are unmistakable, consisting of fleshy, elongated, hollow, sac-like thalli (Fig 3A). In some locations, especially on unprotected outer coasts like Sea Otter Island, Halosaccion appears to replace Fucus. In more protected areas they grow together, with Halosaccion having a slightly lower upper limit.

Odonthalia floccosa. This species is often confused with Rhodymela larix. Both are dark, profusely branching plants (Fig. 2C, 3C). On long, flat beaches (Low Cape, Dolina Pt.) Odonthalia floccosa and Rhodomela larix seem to occur together and could be termed and O. floccosa-R. larix complex. Overall Odonthalia floccosa appears to be more common, however, and occurred at most of our sites.

The upper limit of this species corresponds to the upper limit of the fertile Fucus. Its greatest development, however, occurs lower intertidally where it may dominate. In this case a dark band of Odonthalia can be seen as the lower extent of the fertile Fucus zone. On vertical surfaces

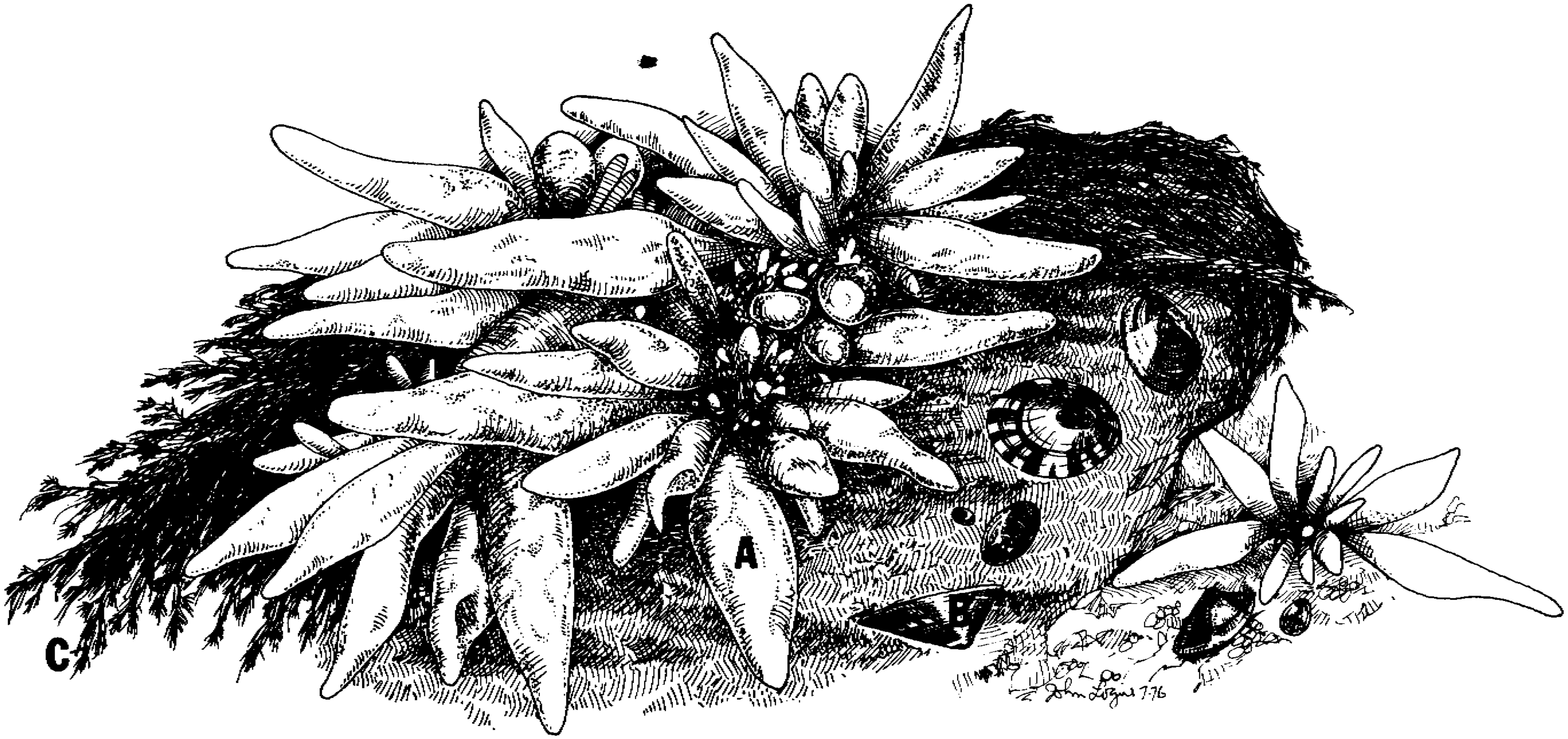

Figure 3. Characteristic species of the middle intertidal zone.
A. Halosaccion glandiforme B. Collisella pelta
C. Odonthalia floccosa

this may be quite dramatic visually as the plants hang in long bundles, four to six inches long (e.g. Spruce Island).

Because of the frequency with which Odonthalia may form thick narrow bands below the area of Fucus dominance, some authors (Nybakken, 1969) have delineated an Odonthalia zone. Based on faunal associations and the extension of the species into the area of Fucus dominance, however, we felt that it is really a co-occurring part of the Fucus subzone (2B).

Pterosiphonia sp. There are several genera and species of so-called "polysiphonous" red algae which occur commonly in the mid intertidal area. All of them are very finely divided and profusely branched forms. (Fig 4C). They usually occur as reddish, flaccid bundles or clumps up to 6 inches long. The different forms are only identifiable with the aid of a microscope. The most common species in our Kodiak collections has been Pterosiphonia bipinnata.

Mytilus edulis. Exposed outer coasts in the Kodiak area are often notable for their lack of mussels. Apparently, Mytilus californianus, the common mussel of exposed coasts of the Pacific northwest, does not grow well in the Gulf of Alaska. In protected or semi-protected waters, or on the protected sides of large hummocks, however, a wide band composed of small (up to 3") mussels is often found. These are "bay mussels", Mytilus edulis (Fig 4A).

After completing their pelagic larval stage, the spat of Mytilus edilis settle out by attaching to such algae as Odonthalia. They then migrate down onto the rocks where they are often able to outcompete the algae for space. Although bay mussels are able to live quite low in the intertidal zone, the effects of predation may limit them to the middle areas of subzone 2B (Cornell, 1972). As they grow, the tightly formed bands of Mytilus edulis may provide shelter and suitable substrate for several species of polychaete worms, nemertean worms and amphipods.

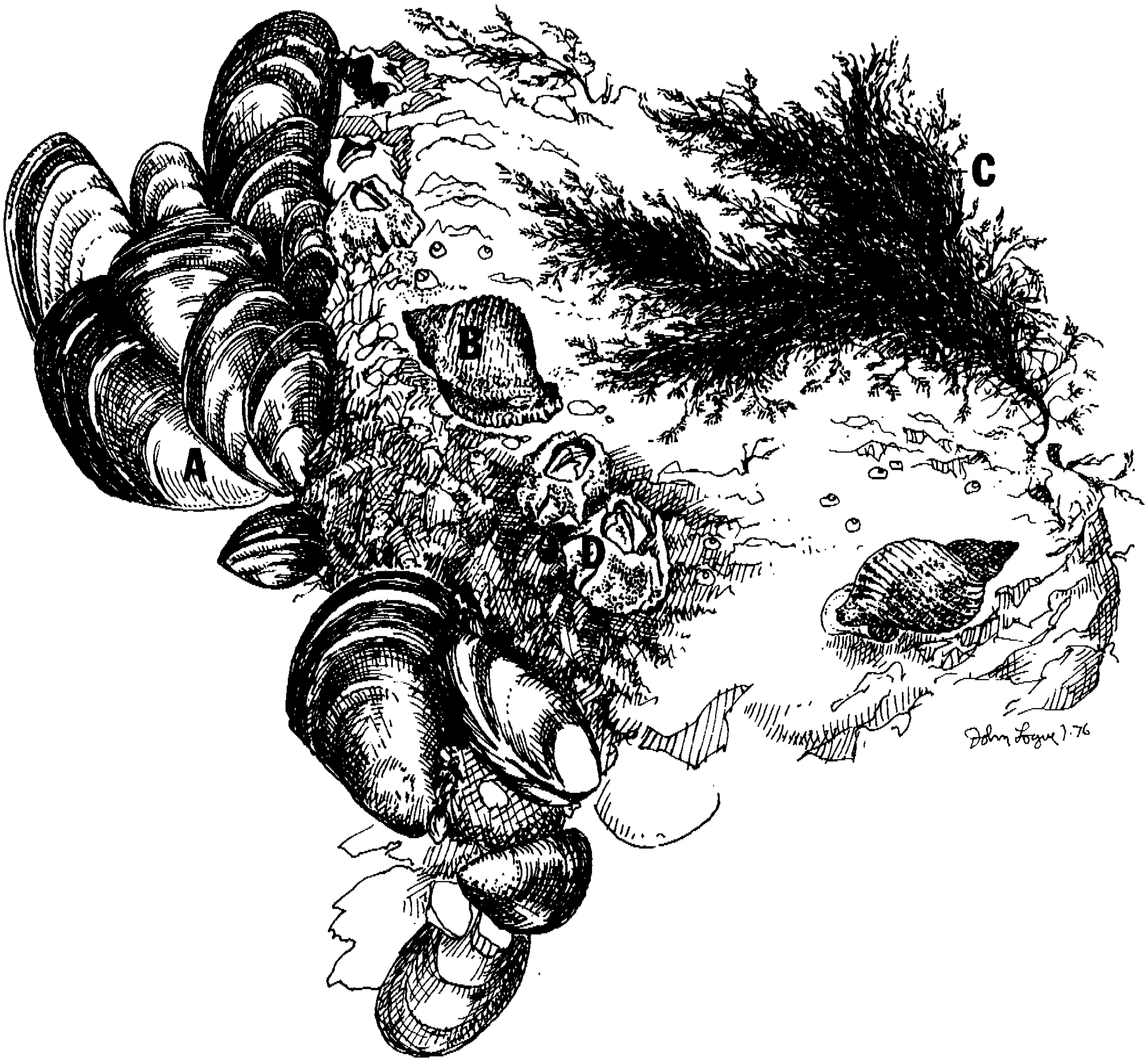

Figure 4. Characteristic species of the middle intertidal zone.
A. Mytilus edulis B. Nucella lima
C. Pterosiphonia bipinnata D. Balanus glandula

Balanus cariosus. This distinctive barnacle can be recognized by the vertical tubular ridges which line the sides of the test (Fig 6B). Small individuals can be distinguished from B. glandula by the lack of a calcareous plate at the base of the animal which is left behind when B. glandula is scraped from the rocks. Balanus cariosus is one of the most ubiquitous animals found in the intertidal zone, occurring at all sites and often extending from the upper part of zone 2 to the upper sublittoral. The species has its greatest development, however, in the mid to lower intertidal areas (0-4') where individuals may become 5 cm or more in diameter. They appear to compete with sponges and mussels for space. Like mussels, large B. cariosus often provide habitat for worms and other small vertebrates and they also often end up in the stomachs of starfish and carniverous snails.

Nucella (=Thais) lima. Two species of large carniverous snails may be found in subzone 2B. Nucella lima (Fig 4B) is the most common species around Kodiak, but in protected waters Nucella lamellosa may become very abundant. They can often be found drilling holes through the shells of mussels and barnacles which they feed on.

Subzone 2C. Between the zone of Fucus dominance and the zone which is dominated by kelps, there is a tendency for a dense band of red algae to develop. The principal component of this band is Rhodymenia palmata* (Fig 5A). This is the same alga which comprises the Rhodyphyceae zone described by Lewis (1964) for northern Scotland and Ireland. His description of the Atlantic community almost perfectly fits the situation we found on Kodiak, "These algae (several species of red algae including R. palmata) may be only lightly scattered among the thinning barnacles and barely warrent recognition as a regular subzone, or they may form a highly conspicuous belt of vegetation so thick that all barnacles, littorinids, dog whelks and even limpets may be completely excluded."

* A recent paper (Guiry, 1975) proposes changing the name to Palmaria palmata.

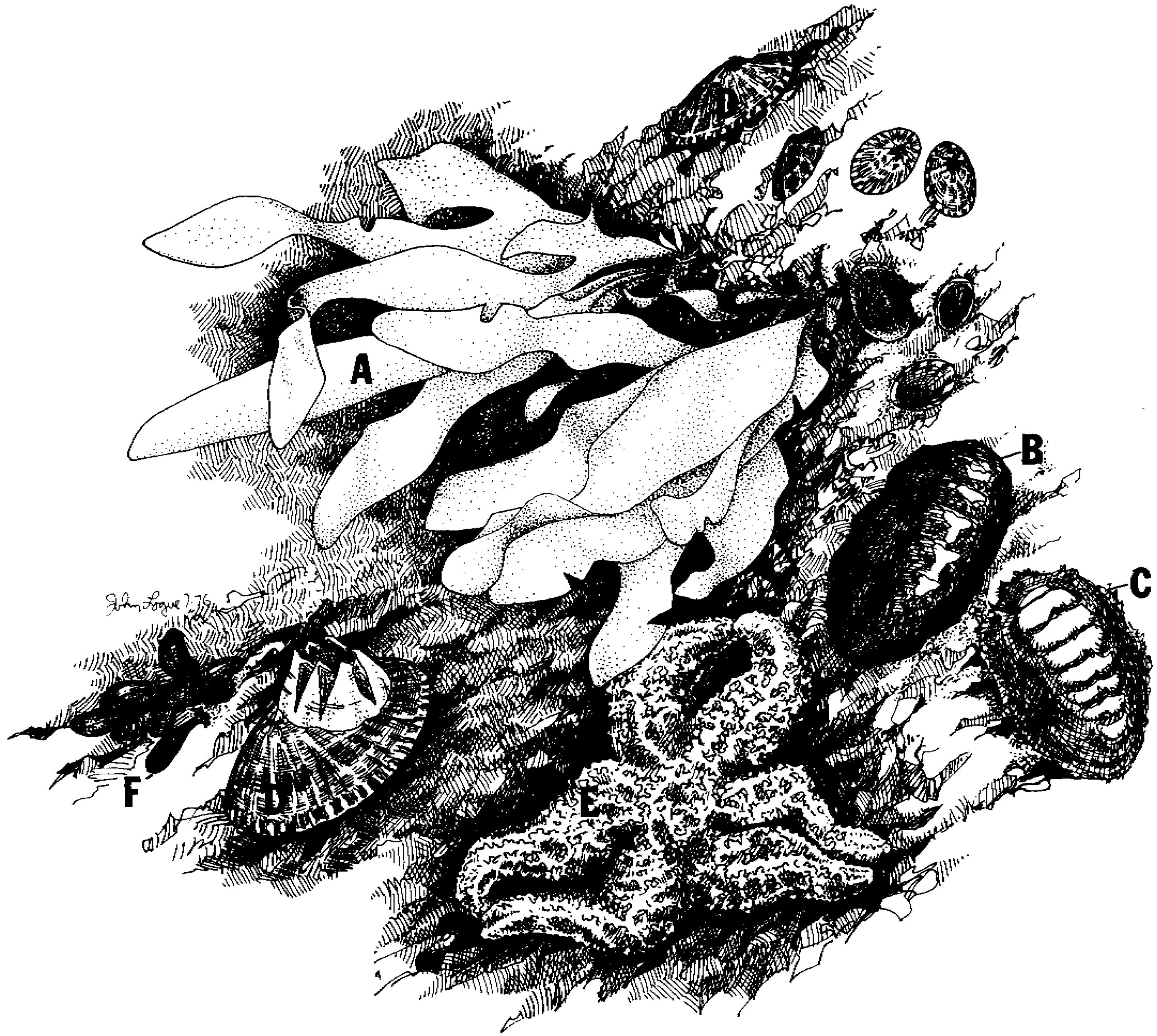

Figure 5. Characteristic species of the lower intertidal zone.
A. *Rhodymenia palmata* B. *Katherina tunicata*
C. *Mopalia mucosa* D. *Notoacmea scutum*
E. *Leptasterias hexactis* F. *Cucumeria pseudocurata*

This band is apparently absent at lower latitudes in the Northern Pacific, as Weineman (1961) did not report it from Amchitka (51°N). and Stephenson did not report it from Vancouver Island (49°N). It is quite a dominant feature of the northern Gulf of Alaska, however, and we have found it across the Gulf at latitudes above 55°N.

We found two forms of Rjodymenia to be common in the Kodiak area. The more finely divided R. palmata f. sariensis (often listed as Callophyllis flabellulata) was often found growing in a dense band above another dense band of R. palmata (Fig 5A) which has a less divided blade. This was especially apparent at Sundstrom Island where the two forms tended to exclude all other biota similar to the situation described by Lewis (1964). R. palmata occurred at every site we visited on Kodiak, but the occurrence of the dense strong bands was unpredictable.

Although this zone is often dominated by R. palmata, several other species of lower intertidal organisms are found here for the first time. These species, although probably subject to dessiccation, are able to live in this subzone because it is covered by water the majority of the time.

Monostroma, Ulva. Two genera of flat bladed, leafy green algae may be quite common in this subzone, especially if Rhodymenia is not luxurient. They each contain several species which are difficult to distinguish. Many are found growing epiphytically on old growths of Rhodymenia palmata. The most common species encountered in our Kodiak collections was M. fuscum. U. lactuca and M. zostericola were also found occasionally.

Katherina tunicata. Several species of chitons occur for the first time in this subzone. Their vertical range may extend on into the subtidal area. The most common of these in Kodiak, and throughout Alaska (Rickets and Calvin, 1968, p 206), is Katherina tunicata (Fig 5B). Although it is thought to prefer surf swept areas (Rickets and Calvin, 1968, p 55), we found it commonly at almost every rocky site we visited. Highest numbers were found on large boulders or high relief bedrock beaches. Other species which we found, and which tended to occur slightly lower intertidally included Mopalia mucosa (Fig 5C) and Tonicella lineata.

Chitons are herbivores and they live by a slowly grazing algae. They, in turn, are occasionally preyed upon by starfish or birds. We found several bird nests on Sundstrom Island which were strewn about with the plates of Katherina tunicata.

Notoacmea (=Acmaea) scutum. This limpet usually occurs fairly low in the intertidal. It can (with luck) be distinguished from other limpets by its low, flat shape (Fig 5D).

Leptasterias hexactis. This small (1-6") green, six rayed form (Fig 5E) was the most common sea star we encountered. It can be found throughtout the mid and lower intertidal zones. The location seems to depend on the availability of crevices of overhands to avoid desiccation. We also found that they are less common on exposed outer coasts.

Leptasterias feeds on a variety of other animals including barnacles, chitons, and small bivalves. A review of the feeding behavior of this and several other common intertidal sea stars is found in Mauzey et al (1968).

Cucumeria pseudocurata. Several small sea cucumbers are found intertidally in Alaska. A small, black form, Cucumeria pseudocurata (Fig 5F) was found at several Kodiak sites. Although normally inconspicuous, because of their size and ability to hide in small crevices, they are often quite abundant. They feed by filtering micro-organisms and detritus.

ZONE 3

This zone, the sublittoral fringe, begins at approximately MLLW (0.0). On some west coast beaches the MLLW level provides the most conspicious break in zonation and floral dominance. On the Oregon coast, for example, Doty (1946, p 323) reported that there are apparently no algal species which occur both above and below MLLW.

In the Kodiak area we also found a strong floral break about MLLW. Although the height is somewhat variable, biota above the floral break were dominated by relatively small foliose red and brown algae. Biota below this level were dominated by large-bladed brown algae (kelps), and small stony, pink coralline algae. The differences were not as strong as the one described by Doty, however, and it did not always occur at MLLW. We often found Rhodymenia and occasionally Fucus, the principal floral components of Zone 2 growing below MLLW, and Alaria the principal floral component of Zone 3, growing above MLLW. Several invertebrate species appeared to do well in both areas.

Organisms living in Zone 3 are only uncovered during minus tides. These occur on approximately half the days of the year. Exposure is usually brief, especially in lower areas, and spray may continue to keep the area quite wet.

We have divided Zone 3 into two subzones. The upper is dominated by species of Alaria. The lower, which continues on into the true subtidal is dominated by species of Laminaria. This division is seldom made by other authors, although Lewis (1964, p 135) and Stephenson and Stephenson (1972, p371) recognized the floral differences in their descriptions of the upper subtidal or infralittoral fringe in the northern Atlantic. Other authors (Nybakken, 1961; Weinmann, 1969) have included the Alaria belt in the littoral rather than the sublittoral zone. Stephenson and Stephenson included the Alaria belt in the midlittoral zone on the Atlantic coast (1972, p 192) and in the infralittoral zone on the Pacific coast of North America (1972, p 240).

Subzone 3A. The principal component of this subzone is Alaria, one of several large brown algae commonly referred to as kelps (Fig 6A). We found extensive beds of Alaria at every site visited in the Kodiak area. Alaria marginata was the most common form, but we occasionally found A. nana and A. tenuifolia. A fistulosa, normally a subtidal species, was found growing intertidally on Whale Island in July 1976.

The Alaria subzone is one of the most conspicious parts of the intertidal area. The broad blades, sometimes fifteen feet long, drape over rock surfaces often completely covering the substrate. This cover provides shading and probably allows organisms which are sensitive to dessication the opportunity to live higher in the intertidal.

Ptilota spp. This feathery, fern-like, highly branched alga may be recognized by its vibrant dark red coloration. It grows in large clumps which may include branches as long as 6-10". Although not present at all sites, this species and a closely allied form, Neoptilota asplenoides were quite abundant at some sites, especially Sud Island. We often found it as drift.

Halidondria panicea. Many of the rocks in this zone are covered with highly colored sponges. These often make thick encrusting growths with small volcano-like pores (ostia). The yellow or yellow-green form is Halidondria panicea (Fig 6C) which occurs on most rocky shores around Kodiak. It can be quickly distinguished from similar forms by its highly offensive odor which is noticable when it is scraped from rocks. A less common form which produces purplish colonies is Haliclona.

Crisia, Filicrisia. Two types of ectoprocts (bryozoa) have been found abundantly at some of our sites in the Kodiak area. Both Crisia and Filicrisia

Figure 6. Characteristic species of the lower intertidal and upper infralittoral zones. A. Alaria sp. B. Balanus cariosus C. Halichondria panicea D. Henrecia leviscula

are brownish, thin encrusting forms somewhat resembling sandpaper. They grow in patches up to a few inches in diameter. Along with coralline algae they may cover much of the rocks in the sublittoral fringe.

Henricia leviscula. This sea star (Fig 6D) is a very visible intertidal organism because of its bright red coloring. Formerly thought to be a ciliary plankton feeder, it is now believed that Henricia also feeds on encrusting sponges and bryozoa (Mauzey et. al. 1968). It is one of the more common sea stars in the Kodiak region, although it was rarely found in quadrat collections.

Subzone 3B. Organisms living in this subzone are exposed only a few hours each month and the community is almost subtidal in character. Populations tend to continue, without break, into the true subtidal region* Although this subzone occurs at the lowest intertidal levels, some of the representative species may be found living higher in areas with tide pools or shading and heavy spray.

Laminaria. The laminarian kelps begin their dominance in this zone. These large, broad bladed algae (Fig. 7A) are common throughout the world at higher latitudes in both southern and northern hemispheres. In the Kodiak area Laminaria dentigera was the most common species. We also found L. longipes at Sud Island and Sea Otter Island.

Coralline algae. Rocks at the lower intertidal levels are usually covered with heavy growths of pink, coralline algae. These may be scale-like encrusting forms such as Lithothamnion (Fig 7B) or erect articulated forms such as Bossiella or Corallina (Fig 7C). All are highly calcified. They occur in tide pools at upper levels, and on exposed rocks throughout Zone 3.

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* The lowest tide predicted for Kodiak in 1975-76, was a -2.9. Thus, the -3' level can probably be used to approximate the beginning of the true subtidal which is never exposed.

They appear to reach their greatest abundance in subzone 3B and in the true subtidal areas.

Acmaea mitra. This limpet is only found in lower subtidal areas or large tide pools. Although normally white in color it may be covered with coralline algae which give it a pink coloration. Its swollen, high-peaked shape gives it a characteristically unmistakable form (Fig 7D). This shape is often likened unto a "Chinaman's hat", from which it derives its common name.

Figure 7. Characteristic species of the upper infralittoral zones.
A. Laminaria sp. B. Lithothamnion sp. C. Bossiella sp.
D. Acmaea mitra

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INTERTIDAL SECTION--PART B

Species occurrences and distributions at quantitative sampling sites in the Kodiak area

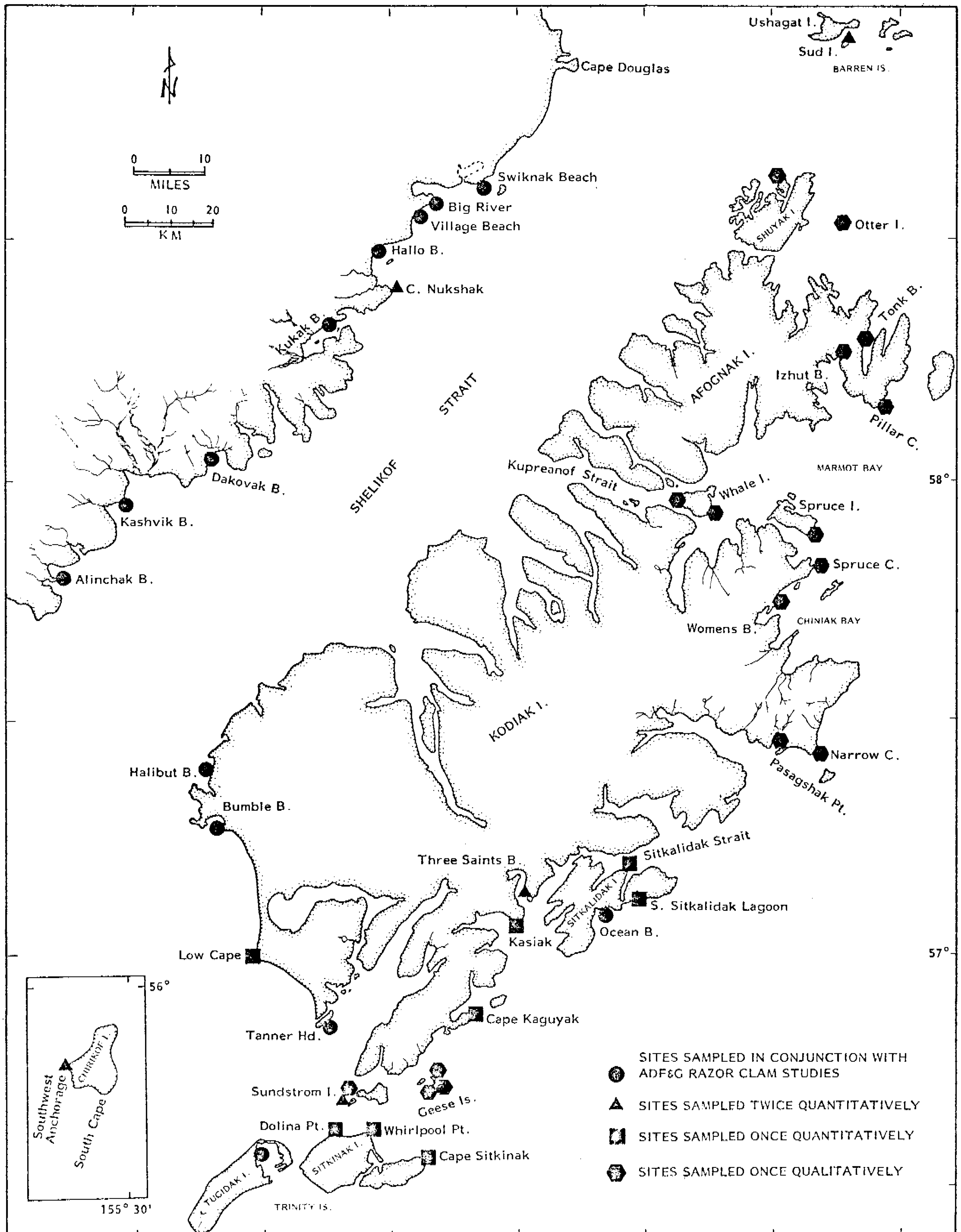


Figure 8. Sites sampled in the Kodiak area during 1975-76.

SPECIES OF SUD ISLAND

CHLOROPHYTA
- Chlorophyta
- Ulothrix laetevirens
- Monostroma sp.
- Monostroma fuscum
- Monostroma zostericola
- Ulva sp.
- Cladophora sp.
- Spongomorpha sp.
- Spongomorpha coalita
- Spongomorpha spinescens

PHAEOPHYTA
- Phaeophyta
- Ectocarpaceae
- Ectocarpus sp.
- Ectocarpus simulans
- Pylaiella littoralis
- Ralfsia fungiformis
- Elachistea fucicola
- Soranthera ulvoidea
- Petalonia fascia
- Phaestrophion irregulare
- Laminariaceae
- Laminaria sp.
- Laminaria longipes
- Laminaria yezoensis
- Alaria sp.
- Alaria fistulosa
- Alaria marginata
- Alaria nana
- Alaria pylaii
- Alaria taeniata
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Acrochaetium sp.
- Cryptosiphonia woodii
- Endocladia muricata
- Gloiopeltis furcata
- Petrocelis franciscana
- Corallinaceae
- Mesophyllum lamellatum
- Bossiella sp.
- Bossiella chiloensis
- Bossiella plumosa
- Corallina sp.

Corallina vancouveriensis
Cryptonemiaceae
Callophyllis sp.
Callophyllis flabellulata
Callophyllis pinnata
Ahnfeltia plicata
Gigartina sp.
Gigartina papillata
Iridaea sp.
Iridaea cordata
Iridaea cornucopiae
Rhodoglossum californicum
Fauchea laciniata
Halosaccion glandiforme
Rhodymenia sp.
Rhodymenia palmata
Rhodymenia pertusa
Ceramiaceae
Microcladia borealis
Microcladia coulteri
Ptilota sp.
Ptilota filicina
Ptilota tenuis
Neoptilota sp.
Neoptilota asplenioides
Neiptilota hypnoides
Delesseriaceae
Rhodomelaceae
Pterosiphonia sp.
Pterosiphonia bipinnata
Pterosiphonia dendroidea
Rhodomela larix
Odonthalia sp.
Odonthalia floccosa

ANTHOPHYTA
Potamogetonaceae

PORIFERA
Porifera

CNIDARIA
Hydroidea
Eudendrium annulatum
Anthozoa

TURBELLARIA
Turbellaria

RHYNCHOCOELA
Rhynchocoela
Emplectonema gracile

NEMATODA
Nematoda

ANNELIDA

Polychaeta
Halosydna brevisetosa
Phloe minuta
Phyllodocidae
Anaitides sp.
Eteone longa
Eulalia sp.
Eulalia viridis
Eulalia bilineata
Eulalia quadrioculata
Syllidea
Autolytus prismaticus
Typosyllis sp.
Typosyllis alternata
Typosyllis armillaris
Typosyllis a adamantea
Exogone sp.
Exogone gemmifera
Exogone lourei
Sphaerosyllis sp.
Sphaerosyllis pirifera
Sphaerosyllis brandhorsti
Syllides japonica
Nereis sp.
Nereis pelagica
Nereis zonata
Glycera capitata
Onuphis iridescens
Eunicidae
Lumbrineris sp.
Lumbrineris zonata
Lumbrineris inflata
Naineris sp.
Naineris quadricuspida
Paraonidae
Spionidae
Polydora sp.
Spio filicornis
Boccardia sp.
Boccardia natrix
Boccardia proboscidea
Pygospio sp.
Cirratulus sp.
Cirratulus cirratus
Tharyx sp:
Capitellidae
Capitella capitata
Maldanidae
Sabellariidae
Idanthyrus armatus

Ampharetidae
Terebellidae
Nicolea zostericola
Sabellidae
Chone gracilis
Chone infundibuliformis
Potamilla neglecta
Pseudopotamilla reniformis
Amphiglena pacifica
Fabricia sabella
Fabricia crenicollis
Pseudosabellides lettoralis
Dexiospira spirillum
Oligochaeta
Enchytraeidae
Hirudinea

POLYPLACOPHORA

Polyplacophora
Tonicella lineata
Katharina tunicata
Schizoplax brandtii

PELECYPODA

Mytilus edulis
Musculus sp.
Musculus niger
Musculus vernicosus
Turtonia occidentalis
Protothaca staminea
Hiatella arctica

GASTROPODA

Gastropoda
Acmaeidae
Collisella pelta
Collisella digitalis
Margarites sp.
Margarites pupillus
Littorina sp.
Littorina sitkana
Littorina aleutica
Littorina scutulata
Haloconcha reflexa
Lacuna marmorata
Lacuna vincta
Barleeia sp.
Cerithiopsis sp.
Nucella sp.
Nucella lima
Buccinum sp.
Buccinum baeri
Searlesia dira

Odostomia sp.
Cylichna occulta
Onchidella borealis
Siphonaria thersites

ARACHNIDA

Acarina
Halacaridae
Pseudoscorpionida

PYCNOGONIDA

Pycnogonida
Phoxichilidium femoratum
Ammothea pribilofensis

CRUSTACEA

Crustacea
Platycopa
Harpacticoida
Thoracica
Balanus sp.
Balanus cariosus
Balanus glandula
Balanus rostratus
Chthamalus dalli
Mysidacea
Cumella sp.
Tanidacea
Tanais sp.
Isopoda
Synidotea sp.
Pentidotea wosensenskii
Idothea fewkesi
Sphaeromatidae
Gnorimosphaeroma sp.
Gnorimosphaeroma oregonensis
Exosphaeroma sp.
Exosphaeroma amplicauda
Ianiropsis kincaidi kincaidi
Munna sp.
Amphipoda
Caprellidae
Cercops compactus
Caprella sp.
Caprella cristibranchium
Caprella alaskana
Caprella laeviuscula
Decapoda
Pagurus h hirsutiusculus
Pugettia sp.
Pugettia gracilis
Cancer oregonensis

INSECTA

Insecta
Diptera
Tipulidae
Chironomidae
Culicidae
Cicadellidae
Coleoptera
Staphinidae

BRYOZOA

Bryozoan
Hippothea hyalina
Crisia sp.
Flustrella sp.

ASTEROIDEA

Asteroidea
Leptasterias sp.
Leptasterias hexactis

OPHIUROIDEA

Ophiuroidea
Ophiopholis aculeata

HOLOTHUROIDEA

Holothuroidea
Cucumaria sp.
Cucumaria pseudocurata

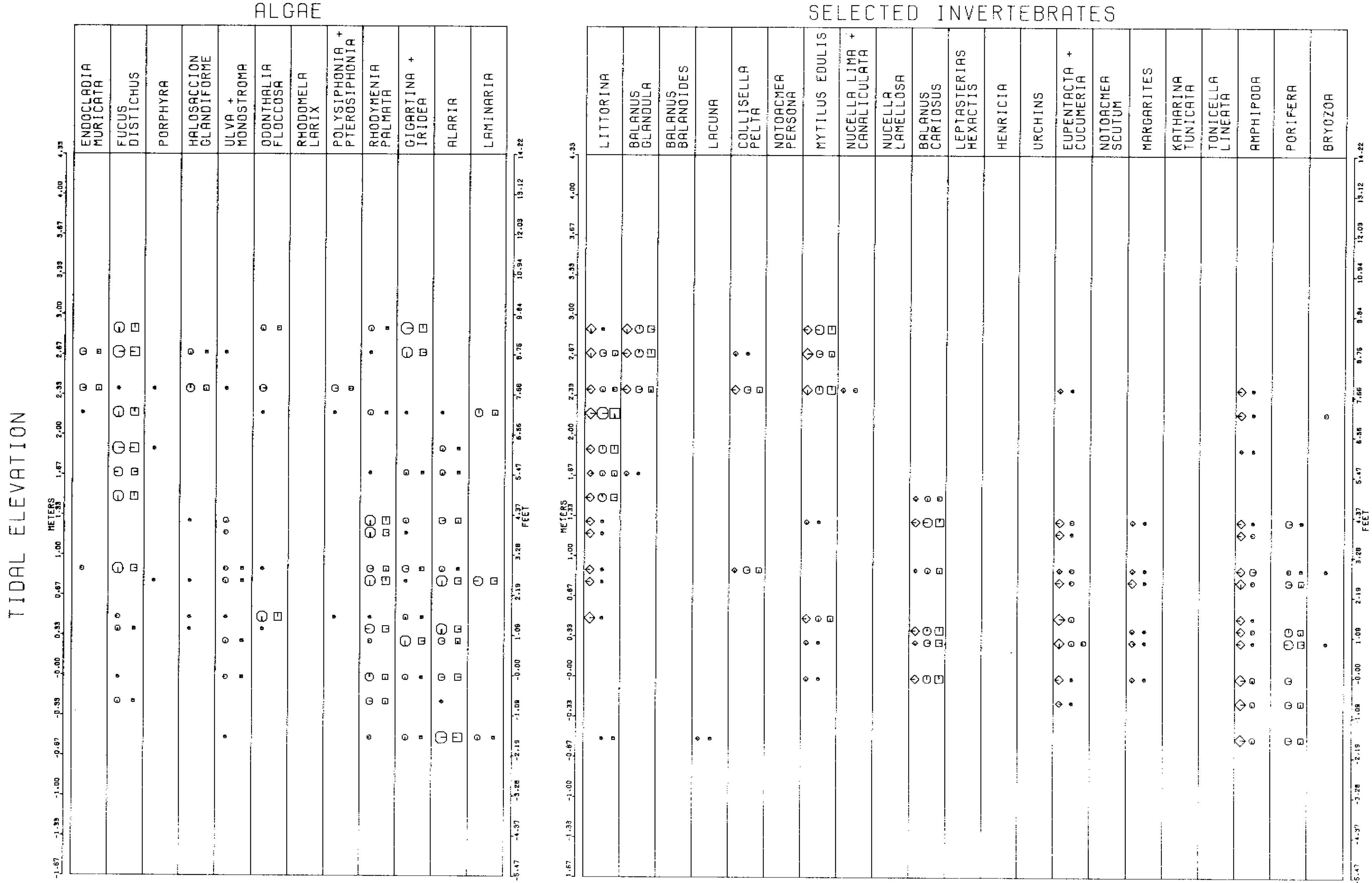
UROCHORDATA

Urochordata
Aplousobranchia
Amaroucium glabrum

TELEOSTEI

Cottidae

DOMINANT INTERTIDAL ORGANISMS



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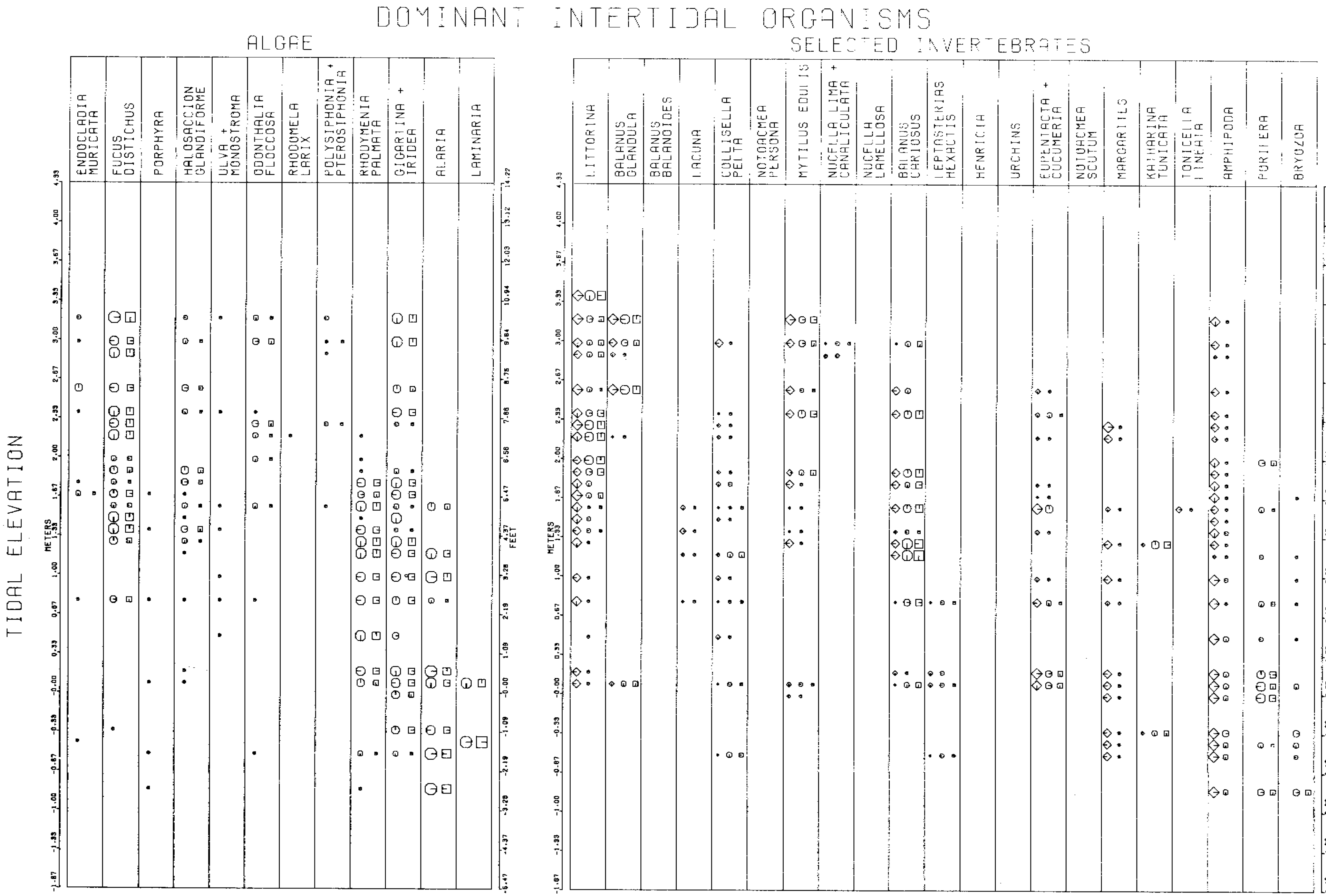
LATITUDE: 58 54 30 N
LONGITUDE: 152 12 40 W
OBSRV. RANGE: -0.5 M TO 2.9 M

COUNT OF INDIVIDUALS KEY
FRAGMENT
1
2-5
6-10
11-25
26-100
101-250
>250

WET WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

DRY WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250



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LATITUDE: 58 54 30 N
LONGITUDE: 152 12 40 W
OBSRV. RANGE: -0.8M TO 3.4M

COUNT OF INDIVIDUALS KEY	
•	FRAGMENT
•	1
◊	2-5
◊	6-10
◊	11-25
◊	26-100
◊	101-250
◊	>250

WET WEIGHT KEY UNITS=GRAMS	
•	0.1-.50
○	.51-1.0
○	1.1-5.0
○	5.1-20.0
○	20.1-50.0
○	50.1-100.0
○	100.1-250.0
○	>250

DRY WEIGHT KEY UNITS=GRAMS	
•	0.1-.50
□	.51-1.0
□	1.1-5.0
□	5.1-20.0
□	20.1-50.0
□	50.1-100.0
□	100.1-250.0
□	>250

SPECIES OF SPECTACLE ISLAND

CHLOROPHYTA
- Monostroma fuscum
- Ulva sp.
- Ulva fenestrata
- Ulva lactuca
- Cladophoraceae
- Urospora mirabilis
- Cladophora seriacea

PHAEOPHYTA
- Phaeophyta
- Ectocarpus simulans
- Pylaiella littoralis
- Spongonema tomentosum
- Elachistea fucicola
- Desmarestia sp.
- Soranthera ulvoidea
- Petalonia sp.
- Scytosiphon lomentaria
- Laminaria sp.
- Alaria sp.
- Alaria taeniata
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Acrochaetium sp.
- Cryptosiphonia woodii
- Endocladia muricata
- Gloiopeltis furcata
- Petrocelis sp.
- Petrocelis franciscana
- Bossiella sp.
- Corallina sp.
- Corallina vancouveriensis
- Callophyllis sp.
- Callophyllis flabellulata
- Callophyllis pinnata
- Gigartinaceae
- Gigartina sp.
- Gigartina papillata
- Gigartina stellata
- Iridaea sp.
- Iridaea cornucopiae
- Halosaccion glandiforme
- Rhodymenia palmata
- Microcladia borealis
- Ptilota sp.

Neoptilota sp.
Neoptilota asplenioides
Rhodomelaceae
Pterosiphonia bipinnata
Odonthalia floccosa
Porifera hydroidea

TURBELLARIA

Turbellaria

RHYNCHOCOELA

Rhynchocoela
Emplectonema gracile

NEMATODA

Nematoda

ANNELIDA

Polychaeta
Eulalia Bilineata
Typosyllis elongata
Typosyllis pulchra
Typosyllis a adamantea
Sphaerosyllis sp.
Nereis sp.
Nereis pelagica
Sphaerodoropsis minutum
Spionidae
Capitella capitata
Chone gracilis
Amphiglena pacifica
Fabricia sabella
Fabricia pacifica
Fabricia crenicollis
Dexiospira spirillum
Enchytraeidae

PELECYPODA

Pelecypoda
Mytilus edulis
Musculus sp.
Musculus vernicosus
Modiolus modiolus
Pododesmus macroschisma
Turtonia occidentalis

GASTROPODA

Gastropoda
Acmaeidae
Collisella sp.
Collisella pelta
Collisella digitalis
Notoacmea scutum
Notoacmea persona
Margarites helicinus
Margarites beringensis

Moelleria costulata
Littorinidae
Littorina sitkana
Littorina aleutica
Littorina scutulata
Haloconcha reflexa
Facuna marmorata
Barleeia sp.
Odostomia sp.
Siphonaria thersites

ARACHNIDA

Halacaridae
Pseudoscorpionida

PYCNOGONIDA

Ammothea latifrons
Ammothea pribilofensis

CRUSTACEA

Platycopa
Harpacticoida
Thoracica
Balanus sp.
Balanus cariosus
Balanus glandula
Chthamalus dalli
Pentidotea wosensenskii
Sphaeromatidae
Exosphaeroma sp.
Exosphaeroma amplicauda
Dynamenella sheari
Munna sp.
Munna stephenseni
Amphipoda

INSECTA

Diptera
Chironomidae
Coleoptera
Staphinidae

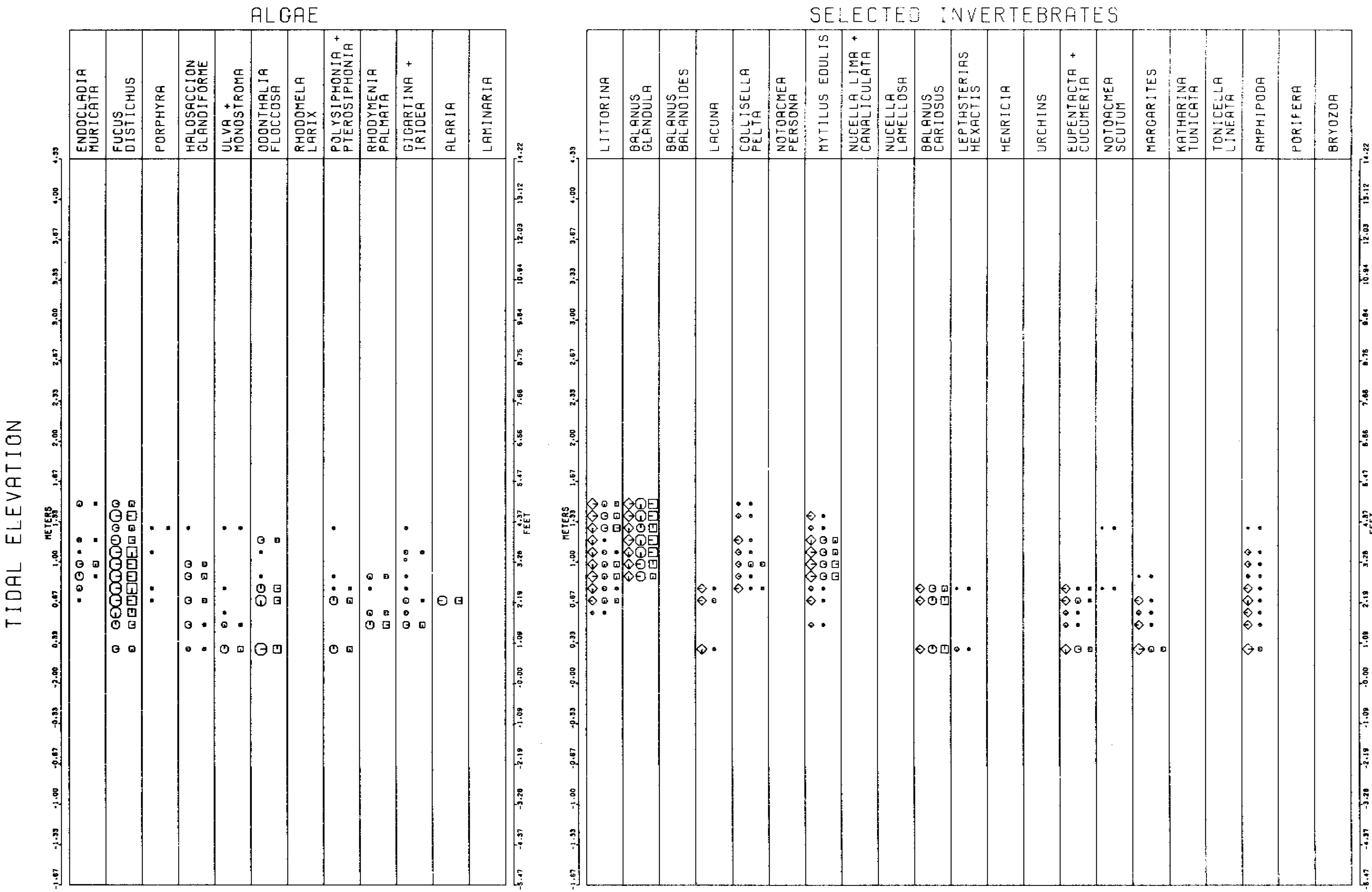
ASTEROIDEA

Leptasterias hexactis

HOLOTHUROIDEA

Cucumaria pseudocurata

DOMINANT INTERTIDAL ORGANISMS



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LATITUDE: 55 7 20 N
LONGITUDE: 159 44 60 W
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COUNT OF INDIVIDUALS KEY
• FRAGMENT
1
2-5
6-10
11-25
26-100
101-250
>250

WET WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

DRY WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

SPECIES OF CHIRIKOF ISLAND

CHLOROPHYTA
- Chlorophyta
- Monostroma sp.
- Monostroma fuscum
- Monostroma zostericola
- Enteromorpha linza
- Ulva sp.
- Ulva fenestrata
- Ulva lactuca
- Ulva rigida
- Lola lubrica
- Spongomorpha spinescens

BACILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Phaeophyta
- Ectocarpus sp.
- Pylaiella littoralis
- Ralfsia fungiformis
- Saundersella simplex
- Analipus japonicus
- Desmarestia aculeata
- Soranthera ulvoidea
- Melanosiphon intestinate
- Petalonis sp.
- Petalonis fasciata
- Colpomenia bullosa
- Scytosiphon lomentaria
- Dictyosiphon sp.
- Coilodesme sp.
- Coilodesme polygnampta
- Agarum sp.
- Laminariaceae
- Laminaria sp.
- Laminaria longipes
- Laminaria yezoensis
- Alaria sp.
- Alaria marginata
- Alaria taeniata
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Acrochaetium sp.
- Endocladia muricata
- Corallinaceae
- Tenarea sp.

Bossiella sp.
Bossiella chiloensis
Bossiella plumosa
Corallina sp.
Lithothamnion sp.
Ahnfeltia sp.
Ahnfeltia plicata
Gigartina sp.
Gigartina papillata
Gigartina latissima
Gigartina stellata
Iridaea sp.
Iridaea cornucopiae
Halosaccion sp.
Halosaccion glandiforme
Halosaccion saccatum
Rhodymenia sp.
Rhodymenia palmata
Rhodymenia pertusa
Microcladia borealis
Microcladia coulteri
Ptilota sp.
Ptilota filicina
Neiptilota sp.
Neoptilota asplenioides
Tokidadendron bullata
Rhodomelaceae
Pterosiphonia sp.
Pterosiphonia bipinnata
Rhodomela larix
Odonthalia sp.
Odonthalia floccosa
Odonthalia washingtoniensis

ANTHOPHYTA
- Potamogetonaceae
- Zostera marina

PORIFERA
- Porifera
- Anthozoa

TURBELLARIA
- Turbellaria

RHYNCHOCOELA
- Rhynchocoela
- Emplectonema gracile

NEMATODA
- Nematoda

ANNELIDA
- Polychaeta
- Phyllodocidae
- Anaitides sp.

Eteone sp.
Eteone longa
Eulalia sp.
Eulalia bilineata
Eulalia quadrioculata
Syllidea
Typosyllis sp.
Typosyllis alternata
Typosyllis pulchra
Exogone sp.
Exogone gemmifera
Sphaerosyllis sp.
Sphaerosyllis pirifera
Syllides japonica
Nereis sp.
Nereis pelagica
Nereis vexillosa
Nereis zonata
Sphaerodoropsis minutum
Glycera capitata
Lumbrineris sp.
Lumbrineris inflata
Naineris sp.
Naineris quadricuspida
Naineris laevigata
Polydora sp.
Polydora ciliata
Boccardia sp.
Boccardia natrix
Cirratulidae
Cirratulus sp.
Cirratulus cirratus
Tharyx sp.
Capitella capitata
Nicomache sp.
Nicomache personata
Polycirrus medusa
Sabellidae
Chone gracilis
Amphiglena pacifica
Fabricia sabella
Fabricia crenicollis
Pseudosabellides littoralis
Dexiospira spirillum
Enchytraeidae
Hirudinea

POLYPLACOPHORA

Polyplacophora
Katharina tunicata
Schizoplax brandtii

PELECYPODA

- Pelecypoda
- Mytilus edulis
- Musculus sp.
- Musculus discors
- Musculus vernicosus
- Turtonia occidentalis
- Protothaca staminea
- Heatella arctica

GASTROPODA

- Gastropoda
- Collisella sp.
- Collisella pelta
- Collisella digitalis
- Notoacmea scutum
- Margarites helicinus
- Margarites beringensis
- Littorina sitkana
- Littorina aleutica
- Littorina scutulata
- Haloconcha reflexa
- Lacuna marmorata
- Lacuna vincta
- Barleeia sp.
- Cerithiopsis sp.
- Nucella lima
- Buccinum baeri
- Searlesia dira
- Odostomia sp.

ARACHNIDA

- Halacaridae

PYCNOGONIDA

- Phoxichilidium quadradentatum
- Ammothea pribilofensis

CRUSTACEA

- Platycopa
- Harpacticoida
- Balanus sp.
- Balanus balanoides
- Balanus cariosus
- Balanus glandula
- Chthamalus dalli
- Cumacea
- Cumella sp.
- Tanidacea
- Tanaidae
- Isopoda
- Pentidotea wosensenskii
- Idothea fewkesi
- Sphaeromatidae

Gnorimosphaeroma oregonensis
Exosphaeroma sp.
Exosphaeroma amplicauda
Ianiropsis kincaidi kincaidi
Munna sp.
Amphipoda
Ampithoe sp.
Calliopiella pratti
Ischyroceridae
Caprellidae
Caprella sp.
Caprella irregularis
Pagurus h hirsutiusculus
Pugettia gracilis
Cancer sp.
Cancer oregonensis
Telmessus cheiragonus

INSECTA
Chironomidae

BRYOZOA
Bryozoan
Microporina sp.

BRACHIPODA
Brachiopoda

ASTEROIDEA
Asteroidea
Henricia sp.
Leptasterias sp.
Leptasterias hexactis

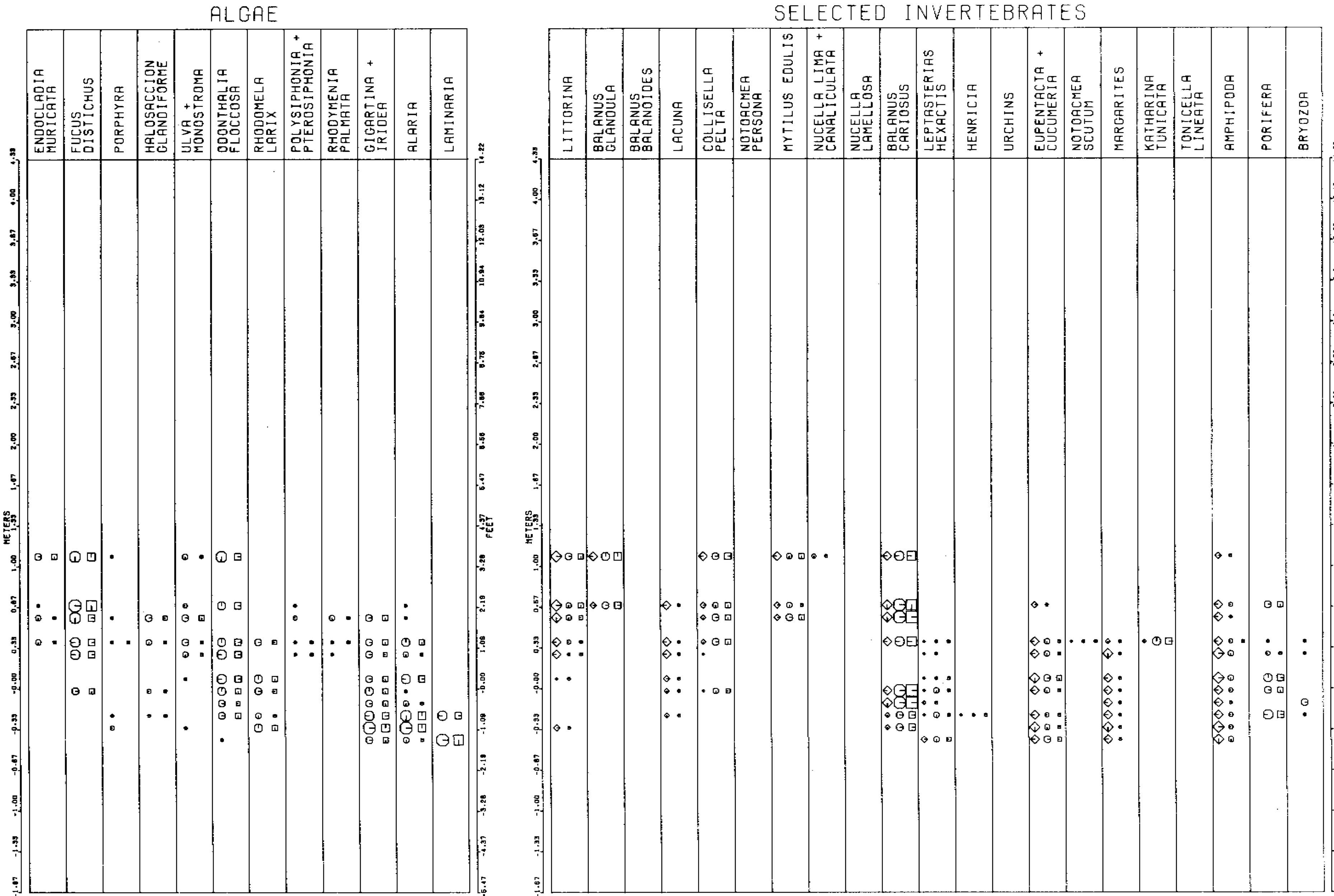
OPHIUROIDEA
Ophiuroidea
Cucumaria pseudocurata

UROCHORDATA
Urochordata

TELEOSTEI
Liparis sp.

DOMINANT INTERTIDAL ORGANISMS

TIDAL ELEVATION 173



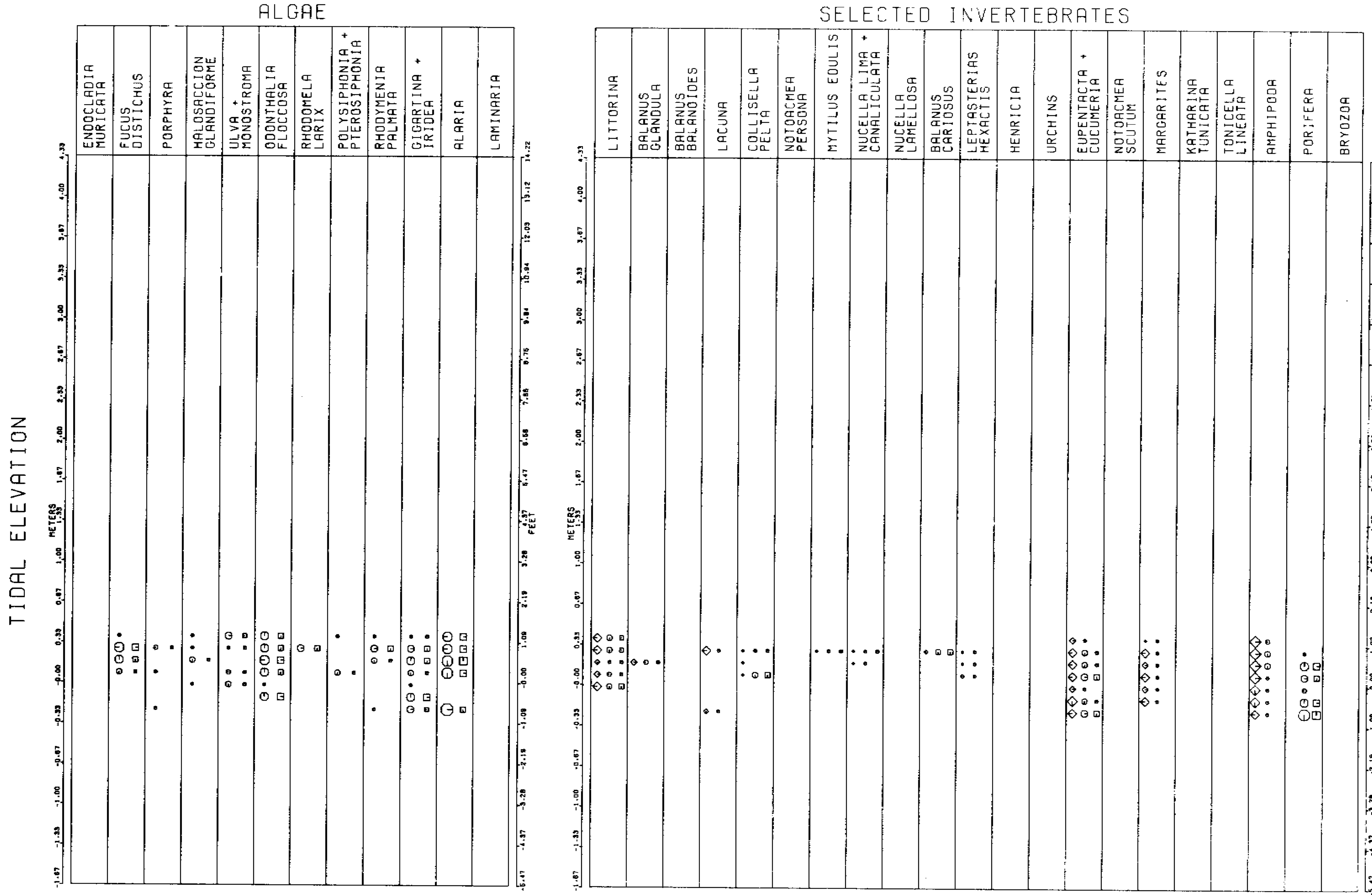
STATION: CHIRIKOF ISLAND
DATE: 75/ 5/27
LATITUDE: 55 49 60 N
LONGITUDE: 156 44 10 W
OBSRV. RANGE: -0.4 M TO 1.1 M

COUNT OF INDIVIDUALS KEY	
•	FRAGMENT
	1
	2-5
	6-10
	11-25
	26-100
	101-250
	>250

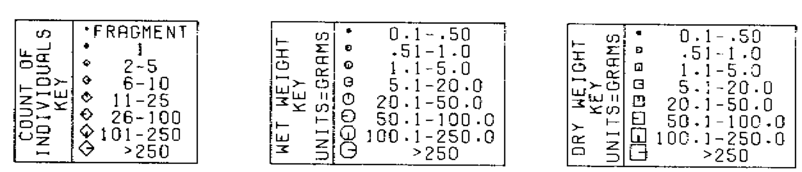
WET WEIGHT KEY UNITS=GRAMS	
	0.1-.50
	.51-1.0
	1.1-5.0
	5.1-20.0
	20.1-50.0
	50.1-100.0
	100.1-250.0
	>250

DRY WEIGHT KEY UNITS=GRAMS	
	0.1-.50
	.51-1.0
	1.1-5.0
	5.1-20.0
	20.1-50.0
	50.1-100.0
	100.1-250.0
	>250

DOMINANT INTERTIDAL ORGANISMS



STATION: CHIRIKOF ISLAND
DATE: 75/ 8/10
LATITUDE: 55 49 60 N
LONGITUDE: 156 44 10 W
OBSRV. RANGE: -0.2M TO 0.4M



SPECIES OF SUNDSTROM ISLAND

CHLOROPHYTA
- Chlorophyta
- Ulothrix laetevirens
- Monostroma sp.
- Monostroma fuscum
- Monostroma zostericola
- Ulva lactuca
- Prasiola meridionalis
- Rosenvingiella constricta
- Schizogonium murale
- Spongomorpha spinescens

BARILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Phaeophyta
- Ralfsia fungiformis
- Elachistea fucicola
- Soranthera ulvoidea
- Petalonia sp.
- Phaestrophion irregulare
- Hedophyllum sessile
- Laminaria sp.
- Laminaria dentigera
- Laminaria longipes
- Alaria sp.
- Alaria crispa
- Alaria marginata
- Alaria praelonga
- Alaria taeniata
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Acrochaetium sp.
- Cryptonemiales
- Cryptosiphonia woodii
- Endocladia muricata
- Petrocelis sp.
- Petrocelis middendorffii
- Corallinaceae
- Bossiella sp.
- Bossiella chiloensis
- Bossiella plumosa
- Corallina sp.
- Corallina vancouveriensis
- Lithothamnion sp.
- Callophyllis sp.

Callophyllis flabellulata
Ahnfeltia plicata
Gigartinaceae
Gigartina sp.
Gigartina papillata
Gigartina stellata
Iridaea sp.
Iridaea cornucopiae
Halosaccion glandiforme
Rhodymenia palmata
Antithamnion sp.
Callithamnion pikeanum
Microcladia borealis
Ptilota sp.
Neoptilota sp.
Neoptilota asplenioides
Pterosiphonia bipinnata
Rhodomela larix
Odonthalia sp.
Odonthalia aleutica
Odonthalia floccosa
Odonthalia washingtoniensis

ANTHOPHYTA
Potamogetonaceae
Zostera marina

PORIFERA
Porifera

CNIDARIA
Anthozoa

TURBELLARIA
Turbellaria

RHYNCHOCOELA
Rhynchocoela
Emplectonema gracile

NEMATODA
Nematoda

ANNELIDA
Polychaeta
Arctonoe sp.
Harmothoe imbricata
Phloe minuta
Dysponetecus sp.
Phyllodocidae
Anaitides sp.
Eteone longa
Eulalia sp.
Eulalia bilineata
Eulalia quadrioculata
Syllidea
Autolytus sp.

Syllis sp.
Typosyllis sp.
Typosyllis alternata
Typosyllis armillaris
Typosyllis pulchra
Typosyllis stewarti
Typosyllis fasciata
Typosyllis a adamantea
Typosyllis hyalina
Eusyllis assimilis
Exogone louvei
Sphaerosyllis sp.
Sphaerosyllis pirifera
Syllides japonica
Nereidae
Nereis sp.
Nereis pelagica
Nereis grubei
Sphaerodoridium gracilis
Sphaerodoropsis minutum
Eunice valens
Lumbrineris sp.
Lumbrineris zonata
Lumbrineris inflata
Protodorvillea gracilis
Naineris laevigata
Naineris laevigata
Spionidae
Polydora sp.
Polydora ciliata
Spio filicornis
Boccardia sp.
Boccardia columbiana
Boccardia natrix
Cirratulus sp.
Cirratulus cirratus
Tharyx sp.
Capitella capitata
Ampharetidae
Asabellides littoralis
Polycirrus medusa
Sabellidae
Chone gracilis
Potamilla neglecta
Pseudopotamilla reniformis
Schizobranchia insignis
Amphiglena pacifica
Fabricia sabella
Fabricia crenicollis
Pseudosabellides littoralis

Dexiospira spirillum
Enchytraeidae
Hirudinea

POLYPLACOPHORA

Polyplacophora
Cynoplax dentiens
Lepidochiton sharpei
Tonicella lineata
Katharina tunicata
Mopalia ciliata
Mopalia mucosa
Schizoplax brandtii

PELECYPODA

Mytilus edulis
Musculus sp.
Musculus discors
Musculus vernicosus
Musculus olivaceous
Modiolus modiolus
Turtonia occidentalis
Protothaca staminea
Hiatella arctica

GASTROPODA

Gastropoda
Acmaea mitra
Collisella sp.
Collisella pelta
Collisella digitalis
Notoacmea scutum
Margarites helicinus
Margarites pupillus
Margarites beringensis
Homalopoma sp.
Littorina sitkana
Haloconcha reflexa
Lacuna sp.
Lacuna marmorata
Lacuna victa
Alvinia compacta
Cingula sp.
Barleeia sp.
Cerithiopsis sp.
Melanella micrans
Velutina velutina
Nucella sp.
Nucella lamellosa
Nucella lima
Buccinum baeri
Searlesia dira
Odostomia sp.

Onchidella borealis
Siphonaria sp.
Siphonaria thersites

ARACHNIDA

Acarina
Halacaridae
Pseudoscorpionida

PYCNOGONIDA

Pycnogonida
Phoxichilidium femoratum
Ammothea pribilofensis

CRUSTACEA

Crustacea
Harpacticoida
Thoracica
Balanus sp.
Balanus cariosus
Balanus glandola
Chthamalus dalli
Tanidacea
Tanaidae
Pentidotea wosensenskii
Idothae fewkesi
Gnorimosphaeroma oregonensis
Exosphaeroma sp.
Exosphaeroma amplicauda
Dynamenella sheari
Ianiropsis kincaidi kincaidi
Munna sp.
Munna stephenseni
Amphipoda
Parallorchestes ochotensis
Caprellidae
Pagurus sp.
Pagurus beringanus
Pagurus h hirsutiusculus
Pugettia gracilis
Cancer oregonensis

INSECTA

Insecta
Anurida maritima
Diptera
Chironomidae
Coleoptera

BRYOZOA

Bryozoan
Hippothea hyalina
Filicrisia sp.
Flustrellidae

ASTEROIDEA

Asteroidea
Henricia sp.
Henricia sanguinolenta
Leptasterias sp.
Leptasterias hexactis

OPHIUROIDEA

Ophiuroidea
Ophiopholis aculeata
Cucumaria pseudocurata

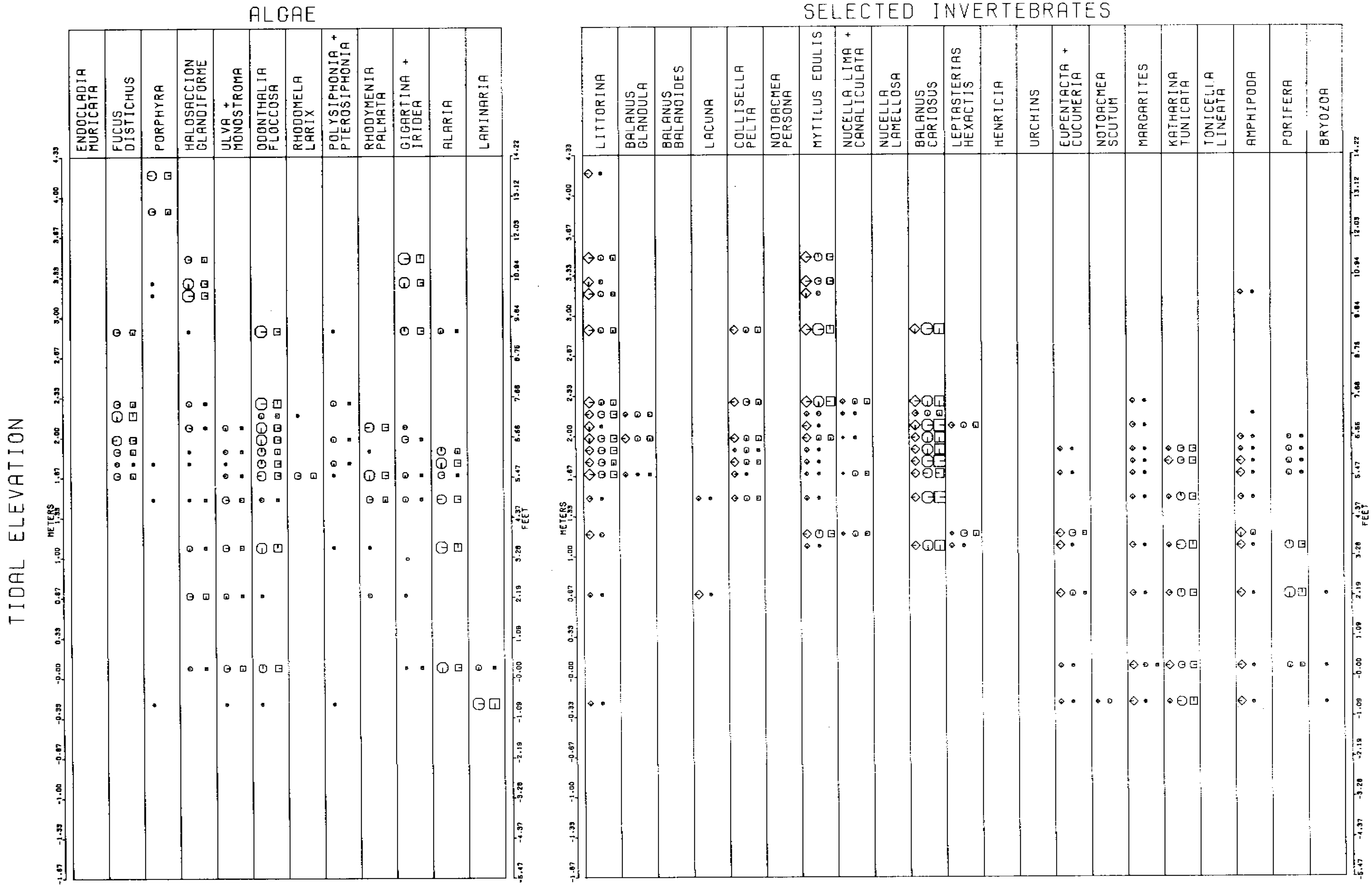
UROCHORDATA

Urochordata
Styela clavata

TELEOSTEI

Teleostei

DOMINANT INTERTIDAL ORGANISMS



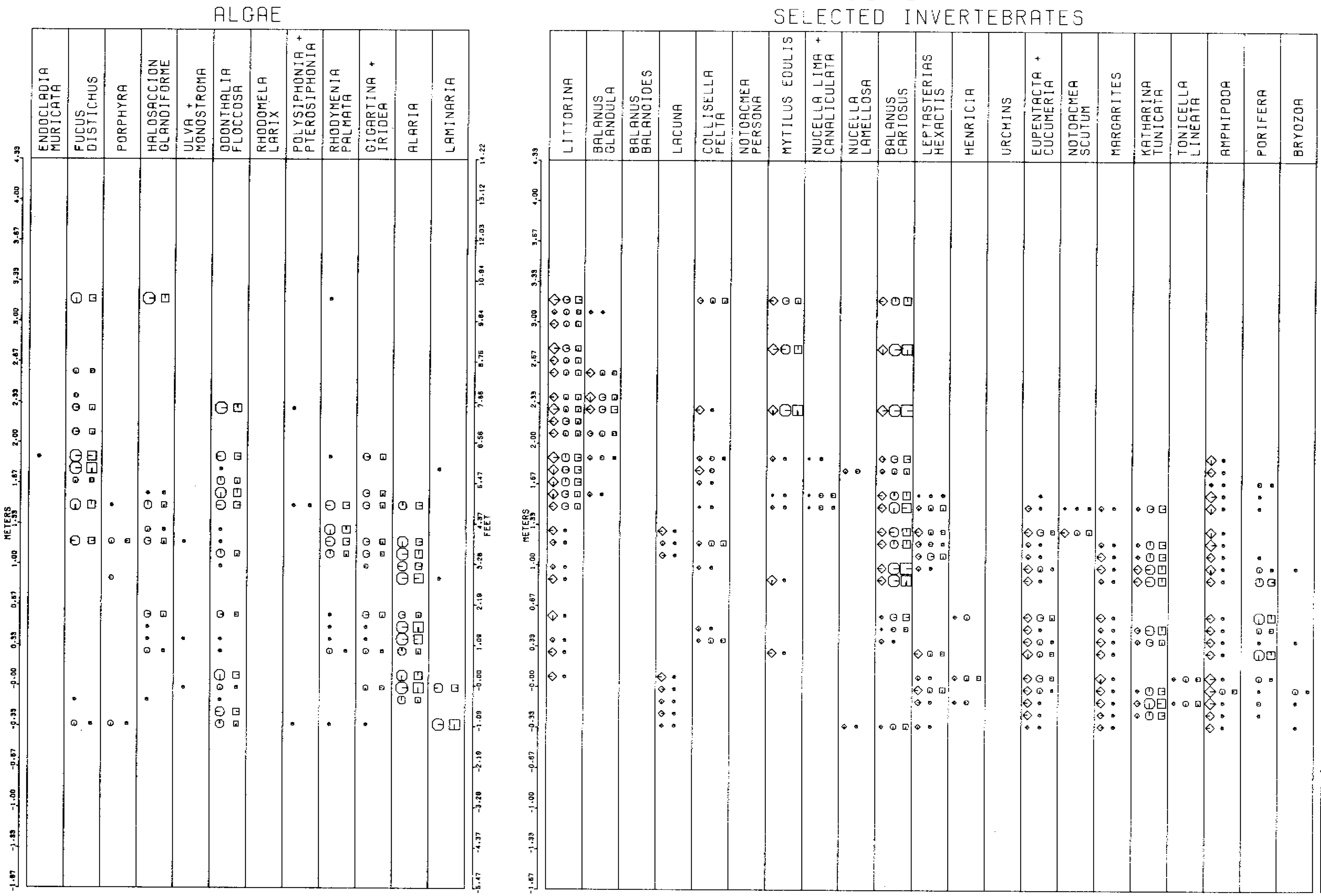
STATION: SUNDSTROM ISLAND
DATE: 75/ 5/28
LATITUDE: 56 41 50 N
LONGITUDE: 154 8 60 W
OBSRV. RANGE: -0.2M TO 4.2M

COUNT OF INDIVIDUALS KEY
- FRAGMENT
- 1
- 2-5
- 6-10
- 11-25
- 26-100
- 101-250
- >250

WET WEIGHT KEY UNITS=GRAMS
- 0.1-.50
- .51-1.0
- 1.1-5.0
- 5.1-20.0
- 20.1-50.0
- 50.1-100.0
- 100.1-250.0
- >250

DRY WEIGHT KEY UNITS=GRAMS
- 0.1-.50
- .51-1.0
- 1.1-5.0
- 5.1-20.0
- 20.1-50.0
- 50.1-100.0
- 100.1-250.0
- >250

DOMINANT INTERTIDAL ORGANISMS



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STATION: SUNDSTROM ISLAND
DATE: 75/ 8/ 9
LATITUDE: 56 41 50 N
LONGITUDE: 154 8 60 W
OBSRV. RANGE: -0.3M TO 3.2M

COUNT OF INDIVIDUALS KEY	
	FRAGMENT
	1
	2-5
	6-10
	11-25
	26-100
	101-250
	>250

WET WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

DRY WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

SPECIES OF THREE SAINTS BAY

CHLOROPHYTA
- Chlorophyta
- Monostroma sp.
- Monostroma fuscum
- Ulva sp.
- Lola lubrica
- Chaetomorpha sp.
- Cladophora sp.
- Cladophora seriacea
- Spongomorpha coalita
- Spongomorpha spinescens

BACILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Phaeophyta
- Ectocarpus simulans
- Pylaiella littoralis
- Laminariaceae
- Laminaria sp.
- Laminaria groenlandica
- Alaria sp.
- Alaria marginata
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Acrochaetium sp.
- Endocladia muricata
- Bossiella chiloensis
- Bossiella plumosa
- Corallina sp.
- Corallina vancouveriensis
- Lithothamnion sp.
- Callophyllis sp.
- Callophyllis flabellulata
- Iridaea sp.
- Iridaea cornucopiae
- Halosaccion glandiforme
- Rhodymenia sp.
- Rhodymenia palmata
- Callithamnion sp.
- Callithamnion pikeanum
- Ptilota sp.
- Neoptilota sp.
- Phycodrys riggii
- Pterosiphonia bipinnata
- Rhodomela larix

Odonthalia sp.
Odonthalia floccosa
Odonthalia kamschatica

PORIFERA
Porifera

CNIDARIA
Hydroidea
Eudendrium sp.
Abietinaria sp.
Anthozoa

TURBELLARIA
Turbellaria

RHYNCHOCOELA
Rhynchocoela
Emplectonema gracile

NEMATODA
Nematoda

ANNELIDA
Polychaeta
Phloe minuta
Paleanotus bellis
Eteone sp.
Eteone longa
Eulalia sp.
Eulalia quadrioculata
Syllidea
Autolytus sp.
Autolytus cornutus
Autolytus trilineatus
Autolytus convolutus
Syllis sp,
Typosyllis sp.
Typosyllis alternata
Typostllis armillaris
Typosyllis pulchra
Typosyllis stewarti
Typosyllis a adamantea
Eusyllis sp.
Exogone gemmifera
Exogone lourei
Sphaerosyllis pirifera
Nereis sp.
Nereis pelagica
Nereis vexillosa
Sphaerodoropsis minutum
Glycera capitata
Lumbrineris inflata
Naineris sp.
Naineris laevigata
Paraonidae

Prionospia malmgreni
Pygospio sp.
Cirratulus sp.
Cirratulus cirratus
Capitella capitata
Owenia fusiformis
Polycirrus medusa
Sabellidae
Chone gracilis
Amphiglena pacifica
Fabricia sabella
Fabricia pacifica
Fabricia crenicollis
Dexiospira spirillum
Oligochaeta
Enchytraeidae

POLYPLACOPHORA
Polyplacophora
Cynoplax dentiens
Tonicella lineata
Katharina tunicata
Mopalia mucosa
Schizoplax brantii

PELECYPODA
Mytilus edulis
Musculus vernicosus
Mysella planata
Turtonia occidentalis
Protothaca staminea
Hiatella arctica

GASTROPODA
Gastropoda
Collisella pelta
Collisella digitalis
Notoacmea scutum
Cryptobranchia alba
Margarites helicinus
Margarites pupillus
Littorina sitkana
Littorina scutulata
Lacuna marmorata
Lacuna vincta
Barleeia sp.
Cerithiopsis sp.
Velutina velutina
Nucella sp.
Nucella canaliculata
Nucella lamellosa
Nucella lima
Buccinum sp.

Buccinum baeri
Odostomia sp.
Acanthodoris sp.
Onchidella borealis
Siphonaria thersites

ARACHNIDA

Acarina
Halacaridae
Pseudoscorpionida

PYCNOGONIDA

Pycnogonidae

CRUSTACEA

Harpacticoida
Thoracica
Balanus sp.
Balanus balanoides
Balanus cariosus
Balanus glandula
Chthamalus dalli
Archaeomysis grebnitzkii
Cumella vulgaris
Tanidacea
Pentidotea wosensenskii
Sphaeromatidae
Gnorimosphaeroma oregonensis
Dynamenella sheari
Ianiropsis kincaidi kincaidi
Munna sp.
Munna stephenseni
Amphipoda
Paramoera columbiana
Haustorius eous
Allorchestes maleolus
Hyale rubra frequens
Ischyrocerus rhodomelae
Stenothoidae
Caprellidae
Caprella sp.
Pagurus sp.
Pagurus h hirsutiusculus
Pugettia gracilis

INSECTA

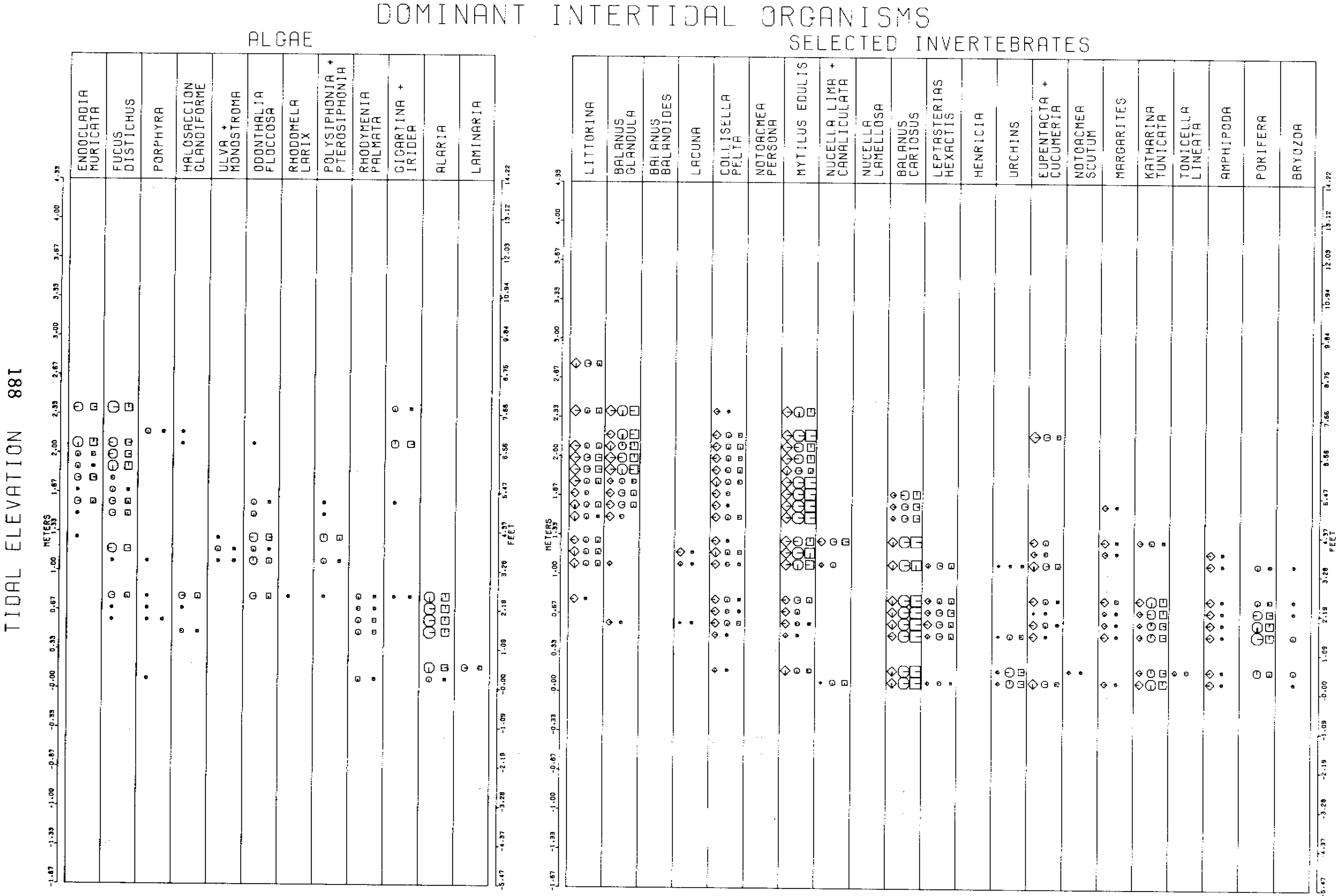
Insecta
Anurida maritima
Diptera
Chironomidae
Coleoptera
Sipunculida

BRYOZOA

Bryozoan

ASTEROIDEA
Asteroidea
Leptasterias sp.
Leptasterias hexactis
ECHINOIDEA
Strongylocentrotus droebachiensis
OPHIUROIDEA
Ophiuroidea
HOLOTHUROIDEA
Cucumaria pseudocurata
TELEOSTEI
Teleostei
Clinocottus embryum
Gymnocanthus pistilliger

DOMINANT INTERTIDAL ORGANISMS



STATION: THREE SAINTS BAY
DATE: 75/ 5/29
LATITUDE: 57 7 80 N
LONGITUDE: 152 28 70 W
OBSRV. RANGE: 0.1 M TO 2.8 M

COUNT OF INDIVIDUALS KEY
- FRAGMENT
- 1
- 2-5
- 6-10
- 11-25
- 26-100
- 101-250
- >250

WET WEIGHT KEY UNITS=GRAMS
- 0.1-.50
- .51-1.0
- 1.1-5.0
- 5.1-20.0
- 20.1-50.0
- 50.1-100.0
- 100.1-250.0
- >250

DRY WEIGHT KEY UNITS=GRAMS
- 0.1-.50
- .51-1.0
- 1.1-5.0
- 5.1-20.0
- 20.1-50.0
- 50.1-100.0
- 100.1-250.0
- >250

SPECIES OF DOLINA POINT

CHLOROPHYTA
- Monostroma sp.
- Spongomorpha spinescens

BACILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Desmarestia aculeata
- Laminaria dentigera
- Alaria sp.
- Alaria nana
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Cryptosiphonia woodii
- Dumontia incrassata
- Endocladia sp.
- Endocladia muricata
- Lithothamnion sp.
- Cryptonemia ovalifolia
- Gigartina sp.
- Iridaea sp.
- Iridaea heterocarpa
- Halosaccion glandiforme
- Rhodymenia palmata
- Ceramium sp.
- Ceramium pacificum
- Microcladia borealis
- Ptilota sp.
- Rhodomelaceae
- Rhodomela sp.
- Rhodomela larix
- Odonthalia sp.
- Odonthalia floccosa
- Odonthalia lyallii
- Odonthalia washingtoniensis

ANTHOPHYTA
- Phyllospadix sp.
- Phyllospadix scouleri

PORIFERA
- Demospongia

CNIDARIA
- Hydroidea
- Anthozoa

TURBELLARIA
- Turbellaria

RHYNCHOCOELA

Rhynchocoela

ANNELIDA

Annelida

Polychaeta

POLYPLACOPHORA

Katharina tunicata

PELECYPODA

Mytilus edulis

Musculus discors

Modiolus modiolus

Turtonia minuta

Protothaca staminea

Hiatella arctica

GASTROPODA

Acmaeidae

Collisella pelta

Notoacmea scutum

Notoacmea persona

Margarites helicinus

Littorina sitkana

Lacuna sp.

Lacuna carinata

Lacuna marmorata

Trichotropis cancellata

Ocenebra interfossa

Nucella sp.

Nucella canaliculata

Nucella lima

Buccinum baeri

PYCNOGONIDA

Achelia chelata

CRUSTACEA

Balanidae

Balanus balanoides

Balanus cariosus

Chthamalus dalli

Pentidotea wosensenskii

Exosphaeroma sp.

Amphipoda

Caprellidae

Pagurus h hirsutiusculus

Telmessus cheiragonus

ASTEROIDEA

Leptasterias hexactis

HOLOTHUROIDEA

Cucumaria pseudocurata

UROCHORDATA

Urochordata

SPECIES OF LOW CAPE

PHAEOPHYTA
- Phaeophyta
- Laminaria sp.
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Porphyra sp.
- Cryptosiphonia woodii
- Endocladia muricata
- Lithothamnion sp.
- Cryptonemia ovalifolia
- Ahnfeltia plicata
- Iridaea punicea
- Ptilota sp.
- Polysiphonia sp.
- Pterosiphonia gracilis
- Rhodomela larix
- Odonthalia floccosa

PORIFERA
- Demospongia

CNIDARIA
- Anthozoa
- Anthopleura sp.
- Tealia sp.

TURBELLARIA
- Turbellaria

RHYNCHOCOELA
- Rhynchocoela

NEMATODA
- Nematoda

ANNELIDA
- Annelida
- Polychaeta

POLYPLACOPHORA
- Schizoplax brandtii

PELECYPODA
- Mytilus edulis
- Musculus discors
- Turtonia minuta
- Protothaca staminea
- Hiatella arctica

GASTROPODA
- Gastropoda
- Collisella pelta
- Collisella digitalis
- Notoacmea scutum
- Notoacmea fenestrata

Margarites helicinus
Littorina sitkana
Lacuna marmorata
Cerithiopsis sp.
Ocenebra interfossa
Nucella sp.
Nucella lima
Buccinum baeri
Searlesia dira
Amphissa columbiana

PYCNOGONIDA

Phoxichilidium femoratum
Ammothea pribilofensis

CRUSTACEA

Harpacticoida
Balanus sp.
Balanus balanoides
Balanus cariosus
Balanus glandula
Chthamalus dalli
Pentidotea resecta
Pentidotea wosensenskii
Exosphaeroma sp.
Amphipoda
Caprellidae
Decapoda
Pagurus sp.
Pagurus h hirsutiusculus
Telmessus cheiragonus

INSECTA

Insecta
Diptera

ASTEROIDEA

Henricia sp.
Leptasterias hexactis

HOLOTHUROIDEA

Cucumaria pseudocurata

SPECIES OF CAPE KAGUYAK

CHLOROPHYTA
- Chlorophyta
- Monostroma sp.
- Enteromorpha compressa
- Spongomorpha spinescens

BACILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Phaeophyta
- Analipus japonicus
- Scytosiphon lomentaria
- Laminaria dentigera
- Alaria sp.
- Alaria nana
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Bangia fuscopurpurea
- Porphyra sp.
- Gloiopeltis furcata
- Cryptonemia ovalifolia
- Gigartina stellata
- Iridaea cornucopiae
- Iridaea heterocarpa
- Halosaccion glandiforme
- Rhodymenia palmata
- Rhodymenia pal f sar
- Ceramiaceae
- Ptilota sp.
- Ptilota tenuis
- Tokidadendron bullata
- Odonthalia sp.

PORIFERA
- Demospongia

CNIDARIA
- Hydroidea

TURBELLARIA
- Turbellaria

RHYNCHOCOELA
- Rhynchocoela

NEMATODA
- Nematoda

ANNELIDA
- Polychaeta
- Spirorbis sp.

POLYPLACOPHORA
- Katharina tunicata

Schizoplax brandtii
PELECYPODA
Mytilus edulis
Musculus discors
Modiolus modiolus
Turtonia minuta
Hiatella arctica
GASTROPODA
Gastropoda
Acmaeidae
Acmaea mitra
Collisella pelta
Collisella digitalis
Notoacmea scutum
Margarites sp.
Margarites helicinus
Margarites pupillus
Littorina sitkana
Lacuna sp.
Lacuna marmorata
Velutina veluttna
Fusitriton oregonensis
Nucella lamellosa
Buccinum baeri
Searlesia dira
Siphonaria thersites
ARACHNIDA
Halacaridae
PYCNOGONIDA
Phoxichilidium femoratum
Ammothea pribilofensis
CRUSTACEA
Thoracica
Balanus balanoides
Balanus cariosus
Balanus glandula
Chthamalus dalli
Pentidotea wosensenskii
Gnorimosphaeroma oregonensis
Exosphaeroma sp.
Amphipoda
Caprellidae
Pagurus hemphilli
Pagurus h hirsutiusculus
INSECTA
Diptera
BRYOZOA
Bryozoan
ASTEROIDEA
Evasterias trochelii

Leptasterias hexactis
OPHIUROIDEA
Ophiopholis aculeata
HOLOTHUROIDEA
Cucumaria pseudocurata

SPECIES OF CAPE SITKINAK

CHLOROPHYTA
- Monostroma sp.

BACILLARIOPHYCEAE
- Bacillariophyceae

PHAEOPHYTA
- Ralfsia sp.
- Laminaria sp.
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Cryptosiphonia sp.
- Cryptonemia ovalifolia
- Ahnfeltia sp.
- Ahnfeltia plicata
- Gigartina papillata
- Gigartina stellata
- Iridaea cornucopiae
- Iridaea heterocarpa
- Halosaccion glandiforme
- Rhodymenia palmata
- Ptilota sp.
- Ptilota tenuis
- Rhodomela sp.
- Rhodomela larix
- Odonthalia floccosa
- Odonthalia lyallii
- Odonthalia washingtoniensis

ANTHOPHYTA
- Phyllospadix sp.

CNIDARIA
- Hydroidea
- Anthozoa

TURBELLARIA
- Turbellaria

RHYNCHOCOELA
- Rhynchocoela

ANNELIDA
- Polychaeta

PELECYPODA
- Turtonia minuta

GASTROPODA
- Collisella pelta
- Notoacmea scutum
- Notoacmea persona
- Margarites helicinus
- Littorina sitkana
- Lacuna sp.

Lacuna marmorata
Nucella lima
Buccinum sp.
Buccinum baeri
Odostomia sp.

PYCNOGONIDA

Pycnogonida
Phoxichilidium femoratum
Ammothea gracilipes
Ammothea pribilofensis

CRUSTACEA

Balanus sp.
Balanus cariosus
Chthamalus dalli
Pentidotea wosensenskii
Sphaeromatidae
Exosphaeroma sp.
Munna sp.
Anthuridae
Amphipoda
Caprellidae
Pagurus sp.
Pagurus h hirsutiusculus

ASTEROIDEA

Leptasterias hexactis

HOLOTHUROIDEA

Cucumaria pseudocurata

UROCHORDATA

Urochordata

SPECIES OF LAGOON POINT

CHLOROPHYTA
- Chlorophyta
- Ulothrix flacca
- Monostroma sp.
- Ulva sp.
- Rhizoclonium sp.
- Spongomorpha sp.
- Spongomorpha arcta
- Spongomorpha spinescens

PHAEOPHYTA
- Phaeophyta
- Scytosiphon lomentaria
- Laminaria sp.
- Laminaria dentigera
- Alaria sp.
- Alaria crispa
- Alaria marginata
- Alaria nana
- Alaria taeniata
- Alaria tenuifolia
- Fucus distichus

RHODOPHYTA
- Rhodophyta
- Bangia fuscopurpurea
- Porphyra sp.
- Cryptosiphonia woodii
- Endocladia muricata
- Petrocelis sp.
- Lithothamnion sp.
- Gigartina stellata
- Iridaea sp.
- Iridaea cornucopiae
- Halosaccion glandiforme
- Rhodymenia sp.
- Rhodymenia palmata
- Rhodymenia pal f sar
- Ceramiaceae
- Antithamnion sp.
- Pleonosporium sp.
- Ptilota sp.
- Rhodomelaceae
- Odonthalia floccosa
- Odonthalia washingtoniensis

PORIFERA
- Porifera
- Demospongia

CNIDARIA

Hydroidea
Anthozoa
Anthopleura sp.
Tealia crassicornis

TURBELLARIA
Turbellaria

RHYNCHOCOELA
Rhynchocoela

NEMERTEA
Nematoda

ANNELIDA
Annelida
Polychafta
Fabricia sabella
Spirorbis sp.
Spirorbis spirillum
Oligochaeta

POLYPLACOPHORA
Polyplacophora
Tonicella lineata
Katharina tunicata
Mopalia ciliata

PELECYPODA
Mytilus edulis
Pododesmus macroschisma
Mysella compressa
Transennella sp.
Protothaca staminea
Hiatella arctica

GASTROPODA
Gastropoda
Acmaea mitra
Collisella sp.
Collisella pelta
Collisella digitalis
Collisella instabilis
Notoacmea scutum
Notoacmea persona
Margarites helicinus
Margarites pupillus
Littorina sp.
Littorina sitkana
Littorina saxatilis
Lacuna sp.
Lacuna carinata
Alvinia compacta
Bittium munitum
Melanella columbiana
Trichotropis insignis
Fusitriton oregonensis

Trophonopsis pacificus
Nucella canaliculata
Nucella lamellosa
Nucella lima
Buccinum baeri
Searlesia dira
Amphissa columbiana
Odostomia elsa
Odostomia elsa
Hermissenda sp.
Onchidella borealis
Siphonaria thersites

ARACHNIDA
- Halacaridae
- Pseudoscorpionida

CRUSTACEA
- Crustacea
- Harpacticoida
- Balanidae
- Balanus balanoides
- Balanus cariosus
- Balanus glandula
- Chthamalus dalli
- Cumacea
- Isopoda
- Pentidotea wosensenskii
- Sphaeromatidae
- Exosphaeroma sp.
- Ianiropsis kincaidi kincaidi
- Munna sp.
- Amphipoda
- Gammaridae
- Caprellidae
- Pagurus sp.
- Pagurus h hirsutiusculus
- Pugettia gracilis

INSECTA
- Insecta
- Collembola
- Diptera
- Tipulidae
- Chironomidae
- Dolichopodidae
- Staphinidae
- Amblopusa·borealis

BRYOZOA
- Bryozoan

ASTEROIDEA
- Leptasterias hexactis

ECHINOIDEA

Strongylocentrotus droebachiensis
OPHIUROIDEA
Ophiopholis aculeata
HOLOTHUROIDEA
Cucumaria sp.
Cucumaria pseudocurata
UROCHORDATA
Urochordata
TELEOSTEI
Cottidae

SPECIES OF SOUTH SITKALIDAK LAGOON

RHYNCHOCOELA
- Heteronemertea
- Rineidae

ANNELIDA
- Polychaeta
- Eteone longa
- Nephtys caeca
- Fabricia sabella
- Oligochaeta

PELECYPODA
- Mytilus edulis
- Turtonia occidentalis
- Macoma calcarea
- Macoma balthica

CRUSTACEA
- Amphipoda

SPECIES OF WHIRLPOOL POINT

RHYNCHOCOELA
- Rineidae
- Amphiporidae

ANNELIDA
- Polychaeta
- Oligochaeta

PELECYPODA
- Turtonia occidentalis

CRUSTACEA
- Amphipoda
- Gammaridae
- Haustoriidae

ABUNDANCE AND SPECIES COMPOSITION OF SUBTIDAL LAMINARIACEAE (BROWN ALGAE) AT NINE SITES AT SOUTHERN KODIAK ISLAND, ALASKA, WITH SOME OBSERVATIONS OF OTHER BROWN ALGAL SPECIES

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CONTENTS

ABSTRACT

Fifty-five samples of benthic brown algae were collected from 1/4 m^2 quadrats using SCUBA at nine subtidal sites on southern Kodiak Island, Alaska in May, 1976. The floating kelps *Alaria fistulosa* and *Nereocystis luetkeana* were excluded from the quadrats. The relative abundance of the species varied, but the most abundant species in the quadrats were *Laminaria dentigera*, *L. yezoensis*, *Pleurophycus gardneri*, *Agarum cribrosum*, and *Alaria* spp. We found fertile plants of all these species. *L. dentigera* dominated at all sampled sites except one, (within a bed of *Nereocystis luetkeana*) where *Pleurophycus gardneri* was the dominant benthic plant. *L. yezoensis* was dominant at one site which was visited but not sampled. The average weight of benthic brown algae for all samples taken was 12 Kg/m^2 and the quadrat range was 2 Kg/m^2 to 35 Kg/m^2.

The reported geographical range of *Lessoniopsis littoralis* is extended slightly westward from Cape Chiniak (152°9'W) to Twoheaded Island (153°35'W). The range of *Pleurophycus gardneri* is extended westward from Montague Island (147°22'W) to Bumble Bay, Kodiak Island (154°43'W). The geographical range of *Alaria marginata* is also extended from Montague Island to Bumble Bay, where it was found at a depth of 8.5 meters. It has previously been reported only in the intertidal zone.

ABUNDANCE AND SPECIES COMPOSITION OF SUBTIDAL LAMINARIACEAE (BROWN ALGAE) AT NINE SITES AT SOUTHERN KODIAK ISLAND, ALASKA, WITH SOME OBSERVATIONS OF OTHER BROWN ALGAL SPECIES

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INTRODUCTION

The subtidal brown algae are an important source of primary productivity in northern waters (Mann 1972a p. 8). These plants enter the food chain by direct grazing, as detritus (Mann, 1972 b p. 377), and as dissolved organic material (Khailov and Burlakov 1969). They also are important as substrate and cover for many animals and plants, and in many countries are an important source of various food and industrial products for man (Michanek 1975).

As participants in research related to preparing Environmental Impact Statements for oil development in the Gulf of Alaska, we were able to make one-day stops with five divers at nine sites in the vicinity of southern Kodiak Island from 12-20 May 1976. Limitations on the study were lack of familiarity with the local area, limited diving time, and strong underwater currents and surge. The floating kelps were excluded because sampling them adequately would have required an effort beyond what we could accomplish in the time available, and because general estimates of their abundance can be made without diving.

Transportation to the general sites and logistic support was by the NOAA ship Surveyor. A motor whaleboat was used to reach diving sites and as surface support for divers.

The objectives of this study were to (1) determine the species composition and general abundance of the major subtidal species of Laminariaceae in the southern Kodiak Island area, and (2) determine size composition and reproductive state of the major species.

DESCRIPTION OF SAMPLING SITES

We sampled six exposed sites on the outer coast, two semi-exposed sites in Sitkalidak Strait, and one site in a protected estuary (Ugak Bay) (Table 1). Floating kelps (*Alaria fistulosa*) Postles and Ruprecht, 1840) were present at all outer coast sites. Usually we sampled inshore of any beds of floating kelp. The exception was at Cape Barnabas, where we sampled beneath a heavy surface overstory of *Nerocystis*.

SAMPLING METHOD

Our sampling scheme was to select an area with a "typical" cover of benthic algae and determine abundance by collecting six 1/4 m^2 quadrats adjacent to a transect line. The general site to be sampled was selected in advance by examining navigation charts. After reaching the chosen area by motor launch, we anchored and made a reconnaissance dive to confirm the presence of brown algae. They were always present. A 30-m transect line was laid perpendicular to the shoreline usually starting from the boat's anchor because of strong surge or current and the need to keep divers oriented to the boat. The precise sampling area was chosen randomly.

Divers placed the quadrat frames on rock within 2 m of the transect line, in algal cover "typical" of the area. Two 1/4 m^2 samples were taken at 0, 15, and 30 m on the line, except at Twoheaded Island, where three samples were taken at 0 and 30 m, and none at 15 m, and at Ugak Bay, where an additional sample was taken about 15 m shoreward of the transect line. When heavy surge made collection of specimens of brown algae smaller than about 10 cm extremely difficult, many were not collected, but their size and numbers were estimated by the diver and recorded on a slate attached to the collecting bag. At each depth all collectable plants and animals were taken from one quadrat, and only the brown algae were taken from the other. One diver swam the entire transect line and took notes on depth distribution, relative algal cover and species of plants and animals present.

PROCESSING SAMPLES

Back on the ship, we weighed, measured, and noted the reproductive state of each plant. Sometimes the motion of the ship affected the precision of weight determinations for individual plants but we assume that errors cancelled out in total. The samples from one site, Lagoon Point, were preserved in formalin and returned to the laboratory where precise weights were taken, including weight of stipe, and new growth and old growth of blade. From the Lagoon Point data we plotted a weight-length graph which we used to check any weights we considered questionable, and to estimate weights of plants of known length but too small to weigh accurately on the rolling ship, and of plants that were not collected due to wave action.

SPECIES FOUND IN QUADRAT SAMPLES

In the quadrats sampled at the nine sites we found six species of the Laminareaceae: Laminaria dentigera Kjellman, 1889, L. yezoensis Miyabe, 1902, L. longipes Bory, 1826, Laminaria sp. (Probably L. groenlandica Rosenvinge, 1893), Pleurophycus gardneri Setchell and Saunders, 1901, and Agarum cribrosum Bory, 1826. We also found some species of the genus Alaria, of the Alariaceae (Table 2).

RELATIVE ABUNDANCE OF EACH SPECIES BY NUMBER AND WEIGHT

The weight and number of each species in the quadrats varied widely among the sites. At the exposed outer coast sites, Laminaria dentigera was usually the dominant form, both in weight and in numbers. By weight, L. dentigera made up from 57.3-91.2% of the outer coast samples and by number from 26.4-90.3% (Table 2). The exception to this was Cape Barnabas, where we sampled under the heavy overstory of a bed of Nereocystis,--here, Pleurophycus was the dominant benthic form, making up 94.1% of the weight and 51.1% of the individual plants.

At the protected estuarine site, Ugak Bay, Agarum made up 37.1% of the weight of the collections, and more than 49.4% of the number. The Laminaria sp. at Ugak Bay is probably L. groenlandica (Rosenvinge, 1893).

A list of the species of Laminariaceae and Alaria sp. found and the percent of the total weight and number of each species in each collection is given in Table 2.

STANDING CROP OF ALL KELP SAMPLED

The average weights per square meter of all species of kelp combined at each site were remarkably uniform between the sites, although the range of values for the individual quadrats was great (Table 3).

The average weight of the Laminareaceae at the six outer coast sites was 12.3 Kg/m^2 (range for quadrats was 2.4 to 35.0 Kg/m^2); for the two semi-protected sites in Sitkalidak Strait the average was 15.4 Kg/m^2 (range for quadrats was 6.8 to 28.8 Kg/m^2); for the one protected estuarine site, where some of the substrate was poor, the average biomass was only 4.8 Kg/m^2 (range for quadrats of 2.0 to 11.2 Kg/m^2). The quadrat with the heaviest growth had 35.0 Kg/m^2, in a monospecific stand of *Laminaria dentigera* at Bear Rocks, Bumble Bay.

WEIGHT CLASSES OF *LAMINARIA DENTIGERA*

The rate of growth (and therefore the age-size relation) of *Laminaria* is strongly related to the light available. For example, under poor light conditions plants can suspend growth for 6 months or more and then resume growth when light becomes adequate (Burrows, 1961 p. 189). With a gradient of light from shallow to deep the shallower plants grow faster and become larger than the deeper plants (Kain, 1976, p. 267, and our own work in southeast Alaska, Calvin and Ellis, manuscript in prep.) In all populations of *L. hyperborea*, (which can be aged from stipe sections,) size for a given age is extremely variable (Kain, 1967, p. 492).

Size cannot be used to determine age in these plants, but size frequency information is useful in comparing populations and can give an indication of growth stages. We constructed a weight frequency histogram of L. dentigera from Lagoon Point, by 10 gm intervals and identified 5 major size categories, 0-49, 50-149, 150-349, 350-500, and above 500 g (Fig. 1). Using these five weight categories we summarized the data for L. dentigera for each of the nine sites. The smallest size was the most frequent at all sites and the largest size the least frequent at most sites (Fig. 2). The greatest weight was accounted for by a few large plants, however.

FERTILITY OF PLANTS

The time we sampled was apparently near the beginning of the spore producing period of the brown algae in the area. Some large plants had only traces of sori (raised rough patches on the blade surface), while a few large Laminaria dentigera had last year's sori (evidence of maturity) on remnants of old growth but none on the new growth.

Laminaria dentigera usually weighed 250 g before it produced sori. In sheltered areas, there was a tendency for smaller plants to be fertile (Table 4).

Laminaria yezoensis, though it grew as large as L. dentigera, tended to have a higher percent fertility than L. dentigera, and to be fertile at a smaller size. This tendency was especially pronounced at Sitkinak Island and Twoheaded Island (Table 4). It may simply mean that L. yezoensis begins soral development earlier in the year. We can find no published accounts of time of soral development or size of plants with sori for either L. dentigera or L. yezoensis. Druehl (1968) in writing the most recent taxonomic summary of the Northeast Pacific species of the genus Laminaria, had no access to fertile plants of either of these species.

Many Pleurophycus were fertile. Since it is an annual, it grows to full maturity in one summer.

We found sori on Agarum only in protected waters.

ADDITIONAL OBSERVATIONS

We have observations on two additional species, Laminaria saccharina (Linneaeus) Lamouroux, 1813, and Nereocystis luetkeana (Mertens) Postels and Ruprecht, 1840, and two additional sites, Ugak Island and Ugak Bay.

Nereocystis luetkeana

Beds of the large bull kelp, Nereocystis, are extremely common on the rocky outer coast areas of southern Kodiak. This species is of interest to commercial harvesters, and Scagel (1961, p. 12) states that individual plants may weigh 25 pounds (11.3 Kg) or more. Though we excluded Nereocystis from our quadrat samples, to obtain some estimate of their size we collected two large fertile specimens from the large bed at the Cape Barnabas site and measured them aboard ship. The measurements were:

	Stipe and Bulb		Blades		Total	
Plant	Length	Weight	Length	Weight	Length	Weight
1	19.6 m	10.4 Kg	6.0 m	29.0 Kg	25.5 m	39.5 Kg
2	18.5 m	10.0 Kg	6.0 m	30.4 Kg	24.5 m	40.4 Kg

These plants far exceed the 11.3 Kg estimate of Scagel, and their blades, at 6 m, exceed Dawson's estimate of 3 to 4 m for blade length (Dawson, 1966, p. 163). In both plants, the blades weigh approximately three times as much the stipe and bulb combined.

From our observations in vicinity of southern Kodiak Island, a reasonable estimate of the density of these plants is one in 8 sq m, therefore their weight per square meter is about 5 Kg. This is in addition to the weight of the benthic algae (mostly Pleurophycus), which averaged 8.5 Kg/m^2 at this site.

Laminaria saccharina

Several specimens of another species, *Laminaria saccharina* (Linnaeous) Lamouroux, 1813 were collected on a sand bottom in 10 feet of water in Tanginak Anchorage. *L. saccharina* was abundant in the general area. In our experience, this species is typically found on sand or silt in protected areas, attached to shell or small stones. The species is described by Druehl as "up to 2 meters long" (Druehl, 1968 p. 544).

Length, weight and presence of sori for four specimens of *L. saccharina* from Tanginak Anchorage are as follows:

Plant	Length-cm	Weight-g	Sori present
1	175	292	No
2	263	498	Yes
3	305	408	Yes
4	306	534	Yes

Ugak Island

We dived shoreward of a Nereocystis bed off Ugak Island to obtain a general visual impression of the area and to compare it with other outer coast sites, particularly Cape Barnabas. We wanted to see if Pleurophycus was the dominant benthic brown alga north of Cape Barnabas, and we concluded that it is not. The cover of Pleurophycus at Ugak Island was high at 6 meters, but by 9 meters Laminaria yezoensis was dominant. This was the only site where Laminaria yezoensis was dominant and here the exceptionally large plants make a heavy forest canopy. The standing crop in this forest appeared to be among the highest we had seen, and the plants extended to at least 18 meters depth.

Ugak Bay

We also dived in Ugak Bay opposite Saltery Bay about half way between the mouth of the bay and our collection site. Laminaria yezoensis was present here though it was absent at our sampling site at the head of the bay.

GENERAL COMMENTS ON THE SPECIES FOUND

Four species constituted over 95% of the benthic kelp in our quadrat samples: Laminaria dentigera Kjellman, 1889, Laminaria yezoensis Miyabe, 1902, Pleurophycus gardneri Setchell and Saunders, 1901, and Agarum cribrosum Bory, 1826. Other Laminariales encountered during our study were Laminaria longipes Bory, 1826, Alaria fistulosa Postels and Ruprecht, 1840, Alaria marginata Postels and Ruprecht 1840, Alaria sp., Nereocyctis luetkeana (Mertens) Postels and Ruprecht, 1840, and Lessoniopsis littoralis (Farlow and Setchell) Reinke, 1903. We did not see Macrocystis integrifolia Bory, 1826 anywhere, not even in the drift along the shore, although it has been reported on Kodiak Island at Cape Chiniak, which is north and east of our sampling sites, by Druehl (1970, p. 241).

The reported range of Laminaria dentigera Kjellman, 1889 in the Pacific is from Yakutat to Attu. It is perennial from the stipe and lives several years. The plants we are calling L. dentigera are distinctly digitate, but differ in several ways from the description of Druehl (1968 p. 546). They may resemble more closely L. platymeris, De la Pylaie (as described by Setchell and Gardner, 1925), which is no longer recognized, having been referred by Druehl (1968 p. 543) to L. groenlandica Rosenvinge, 1893. We examined many specimens including large, mature individuals. At our outer coast sites L. dentigera occurred at depths from approximately 0 to 18 meters.

Laminaria yezoensis Miyabe, 1902, is reported from Shemya and Attu (Palmisano and Estes, manuscript in prep. to Hope Island, B.C. (Druehl, 1970). It is perennial from the stipe. At our sites it often occurred in heavy forests with *L. dentigera*, and the two species were distinguishable only because *L. yezoensis* has an unusual discoid holdfast.

At our sampling sites *L. dentigera* was more plentiful than *L yezoensis*, but at Ugak Island from 9 meters down to about 15 meters *L. yezoensis* was the dominant plant.

Laminaria longipes Bory, 1826, is reported in the Pacific from Attu to Coronation Island, Alaska, but has an isolated population near San Juan Island, Washington (Druehl, 1969). Its subtidal distribution is poorly known (Markham, 1972 p. 151). It is perennial and multiplies predominately vegetatively from a rhizomatous holdfast, and to a lesser extent by spores. *L. longipes* has been reported to produce sori in December (Druehl), and we observed many plants with sori in May. Although our quadrat sampling often did not include its depth range, we noted its presence from 0 to 2 or 3 meters at most of our outer coast sites. Markham (1972, p. 151) stated that *L. longipes* occurs in more protected sites. At Kodiak we found it on exposed outer coast sites, immediately subtidal near the shore, and often at 2 or 3 meters on the wave-swept horizontal tops of large boulders offshore.

Pleurophycus gardneri Setchell and Saunders, 1901 is an annual plant. Its recorded range is Coos Bay, Oregon to Montague Island (147°22'W). Our collections extend this range into Druehl's "non-transitional" zone 10 (Druehl 1970). *Pleurophycus* was the dominant species at the site west of Cape Barnabas (57°8.5'N, 152°52.5'W) under a *Nereocystis* overstory. We found a few specimens at several other sites.

Agarum cribrosum Bory, 1826 extends from Amchitka Island, Alaska (Lebednik and Palmisano, in press) to San Juan Island, Washington (Druehl, 1969). This species was abundant only in protected areas. *Agarum* usually occurred in a band within the *Laminaria* zone, but sometimes extended below it. Those quadrats with much *Agarum* had the lowest total biomass.

Alaria marginata Postels and Ruprecht, 1840 has previously been reported in the intertidal zone from the vicinity of Point Conception, California to Montague Island, Alaska (Widdowson 1971, p. 36). Our collections extend this range westward to Bumble Bay on Kodiak Island (154°43'W), where we collected a fertile specimen in a quadrat sample at 8.5 meters. It has not been reported from the subtidal zone before this.

We found *Lessoniopsis littoralis* (Farlow and Setchell) Reinke, 1903 at Ugak Island, southwest of Cape Barnabas, and at Twoheaded Island (153°35'W). This extends its recorded range slightly west, since Druehl reports it to 152°9'W, Cape Chiniak. We found *L. littoralis* on tops of wave swept boulders at about 2 m, often with *Laminaria longipes*.

Nereocystis luetkeana occurred in large beds along most of the outer coast, and was present at all our outer coast sites. Usually we sampled shoreward of the heaviest *Nereocystis* growth and we placed quadrats to exclude *Nereocystis* plants. We discuss *Nereocystis* at Kodiak Island further under "Additional Observations".

Standing Crop as a Measure of Productivity

The production of the Laminareaceae enters the food chain in three ways: (1) as food by direct grazing of plants by herbivores, which accounts for less than 10% of the plant weight (Mann, 1972b P. 377), (2) as dissolved organic matter as the plant is growing (Khailov and B urlakova, 1969, p. 526), and (3) as detritus formed by erosion at blade tips during normal growth and by decay of entire plants broken loose by storms, which accounts for the balance of the plant weight. Khailov and Burlakova estimated that 37% of the total organic matter synthesized by brown algae is lost directly into the surrounding water as dissolved compounds. Mann determined by periodic measurements that the laminarias in Nova Scotia renew the tissue in their blades between one and five times a year (Mann, 1973 p. 975). We have confirmed this growth regime for L. groenlandica in southeast Alaska and we also discovered that the loss of entire plants is high--in one year we lost over 50% of our marked plants to herbivores and storms (Calvin and Ellis, manuscript in prep.). Because of the laminarias' growth regime, grazing and large loss of dissolved organics, the standing crop of the laminarias is far below their total annual production.

Significance of Subtidal Brown Algae in Southern Kodiak

A large part of the Alaska production of shrimp and king crab comes from the bays and nearshore areas of southern Kodiak Island. Much of the primary productivity to support these populations must be provided by benthic brown algae.

Our data show that the standing crop of brown algae is exceptionally high, and there is a vast area suitable for growth of the algae. On the outer coast of Kodiak the algal zone ranges from the intertidal zone to about 20 meters, or the 10 fathom line, which varies in distance offshore from about 1/4 mile to 6 miles offshore. In addition, some species occur in protected waters, both on rock and sand bottom.

A first attempt at estimating the contribution by benthic kelps can be made by assuming (1) that the biomass produced annually is 50% more than the standing crop (a conservative estimate considering constant erosion at blade ends, grazing, and storm loss of whole plants) (2) that dissolved organic material is released during growth equal to 30% of the annual weight produced (a conservative estimate considering Khailov and Burlakova estimate of up to 37%). The annual production then would be 1.95 times the standing crop. Standing crop + 0.5 standing crop + 0.3 (1.5 standing crop) 1.5 + 0.45 = 1.95 times the standing crop.

Many countries of the world harvest various types of marine algae for industrial purposes, fertilizer, livestock food, and direct use as food by humans (Michanek, 1975). For Japan, Hasegawa and Sanbonsuga (1971, p. 53) state, "The laminariaceous plant is one of the main products of Japan, and the overall yield of *Laminaria* amounts to about 30,000 tons in dried weight a year. Almost all the *Laminaria* yield is used for food." With increasing world population, the Food and Agricultural Organization of the United Nations is assessing worldwide present and future use and availability of ocean food products, both fish and seaweeds.

Obviously the highly productive benthic brown algae of Kodiak Island are important to man--presently as a productivity source to maintain populations of shrimp, king crab and fish--and perhaps in the future as food for humankind.

They should be protected.

ACKNOWLEDGMENTS

Our thanks to: Steve Zimmerman for his support aboard ship as the Senior Scientist and ashore as Project Supervisor. Lou Barr for his suggestions and observations, and invaluable help in diving operations; Joyce Gnagy for specimens of *Laminaria saccharina* and her freely donated help in processing samples on board ship; to the assisting divers, who worked very hard under sometimes difficult conditions, Robert Budke of the Auke Bay Fisheries Laboratory, and Hans Ramm, Bill Harrigan and Steve Thorne of the NOAA ship *Surveyor*; to our coxwain, Bill Vance; and to all the officers and crew of the ship *Surveyor*, who helped us in every way they could.

Figure 1.--Summary of weight categories of <u>Laminaria dentigera</u> at Lagoon Point from six 1/4 m^2 quadrant samples, in 10 gram increments. 18 May, 1976 Depth range -2 to -6 meters.

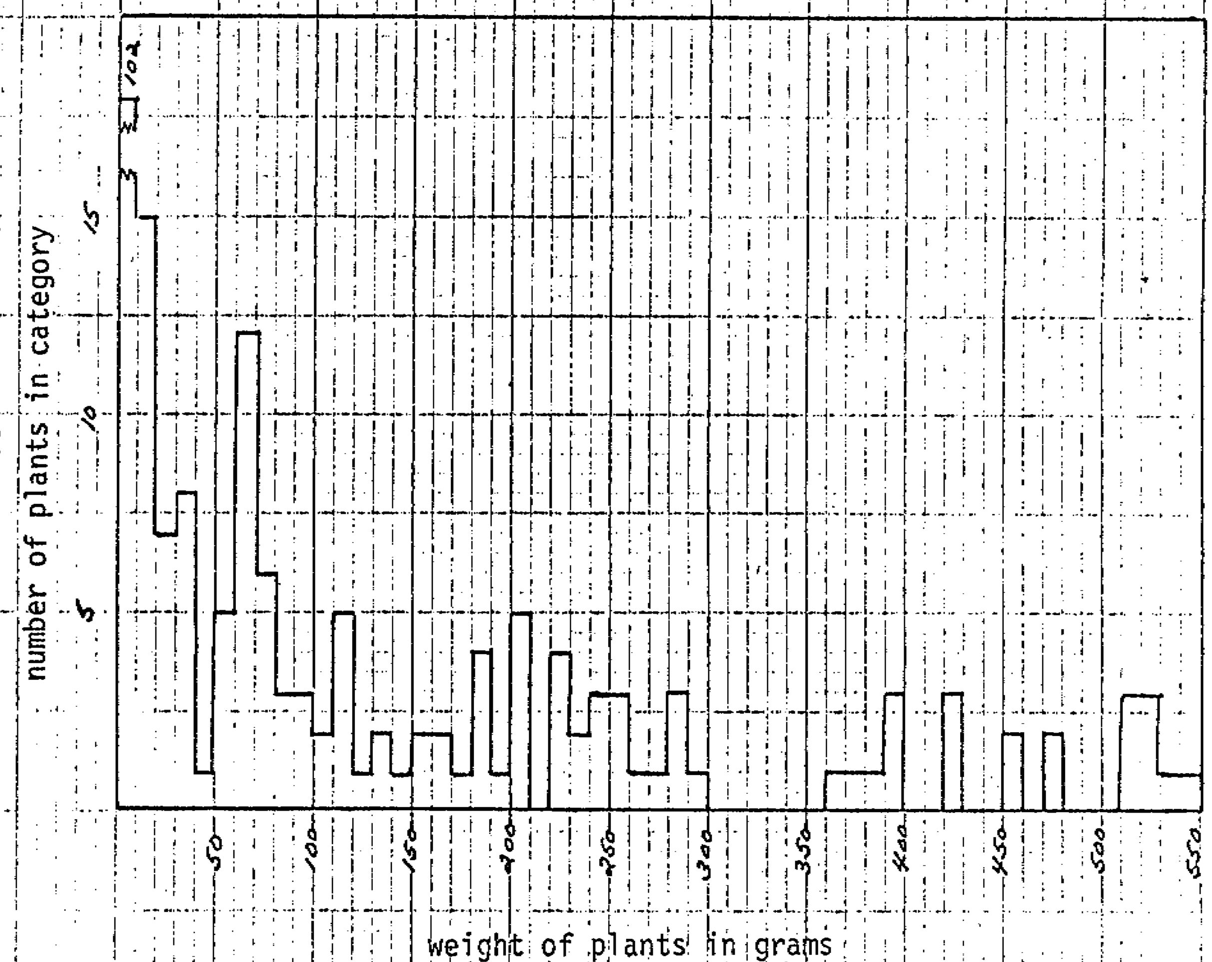
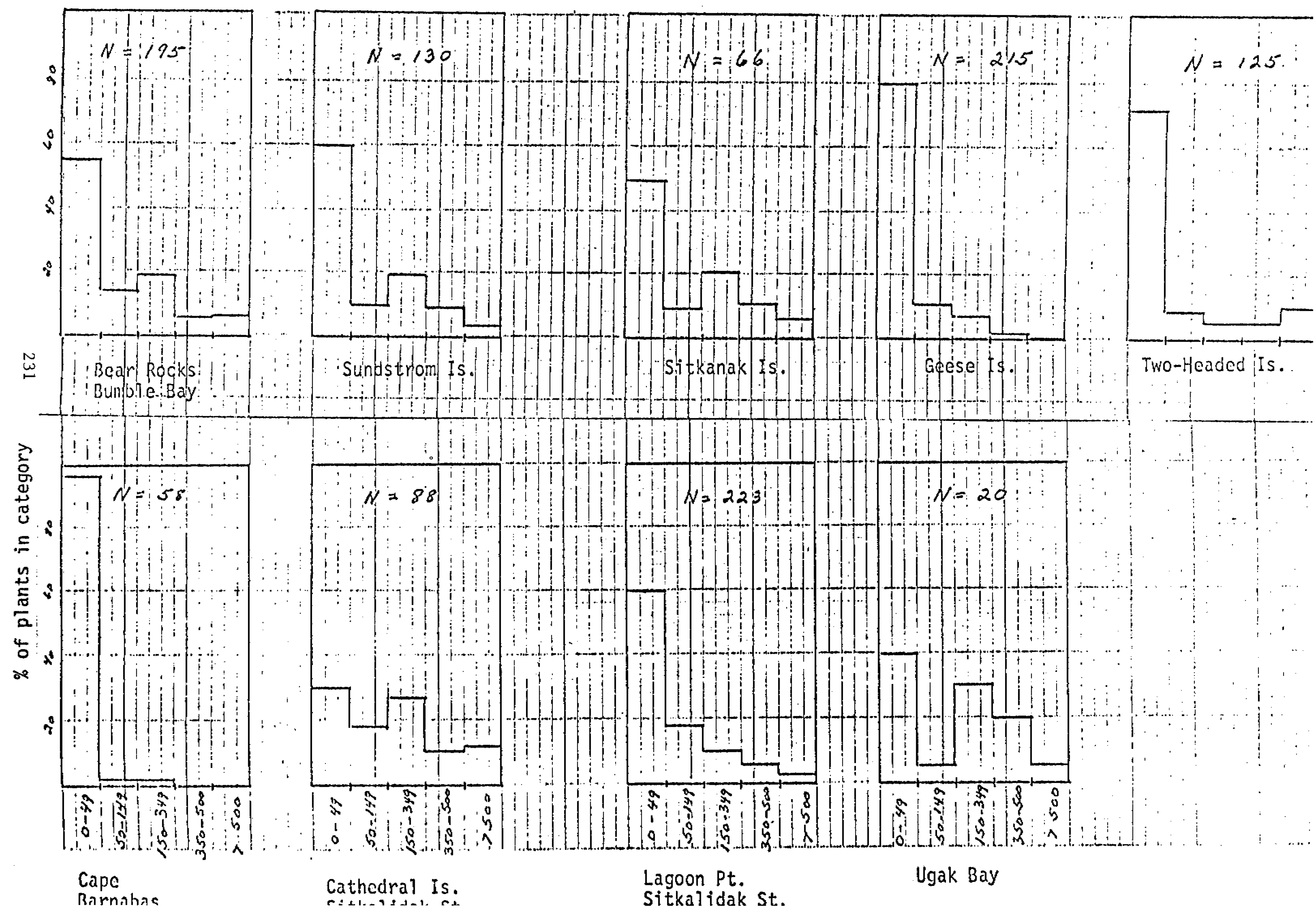


Figure 2.--Percent of *Laminaria dentigera* at Lagoon Point from six 1/4 m^2 quadrant samples, in 10 gram increments. 16 May, 1976 Depth range -2 to -6 meters.



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Research Unit RU 174
July 1-September 30, 1976

BASELINE STUDIES OF DEMERSAL RESOURCES OF THE NORTHERN GULF OF ALASKA SHELF AND SLOPE:

THE AGE COMPOSITION AND GROWTH OF SEVEN SPECIES OF DEMERSAL FISH FROM THE EASTERN GULF OF ALASKA

by

Dr. Walter T. Pereyra

George Hirschhorn

and

Lael L. Ronholt

Growth information collected during the 1975 Northeastern Gulf of Alaska (NEGOA) survey was analyzed for the following species: turbot (Atheresthes stomias), Dover sole (Microstomus pacificus), rex sole (Glyptocephalus zachirus), flathead sole (Hippoglossoides elassodon), Pacific ocean perch (Sebastes alutus), Pacific cod (Gadus macrocephalus) and walleye pollock (Theragra chalcogramma).

Materials and Methods

The age structures collected for these species were otoliths, except for Pacific cod (scales). The collection was a stratified subsample of the length sample with a target of 5 age structures per cm, sex and stratum. The age length key includes age-length data of fish, 20 cm and over, originating in 9 strata (Figure 1). The length frequency distribution to which each such key was applied represents the sum of estimated numbers of fish over 19 cm present in the fishable biomass in Strata 1-9. However, in sampling these strata during 1975, pollock and Pacific cod were not encountered in Stratum 6 (central area, 201-400 m), nor was Pacific ocean perch found in Strata 1 and 7 (eastern area, 1-100 m and western area, 1-100 m).

Applying the proportions at age by cm from the key to the length frequencies provides estimates of numbers of fish in the fishable population by size and age. Summing these by age provided estimates of age composition by species and sex (Table 1). Departures in the totals shown from 100% are due to rounding. The corresponding values of numbers of fish can be found in Ronholt, Shippen and Brown (1976).

The length frequencies at age also provide estimates of mean lengths at age. These are shown in Table 2 for each age within the observed length range. (Lengths shown as integer numbers were based on a single age-length observation.) All mean lengths at age available for each sex and species were fitted by von Bertalanffy parameters (L_∞, k, t_0) using the fitting procedure of Fabens (1965); these estimates are given in Table 3, part 1, labelled "All data points used." These parameter estimates are likely to be affected by gear selection in the case of incoming age groups; they are additionally affected, at high ages, by very low numbers aged (sometimes a single animal). Visual inspection of Figure 2 suggests that a line fitted through all observed data points (dots) would reach length 0 at some negative age in the majority of cases.

The importance of accurate size data at young ages in von Bertalanffy curve fittings was discussed by Fabens (1965), who suggested use of values near 0 corresponding to age 0 if necessary. In the absence of such information we added a data pair ascribing length 0 to age 0. Further, we omitted mean lengths for ages based on fewer than 10 aged individuals. We also followed the practice of considering age groups comprising the left (ascending) limb of the catch curve (frequencies at age) as incompletely recruited and omitted the size information for such age groups as being possibly biased. The parameters obtained from data sets altered in this manner are shown in Table 3, part 2 labelled "Altered Data Set Used."

The parameter estimates from the altered data sets are shown as smooth curves in Figure 2 against which the means at all ages (dots) can be compared. Modal ages are indicated by circles drawn around dots showing their mean length; to the left of these, the deviations of lengths at younger ages are seen as upward in direction from the fitted curve in the majority of cases.

An additional use of parameters from data sets altered in this manner may lie in relating growth parameters to real time measurements of environmental factors, e.g. population density. In such cases it may be desirable to compare estimates of L_∞ and k, which are unaffected by widely varying values of t_0. As shown in Table 3, the values of t_0 are substantially closer to 0 than those computed from the original data sets. Also, the associated standard deviations from fit are generally smaller.

Results

As shown in Table 3, the standard deviations from the fitted curves differ substantially between species and, in many cases, between sexes within species. Their magnitude is generally higher in fittings to the raw data, than to altered data sets. Possible reasons for this were discussed above.

In most comparisons between sexes a dimorphism between males and females is apparent. The females are characterized by higher values of asymptotic length (L_∞) and lower values of growth completion rate (k) than the males of a given species. An exception to this appears from the data collected for Pacific ocean perch; however, the associated departures from fit are among the highest found in any of the 7 species included in Table 3.

Considering the results of fitting the altered data sets, those for Dover sole are based on a very small range of age groups but appear comparable to results from more southerly populations, cf. Demory (1972), Hagermann (1952). Parameter sets for turbot, rex sole and flathead sole are associated with relatively small departures from fit, and the number of individuals aged from each species was ca. 600 or greater. By contrast, the curve fits for Pacific cod and for Pacific ocean perch females were based on fewer than 100 age determinations and were probably less representative on that account. The parameter sets obtained for Pacific cod are comparable to estimates based on Ketchen's (1964) data for Pacific cod males.

The parameter sets for walleye pollock are associated with relatively high standard deviations from fit, although the number sampled of each sex was relatively large (ca. 500). The largest departures in mean length from expectation at (fully recruited) ages appeared highest at age 5 in males, and ages 8 and 9 in females. The associated age composition data were bimodal in both sexes (Table 1).

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Table 1.--Estimated age composition by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age 0														
1											8			
2	1	1 1/									65	72	9	9
3	21	19	2	1	2	2			1		23	21	44	22
4	30	25	6	1	12	15	7	10	8	18	4	6	17	16
5	31	20	13	8	24	12	12	11	19	34			23	32
6	10	12	24	7	32	30	16	10	20	10			2	5
7	4	7	26	15	13	18	18	19	11	7			2	4
8	2	5	21	14	8	7	15	10	6	8			2	5
9	1	4	5	18	6	3	5	13	2	2			1	2
10		2	4	15	1	6	5	7	8	3				2
11		2		8	1	3	5	8	8	6				1
12		1		9	1	1	2	2	10	7				1
13		1		3		1	2	2	5	4				
14		1		2		1	3	3	2	2				
15							2	2						
16							3	1						
17							1	2						
18							1	1						
19							1	1						
Total %	100	100	101	101	100	99	98	102	100	101	100	99	100	99
Total Aged	530	795	150	251	274	307	304	304	158	97	58	84	452	554

1/ Rounded to nearest percent.

Table 2.--Mean length at age by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age 0														
1											35.12	29.48	22 1/	
2	20.00	21.94									44.49	44.49	26.32	25.95
3	23.49	23.58	26.38	28.03	21.47	21.96			21		56.81	59.63	31.60	32.47
4	29.13	29.14	29.30	26.96	22.79	23.37	21.70	22.50	22.92	22.92	68.16	73.53	35.08	38.23
5	33.78	35.32	28.23	31.80	26.81	26.92	23.57	23.94	25.75	25.60	77		37.43	40.89
6	37.56	40.66	34.36	33.84	28.58	29.43	27.17	30.29	25.92	27.12			43.57	45.91
7	39.99	45.33	36.52	37.34	31.10	30.89	28.31	31.71	27.12	28.80			47.47	52.93
8	42.42	48.67	35.47	38.65	32.89	33.84	29.82	34.54	29.86	29.20			49.73	57.33
9	43.15	51.33	34.61	41.35	33.76	34.82	31.19	35.70	33.82	36.14			51.13	60.29
10	45.00	55.72	38.36	41.82	34.57	35.87	32.57	37.75	37.13	39.10			55.76	58.74
11	43	58.55		42.49	35.92	37.20	33.42	38.64	37.83	37.02		71 2/	52.69	61.30
12		61.20		43.23	35.67	37.77	33.81	40.02	38.51	38.14			56.14	59.20
13		60.15		42.32		38.88	34.32	39.75	37.40	38.65			51	57.42
14		65.09		42.16		36.80	34.01	43.54	38.00	38.93				
15		64.47			39	39.10	35.09	40.81						
16		71.01					35.64	41.72						
17						40	31.73	45.00						
18		66.71					36.02	44						
19		78					36.85	45						

1/ Absence of decimal point indicates 1 observation only.
2/ Believed to be in error.

Table 3.--Von Bertalanffy growth parameters by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1. All Data Points Used														
L_∞	47.24	82.29	37.53	45.65	44.98	42.20	35.68	45.54	45.31	41.41	425.50	73.72	55.93	62.62
k	-.22	-.10	-.38	-.16	-.12	-.16	-.26	-.19	-.11	-.19	-.03	-.57	-.20	-.23
t_o	-.44	-.90	.07	-2.73	-2.33	-1.57	.69	.51	-2.50	0.01	-2.03	.12	-1.46	-.37
δ	1.62	2.71	2.15	1.87	.79	.88	1.15	1.18	1.94	2.13	1.38	6.53	2.92	3.08
2. Altered Data Set Used 1/														
L_∞	52.44	82.47	36.36 2/	44.61	39.60	41.33	36.79	45.83	44.21 3/	42.44 4/	95.80 5/	130.21 5/	55.26	73.58
k	-.21	-.11	-.50	-.29	-.21	-.21	-.21	-.17	-.15	-.18	-.31	-.21	-.27	-.16
t_o	.00	-.04	.00	.00	-.02	-.01	.00	-.02	-.09	.06	.01	.01	.06	-.11
δ	0.21	1.07	1.31	0.34	0.41	0.44	0.34	0.41	1.87	3.18	1.18	0.80	1.94	2.39

1/ a. No. at age in age determination date set $n_a \geq 10$, except as noted.
b. Ages below modal age group excluded.
c. $l_t = 0$, $t = 0$ included in data set.

2/ No convergence. Substituted set with ages 6, 7, 8; six is premodal.

3/ n = 7, included.

4/ Ages 5, 8 and 12 only.

5/ $n_{min} = 7$.

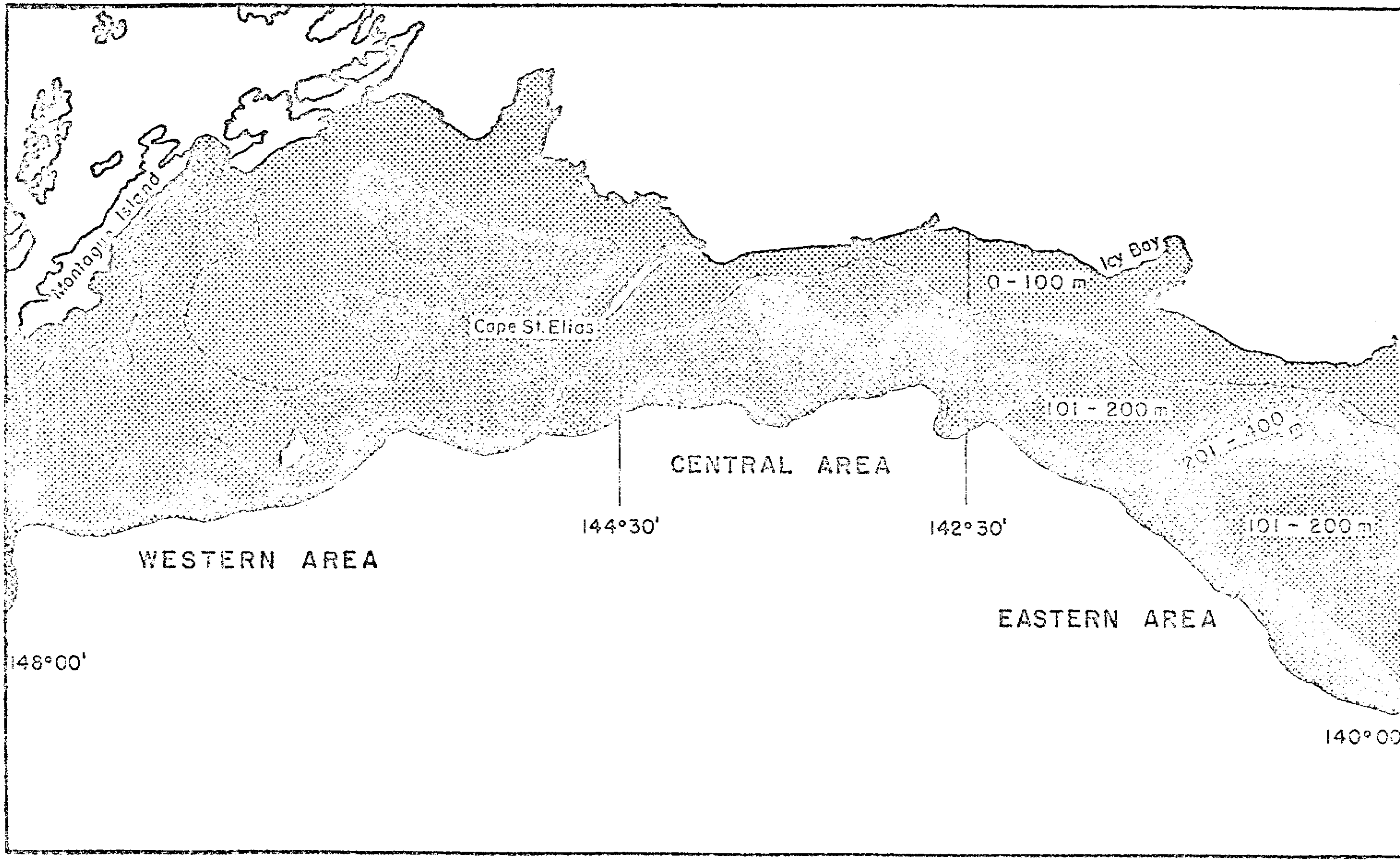

Figure 1.--The NEGOA survey area and the 9 area-depth interval subdivisions.

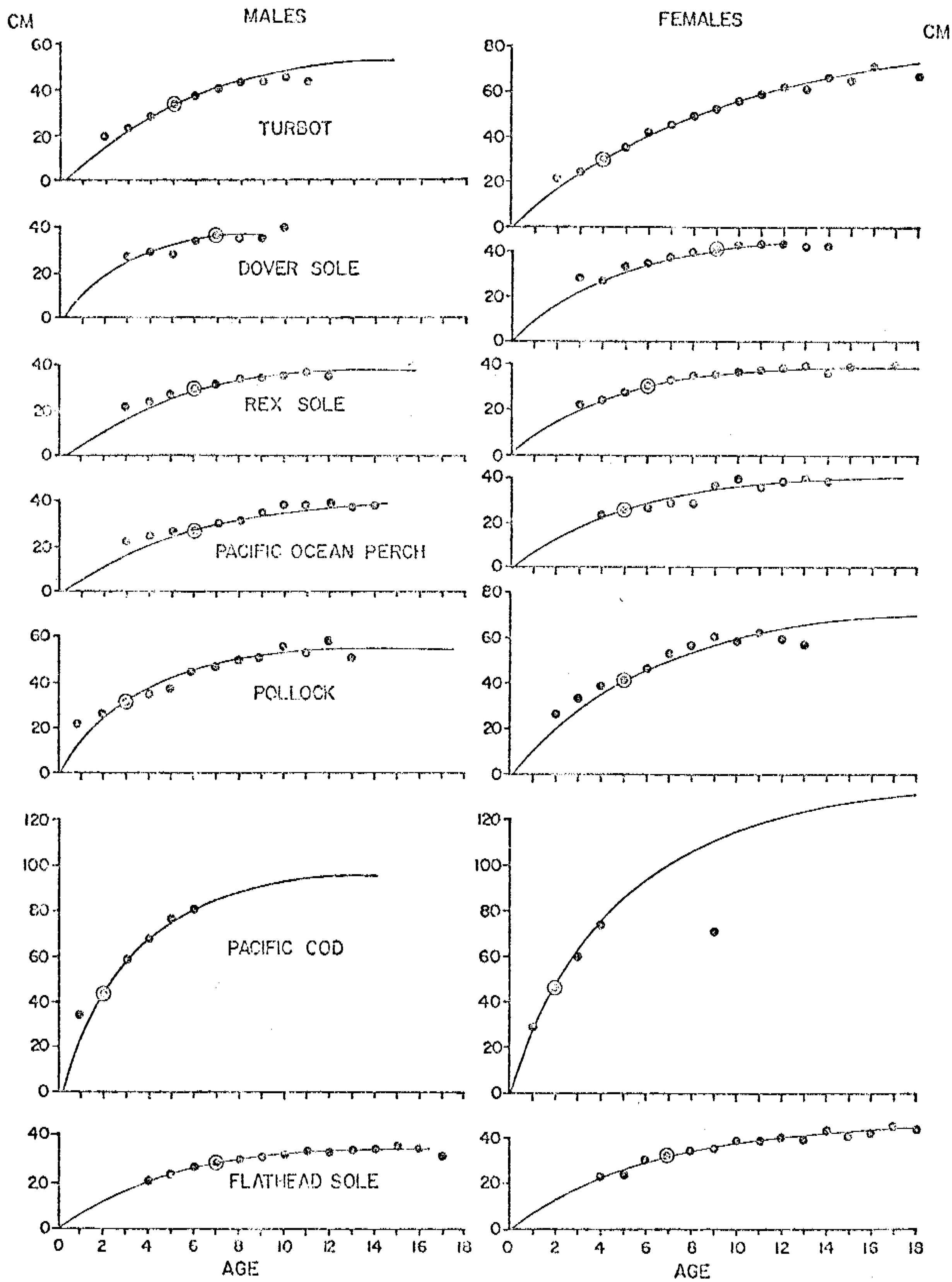

Figure 2.--Mean lengths at age, by sex, for turbot, Dover, rex and flathead sole, Pacific ocean perch, walleye pollock and Pacific cod and growth curves (see text).

Quarterly Report December 1976

RU 174 - Baseline Studies of the Demersal Resources of the Eastern and Western Gulf of Alaska Shelf and Slope: A Historical Review

I. Task Objective

To review and analyze existing literature on the distribution, abundance, and productivity of demersal fish and shellfish from Unimak Pass (165°W long.) to Cape Spencer (137°W long.) including trawl survey data and domestic and foreign catch records.

II. Field or Laboratory Activities

A. Ship or field trip schedule

None involved

B. Scientific Party (all are personnel of the Northwest and Alaska Fisheries Center, Seattle, Washington.

Dr. Walter T. Pereyra (Principle Investigator)

Lael L. Ronholt (Principle Investigator)

Herbert H. Shippen (Fishery Biologist)

Ralph Mintel (Computer Programmer)

C. Methods

Historical survey data are on ADP cards and will be transferred to disk for compiling and analyses. Existing computer programs will be used to provide: (1) species composition and biomass estimates by area, depth, and time; (2) charts showing the distribution and relative abundance (catch in weight per unit area) of the major fish and shellfish species, and (3) average length and length composition of major species.

Biomass estimates will be obtained by the "area swept" technique described by Alverson and Pereyra (1969).

Domestic and foreign fisheries statistics will be examined for historical changes in magnitude of catches by species and fishing grounds.

D. Sample localities/ship or aircraft tracklines

Not applicable.

E. Data collected or analyzed

1. Number and types of samples/observations

No samples have been collected and none are to be collected.

2. Number and types of analyses

Not applicable.

3. Miles of trackline

Not applicable.

III. Results

The scope of the survey area has been extended to include the area from Unimak Pass (165°30'W long.) to Cape Spencer (136°30'W long.). Data sources for the additional areas (165°30'W to 157°W and 140°W to 136°30'W) have been gathered, the data keypunched and verified, and the information now awaits loading onto discs for analysis. Length frequency data analyses for the Yakutat Bay to Semidi Islands area are 30% complete. Records of commercial catches by domestic and foreign fishermen have been reanalyzed according to new and revised area groupings and are 50% complete. Specific areas of outstanding importance to commercial fisheries are being delineated; this task is 75% complete.

A number of interim reports have been completed and submitted to OCSEAP:

1. Areas of importance to commercial fisheries by the United States and Japan in the vicinity of Kodiak Island, Alaska.
2. Japanese fish catches in the area of the test site at $59^{o}45'N$ - $143^{o}00'W$.
3. The age composition and growth of seven species of demersal fish from the eastern Gulf of Alaska.

IV. Preliminary interpretation of results

Not applicable.

V. Problems encountered/recommended changes

No problems have been encountered and the analysis is progressing according to expectation.

RU# 174

Supplemental reference:

Pereyra, W. T. and Ronholt, L. L. Baseline Studies of Demersal Resources of the Northern Gulf of Alaska Shelf and Slope. N.O.A.A. National Marine Fisheries Service/Northwest Fisheries Center, Seattle, Washington. 281 p. (In press 1977)

Supplement to Quarterly Report for RU#174

Areas of Importance to Commercial Fisheries by the United States and Japan in the Vicinity of Kodiak Island, Alaska

by

Herbert H. Shippen

Prepared by the

National Marine Fisheries Service

Northwest and Alaska Fisheries Center

Seattle, Washington

November 1976

Areas of Importance to Commercial Fisheries by the United States and Japan in the Vicinity of Kodiak Island, Alaska

I. General Area: Kenai Peninsula to Semidi Islands (148° W. long. to 157° W. long.), excluding Cook Inlet.

II. Period Covered:

A. United States: 1969-1975

B. Japan: 1964-1974

III. Fisheries and Species:

A. United States:

1. King crabs - Paralithodes camtschatica, P. platypus, P. brevipes, and Lithodes aequispina

2. Snow crabs (Tanner crabs) - Chionoecetes bairdi and C. opilio

3. Dungeness crab - Cancer magister

4. Shrimp - Pandalus borealis, P. goniurus, Pandalopsis dispar, etc.

B. Japan:

1. Trawl fisheries

Arrowtooth flounder (turbot)

Other flatfishes

Pacific ocean perch

Other rockfishes

Sablefish (blackcod)

Pacific cod

Walleye pollock

Other fishes

Shrimp

2. Longline fisheries

Sablefish (blackcod)

Pacific ocean perch

Other rockfishes

Other fishes

IV. United States Fisheries

A. Data source

Records of fish and shellfish catches are available for the period from 1969-1975 as collected by the Alaska Department of Fish and Game. The poundage of king crabs, snow crabs, Dungeness crabs, and shrimp has been examined and analyzed. Fisheries not included in this report are U.S. groundfish landings which except for halibut are too insignificant to make their consideration worthwhile. The areas to which halibut catches were assigned by the International Pacific Halibut Commission were too broad to be of use in identifying important areas of production.

Catches (pounds) by the United States of crabs and shrimp for the years from 1969 through 1975 taken from the records of the Alaska Department of Fish and Game (ADF&G) are shown in Table 1. For the 6-year period shrimp (64%) was the leading product of Alaska's demersal fisheries, exceeding by a large margin the production of crabs. The production of king and snow crabs (17% each) was nearly equal during 1969-1974, while Dungeness crabs (3%) were a relatively small component of the catch.

B. Designation of commercially important areas

The ADF&G records assign each catch to a specific geographic sub-area. The most important sub-areas for each species were assumed to be those which produced approximately ½ percent or more of the total catch for the period from 1969-1975. In round numbers the following minimum catches during any one calendar year were used to designate commercially important sub-areas:

Species	Pounds minimum catch	Percent of total catch, 1969-1974	Number of sub-areas designated
Shrimp	2,000,000	0.47	17
King crab	500,000	0.44	24
Snow crab	500,000	0.45	28
Dungeness crab	100,000	0.54	18

The ADF&G sub-areas meeting the minimum catch criterion are listed in Table 2 which indicates the sub-area number, the species that was found there, the mean catch (pounds) for the years with a recorded catch, the number of such years, and the minimum and maximum catches during the six-year period.

In Table 1, last two columns, the amount and percent of the catch for each year by species from the designated important areas is compared with the total catch. For Dungeness crab the percent of total catch from the 18 commercially important sub-areas ranged from 63 to 92 with an overall mean of 86 percent. For king crabs the annual percent of total catch from the 24 designated areas ranged from 61 to 83 with a mean of 77 percent. For the snow crabs, principally C. bairdi, the 28 designated sub-areas provided from 69 to 87 percent of the annual catch with a mean of 83 percent. The percent of total shrimp catch from the 17 important sub-areas ranged from 70 to 83 percent with a mean of 77 percent.

Locations of the important commercial fishing areas for the Dungeness crab, snow crabs, king crabs, and shrimp are shown in Figures 1 through 5. There are 62 such areas in the vicinity of Kodiak Island of which 42 supply a single fishery, 15 areas provided for two fisheries, and five were important to three fisheries. No area was important to more than three fisheries.

Seasons for Alaskan fisheries are established by the Alaska Board of Fish and Game. In the area south of Cape Douglas and west of 151^{o} W. long. to a depth of 356 m and westward to 172^{o} E. long. the following seasons apply to the various fisheries: (source: Alaska 1975 Shellfish Regulations)

a. Dungeness crab - no closed season except that in the waters of Kodiak district south of the latitude of Boot Point and Cape Ikolik they may be taken from June 15 through April 30;

b. King crabs - from August 15 until closed by emergency order;

c. snow (Tanner) crabs - from November 1 through June 30 unless closed earlier by emergency order;

d. Shrimp - no closed season on shrimp fished with pots. In the waters east of the longitude of Kilokak Rocks (about 156^{o} 12' W. long.) shrimp may be taken by trawls from May 1 through February 28.

V. Japanese Fisheries

A. Data source

The Japan Fisheries Agency provides the Northwest and Alaska Fisheries Center with annual catch records of their fisheries in the North Pacific. The data are presented with respect to gear and species by 1^{o} (latitude) by ½^{o} (longitude) blocks. Data have been reported for the 11-year period from 1964 through 1974. Two classifications of fishing gear are made in this report, trawl and longline. Trawl gears include stern trawl, side trawl, shrimp trawl, and Danish seine. Stern trawls were employed over the entire period; side trawls were used from 1964-1966, shrimp trawls from 1964-1968, and Danish seines from 1965-1967. The longline fishery, directed principally at sablefish, began in 1967 and continues. A minor fishery employing gill nets occurred in 1969, but the species taken were not identified; this fishery took less than 100 metric tons in the single year that it operated.

B. Composition of Japanese fisheries

1. Trawl fishery - For the 11-year period from 1964-1974 the percentage composition by weight is shown in Table 3. More than 80 percent of the catch consisted of Pacific ocean perch (65%) and walleye pollock (17%).

2. Longline fishery - In the 8 years since the beginning of the Japanese longline fishery in 1967, nearly 98 percent of the catch has been sablefish (Table 4).

3. All fisheries - In the 11 years for which catch records are available, the trawl fishery has taken 92 percent of the catch and the longline fishery 8 percent. The weight composition of the total catch by species or group is indicated in Table 5.

C. Distribution of Japanese Demersal fish catches in the vicinity of Kodiak Island

1. The annual mean trawl catch in metric tons (for years with a recorded catch) for each $1^{\circ} \times \frac{1}{2}^{\circ}$ block is shown in Figure 6. The larger trawl catches were made in the blocks where the continental shelf dips down to become the upper slope. It is along this edge that the best catches of Pacific ocean perch are usually made.

2. The annual mean longline catch, predominantly sablefish, is shown in Figure 7. The mean is only for those years in which a catch was

recorded. Like the trawl catch, the blocks with the greatest mean longline catches were those which include the edge of the continental shelf. Sablefish are usually found somewhat deeper than are Pacific ocean perch.

Table 1.--Crab and shrimp catches, 148°-157° W., from 1969-1975, by U.S. fishermen[1]

Year	Species	Total Catch (Pounds)	%	Catch from commercially important areas (Pounds)	% of total
1969	Dungeness	5,861,408	9	5,251,903	90
	King	13,076,292	19	8,034,161	61
	Snow	6,862,516	10	4,723,066	69
	Shrimp	41,353,461	62	33,090,000	80
1970	Dungeness	5,741,438	6	5,288,309	92
	King	12,118,027	14	8,474,017	72
	Snow	7,712,322	9	5,450,858	71
	Shrimp	62,183,569	71	50,208,000	81
1971	Dungeness	1,445,864	1	996,677	69
	King	11,844,514	12	9,535,350	80
	Snow	7,462,784	7	6,312,423	85
	Shrimp	82,166,973	80	68,294,000	83
1972	Dungeness	2,059,536	2	1,781,088	86
	King	15,491,117	18	12,675,526	82
	Snow	12,155,571	14	10,332,220	85
	Shrimp	58,531,712	66	46,879,000	80
1973	Dungeness	2,001,842	2	1,468,826	73
	King	14,452,276	11	11,666,945	81
	Snow	32,438,086	26	28,659,801	79
	Shrimp	77,683,925	61	56,128,000	72
1974	Dungeness	750,057	1	720,091	96
	King	23,013,046	22	19,078,822	83
	Snow	27,385,959	27	22,318,217	82
	Shrimp	52,023,829	50	36,256,000	70
1975[2]	Dungeness	639,813	1	399,953	63
	King	23,997,413	25	18,755,785	78
	Snow	17,515,425	19	15,297,568	87
	Shrimp	51,958,524	55	38,325,000	74
Total (1969-1975)	Dungeness	18,499,958	3	15,906,847	86
	King	113,992,685	17	88,220,606	77
	Snow	111,532,663	17	93,094,153	83
	Shrimp	425,901,993	64	329,180,000	77

1/ Source: Alaska Department of Fish and Game

2/ Preliminary data

Table 2.--Important subareas of production of crabs and shrimp in the Alaska domestic fishery, 1969-1975.

Sub-Area[1/]	Species[2/]	Mean[3/]	No. Years[4/]	Min.[5/]	Max.[5/]
232-30	Snow	132,359	5	1,498	580,456
232-35	Snow	401,038	3	115,139	578,314
252-20	Shrimp	2,956,964	7	14,567	7,010,680
252-30	King	376,472	7	16,698	1,116,209
252-30	Shrimp	1,312,428	7	946,082	1,982,391
252-35	Dungeness	29,914	6	4,364	116,425
252-51	King	305,616	6	24,426	655,806
252-52	King	191,617	7	23,953	693,933
252-52	Snow	390,305	7	234,734	554,452
252-52	Shrimp	6,723,937	7	32,787	16,542,492
252-53	King	138,090	7	3,205	579,525
252-53	Snow	396,520	7	106,604	1,377,014
252-54	Snow	287,550	6	26,256	523,806
252-56	King	211,171	6	55,574	599,839
252-56	Shrimp	4,710,874	5	1,485,192	9,681,993
252-59	King	432,460	7	7,043	1,694,223
252-63	King	305,796	5	41,057	568,332
252-64	Snow	889,969	7	29,984	2,160,054
253-31	King	510,270	7	37,103	1,054,135
254-40	Dungeness	86,908	7	13,742	189,363
256-20	Dungeness	99,100	4	33,285	156,632
257-10	King	371,022	6	53,104	953,000
257-10	Snow	378,424	5	116	1,333,581
257-20	Dungeness	186,103	2	57,730	314,477
257-50	Shrimp	3,020,121	6	47,362	7,736,024
257-70	Dungeness	109,131	2	34,642	183,619
257-70	Snow	342,367	7	6,954	976,360
257-81	King	969,664	7	67,837	2,344,851
257-81	Snow	2,530,339	6	356,171	4,317,232
257-82	King	564,095	6	179,981	946,019
257-82	Snow	1,187,127	4	110,737	3,125,827
257-90	Dungeness	896,422	7	7,540	2,757,628
257-91	King	1,080,582	7	517,169	1,682,194
258-10	Snow	299,458	5	29,440	817,968
258-10	Shrimp	4,007,552	7	2,750,082	5,221,805
258-20	Snow	337,896	4	124,627	751,684
258-20	Shrimp	2,401,760	7	1,068,857	4,199,968
258-51	Shrimp	2,703,444	3	814,252	4,016,545
258-52	Shrimp	2,461,182	3	53,746	7,134,954
258-54	Shrimp	846,882	5	50,954	2,482,674
258-55	Shrimp	10,730,252	7	6,777,405	15,981,116
258-60	King	229,607	7	11,930	562,083
258-60	Shrimp	2,822,956	7	161,884	7,138,818

Table 2.--(continued)

Sub-Area[1/]	Species[2/]	Mean[3/]	No. Years[4/]	Min.[5/]	Max.[5/]
258-80	Dungeness	241,080	5	4,555	671,134
258-80	King	293,074	7	22,688	960,886
258-81	King	2,185,625	7	677,030	3,439,400
258-91	Shrimp	2,007,415	7	25,815	7,895,306
258-92	Dungeness	28,413	5	956	114,651
258-92	King	187,977	7	50,963	362,341
258-92	Snow	1,256,784	7	469,868	2,390,761
258-95	King	458,351	7	34,109	1,433,873
258-96	King	561,336	7	118,250	992,030
258-96	Snow	193,449	6	13,144	605,831
258-97	Snow	264,586	5	540	880,110
259-10	Snow	225,099	6	6,046	752,617
259-21	King	211,851	7	760	756,541
259-30	Dungeness	37,078	7	328	94,633
259-41	Dungeness	329,668	7	104,228	742,264
259-41	Snow	346,557	6	680	992,984
259-41	Shrimp	2,763,976	6	126,334	8,460,042
259-42	Dungeness	167,009	6	2,000	825,642
259-42	Snow	340,808	7	22,276	1,075,404
259-42	Shrimp	3,483,885	5	40,855	7,434,263
259-61	Snow	289,256	7	4,845	695,514
259-62	Snow	156,512	7	22,378	520,348
262-10	Dungeness	314,520	2	141,604	487,435
262-15	Snow	991,331	7	13,364	2,751,006
262-25	Dungeness	65,447	3	32,542	118,197
262-25	Shrimp	1,184,093	3	475,141	2,491,875
262-30	Dungeness	51,741	5	3,152	190,919
262-30	Snow	668,204	5	25,786	1,597,846
262-30	Shrimp	726,133	5	102,167	2,091,960
262-55	Dungeness	132,564	3	22,220	253,399
262-60	Dungeness	176,841	3	2,434	346,164
262-65	Dungeness	136,561	6	21,090	397,153
272-50	Shrimp	1,654,296	3	746,675	2,447,436
291-11	Snow	1,034,278	7	39,184	2,581,366
291-12	King	342,660	7	58,884	1,193,014
291-12	Snow	382,419	7	11,664	1,230,337
291-21	Snow	675,186	7	117,801	1,618,798
291-32	Snow	429,982	7	14,698	809,752
291-42	Snow	167,297	6	14,641	531,940
291-52	King	451,791	6	37,545	1,154,458
291-53	King	1,053,715	7	249,706	2,178,960
291-63	King	989,483	3	207,594	1,940,171
291-73	King	1,119,645	7	407,210	2,648,453
291-73	Snow	219,012	7	81,287	532,584

1/ Locations of these sub-areas (designated by the Alaska Department of Fish and Game) are shown on accompanying charts.

2/ Snow = snow crabs (Chionoecetes species)
King = king crabs (Paralithodes species and Lithodes aequispina)
Dungeness = Dungeness crab (Cancer magister)
Shrimp = Pandalus species, Pandolopsis dispar

Table 2.--(continued)

3/ The mean is only for those years with a recorded catch (pounds).
4/ The number of years with a recorded catch upon which the mean is based.
5/ Pounds.

Table 3.--Composition of the Japanese trawl catch in the vicinity of Kodiak Island, 1964-1974.

Species or group	Total catch (mt)	Percent
Turbot	12,924	4.3
Other flatfishes	6,919	2.3
Pacific ocean perch	195,265	64.9
Other rockfishes	2,179	0.7
Sablefish	15,998	5.3
Pacific cod	6,544	2.2
Walleye pollock	51,441	17.1
Other fishes	5,861	1.9
Shrimp	3,765	1.3
Total	300,896	100.0

Table 4.--Composition of the Japanese long line catch in the vicinity of Kodiak Island, 1967-1974.

Species or group	Total catch (mt)	Percent
Sablefish	25,951	97.9
Pacific ocean perch	68	0.3
Other rockfishes	116	0.4
Other fishes	367	1.4
Total	26,502	100.0

Table 5.--Composition of Japanese fish catches in the vicinity of Kodiak Island, all gears, 1964-1974.

Species or group	Total catch (mt)	Percent
Turbot	12,924	3.9
Other flatfishes	6,919	2.1
Pacific ocean perch	195,333	59.7
Other rockfishes	2,295	0.7
Sablefish	41,949	12.8
Pacific cod	6,544	2.0
Walleye pollock	51,441	15.7
Other fishes	6,228	1.9
Shrimp	3,765	1.1
Total	327,398	99.9

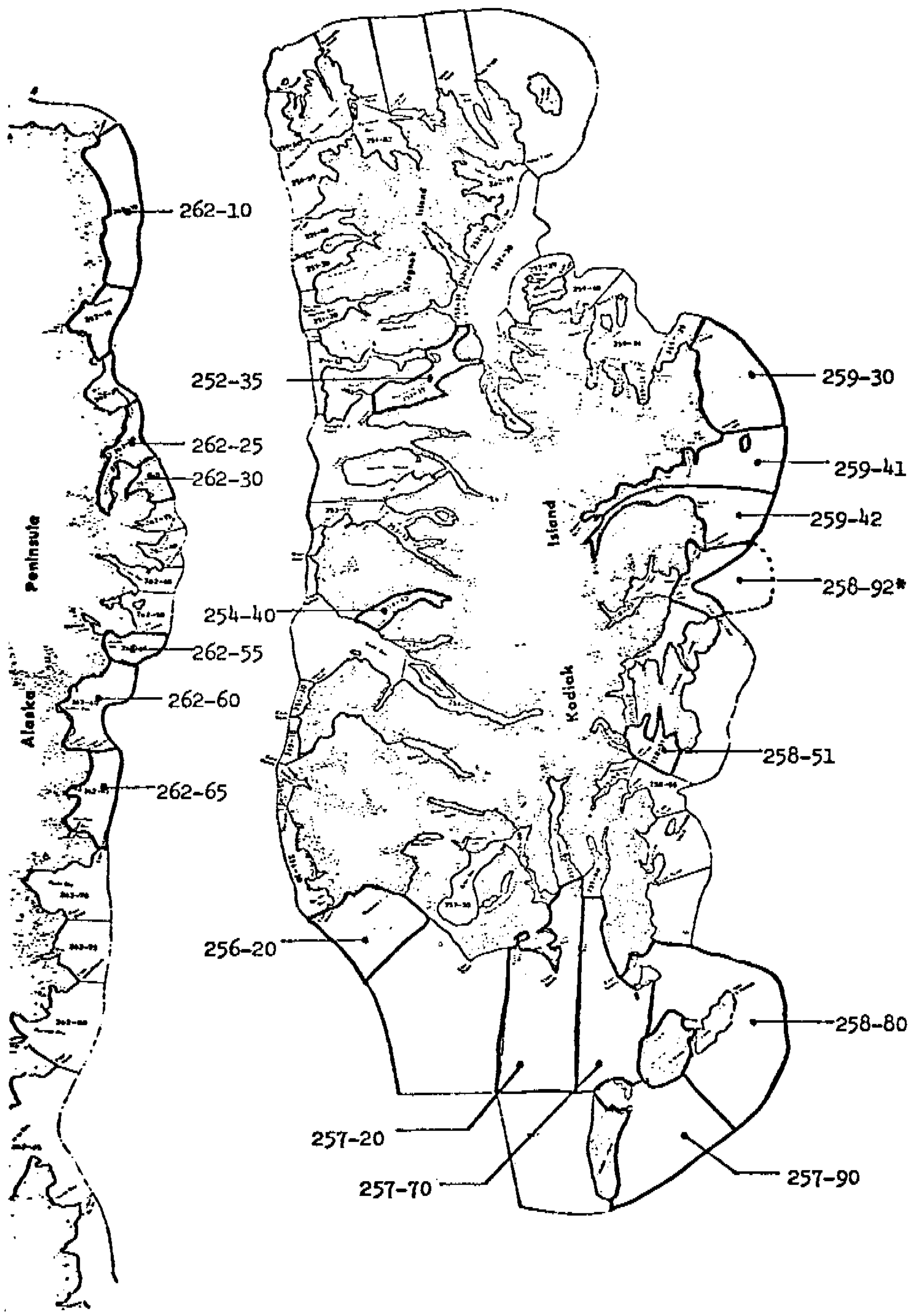

Figure / -- Locations of important commercial fishing areas for Dungeness crabs in the vicinity of Kodiak Island

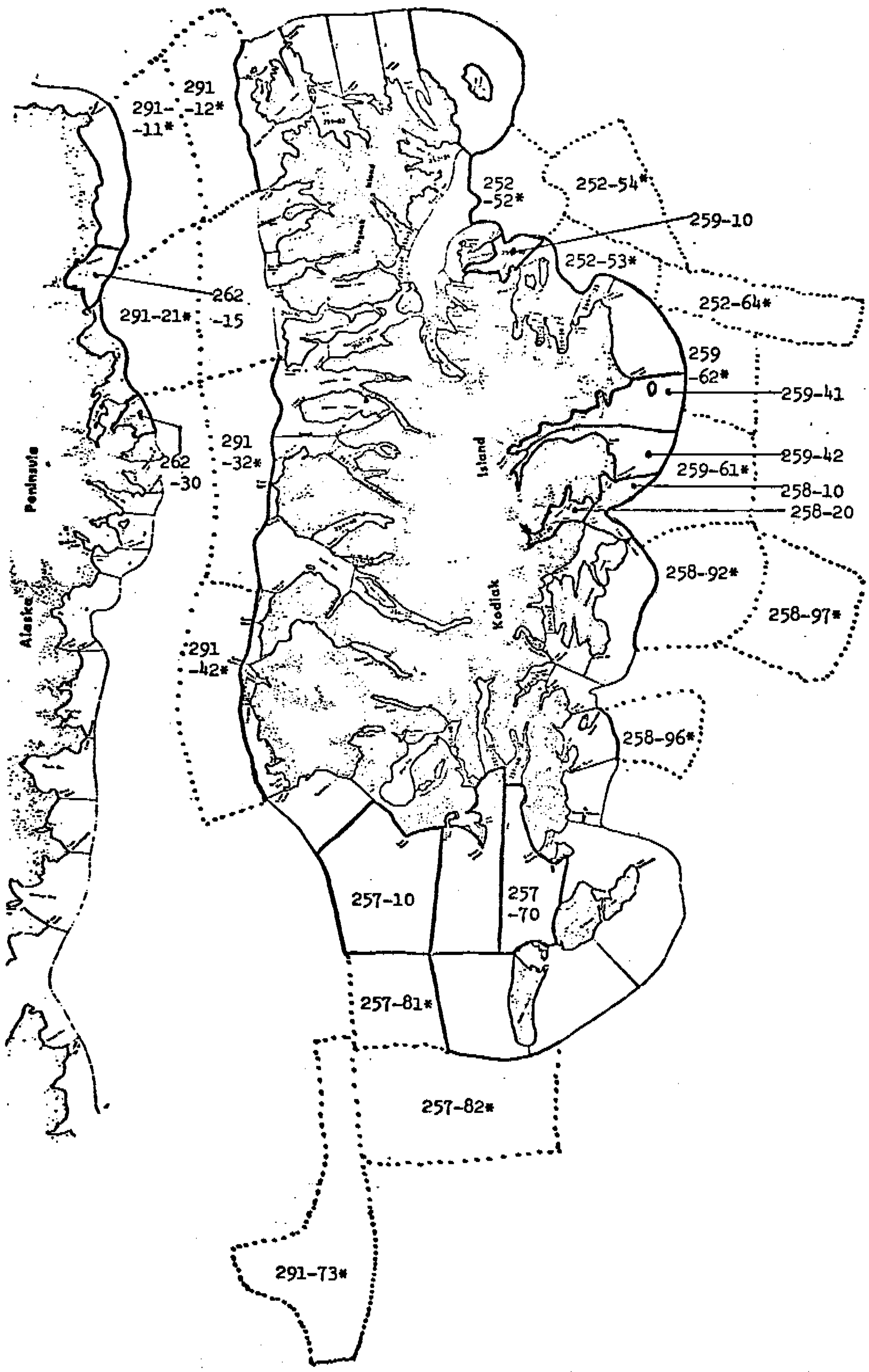

Figure 2 .-- Locations of important commercial fishing areas for snow crabs in the vicinity of Kodiak Island

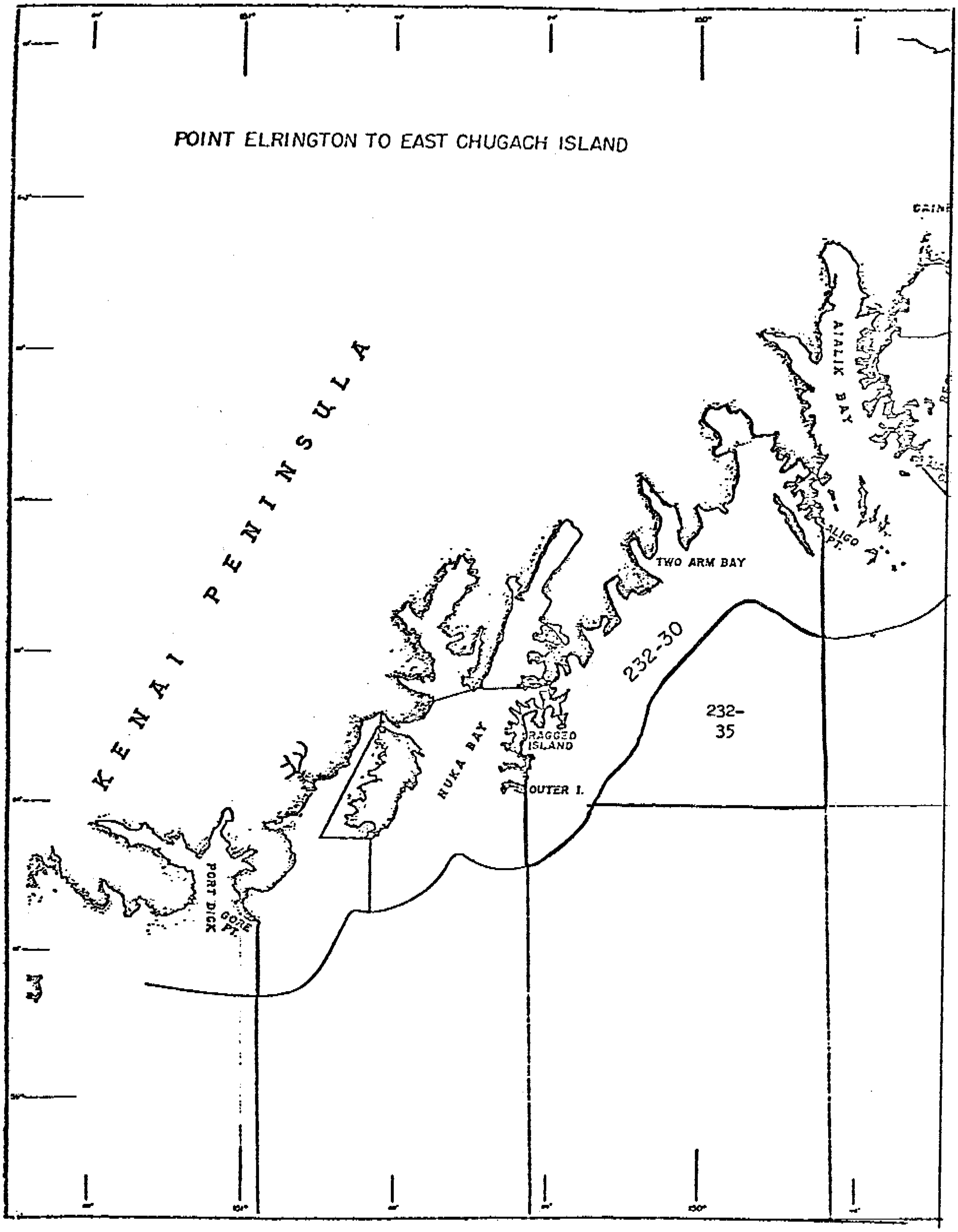

Figure 3 --Locations of important commercial fishing areas for snow (tanner) crabs on the Kenai Peninsula

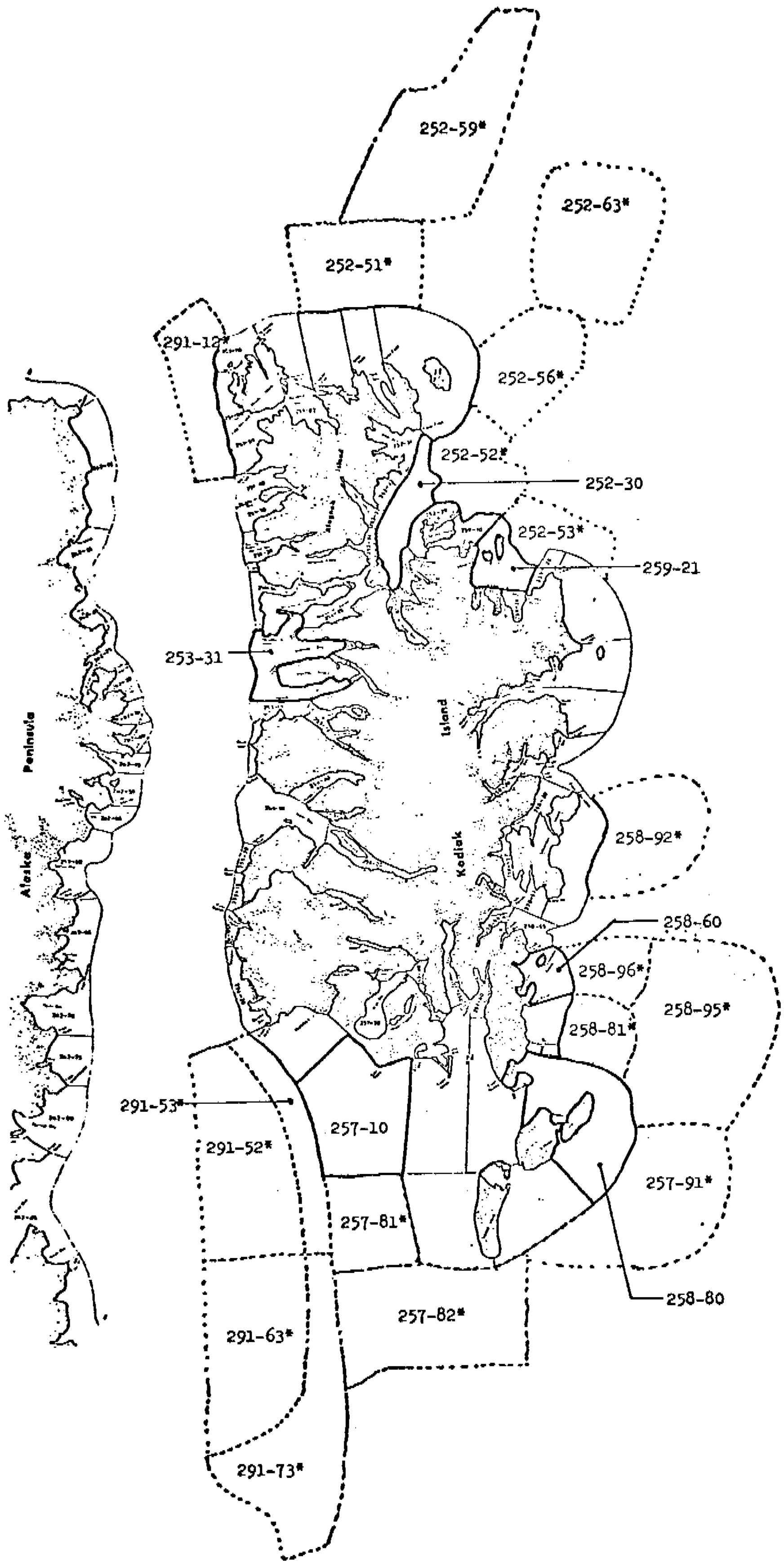

Figure 4 .--Locations of important commercial fishing areas for king crabs in the vicinity of Kodiak Island

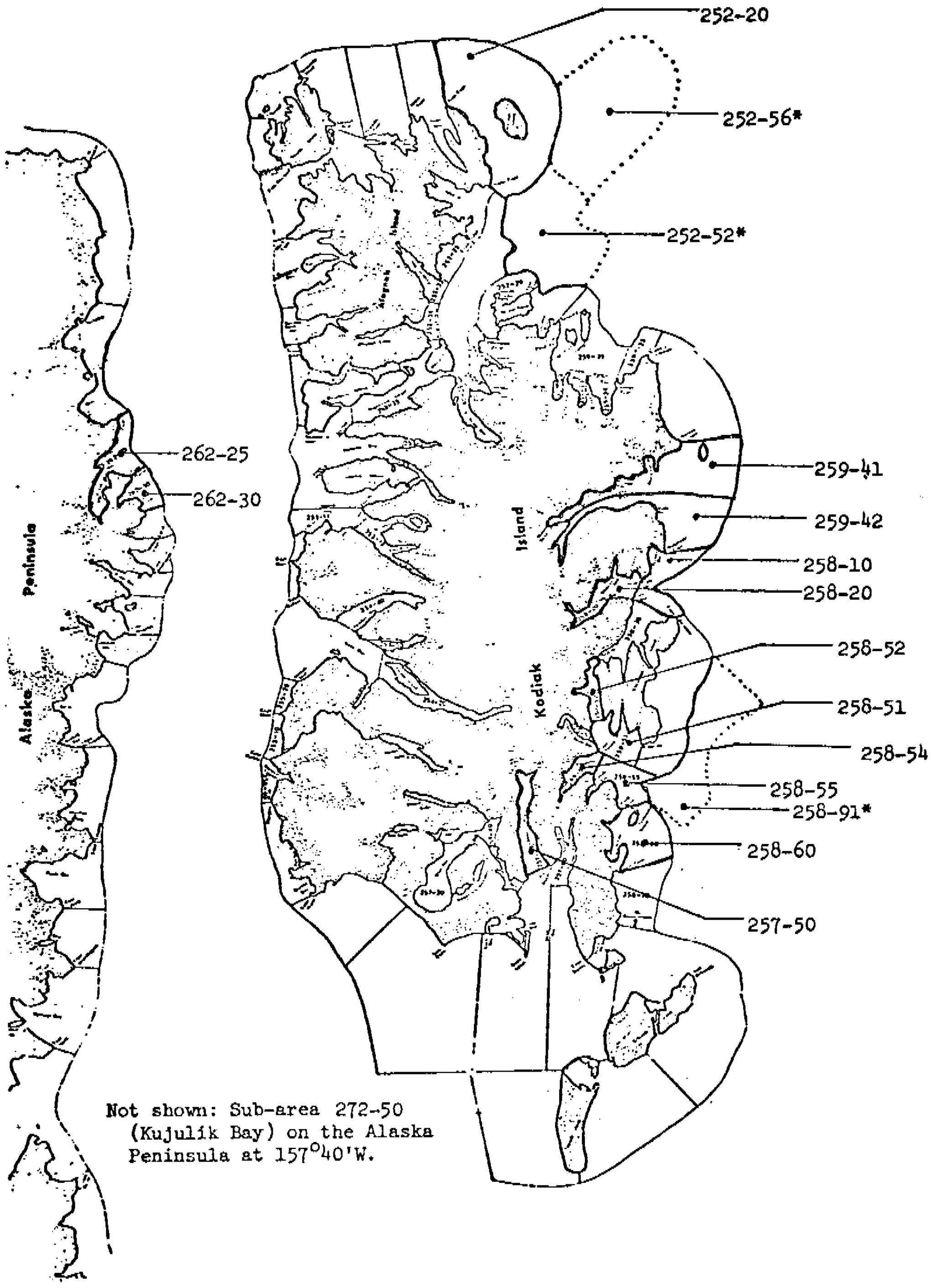

Figure 5 -- Locations of important commercial fishing areas for shrimp in the vicinity of Kodiak Island

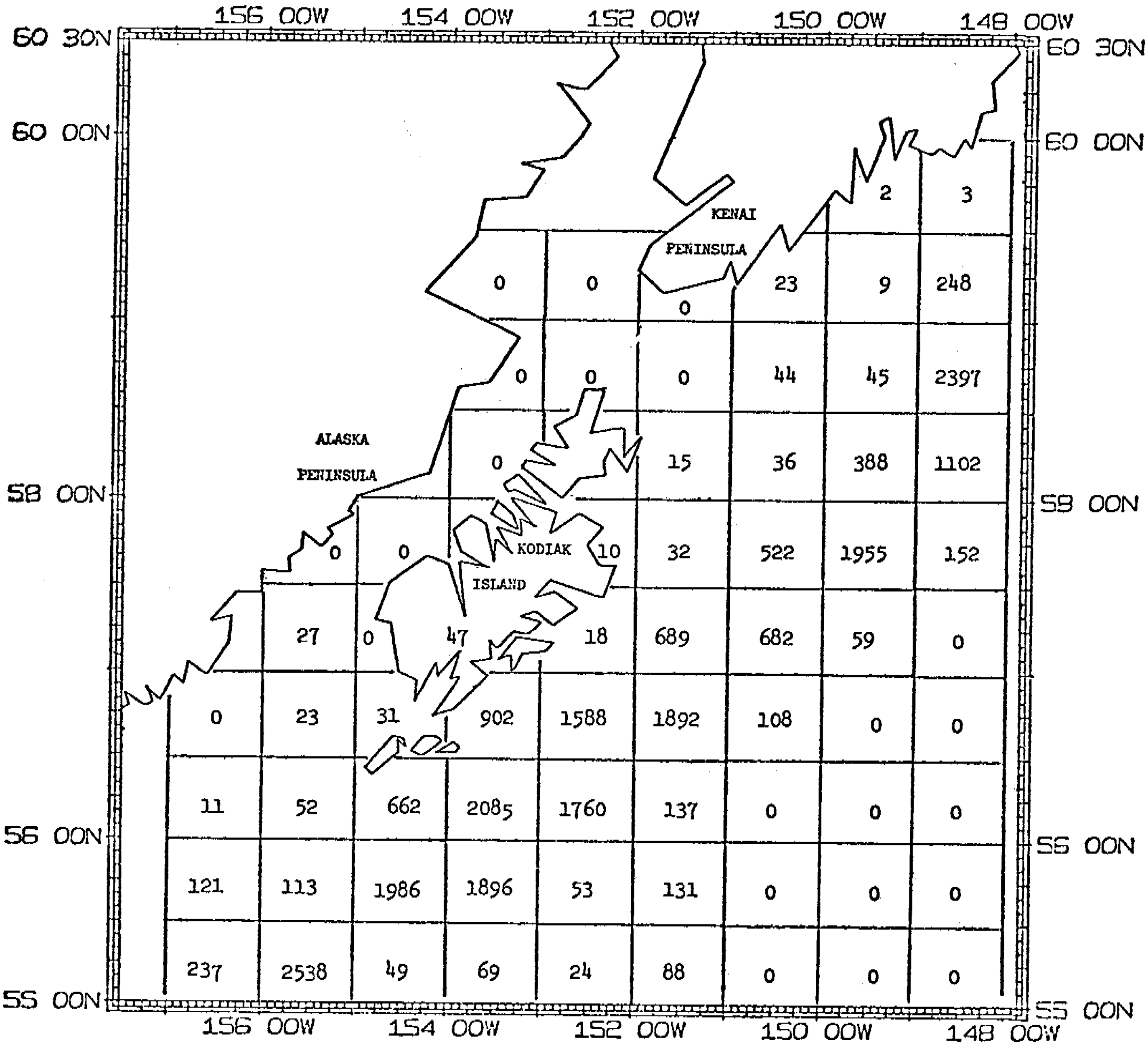

Figure 6 --Japanese demersal fish catch, trawl gear, in metric tons. Mean for the years 1964-1974.

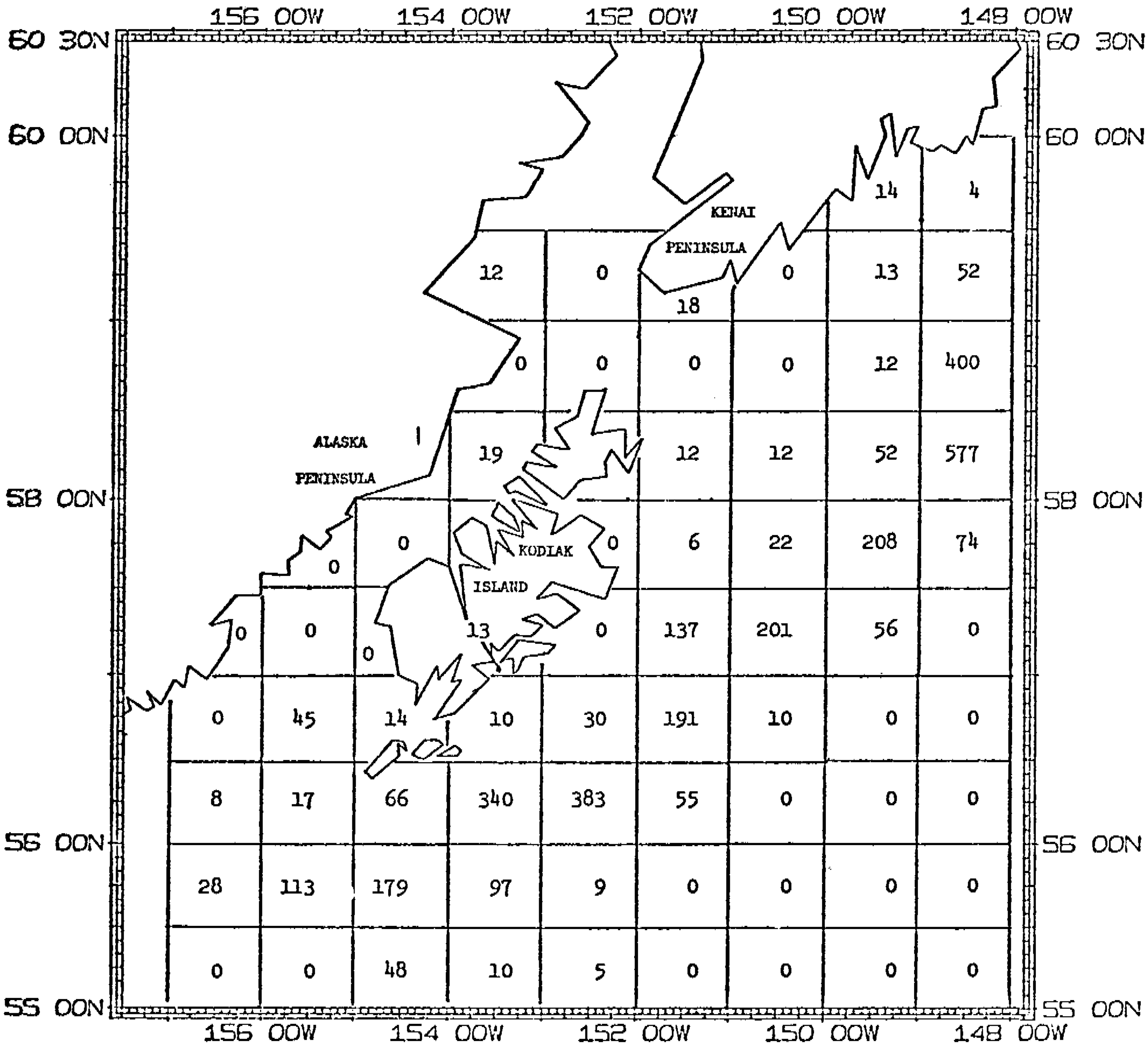

Figure 7 .—Japanese demersal fish catch, longline gear, in metric tons. Mean for the years 1967 -1974.

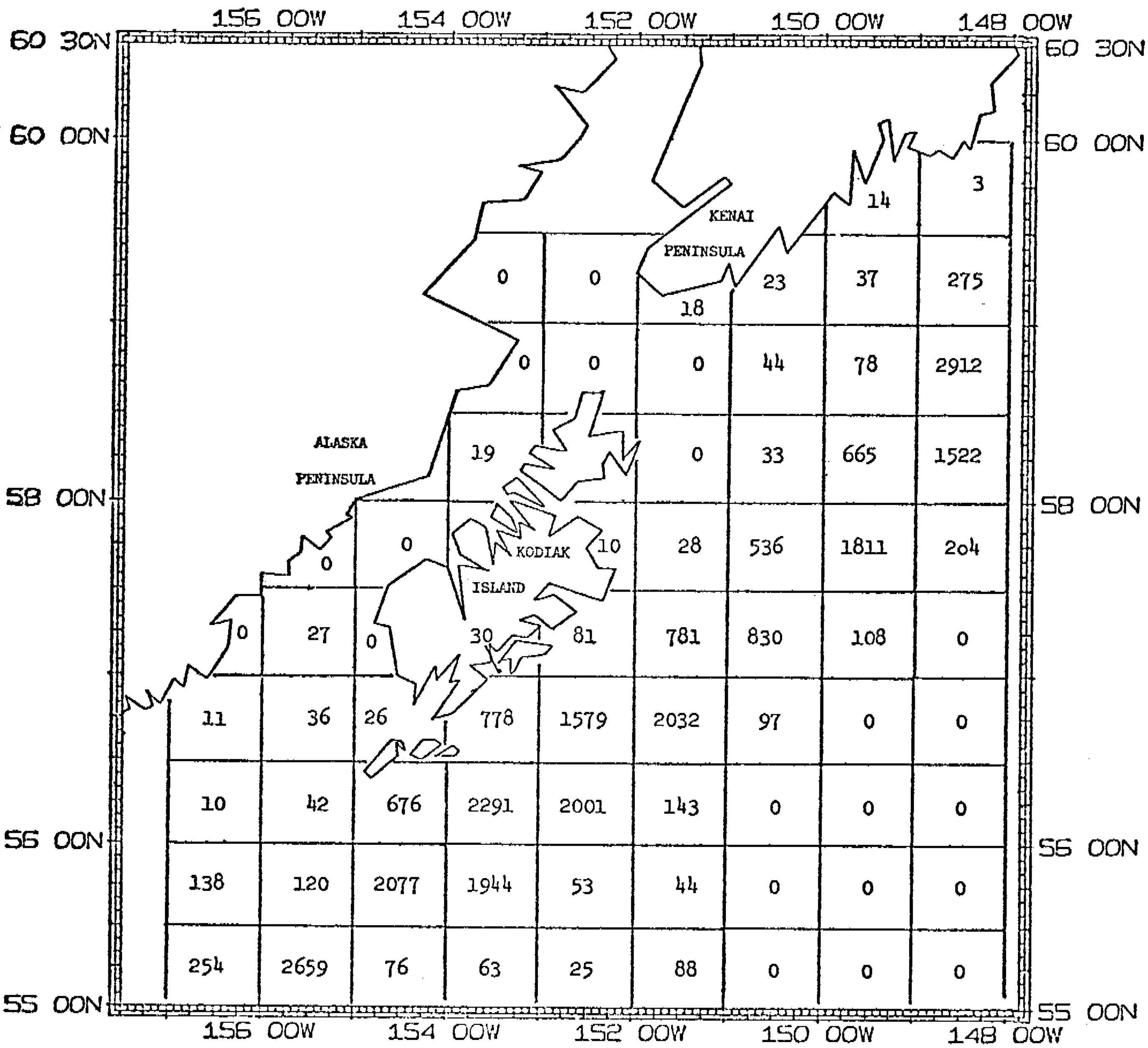

Figure 8 --Japanese demersal fish catch, all species and gears, in metric tons. Mean for the years 1964-1974.

QUARTERLY REPORT

Contract No. R7120802
Research Unit #175
Period October 1, 1976
to December 31, 1976

BASELINE STUDIES OF FISH AND SHELLFISH RESOURCES OF NORTON SOUND AND THE SOUTHEASTERN CHUKCHI SEA

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Research Unit 175-A-14

First Quarterly Report, October-December 1976

I. Task Objectives

The objectives of RU 175-A-14 are to determine the distribution and abundance of fish and shellfish resources in the southern Chukchi Sea and Norton Sound, and estimate the productivity, length, weight, and age distribution of selected demersal fish and shellfish species in order to develop growth models and to provide a data base against which later changes in these parameters may be compared.

II. Field and Laboratory Activities

A. Ship or field trip schedule

1. Ship surveys and personnel

a. Miller Freeman--September 27-October 13; Norton Sound and Northern Bering Sea; Mr. Norman Parks, Mr. Richard MacIntosh, Ms. Nikki Newcomb, Mr. Terrance Sample; all from Resource Assessment and Conservation Engineering Division, NWAFC, NMFS.

B. Methods

1. Ship cruises.--A stratified-systematic sampling design was used for the baseline demersal trawl survey. Station densities were established on the basis of potential for environmental impact. A 30-minute demersal trawl haul was made at each station to quantitatively examine demersal fish and shellfish stocks.

A qualitative assessment of near surface fish stocks was conducted with nightly gillnet sets and occasional pelagic trawling. Locations of gillnet sets were determined by the ship's progress along the cruise track line while pelagic trawling was on a target availability basis.

2. Laboratory activities.--Shore time during the first quarter was spent cataloging specimens obtained during the survey and preparing all data for submission to OCSEAP on magnetic computer tape. Over 1,000 man-hours have been spent checking data entries to insure their accuracy.

III. Results

The Norton Sound-Chukchi Sea demersal survey was successfully completed this quarter. During the 34 nontransit vessel working days in the survey area, 249 trawl hauls were made, including 8 pelagic and 44 replicate demersal tows (Figure 1). A total of 25 of the scheduled 240 demersal trawl stations were found to be untrawlable due to rough bottom. All other stations east of the continental shelf median line[1/] were successfully occupied. Thirty-three (33) gillnet sets also were performed (Figure 2).

Nearly 46,000 length measurements for use in establishing size composition were obtained from the following fish species:

Species	Number measured
Saffron cod (*Elginus gracilis*)	23,008
Arctic cod (*Boreogadus saida*)	3,722
Walleye pollock (*Theragra chalcogramma*)	359
Yellowfin sole (*Limanda aspera*)	6,002
Alaska plaice (*Pleuronectes quadrituberculatus*)	1,520

1/ - A boundary established by the 1958 International Convention of the Continental Shelf for dividing shelf areas adjacent to two territories, in this instance, between the U.S. and U.S.S.R.

Species	Number measured
Starry flounder (Platichthys stellatus)	1,140
Bering flounder (Hippoglossoides robustus)	137
Longhead dab (Limanda proboscidea)	56
Arctic flounder (Liopsetta glacialis)	45
Rainbow (toothed) smelt (Osmerus mordax dentax)	5,766
Pacific herring (Clupea harengus pallasi)	2,972
Capelin (Mallotus villosus)	841

Furthermore, length measurements were also taken from less frequently encountered species.

Independent length-weight-age information was collected on 6 species from the two designated portions of the survey area for otolith sampling. Approximately 1,850 length-weight measurements and otoliths were taken for the following species by region:

Species	North otolith area	South otolith area	Total
Saffron cod (Eliginus gracilis)	184	254	438
Pacific herring (Clupea harengus pallasi)	147	146	293
Yellowfin sole (Limanda aspera)	197	108	305
Rainbow (toothed) smelt (Osmerus mordax dentax)	152	55	207
Alaska plaice (Pleuronectes quadrituberculatus)	209	94	303
Arctic cod (Boreogadus saida)	142	161	303

Ninety-seven (97) stomach samples were collected from saffron cod (Eliginus gracilis) and rainbow (toothed) smelt (Osmerus mordax dentax). These stomachs were preserved in a formalin solution for subsequent analysis.

Various species of snails were also collected during the cruise. A total of 5,236 of the 16,366 individuals collected were preserved for laboratory examination.

IV. Preliminary Interpretation of Results

As was expected, demersal fish populations encountered in the survey region were small. Fish catches throughout the survey area averaged less than 100 pounds per 30-minute trawl haul. The shallower inshore areas were found to be more productive than deeper offshore waters. Average size of several fish and shellfish species taken in the survey region was noticeably smaller than sizes associated with eastern Bering Sea stocks of the same species. Representatives of the families Gadidae, Pleuronectidae, Osmeridae, Clupeidae, and Cottidae were the most commonly encountered fish fauna. Other less frequently taken families included Agonidae, Cyclopteridae, Zoarcidae, and Stichaeidae. Species composition generally did not vary between areas. Tables 1 and 2 summarize some preliminary catch findings by area and depth.

The Gadids represented a major portion of the catches. Arctic cod (Boreogadus saida) was the most common species in the Chukchi Sea and Kotzebue Sound, and their occurrence increased with depth. Saffron cod was the predominant species in the Norton Sound and had the largest average catch per trawl haul. They were, however, less frequently taken in the Chukchi Sea area.

Juvenile saffron cod were generally found to be restricted to the shallows in both areas. They occurred most frequently at depths of 0-25 meters and their density generally decreased with an increase in depth. Both percent occurrence and average weight caught, by depth, were greater in the Norton Sound region than in the Chukchi Sea.

The most frequently encountered Pleuronectid was Alaska plaice (Pleuronectes quadrituberculatus). Starry flounder (Platichthys stellatus) and yellowfin sole (Limanda aspera) also were frequently encountered, and were more commonly taken in the Norton Sound region than the Chukchi Sea. Both starry flounder and yellowfin sole appeared to be restricted to the shallower waters. Their incidence of occurrence and average catch weights dropped sharply with increased depths. Neither species were taken in waters over 50 meters.

Other frequently encountered fish species included rainbow smelt and Pacific herring (Clupea harengus pallasi). Smelt had approximately the same average catch weight in both areas but were more frequently encountered in the Norton Sound region. Conversely, Pacific herring were more common and had a greater catch rate in the Chukchi Sea than in the Norton Sound region.

Cottids were abundant throughout the entire survey area, being represented in nearly all demersal trawl hauls. The plain sculpin (Myoxocephalus joak), shorthorn sculpin (Myoxocephalus scorpius), antlered sculpin (Enophrys claviger) and Gymnocanthus sp. were the cottids most commonly encountered.

Commercially important invertebrate species encountered during the survey included Tanner crab (Chionoecetes opilio), two species of king crab (Paralithodes camtschatica and P. platypus) and several species of snails.

Chionoecetes opilio was the most commonly observed crab species throughout the survey area with the percent of occurrence increasing with depth. Generally, the catches consisted of juveniles with relatively few mature adults taken. Average catches by weight were considerably less than those obtained in the southern portions of the eastern Bering Sea. In the Norton Sound-Chukchi survey area, they were greater in the Chukchi Sea than in Norton Sound. Both species of king crab were present in both areas, but in much smaller numbers than C. opilio.

Snails were widespread in occurrence. The major species encountered included Neptunea heros, N. ventricosa, N. borealis, Beringius beringii, and Pyrulofusus deformis.

Gillnet and Pelagic

Gillnet operations proved to be very unproductive. Catches were small, ranging from approximately 55 fish to no catch. Sets made at inshore areas usually caught more than those made in offshore waters. Most fish were taken in the smaller mesh sizes with Pacific herring and rainbow smelt being the most common species. Other species taken in gillnets included: arctic char (Salvelinus alpinus), pink salmon (Oncorhynchus gorbuscha), and chum salmon (Oncorhynchus keta).

Pelagic trawl hauls were conducted on a random basis because no extensive off-bottom fish concentrations were encountered. Time limitations and equipment malfunctions restricted pelagic trawl operations. Catches were small and provided limited qualitative information. The largest pelagic trawl catch (15 fish) occurred near the entrance of Kotzebue Sound and included rainbow smelt, saffron cod, arctic char, and juvenile pink salmon.

V. Problems Encountered/Recommended Changes

Several species captured during the survey are relatively uncommon and species code numbers for these fish are not presently incorporated into the species code listing furnished by OCSEAP. Suggested codes have been submitted to Mr. Jim Audet of EDS. We are presently awaiting his confirmation of the new codes.

Table 1.--Catch rates (pounds per trawl haul) by area and depth interval for principal fish and shellfish species taken during *Miller Freeman* Cruise MF-76-B.

	CHUKCHI SEA AREA DEPTH (meters)				NORTON SOUND AREA DEPTH (meters)			
	0-25	26-50	>50	Total 1/	0-25	26-50	>50	Total 1/
Saffron cod (juv.)	0.5	0.8	0.01	0.6	7.8	3.3	<0.1	5.5
Saffron cod (adult)	1.6	4.0	--	2.6	31.1	17.6	--	23.7
Arctic cod	0.3	3.5	1.2	2.0	1.7	1.3	--	1.5
Yellowfin sole	1.2	0.2	--	0.5	4.0	0.7	--	2.5
Alaska plaice	2.1	0.8	--	1.1	6.2	1.2	<0.1	1.8
Starry flounder	2.5	2.6	--	2.2	26.3	5.0	--	7.6
Toothed smelt	1.2	2.5	--	1.7	1.3	1.7	--	1.4
Herring	2.6	8.7	--	5.4	0.8	0.9	--	0.8
Tanner crab	5.7	25.3	12.0	16.3	<0.1	3.6	3.5	1.7
King crab (*P. camtschatica*)	0.2	0.1	--	0.1	9.3	6.2	--	7.5
King crab (*P. platypus*)	--	0.3	--	0.1	--	2.5	6.1	1.4
Snail spp.	12.5	21.5	25.5	18.9	13.2	15.2	4.0	13.5

1/ Replicates and gillnets not included.

Table 2.--Percent occurrence by area and depth interval for principal fish and shellfish species taken during *Miller Freeman* Cruise MF-76- .

	CHUKCHI SEA AREA DEPTH (meters)				NORTON SOUND AREA DEPTH (meters)			
	0-25	26-50	50	Total[1/]	0-25	26-50	50	Total[1/]
Saffron cod (juv.)	69%	29%	10%	40%	78%	42%	0%	58%
Saffron cod (adult)	77	42	--	49	100	73	100	89
Arctic cod	65	87	100	81	86	83	--	79
Yellowfin sole	77	24	--	39	92	42	--	66
Alaska plaice	88	74	--	69	89	50	14	68
Starry flounder	54	21	--	30	78	35	--	55
Toothed smelt	77	58	--	57	86	62	--	71
Herring	65	61	--	54	48	50	--	38
Tanner crab	62	92	100	82	23	85	100	53
King crab (*P. camtschatica*)	1	5	--	3	66	25	--	45
King crab (*P. Platypus*)	--	5	--	3	--	35	71	19
Snail spp.	69	85	90	78	63	94	100	78

1/ Replicates and gillnets not included.

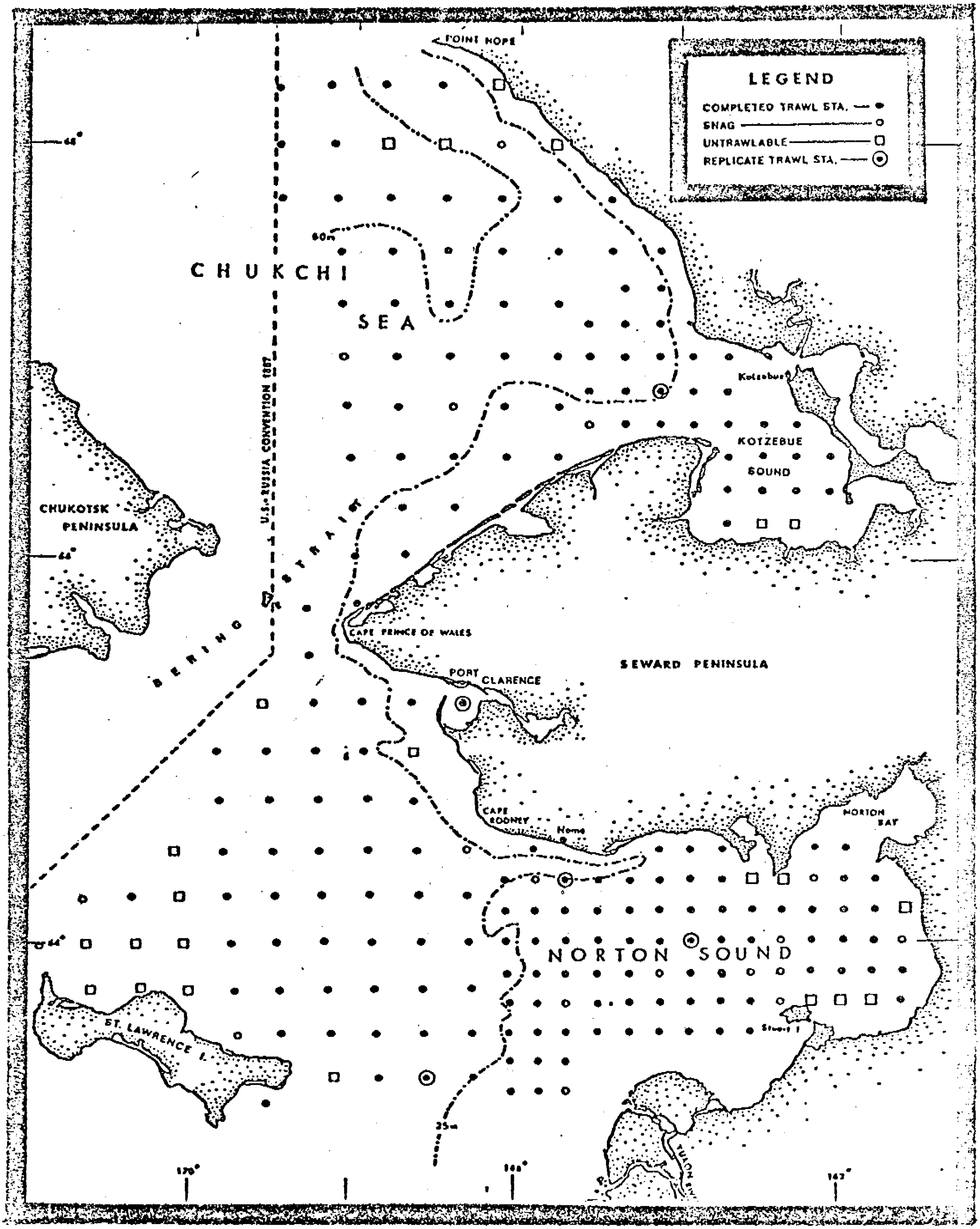


Figure 1.--Demersal trawl stations examined during *Miller Freeman* Cruise MF-76-B.

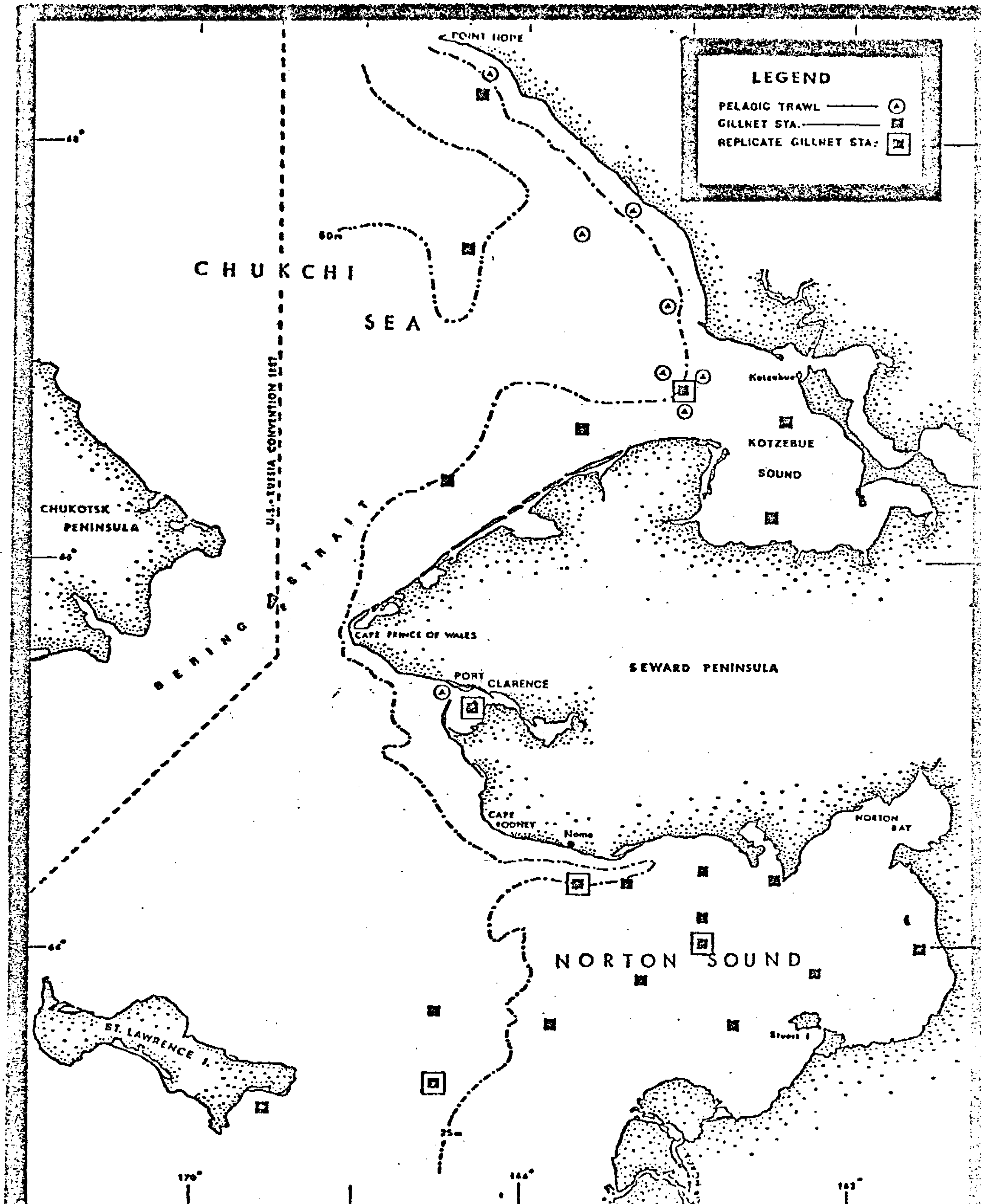


Figure 2.--Location of gillnet stations, pelagic trawl hauls and replicate gillnet sites during *Miller Freeman* Cruise MF-76-B.

Supplemental Reference for RU# 175

Pereyra, W. T., Reeves, J. E., and Bakkala, R. G. Demersal Fish and Shellfish Resources of the Eastern Bering Sea in the Baseline Year 1975. N.O.A.A. National Marine Fisheries Service/ Northwest Fisheries Center. 619 p. (and Data Appendices 534 p.) October 1976. (And Errata).

Quarterly Report

Contract #03-5-022-69
Research Unit #233
Reporting Period - October through December 1976
1 Page

Beaufort Sea Estuarine Fishery Study

Principal Investigator:

Terrence N. Bendock
Fisheries Biologist
Sport Fish Division
Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701

10 January 1977

I. Task objectives

The objectives of the Beaufort Sea Estuarine Fishery Study are as follows:

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 area's petroleum resource progresses.

II. Field or laboratory activities

There was no field work conducted under this contract during the reporting period. The analysis of data obtained during the summer field season is continuing in the laboratory and will hopefully be submitted in an annual report later this spring.

III. Results

The results of our 1976 field work will be submitted and discussed in our April 1977 annual report.

IV. Preliminary interpretation of results

None at the time.

V. Problems encountered/recommended changes

To date we have encountered no problems in conducting the field studies of this project.

Quarterly Report

Contract #03-5-022-56
Research Unit #281
Task Order #20
Reporting Period 10/1 - 12/31/76
Number of Pages 50

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

Dr. Howard M. Feder
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

January 1, 1977

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.

GRAB PROGRAM

II. Field and Laboratory Activities

A. A cruise was completed on board the *Miller Freeman* in Cook Inlet (*Miller Freeman* Leg III) for the period 17 October to 29 October, 1976 (See Fig. 1).

B. Scientific party on cruise:

1. H. M. Feder, Chief Scientist
2. S. Jewett, Research Assistant
3. A. J. Paul, Research Assistant
4. J. A. Cameron, Graduate Student.

C. A continuation of the analysis of samples taken in the past year is in progress at the Marine Sorting Center. All data is being keypunched as it becomes available. Refinement of computer programs for future analysis is in progress. The methods used in Cluster Analysis are outlined in the Annual Report for 1976 and are further discussed in the Quarterly Report of October 1, 1976.

D. Grab material from all stations occupied on R/V *Discoverer* cruise of March 1976 have been submitted to the Marine Sorting Center for processing.

III. Results

A. Northeast Gulf

Processing of these stations will complete the coverage of the Northeast Gulf Grid and results will be submitted when all data is available to permit seasonal comparisons.

B. Cook Inlet (see Cruise Report attached for more detail):

1. Thirteen stations (6, 18, 27, 28A, 31, 33, 37, 40, 42, 45, 46, 49, 54; see Fig. 1) were occupied with the van Veen grab. Five replicates were taken at each station.

2. Qualitative notes were recorded for some of these stations to more rapidly coordinate the grab data with pipe dredge data (see section in this report on Pipe Dredge data). Typically detailed information on clams was included in these notes.

IV. Preliminary Interpretation of Notes

No additional comments (see remarks in Quarterly Report of October 1976). Analysis and assessment of these analyses are still in progress as noted in the October 1976 Quarterly Report.

V. Problems Encountered

None.

TRAWL AND PIPE DREDGE PROGRAM

II. Field and Laboratory Activities

A. A cruise was completed in Cook Inlet 29 October 1976 (see details under GRAB PROGRAM).

B. The trawl and pipe dredge material collected on the above cruise in Cook Inlet was given a preliminary examination in this quarter; intensive examination will be initiated and continued in the next quarter.

C. Dominant clam species from Cook Inlet have been separated from trawl and pipe dredge samples and the material taken to the Seward Marine Laboratory where age and growth studies have begun under supervision of Judy Paul of IMS.

D. All trawl material from the Northeast Gulf is being organized into preliminary report form and as an IMS Technical Report.

E. Food web information is being compiled for Cook Inlet and the Northeast Gulf of Alaska.

III. Results

A. All trawl data from the Northeast Gulf of Alaska is being organized for the Final Report with the Alaska Science Conference paper, *The Distribution, Abundance and Diversity of Epibenthic Invertebrates of the Northeast Gulf of Alaska*, serving as a nucleus for this report.

B. Some specific data and some generalizations from the Northeast Gulf of Alaska trawl survey is being organized for submission in the next quarter as an IMS Technical Report entitled *The Distribution and Abundance of Some Epibenthic Invertebrates of the Northeast Gulf of Alaska with Notes on the Feeding Biology of Selected Species*.

C. Examination of notes from the Lower Cook Inlet cruise (see attached Cruise Report - App. I) has resulted in the organization of a preliminary food web (Fig. 2) and a series of distributional maps of selected common species (see attached maps - App. II).

D. Clam species from Cook Inlet have been aged and measured and all data recorded on computer forms prior to data printout:

(1) 673 *Tellina nuculoides* have been examined.

(2) 555 *Glycymeris subobsoleta* have been examined from one station with 553 of the individuals in the 0^+ to 1^+ year classes.

(3) *Macoma spp.* sorted out of many samples for aging-growth studies.

E. Lower Cook Inlet Workshop attended in November 1976 resulted in a fruitful exchange of information.

IV. Preliminary Interpretation of Results

A. General interpretations of Grab and Trawl data are included in the 1976 Annual Report and the manuscript report attached to the Quarterly Report of October 1976.

B. Preliminary examination of a Cook Inlet food web has indicated that polychaetes, clams, snails, amphipods, shrimp, crabs, and barnacles are common food items. An important finding is the identification of several deposit feeding clam species as important food items for crab and demersal fishes.

C. Another important find of the Cook Inlet cruise of this quarter is the finding of 0^+ and 1^+ year classes of several common species of clams (i.e., *Tellina nuculoides, Glycymeris subobsoleta*, several *Macoma spp., Spisula polynyma*, and *Serripes groenlandicus*)

V. Problems Encountered

No direct problems, however, it is important to point out that we are now just beginning to develop good feelings for benthic tropic interactions in Lower Cook Inlet. Additional on-ship feeding studies (as accomplished on the cruise of this quarter on the Miller Freeman) are essential to complete the food web picture as well as to understand seasonal food habits of important species. It is highly recommended that an additional short trawling cruise be planned for the spring of 1977 where all feeding data will be generated on shipboard. It is possible that only modest additional funding will be needed - a small amount of travel money and shipboard overtime pay. No additional time will be needed at Fairbanks since all data will be generated in the field.

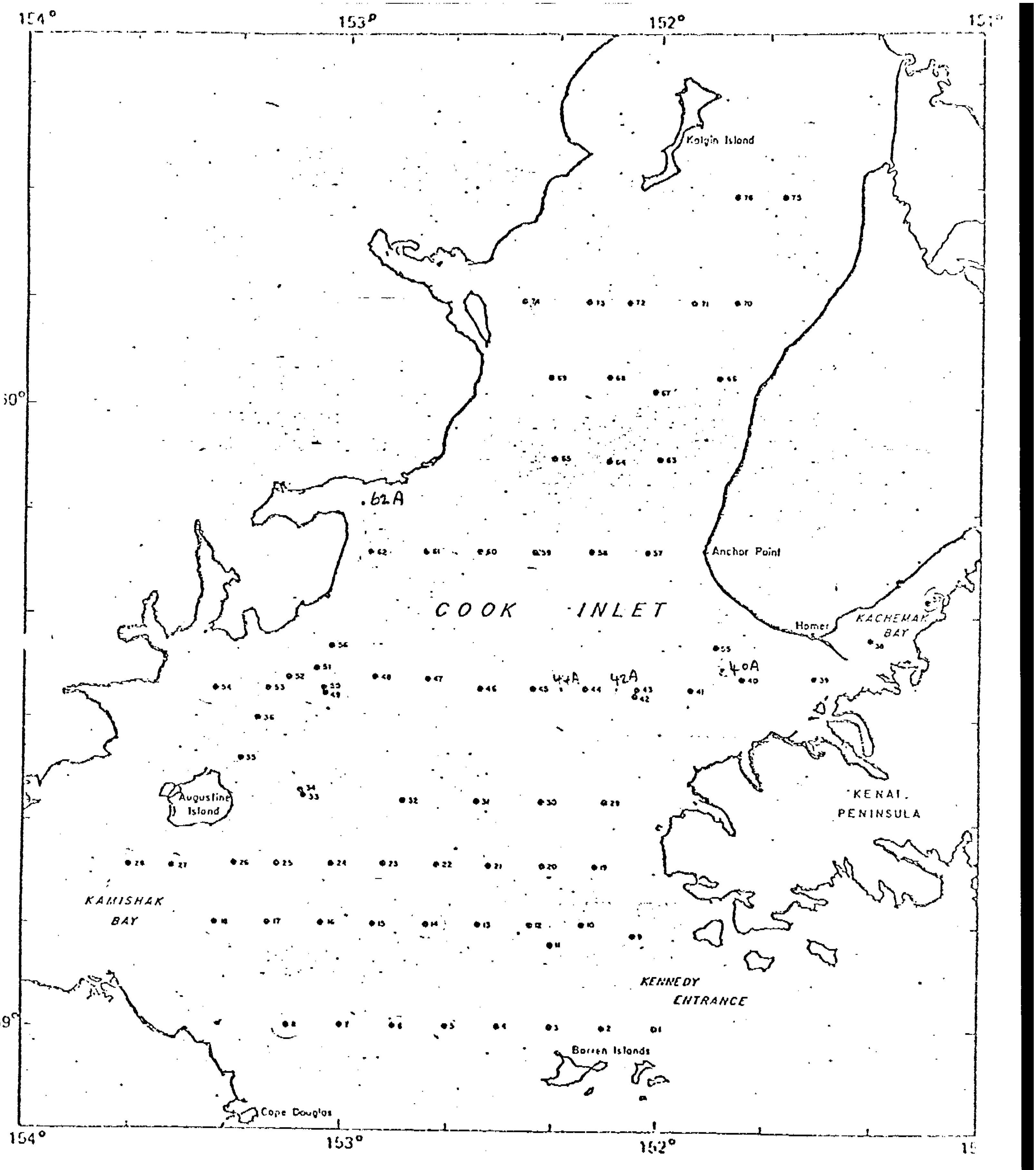


Fig. 1 The benthic biological grid available for sampling in Cook Inlet.

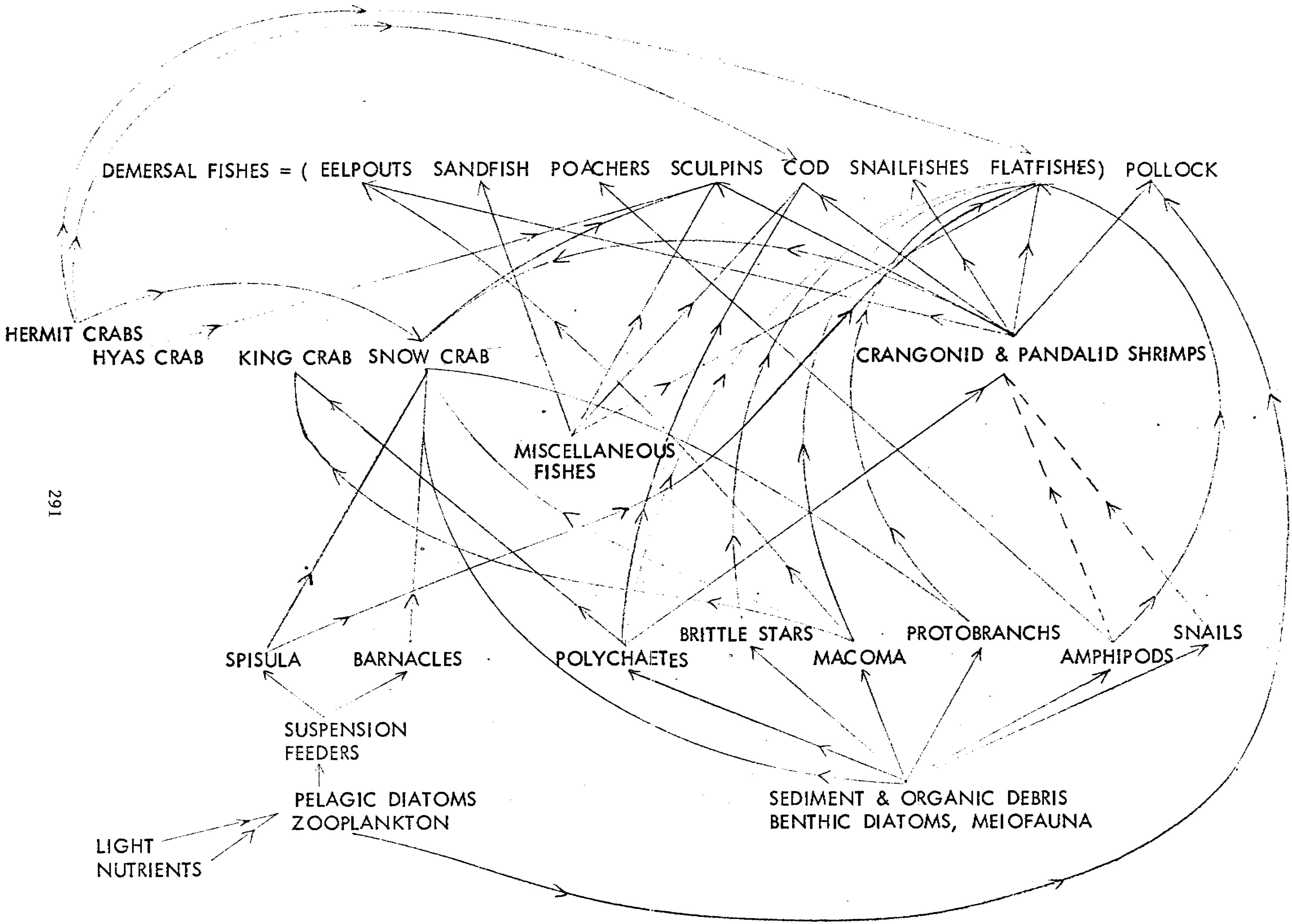


Fig. 2 A preliminary food web for the benthos of Cook Inlet.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 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 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	1/31/77	None
Discoverer Leg IV #812	10/8/75	10/16/75	submitted	None
North Pacific	4/25/75	8/7/75	None	submitted
Discoverer #816	11/23/75	12/2/75	(b)	None
Contract #03-5-022-34	Last	Year	submitted	
Moana Wave	3/30/76	4/15/76	submitted	
Discoverer 001	3/17/76	3/27/76	(b)	
Miller Freeman			(b)	

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

(a) Only samples for Kodiak area were processed and submitted as requested.

(b) Selected samples will be processed in FY '77 pending continuation and funding for this project.

APPENDIX I

Cruise Report for *Miller Freeman*

in Cook Inlet

17 October to 29 October 1976

NOAA SHIP MILLER FREEMAN FRS-21

Cruise Report
RP-4-MF-76B Leg III
10/17/76 - 10/29/76

Title: The distribution and abundance of Marine Benthic Invertebrates in the Gulf of Alaska

Personnel: Howard M. Feder, Principal Investigator
Stephen Jewett, Research Assistant
A. J. Paul, Research Assistant
Jane Anne Cameron, Graduate Student

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Objectives of Cruise: To conduct a continuing benthic biological survey in the lower Cook Inlet area (an extensive embayment of the Gulf of Alaska).

Methods:

1. Sampling gear.

   a. An attempt was made to occupy twelve (12) stations quantitatively by way of replicate sampling (5 grabs) with a $0.1m^2$ van Veen grab.

   b. A pipe dredge (14 inches x 36 inches) was used at every station when seas and weather permitted.

   c. Two types of dragging gear were employed whenever bottom was suitable for each type of gear and weather permitted. Agassiz or Sixby trawl (6.5 ft. x 18 inches opening at mouth) and a large commercial trawl (ship's equipment).

   d. A clam dredge was used on three occasions on sand-bottom stations.

2. Processing of material.

   a. Grab and pipe dredge material was washed on deck with sea water on a 1.0 mm screen. All obvious species were enumerated and recorded during the sorting process. All of the sorted specimens and remaining debris from the grab samples were preserved in formalin for further processing at the Marine Sorting Center, University of Alaska, Fairbanks. Screened residues from pipe-dredge samples taken at stations with large amounts of shell or gravel were carefully examined in the screens, specimens removed and preserved, and the large amount of debris or gravel remaining discarded. An aliquot sample of this debris was typically saved and preserved. Pipe dredge material will be examined in more detail in the laboratory at the Institute of Marine Science, University of Alaska.

b. *Material taken by trawl was separated into buckets, sorted in the laboratory on the ship, and each species counted and weighed. Information on reproductive biology of shrimps and crabs were recorded. In addition, various species were measured and others examined for food items. All material was then preserved in formalin.*

c. *The material taken by clam dredge was sorted into species, each species enumerated and weighed, and all material preserved in formalin.*

Results:

A. *Grab Stations*

1. *Thirteen stations (6, 18, 27, 28A, 31, 33, 37, 40, 42, 45, 46, 49, 54: See Fig. 1) were occupied within Cook Inlet with the van Veen grab. Five replicate samples were taken at each station.*

2. *Qualitative notes were recorded for some of these stations; further detailed analysis will be accomplished at the Marine Sorting Center at the University of Alaska.*

   a. *Station 31: The clam Tellina nuculoides occurred in each replicate sample.*

   b. *Station 18: The clam Macoma sp. occurred in each replicate sample.*

   c. *Station 33: Macoma sp. occurred in all of the replicates.*

   d. *Station 28A (a new station): all grabs appeared to be consistent, with the protobranch clam Yoldia hyperborea, Macoma spp., the clam Musculus sp., polychaetous annelids and amphipods present in each replicate.*

   e. *Station 6: All grabs consistently showed the protobranch clam Nuculana to be present; Macoma was also obvious in all replicates.*

3. *Typically material from van Veen grabs at all microbiological stations was washed and preserved.*

4. *One additional 5-grab station was occupied while the ship was at anchor at Kukak Bay off Shelikof Straits.*

B. *Pipe-Dredge Stations*

1. *A pipe-dredge sample was taken at all grid stations occupied and at various other selected stations (primarily stations occupied by the zooplankton and microbiology groups).*

2. *A total of 60 pipe dredge samples were collected. All specimens in these samples were examined, enumerated and weighed before formalin preservation of the material.*

C. *Clam dredge stations*

1. *This piece of gear was used at three stations.*

2. *No clam areas were sampled successfully by the rather shallow penetration of the dredge. The appearance of siphons of large clams and occasional aggregates of large clams at various stations suggests that hydraulic clam sampling gear be used in the future.*

3. *The clam dredge successfully sampled a wide variety of infaunal and epifaunal invertebrates and proved to be a useful piece of gear when used in conjunction with the pipe dredge and a trawl.*

D. *Trawling Activities*

Eighteen (18) demersal trawls were made at 16 stations in lower Cook Inlet. Two (2) trawls were made at stations 40A and 53 for more extensive coverage. Most demersal trawls were made in the western section of the study area and only two stations were obtained north of Anchor Point. Preliminary analysis delineated at least 59 species of benthic invertebrates and 32 species of fishes (See Table I). Invertebrates were dominated by the snow crab Chionoecetes bairdi and fishes were dominated by the flat fishes. Areas of greatest diversity occurred at stations 5, 25 and 40A. Stomachs of Chionoecetes bairdi were collected from 12 stations and fish stomachs were collected from 15 stations.

Agassiz trawls were made at eight stations. This trawl was used on bottoms that were marginal or too rough for demersal trawling and used specifically to obtain the smaller epibenthic organisms.

E. *Additional accomplishments*

1. *Seven species of clams and one species of mussel were intensively collected at selected stations - Glycymeris subobsoleta, Tellina nuculoides, Macoma sp., Spisula polynema, Serripes sp., Nuculana fossa, Yoldia hyperborea, and Modiolus sp. This is the second collection in six months for some of these clams, and it is now a certainty that age and growth analysis can be accomplished on most of these species. Most of these clams are very common in Kachemak Bay and vicinity.*

2. *Critical biological areas and high diversity stations were once again identified.*

3. *The intensive stomach analysis pursued on crabs and fishes should lead to rapid comprehension of major trophic links in Cook Inlet.*

General Comments:

The cruise was an extremely successful one. The 24-hour ship operation made it possible to broadly sample the benthic biological grid. The ability of Captain J. T. Atwell to navigate the MILLER FREEMAN close inshore made it possible for us to occupy additional inshore stations; something that was lacking in our cruise of the Spring of 1976. In addition, the competence of the officers and crew as well as the MILLER FREEMAN's stability, made it possible for us to successfully operate under severe weather conditions that plagued much of our cruise period.

I cannot offer enough praise for the men of the MILLER FREEMAN. Captain Atwell was always in complete command of all situations, forever pleasant, and most cooperative in all scientific activities. He most effectively integrated all scientific activities. Special commendation should also be given to Lt. Commander Warren Taguchi for his availability and help at all times. The survey technicians were most effective, and extremely helpful throughout and during all weather conditions. We could not have sampled so extensively without their help. We would also like to thank Andy Ness and his fishing crew for their most competent performance under all weather conditions. The officers of the ship were always effective, helpful and good companions. Each member of the crew should also be commended for their individual efforts - always accomplished with good cheer. The morale of the ship is obviously at the highest level - this despite many weeks under cold and rigorous conditions. Once again, a reflection of the high quality of leadership of its officers. The food was always excellent and tastefully prepared. Chief Steward Ben Presley is to be congratulated on the never-ending dining delights of the MILLER FREEMAN; his skills and those of his staff were appreciated by the scientific group.

The station coverage and biological material now available should make it possible to assess some of the critical areas in Cook Inlet.

Suggestions:

I have no suggestions concerning the MILLER FREEMAN; it is undoubtedly the best ship for biological research that I have been associated with.

I would like to suggest that the OCSEAP group responsible for planning ship schedules be more responsive to Principal Investigators' request for ship-time in the late Fall and Winter months. Most of us have operated during these periods in the past, and are fully aware of the need for built in "downtime" on cruises during these turbulent periods. At a past meeting in Seattle we all responded to Lou Butler's request concerning our estimate *for lost sea days during various seasons; however, our comments did not seem to be seriously considered. I had suggested 14-17 days for my Cook Inlet cruise. As it turned out we lost approximately two and one half days due to bad weather, and an additional two days would have permitted us to even more successfully occupy the stations on our grid. Time loss prevented us from returning to stations that offered promising biological data useful to OCSEAP.*

Table I. A SPECIES LIST FOR LOWER COOK INLET
COMMERCIAL TRAWL
October 1976

Invertebrate Taxon

Porifera

Hydrozoa

Ptilosarcus gurneyi

Actiniidae

Tealia crassicornis

Polychaeta

Polynoidae

Chlamys

Pecten caurinus

Clinocardium nuttallii

Serripes groenlandicus

Spisula polynyma

Fusitriton oregonensis

Beringius kennicotti

Neptunea lyrata

Pyrolofusus harpa

Arctomelon stearnsii

Nucella lamellosa

Dorididae

Balanus sp.

Pandalus borealis

Pandalus goniurus

Pandalus hypsinotus

Hippolytidae

Invertebrate Taxon

Lebbeus

Crangonidae

Crangon dalli

Argis dentata

Argis crassa

Pagurus capillatus

Pagurus ochotensis

Pagurus aleuticus

Pagurus kennerlyi

Pagurus confragosus

Pagurus

Elassochirus tenuimanus

Elassochirus cavimanus

Paralithodes camtschatica

Oregonia gracilis

Hyas lyratus

Chionoecetes bairdi

Cancer magister

Cancer oregonensis

Flustra

Flustrella

Terebratalia transversa

Ceramaster patagonicus

Mediaster aequalis

Henricia sp.

Pteraster tesselatus

Crossaster papposus

Evasterias (2 species)

Invertebrate Taxon

Leptasterias sp.

Lethasterias nanimensis

Strongylocentrotus droebachiensis

Strongylocentrotus franciscannus

Gorgonocephalus caryi

Cucumariidae

Urochordata

Fish Taxon

Squalus acanthias

Raja kincaidi

Raja rhina

Osmerus mordax dentex

Mallotus villosus

Clupea harengus pallasi

Cyclopteridae

Gadus macrocephalas

Microgadus proximus

Theragra chalcogramma

Lycodes brevipes

Lycodes palearis

Anoplopoma fimbria

Cottidae

Dasycottus setiger

Myoxocephalus polyacanthocephalus

Hemilepidotus jordani

Gymnocanthus (2 species)

Fish Taxon

Agonus acipenserinus

Astrotheca alascana

Bathymaster signatus

Trichodon trichodon

Pleuronectes quadrituberculatus

Atheresthes stomias

Limanda aspera

Glyptocephalus zachirus

Hippoglossoides elassodon

Hippoglossus stenolepis

Lepidopsetta bilineata

Platichthys stellatus

Pleuronectidae

TABLE 1. DEMERSAL TRAWL SUMMARY

PROJ STA.	GRID NO.	DATE	TIME (GMT)
001	8	292	1721
002	7	292	1938
033	14	294	0320
037	54	294	1527
036	53	294	0428
042	27	295	1656
044	28	296	0116
041	18	296	0520
052	41	297	0259
054	40A	297	0733
069	70	298	0036
073	76A	298	0433
094	62A	298	0242
036	53	299	0402
046	25	299	1525
034	23	299	1742
006	5	302	0833
054	40A	303	2040

TABLE 2. UNTRAWLABLE STATIONS

DATE	GRID NO.
293	9
293	19
294	21
296	37
296	39
297	40
297	42
297	63
298	72
298	75
298	64
299	61
299	46

TABLE 3. AGASSIZ TRAWL SUMMARY

PROJ STA.	GRID NO.	DATE	TIME (GMT)
038	35	294	0532
038	35	294	0611
049	37	296	2004
096	49	299	0547
001	8A	300	0253
001	8C	300	0448
001	8D	300	0543
006	5	302	0059
131	5A	302	0242
005	6	302	0451
131	5A	302	0550
006	5	302	0918

TABLE 4. VAN VEEN GRAB SUMMARY

PROJ STA.	GRID NO.	DATE	REMARKS
008	OSU "C"	293	OSU/UL
017	OSU "H"	293	OSU/UL
022	31	293	IMS
025	OSU "G"	293	OSU/UL
037	54	294	IMS
039	Iniskin Bay	294	IMS
037	54	295	IMS
035	33	295	IMS
041	18	295	IMS
042	27	295	IMS
043	28A	295	IMS
044	28	296	IMS
044	OSU "E"	296	OSU/UL
041	18	296	IMS
047	46	296	IMS
049	37	296	IMS
051	OSU "L"	297	OSU/UL
051	40	297	IMS
052	41	297	IMS
056	OSU "M"	297	OSU/UL
058	45	297	IMS
068	OSU "R"	297	OSU/UL
096	49	299	IMS
097	OSU "F"	299	OSU/UL
098	OSU "EE"	299	OSU/UL
044	OSU "E"	299	OSU/UL
119	Kukak Bay	301	IMS
005	6	302	IMS
132	OSU "B"	302	OSU/UL
053	42	303	IMS

TABLE 5. PIPE DREDGE SUMMARY

PROJ STA.	GRID NO.	DATE	TIME (GMT)
001	8	292	1608
005	6	292	2134
006	5	292	2303
008	OSU "C"	293	0127
011	UW 1	293	0421
012	4	293	0559
013	3	293	0730
014	2	293	0841
015	9	293	1051
016	19	293	1218
018	30	293	1517
019	29	293	1642
022	31	293	1829
028	21	294	0024
031	12	294	0139
033	14	294	0408
033	14	294	0452
034	23	294	0750
035	33	294	0901
036	53	294	1008
037	54	294	1110
038	35	294	1316
041	18	295	1444
042	27	295	1656
044	28	296	0254
045	16	296	0907
046	25	296	0959
047	46	296	1233
049	37	296	2058
051	40	297	0052
052	41	297	0412
052	41	297	0424
052	41	297	0434
053	42	297	0600
053	42	297	0606
053	42	297	0616
054	40A	297	0840
056	OSU "M"	297	1142
057	44	297	1246
058	45	297	1356

TABLE 5. PIPE DREDGE SUMMARY (con't.)

PROJ STA.	GRID NO.	DATE	TIME (GMT)
059	57	297	1647
062	63	297	1807
065	68	297	2020
065	68	297	2030
068	66	297	2237
069	70	297	2359
070	72	298	0226
072	76A	298	0355
074	75	298	0717
075	UW 4	298	0936
078	74	298	1700
083	69	298	1815
086	64	298	1915
089	59	298	2010
090	60	298	2104
094	62A	298	2327
095	61	299	0019
096	49	299	0530
097	OSU "F"	299	0911
025	OSU "G"	299	1915
106	47	299	2106
139	UW 2	303	0913
140	44A	303	1057
057	44	303	1144
141	42A	303	1211
142	55	303	1506

TABLE 6. CLAM DREDGE SUMMARY

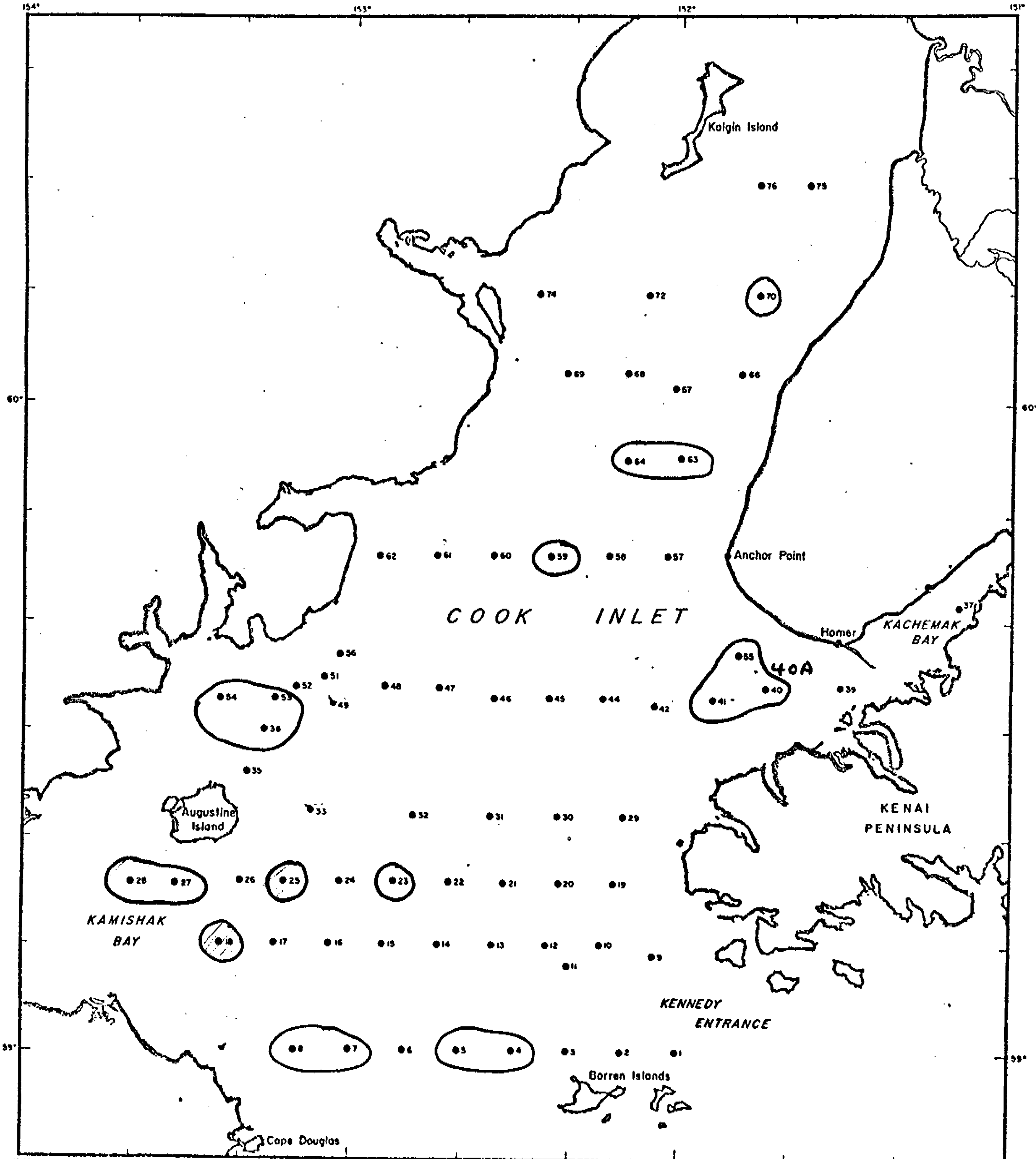
PROJ STA.	IMS GRID NO.	DATE	TIME (GMT)
052	41	297	0447
057	44	297	1305
096	49	299	0647
054	40A	303	1409
054	40A	303	1700
054	40A	303	1746
054	40A	303	1807

APPENDIX II

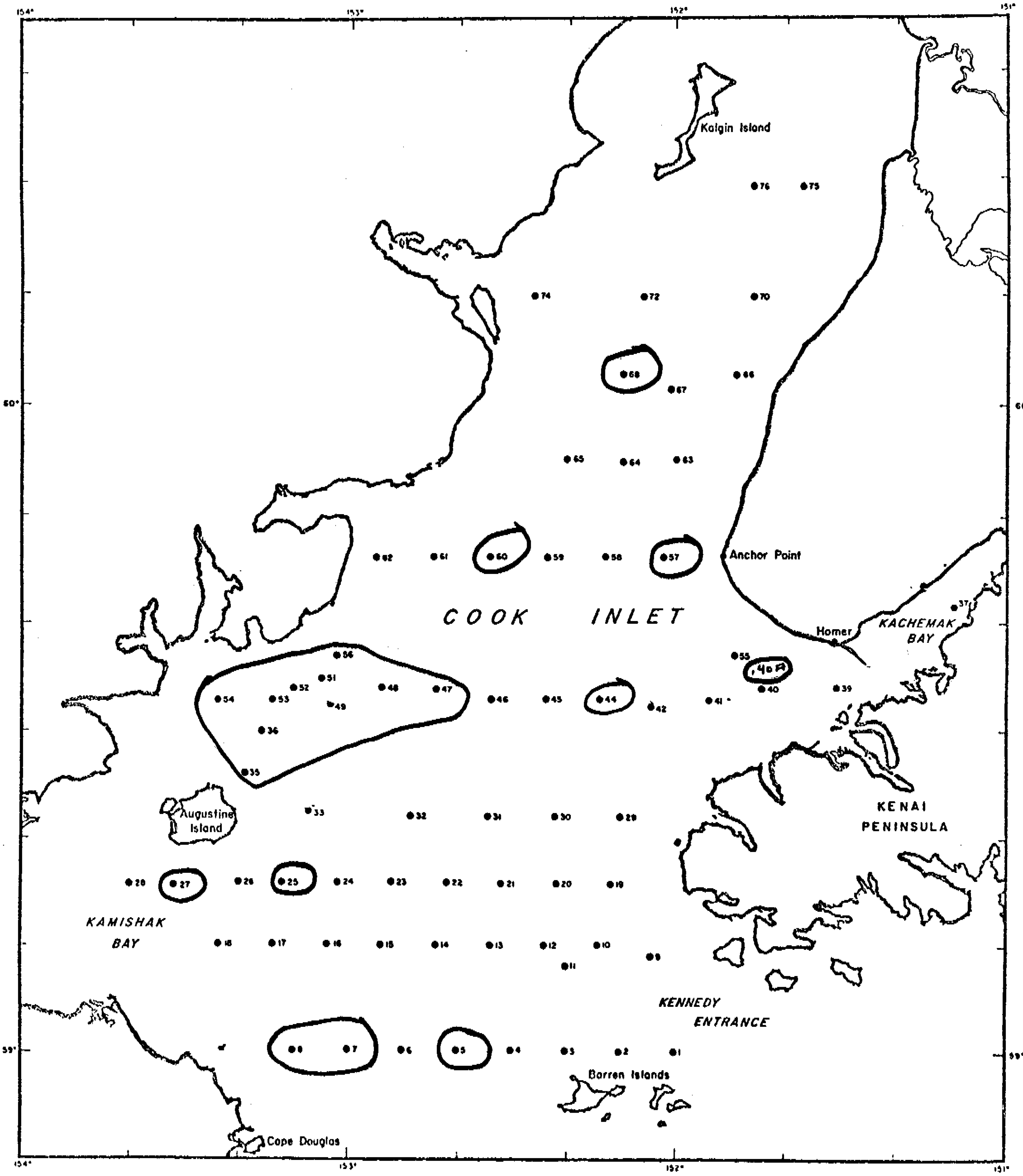
Preliminary Distributional Maps of Common Benthic Species

Based on *Moana Wave* and *Miller Freeman* cruises of 1976.

Data from other sources have not been included in these maps.



Neptunea lyrata



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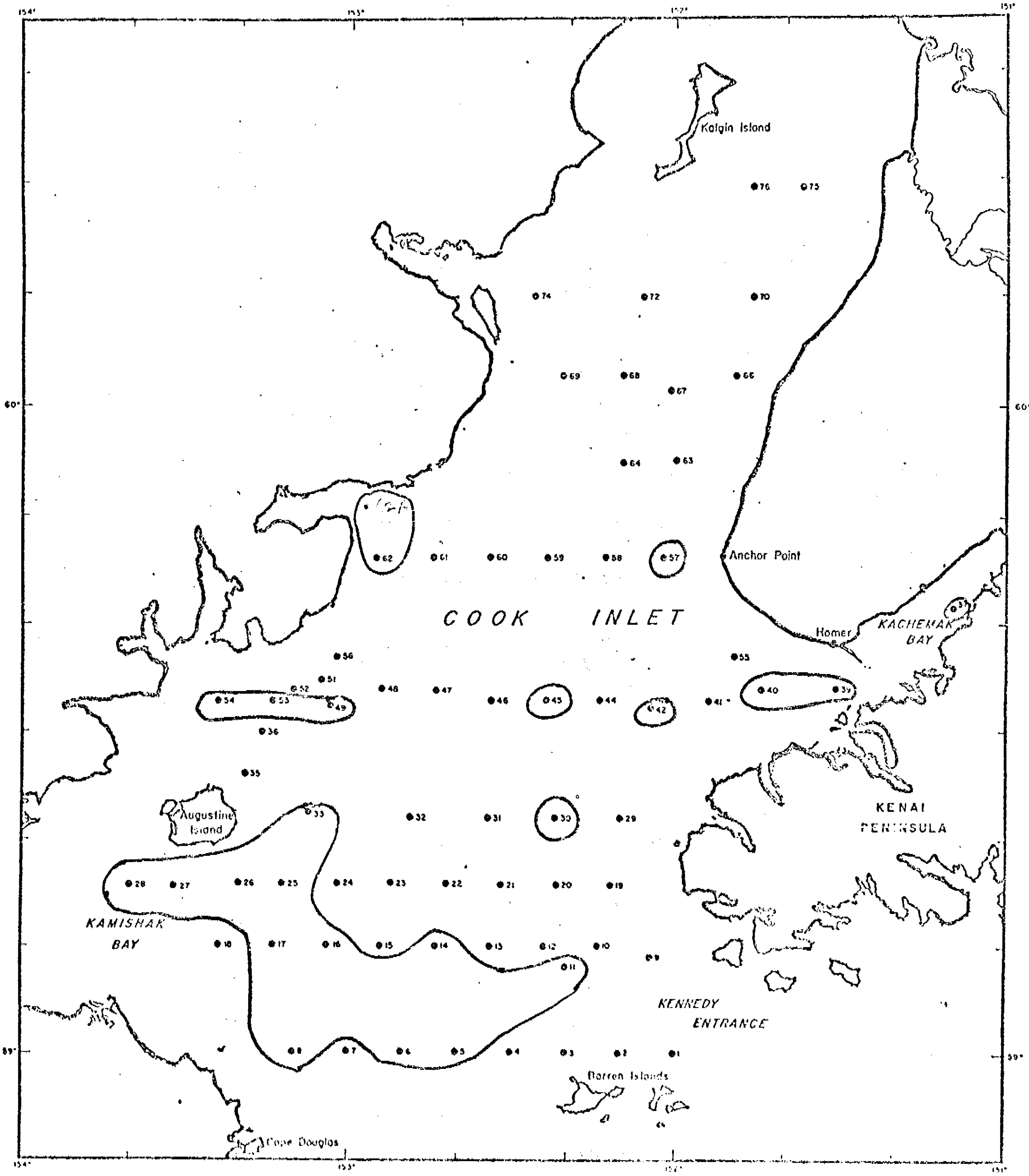
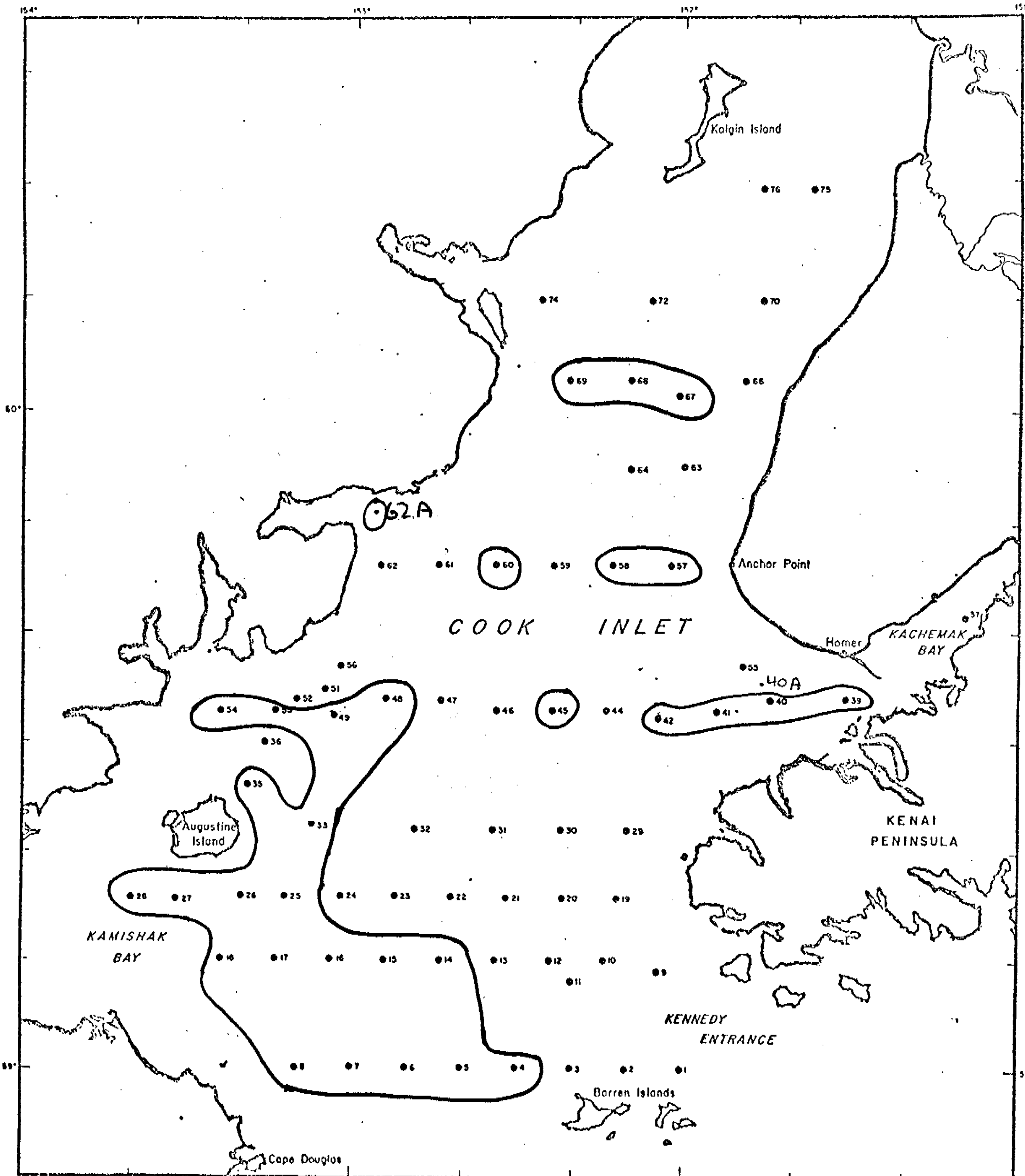
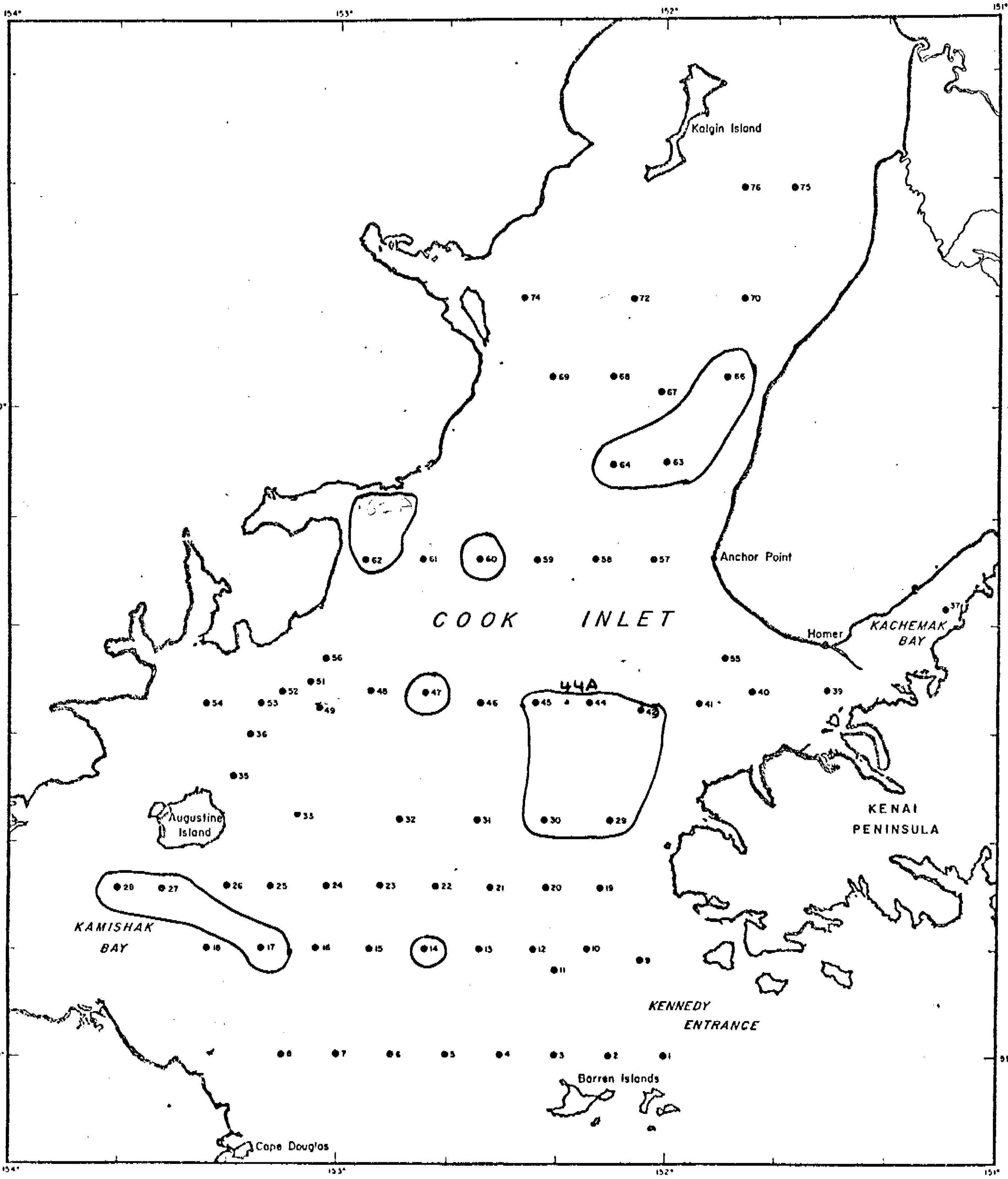


Nuculana fossa

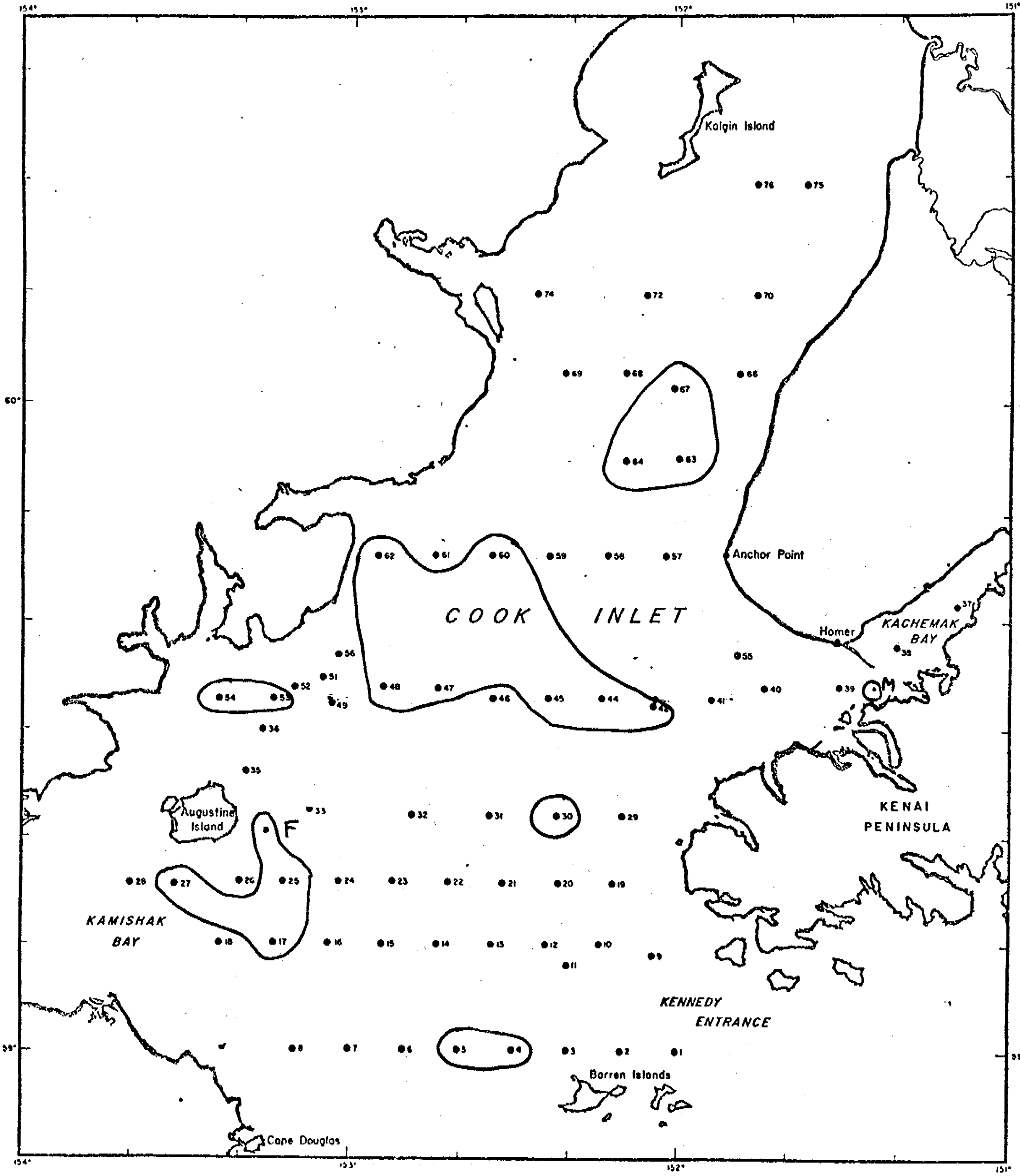


Kalgin Island
COOK INLET
Anchor Point
Homer
KACHEMAK BAY
KENAI PENINSULA
Augustine Island
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas
62A
40A

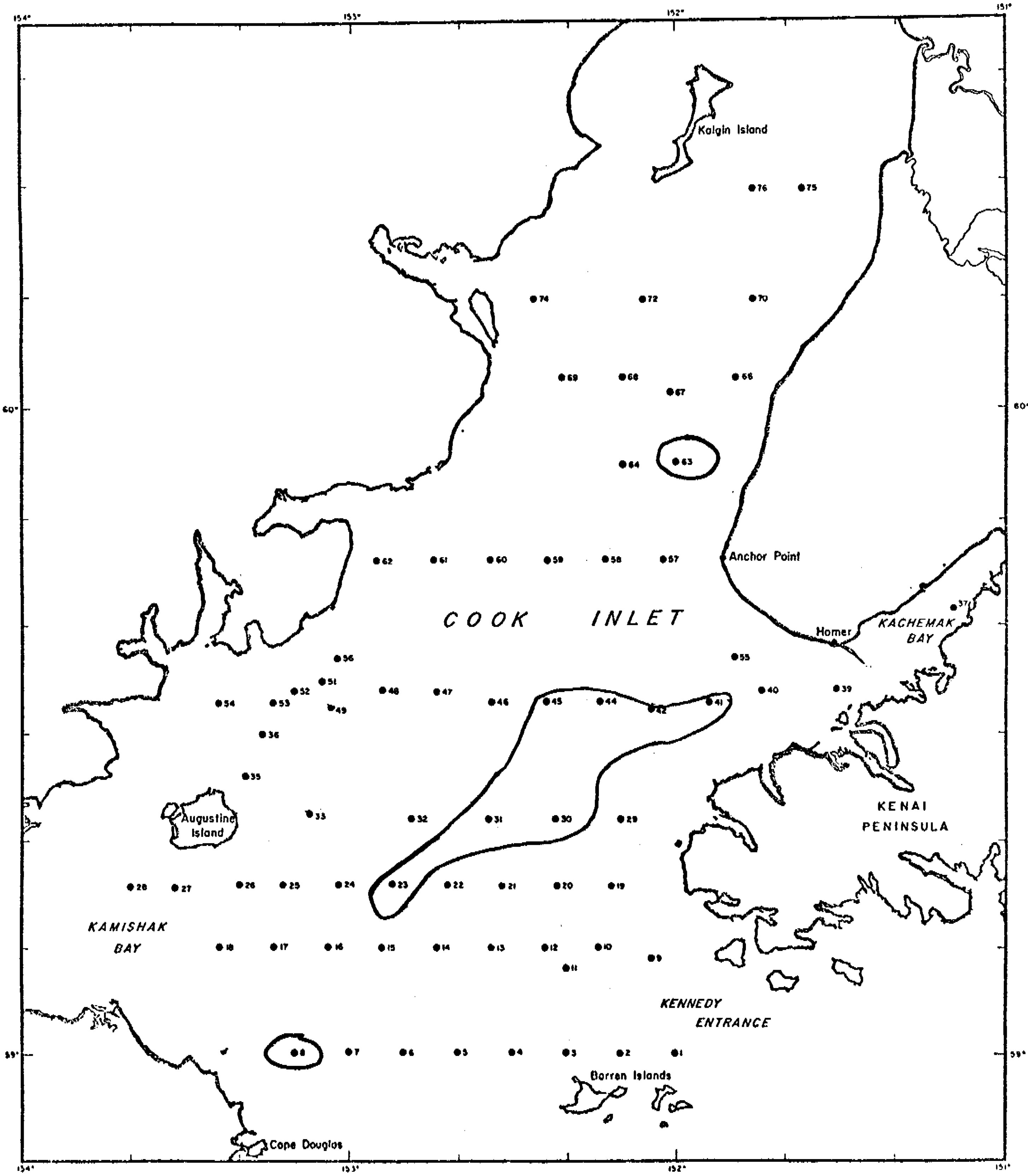
Macoma spp



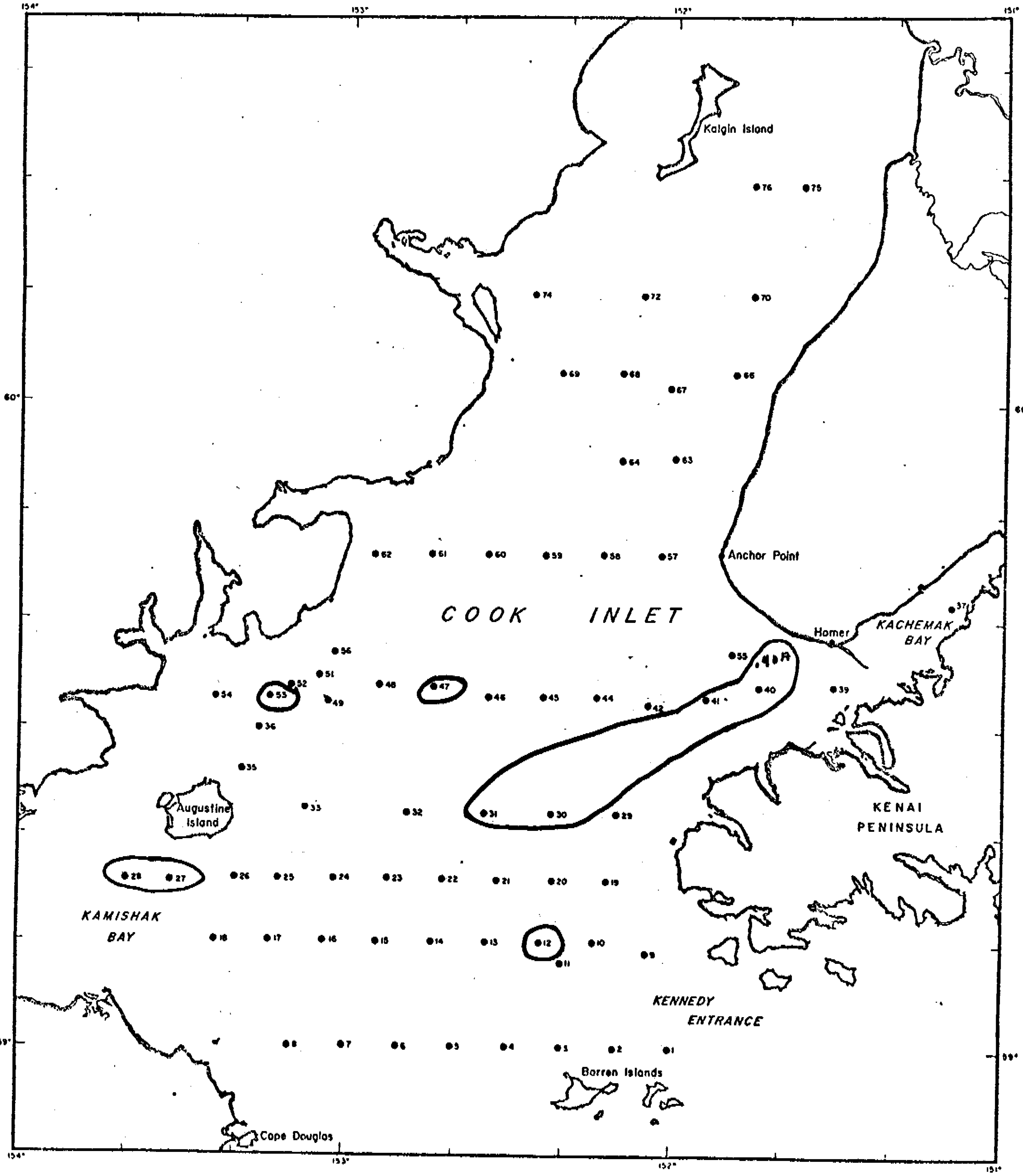
Glycymeris subobsoleta


Kalgin Island
COOK INLET
Anchor Point
Homer
KACHEMAK BAY
KENAI PENINSULA
Augustine Island
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas
F

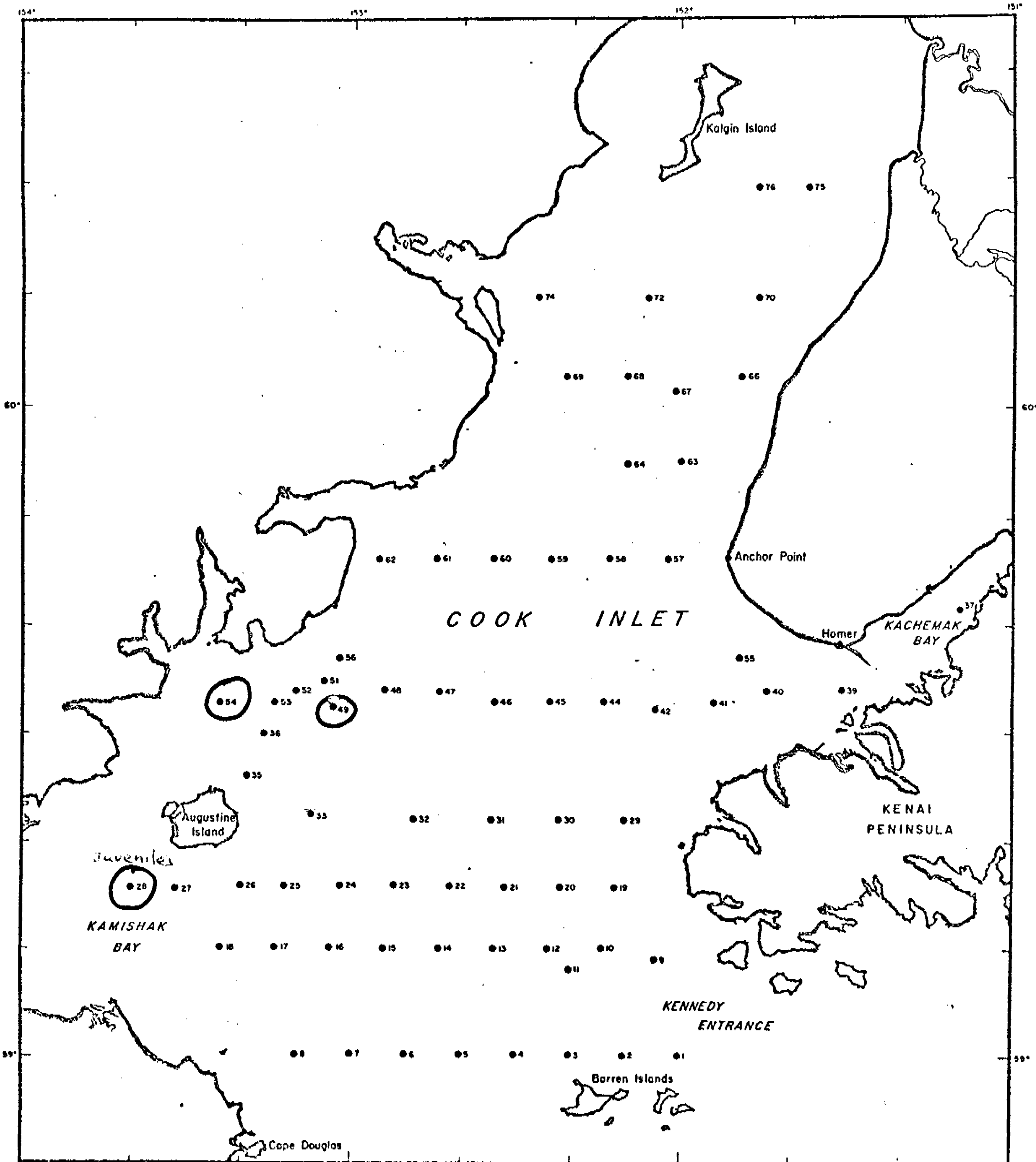
Astarte sp.



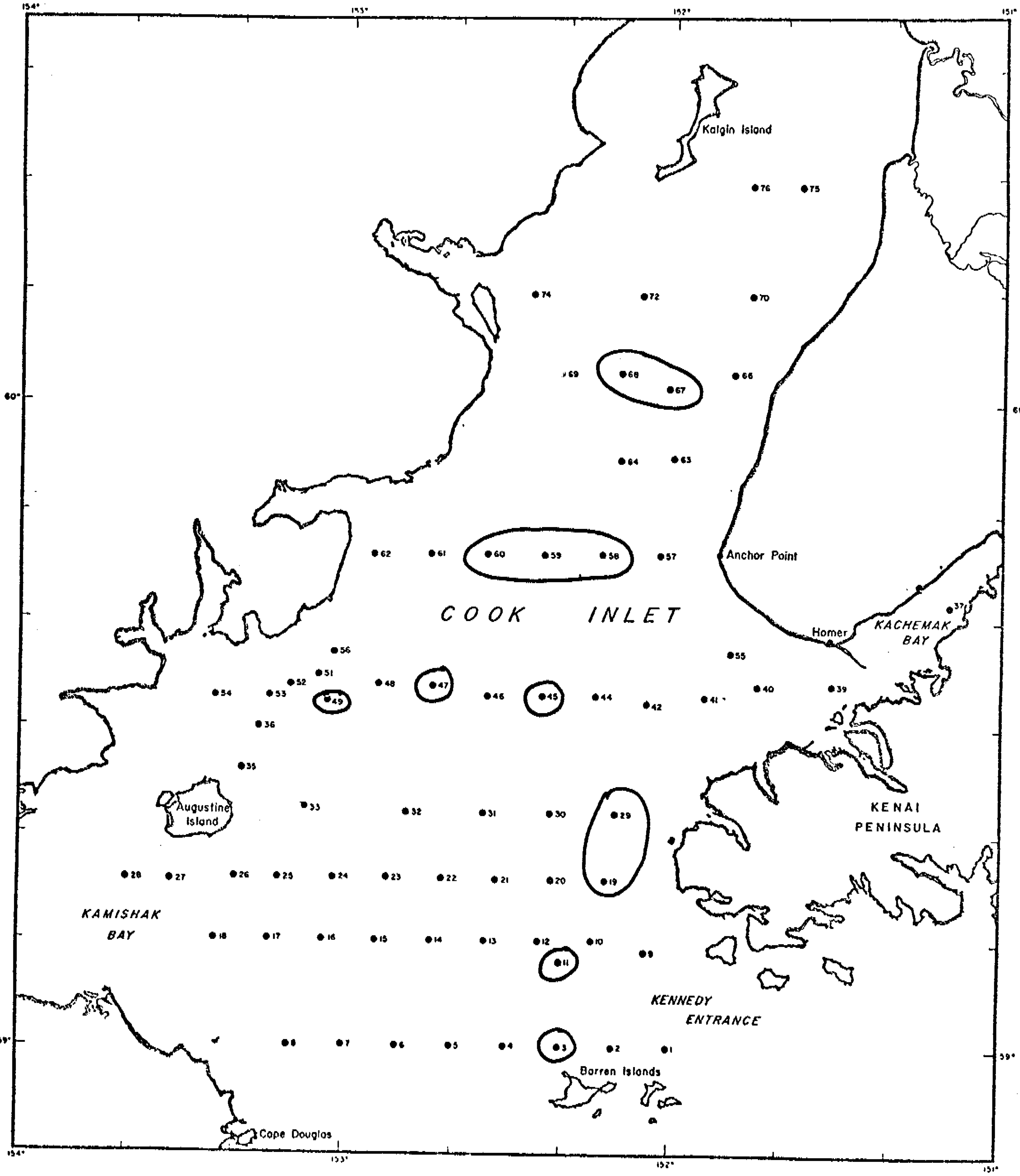
Tellina nuculoides



Spisula polynyma

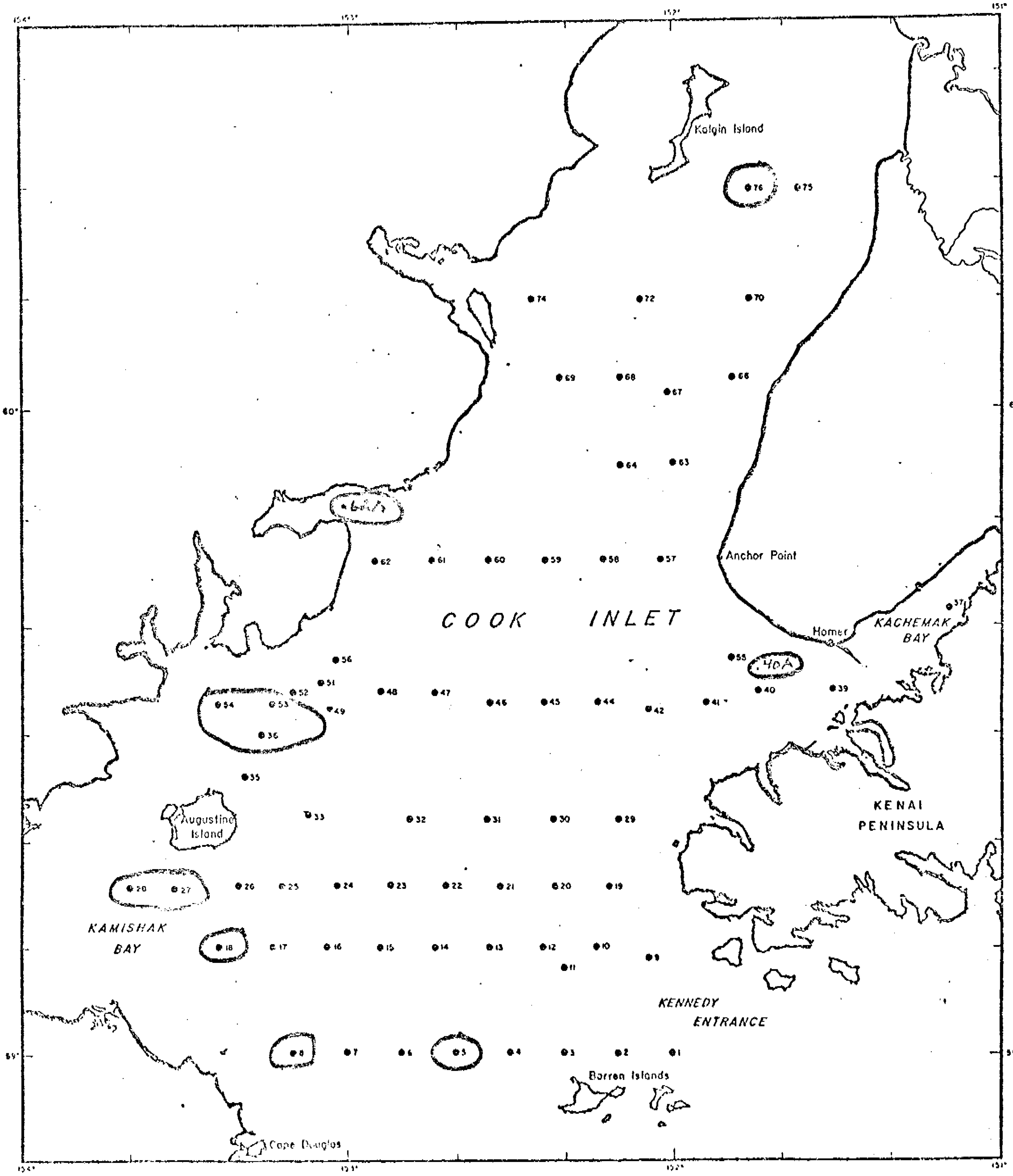

154°
153°
152°
151°
60°
59°
Kalgin Island
Anchor Point
COOK INLET
Homer
KACHEMAK BAY
KENAI PENINSULA
Augustine Island
Juveniles
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas

Serripes

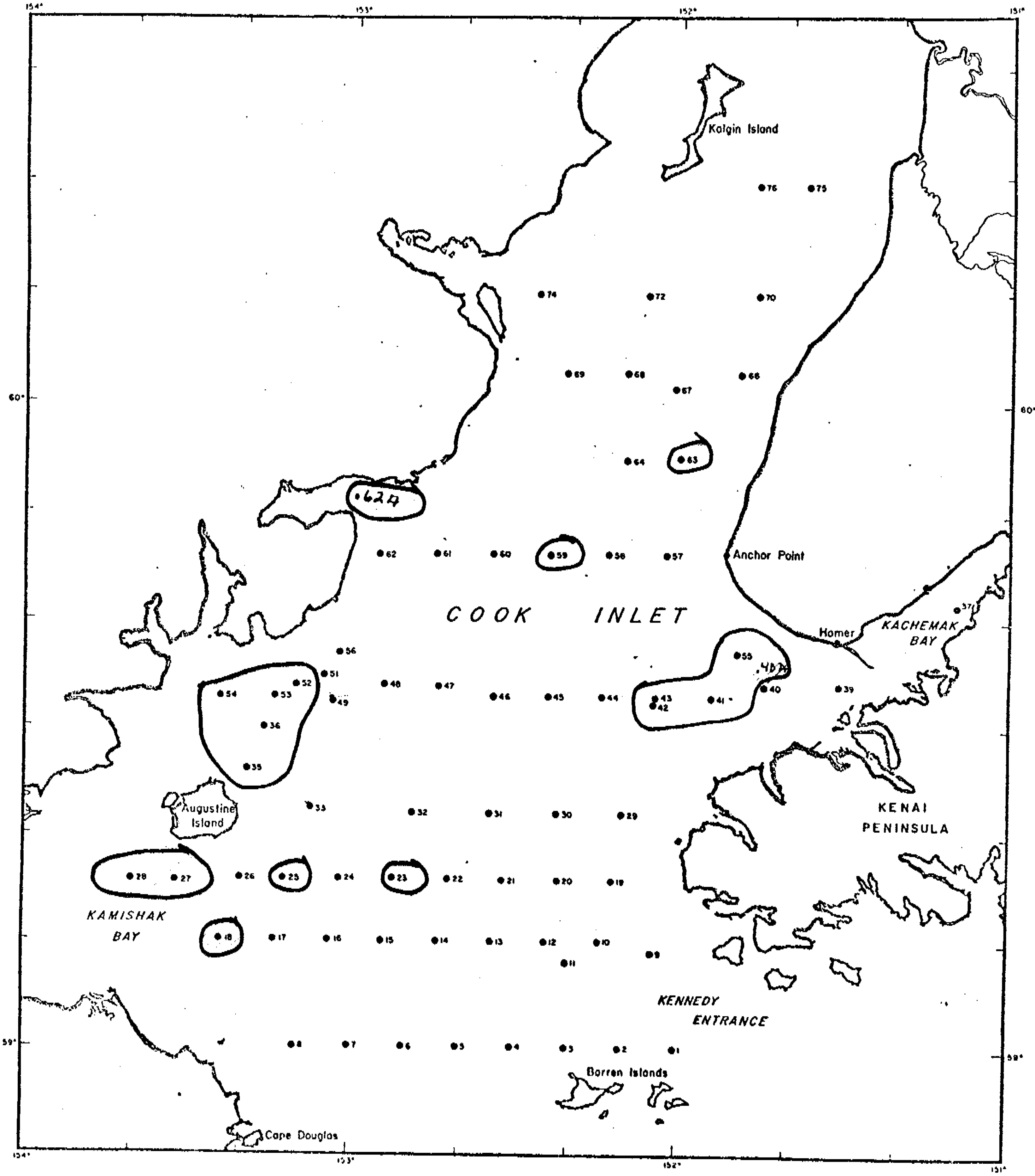


Kalgin Island
COOK INLET
Anchor Point
Homer
KACHEMAK BAY
KENAI PENINSULA
Augustine Island
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas

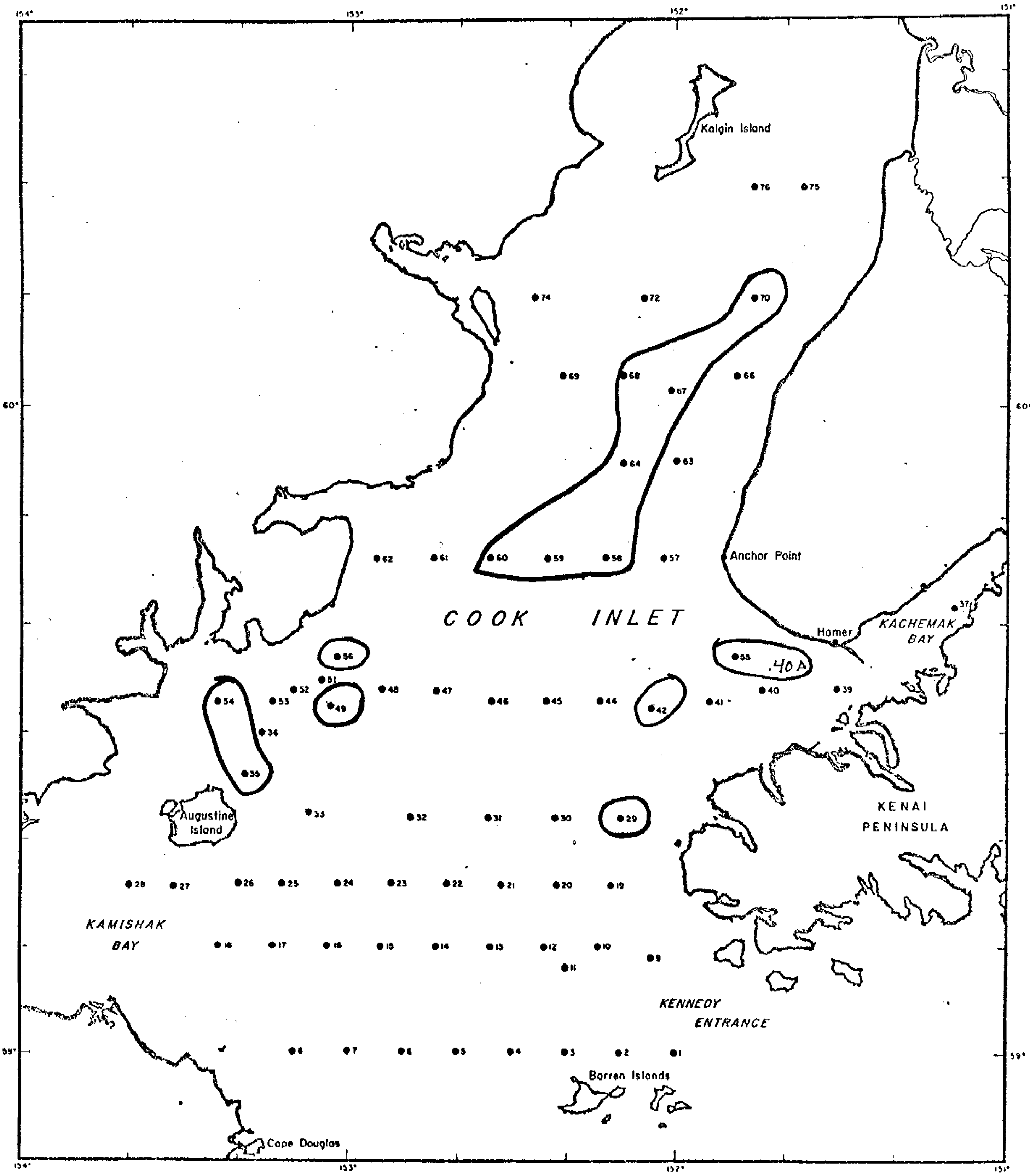
Modiolus sp



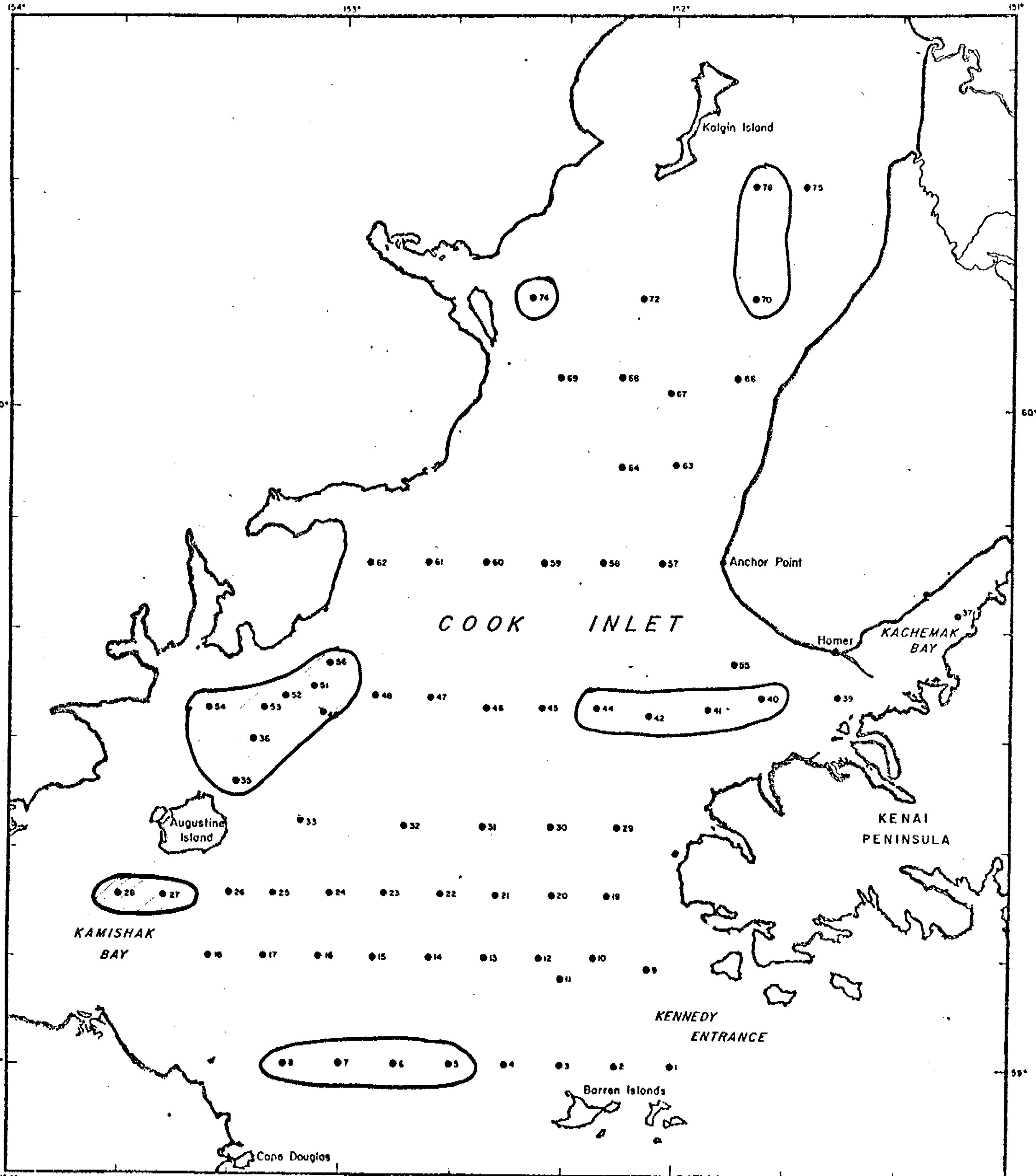
Pagurus capillatus



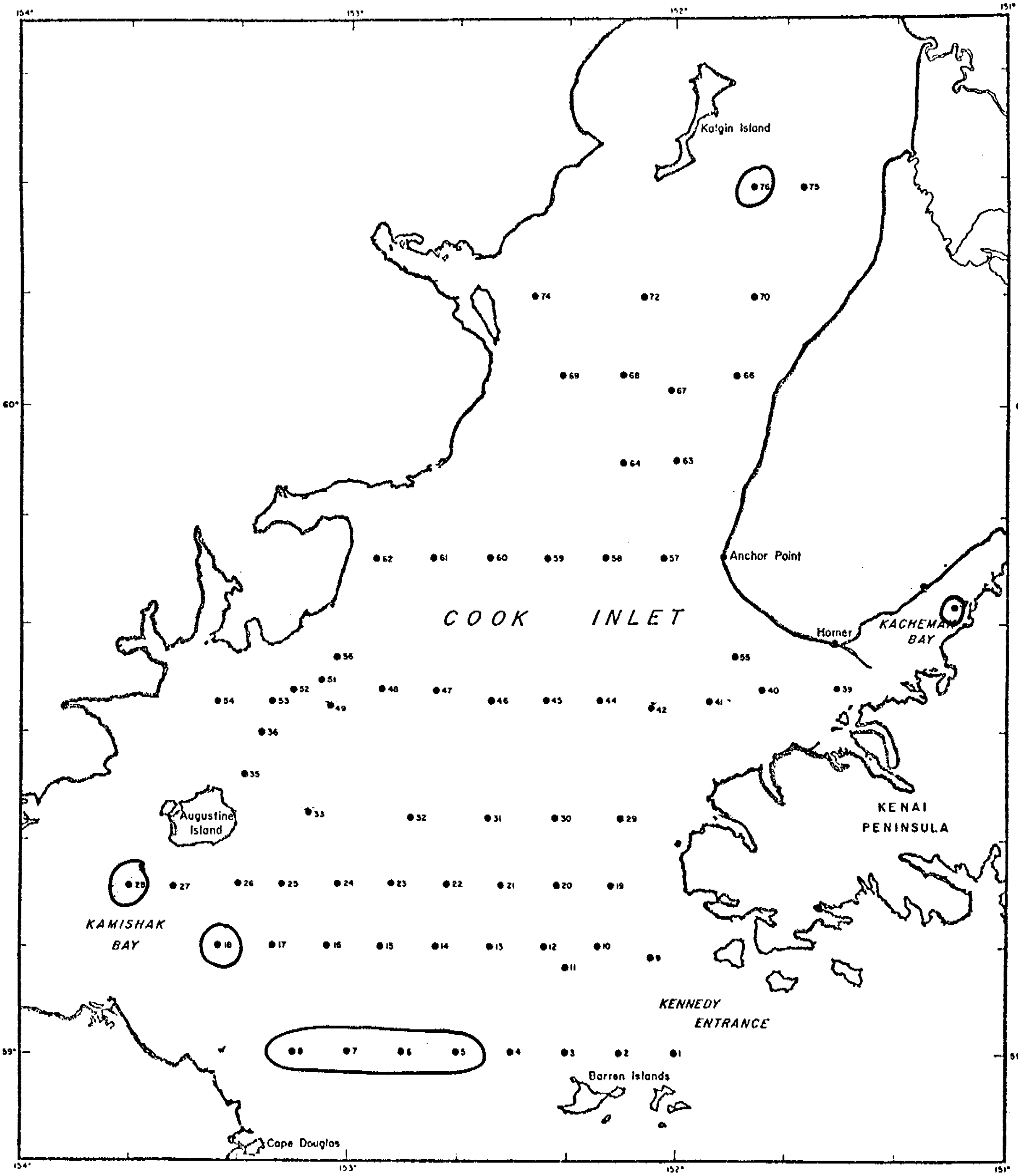
Pagurus ochotensis



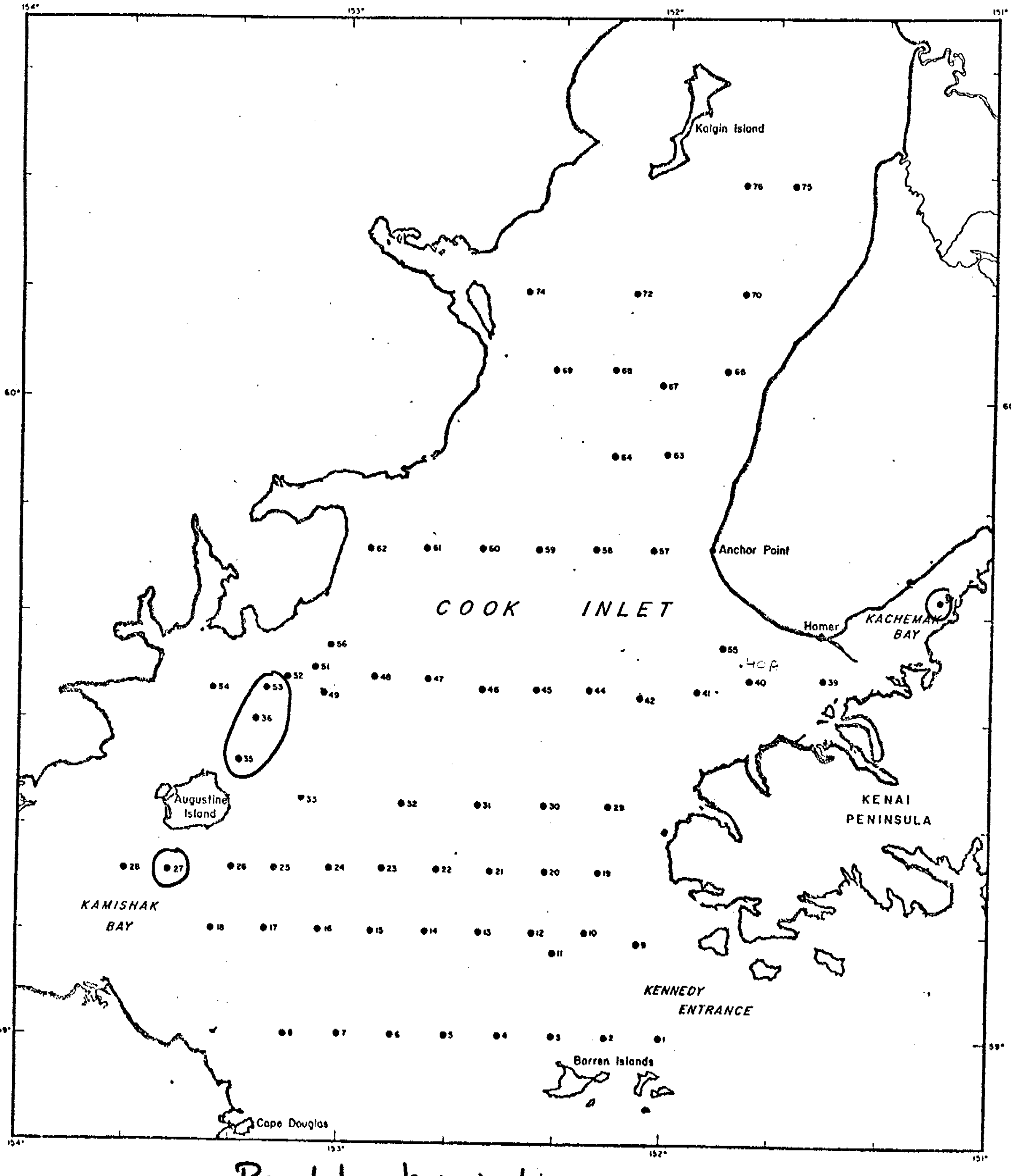
Elassochirus tenuimanus



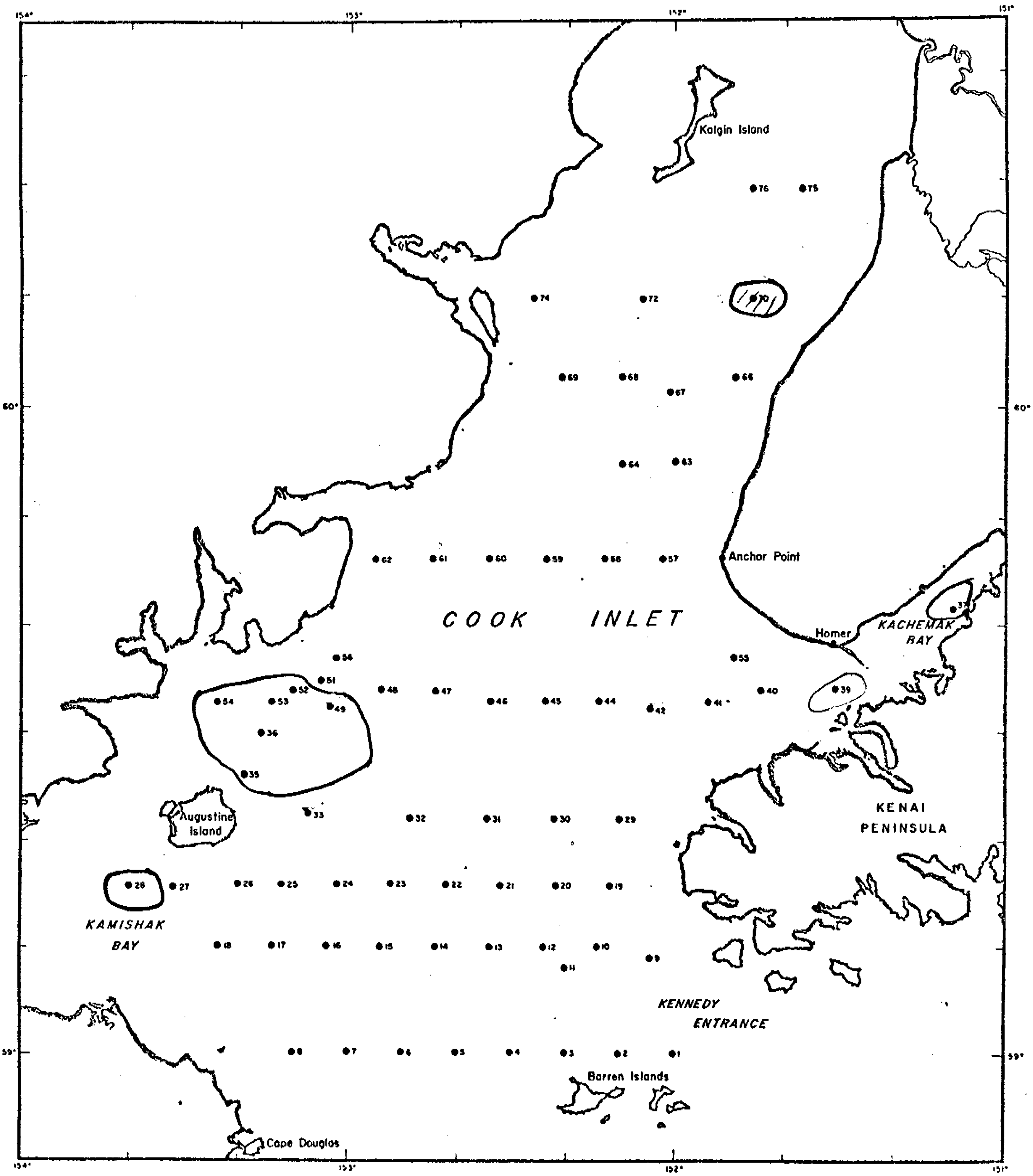
Crangon dalli



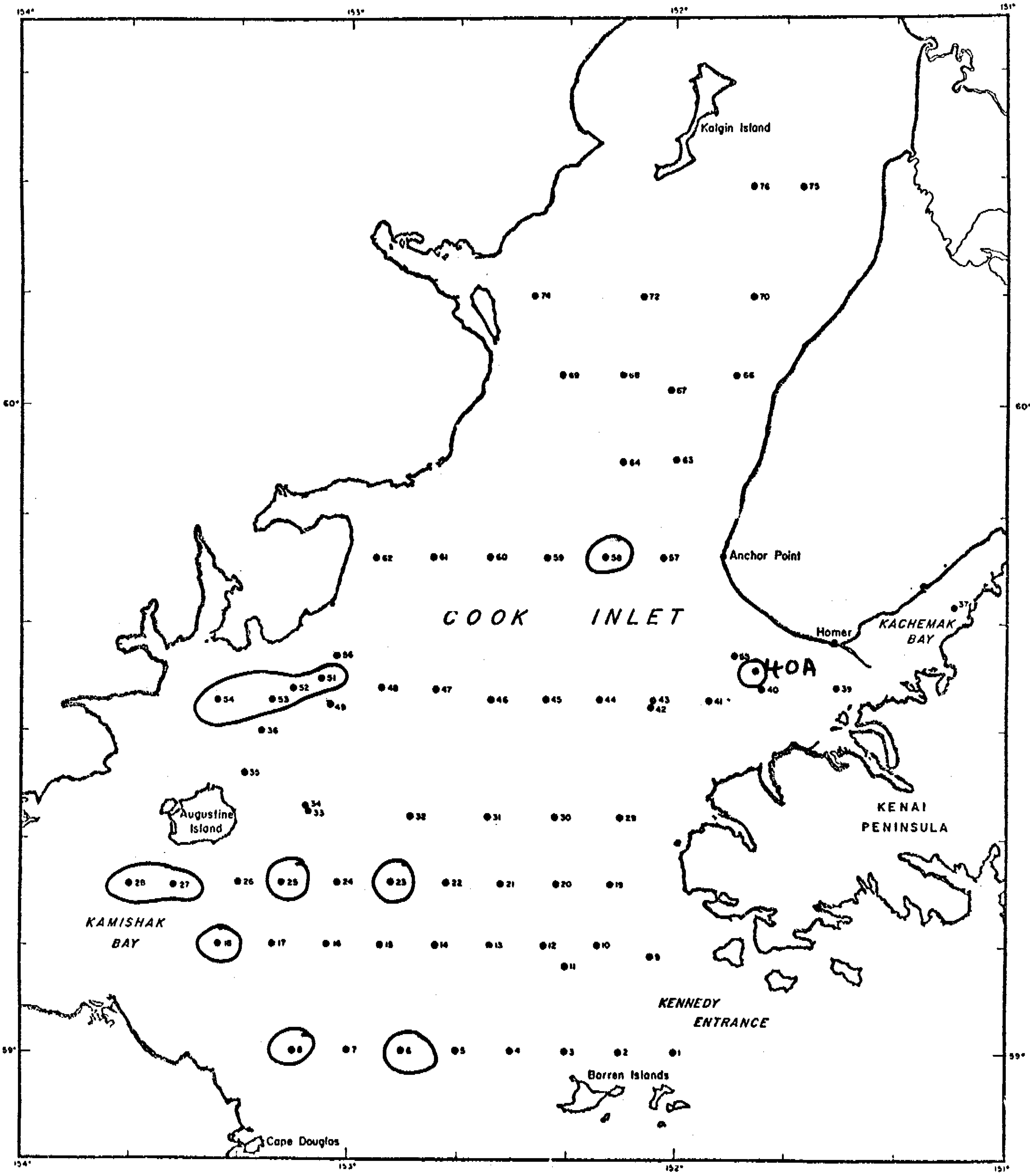
Pandalus borealis



Pandalus hypsinotus

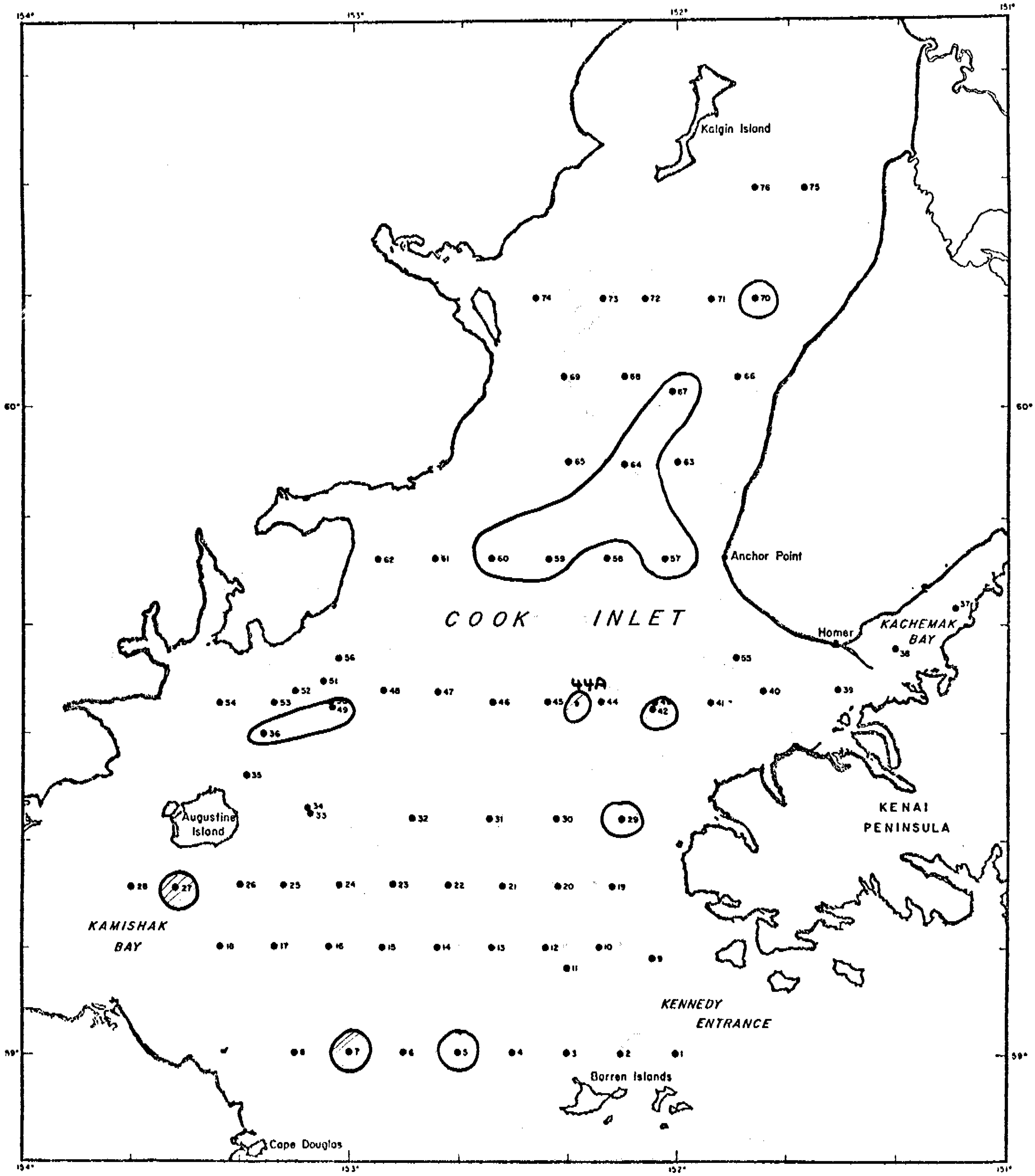


Pandalus goniurus

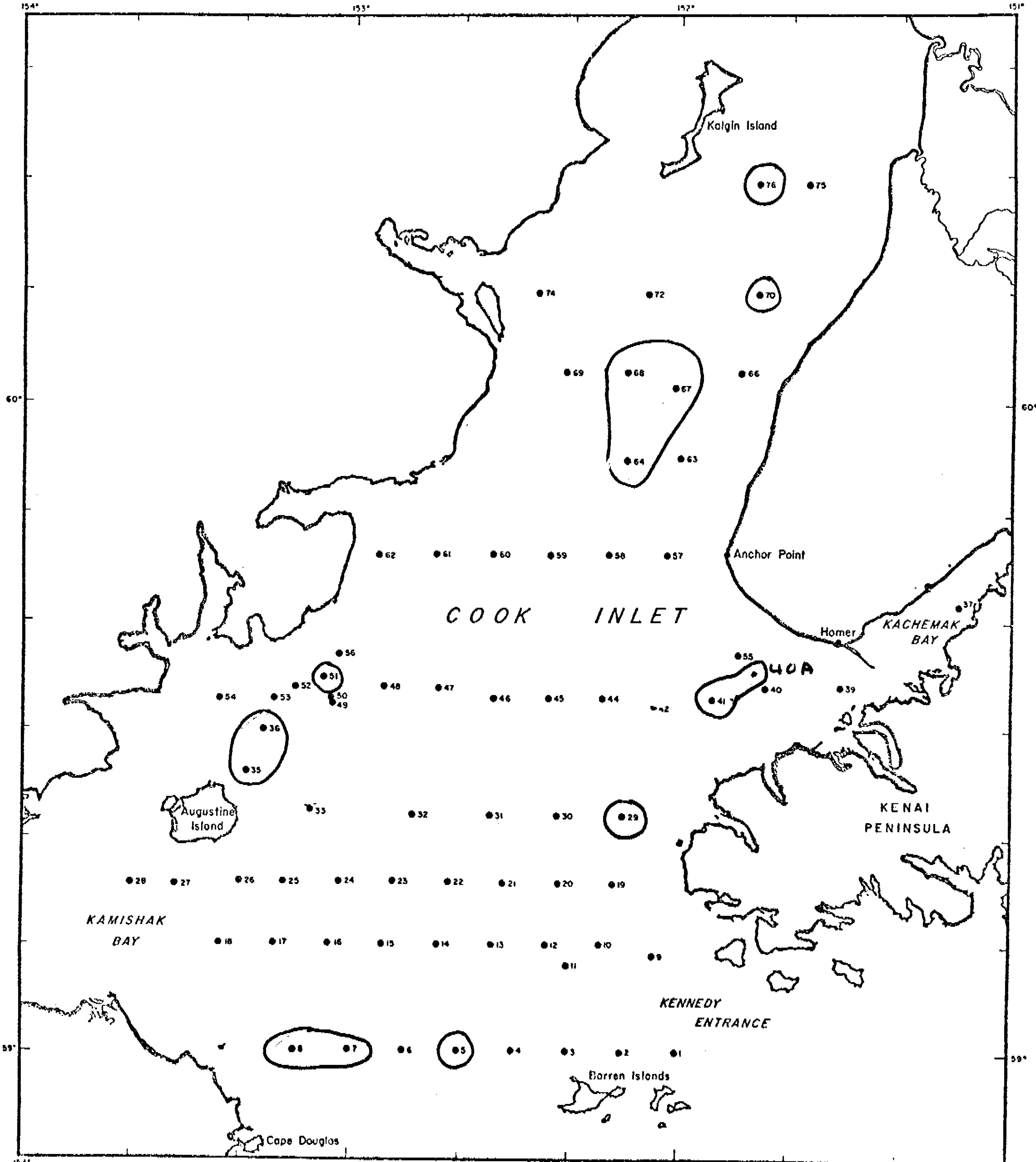


Kalgin Island
COOK INLET
Anchor Point
Homer
KACHEMAK BAY
KENAI PENINSULA
Augustine Island
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas
40A

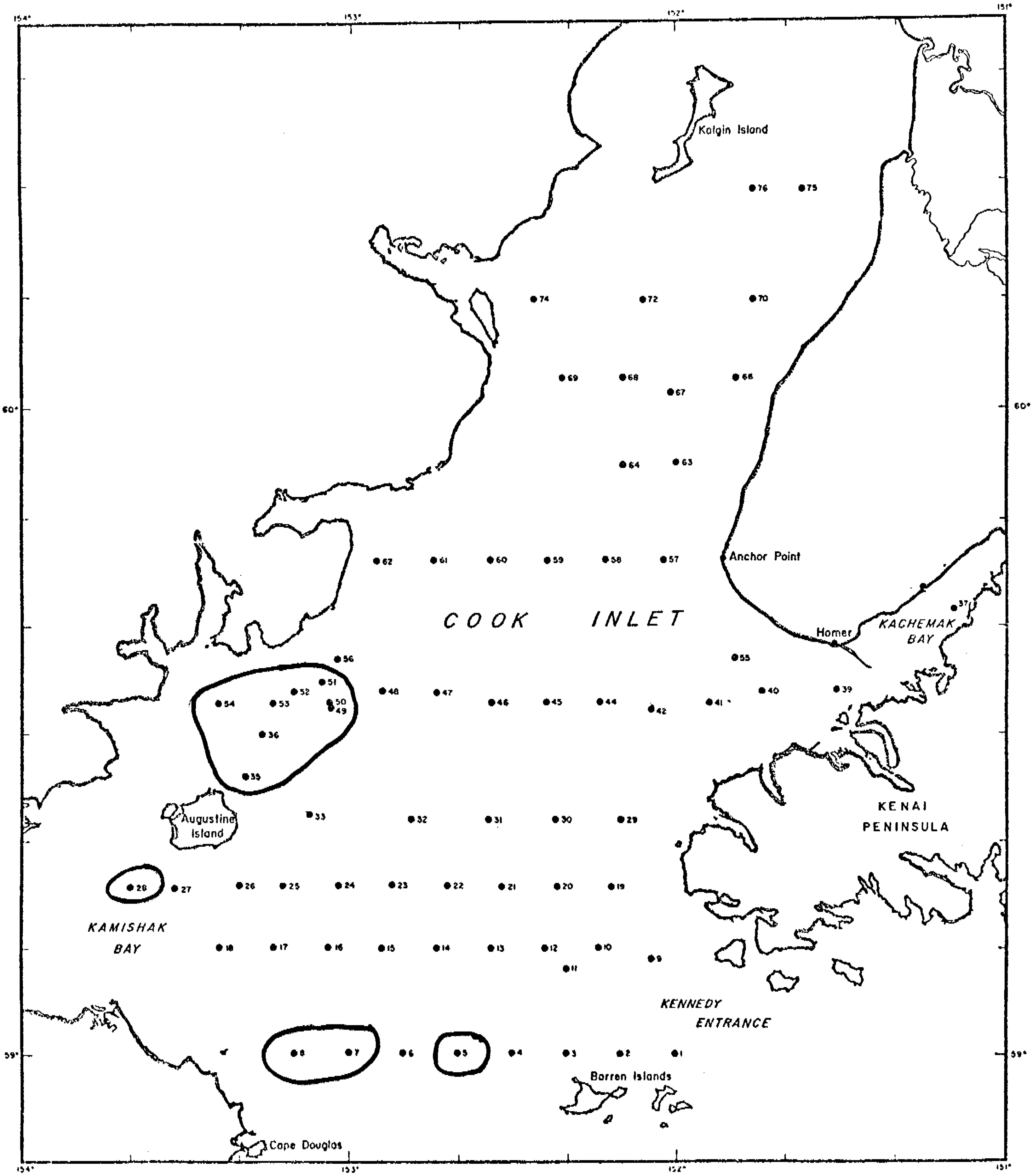
KING CRAB



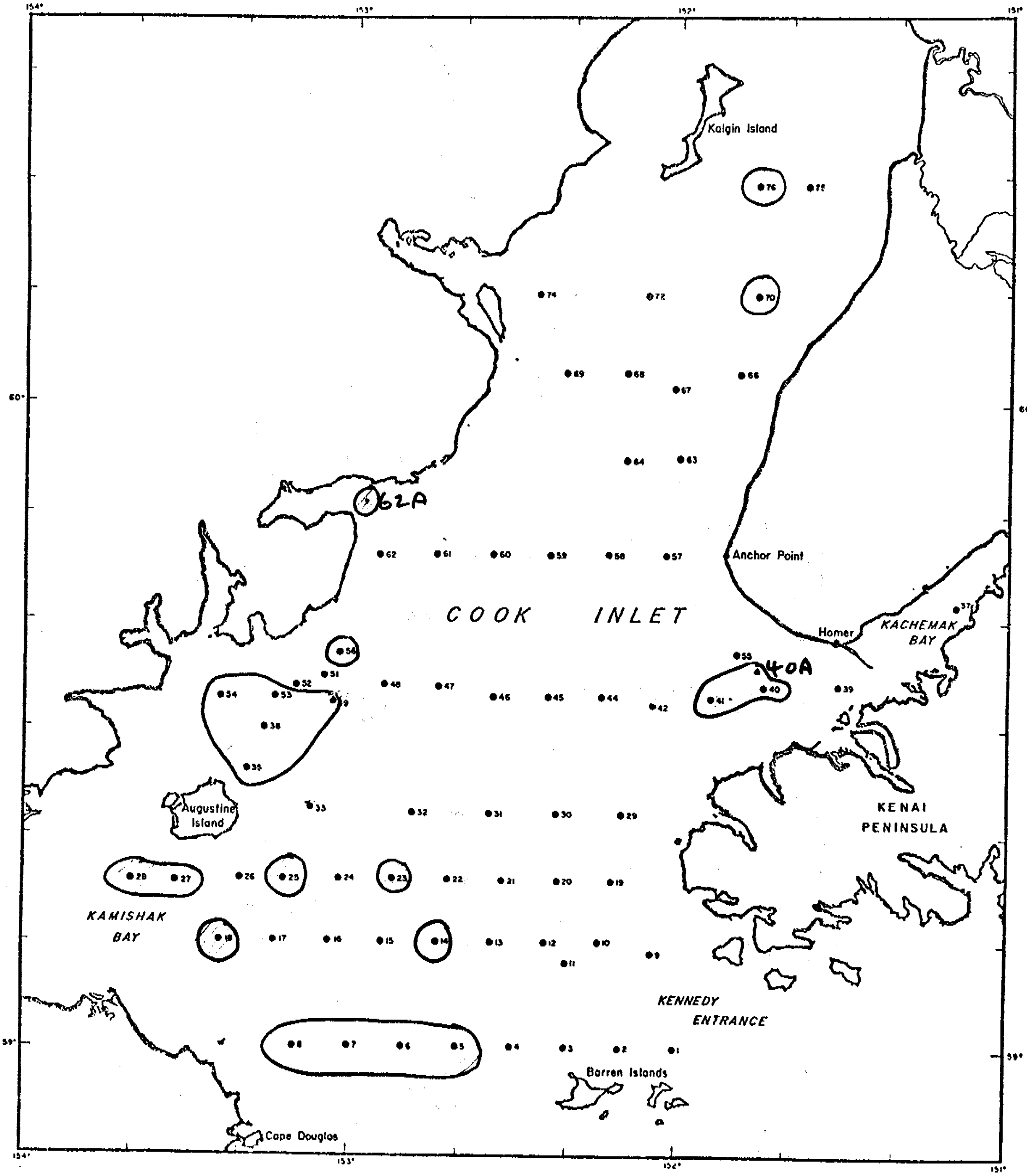
Oregonia gracilis



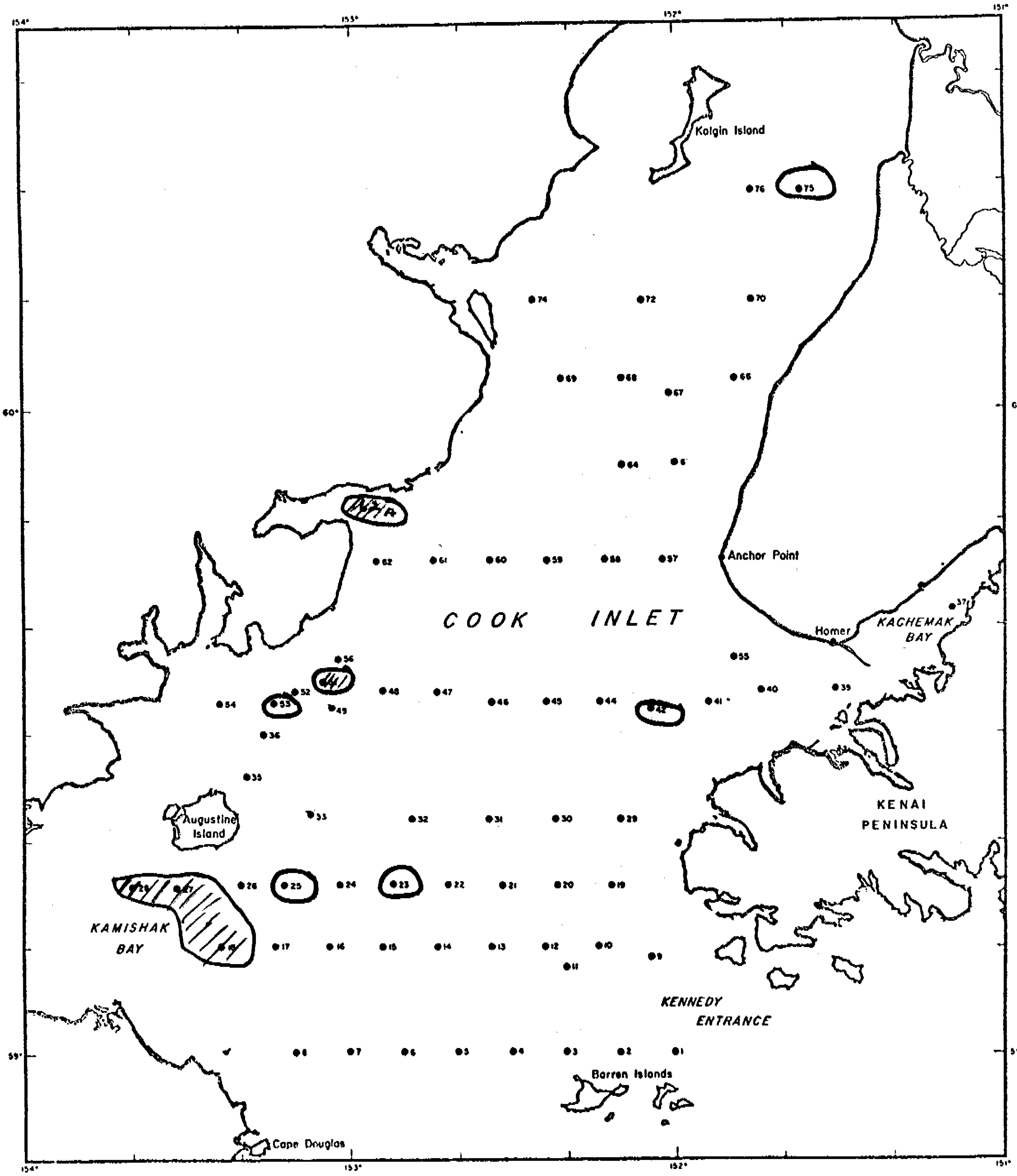
<u>Hyas lyratus</u>



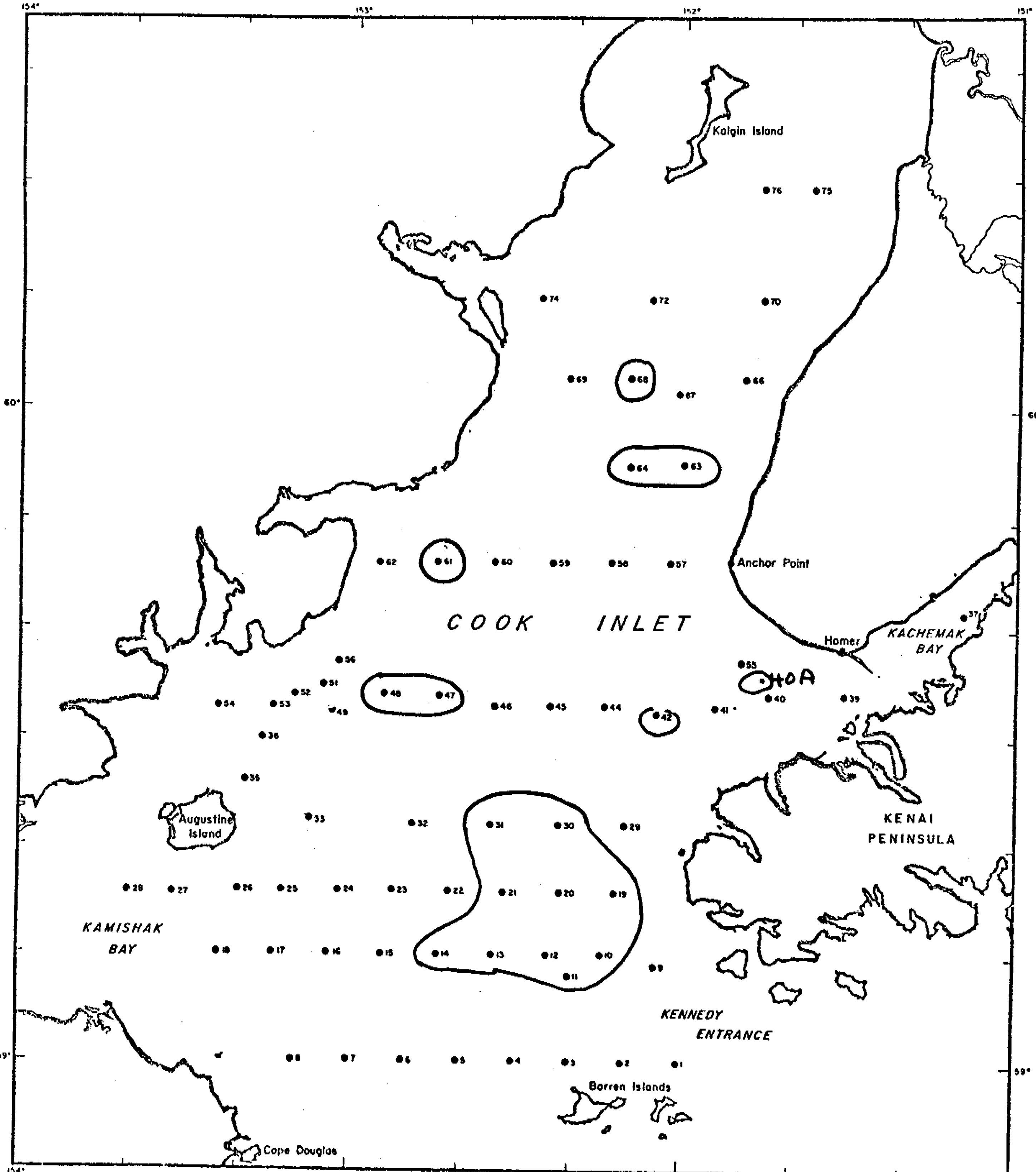
Chionoecetes bairdi - juvenile,



Chionoecetes bairdi adult

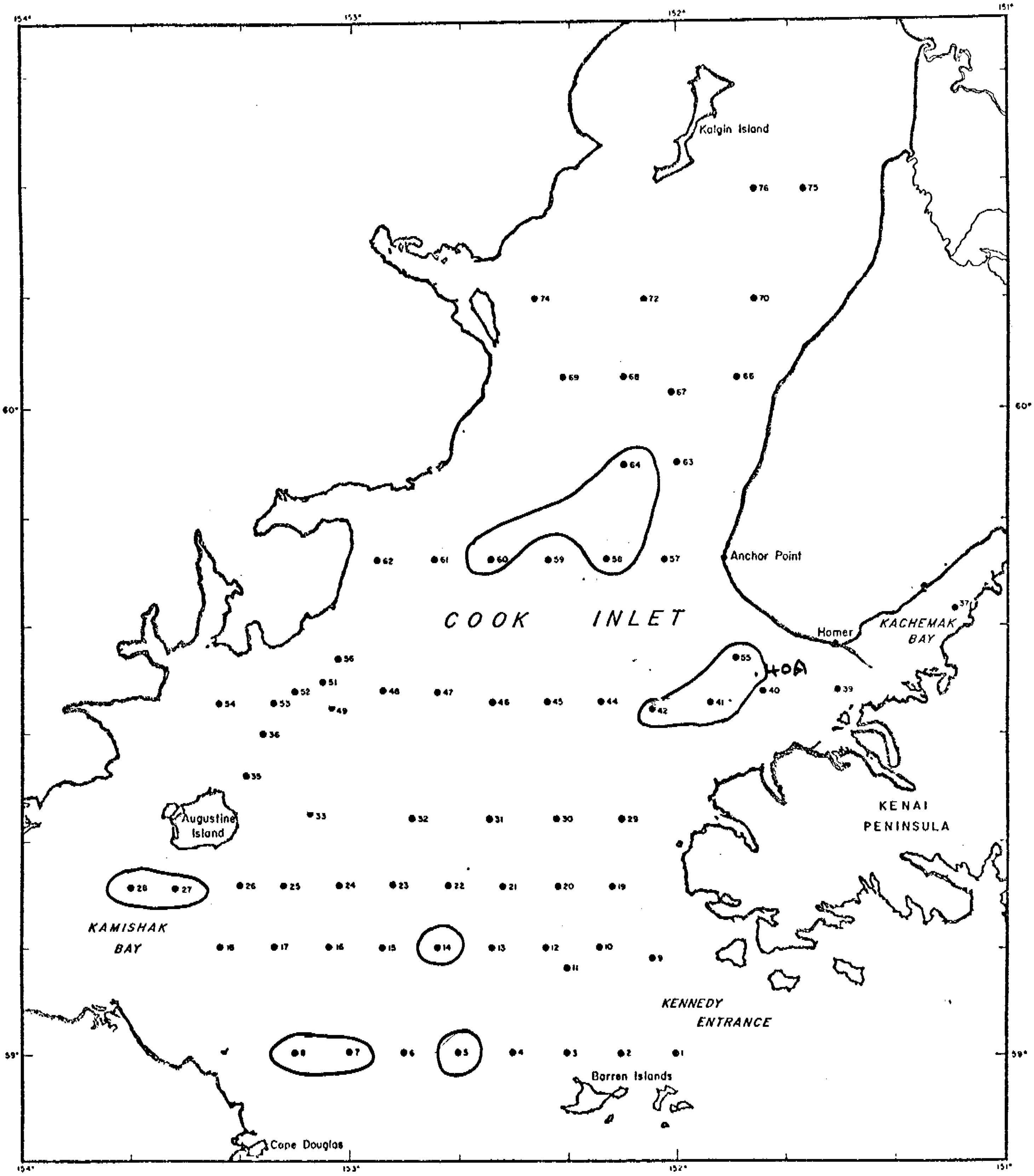


Leptasterias polaris



Kalgin Island
Anchor Point
COOK INLET
Homer
KACHEMAK BAY
40A
KENAI PENINSULA
Augustine Island
KAMISHAK BAY
KENNEDY ENTRANCE
Barren Islands
Cape Douglas

Dendraster



strongylocentrotus droebachiensis

RU# 282

NO REPORT WAS RECEIVED

A final report is expected next quarter

Quarterly Report

Contract #03-5-022-56
Research Unit #284
Task Order # 21
Reporting Period 10/1 - 12/31/76
Number of Pages 4

FOOD AND FEEDING RELATIONSHIPS IN THE BENTHIC AND DEMERSAL FISHES OF THE GULF OF ALASKA AND BERING SEA

Dr. Ronald L. Smith
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

January 1, 1977

I. Task Objectives

Objectives for this quarter included a continuation of very limited archival procedures on recently acquired Bering Sea samples, completion of preliminary sorts on our five target species for the year and devising a computer program for analysis of data to be submitted in the immediate future.

II. Field and Laboratory Activities

A. Ship or field work:

None.

B. Scientific Party Involved in Project:

R. L. Smith, IMS	Principal Investigator
A. C. Paulson, IMS	Research Technician

C. Methods:

Same as previous methods outlined in June 30, 1976, "Procedures and Quality Control".

D. Sample Localities:

No new localities were sampled during this quarter.

E. Data Analyzed:

Up to the present time, the following species have been studied:

Pollock have now been examined from the Gulf of Alaska and the Bering Sea. A total of almost 600 individuals contributed data to the pollock feeding analysis. Our data has been submitted to the OCS coordination office for key punch, storage on magnetic tape, and data submission. Although the additional data gathered since our annual report would necessitate a change of the frequency of occurrence figures slightly, the overwhelming predominance of Euphausiids in the diet has been substantiated for the Gulf of Alaska and the Bering Sea.

Data submission for feeding habits of Rex sole from the Gulf of Alaska was made early in this quarter.

Feeding analyses of Arrowtooth flounder from the Gulf and Greenland Turbot from the Bering have been completed, submitted for key punch, and data submission.

The feeding habits of two additional species have been examined during this quarter. Flathead sole from the Gulf (n=271) were found to feed predominantly on ophuroids. The only other food item identifiable, Euphausiids of the genus Thysanoessa, predominated (%V) at several stations. Dover sole from the Gulf (n=130) were found to rely very heavily on Polychaeta. A variety of taxa were in evidence including both errant and sedimentary forms. In this variety, the Dover sole differs from the Rex sole included ophiuroids, molluscs, and amphipods. Data for both of these species is being key punched and readied for submission to the Project Office.

In comparing our progress with our latest Major Milestones chart, it can be seen that we are on schedule in completing feeding analyses. We are performing well above the level to which we are contractually obligated in that the sample sizes analyzed so far have been far in excess of our estimated levels.

IV. Problems Encountered

Perhaps the biggest problem encountered in this quarter was lack of sufficient funds to engage both myself and my technician in these feeding analyses. I have contributed little time to this project during the quarter as my funding is coming entirely from another source. What time I did spend on the project was donated *gratis*. Much more progress and meaningful analysis could be made if I could draw more than the one month's salary budgeted for me in this year's project. I envision even greater difficulty in the months ahead since all salary funds will have been exhausted for myself and my technician well before the termination of the project.

A second problem we encountered dealt with the development of a computer program to quickly analyze our raw data. As I mentioned in the Analysis section of my "Procedures and Quality Control" memorandum of 30 June, 1976, I plan to provide an analysis of the feeding habits of each species in which the following is reported for each prey taxon:

F: frequency of occurrance (excluding empty stomachs)
V: percentage of total volume of prey
N: percentage of total number of prey
IRI: index of relative importance

$$IRI = (N + V) F$$

mean count per predator
mean volume per predator
mean length of predator
mean fullness of predator
number of predators.

Five size categories, each comprising 20% of the range of standard lengths of predator species will be generated. For each of these size categories, N, F, V, and IRI will be recalculated.

We intended that the data for a predator species would be summarized according to the above characteristics and examined by station and geographic area. I intended to include these analyses in the quarterly reports so that they could be used immediately. Unfortunately, our programming job was submitted to the IMS programming staff in August and has been bumped by every job that has come in since. Only in the last week has work finally begun on this program. Only an additional two week delay should remain before we can begin to do the comparisons I mentioned and start integrating our results. I plan to include these analyses in the next quarterly report.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 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 data 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	(a)			
Miller Freeman	8/16/75	10/20/75	(a)			
Miller Freeman	3/76	6/76	(a)			

Note: [1] Data Management Plan has been approved and made contractual.

(a) Selected species will be examined, data will then be submitted pending continuation and funding of this project in FY '77.

RU# 285

NO REPORT WAS RECEIVED

A final report is expected next quarter

RU# 318

NO REPORT WAS RECEIVED

A final report is expected next quarter

RU# 348

NO REPORT WAS RECEIVED

A final report is expected next quarter

FINAL REPORT

Contract #: 03-5-022-67-TA9 #4
Research Unit #: 349
Reporting period: 1 Jul 1975-30 Sep 1976
Number of pages: 230

Alaska Marine Ichthyoplankton Key

T. Saunders English
Department of Oceanography
University of Washington
Seattle, Washington 98195

30 September 1976

Department Concurrence: Francis A. Richards
Associate Chairman for Research

REF: 76-65

The task of primary emphasis has been A25b--to develop an ichthyoplankton key to aid identification of the marine ichthyoplankton occurring in Alaskan waters. The original task was modified and expanded to include the planktonic larval stages of shrimps and crabs of commercial importance.

This final report contains aids to the identification of planktonic early life history stages of marine fishes, shrimps, and crabs of commercial importance in Alaskan waters. As work progressed, it became apparent that the literature on early life histories was sufficiently incomplete that artificial keys for Alaskan waters would quickly become obsolete as new information becomes available. Therefore, we developed lists of probable species and tables of morphological characteristics to be used in conjunction with illustrations from the literature.

These aids to the identification of planktonic early life history stages of marine fishes, shrimps, and crabs are in continuing use by workers in our laboratory. The format is such that additional information can be incorporated as it becomes available.

Aids for Identification of Early Life History Stages of Marine Fishes in Alaskan Waters

1976

Department of Oceanography
University of Washington

LIST OF TABLES

LIST OF FIGURES

List of Figures (continued)

Introduction

A preliminary list of all reported Alaskan fish species was constructed from several sources (Evermann and Goldsborough 1906; Gilbert and Burke 1912; Kendel, Johnston, Kozak and Lobsiger 1974; Quast and Hall 1972; Wilimovsky 1958, 1963) to provide a foundation for the literature search on those marine fishes which have either a planktonic egg or larva in their life cycle.

A list (Table 1) for pelagic eggs and a list (Table 2) for pelagic larvae was compiled, in part from references on ichthyoplankton collected in Alaskan waters (Faculty of Fisheries 1957-1964; Kashkina 1965a, 1970; Musienko 1963, 1970; Taranetz 1933) and in part from references on studies of artificially spawned and laboratory reared eggs and larvae, as well as eggs and larvae identified from the plankton in other parts of the world (Tables 3 and 4).

A list (Table 5) has been prepared for fish species believed to have pelagic eggs or larvae, but with early life histories unknown to us.

A list (Table 6) of Alaskan marine fishes of primary commercial importance includes only those species that have pelagic eggs or larvae and does not include those fishes found exclusively in freshwater or those which spawn in freshwater.

Characteristics of pelagic eggs expected to be found in Alaskan waters are tabulated (Table 7) for use in identification.

Characteristics of all Alaskan pelagic larvae are summarized (Table 8). These characteristics, when used with illustrations from the literature (Fig. 1 to 50), will aid in larval identification.

In searching the literature for a format most suitable for the identification of Alaskan ichthyoplankton, it became apparent that research still needs to be done on the early life histories of a large number of fishes. Our experience has shown that an artificial key is suitable only when all information is known. A key based on partial knowledge quickly becomes obsolete as new information becomes available.

A bibliography of 167 references is attached.

Table 1. List of fish species known to have pelagic eggs

Clupeidae
Sardinops sagax (Jenyns)

Engraulidae
Engraulis mordax Girard

Gadidae
Boreogadus saida (Lepechin)
Gadus macrocephalus Tilesius
Merluccius productus (Ayres)
Theragra chalcogramma (Pallas)

Scomberesocidae
Cololabis saira (Brevoort)

Carangidae
Trachurus symmetricus (Ayres)

Sphyraenidae
Sphyraena argenta Girard

Scombridae
Sarda chiliensis (Curvier)
Scomber japonicus Houttuyn
Thunnus alalunga (Bonnaterre)
Thannus thynnus (Linnaeus)

Scorpaenidae
Sebastolobus alascanus Bean
Sebastolobus altivelis Gilbert

Anoplopomatidae
Anoplopoma fimbria (Pallas)

Bothidae
Citharichthys sordidus (Girard)

Pleuronectidae
Atheresthes evermanni Jordan & Starks
Atherestes stomias (Jordan & Gilbert)
Eopsetta jordani (Lockington)
Glyptocephalus zachirus Lockington
Hippoglossoides elassodon Jordan & Gilbert
Hippoglossoides robustus Gill & Townsend
Hippoglossus hippoglossus (Linnaeus)
Hippoglossus stenolepis Schmidt
Isopsetta isolepis (Lockington)
Limanda aspera (Pallas)

Table 1. (cont.)

Pleuronectidae (cont.)

Limanda proboscidea Gilbert
Lyopsetta exilis (Jordan & Gilbert)
Microstomus pacificus (Lockington)
Parophrys vetulus Girard
Platichthys stellatus (Pallas)
Pleuronectes quadrituberculatus Pallas
Pleuronichthys coenosus Girard
Pleuronichthys decurrens Jordan & Gilbert
Psettichthys melanostictus Girard
Beinhardtius hippoglossoides (Walbaum)

Molidae

Mola mola (Linnaeus)

Table 2. List of fish species known to have pelagic larvae

Clupeidae
- *Alosa sapidissima* (Wilson)
- *Clupea harengus pallasi* Valenciennes
- *Sardinops sagax* (Jenyns)

Engraulidae
- *Engraulis mordax* Girard

Osmeridae
- *Hypomesus olidus* (Pallas)
- *Hypomesus pretiosus* (Girard)
- *Mallotus villosus* (Müller)
- *Spirinchus starksi* (Fisk)
- *Spirinchus thaleichthys* (Ayres)
- *Thaleichthys pacificus* (Richardson)

Bathylagidae
- *Bathylagus stilbius* (Gilbert)

Myctophidae
- *Benthosema glaciale* (Reinhardt)
- *Diaphus theta* Eigenmann & Eigenmann
- *Lampanyctus regalis* (Gilbert)
- *Lampanyctus ritteri* Gilbert
- *Stenobrachius leucopsarus* (Eigenmann & Eigenmann)
- *Symbolophorus californiense* (Eigenmann & Eigenmann)
- *Tarletonbeania crenularis* (Jordan & Gilbert)

Gadidae
- *Boreogadus saida* (Lepechin)
- *Eleginus gracilis* (Tilesius)
- *Gadus macrocephalus* Tilesius
- *Gadus morhua macrocephalus* Tilesius
- *Merluccius productus* (Ayres)
- *Microgadus proximus* (Girard)
- *Theragra chalcogramma* (Pallas)

Scomberesocidae
- *Cololabis saira* (Brevoort)

Melamphaeidae
- *Melamphaes lugubris* Gilbert

Carangidae
- *Trachurus symmetricus* (Ayres)

Bramidae
- *Brama japonica* Hilgendorf

Sphyraenidae
- *Sphyraena argenta* Girard

Table 2. (cont.)

Trichodontidae
Trichodon trichodon (Tilesius)

Stichaeidae
Anoplarchus insignis Gilbert & Burke
Anoplarchus purpurescens Gill
Bryostemma tarsodes Jordan & Snyder
Xiphister atropurpureus (Kittlitz)
Xiphister mucosus (Girard)

Pholidae
Pholis laeta (Cope)
Pholis ornata (Girard)

Anarhichadidae
Anarhichas orientalis Pallas

Ptilichthyidae
Ptilichthys goodei Bean

Ammodytidae
Ammodytes hexapterus Pallas

Scombridae
Scomber japonicus Houttuyn
Thunnus alalunga (Bonnaterre)
Thunnus thynnus (Linnaeus)

Scorpaenidae
Sebastes aleutianus (Jordan & Evermann)
Sebastes alutus (Gilbert)
Sebastes auriculatus Girard
Sebastes babcocki (Thompson)
Sebastes borealis Barsukov
Sebastes brevispinis (Bean)
Sebastes caurinus Richardson
Sebastes ciliatus (Tilesius)
Sebastes crameri (Jordan)
Sebastes diploproa (Gilbert)
Sebastes elongatus Ayres
Sebastes emphaeus (Starks)
Sebastes entomelas (Jordan & Gilbert)
Sebastes flavidus (Ayres)
Sebastes helvomaculatus Ayres
Sebastes maliger (Jordan & Gilbert)
Sebastes melanops Girard
Sebastes mystinus (Jordan & Gilbert)
Sebastes nebulosus Ayres
Sebastes nigrocinctus Ayres
Sebastes paucispinis Ayres
Sebastes pinniger (Gill)
Sebastes proriger (Jordan & Gilbert)
Sebastes reedi (Westrheim & Tsuyuki)

Table 2. (cont.)

Scorpaenidae (cont.)
Sebastes ruberrimus (Cramer)
Sebastes saxicola (Gilbert)
Sebastes variegatus Quast
Sebastes wilsoni (Gilbert)
Sebastes zacentrus (Gilbert)
Sebastolobus alascanus Bean
Sebastolobus altivelis Gilbert

Anoplopomatidae
Anoplopoma fimbria (Pallas)

Hexagrammidae
Hexagrammos decagrammus (Pallas)
Hexagrammos lagocephalus (Pallas)
Hexagrammos octogrammus (Pallas)
Hexagrammos stelleri Tilesius
Ophiodon elongatus Girard
Pleurogrammus monopterygius (Pallas)

Cottidae
Hemilepidotus hemilepidotus (Tilesius)
Hemilepidotus jordani Bean
Scorpaenichthys marmoratus (Ayres)

Cyclopteridae
Aptocyclus ventricosus (Pallas)
Liparis dennyi Jordan & Starks

Bothidae
Citharichthys sordidus (Girard)
Citharichthys stigmaeus Jordan & Gilbert

Pleuronectidae
Atheresthes evermanni Jordan & Starks
Atheresthes stomias (Jordan & Gilbert)
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Limanda proboscidea Gilbert
Lyopsetta exilis (Jordan & Gilbert)
Microstomus pacificus (Lockington)
Parophrys vetulus Girard
Platichthys stellatus (Pallas)
Pleuronectes quadrituberculatus Pallas
Pleuronichthys coenosus Girard
Pleuronichthys decurrens Jordan & Gilbert
Psettichthys melanostictus Girard
Reinhardtius hippoglossoides (Walbaum)

Table 3. Pelagic eggs: references and sources of eggs

Species	Reference	Area	Plankton		Artificially Spawned Fertilized		Artificially Spawned Unfertilized		Dissected
			Liv.	Pres.	Liv.	Pres.	Liv.	Pres.	
Anoplopoma fimbria	Thompson, 1941	Queen Charlotte Islands,		X				X	
Atheresthes evermanni	Kashkina, 1965a	Commander Is., Bering Sea	?	?					
	Musienko, 1963	Bering Sea	?	?					
Atheresthes stomias	Kashkina, 1965a	Pribilof Is., Bering Sea					?	?	
Boreogadus saida	Musienko, 1970	Bering Sea	?	?					
Citharichthys sordidus	Arora, 1951	San Francisco, Calif.							X
	English, 1966	Puget Sound, Wash., description from literature.							
Cololabis saira	Hatanaka et. al., 1953	Japanese waters	X						
Engraulis mordax	Ahlstrom, 1956	California, Baja Calif.	X						
	Bolin, 1936	Monterey Bay, Calif.	X						

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Eopsetta jordani	Forrester, 1969	British Columbia, description from literature and observation.							
	Forrester & Alderdice, 1967	West Coast Vancouver Is., British Columbia			X				
Gadus macrocephalus	English, 1966	Puget Sound, Wash., description from literature.							
	Forrester, 1964	Strait of Georgia, British Columbia			X				
	Forrester, 1969	British Columbia, description from literature and observation.							
	Mukhacheva & Zviagina, 1960	? (in Russian)							
Glyptocephalus zachirus	Musienko, 1963	Bering Sea	?	?					
Hippoglossoides elassodon	English, 1966	Puget Sound, Wash., description from literature.							
	Forrester & Alderdice, 1968	Strait of Georgia, British Columbia			X		X		

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Hippoglossoides elassodon (cont.)	Miller, 1969	San Juan Islands, Wash.	X	X	X	X	X	X	
	Musienko, 1963	Bering Sea	?	?					
	Musienko, 1970	Bering Sea	?	?					
	Rass, 1959	Kuril Is., NW Pacific	?	?					
	Thompson & Van Cleve, 1936	Gulf of Alaska						X	
Hippoglossus hippoglossus	Kolloen, 1934	Southeast Alaska							X
Hippoglossus stenolepis	Thompson, 1915	British Columbia, Southeast Alaska						X	
	Thompson & Van Cleve, 1936	Gulf of Alaska		X				X	
Isopsetta isolepis	English, 1966	Puget Sound, Wash.	X		X				
	Forrester, 1969	British Columbia, description from literature and observation.							
	Levings, 1968	Queen Charlotte Is., British Columbia			X				

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Limanda aspera	Musienko, 1963	Bering Sea	?	?					
	Musienko, 1970	Bering Sea	?	?					
	Nikolotova, 1970	? (in Russian)							
Limanda proboscidea	Musienko, 1970	Bering Sea	?	?					
	Nikolotova, 1970	? (in Russian)							
Lyopsetta exilis	Blackburn, 1973	Puget Sound	?	?				X	
Merluccius productus	Ahlstrom & Counts, 1955	California, Baja Calif.	X	X					
	English, 1966	Puget Sound, Wash., description from literature.							
Microstomus pacificus	English, 1966	Puget Sound, Wash., description from literature.							
	Hagerman, 1952	California						X	
Mola mola	Clemens & Wilby, 1961	British Columbia							

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Parophrys vetulus	Budd, 1940	Monterey Bay, Calif.			X		X		
	English, 1966	Puget Sound, Wash., description from literature.							
	Forrester, 1969	British Columbia, description from literature and observation.							
	Orsi, 1968	Puget Sound, Wash.			X		X		
Platichthys stellatus	English, 1966	Puget Sound, Wash., description from literature.							
	Musienko, 1963	Bering Sea	?	?					
	Musienko, 1970	Bering Sea	?	?					
	Orcutt, 1950	Monterey Bay, Calif.			X		X		
	Yusa, 1957	Hokkaido, Japan			X		X		
Pleuronectes quadrituberculatus	Musienko, 1963	Bering Sea	?	?					
	Musienko, 1970	Bering Sea	?	?					
Pleuronichthys coenosus	Budd, 1940	Monterey Bay, Calif.	X						
	English, 1966	San Juan Is., Wash.	X						

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Pleuronichthys decurrens	Budd, 1940	Monterey Bay, Calif.	X						
Psettichthys melanostictus	English, 1966	Puget Sound, Wash., description from literature.							
	Hickman, 1959	Puget Sound, Wash.	?	?					
Reinhardtius hippoglossoides	Jensen, 1935	West Greenland							
	Musienko, 1970	Bering Sea	?	?					
Sarda chiliensis	Barnhart, 1927	LaJolla, Calif,	X						
Sardinops sagax	Ahlstrom, 1943	California	?	?					
	Clark, 1934	California					X		X
	Miller, 1952	California, Baja Calif.			X		X		
	Scofield, 1934	California	?	?					
Scomber japonicus	Ahlstrom, 1956	California, Baja Calif.	X						

Table 3. (cont.)

Species	Reference	Area	Plankton Liv.	Plankton Pres.	Artificially Spawned Fertilized Liv.	Artificially Spawned Fertilized Pres.	Artificially Spawned Unfertilized Liv.	Artificially Spawned Unfertilized Pres.	Dissected
Scomber japonicus (cont.)	Fry, 1936	Southern California	X	X					
	Kramer, 1960	California, Baja Calif.		X					
	Rass, 1959	Kuril Is., NW Pacific	?	?					
Sebastolobus alascanus or *S. altivelis*	Pearcy, 1962	Oregon	X						
Theragra chalcogramma	Gorbunova, 1951	? (in Russian)							
	Hamai et. al., 1976	Hokkaido, Japan			X				
	Kanoh, 1954	Hokkaido, Japan			X		X	X	
	Musienko, 1963	Bering Sea	?	?					
	Musienko, 1970	Bering Sea	?	?					
	Rass, 1949	Barents Sea							
	Rass, 1959	Kuril Is., NW Pacific	?	?					
	Serobaba, 1974	Bering Sea		X					
	Yusa, 1954	Hokkaido, Japan			X		X		

Table 3. (cont.)

Species	Reference	Area	Plankton		Artificially Spawned Fertilized		Artificially Spawned Unfertilized		Dissected
			Liv.	Pres.	Liv.	Pres.	Liv.	Pres.	
Thunnus alalunga	Breder & Rosen, 1966	?							
Thunnus thynnus	Breder & Rosen, 1966	?							
Trachurus symmetricus	Ahlstrom, 1956	California, Baja Calif.	X						
	Ahlstrom & Ball, 1954	California, Baja Calif.		X					
	Ahlstrom & Counts, 1955	?	?	?					
	Farris, 1958	California, Baja Calif.		X					
Sphyraena argentea	Barnhart, 1927	LaJolla, Calif.	X						
Scorpaenichthys marmoratus	O'Connell, 1953	California waters.						X	

Table 4. Pelagic larvae: references and sources of larvae

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Alosa sapidissima	Liem 1924	Canadian waters				
	Mansueti & Hardy 1967					
	Mansueti & Kolb 1953	East Coast				
Ammodytes hexapterus	Blackburn 1973	Puget Sound, Wash.	X			X
	Fraser & Hansen 1967	North Atlantic				
	Kobayashi 1961c	NW Pacific				
	Musienko 1963a	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Anarhichas orientalis	Kobayashi 1961a		X	X		X
Anoplarchus insignis	Blackburn 1973	Puget Sound, Wash.	X			X
Anoplarchus purpurescens	Blackburn 1973	Puget Sound, Wash.	X			X
	Musienko 1970	Bering Sea	X			X
Anoplopoma fimbria	Bell & Gharrett 1945	Queen Charlotte Is., British Columbia		X		X
	Blackburn 1973	Puget Sound, Wash.	X			X
	Brock 1940					
	Hayamoto 1962					
	Kashkina 1970	Bering Sea	X			X
	Kobayashi 1957	Aleutian Islands	?			X
	Musienko 1970	Bering Sea	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Aptocyclus ventricosus	Kobayashi 1962	Hokkaido, Japan; N. Pacific	X	X	X	X
	Kyûshin 1975	Hokkaido, Japan		X	X	
	Musienko 1970	Bering Sea	X			X
Atheresthes evermanni	Kashkina 1965a	Commander Is., Bering Sea	X			X
	Musienko 1963a	Bering Sea	X			X
	Pertseva-Ostroumova 1960	East Coast of Russia	X			X
Atheresthes stomias	Musienko 1963a	Bering Sea	X			X
	Pertseva-Ostroumova 1960	East Coast of Russia	X			X
Bathylagus stilbius	Ahlstrom 1969		?			X
	Kaskina 1965a	Commander Is., Bering Sea	X			X
Benthosema glaciale	Moser & Ahlstrom 1974		X			X
Boreogadus saida	Musienko 1970	Bering Sea	X			X
Brama japonica	Mead 1972		?			X
Citharichthys sordidus	Arora 1951	San Francisco, Calif., Monterey Bay, Calif.	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Citharichthys stigmaeus	Townsend 1935	Southeast Alaska	X			X
Clupea harengus pallasi	Blackburn 1973	Puget Sound, Wash.	X			X
	McMynn 1951					
	Musienko 1970	Bering Sea	X			X
	Saville 1965	North Atlantic				
Cololabis saira	Nakamura 1937					
	Yusa 1960	Hokkaido, Japan		X	X	
Diaphus theta	Moser & Ahlstrom 1974		X			X
Eleginus gracilis	Musienko 1970	Bering Sea	X			X
Engraulis mordax	Ahlstrom 1956	California		?		?
	Blackburn 1973	Puget Sound, Wash.	X			X
	Bolin 1936	Monterey Bay, Calif.		X		X
	Kramer & Ahlstrom 1968		?			X
Eopsetta jordani	Forrester & Alderdice 1967	West Coast Vancouver Is., British Columbia		X	X	
	Porter 1964					
Gadus macrocephalus	DeLacy 1933	Gulf of Alaska, SE Alaska	X			X
	Forrester 1964	Strait of Georgia, British Columbia		X	X	

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Gadus macrocephalus (cont.)	Mukhacheva & Zviagina 1960					
Gadus morhua macrocephalus	Musienko 1970	Bering Sea	X			X
Hemilepidotus hemilepidotus and *H. jordani*	Musienko 1970	Bering Sea	?			X
Hexagrammos decagrammus	Kashkina 1970	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Hexagrammos lagocephalus	Kashkina 1970	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Hexagrammos octogrammus	Kashkina 1970	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Hexagrammos stelleri	Kashkina 1970	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Hippoglossoides elassodon	Forrester & Alderdice 1968	Strait of Georgia, British Columbia		X	X	
	Miller 1969	San Juan Is., Wash.		X	X	X
	Musienko 1963	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Hippoglossoides robustus	Musienko 1970	Bering Sea				
Hippoglossus hippoglossus	Nichols 1971	North Atlantic	?			X
Hippoglossus stenolepis	Bell & St. Pierre 1970	North Pacific				
	Musienko 1963	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
	Thompson 1915	British Columbia	X	X		X
	Thompson & Van Cleve 1936	Gulf of Alaska	X			X
Hygophum reinhardti	Moser & Ahlstrom 1974		X			X
Hypomesus olidus	Musienko 1970	Bering Sea	X			X
Hypomesus pretiosus	Blackburn 1973	Puget Sound, Wash.	X			X
Isopsetta isolepis	Levings 1968	Queen Charlotte Is., British Columbia		X	X	
Lampanyctus regalis	Moser & Ahlstrom 1974					
Lampanyctus ritteri	Moser & Ahlstrom 1974					

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Lepidopsetta bilineata	Blackburn 1973	Puget Sound, Wash.	X			X
	Musienko 1963	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Limanda aspera	Musienko 1963	Bering Sea	X			X
	Pertseva-Ostroumova 1960	Sea of Japan				
Limanda proboscidea	Musienko 1963	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
Liparis dennyi	Musienko 1963	Bering Sea	X			X
Lyopsetta exilis	Blackburn 1973	Puget Sound, Wash.	X			X
Mallotus villosus	Musienko 1963	Bering Sea	X			X
	Musienko 1970	Bering Sea	X			X
	Templeman 1948	Newfoundland	X			X
Melamphaes lugubris	Ebeling 1962		?			X
Merluccius productus	Ahlstrom & Counts 1955	California, Baja Calif.	X			X
Microstomus pacificus	Hagerman 1952	California	X		X	
Ophiodon elongatus	Blackburn 1973	Puget Sound, Wash.	X			X
	Musienko 1970	Bering Sea	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Parophrys vetulus	Budd 1940	Monterey Bay, Calif.				
	Hart 1973	California, British Columbia	X		X	X
	Orsi 1968	Puget Sound, Wash.				
Pholis laeta	Blackburn 1973	Puget Sound, Wash.	X			X
Pholis ornata	Blackburn 1973	Puget Sound, Wash.	X			X
Platichthys stellatus	Musienko 1970	Bering Sea	X			X
	Orcutt 1950	Monterey Bay, Calif.		X	X	
	Yusa 1957	Hokkaido, Japan		X	X	
Pleurogrammus monopterygius	Kobayashi 1958	Bering Sea, N. Pacific	?			X
	Musienko 1970	Bering Sea	X			X
Pleuronectes quadrituberculatus	Musienko 1970	Bering Sea	X			X
Pleuronichthys coenosus	Budd 1940	Monterey Bay, Calif.		X		X
Pleuronichthys decurrens	Budd 1940	Monterey Bay, Calif.		X		X
Psettichthys melanostictus	Hickman 1959	Puget Sound, Wash.	X	X		X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Ptilichthys goodei	Kobayashi 1961b	Okhotsk Sea, N. Pacific	X			X
	Richardson & DeHart 1975	Oregon	X			X
Reinhardtius hippoglossoides	Jensen 1935	West Greenland	X			X
	Musienko 1970	Bering Sea	X			X
	Nichols 1971	Norwegian and Barents Seas, Greenland	?			X
Sarda chiliensis	Barnhart 1927	LaJolla, Calif.		X		X
Sardinops sagax	Ahlstrom 1943	California	X	X		X
	Ahlstrom 1966	California, Baja Calif.	X			X
	Clark 1934	California	X			X
	Hart 1938					
	Miller 1952	Baja California		X	X	
	Orton 1953		?			X
	Scofield 1934	California, Baja Calif.		X		X
	Scofield & Lindner 1930					
Scomber japonicus	Fry 1936	California		X		X
	Kramer 1960	California, Baja Calif.	X			X
Scorpaenichthys mormoratus	O'Connell 1953	California	X	X	X	X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastes aleutianus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenco 1972	Gulf of Alaska	X			X
Sebastes alutus	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
	Kashkina 1965a	Commander Is., Bering Sea	X			X
	Kashkina 1970	Bering Sea	X			X
Sebastes auriculatus	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes babcocki	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes borealis	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastes brevispinis	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes caurinus	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes ciliatus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes crameri	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes diploproa	Blackburn 1973	Puget Sound	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes elongatus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastes emphaeus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes entomelus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes flavidus	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes helvomaculatus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes maliger	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes melanops	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska,	X			X
Sebastes mystinus	Blackburn 1973	Puget Sound, Wash.	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastes mystinus (cont.)	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
	Wales 1952	Monterey Bay, Calif.		X		X
Sebastes nebulosus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes nigrocinctus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes paucispinis	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
	Morris 1956	Monterey Bay, Calif.		X	X	
	Moser 1967	Southern California	X			X
Sebastes pinniger	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
	Waldron 1968	Washington	X	X		X
Sebastes proriger	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastes reedi	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes ruberrimus	Blackburn 1973	Puget Sound, Wash.	X			X
	DeLacy et. al. 1964	Puget Sound, Wash. Coast	X	X		X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes saxicola	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
	Morris 1956	Monterey Bay, Calif.		X	X	
Sebastes variegatus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes wilsoni	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastes zacentrus	Blackburn 1973	Puget Sound, Wash.	X			X
	Efremenko & Lisovenko 1972	Gulf of Alaska	X			X
Sebastolobus alascanus	Moser 1974		?			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Sebastolobus altivelis	Moser 1974		?			X
Sphyraena argentea	Orton 1955		?			X
	Barnhart 1927	LaJolla, Calif.		X		X
Spirinchus starksi	Blackburn 1973	Puget Sound, Wash.	X			X
Spirinchus thaleichthys	Blackburn 1973	Puget Sound, Wash.	X			X
Stenobrachius leucopsarus	Moser & Ahlstrom 1974		X			X
Symbolophorus californiense	Moser & Ahlstrom 1974		X			X
Tarletonbeania crenularis	Moser & Ahlstrom 1974		X			X
Thaleichthys pacificus	Blackburn 1973	Puget Sound, Wash.	X			X
Theragra chalcogramma	Hamai et. al. 1971	Hokkaido, Japan		X	X	
	Kashkina 1970	Bering Sea	X			X
	Kobayashi 1963	Bering Sea, N. Pacific	X			X
	Serobaba 1974	Bering Sea	X			X
	Yusa 1954	Hokkaido, Japan		X	X	
Thunnus alalunga	Gorbunova 1954					
	Sanzo 1910		?			X

Table 4. (cont.)

Species	Reference	Area	Pres.	Liv.	Artificially Spawned	Plankton
Thunnus thynnus	Matsumoto et. al. 1972		?			X
	Sanzo 1932		?			X
Trachurus symmetricus	Ahlstrom 1956	California, Baja. Calif.	X			X
	Ahlstrom & Ball 1954	California, Baja Calif.	X			X
Trichodon trichodon	Musienko 1970	Bering Sea	X			X
Xiphister atropurpureus	Blackburn 1973	Puget Sound, Wash.	X			X
Xiphister mucosus	Blackburn 1973	Puget Sound, Wash.	X			X

Table 5. List of fish species thought to have pelagic eggs or larvae

Synaphobranchidae
* § *Synaphobranchus bathybius* Günther

Notacanthidae
* § *Macdonaldia challengeri* (Vaillant)
* § *Polyacanthonotus altus* (Gill & Townsend)
* § *Polyacanthonotus challengeri* (Vaillant)
* § *Polyacanthonotus longus* (Gill & Townsend)

Osmeridae
* § *Osmerus eperlanus* (Linnaeus)

Bathylagidae
* § *Bathylagus borealis* Gilbert
* § *Bathylagus callorhini* (Lucas)
* § *Bathylagus milleri* Jordan & Gilbert
* § *Bathylagus ochotensis* Schmidt
* § *Bathylagus pacificus* Gilbert
*   *Bathylagus stilbius* (Gilbert)

Opisthoproctidae
* § *Macropinna microstoma* Chapman

Gonostomatidae
* § *Cyclothone atraria* Gilbert
* § *Cyclothone microdon* (Günther)
* § *Cyclothone pacifica* Mukhacheva
* § *Cyclothone pallida* Brauer
* § *Cyclothone signata* Garman
* § *Gonostoma gracile* Günther

Melanostomiatidae
* § *Tactostoma macropus* Bolin

Alepocephalidae
* § *Erica salmoneum* Gill & Townsend

Alepisauridae
* § *Alepisaurus richardsonii* Bleeker

Myctophidae
*   *Benthosema glaciale* (Reinhardt)
*   *Diaphus theta* Eigenmann & Eigenmann
* § *Hierops thompsoni* (Chapman)
*   *Hygophum reinhardti* (Lütken)
* § *Lampanyctus beringensis* Schmidt
* § *Lampanyctus gemmifer* Goode & Bean
* § *Lampanyctus jordani* Gilbert
* § *Lampanyctus nannochir* (Gilbert)

* eggs
§ larvae

Table 5. (cont.)

Myctophidae (cont.)
* *Lampanyctus regalis* (Gilbert)
* *Lampanyctus ritteri* Gilbert
* *Stenobrachius leucopsarus* (Eigenmann & Eigenmann)
* *Symbolophorus californiense* (Eigenmann & Eigenmann)
* *Tarletonbeania crenularis* (Jordan & Gilbert)
* § *Tarletonbeania taylori* Mead

Oneirodidae
* § *Oneirodes acanthias* (Gilbert)
* § *Oneirodes bulbosus* Chapman
* § *Oneirodes thompsoni* (Schultz)

Gadidae
* § *Artogadus borisovi* Drjagin
* § *Eleginus navaga* (Pallas)
* § *Lota maculosa* (Lesuer)
* § *Theragra fucensis* (Jordan & Gilbert)

Ophidiidae
* § *Brosmophycis marginata* (Ayres)
* § *Spectrunculus radcliffei* Jordan & Thompson

Zoarcidae
* § *Bothrocara brunneum* (Bean)
* § *Bothrocara mollis* Bean
* § *Bothrocara pusillum* (Bean)
* § *Gymnelis bilabrus* Andriashev
* § *Gymnelis hemifasciatus* Andriashev
* § *Gymnelis viridis* (Fabricius)
* § *Gymnelopsis stigma* (Lay & Bennett)
* § *Lycenchelys jordani* (Evermann & Goldsborough)
* § *Lycodalepis turneri* (Bean)
* § *Lycodopus extensus* Gilbert
* § *Lycodopus fierasfer* Gilbert
* § *Lycodopus grossidens* Gilbert
* § *Lycodopus mandibularis* Gilbert
* § *Lycodopus parviceps* Gilbert
* § *Lycodes agnostus* Jensen
* § *Lycodes brevipes* Bean
* § *Lycodes camchaticus* Gilbert & Burke
* § *Lycodes concolor* Gill & Townsend
* § *Lycodes diapterus* Gilbert
* § *Lycodes digitatus* Gill & Townsend
* § *Lycodes jordani* Evermann & Goldsborough
* § *Lycodes jugoricus* Knipowitsch
* § *Lycodes mucosus* Richardson
* § *Lycodes palearis* Gilbert
* § *Lycodes pallidus* Collett
* § *Lycodes polaris* (Sabine)
* § *Lycodes raridens* Taranetz & Andriashev
* § *Lycodes rossi* Malmgren
* § *Lycodes turneri* Bean

Table 5. (cont.)

Zoarcidae (cont.)
* § *Lycodopsis pacifica* (Collett)
* § *Nalbantichthys elongatus* Schultz

Macrouridae
* § *Coryphaenoides acrolepis* (Bean)
* § *Coryphaenoides cinereus* (Gilbert)
* § *Coryphaenoides clarki* (Jordan & Gilbert)
* § *Coryphaenoides filifera* Gilbert
* § *Coryphaenoides firmisquamis* (Gill & Townsend)
* § *Coryphaenoides lepturus* (Gill & Townsend)
* § *Coryphaenoides pectoralis* (Gilbert)
* § *Coryphaenoides serrula* (Bean)
* § *Coryphaenoides spinulosus* (Gilbert & Burke)
* § *Coryphaenoides suborbitalis* (Gill & Townsend)

Melamphaeidae
* § *Melamphaes cavernosus* Chapman
* § *Melamphaes cristiceps* Gilbert
* § *Melamphaes nycterinus* Gilbert
* § *Melamphaes rugosus* Chapman

Lamprididae
* § *Lampris regius* (Bonnaterre)

Zeidae
* § *Allocyttus verrucosus* (Gilchrist)

Trachipteridae
* § *Trachipterus altivelis* Kner

Gasterosteidae
* § *Aulorhynchus flavidus* Gill

Sciaenidae
* § *Cynoscion nobilis* (Ayres)

Pentacerotidae
* § *Pseudopentaceros richardsoni* (Smith)

Stichaeidae
* § *Acantholumpenus mackayi* (Gilbert)
* § *Alectridium aurantiacum* Gilbert & Burke
* § *Anisarchus medius* Reinhardt
* § *Bryozoichthys lysimus* (Jordan & Snyder)
* § *Bryozoichthys marjorius* McPhail
* § *Chirolophis nugator* (Jordan & Williams)
* § *Chirolophis polyactocephalus* (Pallas)
* § *Chirolophis tarsodes* (Jordan & Synder)
* § *Eumesogrammus praecisus* (Krøyer)
* § *Gymnoclinus cristulatus* Gilbert & Burke
* § *Leptoclinus maculatus* (Fries)

Table 5. (cont.)

Stichaeidae (cont.)
* § *Lumpenus fabricii* (Valenciennes)
* § *Lumpenus aracilis* (Ayres)
* § *Lumpenus maculatus* (Fries)
* § *Lumpenus mackayi* Gilbert
* § *Lumpenus medius* Reinhardt
* § *Lumpenus sagitta* Wilimovsky
* § *Lyconectes aleutensis* Gilbert
* § *Phytichthys chirus* (Jordan & Gilbert)
* § *Poroclinus rothrocki* Bean
* § *Stichaeus punctatus* (Fabricius)
* § *Xiphister versicolor* Gilbert & Burke

Anarhichadidae
* § *Anarrhichthys ocellatus* Ayres

Zaproridae
* § *Zaprora silenus* Jordan

Ammodytidae
* § *Ammodytes personatus* Girard

Scombridae
§ *Sarda chiliensis* (Cuvier)

Stromateidae
* *Icichthys lockingtoni* Jordan & Gilbert

Icosteidae
* § *Icosteus aenigmaticus* Lockington

Scorpaenidae
* § *Sebastes glaucus* (Hilgendorf)
* § *Sebastes melanostomus* (Eigenmann & Eigenmann)
* § *Sebastes polyspinus* (Taranetz & Moiseev)
* § *Sebastes ruber* (Cramer)
* § *Sebastes rupestris* (Gilbert)
* § *Sebastes swifti* (Evermann & Goldsborough)

Anoplopomatidae
* § *Erilepis zonifer* (Lockington)

Cottidae
* § *Blepsias bilobus* Cuvier
* § *Blepsias cirrhosus* (Pallas)
* § *Dasycottus setiger* Bean
* § *Enophrys bison* (Girard)
* § *Enophrys diceraus* (Pallas

Table 5. (cont.)

Cottidae (cont.)

* § *Gilbertidia sigalutes* (Jordan & Starks)
* § *Hemilepidotus papilio* (Bean)
* § *Hemilepidotus spinosus* (Ayres)
* § *Hemilepidotus zapus* (Gilbert & Burke)
* § *Leptocottus armatus* Girard
* § *Myoxocephalus axillaris* (Gill)
* § *Myoxocephalus batrachoides* Gilbert & Burke
* § *Myoxocephalus jaok* (Cuvier)
* § *Myoxocephalus mednius* Bean
* § *Myoxocephalus niger* (Bean)
* § *Myoxocephalus polyacanthocephalus* (Pallas)
* § *Myoxocephalus quadricornis* (Linnaeus)
* § *Myoxocephalus paryulus* Gilbert & Burke
* § *Myoxocephalus platycephalus* (Pallas)
* § *Myoxocephalus scorpioides* (Fabricius)
* § *Myoxocephalus scorpius* (Linnaeus)
* § *Myoxocephalus stelleri* Tilesius
* § *Myoxocephalus verrucosus* (Bean)
* § *Nautichthys oculofasciatus* (Girard)
* § *Nautichthys robustus* Peden
* § *Nautichthys pribilovius* (Jordan & Gilbert)
* § *Psychrolutes paradoxus* Günther
* § *Rhamphocottus richardsoni* Günther

Pleuronectidae

* *Atheresthes stomias* (Jordan & Gilbert)
* *Citharichthys stigmaeus* Jordan & Gilbert
* § *Embassichthys bathybius* (Gilbert)
§ *Glyptocephalus zachirus* Lockington
* § *Inopsetta ischyra* (Jordan & Gilbert)
* § *Liopsetta glacialis* (Pallas)

Molidae

§ *Mola mola* (Linnaeus)

Table 6. Alaskan marine fish of major commercial importance

Alosa sapidissima (Wilson) American shad
Anoplopoma fimbria (Pallas) sablefish
Atheresthes evermanni Jordan & Starks Kamchatka flounder

Citharichthys sordidus (Girard) Pacific sanddab
Citharichthys stigmaeus Jordan & Gilbert speckled sanddab
Clupea harengus pallasi Valenciennes Pacific herring
Cynoscion nobilis (Ayres) white seabass

Engraulis mordax Girard northern anchovy
Eopsetta jordani (Lockington) petrale sole

Gadus macrocephalus Tilesius Pacific cod
Glyptocephalus zachirus Lockington rex sole

Hexagrammos decagrammus (Pallas) kelp greenling
Hexagrammos lagocephalus (Pallas) rock greenling
Hexagrammos octogrammus (Pallas) masked greenling
Hexagrammos stelleri Tilesius whitespotted greenling
Hippoglossoides elassodon Jordan & Gilbert flathead sole
Hippoglossoides robustus Gill & Townsend Bering flounder
Hippoglossus stenolepis Schmidt Pacific halibut

Isopsetta isolepis (Lockington) butter sole

Lepidopsetta bilineata (Ayres) rock sole
Limanda aspera (Pallas) yellowfin sole
Limanda proboscidea Gilbert longhead dab
Lyopsetta exilis (Jordan & Gilbert) slender sole

Mallotus villosus (Müller) capelin
Merluccius productus (Ayres) Pacific hake
Microgadus proximus (Girard) Pacific tomcod
Microstomus pacificus (Lockington) Dover sole

Ophiodon elongatus Girard lingcod

Parophrys vetulus Girard English sole
Platichthys stellatus (Pallas) starry flounder
Pleurogrammus monopterygius (Pallas) Atka mackerel
Pleuronectes quadrituberculatus Pallas Alaska plaice
Pleuronichthys coenosus Girard C-O sole
Pleuronichthys decurrens Jordan & Gilbert curlfin sole
Psettichthys melanostictus Girard sand sole

Reinhardtius hippoglossoides (Walbaum) Greenland halibut

Sardinops sagax (Jenyns) Pacific sardine
Scomber japonicus Houttuyn chub mackerel
Sebastes alutus (Gilbert) Pacific ocean perch

Table 6. (cont.)

Theragra chalcogramma (Pallas)	walleye pollock
Thunnus alalunga (Bonnaterre)	albacore
Thunnus thynnus (Linneaus)	bluefin tuna

Table 7. Characteristics of pelagic eggs

Species	Diameter (mm)	Oil Globule (mm)	Perivitelline	Source	Other Features
Anoplopoma fimbria	1.98-2.21		Small	Planktonic, preserved	
Atheresthes evermanni	2.05-2.20		11.3-16.2%	Planktonic, preserved	
Atheresthes stomias	1.7-2.0		Small	Planktonic, preserved	
Boreogadus saida	1.6-1.8			Planktonic, preserved	
Citharichthys sordidus	0.57-0.77		Small	Ovaries, preserved	
Cololabis saira	2.06-2.13	Small Globules		Artificially spawned, fertile, live	Filaments at one pole, attach to objects
Engraulis mordax	0.65-0.82 by 1.23-1.55		On each end	Planktonic, live	Ellipsoidal
Eopsetta jordani	1.13-1.52		Small	Artificially spawned, unfertile	
Gadus macrocephalus	0.98-1.08		Small	Artificially spawned, fertile	Demersal early stages
Glyptocephalus zachirus	1.38-1.70		Small	Planktonic, preserved	

Table 7. (cont.)

Species	Diameter (mm)	Oil Globule (mm)	Perivitelline	Source	Other Features
Hippoglossoides elassodon	2.27-2.86		Large	Planktonic, preserved	Spherical or slightly ellipsoidal
Hippoglossoides robustus	2.04-2.69			Planktonic, preserved	
Hippoglossus stenolepis	2.90-3.80		Moderate	Planktonic, preserved	Honeycombed shell
Isopsetta isolepis	0.93-1.10		Small	Artificially spawned, fertile	Reticulate shell
Limanda aspera	0.68-0.88		Small	Planktonic, preserved	
Limanda proboscidea	0.72-0.87			Planktonic, preserved	
Lyopsetta exilis	1.40-1.74			Planktonic, preserved and artificially spawned, preserved, unfertile	
Merluccius productus	1.07-1.18	0.27-0.34	Small	Planktonic, preserved	Slightly adhesive
Microstomus pacificus	2.05-2.57		Small	Planktonic	Wrinkled shell. Slightly translucent
Parophrys vetulus	0.93-1.05		Small	Artificially spawned, fertile	

Table 7. (cont.)

Species	Diameter (mm)	Oil Globule (mm)	Perivitelline	Source	Other Features
Platichthys stellatus	0.89-0.94		Small	Artificially spawned, fertile	
Pleuronectes quadrituberculatus	1.90-2.05			Planktonic, preserved	
Pleuronichthys coenosus	1.88		Small	Planktonic, live	Hexagons on shell 0.042 mm
Pleuronichthys decurrens	1.31-1.50		Small	Planktonic, live	Hexagons on shell 0.037 mm
Reinhardtius hippoglossoides	4.0 -4.5		Small	Artificially spawned, unfertile, preserved	
Sarda chiliensis	1.50	0.28	Small	Planktonic, live	Oil globule, yellowish brown
Sardinops sagax	1.15-1.83	0.16	Large	Artificially spawned, fertile	
Scomber japonicus	0.9 -1.2	0.26	Small	Planktonic, live	
Sebastolobus altivelis or *S. alascanus*	1.2 -1.4	0.20		Planktonic, live and preserved	Adhesive. Float in masses

Table 7. (cont.)

Species	Diameter (mm)	Oil Globule (mm)	Perivitelline	Source	Other Features
Sphyraena argentea	1.02	0.20	Small	Planktonic, live	Oil globule, brownish
Theragra chalcogramma	1.24-1.70	5-6. Later 2-3	Small	Artificially spawned, fertile	Reticulate shell
Thunnus alalunga	0.84-0.94			Planktonic?	
Thunnus thynnus	∿1.0			Plantonic?	
Trachurus symmetricus	0.90-1.08	0.26	Small 0.09	Planktonic, preserved	
Scorpaenichthys marmoratus	1.4 -1.7	0.27		Artificially spawned, unfertile, preserved	+1-4 small oil globules
Psettichthys melanostictus	.86- .96		Small	Artificially spawned, live, fertile	(English unpubl.)

Table 8. Characteristics of pelagic larvae

LARVAL CHARAC-TERISTICS	CLUPEIDAE			ENGRAULIDAE	OSMERIDAE			
	Alosa sapidissima	*Clupea harengus pallasi*	*Sardinops sagax*	*Engraulis mordax*	*Hypomesus pretiosus*	*Mallotus villosus*	*Spirinchus starksi*	*Spirinchus thaleichthys*
Yolk-sac stage	yes		yes	yes		yes		
Size when hatched (mm)	7.0-10.0	4.0-10.0	3.0-3.5	2.5-3.0	$\sim$3	3		$\sim$7.0
Position of anus	80%	80-85%	80%	70-85%	70-80%	77-81%	70-85%	70-85%
Fin ray counts	(Vary with development of larvae. Numbers following are for mature larvae and adults.)							
Dorsal	16-17	15-21	17-20	14-16	9-10	10-14	8-9	8-9
Anal	21-22	14-20	17-19	20-23	13-16	16-23	15-18	16-18
Pectoral	$\sim$16	$\sim$17	17-18	17	14-16	16-20	10-11	10-12
Pelvic	9	$\sim$9	8-9	6	8	9	8	8
Others					adipose	adipose	adipose	adipose
Oil globule	no	no	0.16 mm	no		yes		
Vertebrae	53-59	51-53	$\sim$51	$\sim$45	64-68	65-66	60-63	60-63
Myomeres								
Yolk-sac larva	62		48	41-46		64-72		
larvae	64-66	56-58	48					
Gillrakers on 1st arch					31-36	26-37	33-34	39-47
Other features								

Table 8. (cont.)

LARVAL CHARACTERISTICS		CLUPEIDAE		ENGRAULIDAE	OSMERIDAE			
	Alosa sapidissima	*Culpea harengus pallasi*	*Sardinops sagax*	*Engraulis mordax*	*Hypomesus pretiosus*	*Mallotus villosus*	*Spirinchus starksi*	*Spirinchus thaleichthys*
Pigmentation				No pigmentation on young larvae				
Head								
Trunk								
dorsal margin		None on ventral midline posterior to anus	Two dorsal rows					
ventral margin				Few spots		Line of spots yolk sac-tail		
Fin fold								
Gut		Two rows	Migrate around gut	Similar to *Clupea*		One spot above anus		
Yolk-sac	yes	no	no	no	no	no	no	no
Color			Brownish yellow					

Table 8. (cont.)

LARVAL CHARACTERISTICS	OSMERIDAE	BATHYLAGIDAE	MYCTOPHIDAE	GADIDAE			
	Thaleichthys pacificus	*Bathylagus stilbius*	*Stenobrachius leucopsarus*	*Gadus macrocephalus*	*Gadus morhua macrocephalus*	*Merluccius productus*	*Theragra chalcogramma*
Yolk-sac stage				yes	yes	yes	yes
Size when hatched (mm)	5-7			3.3-3.8	3.2-3.6	2.4	3.5-4.3
Position of anus	70-85%	39%	∿50%	40-45%		42%	30-34%
Fin ray counts	(Vary with development of larvae. Numbers following are for mature larvae and adults.)						
Dorsal	10-12	9-10	12-15	D1 10-13 D2 13-16 D3 14-17	D1 13-16 D2 19-24 D3 18-21	D1 10-11 D2 39-44	D1 10-13 D2 13-16 D3 15-19
Anal	18-22	12-13	14-16	A1 16-19 A2 15-18	A1 20-24 A2 17-22	40-43	A1 17-21 A2 16-21
Pectoral	10-12	8-9	∿11	19-22		14-16	18-21
Pelvic	8	9	8	6-7	6-7	6-8	6-7
Others	adipose	adipose	adipose				
Oil globule				no	no	0.33 mm	no
Vertebrae	65-72			50-53	49-53	51-55	48-50
Myomeres							
Yolk-sac larva						43	43
larvae						45	

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	OSMERIDAE *Thaleichthys pacificus*	BATHYLAGIDAE *Bathylagus stilbius*	MYCTOPHIDAE *Stenobrachius leucopsarus*	GADIDAE *Gadus macrocephalus*	*Gadus morhua macrocephalus*	*Merluccius productus*	*Theragra chalcogramma*
Gillrakers on 1st arch							
Other features							
Pigmentation							
Head						Occipital spot	Few
Trunk							
dorsal margin				Two bands		Midway, anus to tail	Two bands on trunk
ventral margin							
Fin folds							
Gut				Along dorsal margin		Along dorsal margin	Along dorsal margin
Yolk-sac	no	no	no	no	no	yes	no
Color				Black	Black	Black	Black

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCOMBER-ESOLIDAE *Cololabis saira*	CARANGIDAE *Trachurus symmetricus*	BRAMIDAE *Brama japonica*	SPHYRAENIDAE *Sphyraena argentea*	STICHAEIDAE *Anoplarchus insignis*	*Anoplarchus purpurescens*	*Chirolophis nugator*
Yolk-sac stage	yes	yes		yes			
Size when hatched (mm)	6.8-7.8	~2.5		~2.5	~6	~7.5	
Position of anus	63%	53-60%		53-57%	35-43%	35-40%	35-40%
Fin ray counts							
Dorsal	9-11	D1 8 D2 33-34	33-36	D1 5-6 D2 8-11	57-64	57	53-55
Anal	12-14	A1 1-2 A2 29	27-30	9-11	40-46	39-40	38-43
Pectoral	~13	22-24	22	14-16	9-10	?	~14
Pelvic	6	6	6	6	absent	absent	5
Others	Finlets 5-6						
Oil globule	0.26 mm	0.26 mm		yes		yes	
Vertebrae	62-64	24	39-41	24	62-68	60	
Myomeres							
Yolk-sac larvae		21-22			60-65	60-65	~52
larvae							

Table 8. (cont.)

LARVAL CHARAC- TERISTICS	SCOMBER- ESOLIDAE *Cololabis saira*	CARANGIDAE *Trachurus symmetricus*	BRAMIDAE *Brama japonica*	SPHYRAENIDAE *Sphyraena argentea*	STICHAEIDAE *Anoplarchus insignis*	*Anoplarchus purpurescens*	*Chirolophis nugator*
Gillrakers on 1st arch							
Other features			Spines on preopercle Serrated upper lip				Gut with loop
Pigmentation	No pigment on fin folds						
Head	Crown	Crown		Crown snout			
Trunk dorsal margin	yes	yes		Laterally migrate to margins on anterior half			
ventral margin		yes					
Fin folds	none			Early on dorsal. Behind anus			
Gut		Along dorsal margin		Dorsal margin below gut			
Yolk-sac	yes	On oil globule		Posterior			
Color	Indigo-green	Black (preserved only)					

Table 8. (cont.)

LARVAL CHARACTERISTICS	STICHAEIDAE			PHOLIDAE			PTILICHTHYIDAE	AMMODYTIDAE
	Lumpenus sagitta	*Xiphister atropurpureus*	*Xiphister mucosus*	*Apodichthys flavidus*	*Pholis laeta*	*Pholis ornata*	*Ptilichthys goodei*	*Ammodytes hexapterus*
Yolk-sac stage								
Size when hatched (mm)	∿13	∿13	∿17					∿7.4
Position of anus	42–48%	∿45%	52%	55–65%	55–65%	55–65%	35–40%	58–65%
Fin ray counts								
Dorsal	66–72	65–73	71–77	40–45	74–80	74–79	137–145	54–59
Anal	46–51	40–52	46–50	39–43	37–39	37–40	180–196	24–30
Pectoral	∿17	minute flaps	minute flaps	∿14	∿11	∿12	13	∿13
Pelvic	4	absent	absent	absent	2	2	absent	absent
Others								Caudal PrC 8+7 BrC 7+6
Oil globule								
Vertebrae	78–80	73–74	82–83				227–240	65–70
Myomeres								
Yolk-sac larvae		69–72	80	96	80–85	80–85	225–229	61–66
Larvae								

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	STICHAEIDAE			PHOLIDAE			PTILICH-THYIDAE	AMMODYTIDAE
	Lumpenus sagitta	*Xiphister atropur-pureus*	*Xiphister mucosus*	*Apodichthys flavidus*	*Pholis laeta*	*Pholis ornata*	*Ptilichthys goodei*	*Ammodytes hexapterus*
Gillrakers on 1st arch								
Other features								
Pigmentation		Intense	Intense					
Head		On isth-mus	None on isthmus				Jaw, throat & hind brain	
Trunk dorsal margin			Row on each side of mid-line				Above gut to tail	Late stages
ventral margin							Hindgut to tail	yes
Fin folds	Spot on pectoral base							Around base
Gut	Row on dorsal margin	Line from anus to pectoral fin on dorsal margin	Dorsal third				Dorsal & ventrally	Dorsal & laterally
Yolk-sac								Ventral margin
Color							Light green yellow orange maroon	

Table 8. (cont.)

LARVAL CHARACTERISTICS	SCOMBRIDAE *Scomber japonicus*	*Thunnus alalunga*	*Thunnus thynnus*	SCORPAENIDAE *Sebastes aleutianus*	*Sebastes alutus*	*Sebastes auriculatus*	*Sebastes babcocki*	*Sebastes borealis*
Yolk-sac stage								
Size when hatched (mm)	3.0-3.5				5.3	4.7-6.7		
Position of anus	49-67%		43-60%	32-36%	42%	28-38%	28-38%	28-38%
Fin ray counts								
Dorsal	D1 9-10 D2 13 Df 5-6	D1 13-14 D2 15-16 Df 7	D1 13-14 D2 14 Df 8	26-27	27-30	26	27	26
Anal	A1 13 Af 5-6	A1 14-15 Af 7-8	A1 13 Af 7-8	10-11	9-12	10	9-10	10
Pectoral	20			18-19	18	18	19	17-20
Pelvic	6	6	6	6	6	6	6	6
Others								
Oil globule	0.22-0.31 mm			yes	yes	yes	yes	yes
Vertebrae	30	38	38		26			26
Myomeres								
Yolk-sac larvae	31, 34			32-33		29-33	29-33	29-33
Larvae	31			26	26-28	26	26	26

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCOMBRIDAE			SCORPAENIDAE				
	Scomber japonicus	*Thunnus alalunga*	*Thunnus thynnus*	*Sebastes aleutianus*	*Sebastes alutus*	*Sebastes auriculatus*	*Sebastes babcocki*	*Sebastes borealis*
Gillrakers on 1st arch				30-34	30-38	25-30	30-31	27-31
Other features								
Pigmentation	pigment on oil globule							
Head	Crown, snout, behind eye							
Trunk dorsal margin / ventral margin	Laterally with band midway to tail							
Fin folds								
Gut	yes							
Yolk-sac	yes							
Color	Yellow Black							

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCORPAENIDAE *Sebastes brevispinis*	*Sebastes caurinus*	*Sebastes ciliatus*	*Sebastes crameri*	*Sebastes diploproa*	*Sebastes elongatus*	*Sebastes emphaeus*	*Sebastes entomelas*
Yolk-sac stage								
Size when hatched (mm)	4.0	4.1-6.0			5.0-5.2	∿5.0		
Position of anus	28-34%	28-38%	28-38%	28-38%	28-38%	28-38%	28-38%	28-38%
Fin ray counts								
Dorsal	28-30	26	28	25	25-26	26	27-28	27-29
Anal	10	9	11	8-10	9-10	9	10	11-13
Pectoral	16-18	17	18	18-20	18	16-17	17	17
Pelvic	6	6	6	6	6	6	6	6
Others								
Oil globule	yes	yes	yes	yes	yes	yes	yes	yes
Vertebrae								
Myomeres								
Yolk-sac larvae	31-32	29-33	29-33	29-33	29-33	29-33	29-33	29-33
Larvae	26	26	26	26	26	26	26	26
Gillrakers on 1st arch	33-36	26-32	35	29-34	32-37	28-33	41-45	35-37
Other features								

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCORPAENIDAE *Sebastes brevispinis*	*Sebastes caurinus*	*Sebastes ciliatus*	*Sebastes crameri*	*Sebastes diploproa*	*Sebastes elongatus*	*Sebastes emphaeus*	*Sebastes entomelas*
Pigmentation								
Head								
Trunk dorsal margin								
ventral margin						Middle two-thirds		
Fin folds								
Gut						Dorsal margin		
Yolk-sac								
Color								

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCORPAENIDAE							
	Sebastes flavidus	*Sebastes helvo-maculatus*	*Sebastes maliger*	*Sebastes melanops*	*Sebastes mystinus*	*Sebastes nebulosus*	*Sebastes nigro-cinctus*	*Sebastes paucispinus*
Yolk-sac stage								
Size when hatched	4.5		5.0					4.0-6.0
Position of anus	28-38%	28-38%	28-38%	28-38%	28-34%	28-38%	28-38%	35-44%
Fin ray counts								
Dorsal	27-28	26	26-27	27-28	28-29	26	27	27
Anal	11	9	10	11	11-12	10	10	12
Pectoral	18	16-17	17	18-19	17-18	18	19	15
Pelvic	6	6	6	6	6	6	6	6
Others								
Oil globule	yes	yes	yes	yes	yes	yes	yes	yes
Vertebrae								
Myomeres								
Yolk-sac larvae	29-33	29-33	29-33	29-33	31-32	29-33	29-33	
Larvae	26	26	26	26	26	26	26	25-27
Gillrakers	34-39	28-33	30-33	33-39	33-38	27-31	27-31	28-31

Table 8. (cont.)

LARVAL CHARAC-TERISTICS	SCORPAENIDAE							
	Sebastes flavidus	*Sebastes helvo-maculatus*	*Sebastes maliger*	*Sebastes melanops*	*Sebastes mystinus*	*Sebastes nebulosus*	*Sebastes nigro-cinctus*	*Sebastes paucispinus*
Other features								Larvae yolk-less when released from females. Numerous head spines
Pigmentation								
Head								Few
Trunk dorsal margin								None
ventral margin								Middle third
Fin folds								Pectoral margins
Gut								yes
Yolk-sac								
Color								Silver-grey

Table 8. (cont.)

	SCORPAENIDAE					
LARVAL CHARACTERISTICS	*Sebastes pinniger*	*Sebastes proriger*	*Sebastes reedi*	*Sebastes ruberrimus*	*Sebastes saxicola*	*Sebastes variegatus*
Yolk-sac stage						
Size when hatched	3.1-3.9		~6.0	5.0	4.3	
Position of anus	34%	28-38%	28-38%	28-38%	36-40%	28-38%
Fin ray counts						
Dorsal	27-28	27-28	27-28	28	26	27-28
Anal	10	10	10-11	10	10	10
Pectoral	17	17	19	19	16	18
Pelvic	6	6	6	6	6	6
Others						
Oil globule	yes	yes	yes	yes	yes	yes
Vertebrae						~26
Myomeres						
Yolk-sac larvae	29-33	29-33	29-33	29-33	29-33	29-33
Larvae	26	26	26	26	25-27	26
Gillrakers on 1st arch	41-45	36-43	31-35	26-30	31-34	36-40
Other features						

Table 8. (cont.)

LARVAL CHARACTERISTICS	SCORPAENIDAE					
	Sebastes pinniger	*Sebastes proriger*	*Sebastes reedi*	*Sebastes ruberrimus*	*Sebastes saxicola*	*Sebastes variegatus*
Pigmentation						
Head					None	
Trunk						
dorsal margin					Middle fourth	
ventral margin					Anterior two-thirds	
Fin folds					Pectorals unpigmented	
Gut					yes	
Yolk-sac						
Color						

Table 8. (cont.)

LARVAL CHARACTERISTICS	SCORPAENIDAE *Sebastes wilsoni*	SCORPAENIDAE *Sebastes zacentrus*	SCORPAENIDAE *Sebastolobus alascanus*	SCORPAENIDAE *Sebastolobus altivelis*	ANOPLOPOMATIDAE *Anoplopoma fimbria*
Yolk-sac stage					
Size when hatched			∿3.0		
Position of anus	28-38%	29-34%	∿36%	∿36%	50-54%
Fin ray counts					
Dorsal	26-27	27-28	24-25	23-24	D1 19-27 D2 17-21
Anal	9	10	8	8	18-22
Pectoral	17	17	22-23	22-24	16-17
Pelvic	6	6	6	6	6
Others					
Oil globule	yes	yes	0.2		no
Vertebrae			29-31	28-29	61-66
Myomeres					
Yolk-sac larvae	29-33	30-31			
Larvae	26	26			
Gillrakers on 1st arch	38-43	31-37	18-23	21-26	
Other features					

Table 8. (cont.)

LARVAL	SCORPAENIDAE *Sebastes wilsoni*	*Sebastes zacentrus*	*Sebastolobus alascanus*	*Sebastolobus altivelis*	ANOPLOPOMATIDAE *Anoplopoma fimbria*
Pigmentation					
Head					
Trunk					
dorsal margin					
ventral margin			Midway between anus and tail	Midway between anus and tail	
Fin folds					Pectoral in late stages
Gut			Hind portion	Hind portion	
Yolk-sac			Posterior portion	Posterior portion	
Color			Black	Black	

Table 8. (cont.)

LARVAL CHARACTERISTICS	HEXAGRAMMIDAE *Hexagrammos decagrammus*	*Hexagrammos lagocephalus*	*Hexagrammos octogrammus*	*Hexagrammos stelleri*	*Ophiodon elongatus*	*Pleurogrammus monopterygius*
Yolk-sac stage						
Size when hatched (mm)	∿8.0	9.0	6.0-7.0		7.0-10.0	∿10.0
Position of anus					42-45%	
Fin ray counts						
Dorsal	45-46	43-45	41-44	41-49	45-51	
Anal	24-25	21-22	22-25	23-25	24-27	
Pectoral	19	19	19	19		
Pelvic	6	6	6	6	6	
Others						
Oil globule					yes	yes
Vertebrae					55-57	
Myomeres						
Yolk-sac larvae						
Larvae						
Gillrakers on 1st arch						
Other features					Bright yellow oil globule near liver	Eggs contain numerous fat droplets

Table 8. (cont.)

	HEXAGRAMMIDAE					
LARVAL CHARACTERISTICS	*Hexagrammos decagrammus*	*Hexagrammos lagocephalus*	*Hexagrammos octogrammus*	*Hexagrammos stelleri*	*Ophiodon elongatus*	*Pleurogrammus monopterygius*
Pigmentation						
Head					Crown, snout and isthmus	Crown
Trunk						
dorsal margin						yes
ventral margin						
Fin folds					Intense dorsal and anal	
Gut					Dorsal margin	yes
Yolk-sac						
Color					Black	Blue-green Black

Table 8. (cont.)

LARVAL CHARAC- TERISTICS	COTTIDAE *Hemilepidotus hemilepidotus*	COTTIDAE *Scorpaen- ichthys marmoratus*	CYCLOPTERIDAE *Aptocyclus ventricosus*	CYCLOPTERIDAE *Liparis dennyi*	BOTHIDAE *Citharichthys sordidus*	BOTHIDAE *Citharichthys stigmaeus*
Yolk-sac stage			no			
Size when hatched (mm)		4.5-5.9	6.5-7.0			
Position of anus		46-56%	33-67%	42-47%	33-40%	∿33%
Fin ray counts						
Dorsal	40	26-29	D1 4-5 D2 10-13	37-40	86-102	79-92
Anal	15	11-13	8-10	30-34	67-81	59-72
Pectoral	16	15	18-21	36-39		
Pelvic	5	6	Modified to form suck- ing disk	Modified to form suck- ing disk	6	6
Others						
Oil globule		0.27	0.8		0.09-0.1	∿0.1
Vertebrae	35	∿35	23-28		38-39	36
Myomeres						
Yolk-sac larvae			19			
Larvae					38-39	36-37
Gillrakers						
Other features						

Table 8. (cont.)

LARVAL CHARAC- TERISTICS	COTTIDAE *Hemilepidotus hemilepidotus*	*Scorpaen- ichthys marmoratus*	CYCLOPTERIDAE *Aptocyclus ventricosus*	*Liparis dennyi*	BOTHIDAE *Cictharichthys sordidus*	*Citharichthys stigmaeus*
Pigmentation						
Head			3 bands on head and body			
Trunk dorsal margin						
ventral margins						
Fin folds	Along margins					
Gut	Dorsal margin					
Yolk-sac		yes				
Color			Blackish brown			

Table 8. (cont.)

LARVAL CHARACTERISTICS	PLEURONECTIDAE *Atheresthes evermanni*	*Atheresthes stomias*	*Eopsetta jordani*	*Glyptocephalus zachirus*	*Hippoglossoides elassodon*	*Hippoglossus stenolepis*
Yolk-sac stage	yes	yes	yes		yes	yes
Size when hatched (mm)			2.4-3.7		3.3-6.9	7.8-15.0
Position of anus	31-33%	26-27%	50%	25%	25-40%	32-41%
Fin ray counts						
Dorsal		92-109	87-101	87-110	75-85	90-106
Anal		72-90	67-79	78-93	55-68	69-80
Pectoral						19
Pelvic		6	6	6	6	6
Others						Caudal: 19
Oil globule	no	no	no	no	no	no
Vertebrae		47-49	41-44	62-65	42-46	49-51
Myomeres						
Yolk-sac larvae					42-44	
Larvae				58	42-44	
Gillrakers on 1st arch					16-24	
Other features	Row of spines above eye plus one along preopercle	Rows of spines along preopercle and above eyes				

Table 8. (cont.)

	PLEURONECTIDAE					
LARVAL CHARACTERISTICS	*Atheresthes evermanni*	*Atheresthes stomias*	*Eopsetta jordani*	*Glypto-cephalus zachirus*	*Hippo-glossoides elassodon*	*Hippo glossus stenolepis*
Pigmentation			None in newly hatched		Highly variable	Few cells in late stages
Head	Crown				Crown	
Trunk						
dorsal margin	Two patches				Four bands in later stages	
ventral margin						
Fin folds					Dorsal and ventral margins	Posterior dorsal and ventral
Gut	Hind half				Hind portion	Along dorsal margin
Yolk-sac			yes		yes	no
Color					Black or brown Yellow	

Table 8. (cont.)

	PLEURONECTIDAE					
LARVAL CHARACTERISTICS	*Isopsetta isolepis*	*Lepidopsetta bilineata*	*Limanda aspera*	*Lyopsetta exilis*	*Microstomus pacificus*	*Parophrys vetulus*
Yolk-sac stage	yes				yes	yes
Size when hatched (mm)		3.6-5.0				∿2.8
Position of anus	30-33%	33-37%		32-37%	34-38%	∿33%
Fin ray counts						
Dorsal	78-92	65-82	61-69	72-78	94-116	72-92
Anal	58-69	50-65	48-58	57-65	80-96	54-70
Pectoral		10-13				
Pelvic	6		6	6		6
Others	Caudal: 18			Caudal: 19	Caudal: 20-22	
Oil globule	no		no	no	no	no
Vertebrae	39-42		39-40	42-45	51-54	41-44
Myomeres						
Yolk-sac larvae						
Larvae	41			38-43		
Gillrakers on 1st arch						
Other features					2 pairs spines near occipital region	

Table 8. (cont.)

LARVAL CHARACTERISTICS	PLEURONECTIDAE *Isopsetta isolepis*	*Lepidopsetta bilineata*	*Limanda aspera*	*Lyopsetta exilis*	*Microstomus pacificus*	*Parophrys vetulus*
Pigmentation	Differ from *Parophrys* by absence of melanophores on head and dorsal midline					
Head	At the jaw	Mandible, behind the eye		Most of head		Crown around eyes
Trunk						
dorsal margin	2 or 3 patches or bands at $\frac{1}{4}$, $\frac{1}{2}$ and near tail	2 patches		Whole trunk and tail		Band half way to tail. Extends above and below
ventral margin		Line and 2 patches				
Fin folds		Opposite trunk pigments		Dorsal and ventral margins	Dorsal and ventral margins	
Gut	Ventral surface	Posterior portion		Posterior portion		Hind portion
Yolk-sac				yes		no
Color	Yellow Black	Black		Yellow Black	Black	Yellow

Table 8. (cont.)

LARVAL CHARACTERISTICS	PLEURONECTIDAE *Platichthys stellatus*	*Pleuronichthys coenosus*	*Pleuronichthys decurrens*	*Psettichthys melanostictus*	*Reinhardtius hippoglossoides*
Yolk-sac stage				yes	yes
Size when hatched (mm)	1.9-3.4	5.5	3.9	∿2.8	∿10.0
Position of anus	36-43%	∿46%	∿45%	34-39%	31-36%
Fin ray counts					
Dorsal	52-66	65-78	66-79	72-88	83-108
Anal	38-47	46-56	46-52	53-56	62-79
Pectoral					11-15
Pelvic	7	6	6	6	6
Others	Caudal: 18				
Oil globule	no	no	no	no	no
Vertebrae	34-37	36-38	38-39	37-39	60-64
Myomeres					
Yolk-sac larvae					
Larvae				36-41	
Gillrakers on 1st arch					
Other features					

Table 8. (cont.)

	PLEURONECTIDAE				
LARVAL CHARACTERISTICS	*Platichthys stellatus*	*Pleuronichthys coenosus*	*Pleuronichthys decurrens*	*Psettichthys melanostictus*	*Reinhardtius hippoglossoides*
Pigmentation					
Head					Crown around eyes
Trunk					
dorsal margin	yes	Scattered over entire body	Scattered over entire body	Several patches	
ventral margin				Several patches	Gut to tail
Fin folds	Dorsal margin. Few ventral.	Entirely except tail	Band midway to tail	Dorsal and ventral margins	Posterior half
Gut	Hind portion	yes	yes	Hind portion	yes
Yolk-sac	yes	yes	yes	yes	yes
Color	Yellow Light Green Black	Amber Black	Yellow Black	Brown	

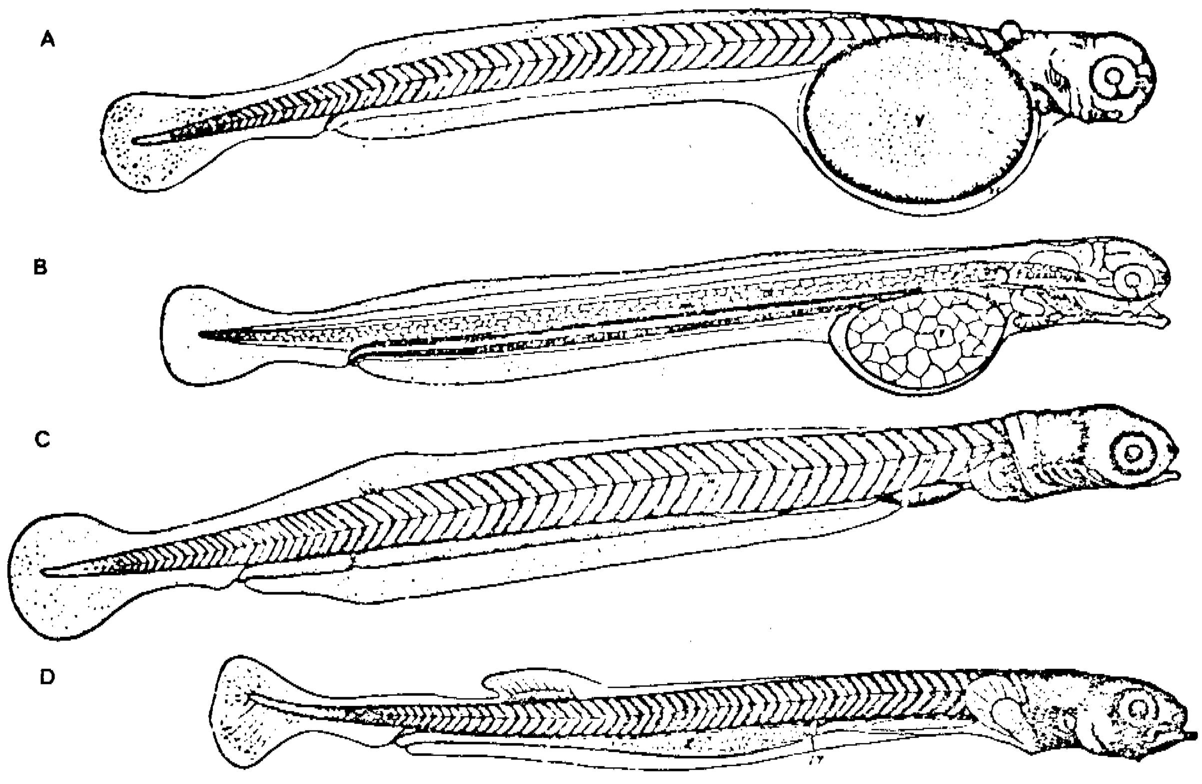


Fig. 1. Larval stages of *Alosa sapidissima*

A. Larva immediately after hatching. B. 3 days after hatching.
C. 5 days after hatching. D. 17 days after hatching.
(Mansueti and Kolb 1953)

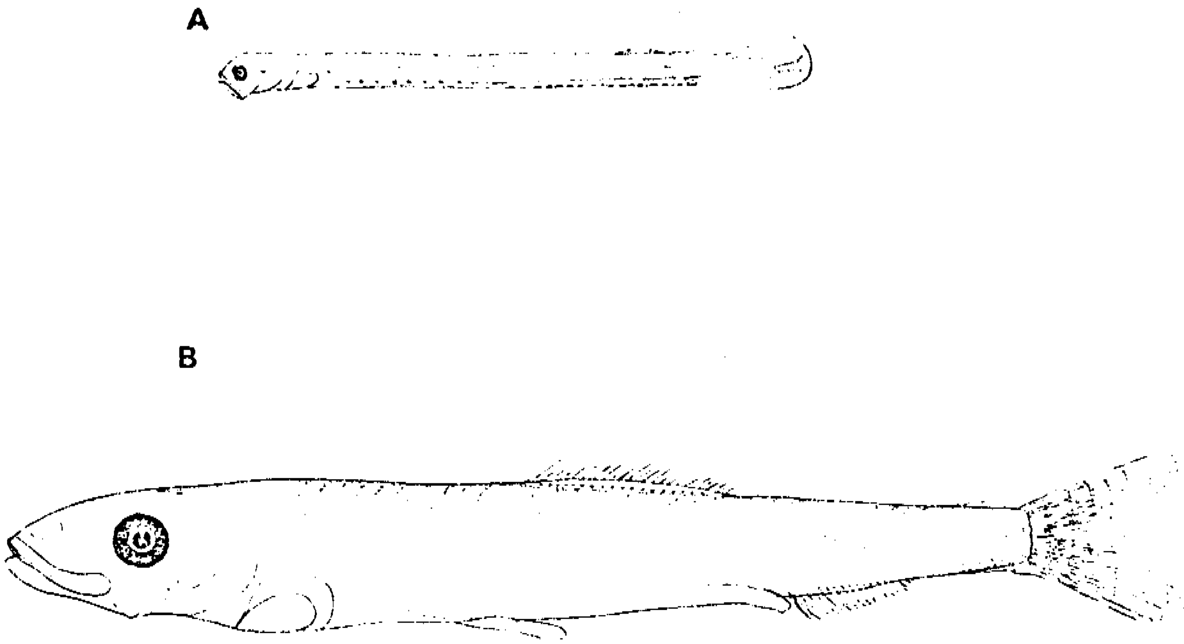


Fig. 2. *Clupea harengus pallasi* Valenciennes

A. 11 mm herring larva. B. 41 mm herring larva. (Saville 1965)

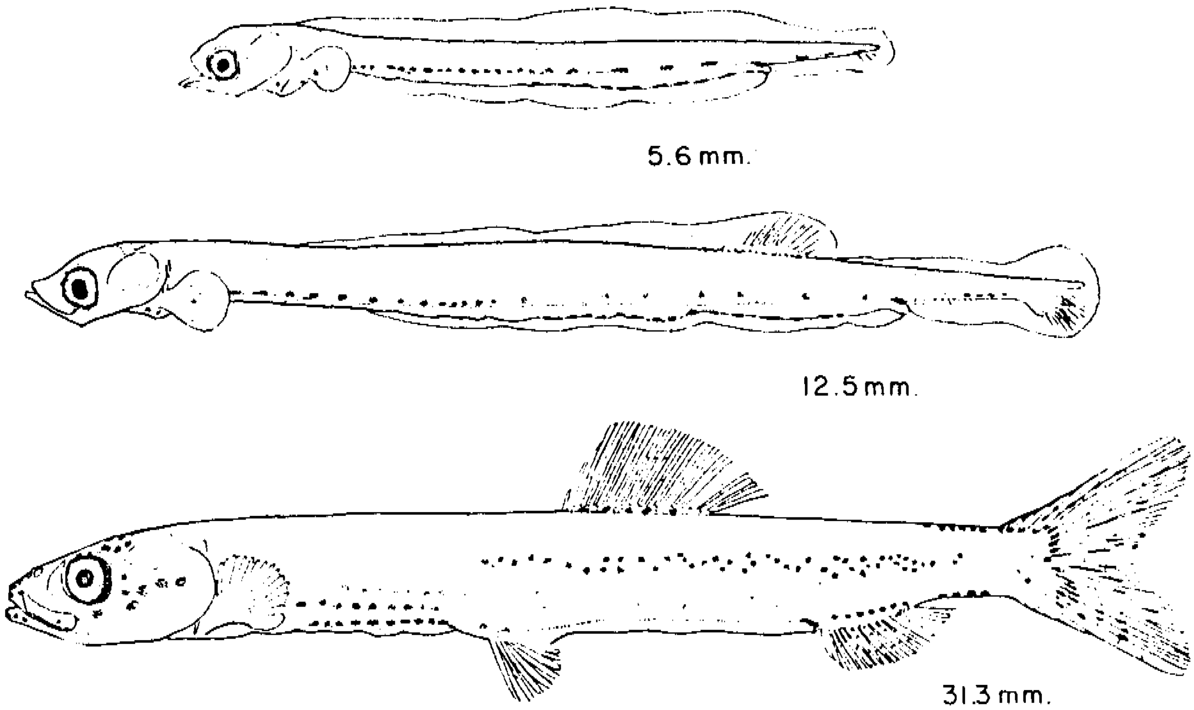


Fig. 3. Early life history stages of *Sardinops sagax* (Jenyns)

Larvae 5.6 mm, 12.5 mm, and metamorphosing specimen of 31.3 mm, standard length (SL). (Ahlstrom 1966)

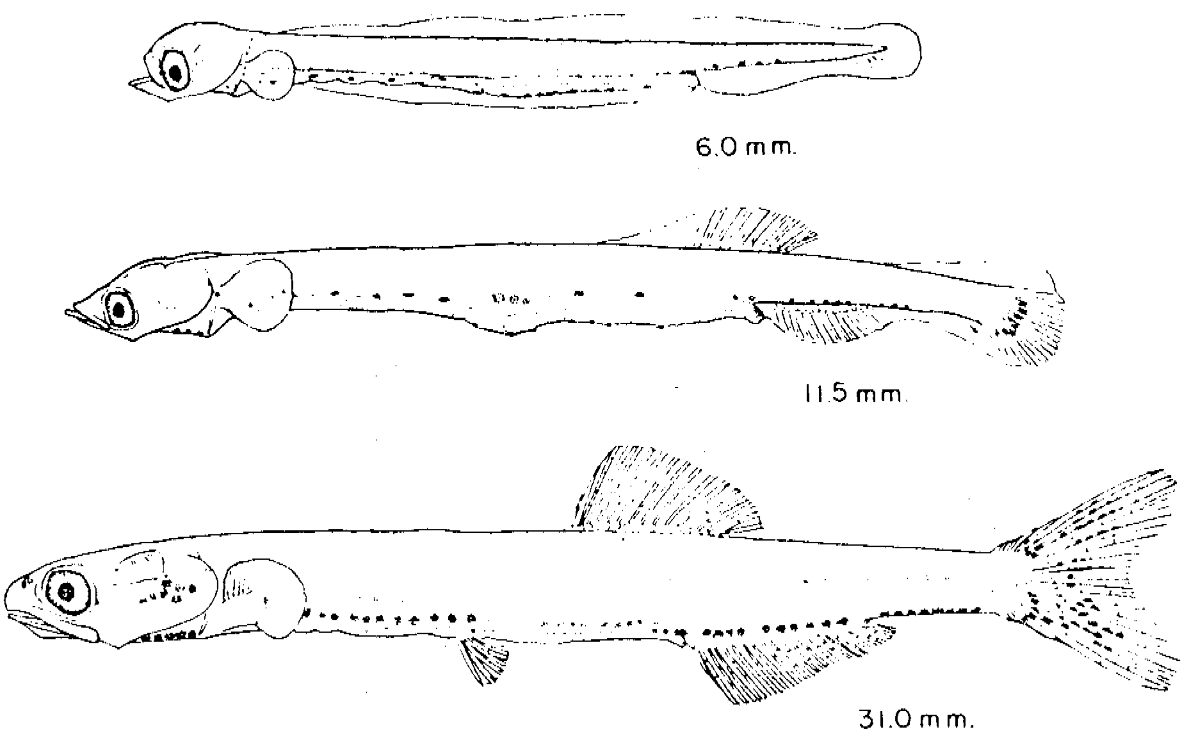


Fig. 4. Early life history stages of *Engraulis mordax* Girard

Larvae 6.0 mm, 11.5 mm, and metamorphosing specimen of 31.0 mm, SL. (Ahlstrom 1966)

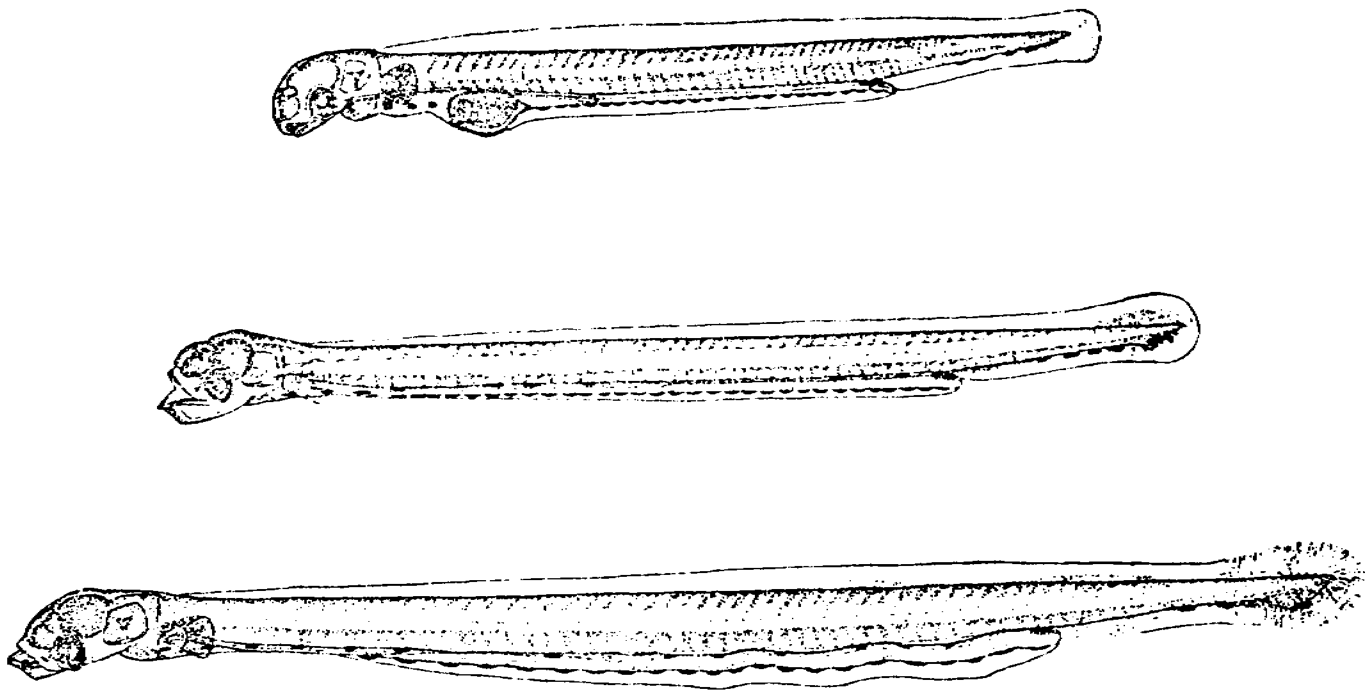


Fig. 5. *Mallotus villosus* (Müller)
Larvae 5 mm, 7 mm, and 9 mm long. (Templeman 1948)

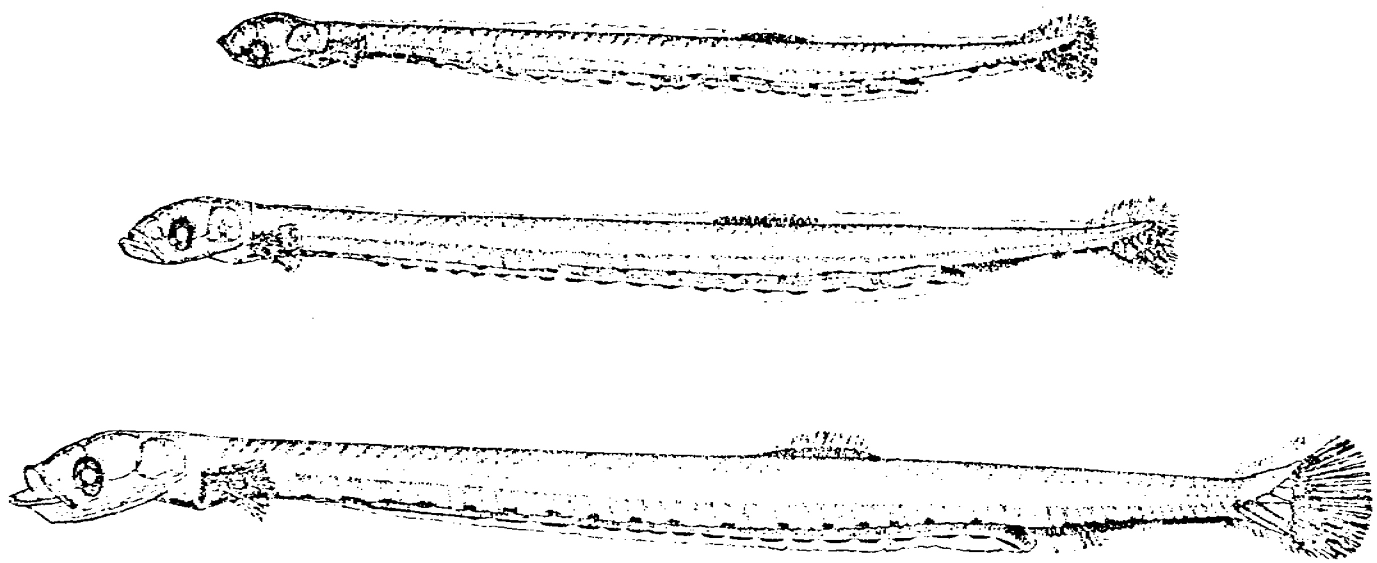


Fig. 6. *Mallotus villosus* (Müller) (continued)
Larvae 11 mm, 13 mm, and 16 mm long. (Templeman 1948)

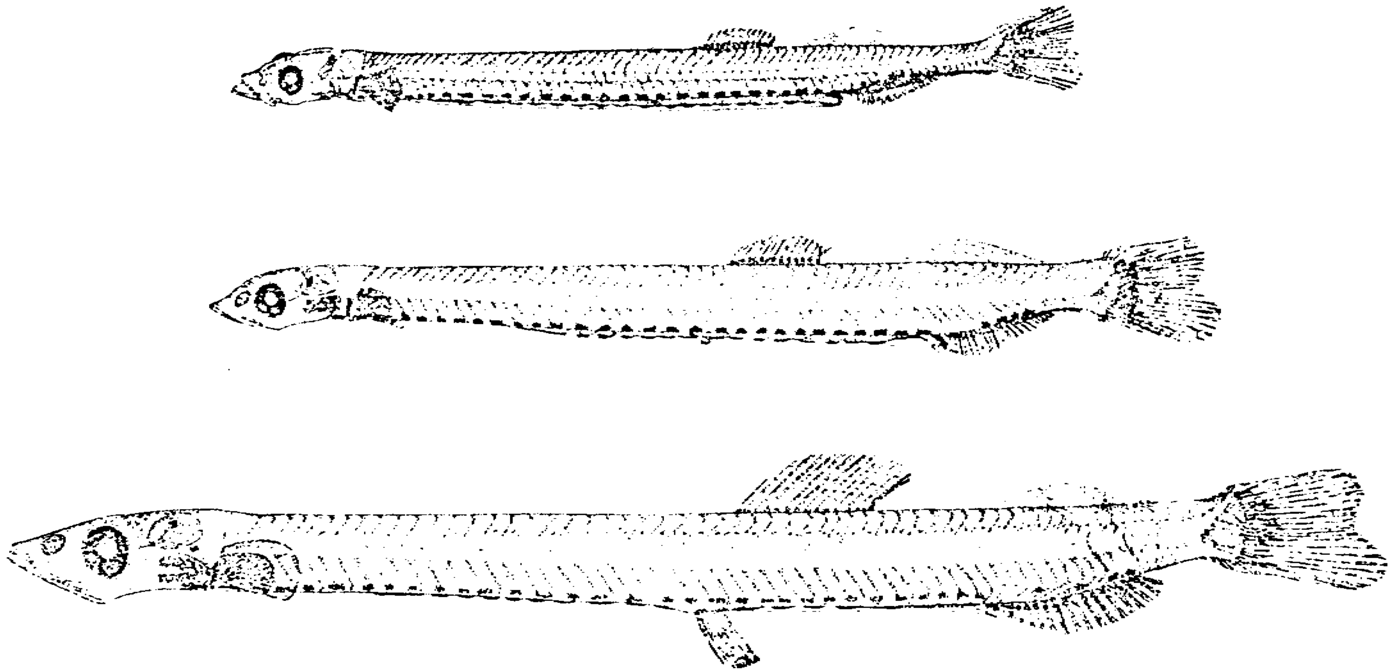
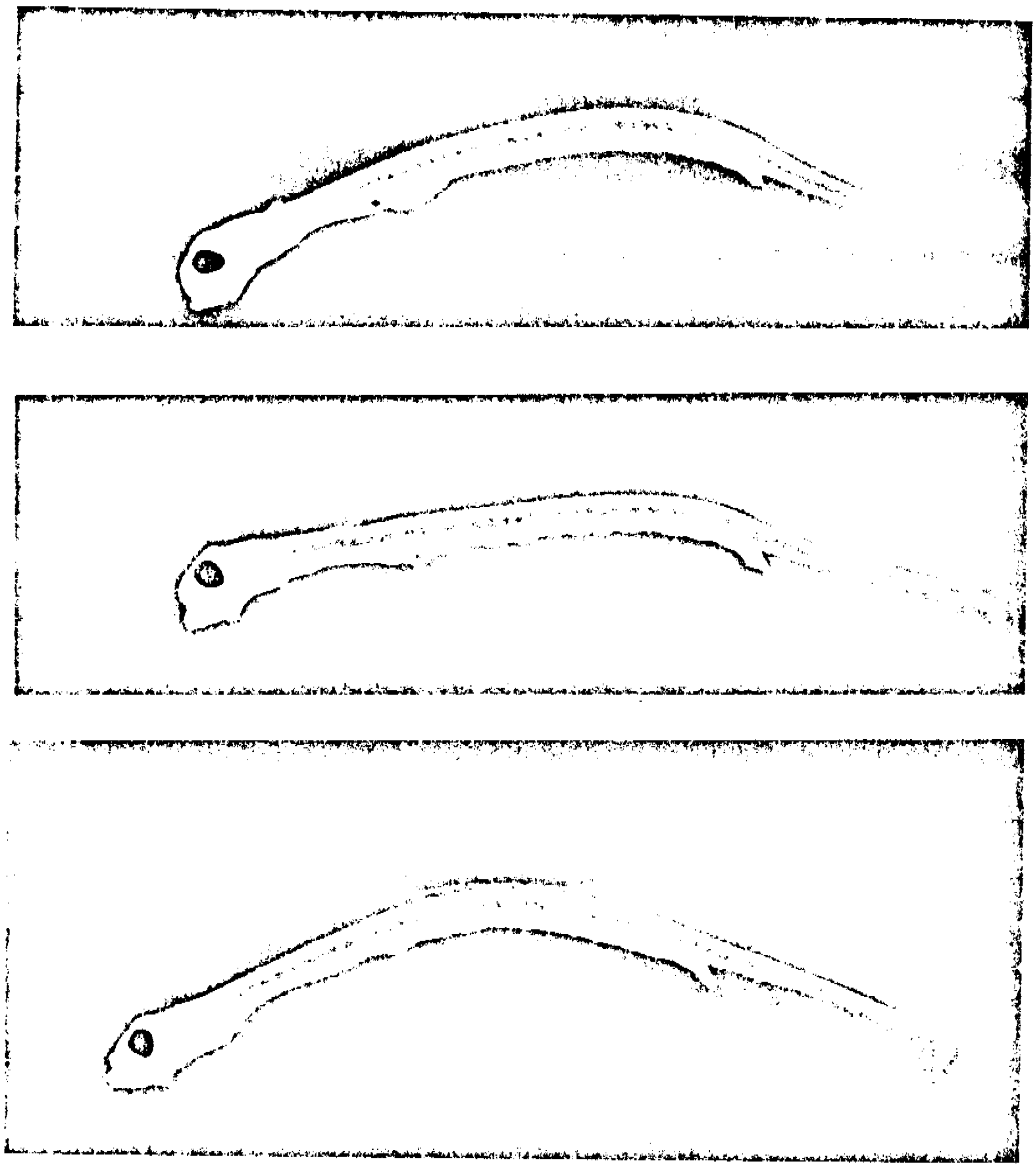


Fig. 7. *Mallotus villosus* (Müller) (continued)
Larvae 21 mm, 29 mm, and 40 mm long. (Templeman 1948)



A

B

C

Fig. 8. *Spirinchus thaleichthys* (Ayres)

A. 8.0 mm 1 day old larva. B. 7.6 mm 5 day old larva. C. 8.0 mm 10 day old larva. (Moulton 1970)

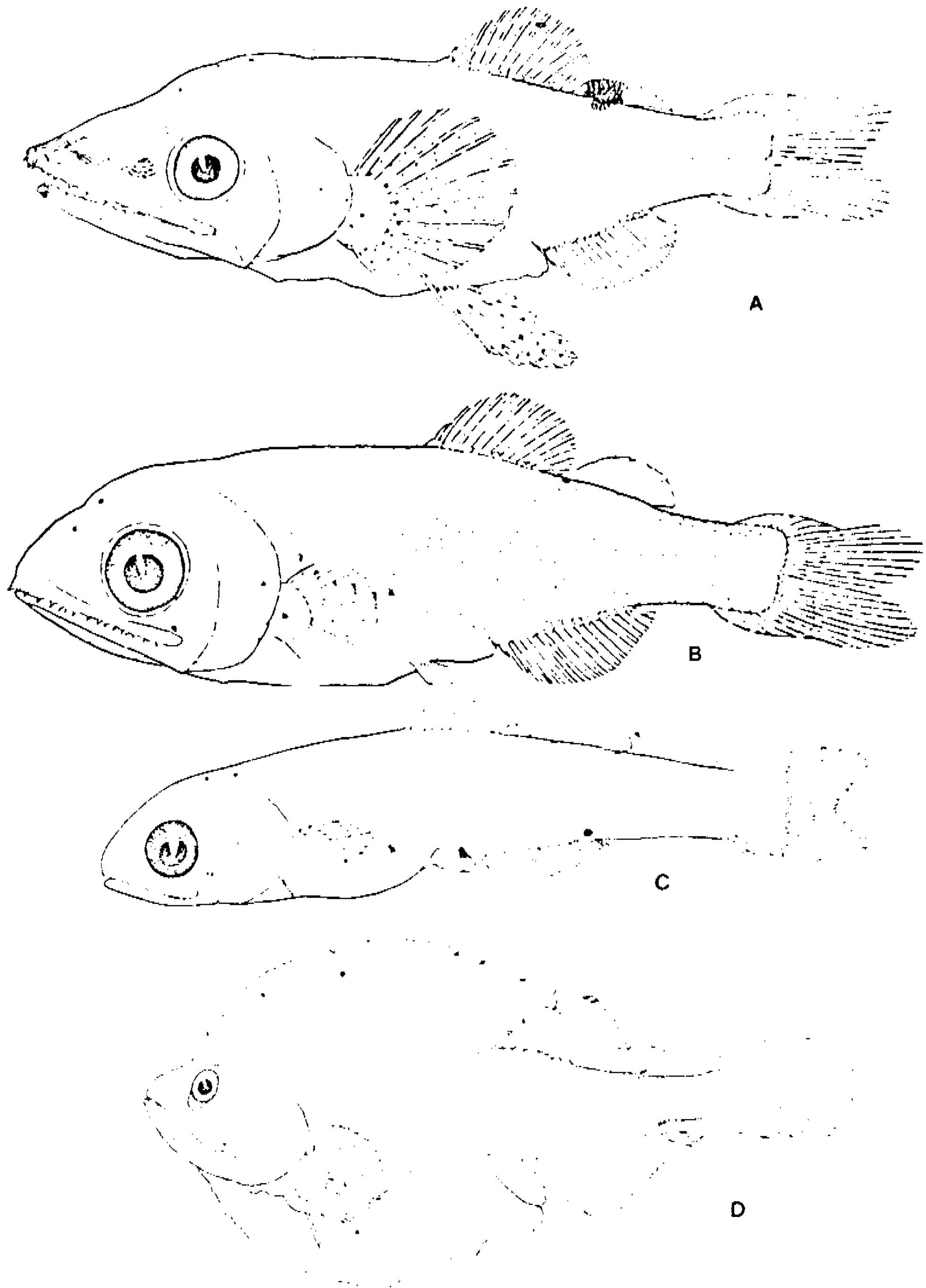


Fig. 9. Myctophidae

A. *Lampanyctus regalis* (Gilbert), 9.1 mm.
B. *Lampanyctus ritteri* Gilbert, 10.1 mm.
C. *Stenobrachius leucopsarus* (Eigenmann and Eigenmann), 10.4 mm.
D. *Tarletonbeania crenularis* (Jordan and Gilbert), 18.9 mm.
(Moser and Ahlstrom 1974)

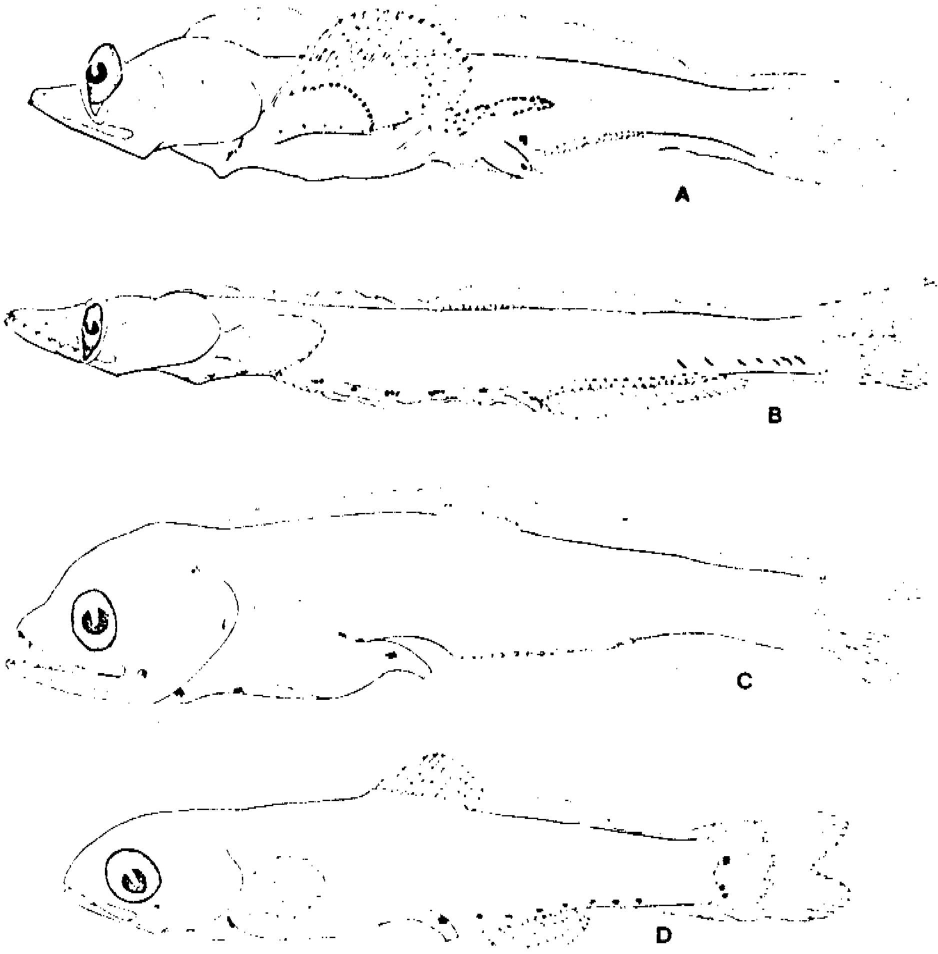


Fig. 10. Myctophidae (continued)

A. *Symbolophorus californiense* (Eigenmann and Eigenmann), 9.6 mm.
B. *Hygophum reinhardti* (Lütken), 12.8 mm.
C. *Benthosema glaciale* (Reinhardt), 7.2 mm.
D. *Diaphus theta* Eigenmann and Eigenmann, 6.9 mm.
(Moser and Ahlstrom 1974)

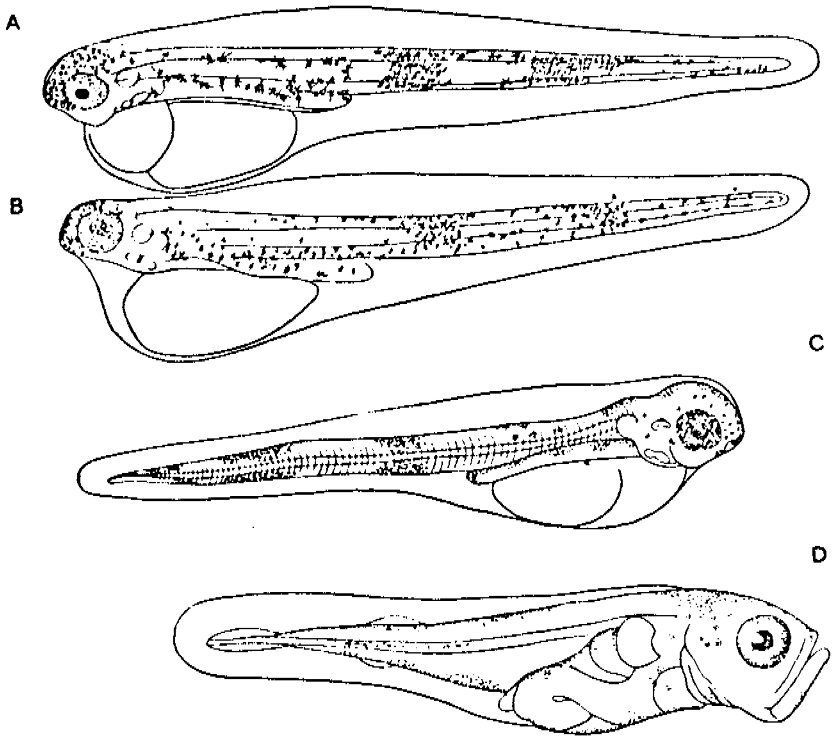


Fig. 11. *Gadus morhua macrocephalus* Tilesius

A. 3.83 mm. B. 3.95 mm. C. 4.4 mm. D. 5.7 mm. (Gorbonova 1954)

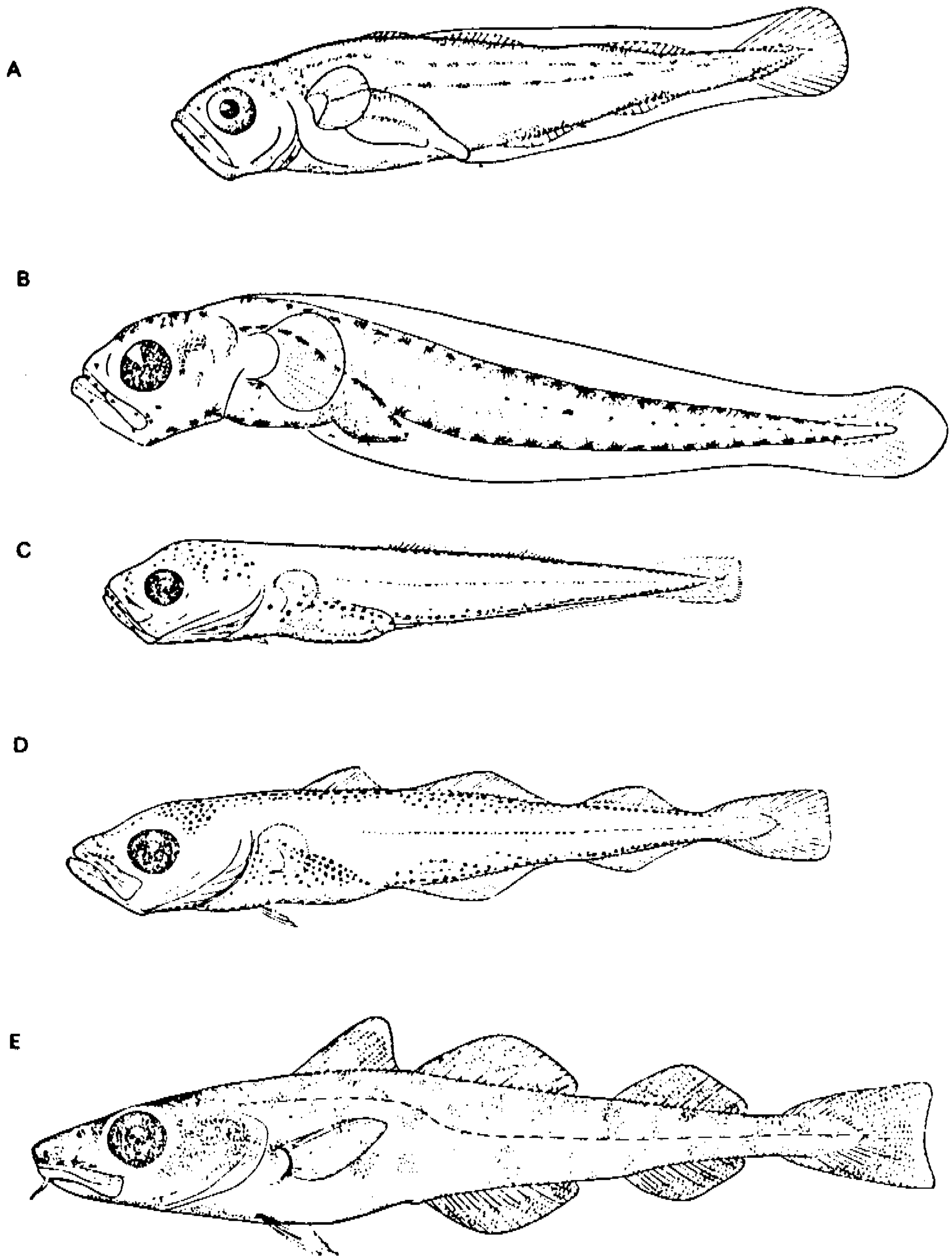


Fig. 12. *Gadus morhua macrocephalus* (continued)

A. 9.4 mm. B. 9.0 mm. C. 12.5 mm. D. 25.0 mm.
E. 144.8 mm. (Gorbunova 1954)

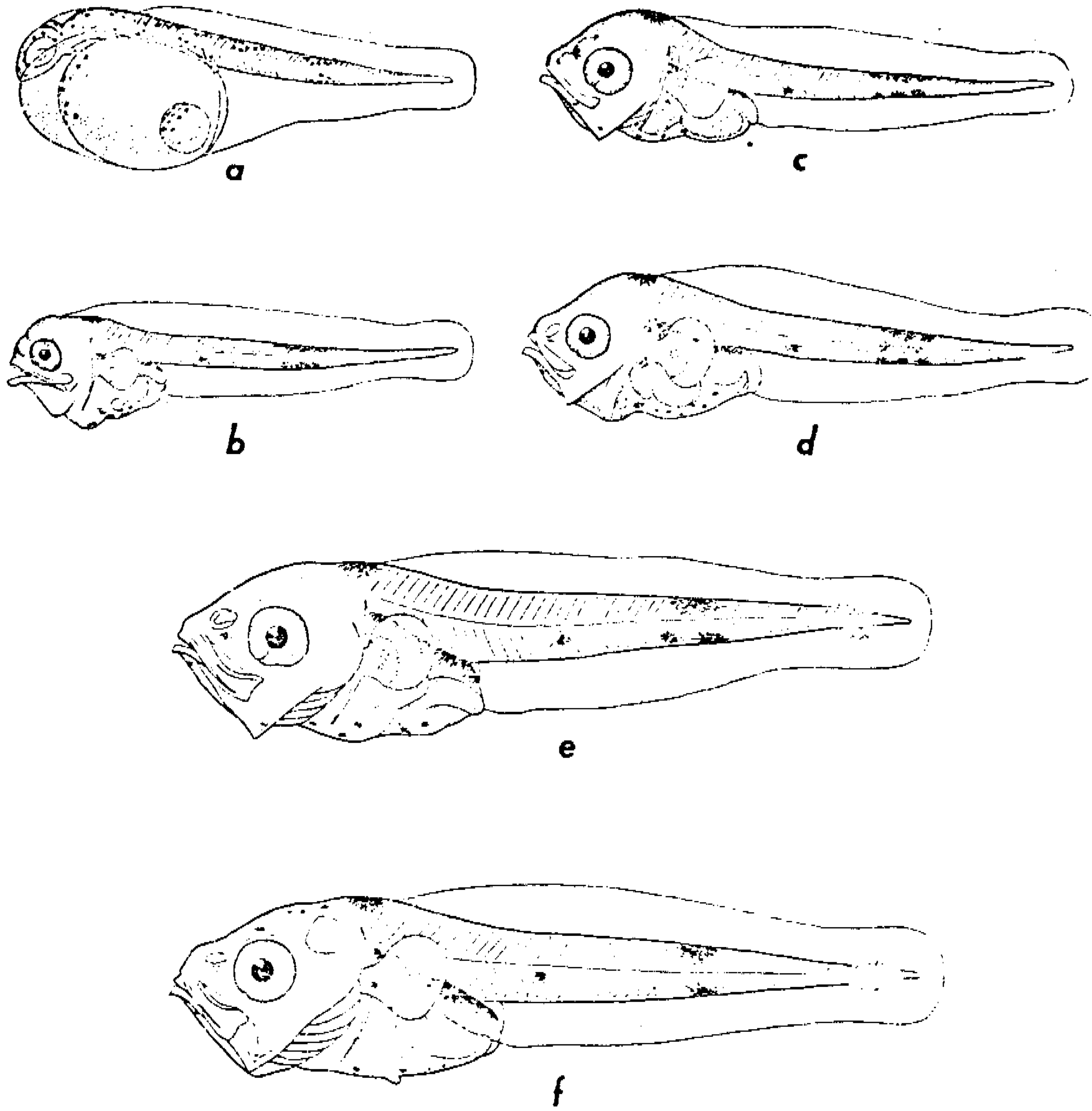


Fig. 13. *Merluccius productus* (Ayres)

A. 2.4 mm. B. 3.0 mm. C. 4.3 mm. D. 4.7 mm. E. 6.3 mm. F. 7.7 mm. (Ahlstrom and Counts 1955)

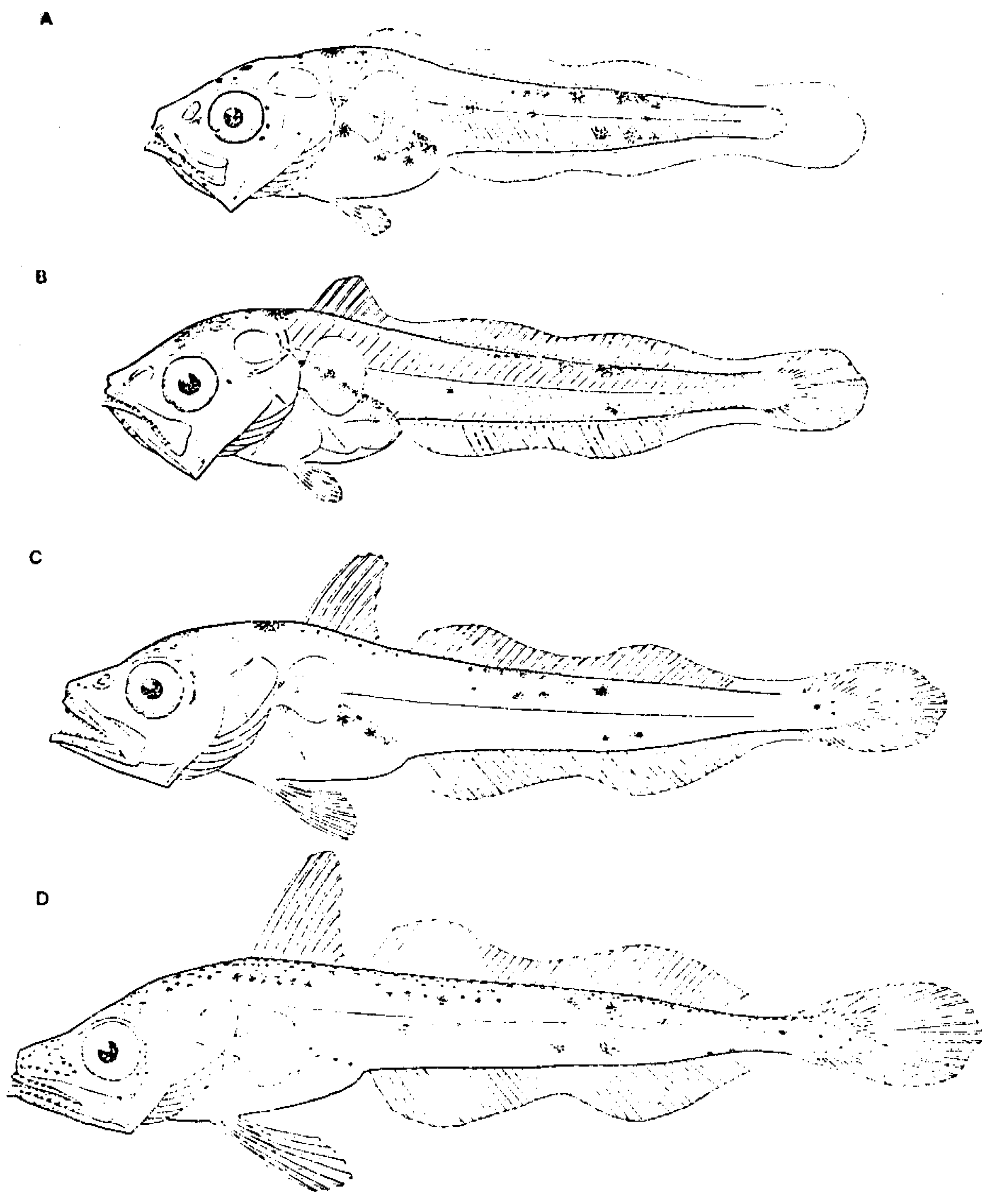


Fig. 14. *Merluccius productus* (continued)

A. 10.1 mm. B. 11.0 mm. C. 15.75 mm. D. 20.0 mm.
(Ahlstrom and Counts 1955)

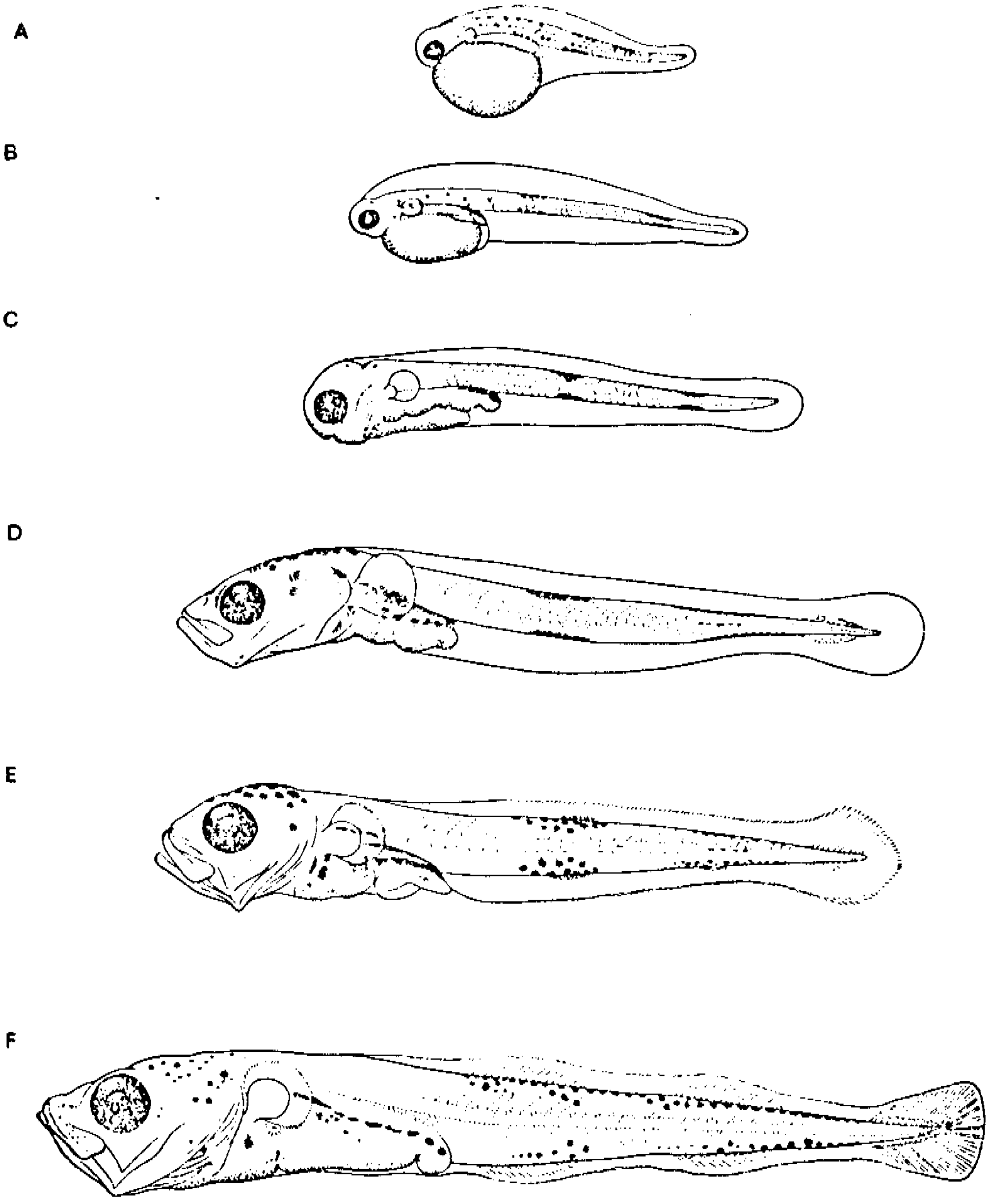


Fig. 15. *Theragra chalcogramma* (Pallas)

A. 3.5 mm. B. 5.5 mm. C. 6.5 mm. D. 9.3 mm. E. 9.8 mm.
F. 15.0 mm. (Gorbunova 1954)

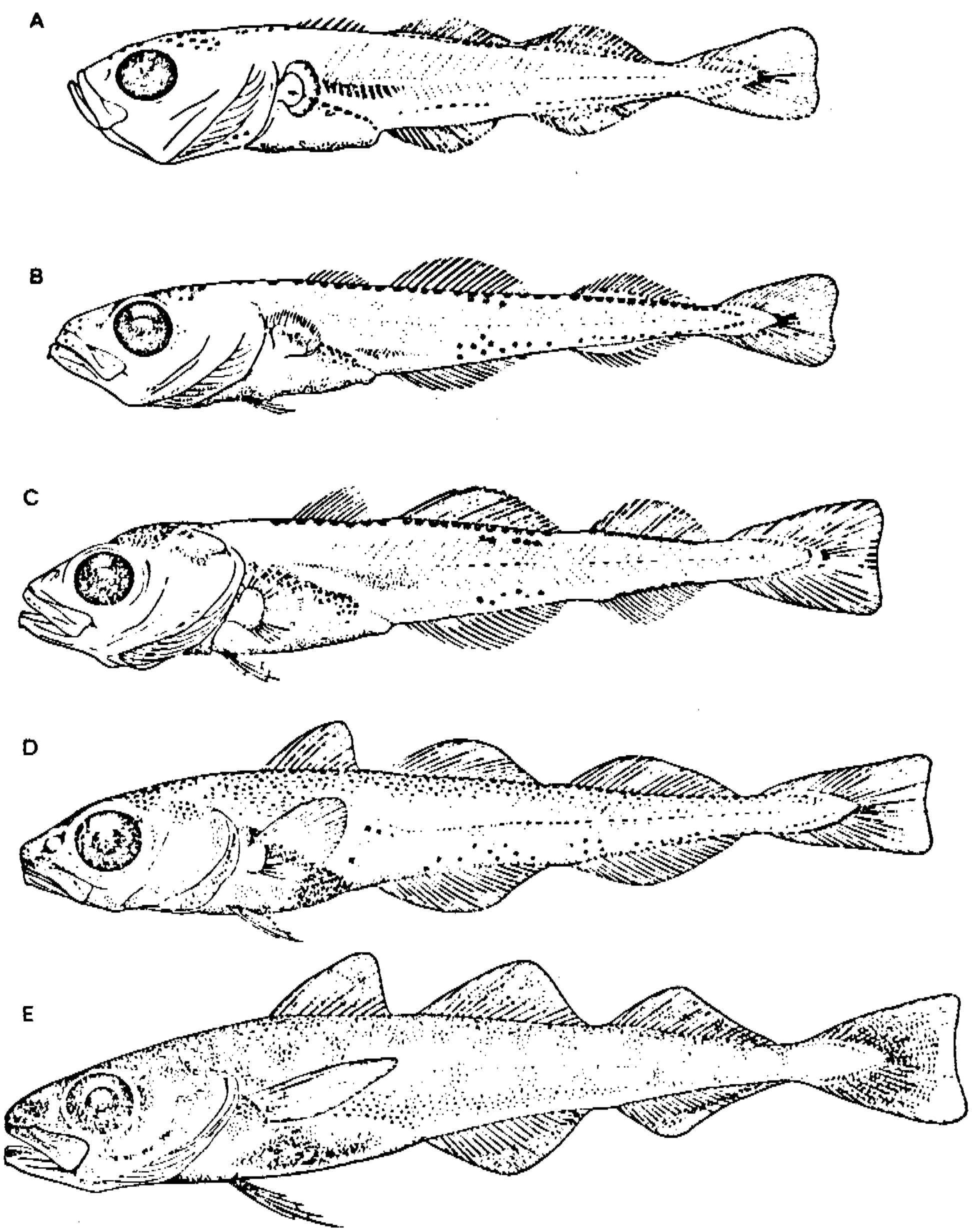


Fig. 16. *Theragra chalcogramma* (continued)

A. 16.7 mm. B. 21.3 mm. C. 30.0 mm. D. 40.0 mm.
E. 100.0 mm. (Gorbunova 1954)

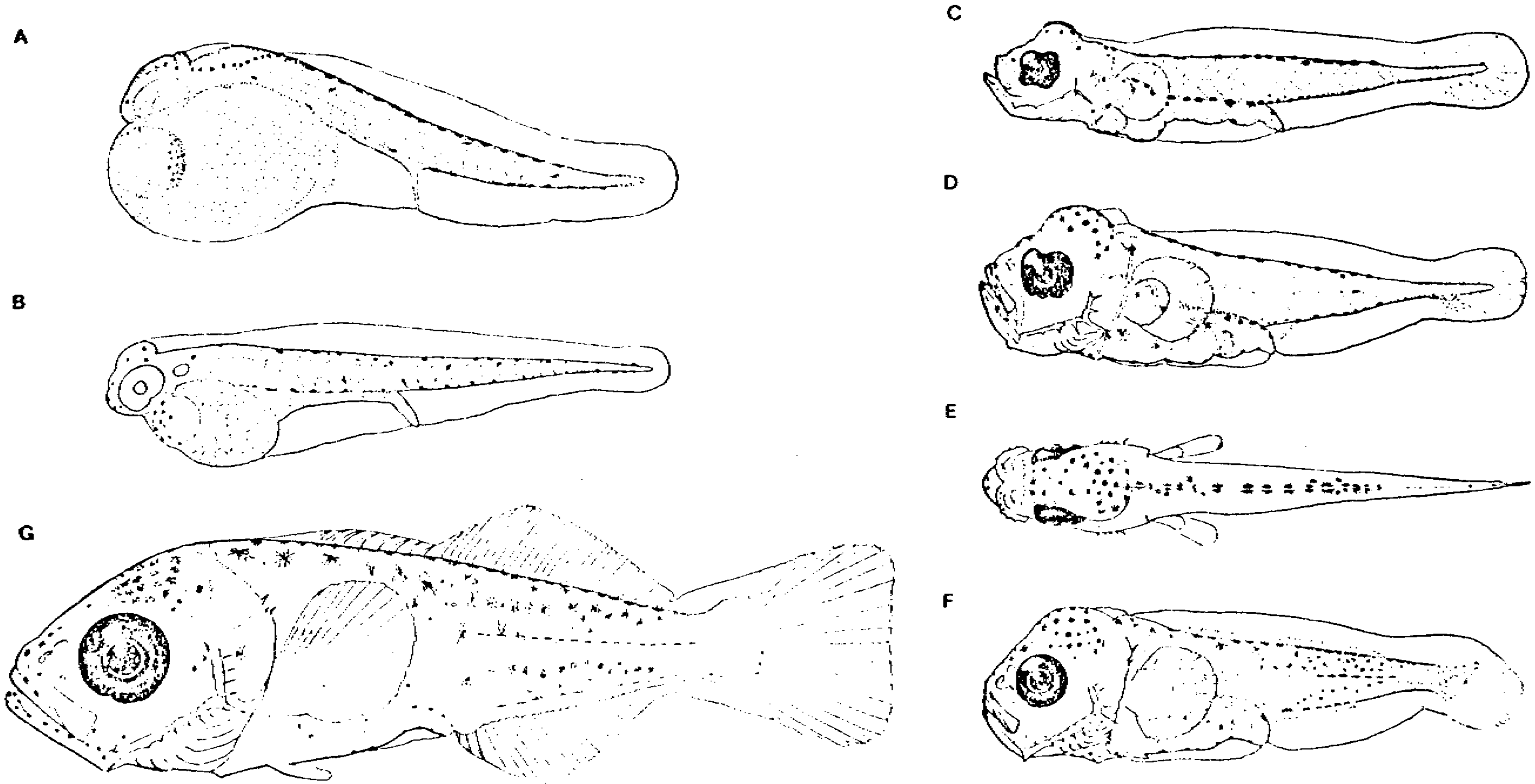


Fig. 17. *Trachurus symmetricus* (Ayres)

A. Yolk-sac larva, 2.0 mm. B. Yolk-sac larva, 2.8 mm. C. Larva, 3.5 mm. D. Larva, 4.9 mm (lateral view). E. Larva, 4.9 mm (dorsal view). F. Larva, 7.4 mm. G. Larva, 10.0 mm. (Ahlstrom and Ball 1954)

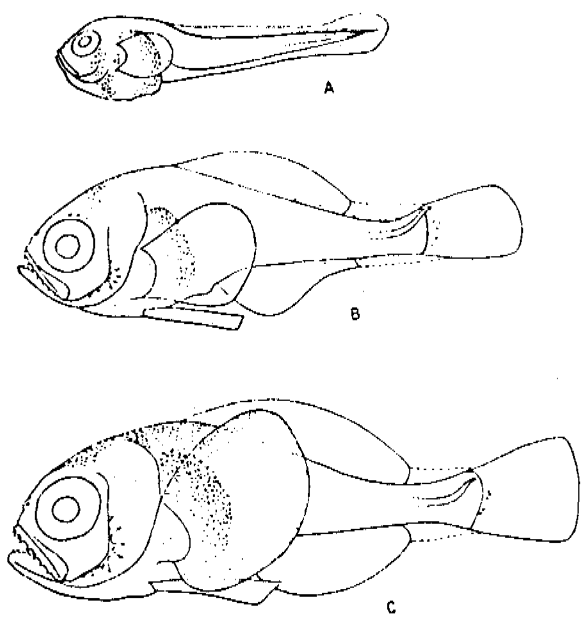


Fig. 18. *Brama japonica* Hilgendorf

A. **6.0 mm.** **B.** 7.4 mm. C. 8.8 mm. (Mead 1972)

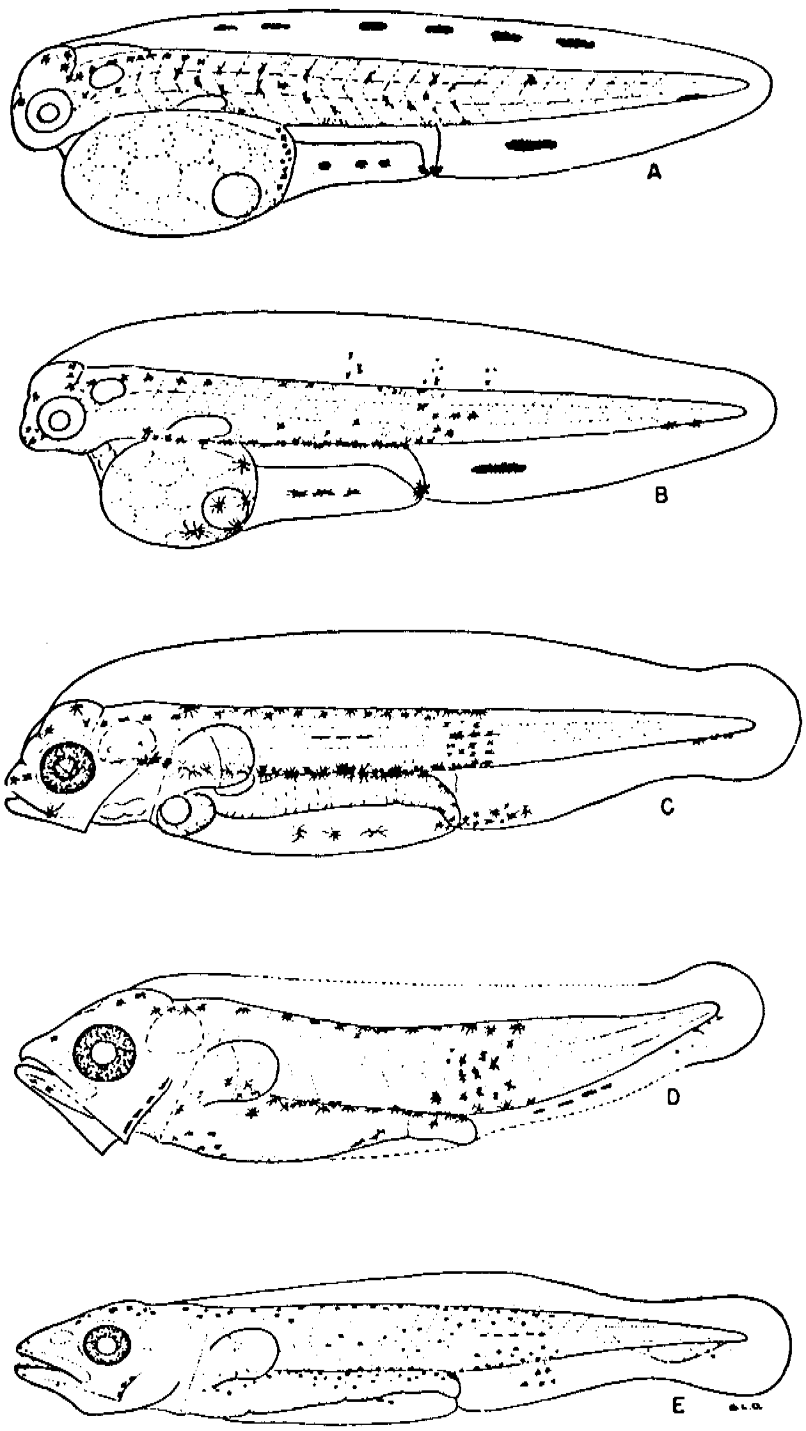


Fig. 19. *Sphyraena argentea* Girard

A. Recently hatched ~2.5 mm. B. 1 day larva.
C. 3 day larva. D. ~4.0 mm. E. ~7.0 mm.
A-C based on live specimans, thus show areas of yellow pigment. (Orton 1955)

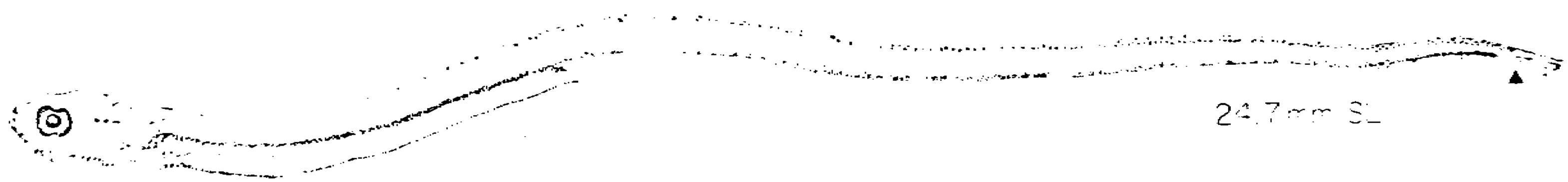


Fig. 20. Larva of quillfish, *Ptilichthys goodei* (Bean)
Arrow indicates point of reference for SL. (Richardson and DeHart 1975)

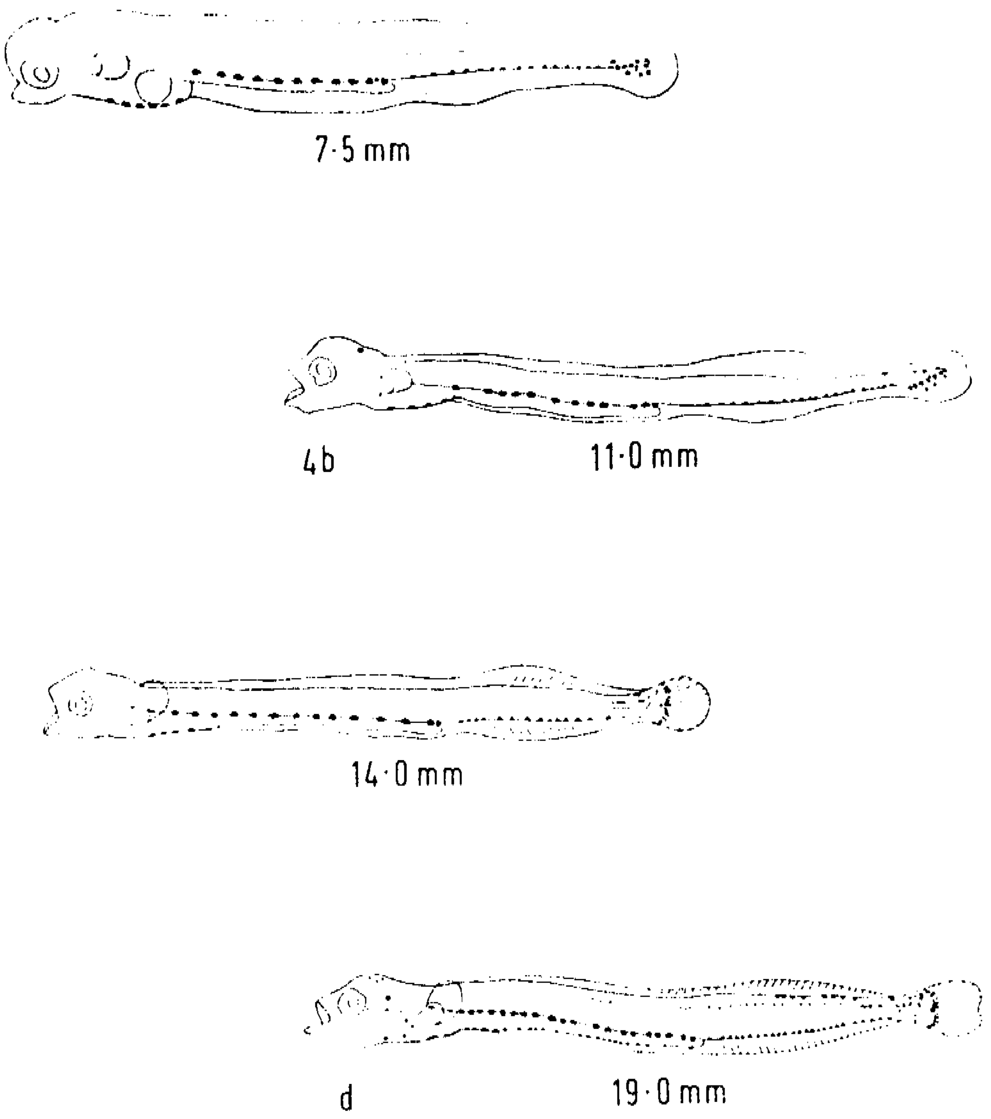


Fig. 21. Larvae of *Ammodytes hexapterus* (Pallas) (Fraser and Hansen eds. 1967)

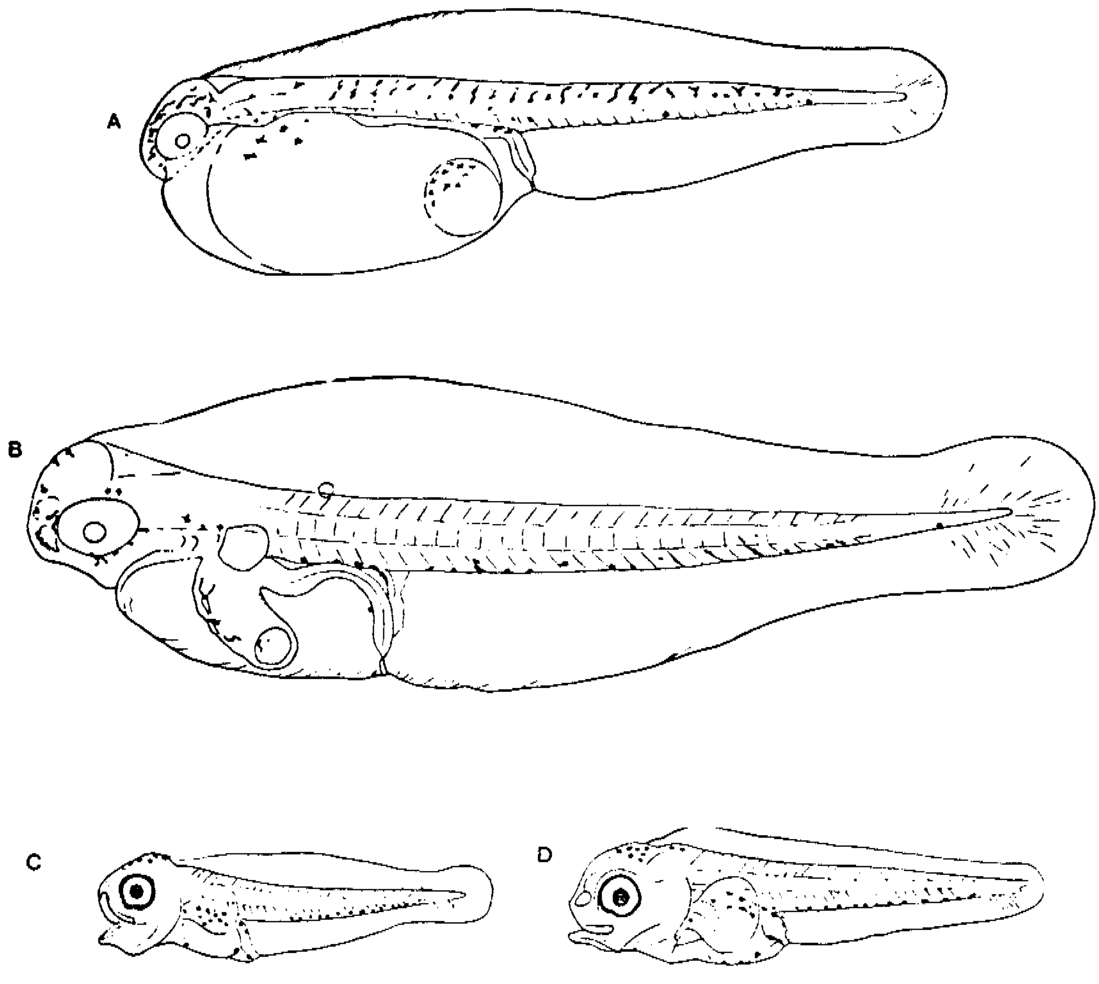


Fig. 22. *Scomber japonicus* Houttuyn

A. Yolk-sac larva, 3.3 mm, just after hatching. B. Yolk-sac larva, 3.5 mm, with yolk about two-thirds absorbed. C. Larva 4.0 mm. D. Larva 5.0 mm. (Kramer 1969)

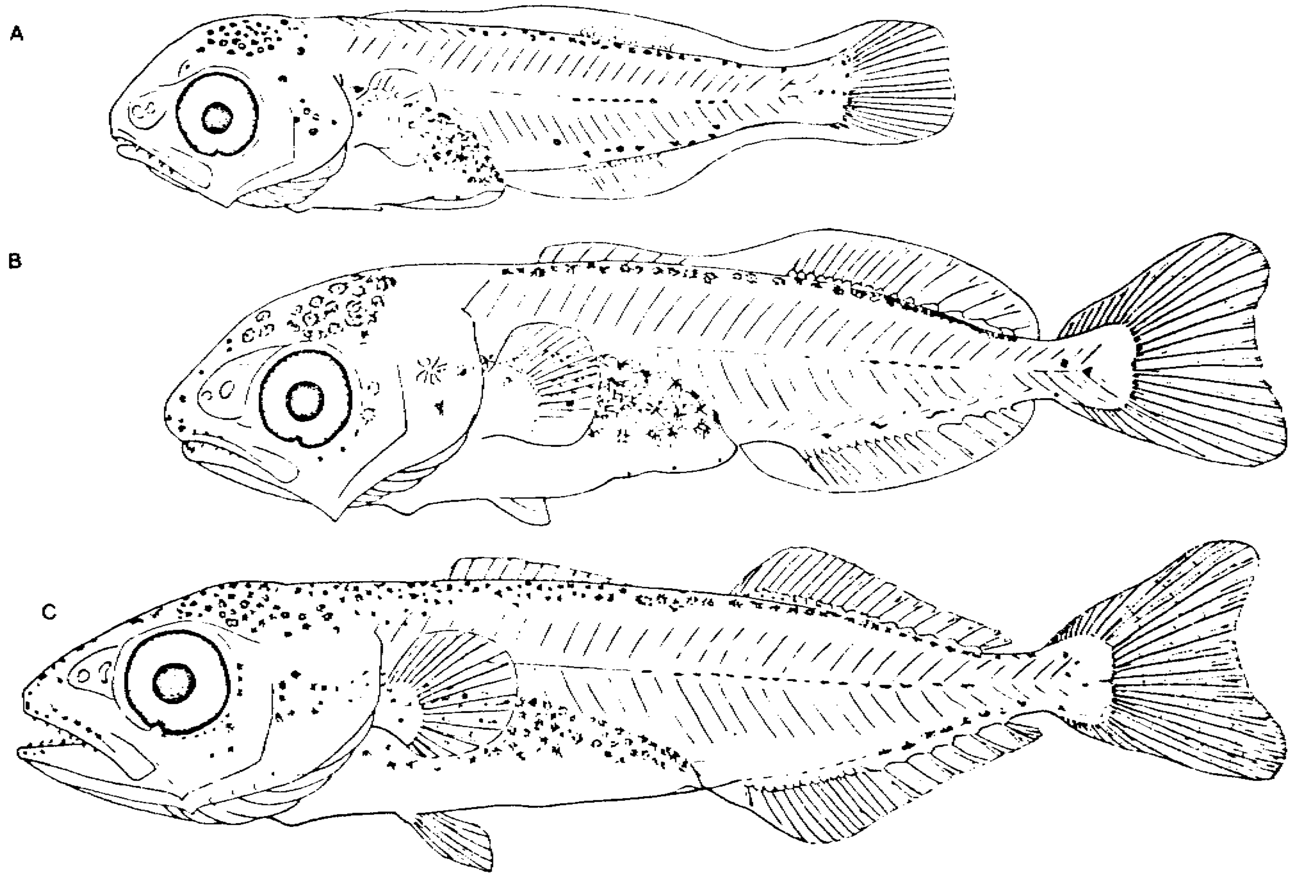


Fig. 23. *Scomber japonicus* (continued)

A. Larva 7.8 mm. B. Larva 10.5 mm. C. Late larva 16.5 mm. (Kramer 1969)

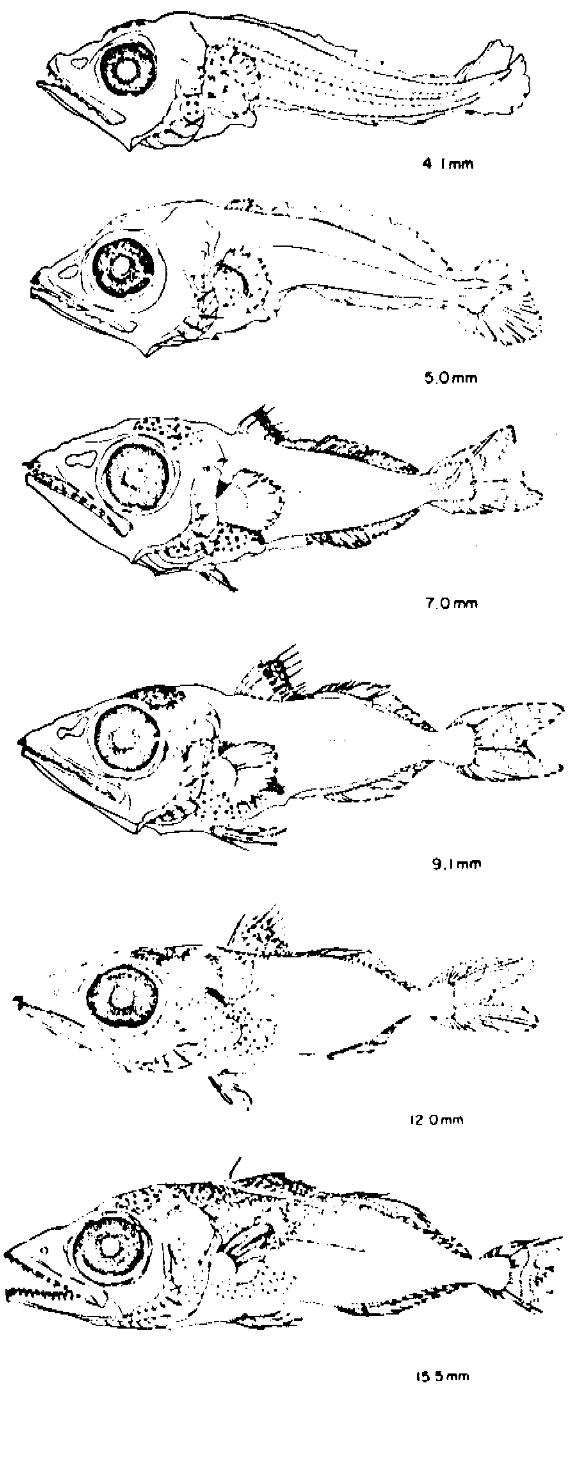


Fig. 24. *Thunnus alalunga* (Bonnaterre). (Matsumoto *et al.* 1972)

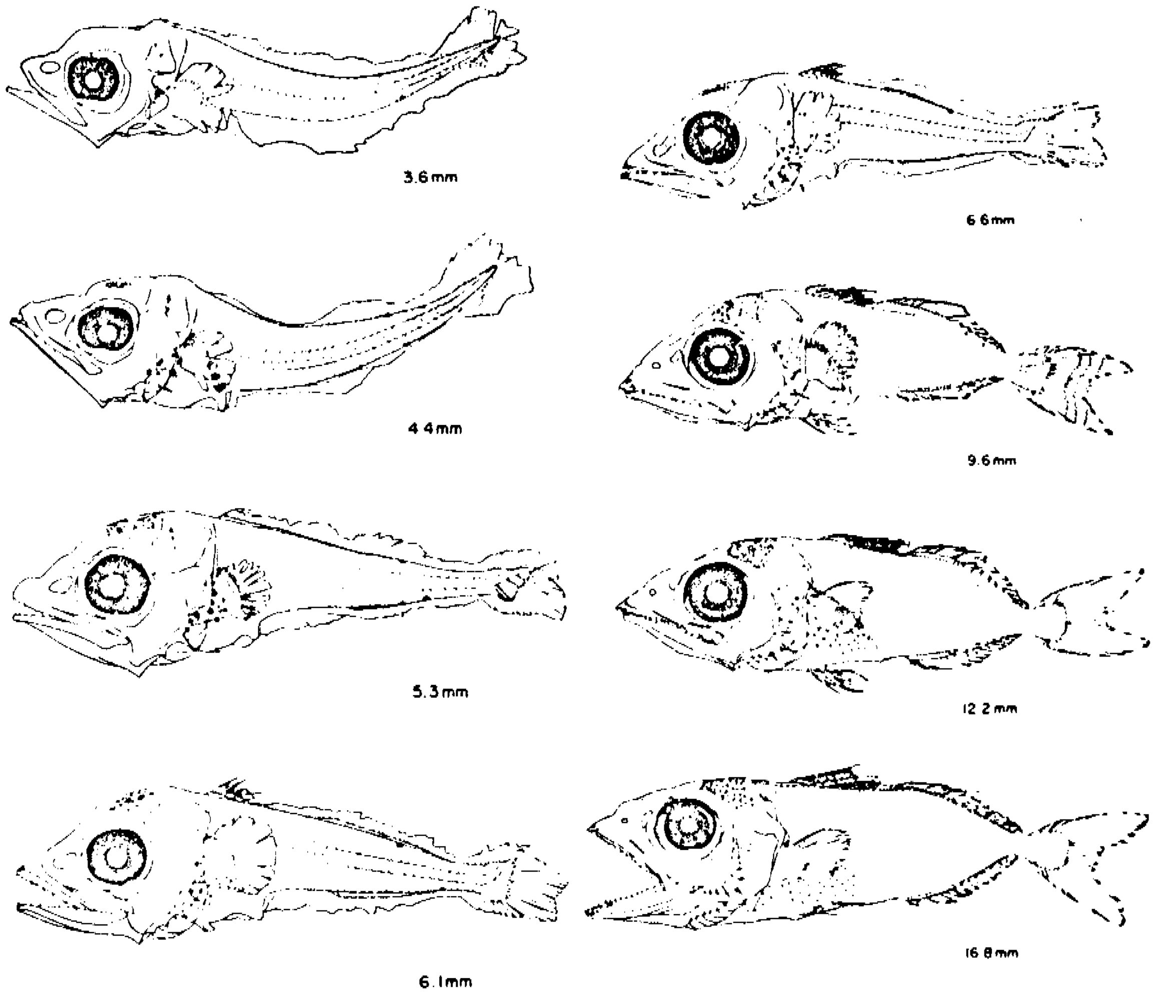


Fig. 25. *Thunnus thynnus* (Linneaus). (Matsumoto *et al.* 1972)

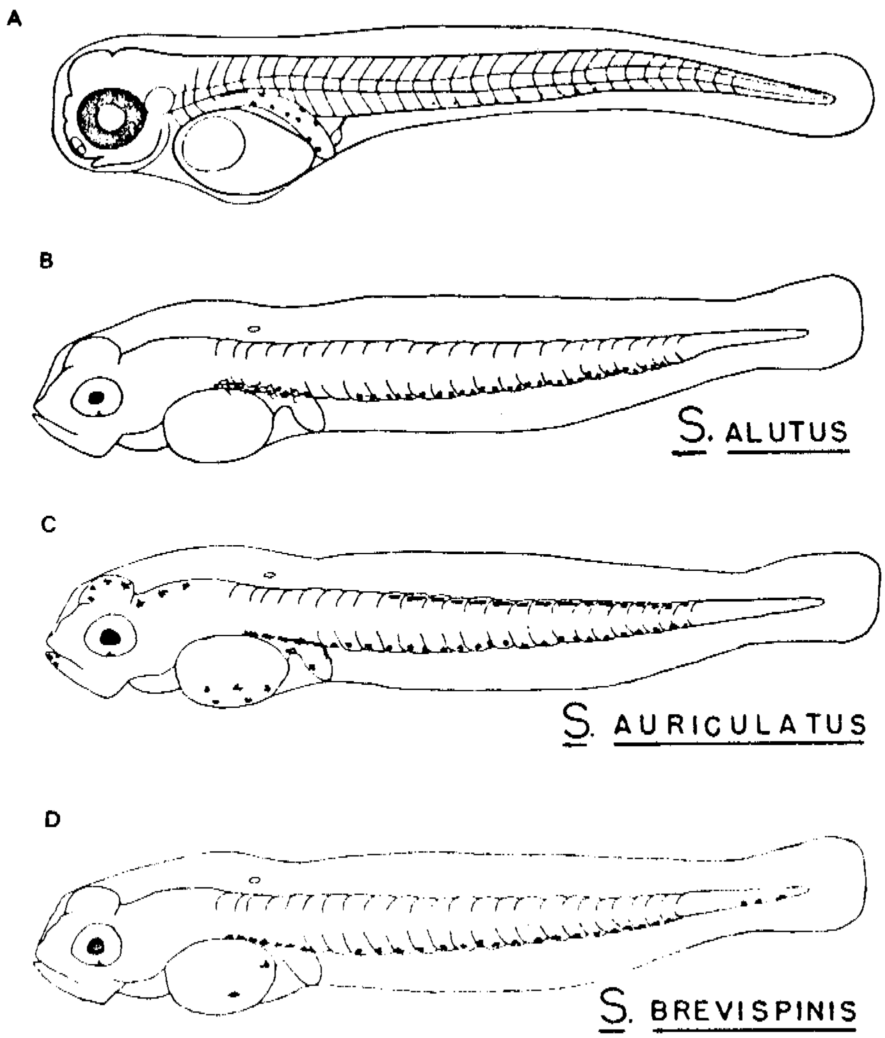


Fig. 26. *Sebastes* species

A. *S. aleutianus* (Jordan and Evermann), ∿4.1 mm.
B. *S. alutus* (Gilbert), ∿5.3 mm.
C. *S. auriculatus* Girard, ∿5.8 mm.
D. *S. brevispinis* (Bean), ∿4.0 mm.
(A, Efremenko and Lisovenko 1972; B-D, DeLacy *et al.* 1964)

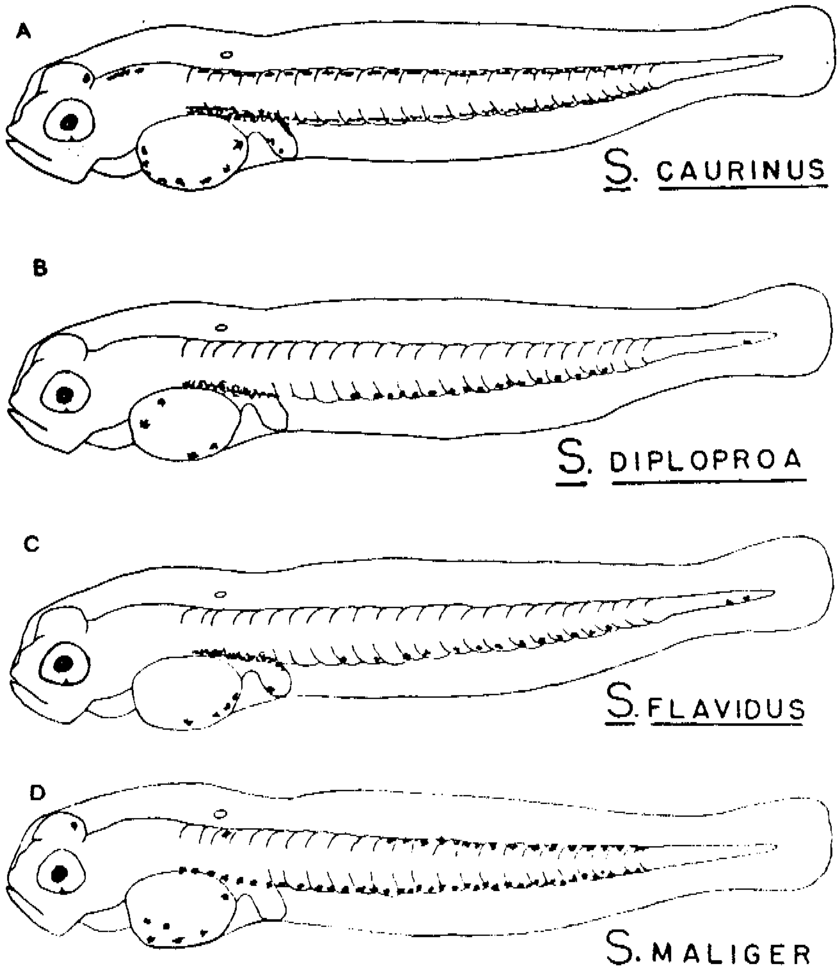


Fig. 27. *Sebastes* species (continued)

A. *S. caurinus* Richardson, ∿5.5 mm.
B. *S. diploproa* (Gilbert), ∿5.0 mm.
C. *S. flavidus* (Ayres), ∿4.5 mm.
D. *S. maliger* (Jordan and Gilbert), ∿5.0 mm.
(DeLacy *et al.* 1964)

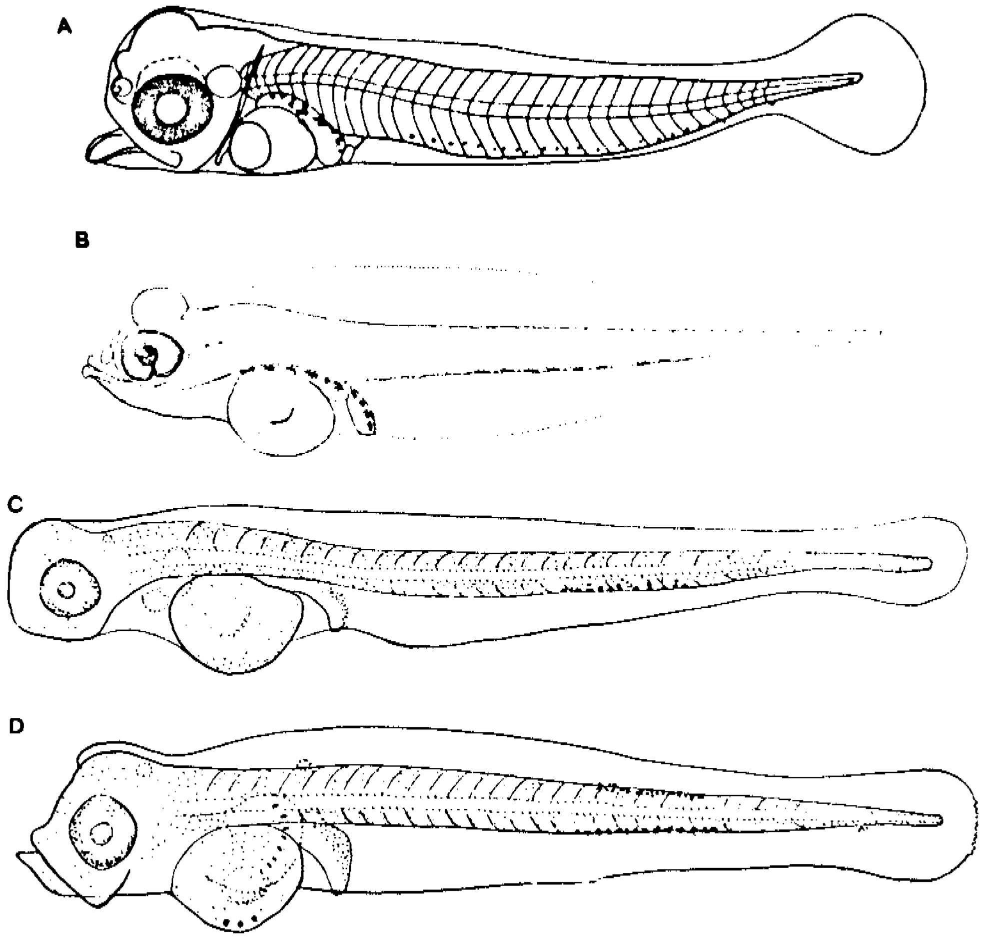


Fig. 28. *Sebastes* species (continued)

A. *S. mystinus* (Jordan and Gilbert), ∿5.2 mm.
B. *S. paucispinis* Ayres, ∿6.0 mm.
C. *S. pinniger* (Gill), newly-hatched larva.
D. *S. pinniger* (Gill), 2-week old larva.
(A, Efremenko and Lisovenko 1972; B, Morris 1956; C-D, Waldron 1968)

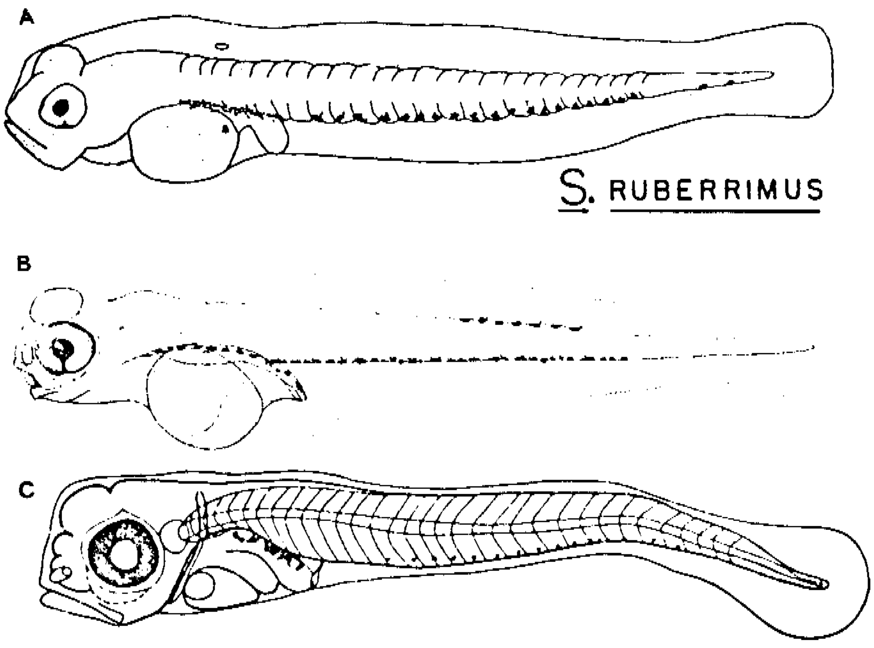


Fig. 29. *Sebastes* species (continued)

A. *S. ruberrimus* (Cramer), ∿5.0 mm.
B. *S. saxicola* (Gilbert), 4.3 mm.
C. *S. zacentrus* (Gilbert), ∿4.2 mm.
(A, DeLacy *et al.* 1964; B, Morris 1956; C, Efremenko and Lisovenko 1972)

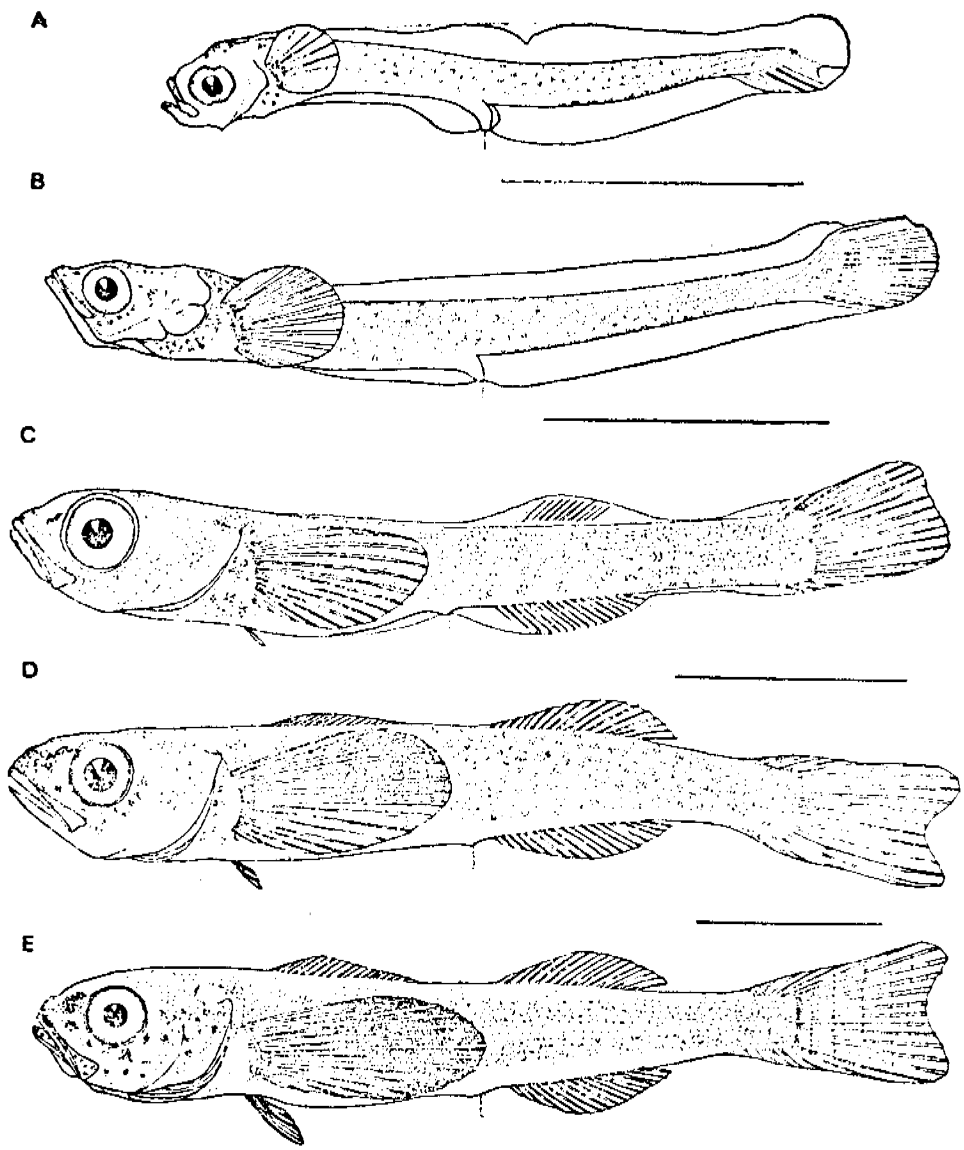


Fig. 30. Larvae and young of *Anoplopoma fimbria* (Pallas)

A. 11.3 mm total length. B. 15.3 mm. C. 19.8 mm. D. 25.7 mm. E. 30.2 mm. (Kobayashi 1957)

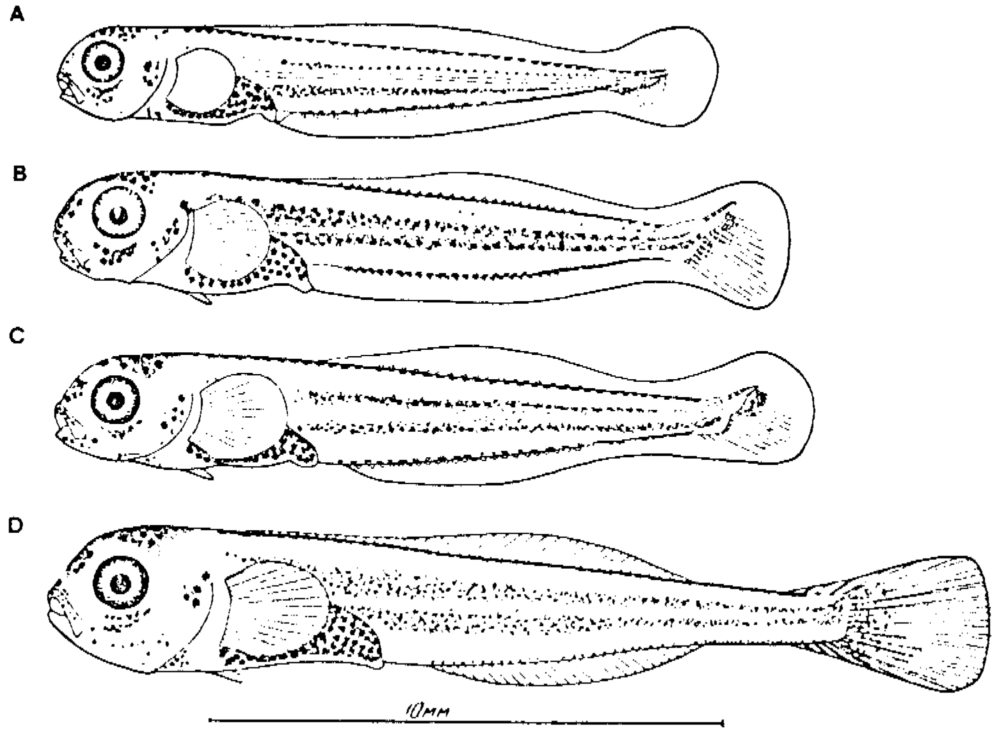


Fig. 31. *Hexagrammos decagrammus* (Pallas)

A. 12.0 mm. B. 13.4 mm. C. 13.8 mm. D. 15.5 mm.
(Gorbunova 1962)

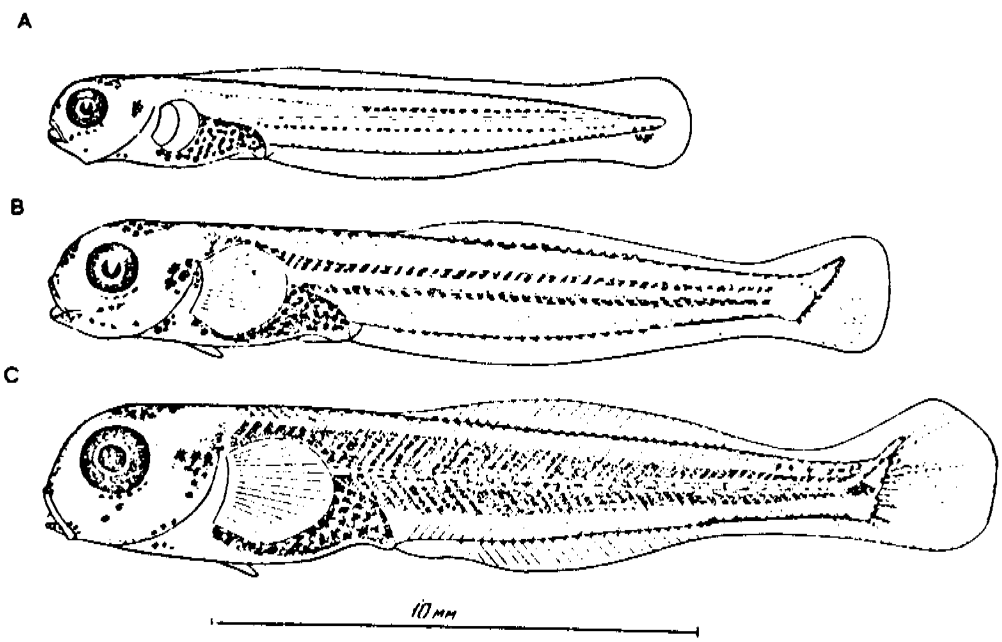


Fig. 32. *Hexagrammos lagocephalus* (Pallas)
A. 12.6 mm. B. 16.1 mm. C. 17.0 mm. (Gorbunova 1962)

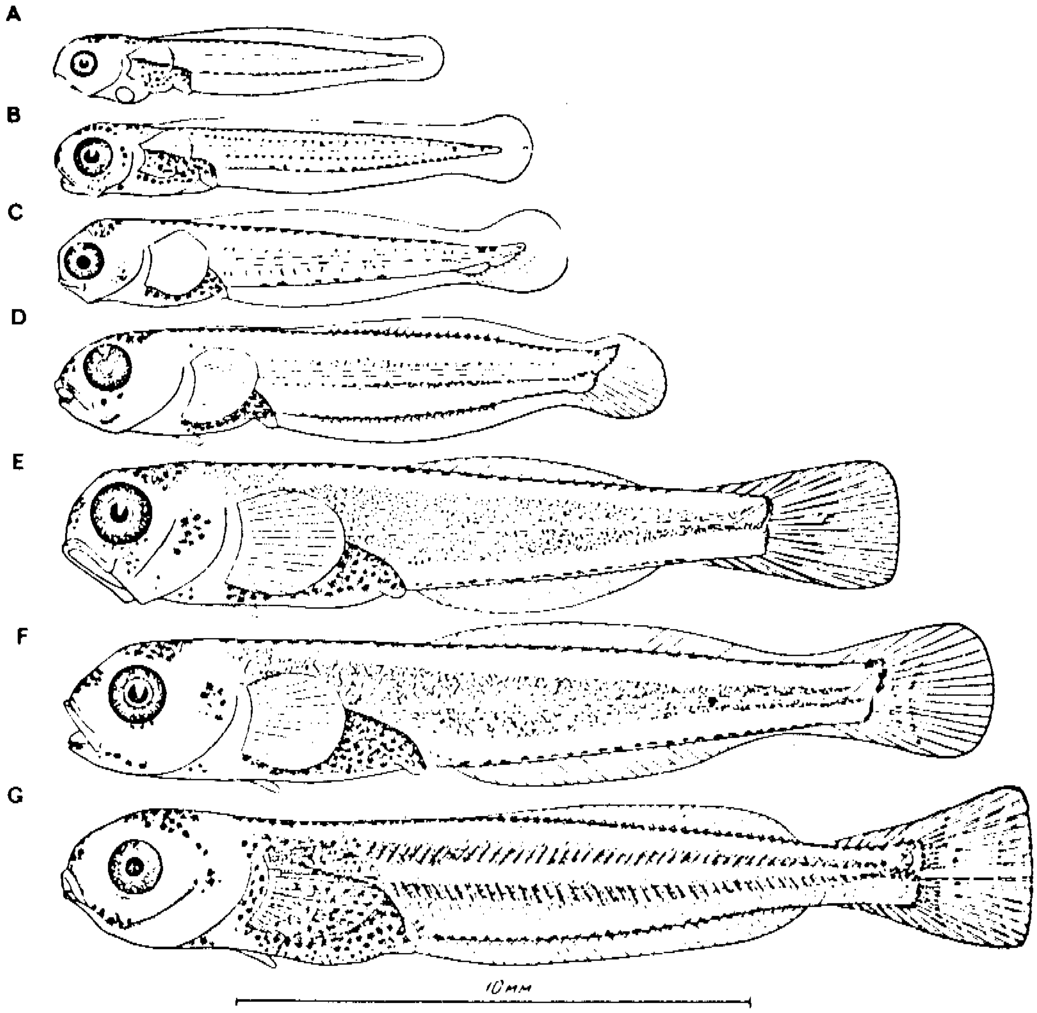


Fig. 33. *Hexagrammos octogrammus* (Pallas)

A. 7.1 mm. B. 8.7 mm. C. 9.2 mm. D. 10.9 mm. E. 13.9 mm. F. 15.9 mm. G. 16.7 mm. (Gorbunova 1962)

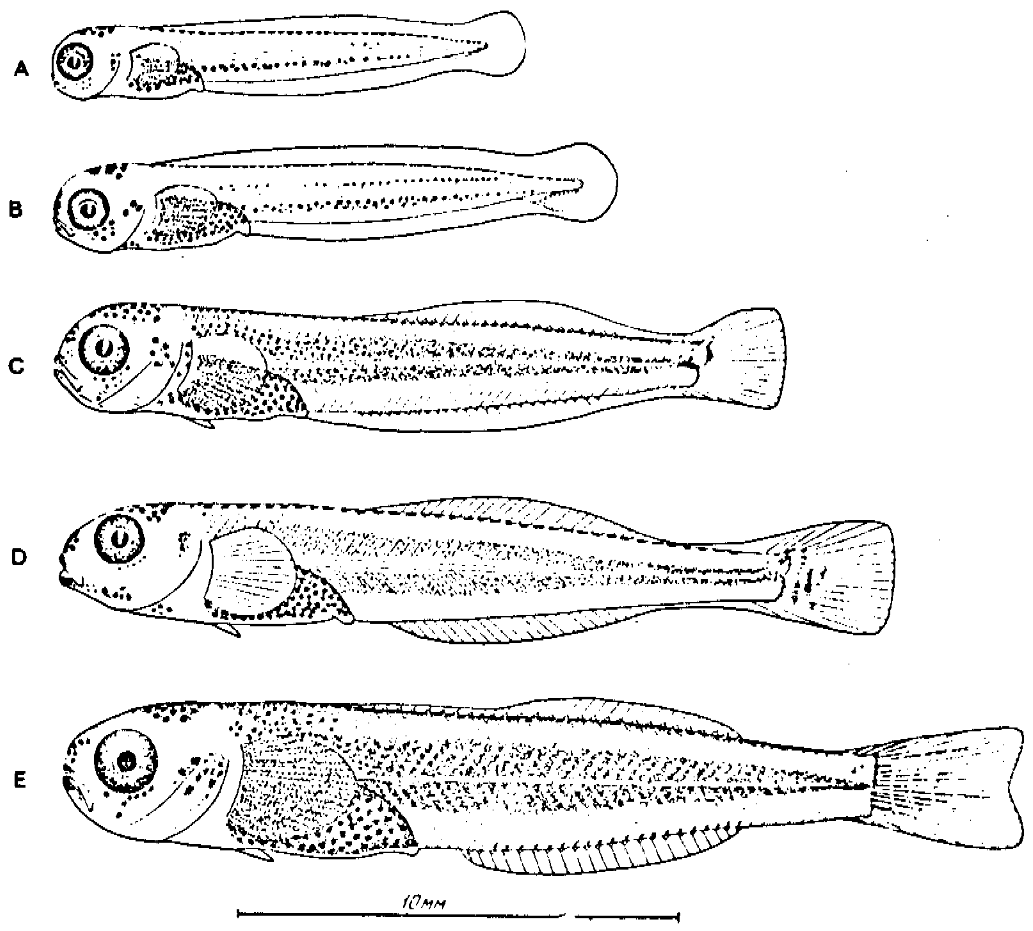


Fig. 34. *Hexagrammos stelleri* Tilesius

A. 10.1 mm. B. 12.2 mm. C. 15.0 mm. D. 16.6 mm. E. 18.6 mm. (Gorbunova 1962)

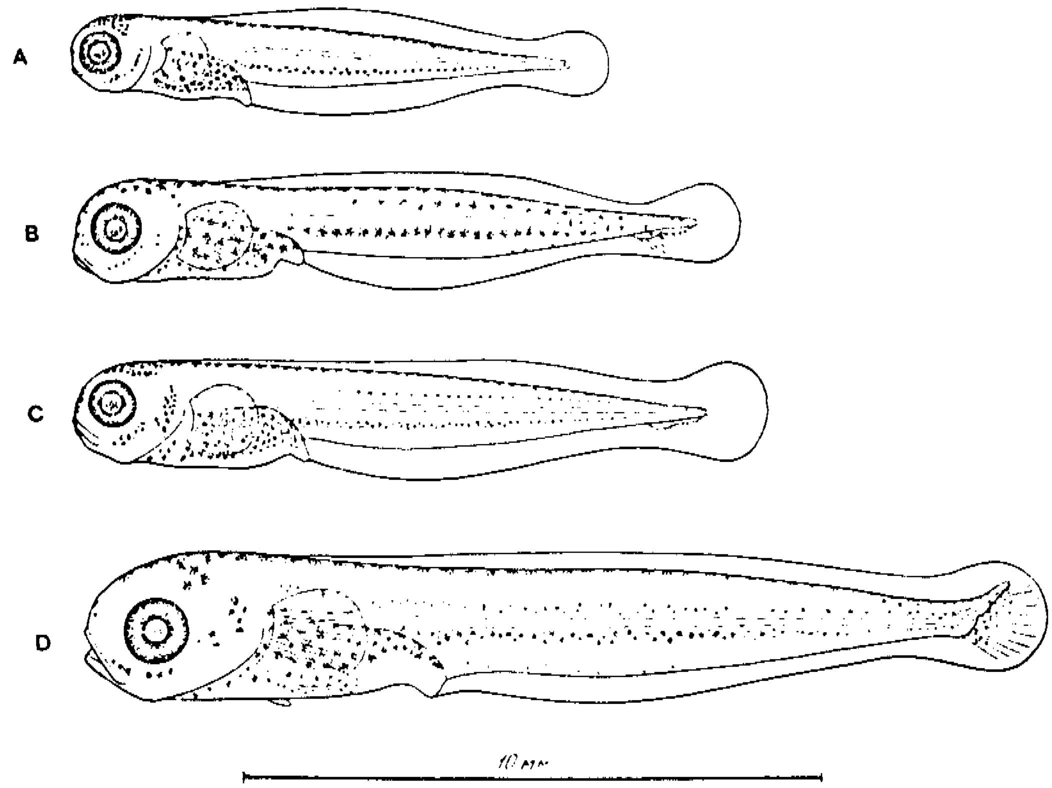


Fig. 35. *Hexagrammos superciliosus* (Pallas)

A. 8.7 mm. B. 10.9 mm. C. 11.3 mm. D. 16.7 mm. (Gorbunova 1962)

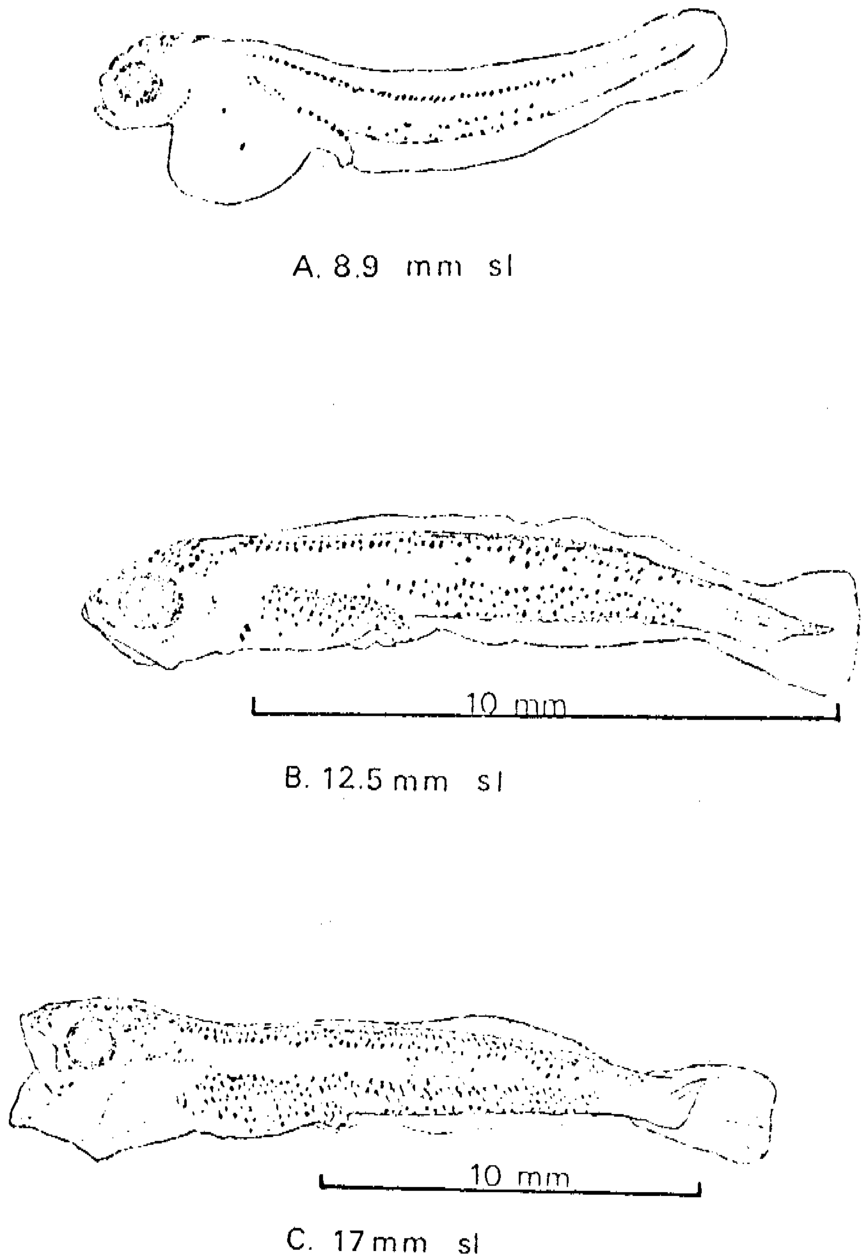


Fig. 36. *Ophiodon elongatus* (Girard)
(Blackburn 1973)

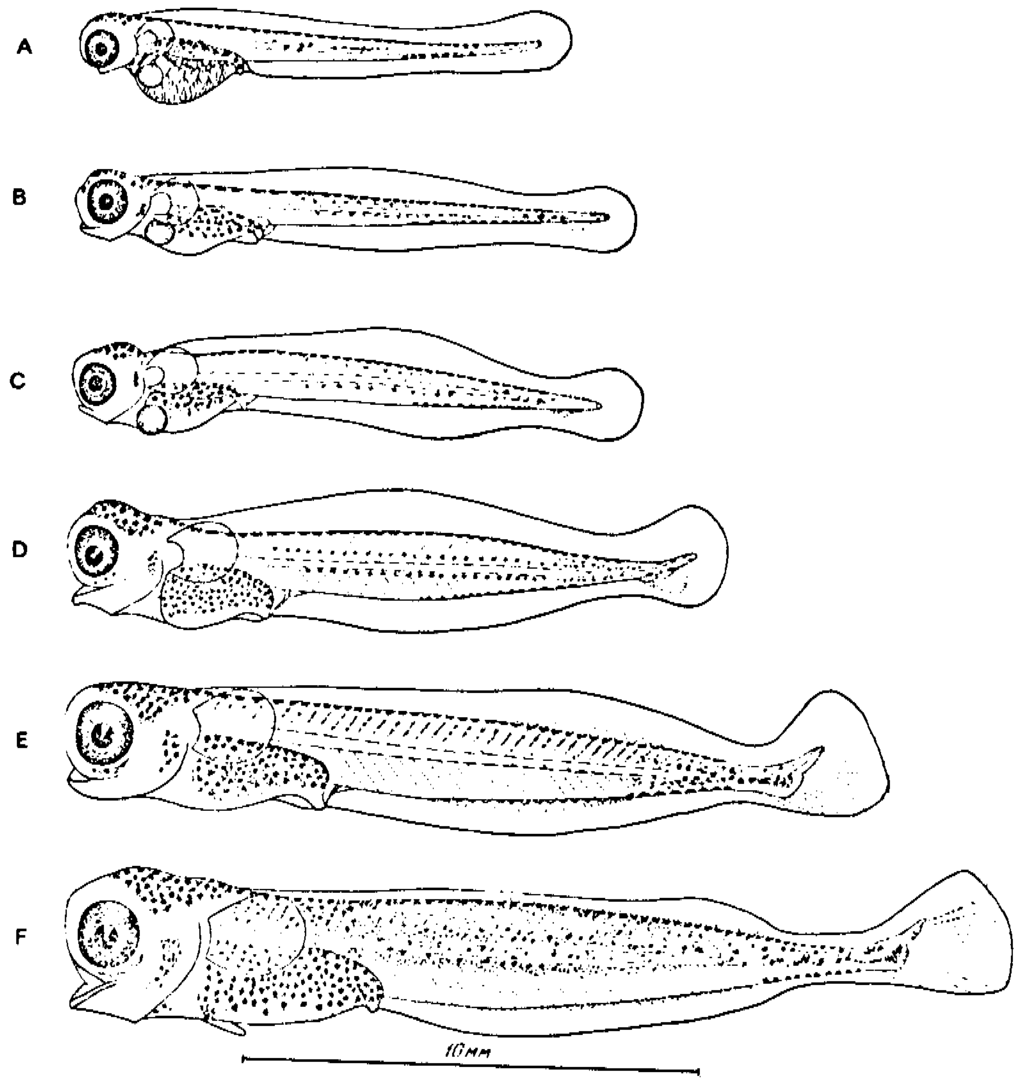


Fig. 37. *Pleurogrammus monopterygius* (Pallas)

A. 10.5 mm. B. 11.8 mm. C. 12.0 mm. D. 14.1 mm.
E. 17.3 mm. F. 19.4 mm. (Garbunova 1962)

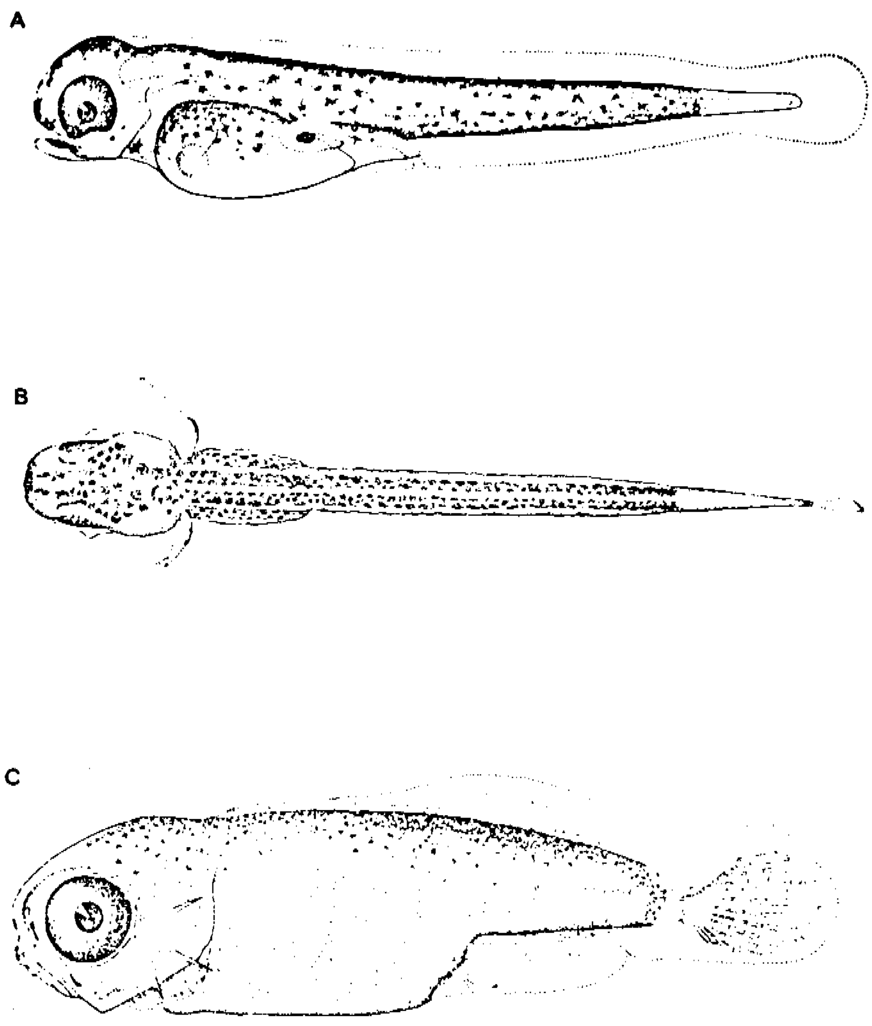


Fig. 38. *Scorpaenichthys marmoratus* (Ayres)

A. Newly-hatched larva at 5.85 mm. B. 6.26 mm (dorsal view).
C. 10.0 mm. (O'Connell 1953)

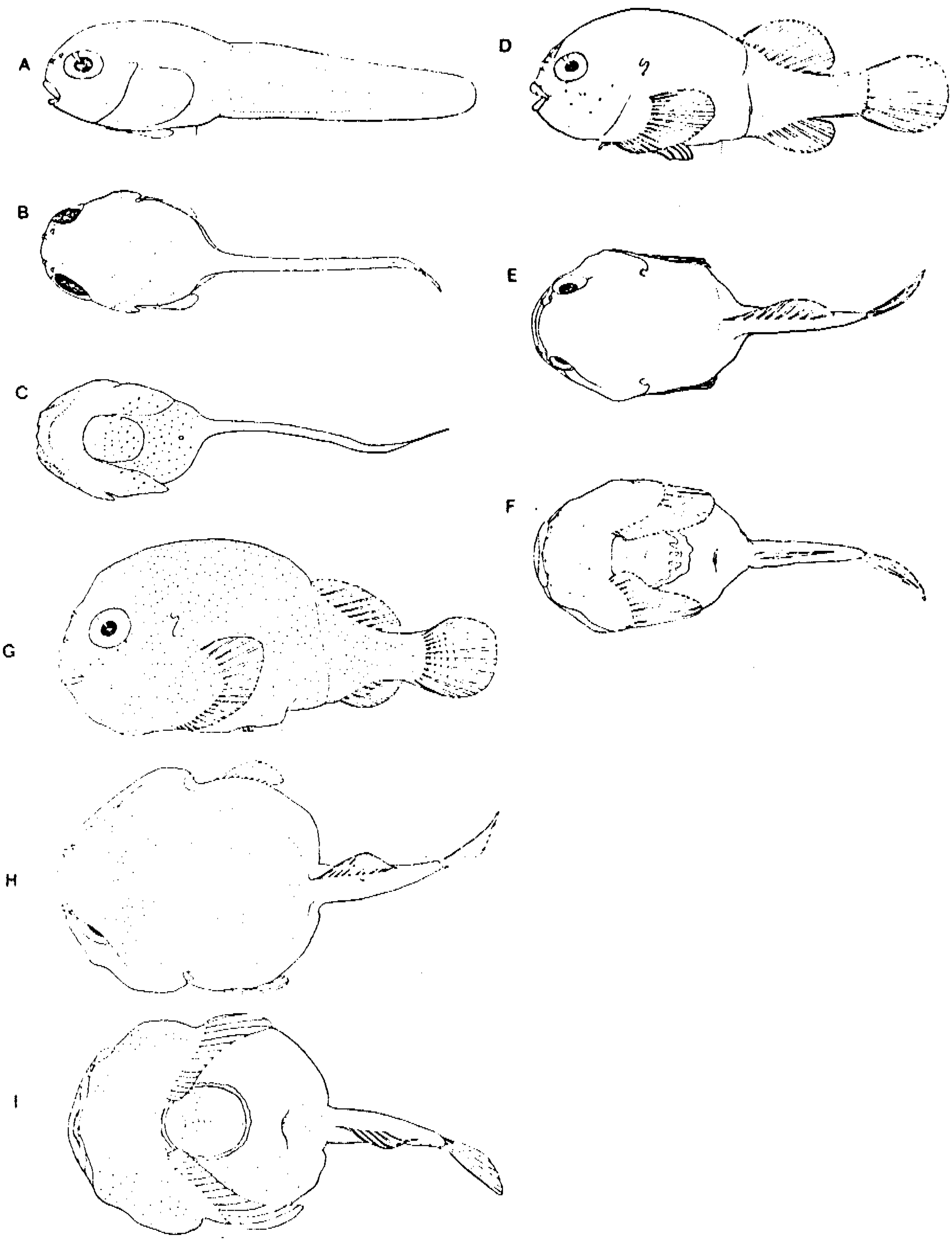


Fig. 39. *Aptocyclus ventricosus* (Pallas)

Newly-hatched larvae, total length 6.0 mm: A. Lateral view. B. Dorsal view. C. Ventral view. Larva, total length 9.9 mm: D. Lateral view. E. Dorsal view. F. Ventral view. Larva, total length 12.9 mm: G. Lateral view. H. Dorsal view. I. Ventral view. (Kobayashi 1962)

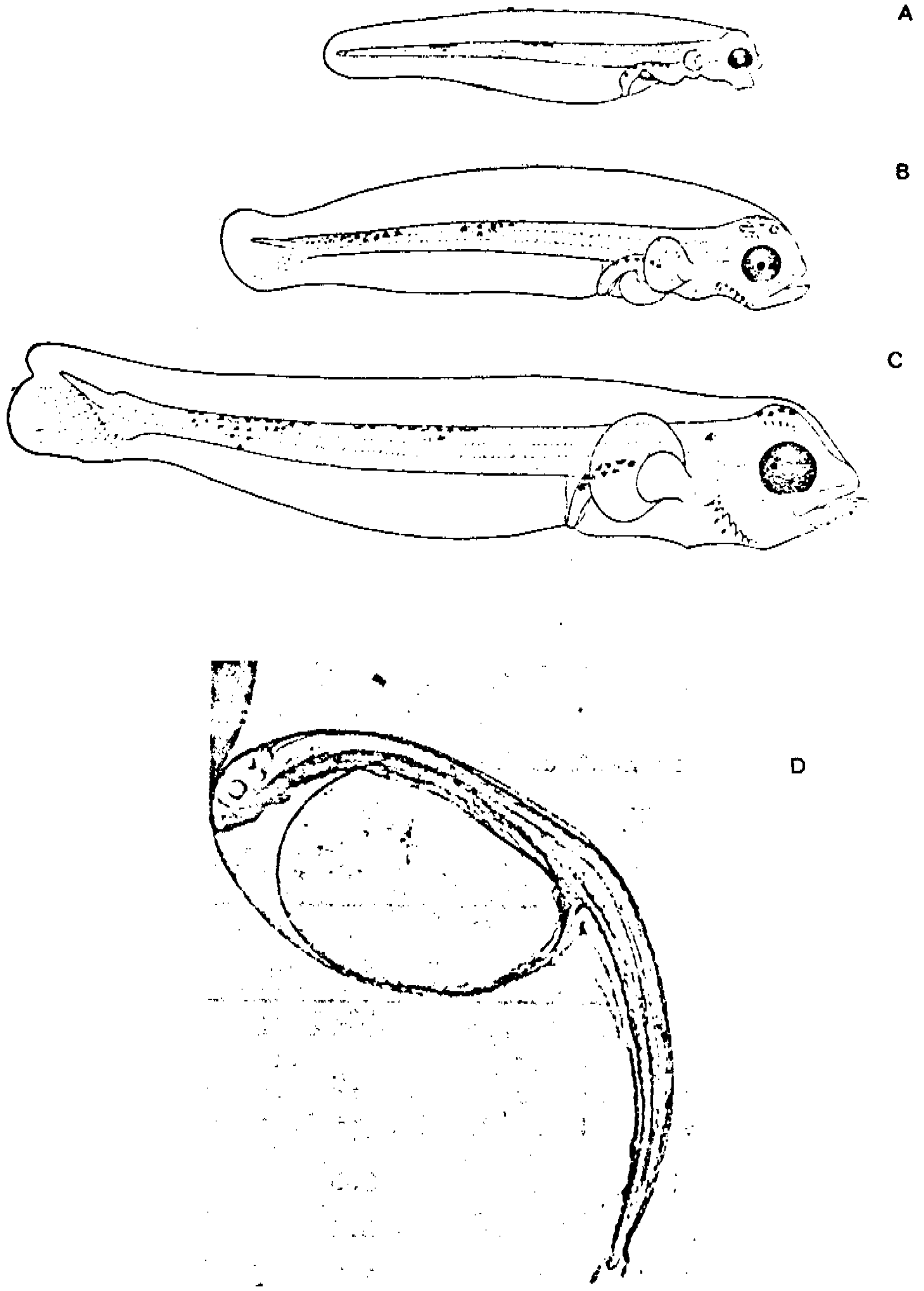


Fig. 40. A-C. Larvae of *Atheresthes evermanni* Jordan and Starks
A. 8.75 mm. B. 11.9 mm. C. 14 mm. (Pertseva-Ostroumova 1960)
D. Larva of *Eopsetta jordani* (Lockington). ∿3.25 mm. (Forrester and Alderdice 1967)

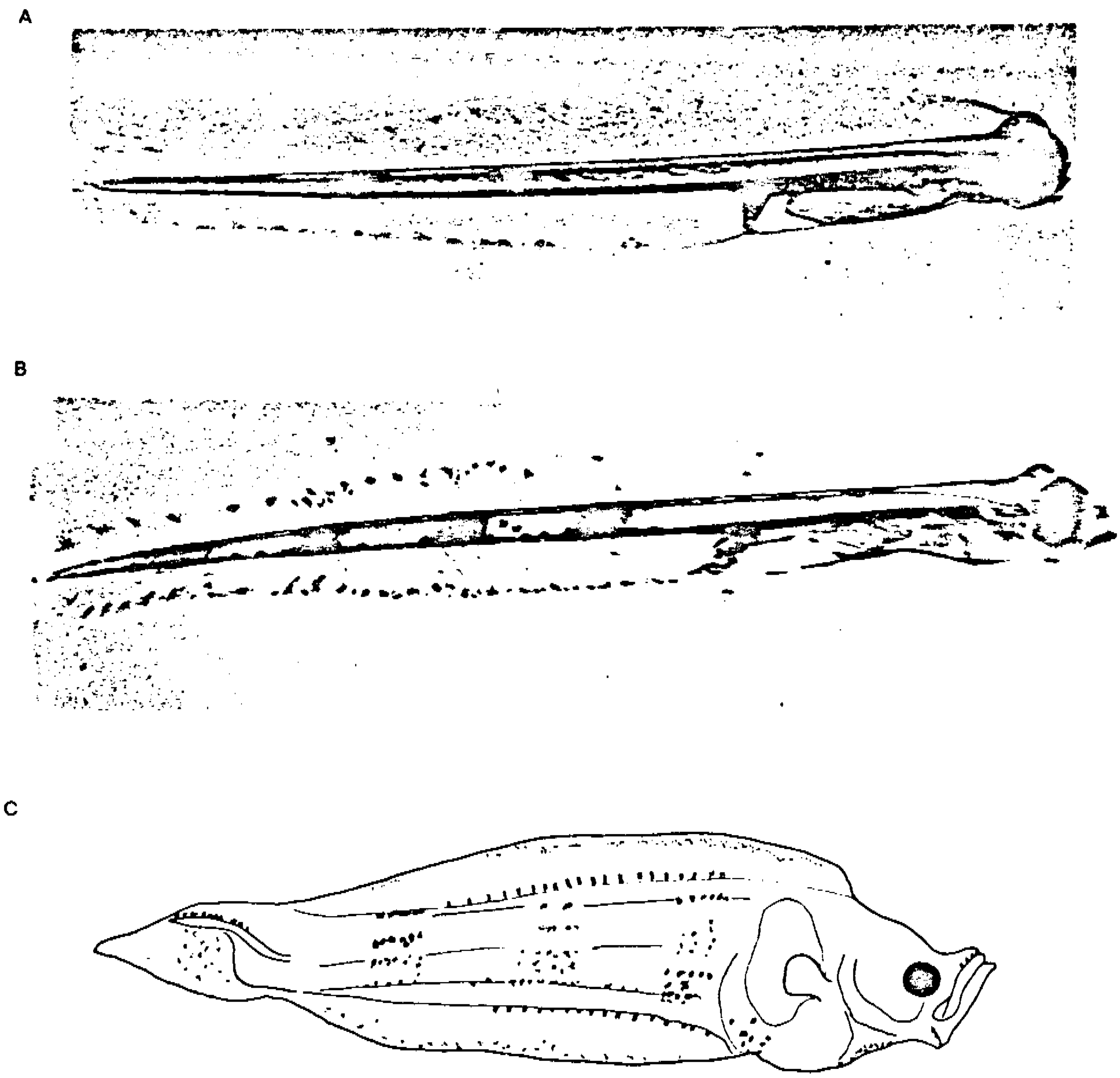


Fig. 41. *Hippoglossoides elassodon* (Jordan and Gilbert)

A. Less than 24 hours old (24 x). B. 7 days old (23 x). C. Metamorphic larva, 11.0 mm TL; estimated age 2-3 months. (Miller 1969)

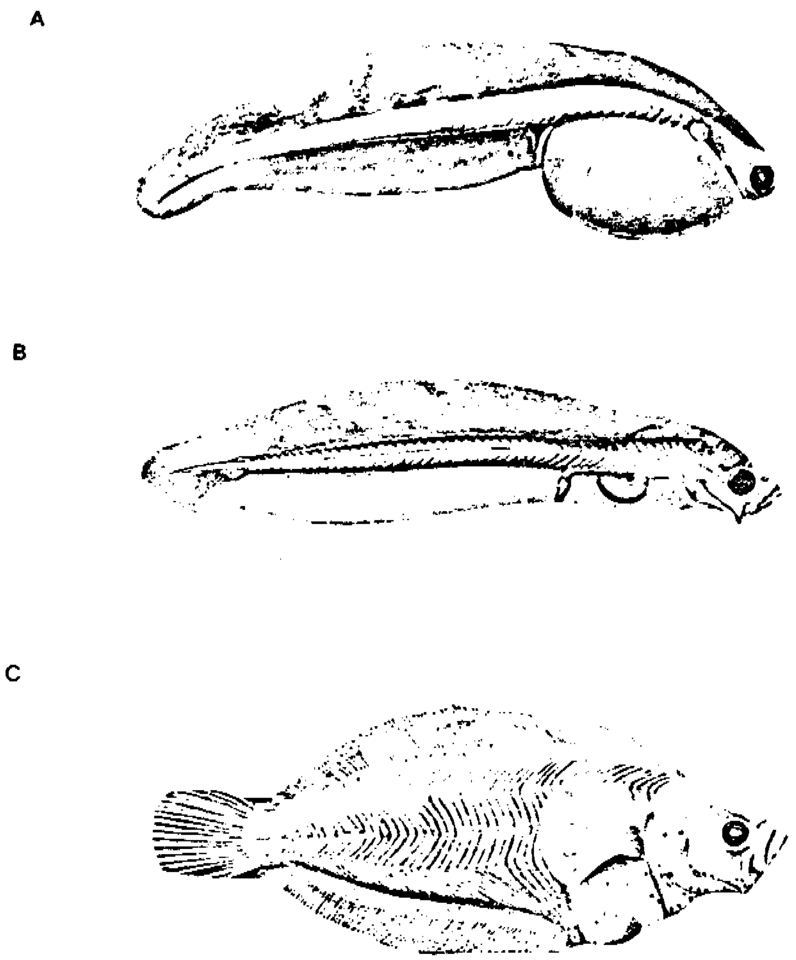


Fig. 42. *Hippoglossus hippoglossus stenolepis* (Vernidub)

A. Newly-hatched larva with yolk-sac, 10.0 mm. B. 17.0 mm.
C. 22.0 mm. (Bell and St. Pierre 1970)

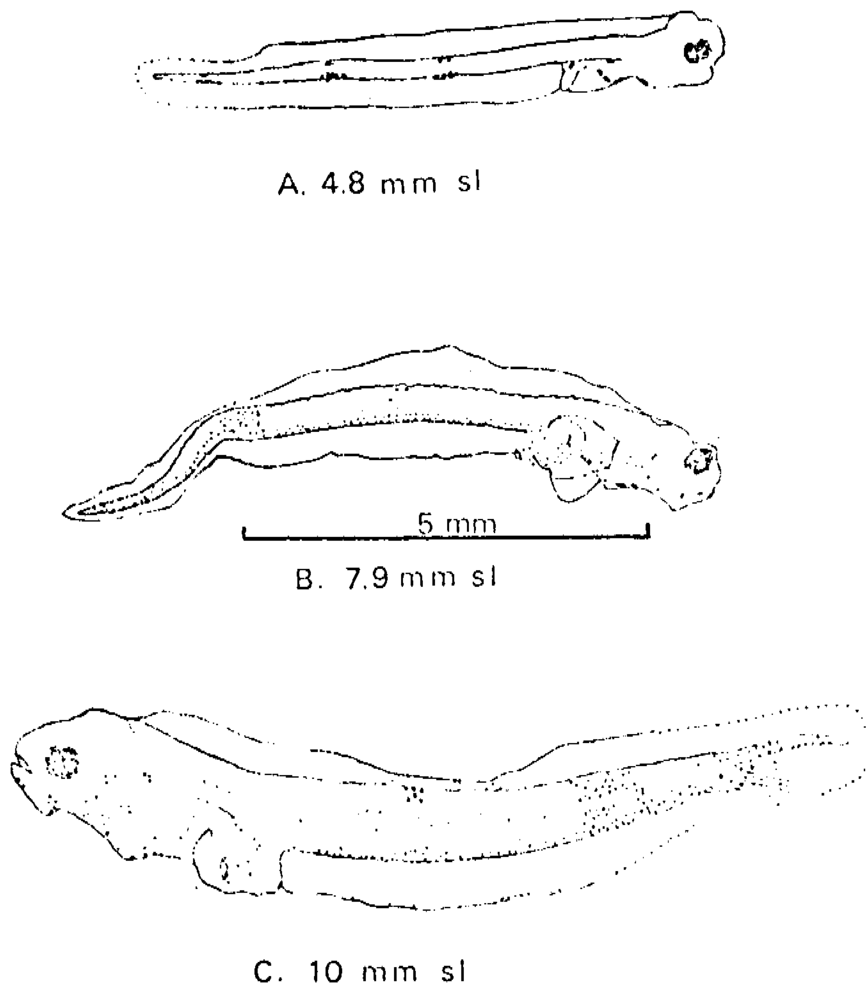


Fig. 43. *Isopsetta isolepis* (Lockington)
(Blackburn 1973)

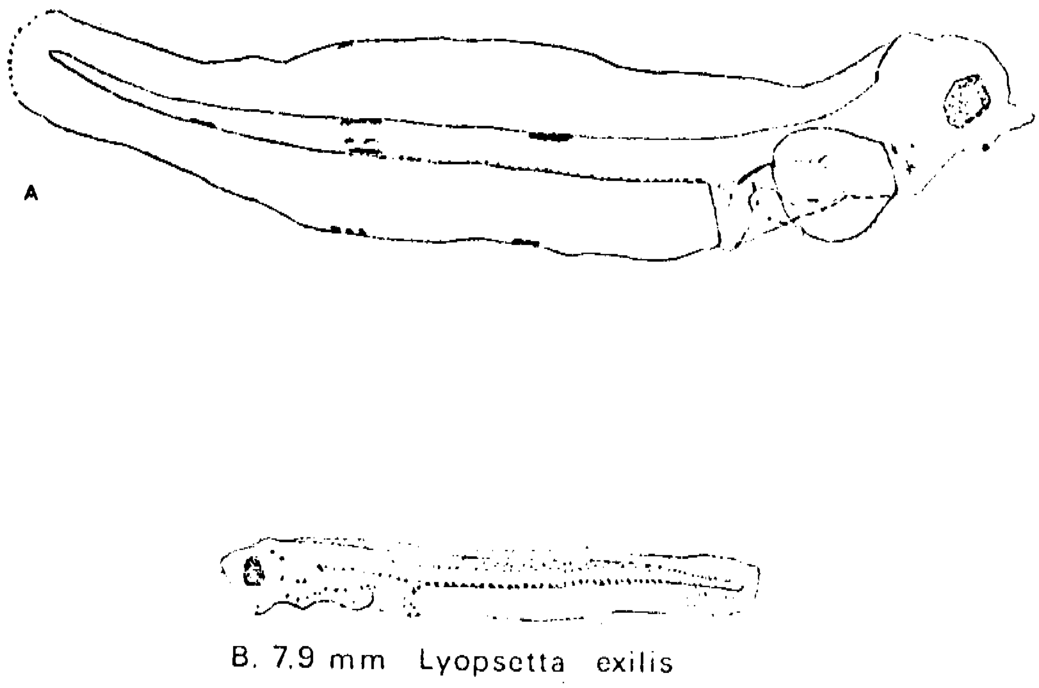


Fig. 44. A. *Lepidopsetta bilineata* (Ayres), 4.4 mm. B. *Lyopsetta exilis* (Jordan and Gilbert). (Blackburn 1973)

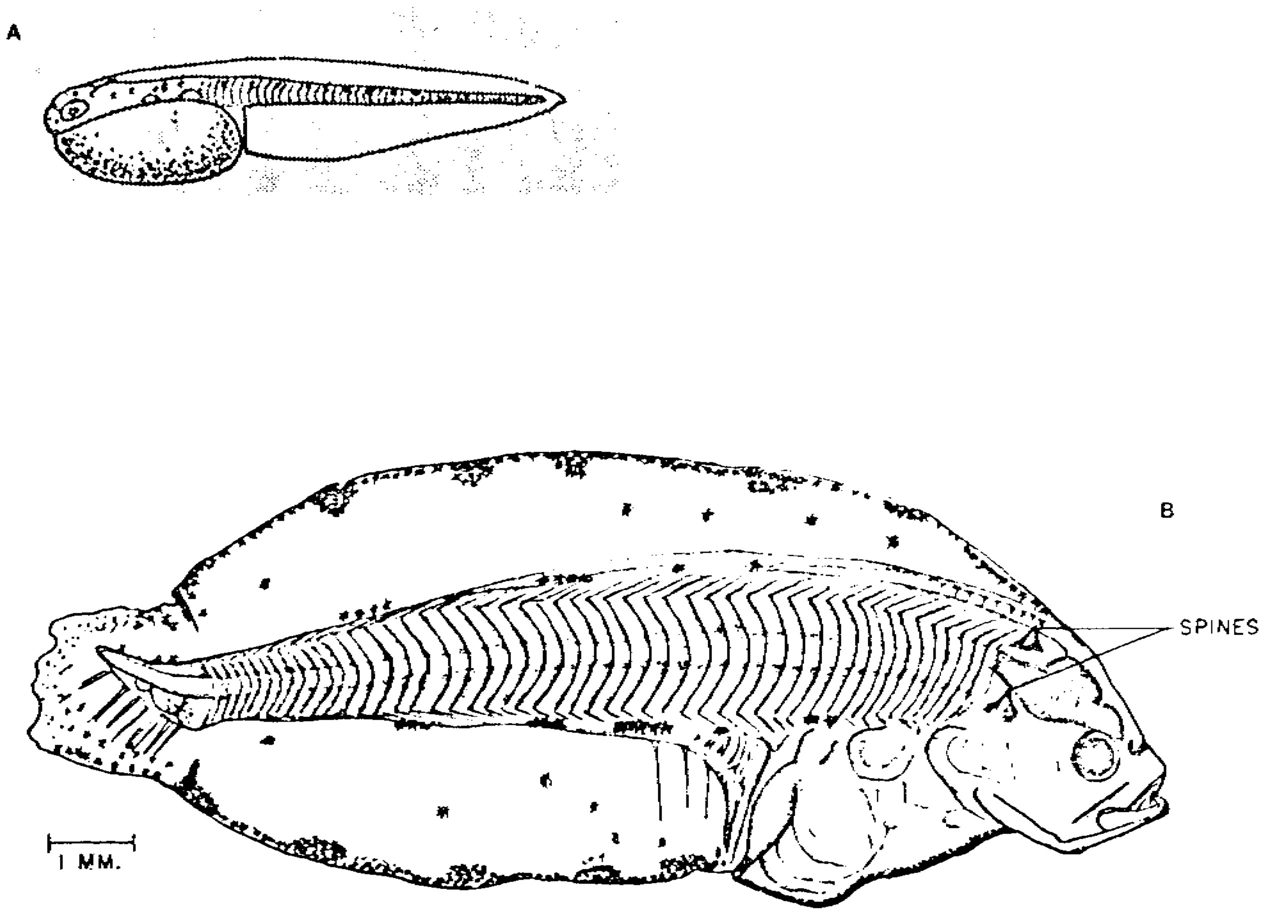


Fig. 45. A. *Limanda aspera* (Pallas). 18 hr 40 min old. B. *Microstomus pacificus* (Lockington). 11.5 mm. (A, Nikolotova 1970; B, Hagerman 1952)

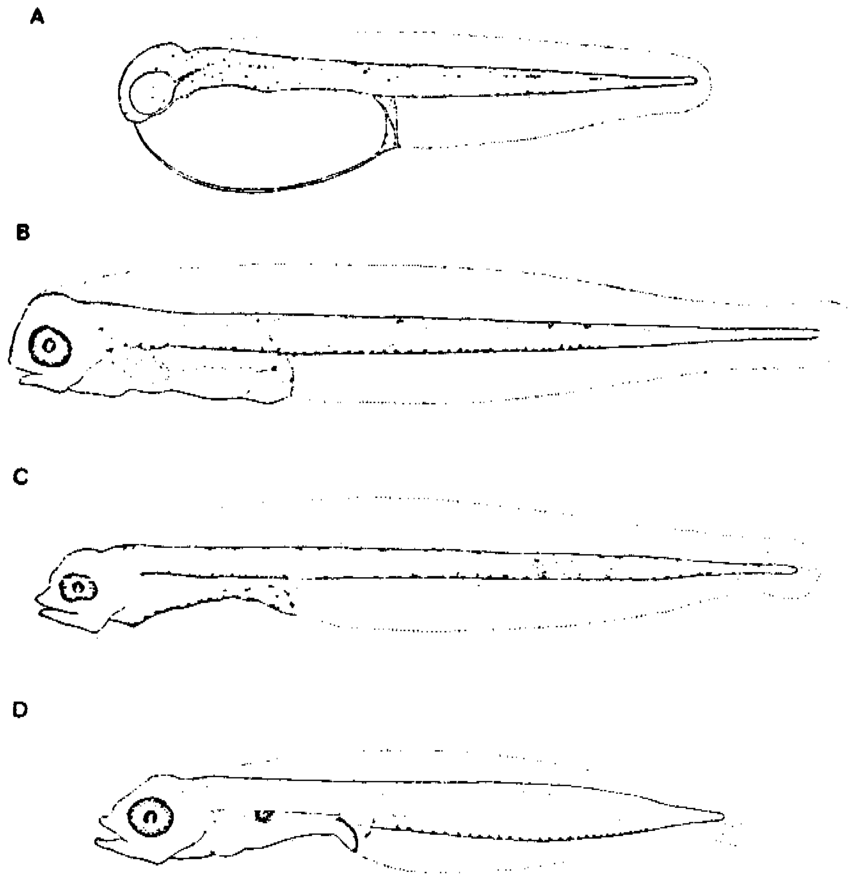


Fig. 46. *Parophrys vetulus* (Girard)

A. Larva just after hatching, 2.8 mm. B. Larva four days old, 3.8 mm. C. Larva nine days old, 4.0 mm. D. Larva, 6.3 mm. (Budd 1940)

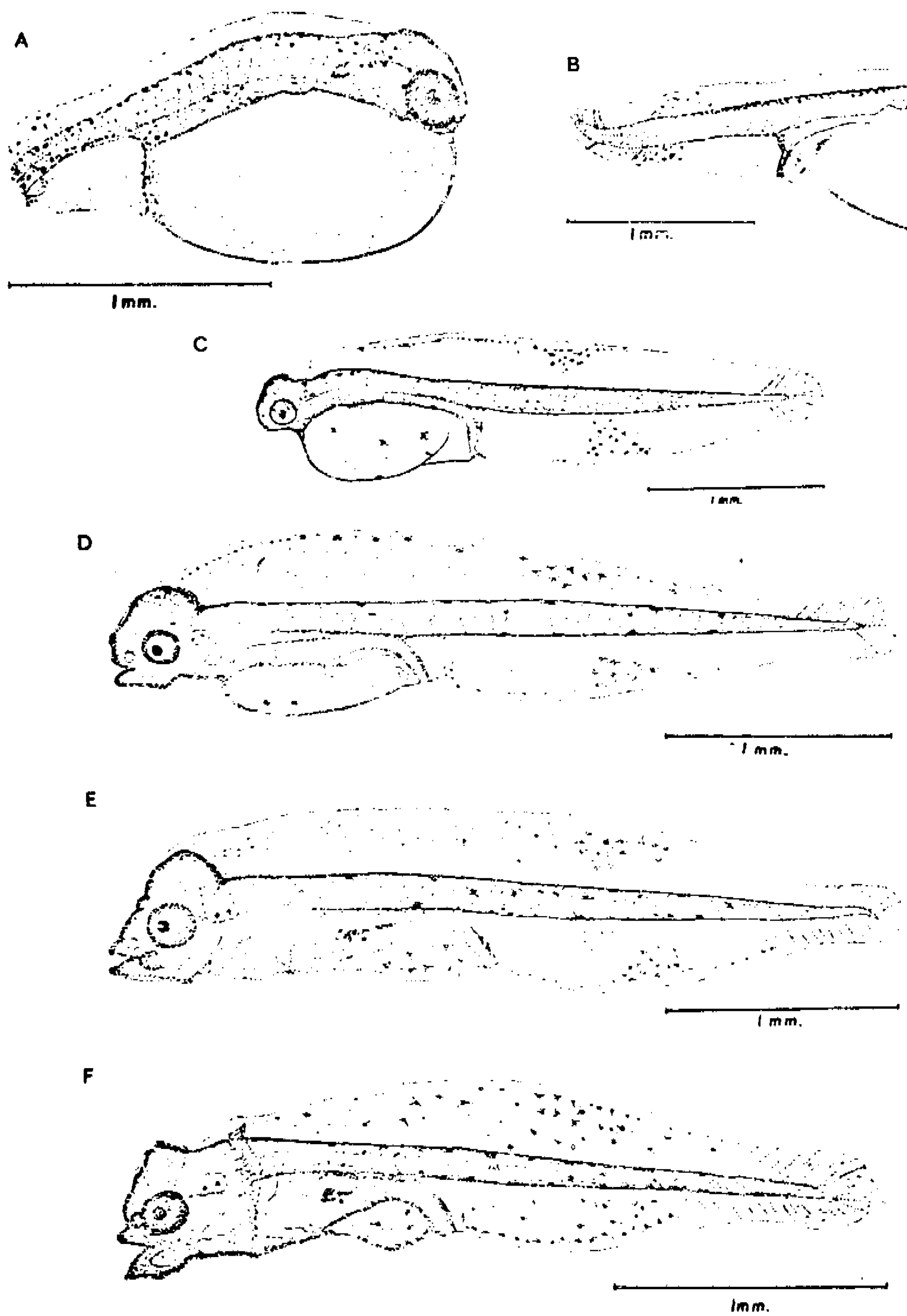


Fig. 47. *Platichthys stellatus* (Pallas)

A. Newly-hatched larva. B. 12-hour larva. C. 2-day larva.
D. 4-day larva. E. 7-day larva. F. 10-day larva. (Orcutt 1950)

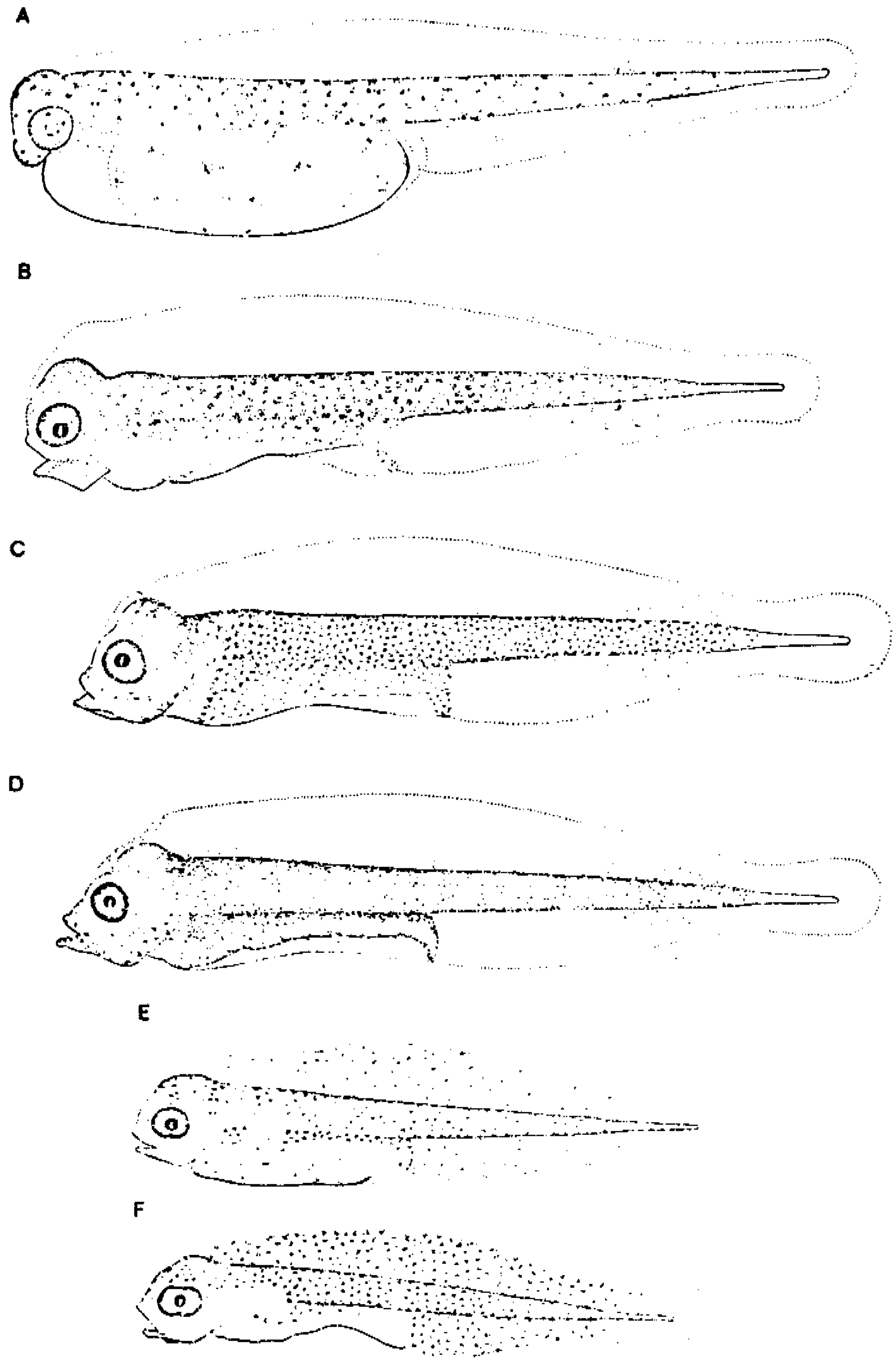


Fig. 48. A–D. *Pleuronichthys decurrens* Jordan and Gilbert

A. Larva just after hatching, 3.88 mm. B. Larva 4 days old, 4.35 mm. C. Larva 7 days old, 4.62 mm. D. Larva 9 days old, 4.72 mm. E–F. *Pleuronichthys coenosus* Girard. E. Larva just after hatching, 5.54 mm. F. Larva 8 days old. (Budd 1940)

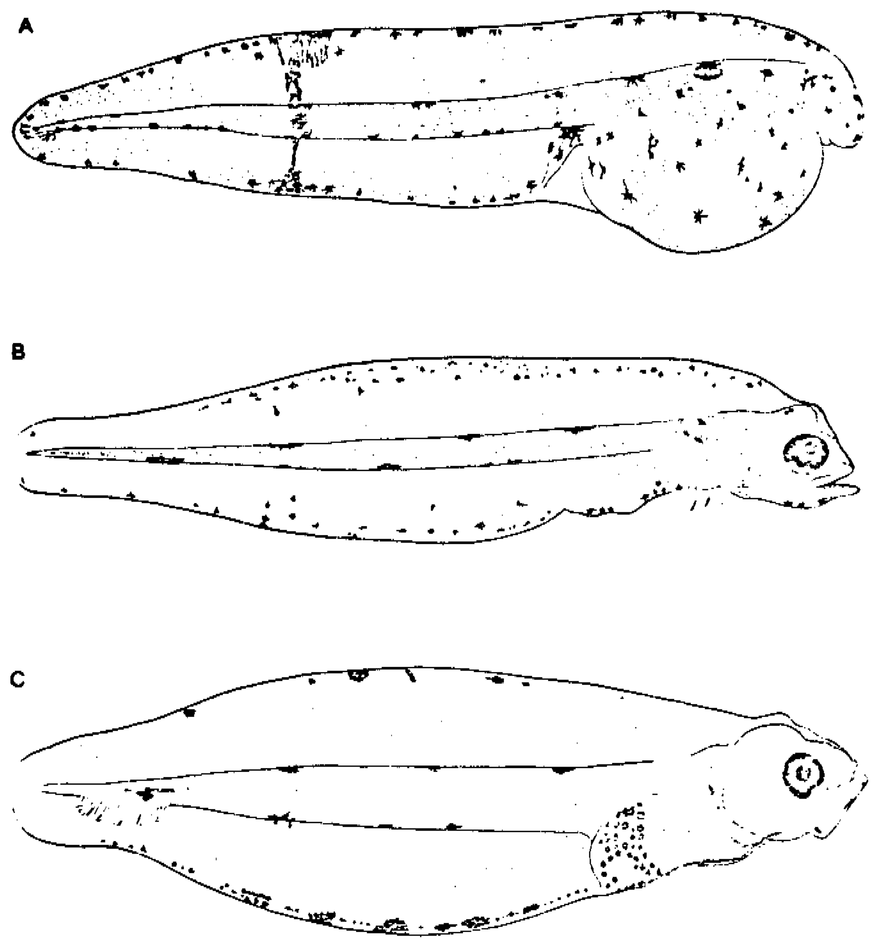


Fig. 49. *Psettichthys melanostictus* Girard

A. 1 day old larva, approximately 3.0 mm. B. 10 day old larva, 4.0 mm. C. 7.5 mm larva. (Hickman 1959)

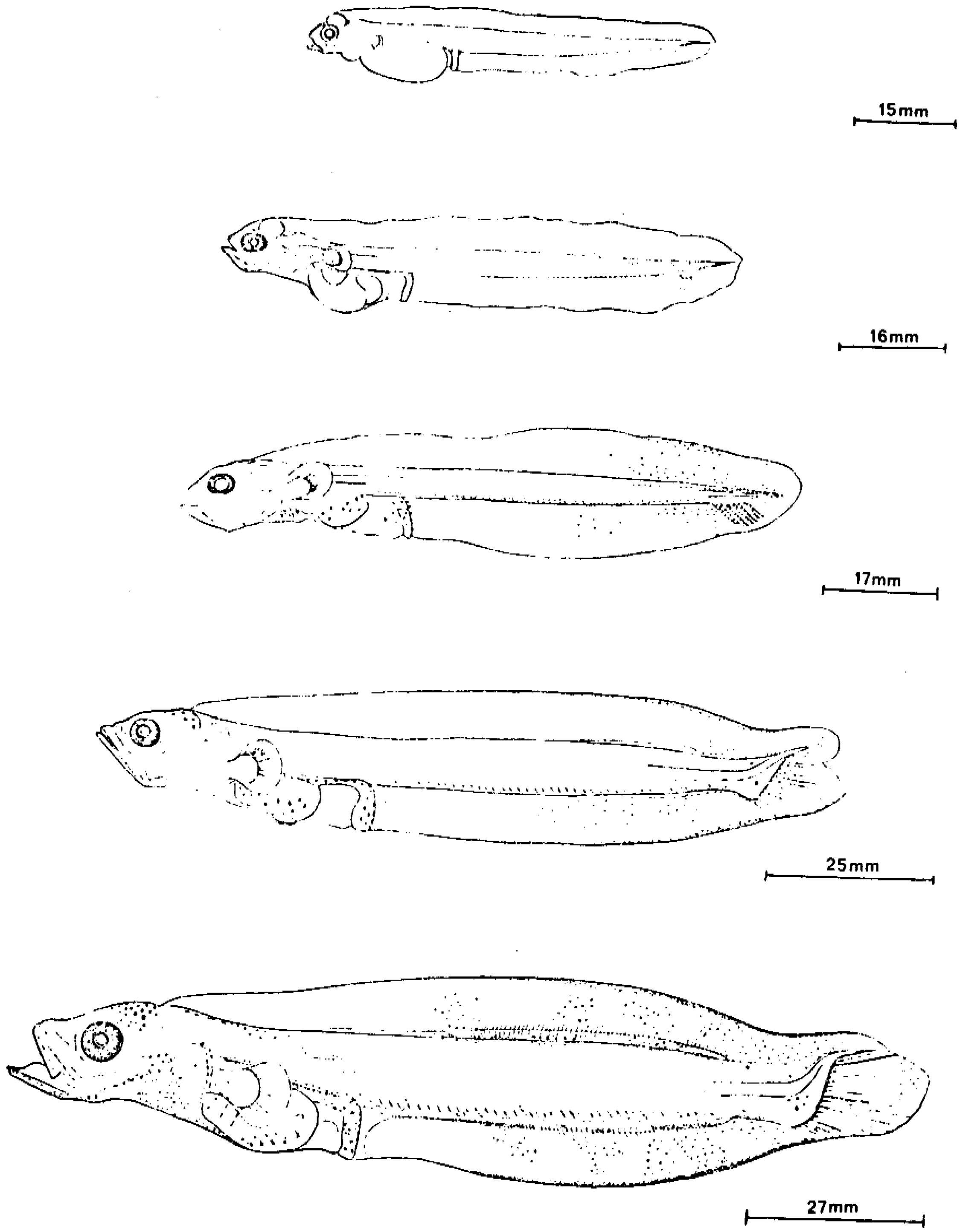


Fig. 50. *Reinhardtius hippoglossoides* (Walbaum)
Dimensions given indicate the natural size. (Jensen 1935)

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FORRESTER, C. R. 1964B. DEMERSAL QUALITY OF FERTILIZED EGGS OF ROCK SOLE (LEPIDOPSETTA BILINEATA AYRES). J. FISH. RES. BD CAN. 21:1531-1532. (ARTIFICIALLY SPAWNED AND FERTILIZED YOUNG EGGS) 570.5 C16J FO

FORRESTER, C. R. 1964C. RATE OF DEVELOPMENT OF EGGS OF ROCK SOLE (LEPIDOPSETTA BILINEATA AYRES). J. FISH. RES. BD CAN. 21:1533-1534. (EGG MEASUREMENTS, RATE OF DEVELOPMENT, SPAWNING SEASON) 570.5 C16J FO

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GORBUNOVA, N. N. 1951. EGGS OF THE ALASKA POLLOCK AND THEIR DEVELOPMENT [IN RUSSIAN!. IZV. TIKHOOKEAN. NAUCHNO-ISSLED. INST. RYB. KHOZ. OKEANOGR. 34:89-97. (THERAGRA CHALCOGRAMMA, EGG AND LARVAL ILLUSTRA-TIONS) 639.206 T44I FO

GORBUNOVA, N. N. 1954. REPRODUCTION AND DEVELOPMENT OF THE WALLEYE POLLOCK [IN RUSSIAN!. TRUDY INST. OKEANOL. 11:132-195. (BOREOGADUS SAIDA, ELEGINUS GRACILIS, GADUS MACROCEPHALUS, THERAGRA CHALCOGRAMMA, ILLUSTRATIONS) 551.4606 AK13T FO

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KANOH, Y. 1954. ON THE BUOYANCY OF THE EGG OF ALASKA POLLOCK, THERAGRA CHALCOGRAMMA. JAP. J. ICHTHYOL. 3:238-246. (UNFERTILIZED AND ARTIFICIALLY FERTILIZED SPAWNED EGGS) 597.05 JA FO

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KOBAYASHI, K. 1961B. LARVAE AND YOUNG OF THE QUILL-FISH, PTILICHTHYS GOODEI BEAN, FROM THE OKHOTSK SEA [IN JAPANESE, ENGLISH ABSTRACT! BULL. FAC. FISH. HOKKAIDO UNIV. 12:5-8. (DESCRIPTIONS OF PLANKTONIC LARVAE, GEOGRAPHICAL DISTRIBUTION) 639.2065 H689BA FO

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Aids for Identification of

Early Life History Stages of Shrimps

in Alaskan Waters

1976

Department of Oceanography
University of Washington

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Introduction

A list of the commercially important shrimp of Alaska summarizes three separate studies.

Three keys to the genera of the family Pandalidae, the species of *Pandalopsis,* and the species of *Pandalus* include all adult shrimps of this family.

Larval studies of pandalid shrimps are listed (Table 1) and important indentifying features are summarized (Table 2), with the exception of the two species of *Pandalopsis* in Table 1 and *Pandalus goniurus* and *P. montagui tridens*. First stage larval studies were reported (Ivanov 1963 and 1970), but translations were not available. Illustrations from larval studies were taken from the literature (Fig. 1 to 9).

A bibliography of 13 references is attached.

Wigutoff (1953) reports the following species that make up the commercial shrimp catch near Petersburg, Alaska.

Pandalus borealis Kröyer	northern pink shrimp
Pandalopsis dispar Rathbun	side-stripe shrimp
Pandalus goniurus Stimpson	humpy shrimp
Pandalus platyceros Brandt	spot shrimp
Pandalus hypsinotus Brandt	coon-stripe shrimp

The first 3 species make up 85-95% of the catch, each almost equally divided in percentage.

Exploratory shrimp fishing by the M/V *John N. Cobb* (Greenwood, 1959) in the Lower Cook Inlet, Shelikof Strait and around Kodiak Island areas resulted in the following species of shrimp in commercial quantities.

Pandalus borealis
Pandalopsis dispar
Pandalus hypsinotus

Additional exploratory shrimp fishing by the *Cobb* (Ronholt, 1963) throughout southern Alaskan waters showed these commercially important shrimp to be in relative abundance.

Pandalus borealis	the most abundant in S.E. Alaska to the Peninsula area
Pandalus dispar	most abundant in Central Alaska and Peninsula waters
Pandalus jordani Rathbun	S.E. Alaska
Pandalus hypsinotus	all regions
Pandalus platyceros	all regions south and east of Cook Inlet

P. hypsinotus and *P. platyceros* made up the minor portion of trawl catches.

KEY TO THE GENERA OF PANDALIDAE

I. Antennules twice the length of the carapace. Merus of the third maxillipeds and ischium of the first legs strongly laminate. .... *Pandalopsis*

II. Antennules shorter than the carapace. Merus and ischium not as above or only slightly laminate .... *Pandalus*

KEY TO THE SPECIES OF *PANDALOPSIS*

1. Dorsal margin of rostrum with spines on the distal half. .... *P. dispar*

1'. Dorsal margin of rostrum without spines on the distal half 2

2. Rostrum more than twice the length of the carapace. Dactyls of the chelae more than one half the length of the manus. .... *P. longirostris*

2'. Rostrum less than twice the length of the carapace. Dactyls of the chelae less than one half the length of the manus. .... *P. aleutica*

KEY TO THE SPECIES OF *PANDALUS*

1\. Third and fourth abdominal segments terminated with a dorsal median spine . . . . *P. borealis*
1! Third and fourth segments unarmed 2

2\. Third abdominal segment slightly flattened laterally, forming a carina, which may or may not be lobed 3
2! Third abdominal segment not as above 4

3\. Rostrum with spines on distal half of superior margin . . *P. jordani*
3! Rostrum without spines on distal half of superior margin. . . . . *P. goniurus*

4\. Dorsal spines behind middle of the carapace 5
4! Dorsal spines not behind middle of carapace (occasionally see *P. danae*.) 7

5\. Dorsal spines more than 15 (17-21), on a pronounced ridge which extends almost to posterior margin of carapace. . . . *P. hypsinotus*
5! Dorsal spines less than 15 6

6\. Antennal scale narrow, terminal half of blade narrower than spine axis. Telson with 3-5 pairs of lateral spinules; tip of rostrum usually bifid . . . . *P. stenolepis*
6! Terminal half of antennal scale wider than spine axis. Telson with 5 or 6 pairs of lateral spinules; tip of rostrum usually trifid. . . . . *P. danae*

7\. Sixth abdominal segment more than twice as long as wide. . . *P. montagui tridens*
7! Sixth abdominal segment less than twice as long as wide. . . . . . *P. platyceros*

Table 1. Larval pandalid shrimp: references and sources of larvae

Pandalopsis dispar Rathbun		side-stripe shrimp	
Area studied:	Nanaimo, B.C.	Berkeley, A. A.	1930
Pandalus borealis Kröyer		northern pink shrimp	
Area studied:	Hokkaido, Japan	Kurata, H.	1964
	Nanaimo, B.C.	Berkeley, A. A.	1930
Pandalus danae Stimpson		dock shrimp	
Area studied:	Nanaimo, B.C.	Berkeley, A. A.	1930
Pandalus goniurus Stimpson		humpy shrimp	
Area studied:	Okhotsk Sea	Ivanov, B. G.	1965
Pandalus hypsinotus Brandt		coon-stripe shrimp	
Area studied:	Hokkaido, Japan	Kurata, A.	1964
	Nanaimo	Berkeley, A. A.	1930
	Katsitsna, Alaska	Haynes, E.	1976
Pandalus jordani Rathbun		ocean pink shrimp	
Area studied:	Seattle, Wash.	Lee, Y. J.	1969
	Crescent City, Calif.	Modin, J. D. & R. W. Cox	1967
Pandalus montagui tridens Rathbun			
Area studied:	Russian waters	Ivanov, B. G.	1971
Pandalus platyceres Brandt		spot shrimp	
Area studied:	Seattle, Wash.	Price, V. A. & K. K. Chew	1972
	Nanaimo, B. C.	Berkeley, A. A.	1930
Pandalus stenolepis Rathbun			
Area studied	Nanaimo, B. C.	Needler, A. B.	1938

Other reported Pandalid species, no larval studies done:

Pandalopsis aleutica Rathbun	Rathbun, M. J.	1904
Pandalopsis longirostris Rathbun	Rathbun, M. J.	1904

Table 2. Characteristics of pandalid shrimp larvae

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalopsis dispar (Berkeley, 1930) first stages hatched in the lab later stages from plank-ton	1	10	More advanced than other Pandelids. Very long, jointed, antennal flagellum	5	3	Immobile		6th as long as the first five
	2	13		9-10	3-4	Stalked	Supraocular spines	
	3	16		12-13	5-6			
	4		Undescribed					
	5?	30		15	10			Pleurae nearly adult

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Telson Lateral spines	Terminal spines	Uropods
Pandalopsis dispar (cont.)	1	Divided		Chelate	Simple. No Exopodite			Bilobed buds		12 pr. plumose	Enclosed
	2			Better developed				Bilobed, not jointed nor setose	2 pr.	5 pr. plumose	Enclosed
	3		Slight claw					Biramus	2 pr.	5 pr. slightly plumose	Free & biramus
	4	(Undescribed)									
	5		Vestigial claw	Slightly unequal				Adult in shape	6 pr.	7 pr. slightly plumose	

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus borealis (Berkeley, 1930)	1	5	Least developed. Pereiopods poorly developed	0	0	Immobile		
first stages hatched in the lab,	2	7		0	0	Stalked	Supraocular spines	
later stages from plank-ton	3	8-9	Similar to second stage	2	0			
	4	9-10	Similar to third stage	4	0			
	5	14		11-12 (4-5 on Carapace)	0			
	6	?		14 + 1 at tip	0			

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Telson Lateral spines	Telson Terminal spines	Uropods
Pandalus borealis (cont.)	1	Fused	1-3 biramus	curved bars		Uniramus	Uniramus			7 pr. plumose	Enclosed
	2	Indistinctly divided	- - - -	All pereiopods segmented			- - - -	Buds		7 pr. plumose	Enclosed
	3	Divided						Buds		8 pr. plumose	Free. Inner rami smaller
	4							Biramus, no setae nor joints	3 pr.	5 pr.	Rami well developed
	5			Claw				Jointed with setae	3 pr.	5 pr.	
	6			Claw well developed				Appendices internae present	4 pr.	5 pr. Middle pair longer	

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus danae (Berkeley, 1930)	1	6		0	0	Immobile	Rounded prominence behind rostrum & near posterior edge	
first stages hatched in the lab,	2	8		0	0	Stalked	Supraocular spines	
later stages from plankton	3	9	Similar to 2nd stage	minute 2-3	0			Pleurae beginning to develop
	4	12		8-10	3-5			
	5	14		10-12 (2-3 on Carapace)	4-5			
	6	17	Almost adult	10-12	4-5		No supraocular spines	

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	Pereiopods 2nd	Pereiopods 3rd	Pereiopods 4th	Pereiopods 5th	Pleopods	Telson Lateral spines	Telson Terminal spines	Uropods
Pandalus danae (cont.)	1	Divided	Unsegmented	Segmented	Segmented	Similar to 3rd	Similar to 3rd	None visible		7 pr. plumose	Enclosed
	2			Claw				None visible		8 pr. plumose	Enclosed
	3							None visible	3 pr.	5 pr. plumose	Free
	4		Small claw	Well developed claw				Buds	3 pr.	5 pr. barely plumose	Rami well developed
	5		Claw smaller	Left longer				Biramus	3 pr.	5 pr.	
	6							Still unjointed	3 pr.	5 pr. (3 setae)	

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus hypsinotus (Haynes, 1976) raised in lab	1	5.8	Very similar to *P. danae* but much more slender and shorter (Berkeley, 1930)	0	0	Immobile	Angular prominence behind rostrum & near posterior edge in all stages	
	2	6.1		0	0	Stalked		
	3	6.7					Supraorbital spine absent	
	4	7.5		11-13	3-4			
	5	9.2		16-18	4-5			
	6	10.8		16-20	4-7			

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Lateral spines	Terminal spines	Uropods
Pandalus hypsinotus (cont.)	1	Fused	- - - - All pereiopods segmented - - - - 1st and 2nd with exopodites					None visible		7 pr. plumose	Enclosed
	2	Divided						Buds		8 pr. plumose	Enclosed
	3			Claw				Buds	2 pr.	7 pr.	Free and biramus
	4		Exopodites reduced	Left longer				Cleft unjointed	2 pr.	3 pr. plumose spines 2 pr. setae	
	5		Exopodite remnants					Bilobed, segmented, no setae	2 pr.	3 pr. plumose spines 2 pr. setae	
	6		No exopodites					Biramus segmented with setae	3 pr.	3 pr plumose spines 1 pr. setae	

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus jordani (Modin & Cox, 1967) raised in lab	1	5	Measured from tip of antennal scale to tip of telson	0	0	Immobile		
	2	6.5		0	0	Stalked		
	3	7	Nearly the same as second stage	0	0			
	4	7.5		0	0			
	5	8	Similar to fourth stage	2	0			
	6	9.5		8-9				
	7	11	Similar to sixth stage					
	8	12						
	9	13						
	10	14.5	Similar to ninth stage					
	11	17						

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Telson Lateral spines	Telson Terminal spines	Uropods
Pandalus jordani (cont.)	1	Fused	1-3 biramus curved bars			Uni-ramus	Uni-ramus	None visible		7 pr. plumose	Enclosed
	2	Divided	Exopodites fully developed		Still rudimentary - - -			None visible		8 pr. plumose	Free and biramus
	3				Devel-oped	Undeveloped - -		None visible		8 pr. plumose	Well devel-oped
	4					Developed - - -		None visible	3 pr.	5 pr. plumose	
	5							Buds	3 pr.	5 pr. plumose	
	6			Claw				4 pr. biramus	3 pr.	5 pr. plumose	
	7							4 pr. biramus	3 pr.	5 pr.	
	8							1st pleo-pod, rudi-mentary	3 pr.	5 pr.	
	9		Develop-ing Chela			Without exopo-dites		5 pr. biramus	5 pr.	5 pr.	
	10								5 pr.	5 pr.	
	11		Claw			Without exopo-dites			7 pr.	5 pr.	

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus Platyceros (Price and Chew, 1972) raised in lab	1	8.1		12-13		Immobile	23-25 denticles along outer edges	Fine denticles along first 5 segments
	2	10.0		15	3-4	Stalked	Fewer denticles. Supraorbital spine present	
	3	11.0		15-16	4		Few denticles	Few denticles
	4	11.5-12		15-17	5-6			Margins with setae
	5	12-13	This is post-larval stage	18	6		No supraorbital spine	More setae
	6	14-15		18	6-7			
	7-9		Minor differences					

Table 2. (cont.)

	Stage	6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Telson Lateral spines	Telson Terminal spines	Uropods
Pandalus platyceros (cont.)	1	Divided	- - -	Exopodites 2nd with chelae	- - -	No exopodites		Buds		8 pr. plumose	Enclosed
	2							Bilobed		8 pr.	Enclosed
	3		Exopodites smaller						3 pr.	5 pr.	Free
	4							Well developed	4 pr.	4 pr.	
	5		- - - No	Exopodites Left longer	- - -				5 pr.	2 pr. 2 pr setae	
	6										
	7-9										

Table 2. (cont.)

	Stage	Average Length (mm)	Comments	Rostral dentition dorsal	Rostral dentition ventral	Eyes	Carapace	Abdomen
Pandalus stenolepis (Needler, 1938) first and second stages reared in lab. Second to seventh stages from plankton	1	5		0	0	Immobile	Fringed with denticles	Fine denticles along first 5 segments
	2	6		4-5		Stalked	Supraocular spines	
	3	8		8-9	2			Few denticles
	4	9		10-12	4		Few denticles	Few denticles
	5	12					Few denticles	Few denticles on 3, 4 & 5th segments
	6	14		10	5		No denticles	No denticles
	7		Post larval form	11	6		No supraorbital spines	

Table 2. (cont.)

	Stage	Abdomen 6th & 7th segments	Pereiopods 1st	2nd	3rd	4th	5th	Pleopods	Telson Lateral spines	Terminal spines	Uropods
Pandalus stenolepis (cont.)	1	Fused	1-3 biramus curved bars			Uni-ramus	Uni-ramus	None visible		7 pr. plumose	Enclosed
	2	Fused	Seg-mented	- - - - - 2-5 unsegmented - - - - -						8 pr. plumose	Enclosed
	3		- - 1-3 with exopodites - -					Buds	3 pr.	5 pr. plumose	Free
	4							Unseg-mented but biramus			
	5			Claw				Segmented	4 pr.	5 pr. plumose	
	6			Left longer						5 pr. plumose	
	7		- - Exopodites reduced - -								

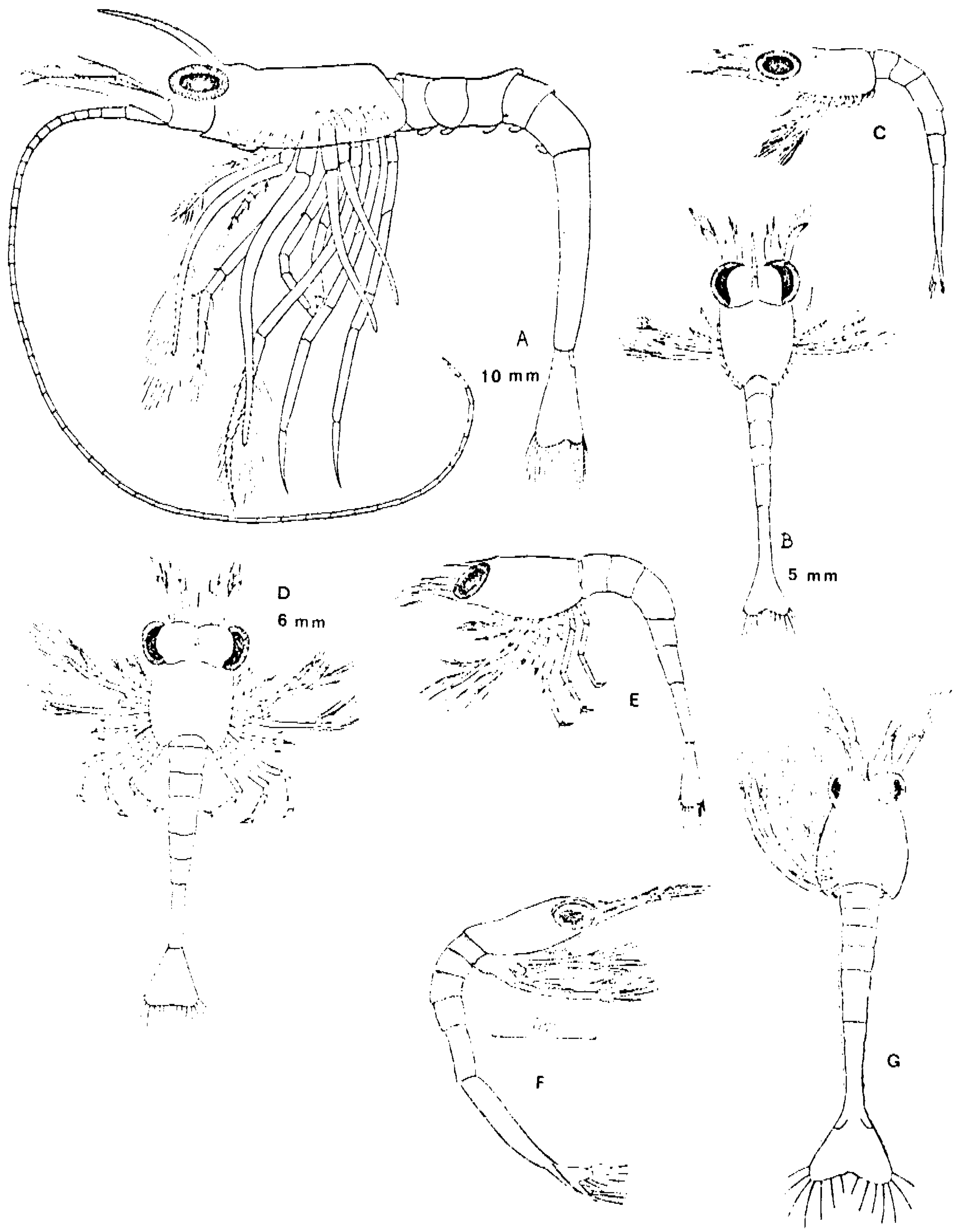

Fig. 1. First stage larvae. A. *Pandalopsis dispar*. B. *Pandalus borealis* dorsal view. C. Same, lateral view. D. *Pandalus danae* dorsal view. E. Same, lateral view. F. *Pandalus goniurus* lateral view. G. Same, dorsal view. (A–E, Berkeley 1930; F–G, Ivanov 1965)

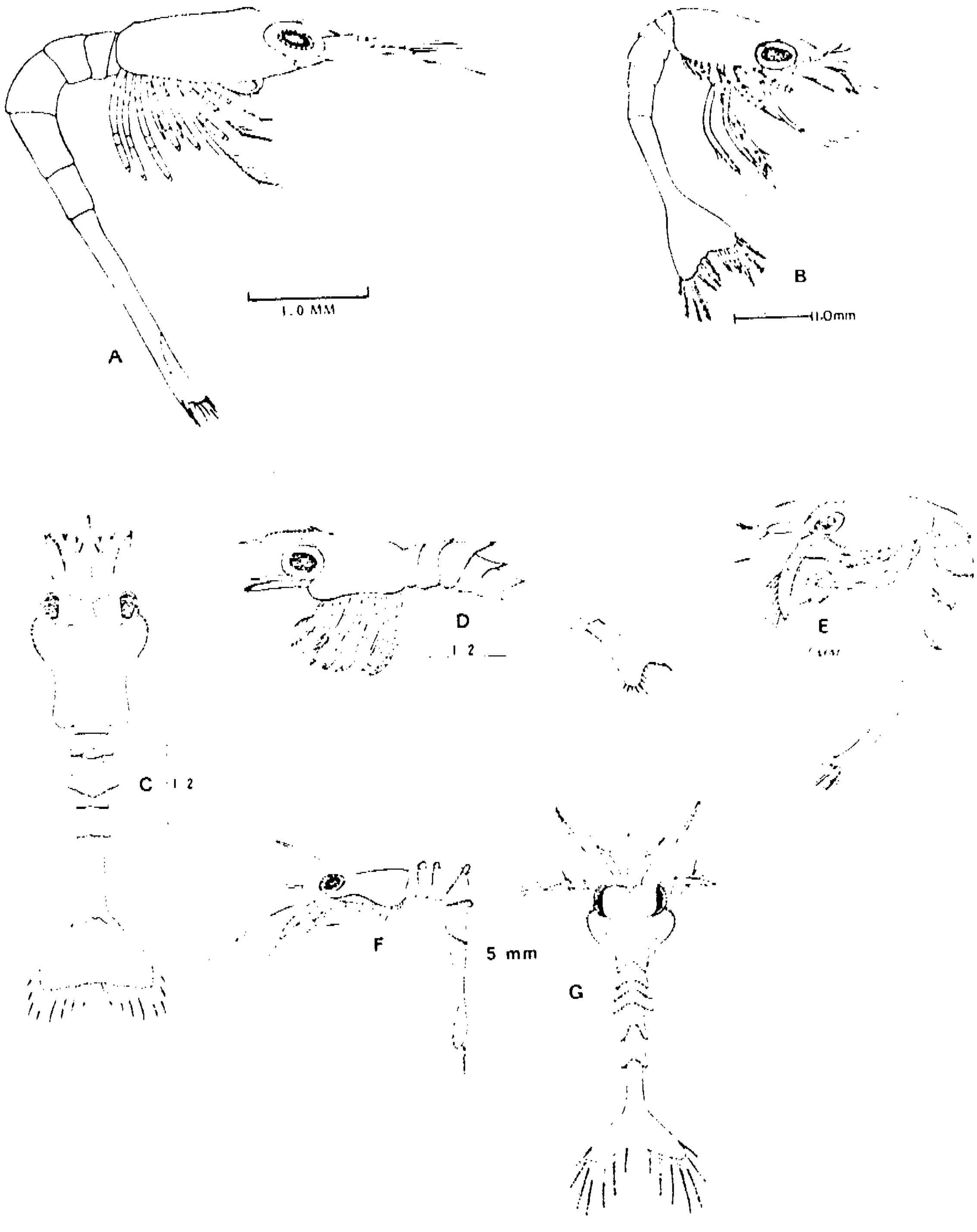

Fig. 2. First stage larvae. A. *Pandalus hypsinotus*. B. *Pandalus jordani*. C. *Pandalus platyceros* dorsal view. D. Same, lateral view. E. *Pandalus montagni tridens*. F. *Pandalus stenolepis* lateral view. G. Same, dorsal view. (A, Haynes 1976; B, Modin and Cox 1967; C-D, Price and Chew 1972; E, Ivanov 1971; F-G, Needler 1938)

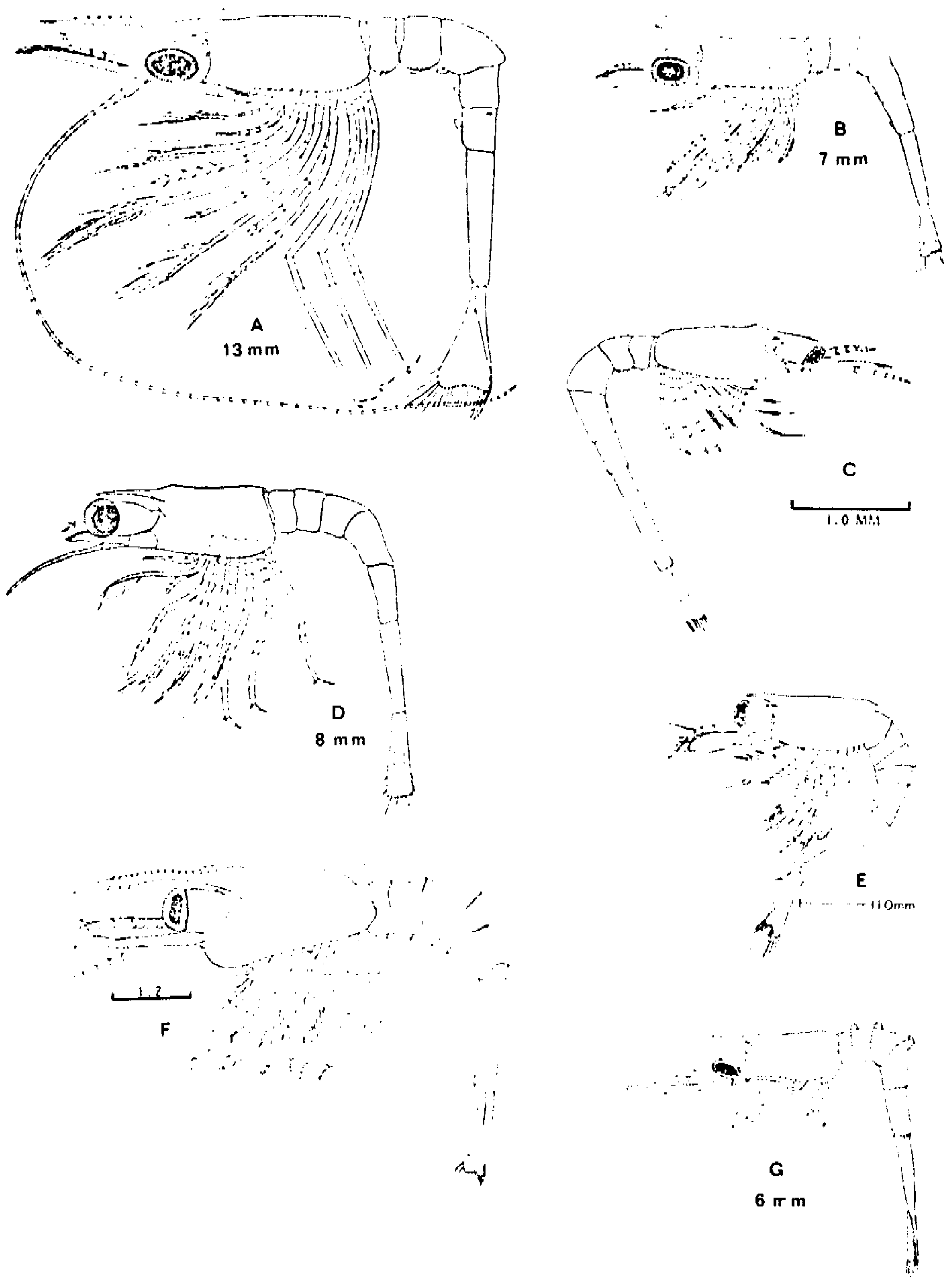

Fig. 3. Second stage larvae. A. *Pandalopsis dispar*. B. *Pandalus borealis*. C. *Pandalus hypsinotus*. D. *Pandalus danae*. E. *Pandalus jordani*. F. *Pandalus platyceros*. G. *Pandalus stenolepis*. (A-B, D, Berkeley 1930; C, Haynes 1976; E, Modin and Cox 1967; F, Price and Chew 1972; G, Needler 1938)

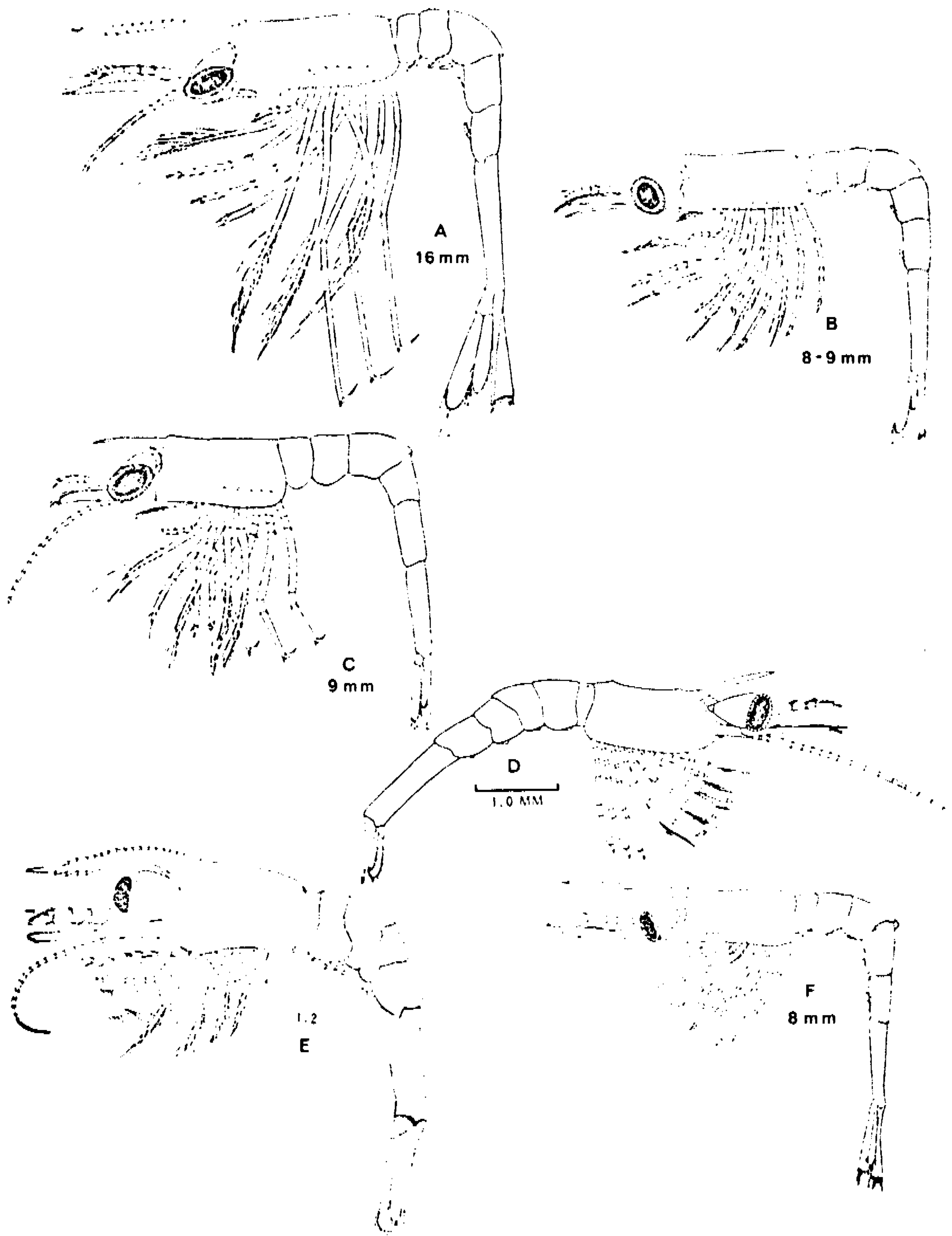

Fig. 4. Third stage larvae. A. *Pandalopsis dispar*. B. *Pandalus borealis*. C. *Pandalus danae*. D. *Pandalus hypsinotus*. E. *Pandalus platyceros*. F. *Pandalus stenolepis*. (A–C, Berkeley 1930; D, Haynes 1976; E, Price and Chew 1972; F, Needler 1938)

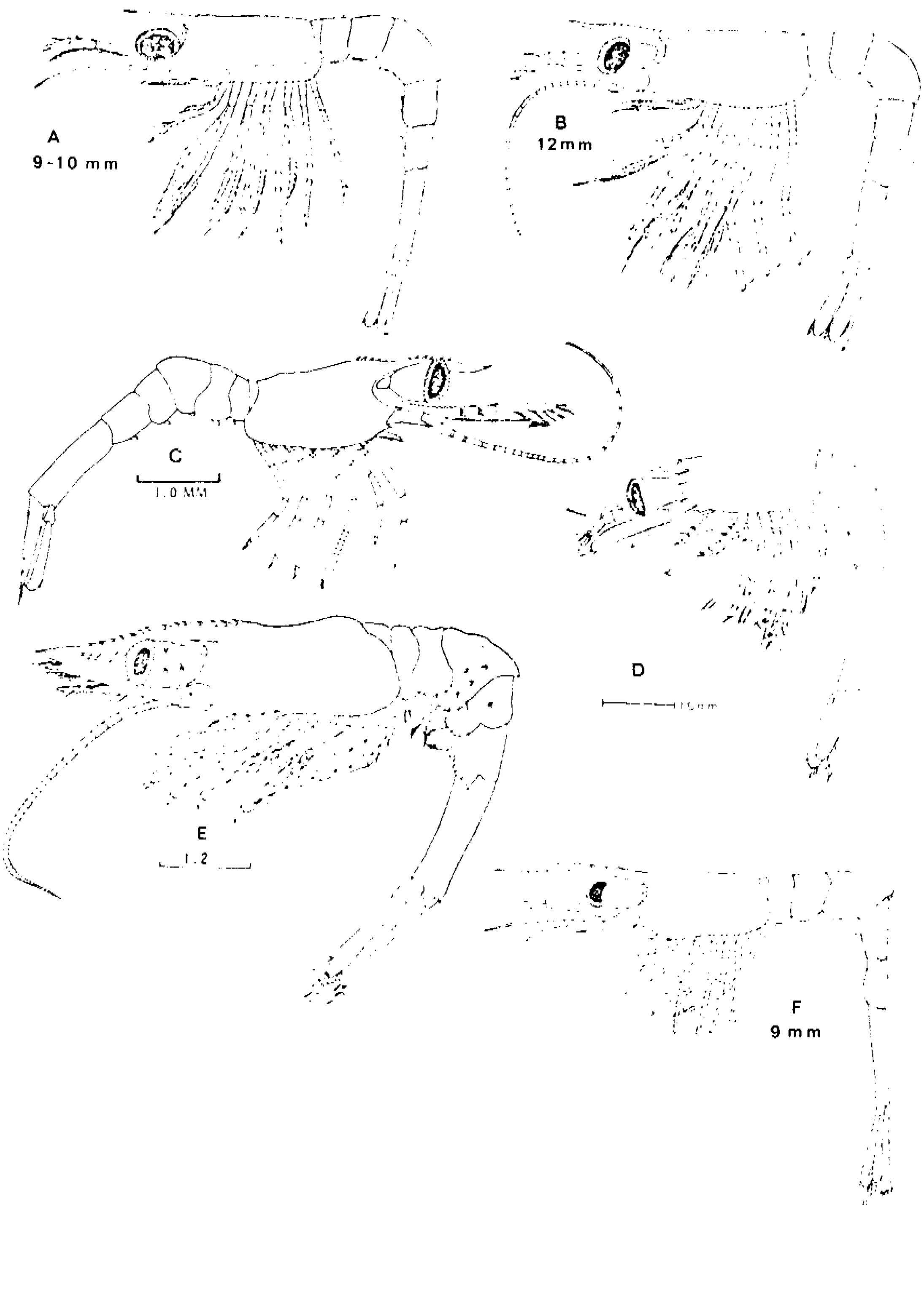

Fig. 5. Fourth stage larvae. A. *Pandalus borealis*. B. *Pandalus danae*. C. *Pandalus hypsinotus*. D. *Pandalus jordani*. E. *Pandalus platyceros*. F. *Pandalus stenolepis*. (A-B, Berkeley 1930; C, Haynes 1976; D, Modin and Cox 1967; E, Price and Chew 1972; F. Needler 1938)

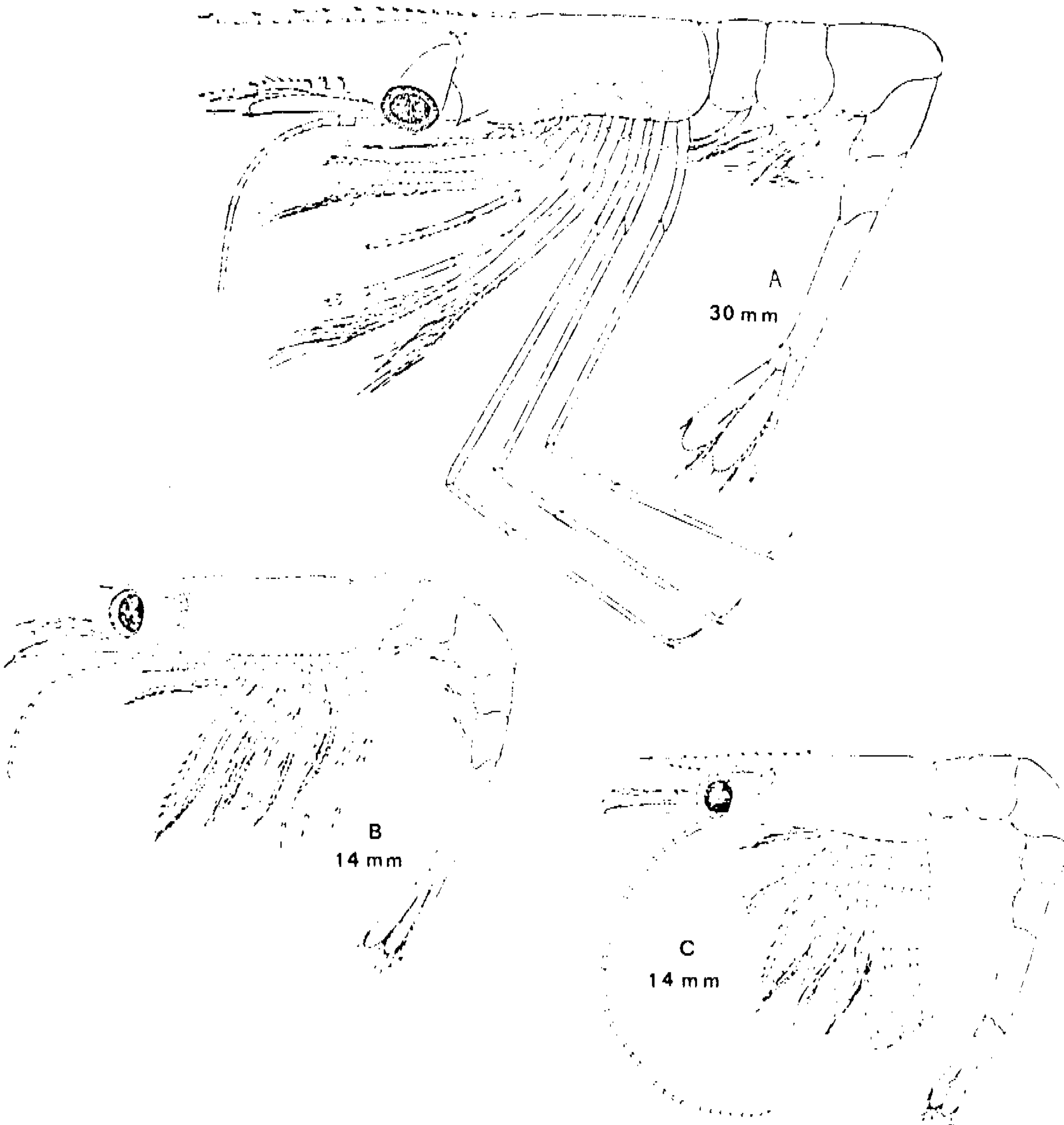

Fig. 6. Fifth stage larvae. A. *Pandalopsis dispar*. B. *Pandalus borealis*. C. *Pandalus danae*. (A-C, Berkeley 1930)

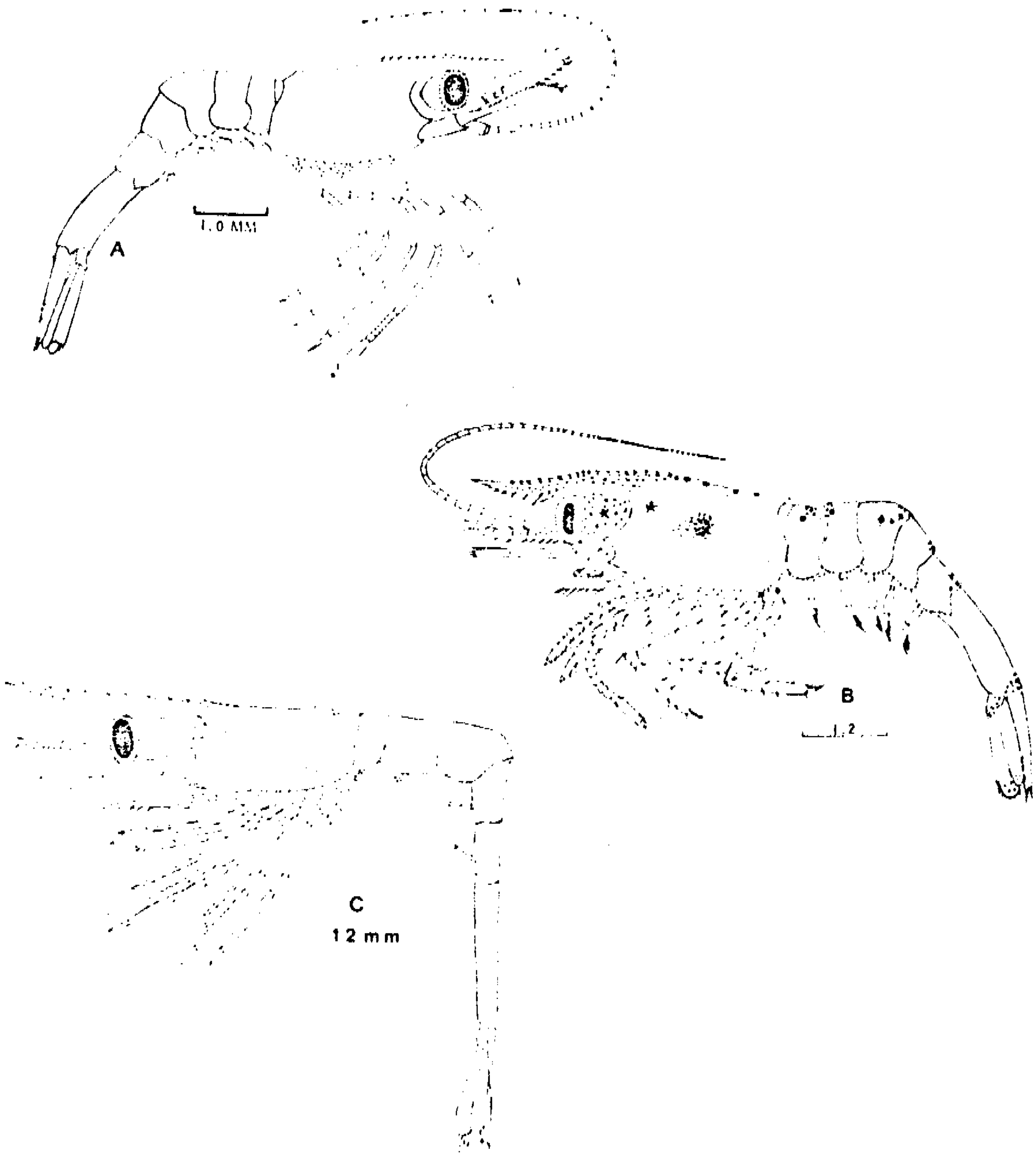

Fig. 7. Fifth stage larvae. A. *Pandalus hypsinotus*. B. *Pandalus platyceros*. C. *Pandalus stenolepis*. (A, Haynes 1976; B, Price and Chew 1972; C, Needler 1938)

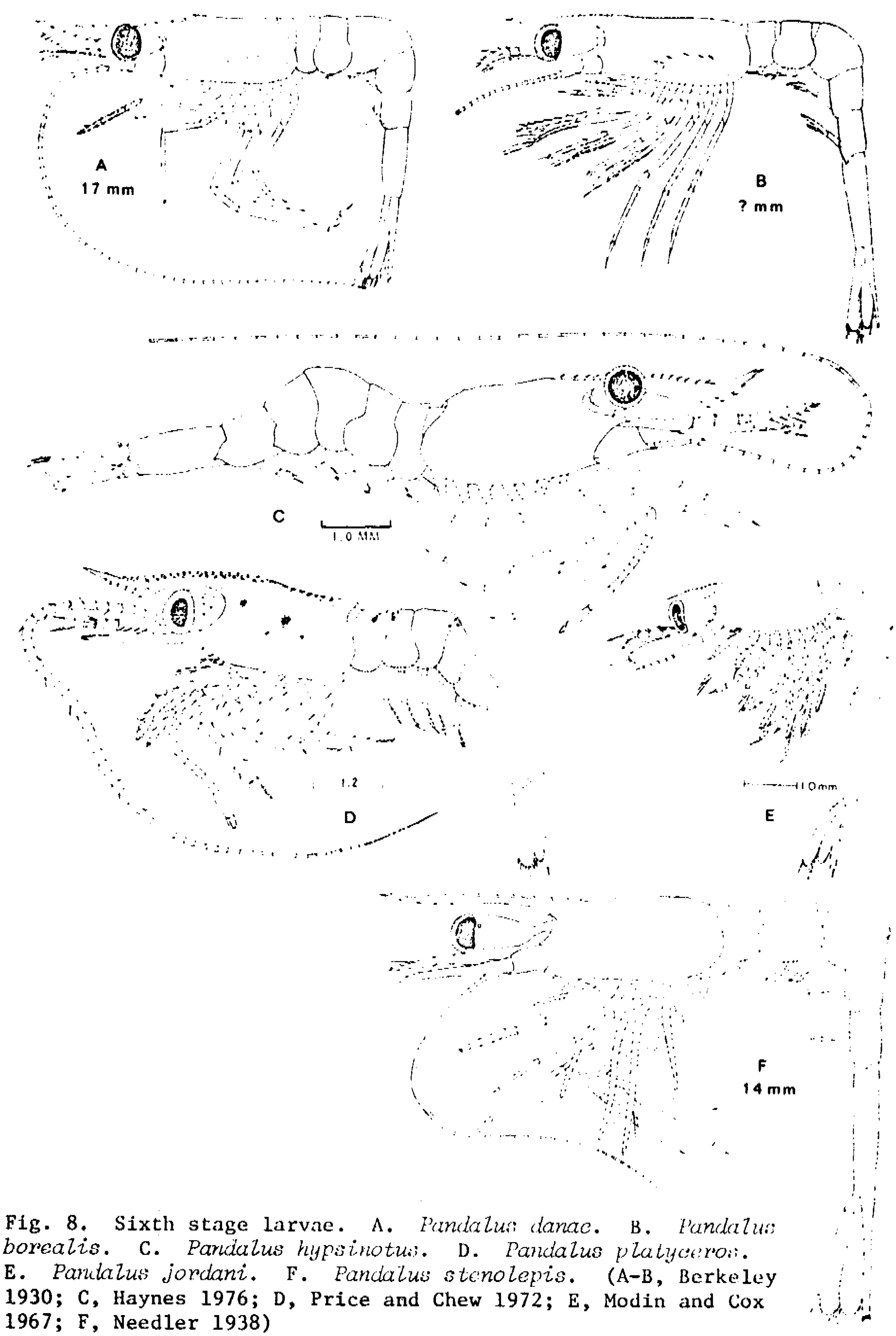

Fig. 8. Sixth stage larvae. A. *Pandalus danae*. B. *Pandalus borealis*. C. *Pandalus hypsinotus*. D. *Pandalus platyceros*. E. *Pandalus jordani*. F. *Pandalus stenolepis*. (A-B, Berkeley 1930; C, Haynes 1976; D, Price and Chew 1972; E, Modin and Cox 1967; F, Needler 1938)

Fig. 9. Ninth and eleventh stage larvae. *Pandalus jordani*. (Modin and Cox 1967)

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Aids for Identification of Early Life History Stages of Crabs in Alaskan Waters

1976

Department of Oceanography
University of Washington

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Introduction

A list of species of Alaskan crabs (Anomura, Brachyura) was prepared (table 1) from the following references: Garth (1958), Haig (1960), Hart (1968 and 1971b), Hosie and Gaumer (1974), Hoffman (1968), Makarov (1938), McLaughlin (1963 and 1974), McLaughlin and Haig (1973), Menzies (1948), Rathbun (1910, 1917, 1925, 1930), and Schmitt (1921). Of these, the commercially important ones are the king crabs, tanner crabs and Dungeness crab (Alaska Dept. of Fish and Game, 1974). The king crab, *Paralithodes camtschatica* (Tilesius), and the blue king crab, *Paralithodes platypus* (Brandt) are taken commercially, but the third species *Paralithodes brevipes* Brandt is not (Marukawa, 1933). There are three species of "tanner" crabs found in Alaskan waters. *Chionoecetes bairdi* Rathbun is the only tanner crab fished commercially south or east of the Aleutian Islands, but the commercial catch from the Bering Sea includes both *C. bairdi* and *C. opilio* (O. Fabricius) (Brown, 1971). Although the third species, *Chionoecetes angulatus* Rathbun is of commercial size, it inhabits the abyssal plains and therefore is not taken commercially (Brown, 1971). The Dungeness crab, *Cancer magister* Dana, is the only species of the genus to be taken commercially. A sixth species, *Erimacrus isenbeckii* (Brandt), known as the Korean hair crab, is believed to be fished commercially in Japan and extends into Alaskan waters (Rathbun, 1930).

Williamson (1969) discusses terminology of the larval stages; prezoea, zoea, and megalopa. In this study, the prezoea is considered an embryonic stage separate from the first zoeal stage because it is still covered by the embryonic cuticle and is too short-lived to be found in the plankton. The number of zoeal stages varies with species but all species studied have one megalopa stage. The term megalopa includes the specialized term Glaucothöe which refers only to the post-zoeal stage of the Paguridea.

Nomenclature of the larval appendages follows that of Gurney (1942) for the antennule, antenna, mandible, maxillule, and maxilla, but maxilliped rather than maxillipede is used. The term "telson process" includes spines, setae, or hairs on the telson.

A bibliography of 60 references is attached.

King Crabs

The most comprehensive review of the literature on the larval development of lithodid crabs appears in Hart's (1965) paper describing the life history and larval development of *Cryptolithodes typicus*. She discusses the deficiencies of the paper by Miller and Coffin (1961) on *Hapalogaster mertensii*, but does not include the nearly concurrent publication by Kurata (1964) on the lithodid larvae of Hokkaido. The most recent work on lithodid larvae, Hoffman's (1968) paper on

Table 1. Species of Anomuran and Brachyuran crabs of Alaskan waters

Order DECAPODA

Suborder Reptantia

Section Anomura

Family Diogenidae

Paguristes turgidus (Stimpson)

Family Galatheidae

Munida quadrispina Benedict
Munidopsis beringana Benedict

Family Lithodidae

Acantholithodes hispidus (Stimpson)
Cryptolithodes sitchensis Brandt
Cryptolithodes typicus Brandt
Dermaturus mandtii Brandt
Hapalogaster grebnitzkii Schalfeew
Hapalogaster mertensii Brandt
Lithodes aequispina Benedict
Lithodes couesi Benedict
Lopholithodes mandtii Brandt
Oedignathus inermis (Stimpson)
Paralithodes brevipes Brandt
Paralithodes camtschatica (Tilesius)
Paralithodes platypus (Brandt)
Paralomis multispina (Benedict)
Paralomis verrilli (Benedict)
Phyllolithodes papillosus (Brandt)
Placetron wosnessenskii Schalfeew
Rhinolithodes wosnessenskii Brandt

Family Paguridae

* *Discorsopagurus schmitti* (Stevens)
Elassochirus cavimanus (Miers)
Elassochirus gilli (Benedict)
Elassochirus tenuimanus (Dana)
Labidochirus splendescens (Owen)
* *Orthopagurus minimus* (Holmes)
Pagurus aleuticus (Benedict)
Pagurus armatus (Dana)
Pagurus beringanus (Benedict)
Pagurus brandti (Benedict)
Pagurus capillatus (Benedict)
Pagurus caurinas Hart
Pagurus confragosus (Benedict)

* The distribution of these species is discontinuous in published reports. Recorded in Russian waters and off British Columbia, they probably occur in Alaska but have been missed by collectors since they are so inconspicuous.

Table 1. (cont'd)

Family Paguridae (cont'd)

Pagurus cornutus (Benedict)
Pagurus granosimanus (Stimpson)
Pagurus hirsutiusculus hirsutiusculus (Dana)
Pagurus kennerlyi (Stimpson)
Pagurus mertensii Brandt
Pagurus middendorffii Brandt
Pagurus ochotensis Brandt
Pagurus rathbuni (Benedict)
Pagurus setosus (Benedict)
Pagurus stevensae Hart
Pagurus tanneri (Benedict)
Pagurus trigonocheirus (Stimpson)
Pagurus townsendi (Benedict)
Parapagurus pilosimanus benedicti De Saint Laurent

Family Porcellanidae

Pachycheles rudis Stimpson
Petrolisthes eriomerus Stimpson

Section Brachyura

Superfamily Brachyrhyncha

Family Atelecyclidae

Subfamily Atelecyclinae

Erimacrus isenbeckii (Brandt)
Telmessus cheiragonus (Tilesius)

Family Cancridae

Cancer branneri Rathbun
Cancer gracilis Dana
Cancer magister Dana
Cancer oregonensis (Dana)
Cancer productus (Randall)

Family Grapsidae

Hemigrapsus nudus (Dana)
Hemigrapsus oregonensis (Dana)

Family Pinnotheridae

Subfamily Pinnotherinae

Fabia subquadrata (Dana)

Subfamily Pinnothereliinae

Pinnixa faba (Dana)
Pinnixa littoralis Holmes
Pinnixa occidentalis Rathbun
Pinnixa schmitti Rathbun

Family Xanthidae

Lophopanopeus bellus bellus (Stimpson)

Table 1. (cont'd)

Superfamily Oxyrhyncha

Family Majidae

Subfamily Acanthonychinae

Mimulus foliatus Stimpson
Pugettia gracilis Dana
Pugettia producta (Randall)
Pugettia richii Dana

Subfamily Oregoniinae

Chionoecetes angulatus Rathbun
Chionoecetes bairdi Rathbun
Chionoecetes opilio (O. Fabricius)
Hyas coarctatus Leach
Hyas coarctatus alutaceus Brandt
Hyas lyratus Dana
Oregonia bifurca Rathbun
Oregonia gracilis Dana

Subfamily Pisinae

Chorilia longipes Dana
Scyra acutifrons Dana

Paralithodes platypus, reviews the Kurata (1964) paper and other Japanese literature, Sato (1958) and Marukawa (1933), from full translations.

The larvae of all three species of *Paralithodes* found in Alaskan waters have now been described in the literature. The first complete description of the larval stages of *Paralithodes camtschatica* was by Marukawa (1933). His source of zoeal stages I and II was eggs hatched in the laboratory, and that of later stages was the plankton (Hoffman, 1968). Sato (1958) also discussed and illustrated (text figs. 1 and 2) the development of larvae of *P. camtschatica*. Larvae intermediate between the normal last zoea and the megalopa were described for *P. camtschatica* and *P. brevipes* from specimens reared in the laboratory (Kurato, 1960), but these are considered to be a few abnormal individuals (Hart, 1965). Kurata (1956) reared *Paralithodes brevipes* and found that this species has only three zoeal stages instead of the four formerly assumed to characterize the genus.

The four zoeal stages and single megalopal stage of *Paralithodes platypus* were reared in the laboratory from the eggs of a known gravid female and illustrated (text figs. 3 and 4) by Hoffman (1968) Prior to 1968 the larvae of *P. platypus* had been the least thoroughly described.

> "Marukawa (1933) illustrated the first zoeal stage but because he made no mention of rearing these larvae, it is assumed that they were taken from the plankton. Sato (1958) illustrated zoeal stages I-IV but gave no detailed descriptions. The illustration of the first zoeal stage was based on Marukawa's work and those of stages II-IV were made from individuals collected from the intestinal tract of juvenile pink salmon. Thus, the source of Sato's material was not larvae reared in culture as Hart (1965) had assumed. Kurata (1964) described stage I zoeae taken from the plankton. This larval stage was the only one that he obtained. Kurata briefly discussed stages II-IV, basing his comments on Sato's (1958) work." Hoffman, 1968

Table 2 summarizes the larval characteristics of the various stages of the three species of *Paralithodes*. Carapace length is the straight-line distance from the posterior margin of the orbit to the mid-dorsal margin of the carapace. This measurement is the least subject to variations caused by preservation and handling and it is also generally used in studies of juvenile and adult crabs (Hoffman, 1968). Total body length is the distance from the tip of the rostrum to the posterior margin of the telson, not including the telson processes. Accurate measurement is difficult to obtain in preserved larvae because the abdomen is generally flexed tightly beneath the carapace. It requires the

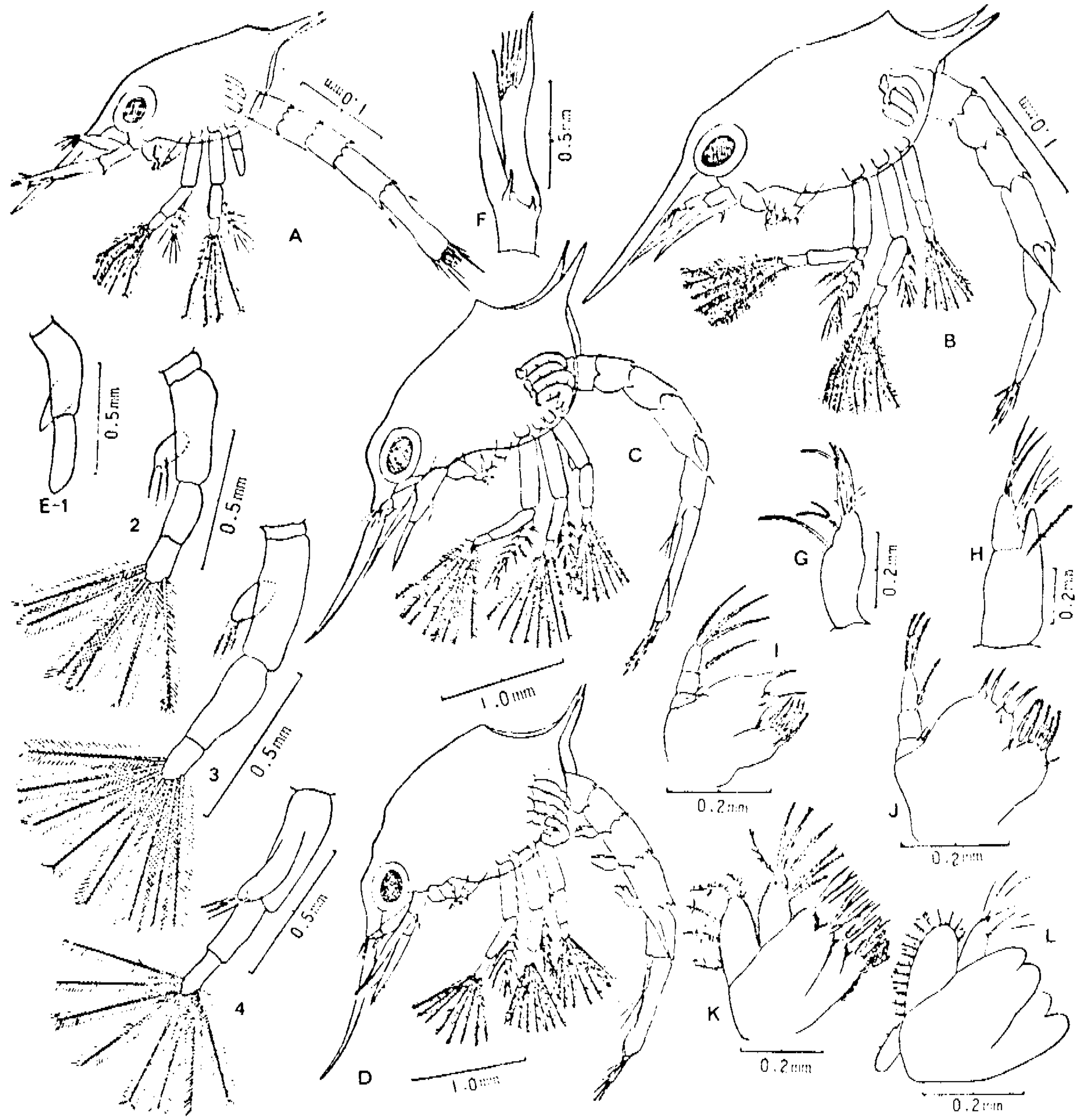


Fig. 1. *Paralithodes camtschatica*: zoeal larvae development (Sato, 1958). Scales as shown.

A-D. Zoeal stages 1-4 (lateral view). E 1-4. 3rd maxillipeds, stages 1-4. F. Antenna 1st zoea. G. Antennule 2nd zoea. H. Antennule 4th zoea. I. Maxillule 1st zoea. J. Maxillule 4th zoea. K. Maxilla 1st zoea. L. Maxilla 4th zoea.

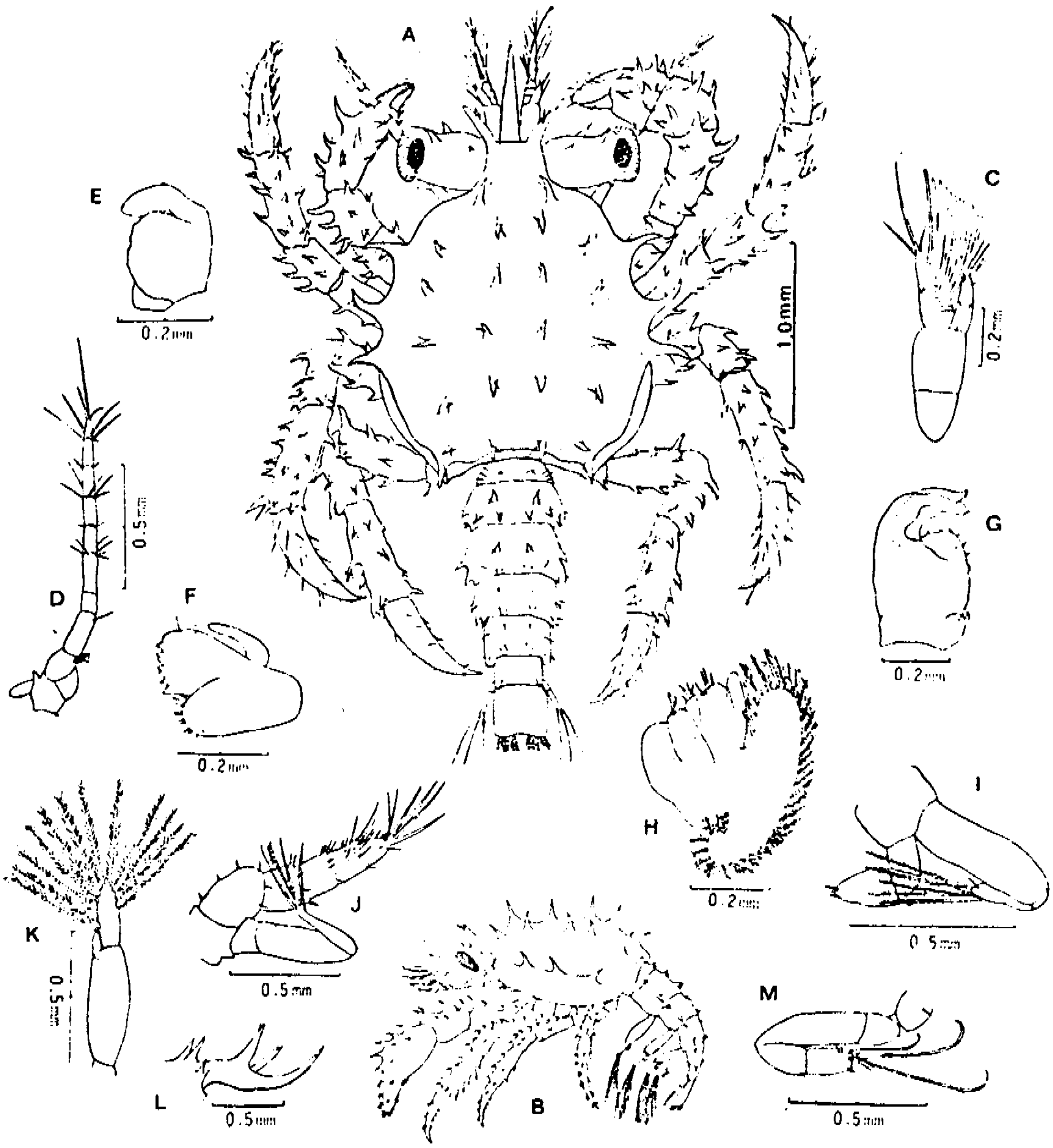


Fig. 2. *Paralithodes camtschatica*: megalopa

A. Dorsal view (Sato and Tanaka, 1949). B. Lateral view (Kurata, 1960). C. Antennule (Sato, 1958). D. Antenna (Sato, 1958). E. Mandible (Sato, 1958). F. Maxillule (Sato, 1958). G. Maxilla (Sato, 1958). H. 1st maxilliped (Sato, 1958). I. 2nd maxilliped (Sato, 1958). J. 3rd maxilliped (Sato, 1958). K. Pleopod (Sato, 1958). L. Rostrum (lateral view) (Sato, 1958). M. 5th thoracic limb (Sato, 1958).

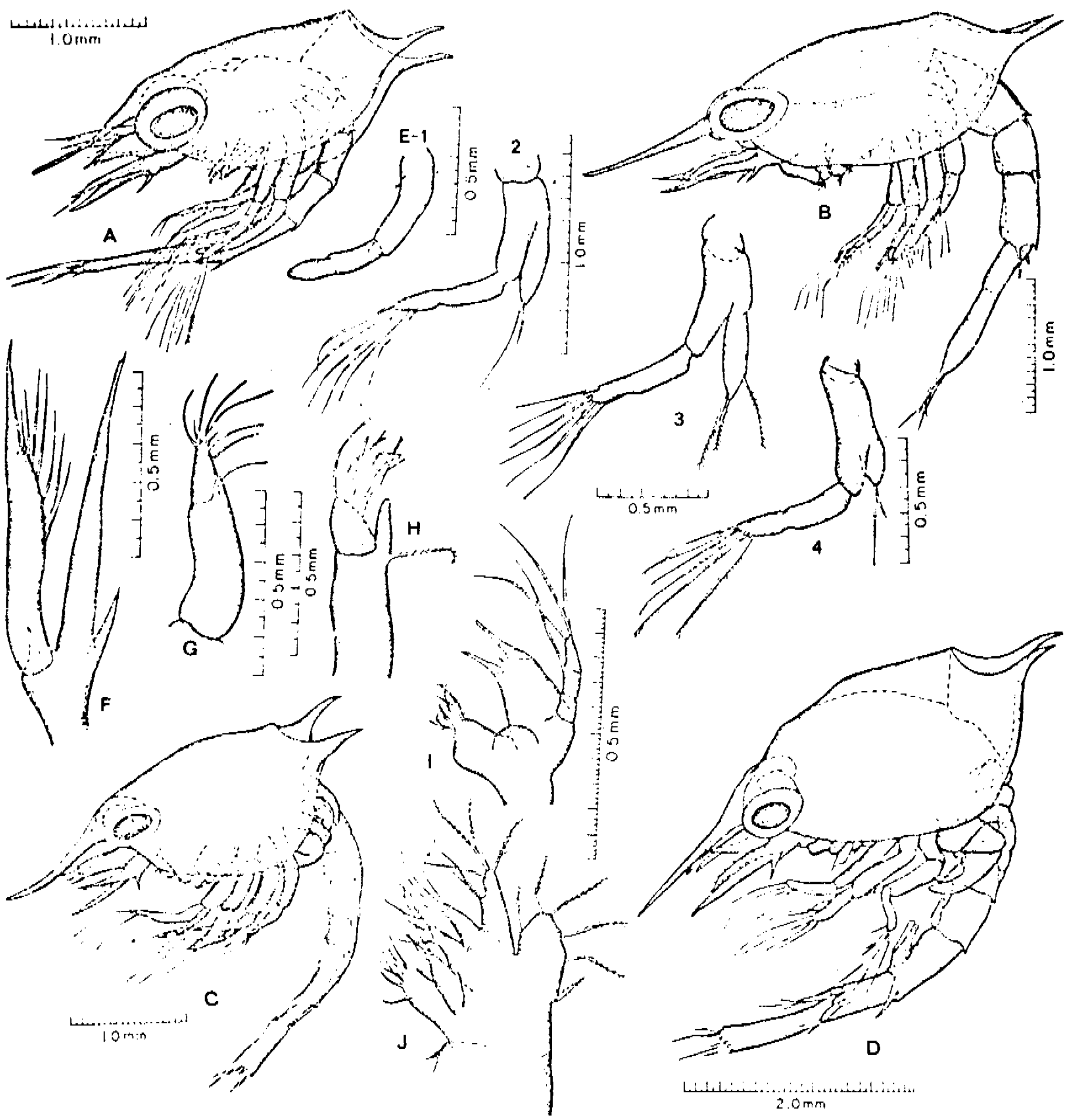


Fig. 3. *Paralithodes platypus*: zoeal larvae development (Hoffman, 1968)

A-D. Zoeal stages 1-4 (lateral view). **E 1-4.** 3rd maxillipeds, stages 1-4. **F.** Antenna 2nd zoea. **G.** Antennule 1st zoea. **H.** Antennule 4th zoea. **I.** Maxillule 1st zoea. **J.** Maxilla 1st zoea.

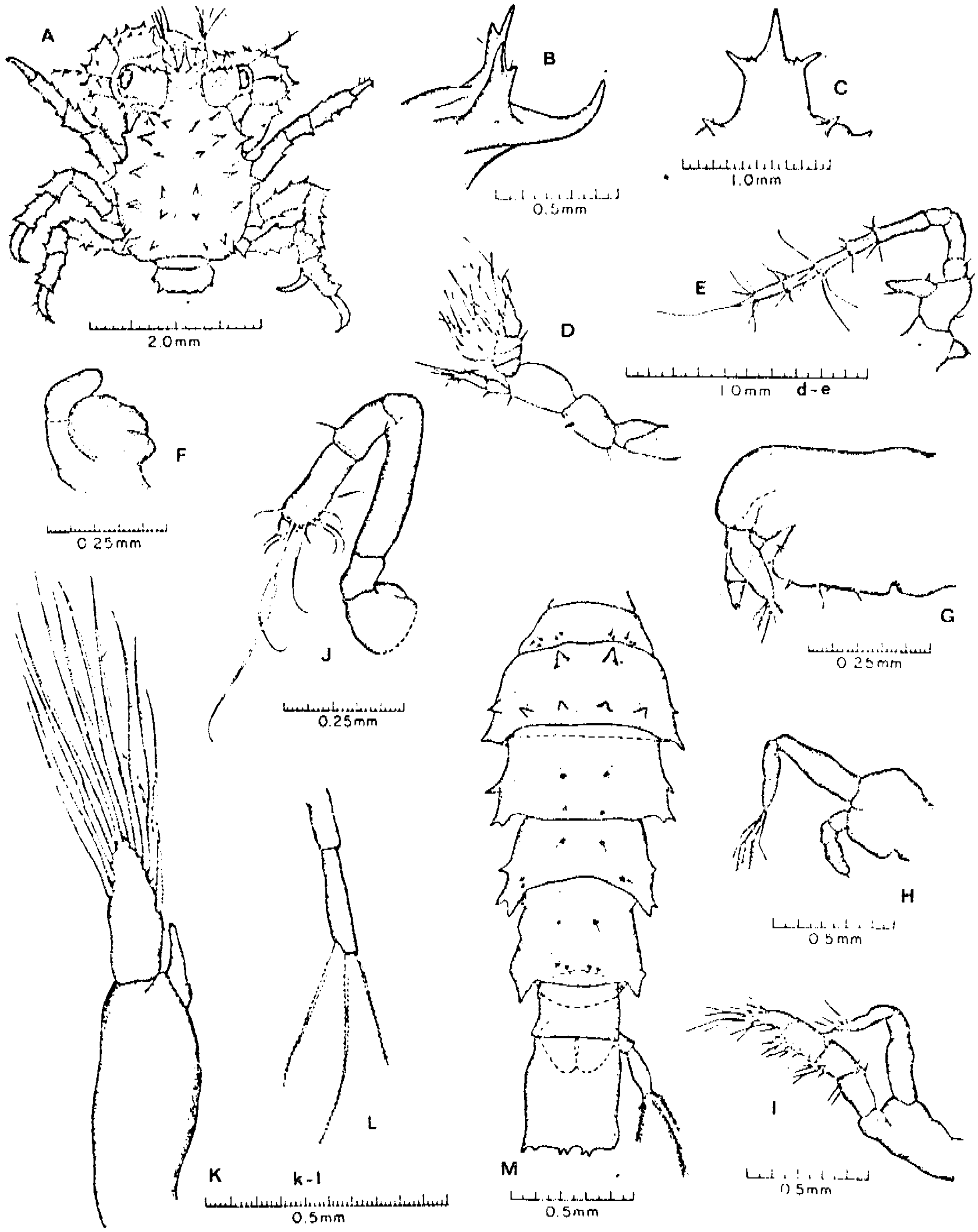


Fig. 4. *Paralithodes platypus*: megalopa
(Hoffman, 1968) Scales as shown.

A. Dorsal view. B. Rostrum (lateral view). C. Rostrum (dorsal view). D. Antennule. E. Antenna. F. Mandible (right). G. 1st maxilliped. H. 2nd maxilliped. I. 3rd maxilliped. J. 5th pereiopod. K. Pleopod. L. Uropod. M. Abdomen and telson.

Table 2. Comparison of *Paralithodes* species: data from Hoffman (1968), Sato's figures (1958), Marukawa (1933), Kurata (1964), Kurata (1956) and Sato & Tanaka (1949).

	Total body length*	Telson processes	Setae antennule	Spines protopodite maxillule basal endite	Spines protopodite maxilla basal endite	Spines protopodite maxilla coxal endite	Setation formula 1st maxilliped	Setae exopodites of maxillipeds	r.d.l.* t.c.l.*	Pairs of spines brachial region carapace	Carapace length*	Pleopods	Uropods
							First zoeae						
P. brevipes	5.2	8+8	-	-	-	-	---	4	3.1	-	1.41	---	---
P. camtschatica	4.56	8+8	7+3	2+2	9	12	4,3,1,2,3	4	-	-	1.45	not evident	not evident
P. platypus	4.9	9+9	7+2	2+2	9	12	6,2,2,5,2	4	3.2	-	1.2	not evident	not evident
							Second zoeae						
P. brevipes	5.8	8+8	-	-	-	-	---	6	3.4-3.5	-	1.49	not evident	not evident
P. camtschatica	-	8+8	-	4+2	9	12	4,3,2,2,3	6-7	-	-	1.4	not evident	not evident
P. platypus	5.2	9+9	8+2	-	-	-	5,2,2,3,4	6	3.4	-	1.3	tissue buds	tissue buds
							Third zoeae						
P. brevipes	6.2	8+8	-	-	-	-	---	8	3.6-3.7	-	1.68	---	2 segments
P. camtschatica	-	8+8	-	-	9	12	4,3,2,3,4	8	-	-	1.5	small	1 segment
P. platypus	5.5	9+9	8+2-3	-	-	-	5,2,2,3,4	6	3.5	-	1.6	small	1 segment
							Fourth zoeae						
P. brevipes	no fourth stage zoeae												
P. camtschatica	-	8+8	8+1	-	9	12	3,3,2,3,4	8	-	-	1.5	---	2 segments
P. platypus	6.8	9+9	8-9+2	-	-	-	5,2,2,3,4	6	4.5	-	2.0	2 segments	2 segments
							Megalopae						
P. brevipes	3.7	-	-	-	-	-	---	-	-	13	2.1	---	---
P. camtschatica	-	-	dense	-	-	-	---	-	-	14	2.0	---	---
P. platypus	-	-	31	-	-	-	---	15	2.6	15	1.8	abdomen 2-5	abdomen 6

*Measurements explained in text.

summation of several chords of the arch formed by the dorsal margin of the body. Total carapace length (t.c.l.) of *Paralithodes* sp. is analogous to rostral-dorsal length (r.d.l.) of species with a single dorsal spine. It is the straight-line distance from the tip of the rostrum to the tip of the lateral spine. In the megalopa, total carapace length is measured from the tip of the rostrum to the posterior mid-dorsal margin.

Korean Hair Crab

The larval development of the Atelecyclidae, including both species found in Alaska (Table 1) and *Telmessus acutidens* (Stimpson) from the Sea of Japan, has been described and illustrated by Kurata (1963a).

According to Kurata (1963a), the five zoeal stages (text fig. 5) and one megalopa of *Erimacrus isenbeckii* (Brandt) are larger than the corresponding stages of *Telmessus cheiragonus* (Tilesius). The zoeae of *E. isenbeckii* have lateral knobs on the second and third abdominal segments whereas the zoeae of *T. cheiragonus* have lateral knobs on the second segment only. Both species have zoeae with three lateral spines on each telson furca, but the anterior pair is 5/7 the length of the furca in *E. isenbeckii* compared with 1/3 the length of the furca in *T. cheiragonus*. Another difference between the zoeae is that the antennal exopod of *E. isenbeckii* is 1/3 the length of the spinous process, whereas the antennal exopod of *T. cheiragonus* is 1/4 the length of the spinous process. In the second stage zoeae the number of natatory setae varies (10 in *T. cheiragonus* and *T. acutidens* and 12 in *E. isenbeckii*).

The carapace of the megalopa of *E. isenbeckii* (megalopa key fig. 5) has a broad depressed frontal region and dorsal spines are absent (Kurata, 1963a). The rostrum ends anteriorly in three short teeth, the blunt central tooth and the pointed, inwardly curved lateral teeth. The megalopa of *T. cheiragonus* (megalopa key fig. 5) is similar but smaller in size. The postero-lateral margin of the fifth abdominal segment is rounded and, in *E. isenbeckii*, inferior to the posterior end of the sixth abdominal segment. In *T. cheiragonus* it projects backward, reaching well beyond the posterior end of the sixth abdominal segment. The carapace has a distinct lateral process near the middle of each side with very prominent carinae in *T. cheiragonus* which are absent in the megalopa of *E. isenbeckii*. The last pleopods of *E. isenbeckii* have 1-2 and 17-18 setae on the basal segment and exopod respectively whereas those of *T. cheiragonus* have 1 and 12 setae. Neither species has feelers on the tip of leg 5, but *E. isenbeckii* has small spines on the coxa of leg 5 and on the ischia of legs 1-4 and *T. cheiragonus* has spines on the coxae of legs 1-5 and on the ischia of legs 1-3. Further details of these species are probably available from Kurata (1963a) but the main body of text has not yet been translated.

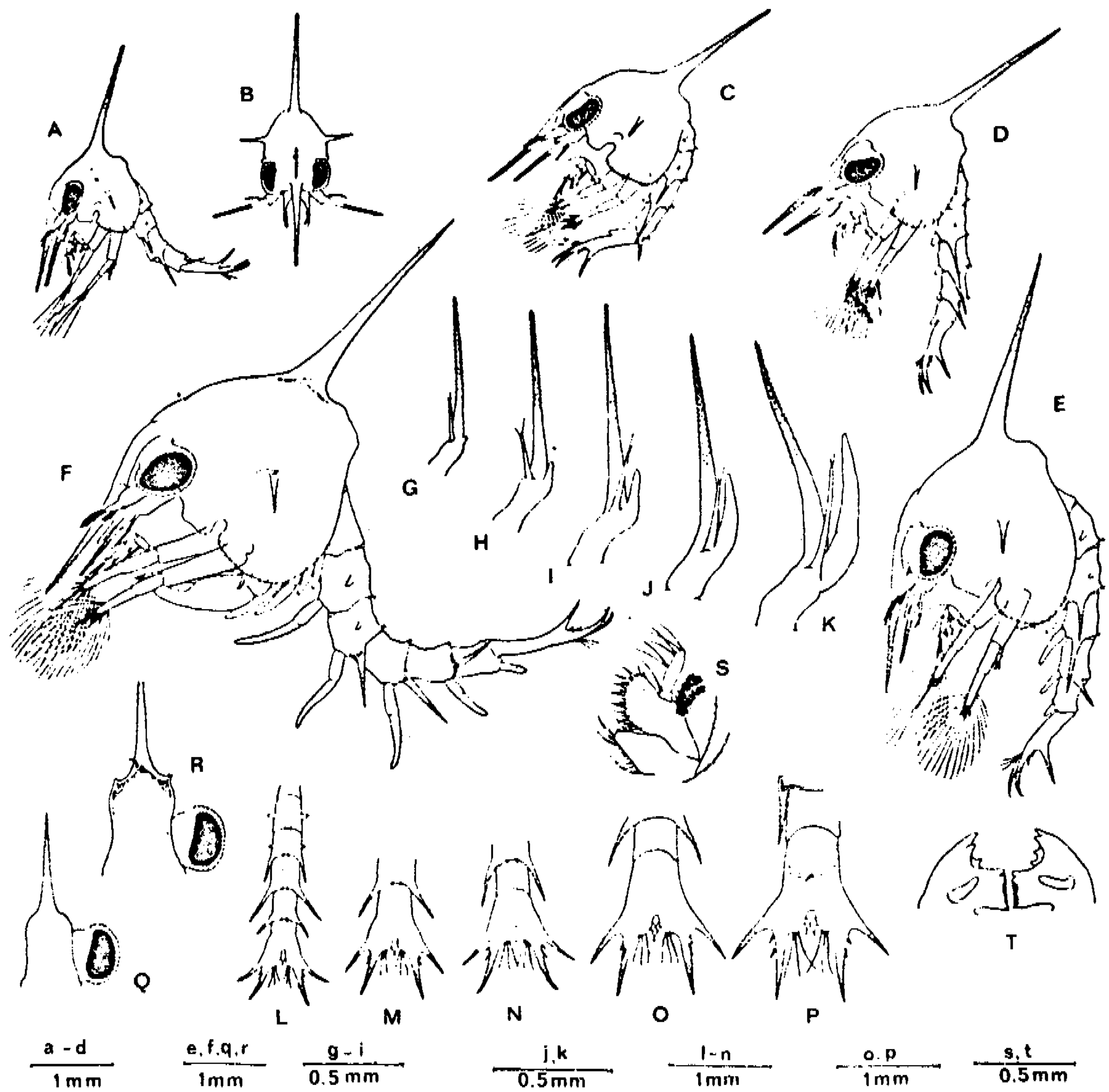


Fig. 5. *Erimacrus isenbeckii*: zoeal larvae development (Kurata, 1963a) Scales as shown.

A. 1st zoea (lateral view). B. 1st zoea (anterior view). C. 2nd zoea (lateral view). D. 3rd zoea (lateral view). E. 4th zoea (lateral view). F. 5th zoea (lateral view). G-K. Antenna, zoeae 1-5. L-P. Telsons, zoeae 1-5. Q. Rostrum (dorsal view) 4th stage. R. Rostrum (dorsal view) 5th stage. S. Maxillule, 5th stage. T. Mandibles, 5th stage.

Prior to Kurata's paper the only description of *Erimacrus isenbeckii* was that of a fifth stage zoea from the plankton by Aikawa (1937).

Dungeness Crab

Very little literature has been published on the larval development of Alaskan species of the genus *Cancer*. Mir (1961) described the first zoea of *Cancer magister* giving the number and arrangement of setae on the maxillule and maxilla. According to other references MacKay (1934, 1942) partially described a pre-zoeal and zoeal stage of *Cancer magister* but these papers have not been available. A further account of the pre-zoeal stage of *Cancer magister* was given by Buchanan and Millemann (1969). Of the five species of *Cancer* in Alaskan waters (Table 1), only two, *Cancer magister* Dana and *Cancer productus* (Randall), have been reared in the laboratory and described in detail. Poole (1966) provided a complete description and illustrations (text fig. 6 and megalopa key fig. 2) of the larval stages of *Cancer magister*. Trask (1970) continued the study, with a full description of *Cancer productus* larvae and compares the two species (Table 3). Table 3 also includes data from Lough (1975) on *Cancer oregonensis*.

Tanner or Snow Crab

The subfamily Oregoniinae comprises three genera, *Oregonia*, *Hyas*, and *Chionoecetes* (Garth, 1958). The larval development of only a few of the species of the Oregoniinae that occur in Alaska (Table 1) is known. Lebour (1928) described the first zoea of *Hyas coarctatus* (Leach) which he reared from the egg, but his second zoea and megalopa, which changed to a juvenile, were taken from the plankton. Kurata (1963b) described zoeal stages of *H. coarctatus alutaceus* Brandt, but his specimens were also taken from the plankton. *Oregonia gracilis* Dana and *Hyas lyratus* Dana were reared by Hart (1960) who separates them from each other by slight differences in size, color, and spinulation.

More work needs to be done on the larval development of Alaskan *Chionoecetes*. Haynes (1973) described and illustrated (text fig. 7) the first zoeal stage of *Chionoecetes bairdi* Rathbun and compared it to that of *Chionoecetes opilio* (O. Fabricius). Motoh (1973) provided the full larval development of *C. opilio* (text fig. 8 and megalopa key fig. 7) from laboratory-reared specimens. Prior to 1973 only the prezoea of *C. opilio* had been described (Aikawa, 1937 and Kon, 1967).

Fig. 6. *Cancer magister*: zoeal larvae development (Poole, 1966)

A. 1st zoea (anterior view) x 24. B. 2nd zoea (anterior view) x 24.
C. 3rd zoea (lateral view) x 16. D. 4th zoea (lateral view) x 12.
E. 5th zoea (lateral view) x 10. F. 1st maxilliped, 2nd zoea x 60.
G. Maxillule, 1st zoea x 100. H. Maxillule, 2nd zoea x 100.
I–M. Antennae, zoeae 1-5 (1 x 100, 3 x 50, 2, 4, 5 x 60).

Table 3. Comparison of *Cancer* species (Trask, 1970) with additional data from Lough (1975)

	Total body length (mm) including rostral spine	Spines inner margin telson furca	Setae antennule	Spines protopodite maxillule basal endite	Spines protopodite maxillule coxal endite	Spines protopodite maxilla basal endite	Spines protopodite maxilla coxal endite	Setae scaphognathite	Setation formula endopodite, 1st maxilliped, distal to proximal	Setae exopodites of maxillipeds	Pleopods	Hooked setae pleopod endopodites
First zoeae												
C. productus	2.5	3+3	3	5	6	9	7	3	3,2,1,2,5	4		
C. magister	2.5	3+3	3	5	6	9	7	4	3,2,1,2,5	4		
C. oregonensis	2.24	3+3	-	-	-	-	-	-	---	4		
Second zoeae												
C. productus	3.0	3+3	6	7	6	10	7	11	3,2,1,2,5	6		
C. magister	3.44	4+4	6	7	6	10	7	11	3,2,1,2,5	6		
C. oregonensis	3.28	3+3	-	-	-	--	-	--	---	6		
Third zoeae												
C. productus	3.5	5+5	6	9	8	12	7	19	3,2,1,2,5	8		
C. magister	4.0	5+5	6	9	8	12	7	19	3,2,1,2,5	8		
C. oregonensis	3.8	4+4	-	-	-	--	-	--	---	8		
Fourth zoeae												
C. productus	4.0	5+5	8	13	9	12	7	25	3,2,1,2,6	10	1 segment	
C. magister	7.44	5+5	8	14	11	16	7	27-32	3,2,1,2,6	10	1 segment	
C. oregonensis	5.20	-	-	--	--	--	-	--	---	10	1 segment	
Fifth zoeae										1st 2nd		
C. productus	5.5	5+5	24	17	10	16	8	37-38	3,2,1,2,6	12, 13	2 segments	
C. magister	9.0	5+5	29	21-23	16	24	10	49-50	3,2,1,2,6	12, 13	2 segments	
C. oregonensis	5.92	-	--	--	--	--	--	--	---	--, 11	2 segments	
Megalopae										1st 2nd 3rd	*Setae exopodites*	
C. productus	6.0	-	35	30-32	15-17	22	12	62-64	---	6, 5, 6	21,19,19,19,12	3-4
C. magister	11.0	-	52	38-43	29-31	36-40	16	110-124	---	7, 6, 10	32,32,32,28,22	4-5
C. oregonensis	6.0	-	-	--	--	--	--	--	---	- - -	22,22,22,22,11-12	4-5

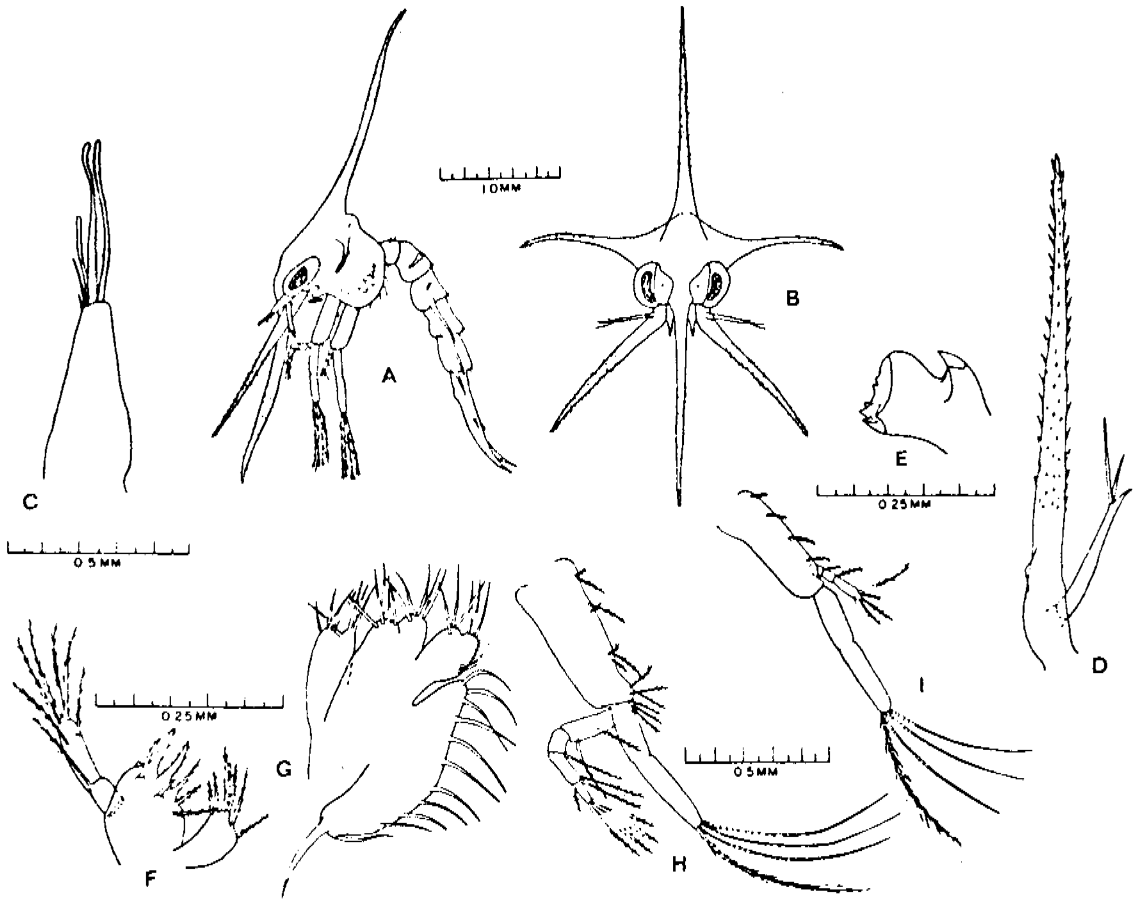


Fig. 7. *Chionoecetes bairdi*: zoea 1st stage Scales as shown.

A. Lateral view. B. Anterior view. C. Antennule. D. Antenna. C. Mandible. F. Maxillule. G. Maxilla. H. 1st maxilliped. I. 2nd maxilliped.

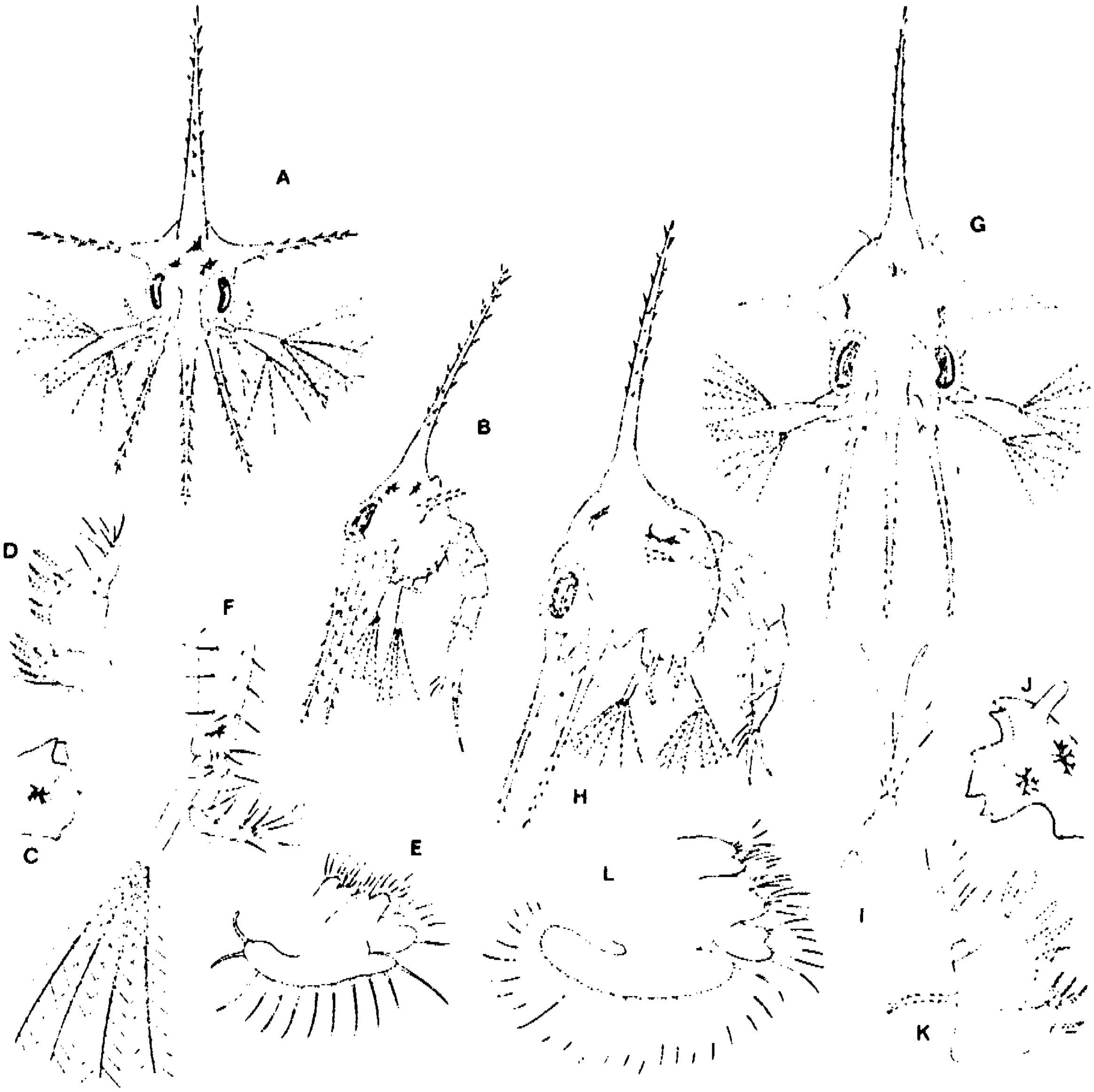


Fig. 8. *Chionoecetes opilio*: zoeal larvae development (Motoh, 1973)

First zoea A-F: A. Anterior view x 30. B. Lateral view x 30. C. Mandible x 150. D. Maxillule x 150. E. Maxilla x 150. F. 1st maxilliped x 75.

Second zoea G-L: G. Anterior view x 30. H. Lateral view x 30. I. Antennule x 60. J. Mandible x 150. K. Maxillule x 150. L. Maxilla x 150.

The Key to the Zoeal Larvae of Decapod Crustacea provides a separation of the zoea of subfamily Oregoniinae from the other subfamilies of the Majidae, but gaps in the literature make identification of genera uncertain. The megalopae of *Hyas* and *Oregonia* (megalopa key fig. 6) may be distinguished from those of *Chionoecetes* on the basis of carapace spinulation (see Key to the Families of Brachyuran Megalopae).

KEY TO THE ZOEAL LARVAE OF FAMILIES OF DECAPOD CRUSTACEA

The following illustrated key to the zoeal larvae of families of decapod Crustacea is essentially that of J. F. L. Hart (1971) with the separation of Paguridae from Lithodidae by Lough (1975) and Atelecyclidae from Cancridae in this study.

1. Carapace globular; only the exopodites of the 1st and 2nd maxillipeds bear swimming setae (4 in 1st zoea); 3rd maxillipeds, pereiopods, and pleopods develop gradually and are prominent but not functional in late zoeae (Fig. 1)................................2

1'. Carapace elongate or shrimp-like; swimming setae usually on more of the thoracic appendages than just 1st and 2nd maxillipeds.....9

2. Telson broad and flat, armed with numerous setae or spines on rounded posterior margin; uropods develop in late zoeae (Fig. 2) ....HIPPIDAE

2'. Telson forked and armed with no more than 3 spines and 5 setae on each fork; no uropods developed in any zoea (Fig. 3).............3

3. Two zoeae only, nonfunctional appendages somewhat developed in 1st zoea; 2nd zoea with 6 swimming setae on exopodite of each maxilliped and nonfunctional appendages large; large zoeae (Oxyrhyncha) 4

3'. Usually more than 2 zoeae; 1st zoea small and usually no indication of nonfunctional appendages, until later zoeae with 6-12 swimming setae (Brachyrhyncha)...5

4. Carapace with rostral, dorsal, and lateral spines; antenna with very spiny protopodite process which is much longer than exopodite; 2 spines at base of each telson fork (Fig. 3, 4) ....OREGONIINAE

4'. Carapace without lateral spines and rostral may be small; antenna with smooth or minutely sinulose protopodite process, which is subequal to exopodite; 1 spine on base of each telson fork (Fig. 5) ............ACANTHONYCHINAE and PISINAE

5. Carapace with rostral, dorsal and lateral spines present; 4 or 5 zoeae 6

5'. Carapace without lateral spines; 2 zoeae (Fig. 6)....PINNOTHERIDAE (Pinnotheres)

6. Abdomen with 5th segment expanded laterally (Fig. 7). PINNOTHERIDAE (except Pinnotheres)

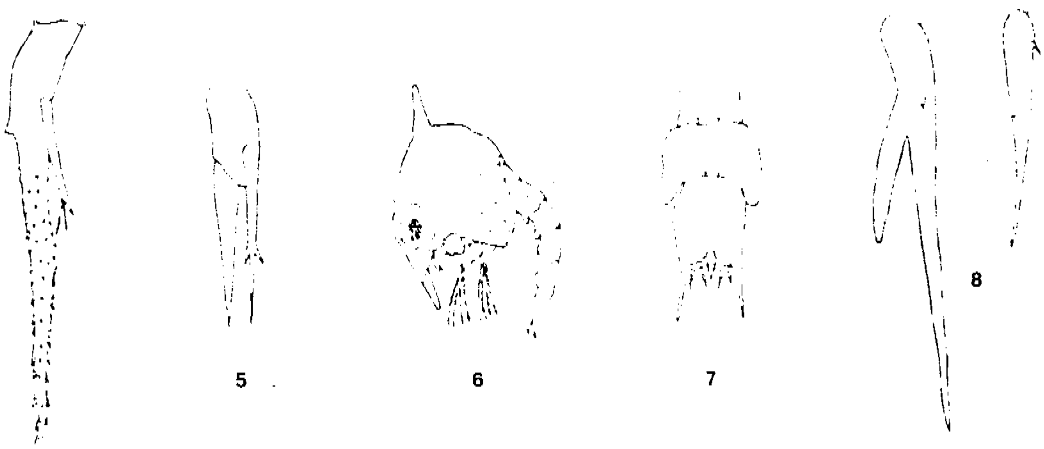
6'. Abdomen with segments no expanded laterally 7

7. Telson fork without spines (Fig. 1).................... GRAPSIDAE

7'. Telson fork with spine or spines 8

8. Antenna with long, smooth protopodite process and minute exopodite (Fig. 8).. XANTHIDAE

8'. Antenna with spinulate protopodite process and exopodite not minute 23



4 5 6 7 8

9. Telson with large median tooth on posterior margin (Fig. 9)..... 10

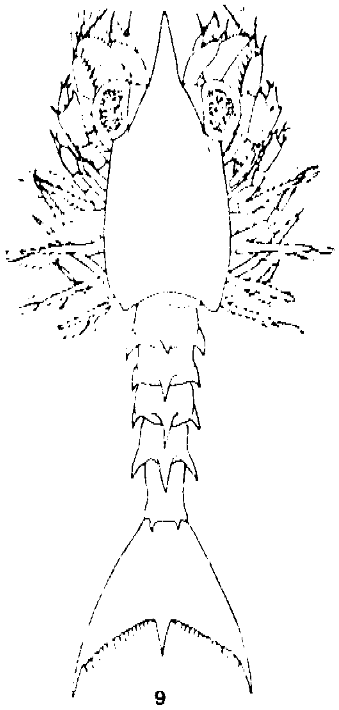
9'. Telson without a large median tooth on posterior margin 11

10. Rostrum flattened and serrate on margins; 3, 4, or 5 pairs of pereiopods with exopodites (Fig. 10)...................... AXIIDAE and CALLIANASSIDAE

10'. Rostrum not flattened nor serrate; 5 pairs of pereiopods with exopodites (Fig. 9)................................ NEPHROPSIDAE

11. Exopodite of antenna segmented throughout length; telson with 2 cylindrical rami bearing long setae (Fig. 11)..................12

11'. Exopodite of antenna unsegmented or segmented only near distal end; telson flattened, and posterior margin relatively straight or with tips tapering to a sharp point 13



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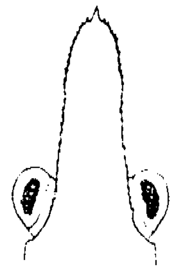

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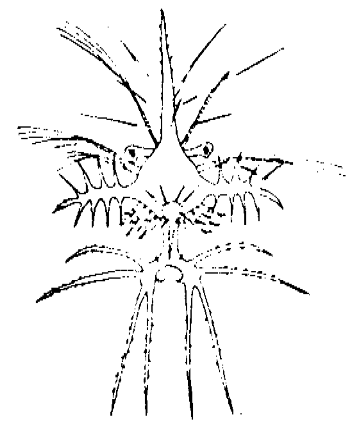

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12. Carapace with branched spiny processes, and usually one spiny process near mid-dorsal posterior margin (Fig. 11) (early zoeae) .... SERGESTIDAE

12'. Carapace not so (early zoeae) .... PENAEIDAE

13. Third maxilliped with endopodite arising from distal part of basipodite (Fig. 12) 17

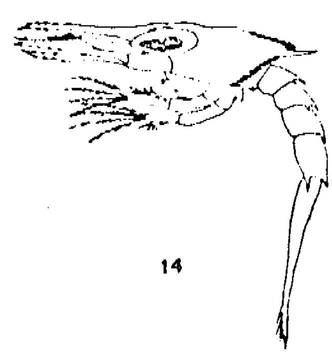
13'. Third maxilliped with endopodite arising from proximal part of basipodite (Fig. 13) 14

14. Rostrum serrate on margins; posterior margins of carapace serrate (Fig. 14) .... GALATHEIDAE

14'. Rostrum and posterior margins of carapace not so.................15

12

13



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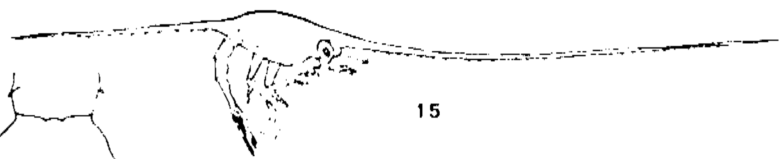
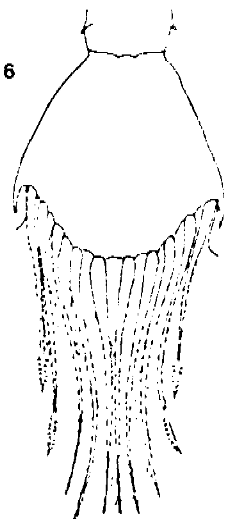
15. Rostrum at least twice as long as carapace and posterior processes as long as carapace: tubular and spinulose; telson flat and wide, with long plumose setae posteriorly (Fig. 15, 16) .... PORCELLANIDAE

15'. Rostrum shorter than carapace, and posterior processes short or absent; telson not as above (Fig. 17)........................... 16





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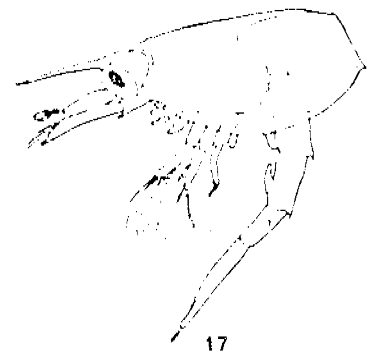

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16. Pereiopods 1-3 with functional exopodites .... UPOGEBIIDAE

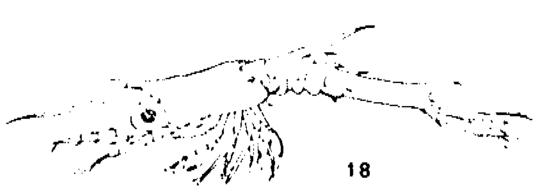
16'. Pereiopods without functional exopodites (Fig. 17)............. 22

17. Telson deeply cleft; pereiopods 1-3 chelate; all pereiopods with functional exopodites (late zoeae) (PENNAEIDEA) 18

17'. Telson not so; pereiopod 3 never chelate; varied number of pereiopods with functional exopodites (CARIDEA) 19

18. Carapace with long rostrum and paired spines at base; abdominal somites with dorsal spines, of which 2nd is largest (Fig. 18) .... PENAEIDAE

18'. Carapace with several paired spinulate or branched spines and one median spine posteriorly; abdominal somites with dorsal and lateral spines (Fig. 19)............................. SERGESTIDAE



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19

19. 5th pereiopod developed early and much longer than others, bearing an elongated apical spine .... ALPHEIDAE

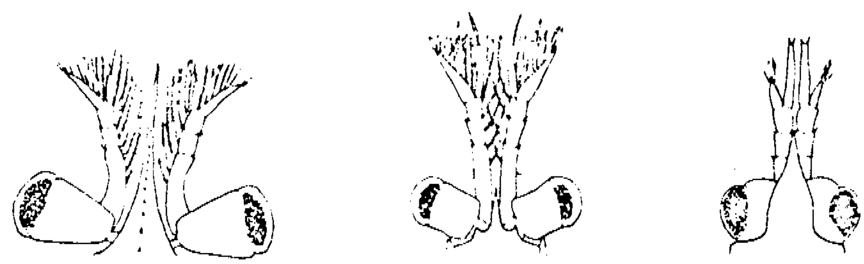
19'. 5th pereiopod not longer than others 20

20. Rostrum slender and may be toothed in late zoeae; eyestalks tapering toward base; antennules slender with bases widely separated (Fig. 20).................................... PANDALIDAE

20'. Not as above 21

21. Rostrum narrow; eyestalks cylindrical; antennules with bases separated by less than their individual width (Fig. 21) .... HIPPOLYTIDAE

21'. Rostrum wide; eyestalks hemispherical, almost touching in mid-line; antennules with bases touching; ventral margin of carapace often dentate (Fig. 22).................................... CRANGONIDAE



20 21 22

22. Uropods broad and blade-like, setae distributed along inner margin of exopodite, apical spine(s) present; posterior processes of carapace generally close together separated by shallow notch with parallel edges; slender appearance (Fig. 23, Lough, 1975 .... PAGURIDAE *

22'. Uropods reduced to stubby appearance or absent in a few rarer species, 3-5 apical setae on exopodite, no apical spine (?); posterior processes of carapace generally farther apart, notch between them is wide with sloped diverging edges; stout appearance (Fig. 24, Lough 1975)............................ LITHODIDAE *

23. Maxillipeds with 10-12 natatory setae in second stage (Fig. 25, Kurata 1963a); anterior lateral spines on telson long (Fig. 26, Aikawa 1937)...................................... ATELECYCLIDAE

23'. Maxillipeds with 6, 8, 10 natatory setae in second, third and fourth stages respectively (Fig.27, Trask, 1970); anterior lateral spines on telson short (Fig. 28, Aikawa 1937).......... CANCRIDAE

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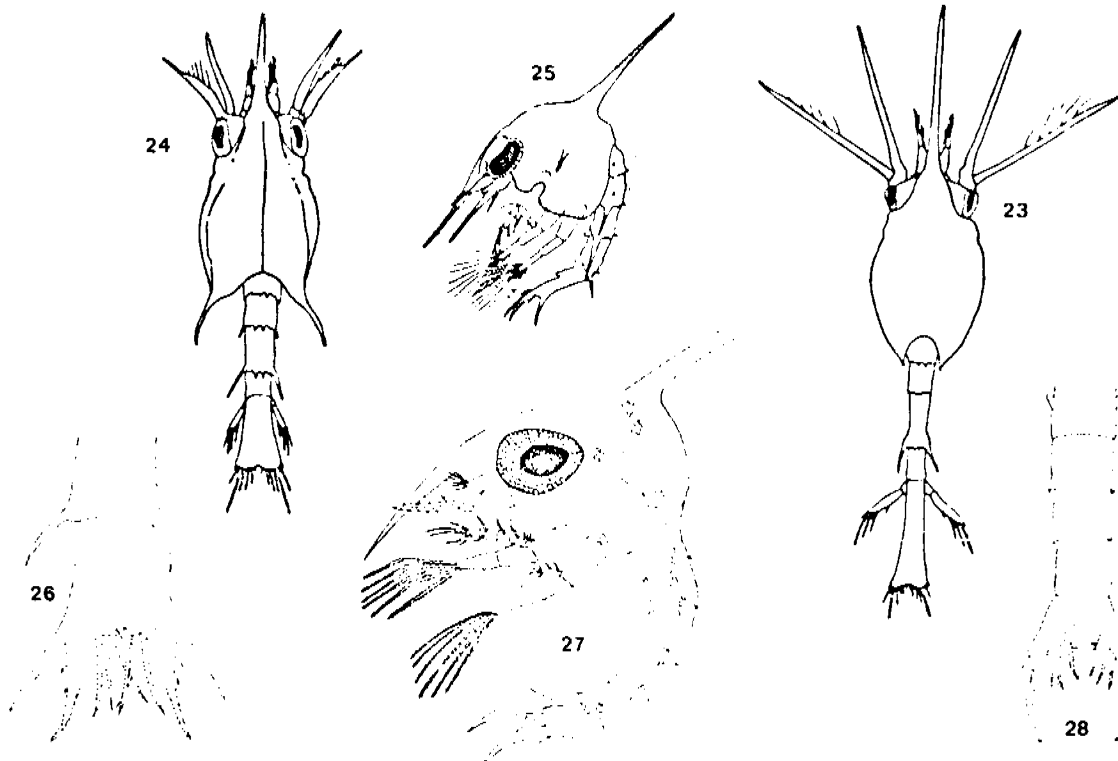
* There are exceptions to these distinctions, such as Cryptolithodes typicus, but the separation is included because it is useful in sorting Paralithodes from many non-commercially important species.



Figs. 23-28. Zoeal larvae key.

KEY TO THE FAMILIES OF BRACHYURAN MEGALOPAE

1. Setae on dactylus of fifth periopod 2

1'. Setae absent from dactylus of fifth pereiopod 4

2. Dactylus of fifth pereiopod with three slightly specialized setae, setae shorter than dactylus; endopodites of pleopods 1-4 have 3 hooked setae, endopodites of pleopod 5 (uropods) not developed; exopodites of pleopods with 16, 16, 15, 13 and 8 long plumose setae; length 2.8 mm, carapace 1.5 by 1.3 mm (Hart, 1935), total length 3.08 mm, carapace 1.68 by 1.44 mm (Lough, 1975) (megalopa key fig. 1).................... XANTHIDAE

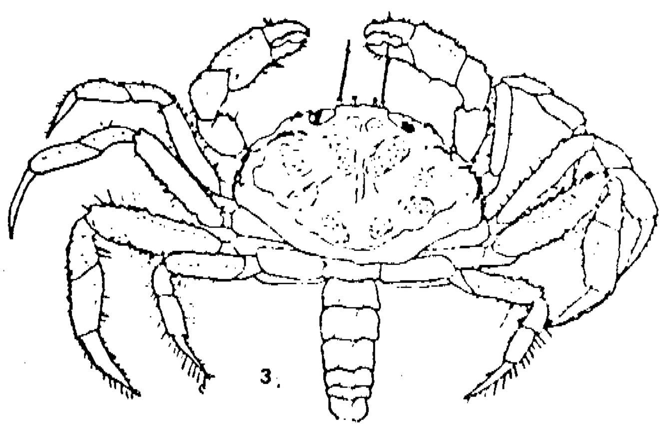
2'. Dactylus of fifth pereiopod with three well-developed setae, setae longer than dactylus 3

3. Carapace with posterior spine and broad pointed rostrum (megalopa key fig. 2) See also text Table 3...................... CANCRIDAE

3'. Carapace without posterior spine, rostrum blunt (megalopa key fig. 1) .... GRAPSIDAE

4. Rostrum blunt and small; carapace may be serrated on lateral edges or regular, surface smooth or rough, shape generally laterally elongated; abdomen may be tucked under cephalothorax in a groove (megalopa key fig. 3) (Lough, 1975) .... PINNOTHERIDAE

4'. Rostrum either blunt with 3 teeth or pointed; carapace with knobs and/or spines, shape is anterior-posteriorly elongated; abdomen not normally tucked under cephalothorax, no ventral groove (Lough, 1975) 5



Megalopa Key Fig. 1. Grapsidae and Xanthidae: megalopae

A. *Hemigrapsus nudus*: megalopa (dorsal view x 15) (Hart, 1935)

B. *H. nudus*: telson x 30 (Hart, 1935)

C. *Hemigrapsus oregonensis*: megalopa (dorsal view x 15) (Hart, 1935)

D. *H. oregonensis*: telson x 30 (Hart, 1935)

E. *Lophopanopeus bellus bellus*: megalopa (dorsal view x 15) (Hart, 1935)

F. *L. bellus bellus*: telson x 60 (Hart, 1935)

G–N. *Hemigrapsus nudus*: G. Antennule x 30. H. Antenna x 30. I. Maxilla x 30. J. 1st maxilliped x 30. K. 2nd maxilliped x 30. L. 3rd maxilliped x 30. M. 5th pereiopod x 30. N. Juvenile crab, 1st maxilliped x 30. (Hart, 1935)

O–T. *Lophopanopeus bellus bellus*: O. Antennule x 60. P. Antenna x 60. Q. Maxilla x 60. R. 1st maxilliped x 60. S. 2nd maxilliped x 60. T. 3rd maxilliped x 60. (Hart, 1935)

U. *Hemigrapsus oregonensis*: juvenile crab x 15. (Hart, 1935)

Megalopa Key Fig. 2. Cancridae: megalopae

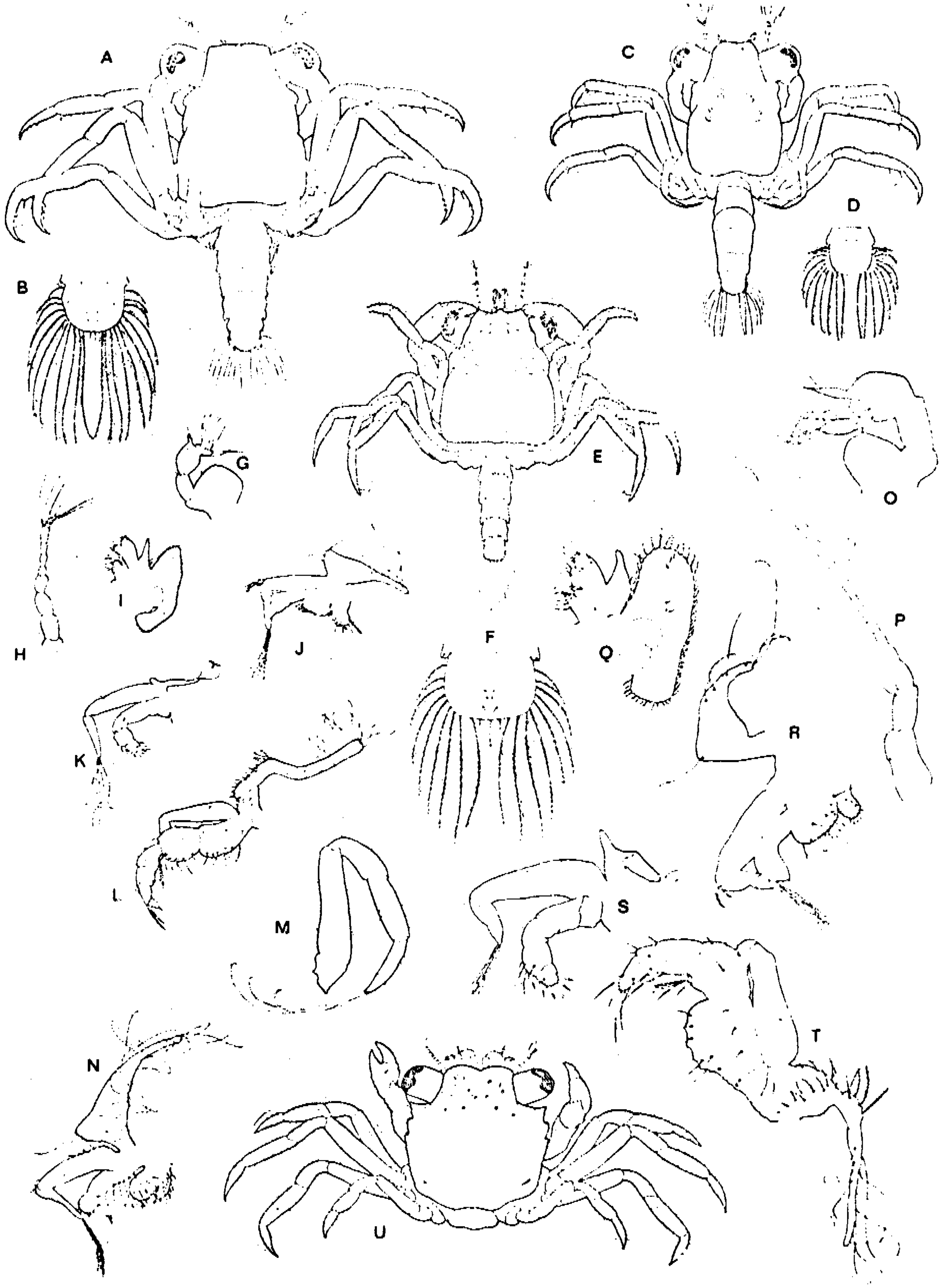
A. *Cancer oregonensis*: megalopa (dorsal view, scale as shown) (Lough, 1975)

B. *Cancer magister*: megalopa (dorsal view x 5) (Poole, 1966)

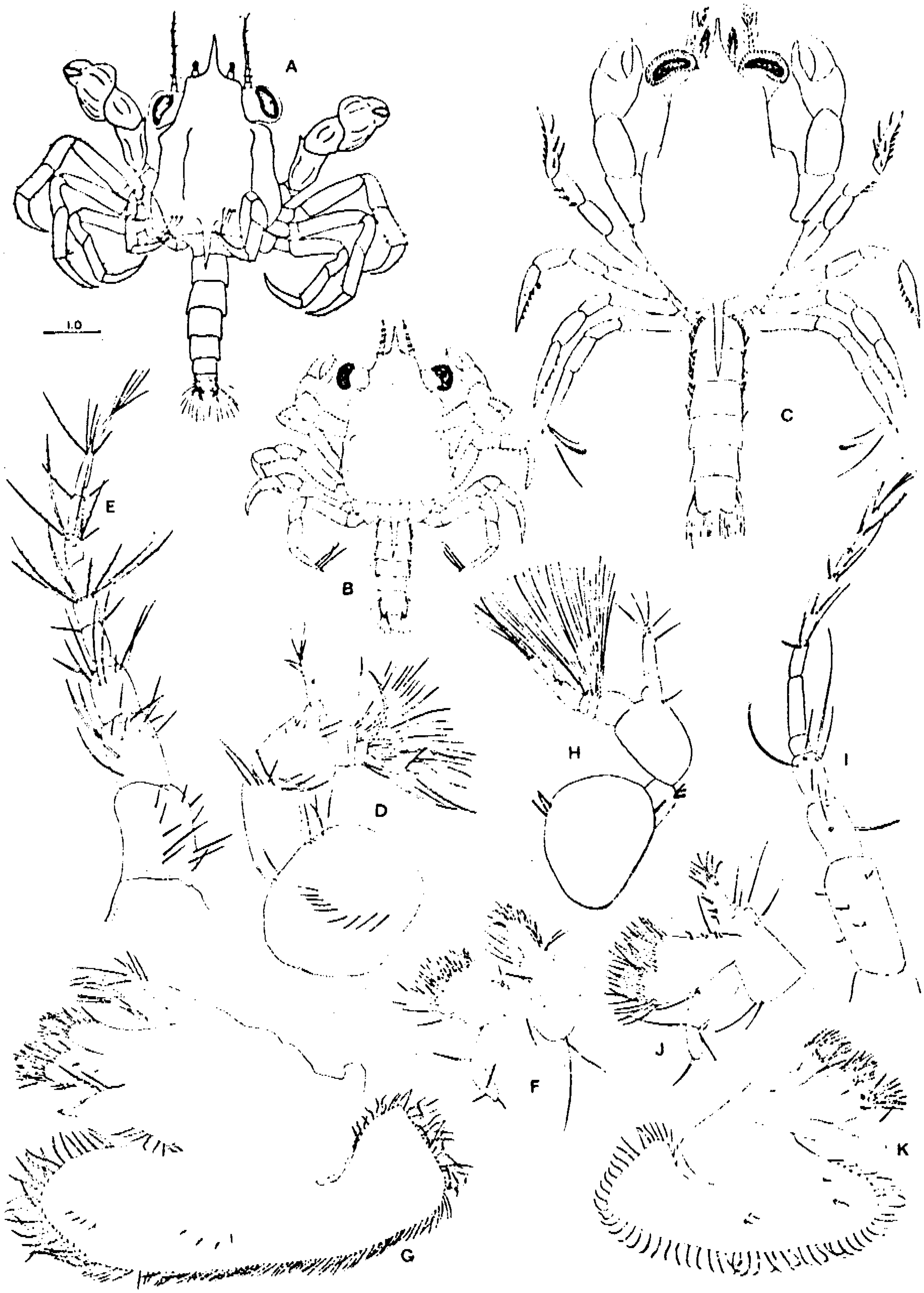
C. *Cancer productus*: megalopa (dorsal view x 16) (Trask, 1970)

D–G. *Cancer magister*: D. Antennule x 32. E. Antenna x 32. F. Maxillule x 32. G. Maxilla x 32. (Poole, 1966)

H–K. *Cancer productus*: H. Antennule x 130. I. Antenna x 70. J. Maxillule x 74. K. Maxilla x 102. (Trask, 1970)



Megalopa Key Fig. 1. Grapsidae and Xanthidae: megalopae



Megalopa Key Fig. 2. Cancridae: megalopae

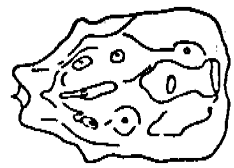
5. Carapace with bumps but no dorsal spines 6

5'. Carapace with 1 or 2 posterior spines, rostrum pointed 7

6. Carapace with posterior bump; rostrum bent down to give a blunt appearance (megalopa key fig. 4) (Lough, 1975)....... *Pugettia* sp.

6'. Carapace without posterior bump; rostrum with 3 short teeth, a blunt central tooth and pointed lateral teeth curved inwardly (megalopa key fig. 5) (Kurata, 1963a) .... ATELECYCLIDAE

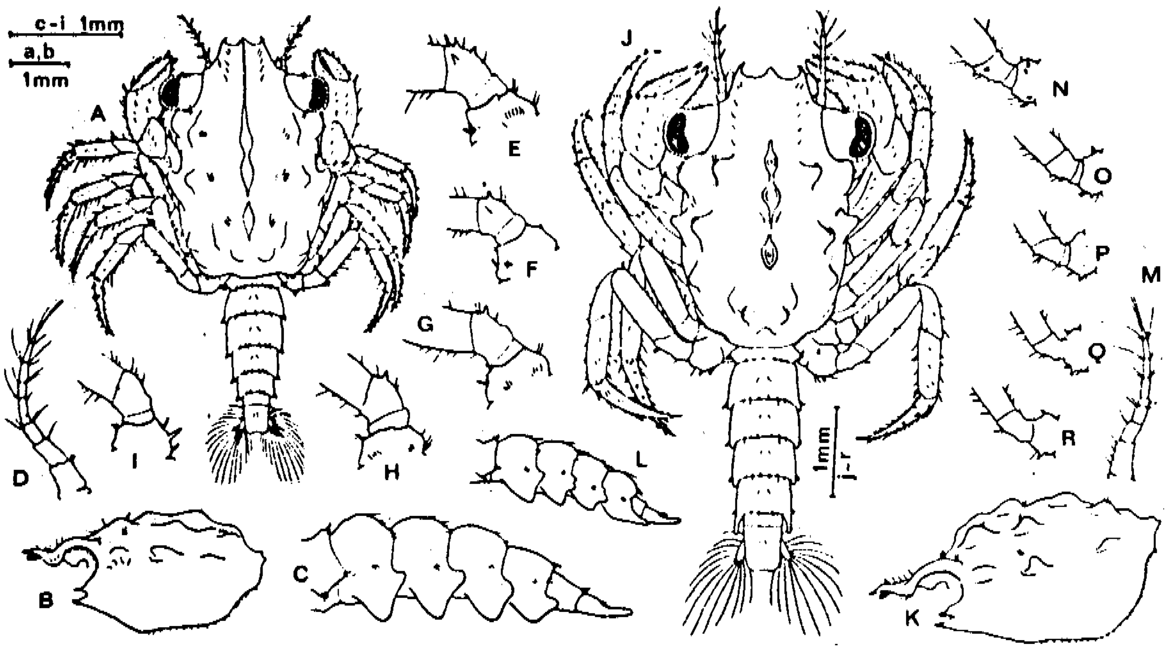
4A



4B

7. Carapace with single posterior spine, a pair of preoccular spines, a pair of postoccular spines and with or without a very small tooth on the anterolateral margin (megalopa key fig. 6). ...... *Oregonia and Hyas* sp.

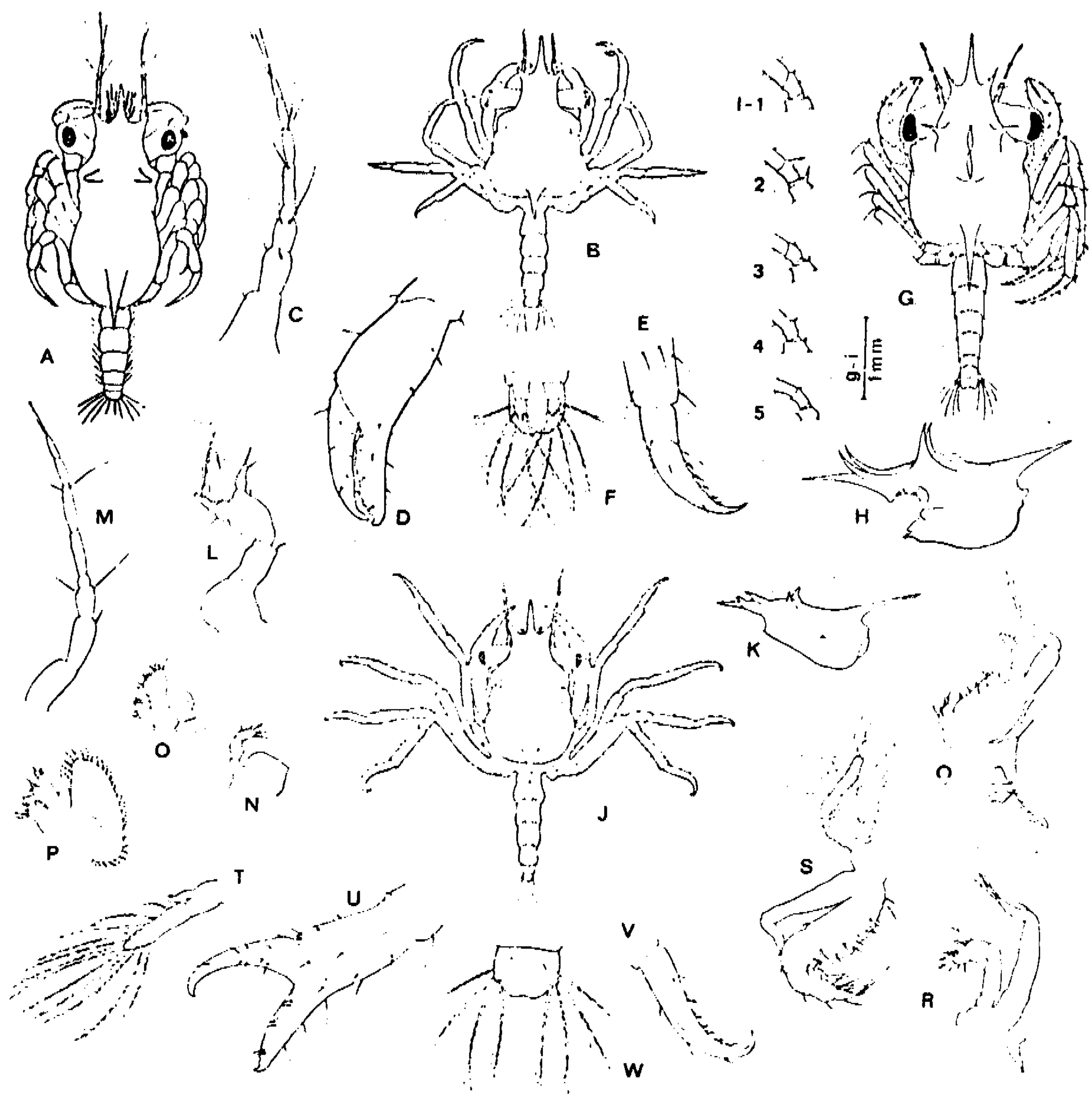
7'. Carapace with pair of posterior spines, a pair of preoccular spines, and a pair of postoccular spines (megalopa key fig. 7). *Chionoecetes* sp.



Megalopa Key Fig. 5. Atelecyclidae: megalopae

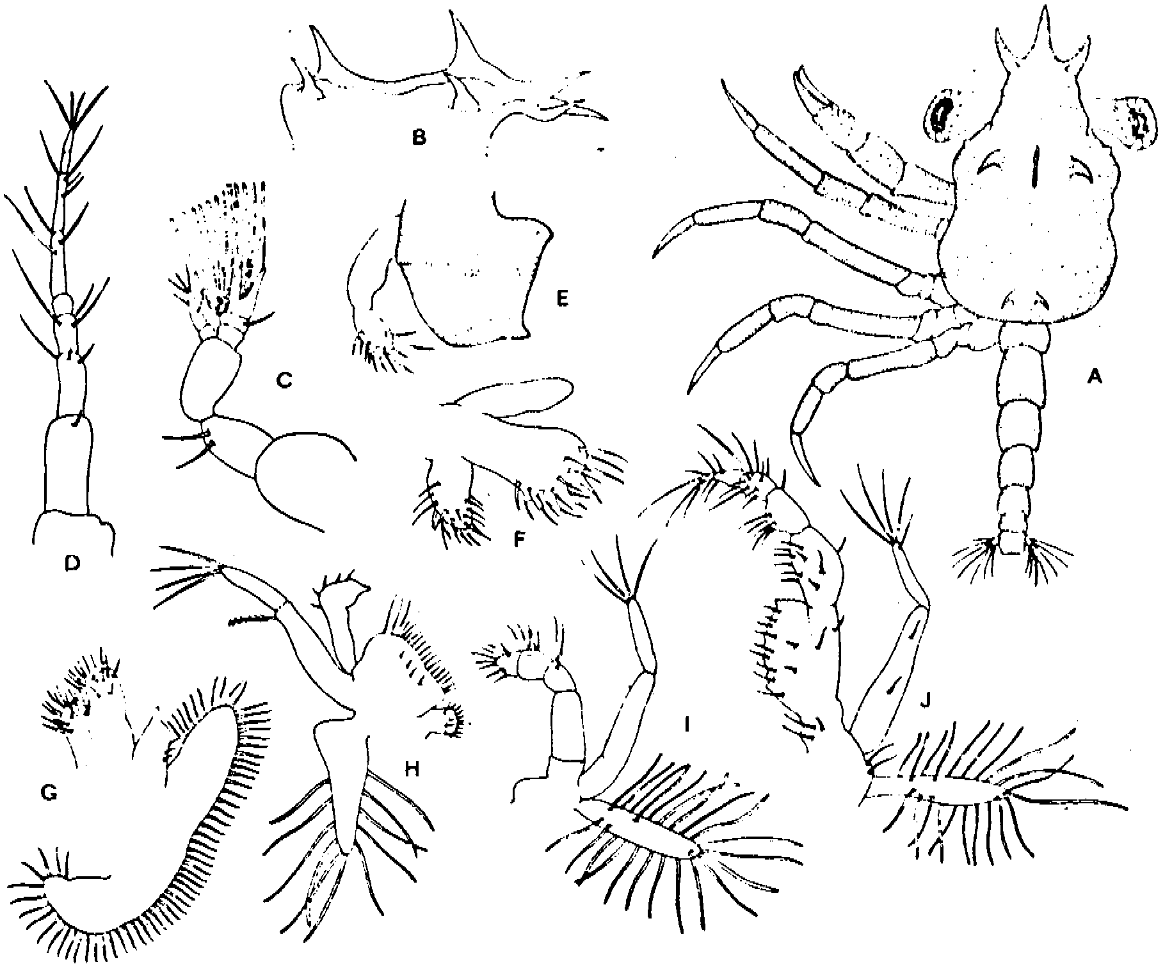
A-I. *Erimacrus isenbeckii*: megalopa. A. Dorsal view. B. Carapace (lateral view). C. Abdomen (lateral view). D. Antenna. E-I. Proximal segments of legs 1-5. (Kurata, 1963a)

J-R. *Telmessus cheiragonus*: megalopa. J. Dorsal view. K. Carapace (lateral view). L. Abdomen (lateral view). M. Antenna. N-R. Proximal segments of legs 1-5. (Kurata, 1963a)



Megalopa Key Fig. 6. *Hyas* and *Oregonia*: megalopae

A. *Hyas coarctatus* (Lebour, 1928) no scale given. Dorsal view - 3.36 mm long; carapace 2.4 x 0.96 mm.
B-F. *Hyas lyratus* (Hart, 1960) no scale given. B. Dorsal view - about 4 mm long; carapace 2.2 x 1.5 mm. C. Antenna. D. Cheliped. E. Dactyl of last leg. F. Telson and uropods.
G-I. *Hyas coarctatus alutaceus* (Kurata, 1963b) scale as shown. G. Dorsal view. H. Carapace (lateral view). I. 1-5 proximal segments of legs 1-5.
J-W. *Oregonia gracilis* (Hart, 1960) no scale given. J. Dorsal view - 4.3 mm long. K. Carapace (lateral view) 3.3 x 1.3 mm. L. Antennule. M. Antenna. N. Mandible. O. Maxillule. P. Maxilla. Q. 1st maxilliped. R. 2nd maxilliped. S. 3rd maxilliped. T. 3rd pleopod. U. Cheliped. V. Dactyl of last leg. W. Telson and uropods.



Megalopa Key Fig. 7. *Chionoecetes opilio*: megalopa
(Motoh, 1973)

A. Dorsal view x 30. B. Carapace (lateral view) x 30. C. Antennule x 75. D. Antenna x 75. E. Mandible x 150. F. Maxillule x 150. G. Maxilla x 150. H. 1st maxilliped x 150. I. 2nd maxilliped x 150. J. 3rd maxilliped x 150.

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DETERMINATION AND DESCRIPTION OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE AND TIMING OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

FIRST INTERIM REPORT

April 15 - August 31, 1976

by

Loren J. Stern
Project Leader

A contribution to biological information needed by OCSEAP in making decisions with respect to offshore oil leases. Work performed under proposal number RU483-76 RFP Tasks A-7 and A-11.

Approved

Submitted September 20, 1976

Associate Director

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FIRST INTERIM REPORT - *KODIAK REGION*

INTRODUCTION

The objective of this report is to summarize the present status of knowledge of distribution, abundance, and timing of salmonids in coastal waters of the Gulf of Alaska as defined below. It forms a portion of a background study designed to provide biological information needed by the Outer Continental Shelf Assessment Program (OCSEAP) in making decisions with respect to offshore oil leasing in the northern Gulf of Alaska and eastern Bering Sea. A second interim report will follow, covering the St. George Basin of the Bering Sea. A final report will then interface the two interim reports and add data not included in the two interim reports.

Study Area

The geographic area covered by the first interim report is marine waters of the Gulf of Alaska bounded by latitudes 150°W and 160°W and by longitudes 54°N and 60°N (Fig. 1). This area will henceforth be termed the *Kodiak region*. Emphasis will be focused on the inshore area from the upper estuaries to the edge of the continental shelf. Total oceanic distributions will be described briefly to show their relation to inshore distribution.

Salmonid Biology

A brief discussion of the taxonomy and life history of salmonids seems appropriate. The term salmonid refers to members of the family Salmonidae (commonly known as the trouts, char, and salmon), which includes fourteen species found on the Pacific Coast of North America. Of these fourteen species, only eight spend part of their life in marine or estuarine waters (Scott and Crossman 1973). Table 1 lists the specific and common names for these species. It is important to stress that salmonids, like other organisms, are quite flexible in their biology. Consequently, exceptions to any generalization made concerning the life history of this group are very common.

After a variable period of marine life mature salmonids return to their natal stream or lake to spawn. The ranges of North American spawning stocks are presented in Figs. 2-9. Note that the northern limit of distribution for the sea-run cutthroat is Prince William Sound which is outside the *Kodiak region*. Consequently, this species will not be discussed in this report. All Pacific salmon (members of the genus *Oncorhynchus*) die after spawning. Such is not the case for the steelhead, cutthroat and Pacific char which can spawn a number of times. In the process of spawning, fertilized eggs are laid in depressions in the stream bottom which are subsequently covered and known as nests or redds. After a variable period of incubation, hatching occurs and the young fish assume an existence in the interstitial gravel areas, deriving nourishment from an attached yolk sac. Soon after resorption of the yolk sac, the young fish emerge from their protected areas in the gravel. There is great variation both between and within species in the duration of freshwater residence of salmonids. Most chum and pink migrate directly to the sea after emergence while other salmonids generally remain from one to three years before leaving the freshwater environment. Some anadromous char and steelhead may remain up to four years in their natal stream before leaving.

Seaward migration occurs primarily in the spring and summer. After reaching the estuary, juvenile salmonids remain in the surface waters (usually upper 1-2 m) close to the shore (Walker 1968 MS), moving gradually offshore as the season progresses. The duration of estuarine life may last up to several months. Not all salmonids leave the estuary; a substantial proportion of the sea-run cutthroat and Pacific char remain in or near the natal stream-estuary system throughout their entire life. Most young Pacific salmon and steelhead trout do leave the estuary and proceed to the open sea. During their first summer, the young salmon tend to remain within a coastal belt approximately 37 km wide (Hartt and Dell 1976 MS). Then responding to some cue many young salmon leave the coastal belt to assume a pelagic existence far offshore. Small numbers of pink salmon and substantial numbers of coho and chinook salmon do not make this offshore migration, but remain in coastal waters for their entire marine life (Milne 1950, 1975; Hartt and Dell MS). Steelhead trout apparently do not remain in coastal waters, but proceed directly offshore upon reaching the open sea (Hartt and Dell 1976 MS).

The time of offshore residence also varies both between and within species. Pink and coho salmon almost invariably spend one year at sea before returning to their natal stream whereas sockeye, chum, and chinook salmon spend from one to six years at sea, with most returning after two to four years. Thus, the age composition of a spawning stock varies according to species and may include several combinations of freshwater and ocean ages.

During their life at sea Pacific salmon and steelhead trout make extensive migrations during which intermingling both between species and age classes of the same species occurs. Mixing even occurs between salmonid stocks of Asian and North American origin (Figs. 2-7). After a period of existence far offshore, the salmonids, using a much discussed yet still unclear mechanism, migrate back to their stream or lake of origin. Enroute, segregation into groups destined to spawn in different areas and at different times occurs. A summary of life history information is presented in Table 2.

Salmonid Economy

Before proceeding further it is important to put the value of the Alaskan salmon fishery in perspective. This fishery, which began in the late 19th century, has been the backbone of what for many years was Alaska's largest industry. Historically, the annual commercial catch of salmonids has accounted for almost half of the total Alaskan fisheries production. Table 3 (from Rogers 1970) shows the relative importance of Alaska's commercial fisheries. In addition, a rapidly growing recreational sport fishery, which averages over 100,000 fish per year (Costello 1972), must also be considered. Attempts at evaluation of the value of sport-caught fish have placed values up to 140 dollars per fish (Tuttle et al. 1975). A more conservative value of fifty dollars per fish still yields an annual recreational sport-fishery value of over 5 million dollars. Finally, a subsistence fishery of over one-half million fish annually must also be considered. In short, the Alaskan salmon fishery is an integral part of the state's social and economic identity.

ADULT SALMONIDS IN NEARSHORE WATERS

The discussion of abundance, distribution and timing will begin with a consideration of the mature adults as they enter coastal waters at the culmination of the marine phase of their spawning migration. The decision to begin the report at this point in the salmonid life cycle is dictated by the fact that only at this time can a geographically comprehensive estimate of population size be made. Next, the young salmonids will be discussed from the time they enter the estuarine waters in the spring until they leave the coastal belt for offshore feeding grounds in the fall and winter. Lastly, the distribution and abundance of adult (age 0.1 and older) salmonids during their offshore phase of life will be presented, with emphasis on their spring-summer return toward coastal waters.

Distribution and Abundance

Estimates of annual abundance of adult salmon stocks will be based upon catch and escapement statistics. Catch data are relatively reliable. Escapement data are less reliable because of the lack of geographically comprehensive data as well as biases inherent in escapement determinations. Despite shortcomings, the data are considered adequate to show the general magnitude of the salmon runs by area and by year.

Before proceeding with the population estimates, a comment on the fisheries is in order. Salmonids are exploited on the high seas, in the nearshore waters and also in the freshwater environment. The following discussion is intended to show the relative magnitude of each fishery.

Salmonids that return to the Kodiak area are exploited to a very limited extent on the high seas by the Japanese mothership fishery which operates as far east as 175°W longitude. Fredin and Worlund (1974) estimated the sockeye catch of this fishery to consist of less than two percent of North American sockeye stocks other than western Alaskan stocks. Chum salmon from the Kodiak area rarely occur west of 175°W (Shepard et al. 1968) and consequently their exploitation by Japan is probably also less than two percent. There is no evidence that any pink or coho salmon bound for the *Kodiak region* are present west of 175°W (Neave et al. 1967, Godfrey et al. 1973). Data on the offshore distribution of North American stocks of chinook salmon and steelhead trout are too limited to accurately assess their mothership catch (see Figs. 6 and 7). However, judging from the many similarities among salmonid species, it is not unreasonable to believe that the catch of North American chinook salmon, excluding western Alaskan stocks, by the Japanese mothership fishery is small. Steelhead trout from the *Kodiak region* are subject in small numbers to high seas fishing by Japan (Fig. 7). Because of their nearshore distribution throughout their marine life, sea-run cutthroat and Pacific char are not caught on the high seas (see Figs. 8 and 9). In summary, the catch by the Japanese mothership fishery of salmonids bound for the *Kodiak region* is insignificant in comparison to the catch of other fisheries.

An extensive commercial fishery which operates close to shore, mainly in bays and estuaries, accounts for by far the largest proportion of the total catch of salmonids (Fig. 10). From these summaries the overall dominance of catch by the commercial fishery can be seen. Of lesser magnitudes are the sport and subsistence fisheries which, in the *Kodiak region*, occur primarily in the freshwater environment. Consequently, commercial catch statistics will be used as the basis for subsequent population estimates. There are no data available on the subsistence and sport catches of sea-run cutthroat and Pacific char. There are also no data on the subsistence catch of steelhead trout.

A complete discussion of salmonid abundance should consider past, present and future levels of population size. Past catches are important in that they indicate the carrying capacities that prevailed under pristine conditions and as such provide goals that are useful to fishery management. At some future time hatchery and other enhancement programs may result in restoration of salmonid stocks to peak levels that occurred before the effect of man's exploitation manifested itself.

Catch Statistics

Catch statistics are available from as early as 1896 for some areas but geographically comprehensive statistics are not available until ten years later. Changes in the geographic partitioning of catch have accompanied changes both in the fishery and regulatory management agencies of Alaska. For example, for many years the catch was broken into relatively large statistical districts (Fig. 11). In 1956 the statistical districts were each subdivided into smaller areas (Fig. 12), thus allowing better geographic definition of commercial catch. Consequently, the presentation of abundance will begin with consideration of historic levels of catch in each district from 1925 to 1972 in order to show the long-term trend of abundance. Following that, abundance will be discussed according to the more detailed areas based upon statistics for the years 1956-72.

Catch statistics may be considered reasonably comparable for all five species of Pacific salmon, but unfortunately, detailed catch statistics are not available for steelhead trout and Pacific char. As no special effort is made by the commercial fishery to catch these species, the catch data probably underestimate the actual abundance of these species. However, because no other basis for population estimates exists, catch statistics will be used as the basis for population estimates of these two species.

Historical catch statistics for the *Kodiak region's* commercial salmon fishery indicate the variable nature of the catches in the years 1925-75 (Fig. 13). Since the figure shows total catches for several major fishing districts combined, cyclic features within districts are not apparent. During the fifty-year period the fishery underwent many changes such as the banning of trap gear in 1959.

Relatively large catches of sockeye were made until the 1950's when rapid decreases continued until 1958. Since then catches have slowly risen to a recent peak of over six million fish in 1970, but far short of the ten million sockeye caught in 1936. However, commercial catches of sockeye in Central Alaska since then have steadily declined to the 1975 catch of slightly over two million fish.

An historical trend similar to that noted for the sockeye is evident in the pink salmon fishery; the trend being one of high catches through the late 1940's, small catches in the 1950's followed by an increase in the 1960's, and a decrease in the 1970's. The typical two-year cyclic nature of pink runs is obscured because of the grouping of several districts in the *Kodiak region* as a whole.

The catch trend for chums is different from that of sockeye and pink salmon. The chum catches peaked in 1929 when over five million chum were caught. It remained fairly constant through 1971, averaging around three million chum annually. In 1972, the catch decreased dramatically to a low of approximately a quarter of a million fish and has remained quite variable since then.

Historically the coho salmon fishery showed peaks of over 1.6 million fish in 1930 and 1942, while averaging approximately 0.6 million fish annually in the intervening years. After 1946 coho catches declined continually until 1953, after which the catches have been variable, averaging around 0.4 million fish each year. The catches dropped to an all time low in 1972 when only 0.25 million fish were caught, but have risen steadily since then.

The chinook salmon fishery has fluctuated less than the fisheries for other species. Chinook catches averaged annually 120,000 fish until 1951 when a peak of 213,000 fish were caught. Since then chinook catches steadily declined until 1964 and have remained relatively constant since then, annually averaging only slightly over 30,000 fish.

As mentioned earlier, historical catch statistics on the Pacific char and steelhead trout are lacking. Because Pacific char were known to prey on young salmon, a char extermination program was instigated which provides some measure of this species' abundance. In 1935 bounties were paid on over 200,000 char tails from Kodiak Island alone (Annual Report 1935, Alaska Fish and Fur Seal Industries, 1935). The program was stopped in 1940 and Pacific char are now considered very valuable as a sport fish. In most areas of the *Kodiak region* Pacific char are relatively abundant, as testified by the high degree of success experienced by anglers fishing from beaches in proximity to river mouths.

The status of steelhead trout stocks in Alaska in general is not well known. Sheppard (1972) reported that Alaskan steelhead stocks were virtually unexploited, but noted also that no population studies on Alaskan steelhead trout stocks existed. Allin (1957) noted that in early years Anchor River steelhead were numerous enough to be included in the commercial coho catch but are now so scarce that commercial fishermen save steelhead trout for their personal use. In short, little can be concluded on the abundance of this species. However, the great value, as in the recreational sport fishery, makes the species very important.

Quantification of the historical catch statistics (Table 4) for the *Kodiak region* yields an annual average catch for the forty-eight year period of over 17 million salmon. The confidence limits for the commercial catch are included such that the variability seen in Fig. 13 may also be quantified. Also given in the table are the peak and 1975 catches. The 1975 catch shows the most recent data available.

Population Estimates

Before estimates of population size can be made, the relationship between catch and escapement must be characterized. This relationship, as do most others relating to salmonids, possesses a large degree of variability. In recent years the Alaska Department of Fish and Game (ADF&G) has developed escapement goals for individual geographic areas. For example, ADF&G has determined that escapements of one-and-a-half to two-and-a-half million pink salmon (depending on the year) are optimum population sizes for the Kodiak district (R. Donnelly, personal communication). As a result the catch-escapement ratio depends on the cycle and the size of the year's run. If 10 million pink salmon return to Kodiak Island the catch-escapement ratio will be approximately five to one. If only 5 million pink salmon return to this district, the catch-escapement ratio will be approximately two to one. Unfortunately, present-day monitoring and forecasting techniques were not available in early years, so that the percentage of the runs caught by the fishery has varied over the years both with area and time. A rough approximation of the average percentage of the run represented by catch is seventy percent. Thus, escapement is estimated as thirty percent of the run or 0.43 x catch (.3/.7). The following discussions of total populations will be based upon this estimated relationship. Table 5 presents total run estimates by district on this basis.

South Alaska Peninsula District. The total runs to the South Alaska Peninsula district averaged approximately 7.4 million fish annually for the years 1925-72 with a potential run size of 22.5 million fish (Table 5a).

The species composition of the South Peninsula district's population of salmon shows the predominance of pink salmon which comprise over fifty percent of the total catch in both even and odd years (Table 6a). Also apparent are the proportionately small numbers of coho and chinook salmon in comparison to the other salmon species.

In discussing the abundance and species composition within the individual statistical areas of the South Peninsula district (Tables 7a and 8a, and Fig. 12), it is important to point out that this district includes areas 283 and 284 that lie west of 160°W and thus are outside of the area previously defined as the *Kodiak region*. However, since they are part of a statistical district that partially lies within the *Kodiak region*, they must be included herein. It will later be shown that many of the sockeye caught in statistical area 284 are of Bristol Bay origin. Using the average annual population estimates (Table 5a) and the relative abundance in each statistical area (Table 7a), an average population size for each statistical area was derived as shown in Table 8a. Note that the largest numbers of salmon, all species combined, were estimated to occur in statistical area 283.

Chignik District. Population estimates for the Chignik district indicate an estimated average total run of approximately 2 million salmon and a potential of 6.3 million salmon (Table 5b). As indicated in the table, the average was calculated for the forty-eight year period from 1925-72.

The species composition of the Chignik district's salmon runs shows that the sockeye are the most abundant species caught in this area (Table 6b). Also important in the salmon fishery are pink salmon which comprise slightly over a third of the total catch of salmon in the Chignik district.

A more refined presentation of abundance shows the extreme importance of statistical area 271 (Chignik Bay) in the commercial sockeye fishery (Table 7b). The table also indicates that a large proportion of the catches of both even-year pink and chum salmon occurs in statistical area 272. Population estimates made in the manner described earlier for each statistical area show that statistical area 271 is the most important area while the other three areas have similar but significantly lower levels of estimated abundance (Table 8b).

Kodiak District. For the purpose of clarification it is important to make the distinction between Kodiak district and *Kodiak region*. The Kodiak district is a statistical area within the geographic area defined as the *Kodiak region* in the introduction of this report (Fig. 1).

Population estimates for the Kodiak district indicate that an average of 11.6 million salmonids return to this district annually during the forty-eight year period with a potential run of 28.9 million fish (Table 5c).

The relative abundance of each species shows the dominance of pink salmon in this district (Table 6c). Pinks annually average approximately ninety percent of the total number of fish caught in the Kodiak district.

The use of more refined statistics indicates that the majority of pink salmon production comes from statistical areas on the southern part of Kodiak Island (areas 256-259) while over seventy percent of the sockeye catches are made in those statistical areas on the west side of Kodiak Island (statistical areas 253-257) (Table 7c). Population estimates for each species and in total by statistical area show that the two statistical areas on the southern part of Kodiak Island (statistical areas 257 and 258) have the most abundant salmon stocks (Table 8c).

<u>Cook Inlet District</u>. The estimated average annual run of adult salmonids in the Cook Inlet district in the past forty-eight years was 4.7 million fish with a potential run of 11.5 million (Table 5d).

The relative abundance of each species indicates that in the Cook Inlet district sockeye and even-year runs of pink dominate the commercial catch (Table 6d). Of special note is the high proportion (eighty-seven percent) of *Kodiak region* chinook caught within the Cook Inlet district.

Greater definition of abundance shows the importance of statistical area 244 in the commercial fishery for all five salmon species in the Cook Inlet district (Table 7d). Population estimates for each statistical area indicate that the average annual return of salmon to statistical area 244 is approximately 2.7 million fish (Table 8d).

Resurrection Bay District. Population estimates of adult salmon in the nearshore waters of the Resurrection Bay district show a total run of approximately 0.1 million fish with a potential peak run of about 0.4 million. Thus runs to Resurrection Bay are more than an order of magnitude less than those of the other districts.

The species composition in the Resurrection Bay district (Table 6e) is similar to that seen in other districts. Sockeye and pink salmon are dominant, with intermediate numbers of chum salmon (and sometimes coho salmon), and relatively small numbers of chinook salmon.

A more defined breakdown into statistical areas demonstrates the relative importance of areas 231 and 232 in relation to statistical area 233. Population estimates by species for each area are presented in Table 8e.

Timing

As mentioned earlier, salmonids enroute from their offshore grounds segregate into units (or races) that are not only bound for specific streams but also particular regimes of timing and location within the streams. Because of this segregation activity, any environmental impact, although it may affect only a small segment of the population, may be extremely important because the segment affected could represent in total one or more individual races. The timing for each race is a function of a combination of genetic and environmental factors. Because of the environmental influence, the timing of salmonid runs varies depending on geographic, climatic, and oceanographic conditions and can result in multimodal runs. However, despite environmental fluctuations, the timing of the arrival of a particular "run" on the spawning ground is amazingly consistent. The peak timing can be expected to occur in relatively the same time period each year (Atkinson et al. 1967, Royce 1965). The timing of the runs as they migrate through the commercial fishery area is, of course, related to their time of spawning. If for some reason a run is "late," then the duration of stay in the nearshore waters will probably be reduced and vice versa.

Catch statistics compiled on a weekly basis can be used to provide a reasonably accurate picture of salmonid timing in most statistical districts. However, because fishing periods must be regulated by the Alaska Department of Fish and Game to insure spawning escapement, the catch does not fully indicate the true shape or duration of the total run. More precise information is available for selected rivers and will be used to supplement the use of catch statistics in describing the timing of adult salmonids as they return to the nearshore waters.

South Peninsula District. The average timing of runs to the South Peninsula district are presented in Figs. 14-16. Although the curves represent forty-eight year averages, the approximate variations can be seen from the ninety-five percent confidence ranges shown for selected dates. Additional data on the runs to this district are provided by Thorsteinson (1955) who reported on the timing of pink runs of 1955. He found the pink run to be bimodal; early runs were seen to enter streams from late July and late August with a peak in mid-August and late runs were noted to begin in mid-August, peak on September 10, and end in early October. Calkins (1957) also reported on the pink runs to the South Peninsula district and included data on the chums as well. He found the 1957 timing of the pink runs essentially identical to that reported by Thorsteinson. Calkins found the chum runs to begin in late July, peak from mid- to late August and end around mid-October. It is important to note that any apparent difference in timing between that indicated by catch statistics and stream surveys is due to the time it takes a fish to depart marine waters and proceed upriver.

Chignik District. The timing of salmon runs to the Chignik district (Figs. 17-19) is similar to that indicated in the South Peninsula district. Thorsteinson (1955) reported that in 1955 pinks began entering the streams in late July and continue through the end of August peaking from August 20-23. Thorsteinson also noted that sockeye begin entering streams in late May, peak in late June, and continue through mid-July. Reports by other researchers (Roos 1957 MS, 1959a MS, 1960; Narver 1963, 1966; Dahlberg 1968; Cleaver 1964; Thompson 1951; Margolis et al. 1966) have noted that the run continued through late September. The variability of timing was emphasized by Dahlberg (1968) who reported that the timing of sockeye runs to Chignik had been unimodal, bimodal, and even trimodal. Roos (1959b) reported that the char enter the Chignik River from July through September.

Kodiak District. The timing of the Kodiak districts' runs using catch statistics is presented in Figs. 20-22. A summary of the information available in the literature is shown in Table 9, the sources of which are given below by species:

Pink salmon - Bevan (1950, 1954a, 1954b, 1956, 1967, 1970, 1974, 1975), Noerenberg (1955 MS, 1959), Sheridan and Meehan (1962), Van Hulle (1971).

Sockeye salmon - Barnaby (1944), Bevan (1954b, 1956, 1967), Cleaver (1964), Gard and Benson (1962, 1963), Margolis et al. (1966), Nelson (1959), Noerenberg (1955 MS), Ricker (1962), Rounsefell (1958), Sheridan et al. (1961), Thompson (1951), Tyler (1960), Van Hulle (1971, 1972).

Chum salmon - Noerenberg (1955 MS), Tyler (1960).

Coho salmon - Marriott (1966), Noerenberg (1955 MS), Van Hulle (1971).

Chinook salmon - Marriott (1966), Noerenberg (1955 MS), Van Hulle (1971).

Steelhead trout - Marriott (1966), Van Hulle (1971, 1973).

Pacific char - Blackett (1968), Marriott (1966), Revet (1962), Van Hulle (1970).

Cook Inlet District. The timing of the Cook Inlet district runs as portrayed by catch statistics are presented in Figs. 23-25. Data on the timing of these runs available in the literature are summarized in Table 10 which is based on information from the following sources.

Pink salmon - Davis (1967a), McHenry (1969, 1970), Noerenberg (1955 MS), Rearden (1965), Reddick (1967, 1969).

Sockeye salmon - Engel (1967, 1969, 1970, 1971, 1973), Hartt (1953), Margolis et al. (1966), Noerenberg (1955 MS), Rearden (1965).

Chum salmon - Logan and Engel (1966), McHenry (1969, 1970), Noerenberg (1955 MS), Rearden (1965), Stefanich (1962), Yancey and Thorsteinson (1963).

Chinook salmon - Andrews (1962), Kubik (1965, 1966, 1973), Logan (1962c, 1963, 1966a), Noerenberg (1955 MS), Rearden (1965), Williams (1967), Yancey and Thorsteinson (1963).

Steelhead trout - Allin (1957), McHenry (1969, 1970).

Char - McHenry (1969, 1970).

Of special mention is the in-depth analysis of the timing of chinook runs to various parts of Cook Inlet as reported by Yancey and Thorsteinson (1963).

Resurrection Bay District. The timing of the runs to the Resurrection Bay district is presented in Figs. 26-28 (based on catch statistics) and Table 11 (as presented in the literature). The sources of data for this table are as follows:

Pink salmon - Logan (1963, 1965, 1966b, 1967, 1969), McHenry (1972, 1973, 1974), Rogers (1972).

Sockeye salmon - Logan (1962a, 1963, 1965, 1966b, 1967, 1969), McHenry (1970, 1972, 1973, 1974), Rogers (1972), Watsjold (1970).

Chum salmon -

Coho salmon - Dunn (1960), Logan (1962a, 1963, 1965, 1966b, 1967, 1969), McHenry (1970, 1972, 1973, 1974), Watsjold (1970).

Chinook salmon - Logan (1966b), McHenry (1972, 1973).

Steelhead trout - Logan (1967, 1969), Watsjold (1970).

Char - Logan (1962a, 1962b, 1963, 1965), McHenry (1973).

Migration

With information presented on the abundance, distribution and timing of adult salmonids in the nearshore waters, their migratory routes will now be discussed based upon the results of coastal tagging projects within the *Kodiak region*. Sufficient tagging has been done throughout the study area to show the major migratory patterns for sockeye, chum, and pink salmon. Data on coho and chinook salmon and steelhead trout are inadequate in most cases. An important general observation from tagging results is that the migratory routes followed by salmonids are not rigidly fixed. For example, Thorsteinson (1956) noted that sockeye bound for Chignik do not approach the coast in the same manner from year to year. What causes these deviations from usual migratory routes is unknown but the offshore distribution and climatic conditions are presumably involved. Rearden (1965) reported that in response to strong southwest winds and tides, sockeye bound for the Kenai and Kasilof Rivers (Cook Inlet) tended to move northward well past their respective rivers of origin, before migrating southward again along the eastern shore until finding their natal stream. Such "wandering" and "to-and-fro" coastal migratory movements have been reported by many researchers (Verhoeven, 1947). Neave (1964) stated that the homeward migration of Pacific salmon may or may not include extensive movements in the coastal belt depending on stocks, species, etc. Differences in migratory behavior between species were also observed by Milne (1957) who reported that the spawning migration of chinook differed from that of coho; chinook migrated long distances in coastal waters, whereas, coho entered coastal waters in close proximity to the natal streams.

With these ideas in mind, the results of coastal tagging research in the *Kodiak region* will now be discussed on a geographic basis beginning in the South Peninsula district and gradually moving east to the Resurrection Bay district.

South Peninsula District. Much of the early coastal tagging work was carried out in the South Peninsula district in waters between Unimak and Unga Islands (Gilbert 1923, Gilbert 1925, Rich and Morton 1929). The objective of this work was to identify the origin of the sockeye caught in this area, since in many years the size of the catch was much larger than that which could be expected based upon local spawning populations. Results indicated a dominant westward movement of sockeye, with a significant proportion of tags recovered in Bristol Bay. Later research (Thorsteinson and Merrell 1964) supported the earlier findings of westward migration; of the fish tagged in the area, sixty-five and sixty-eight percent of the sockeye and chum, respectively, were recovered in western Alaska.

Chignik District. Thorsteinson (1956) has also tagged sockeye taken from the commercial fishery in the Chignik district. These experiments carried out in 1949 and 1952 indicated that very few sockeye caught in Chignik were bound for areas outside that district. However, it is important to note that the Chignik taggings were made within a short period of time (two days in 1949 and one day in 1952) and therefore, may have missed fish bound for Bristol Bay. Combining the results of tagging in the South Peninsula and Chignik districts indicates that the western limits of the coastal approach of Chignik stocks of sockeye occurs between the Shumagin Islands and Pavlof Bay. Dahlberg (1968) extended this hypothesis in concluding that the coastal distribution of adult Chignik sockeye occurs from the Shumagin Islands to Aniakchak Bay with the major entry from the east.

Kodiak District. Similar tagging studies on the northwest coast of Kodiak Island (Rich and Morton 1929, Bevan 1957, 1959) provide further information on the movement of adults in the nearshore waters. Recoveries of sockeye tagged in this area indicate that over ninety percent of the sockeye in this area were migrating southwestward with the majority bound for the Karluk River. Sockeye tagged on the northwest coast of Kodiak Island yielded recoveries in Alitak Bay (southern Kodiak Island), Chignik, South Alaskan Peninsula, Bristol Bay, and Cook Inlet, thus demonstrating substantial wandering.

Cook Inlet District. Coastal migration data are also available from tagging work done in Cook Inlet. Although Thompson (1931) found little emigration of fish tagged within Cook Inlet to areas outside of the Inlet, later research (Tyler and Noerenberg MS) revealed that significant numbers of sockeye tagged south of Chisik Island (located near Tuxedni Bay) in early July were bound for areas west of Cook Inlet. The majority of fish tagged south of Chisik Island and all of the fish tagged north of there were recovered within Cook Inlet.

Finally, coastal tagging in the outer districts of Prince William Sound indicates that a large proportion of the catch in this area is bound for Cook Inlet (Tyler and Noerenberg MS, Noerenberg and Sevoie 1963).

A summary of the results of coastal tagging studies is presented in Fig. 29. In short, the coastal migration of salmonids can be characterized by substantial wandering, probably caused by fluctuations in the factors that influence salmonid migratory behavior. In the following section, which deals with the juvenile salmonids in the nearshore water, flexibility of migratory behavior similar to that of the adults will also be seen.

JUVENILE SALMONIDS IN NEARSHORE WATERS

The amount of information available on the abundance, distribution, timing and migration of juvenile salmonids is generally much less than that available for adults in the same waters. This is in part due to the large amount of information on adults gained from the commercial fishery and to the limited effort that has been made in sampling young salmonids. However, adequate data exist to indicate the general pattern of abundance, distribution and timing of juvenile salmonids upon their entry into the marine environment. Less data are available concerning their duration of stay in estuaries and bays and subsequent movements offshore.

Distribution and Abundance

In general the distribution and abundance of young salmonids entering the marine environment in a given area will be in proportion to the distribution and abundance of the adults entering the nearby streams to spawn. Atkinson et al. (1967) has summarized much of the spawning information and this is the source for the data presented in Figs. 30-34. From the figures, it is evident that juvenile salmonids enter the marine environment throughout all coastal waters of the *Kodiak region*. Similar information has not been summarized for the steelhead trout, but it is known that there are steelhead populations in a number of streams from the Chignik River and eastward (Clemens and Wilby 1962, Hart 1973, Sutherland 1973). A comprehensive stream catalog is also not available for the Pacific char. However, as char are distributed in almost all streams along the Pacific Coast (DeLacy 1941) and because of their dependency on young salmon as food, it is safe to assume that char occupy a large proportion, if not all, of the streams inhabited by Pacific salmon in the *Kodiak region*.

Direct enumeration of juvenile salmon abundance is available for only a small percentage of the total number of streams in the *Kodiak region*. These data are especially useful, however, in estimating the departure timing of young salmonids from natal streams. Other methods of determining abundance of young salmonids include enumeration of eggs, pre-emergent and post-emergent fry per unit area or time. Another method of juvenile sampling, tow netting in the estuaries, provides a more direct method of determining the abundance, distribution and growth of juveniles in the nearshore marine environment. However, all these methods were developed to provide an index of relative abundance of juveniles upon which to base a forecast of adult returns. As a result, these methods cannot be expanded to formulate population estimates of juvenile salmon over large areas. Therefore, in this paper, estimates of the number of juveniles must be based on the size of the parent populations (Table 5). Although the relationship between the spawning population and the resulting juvenile population varies because of fluctuating mortality levels in the early life history stages, the estimates should serve to indicate the general picture of the abundance of juvenile salmonids in the nearshore waters. Before proceeding with the estimation of juvenile population size, an explanation of procedure used is necessary.

The first requirement of the estimation procedure is determination of the size of the spawning population of the particular area. This estimate will be based upon an assumed average escapement of thirty percent of the run as discussed in the section on total run sizes. Further adjustments must be made in some areas where the catch includes appreciable numbers of fish bound for another area. Earlier this was shown to be the case for catches in the South Peninsula district, where a large proportion of the catch was returning to western Alaska. As a result, the percentage of western Alaskan salmonids caught in the South Peninsula district will be estimated at fifty percent. Therefore, the catch in this district is estimated at one-half of the catch presented in Table 4. The catches in the other districts need no adjustment. Thus the spawning escapement will be estimated as 0.43 of the catch in a given district (.3/.7).

Population Estimates

The estimation procedure then involves determination of the number of eggs laid by the parent population. By assuming a one to one male-to-female ratio and using the catches in Table 4, the number of females can be estimated. Then the number of eggs laid can be determined by multiplying the number of females by the average number of eggs per female (presented in Table 2). The determination of juvenile salmonid abundance is completed using average egg to downstream migrant survival levels. As to be expected, these survival levels have great variability in time and space and between species. Donaldson (1963) reported that levels of survival from egg to downstream migrant for sockeye, coho, and chinook average approximately two percent. Because of similar durations of freshwater residence, levels of survival for steelhead and char should also be assumed to be two percent. Survival values for pink and chum juveniles are higher because of their shorter freshwater life and average approximately ten percent (MacKinnon 1970). Using the method explained above yields population estimates of the number of juvenile salmonids that enter the marine environment as presented in Table 12. From Table 12 it is apparent that extremely large numbers of juvenile salmonids are produced within the *Kodiak region*. An average year's production of juvenile salmonids (all species) is estimated at over one-half billion fish with a peak population level of over one and one-half billion fish for the *Kodiak region*.

Timing

Now with estimates of the numbers of juvenile salmonids that enter the *Kodiak region*, it is appropriate to consider when the young fish enter the marine waters. Because of the scarcity of data, instead of considering timing for each area, it is necessary to discuss the timing of juvenile entry on a *Kodiak region*-wide basis. But, before proceeding with this, it is important to note that the timing of seaward migration of juvenile salmonids is subject to fluctuations caused by many factors, chief among which is climate. Hartman et al. (1967) noted that smolt migration timing showed close correlation with latitude with northern populations migrating later, probably in relation to ice thawing and water warming. The same researchers also reported that minor variation in timing could be explained by local physical and climatic changes. The timing of juvenile entry into the marine environment is summarized in Table 13, the sources of which are listed below.

Pinks:	Logan (1966b), Tyler (1976 MS), Walker (1968 MS).
Sockeye:	Barnaby (1944), Dahlberg (1968), Fredin (1963), Gard and Benson (1962, 1963), Israel (1933), Logan (1966b, 1967, 1969), McHenry (1972), Nelson (1959), Phinney (1968), Roos (1960), Thorsteinson and Roos (1958 MS).
Chum:	
Coho:	Allin (1957), Israel (1933), Logan (1963, 1965, 1966b, 1967, 1969), McHenry (1970, 1972, 1973, 1974), Watsjold (1970).
Chinook:	Allin (1957)
Steelhead:	Allin (1957), McHenry (1970), Watsjold (1970).
Char:	Allin (1957), Logan (1962b, 1963, 1966b, 1967, 1969), McHenry (1972).

Migration

Information available on juvenile salmonids after they enter the marine waters of the total *Kodiak region* is scarce. The most definitive data are for the Kodiak Island district, and applies mainly to pink salmon. Since 1962, the Fisheries Research Institute (FRI) of the University of Washington has sampled juvenile salmonids in the bays of Kodiak Island by means of tow nets in order to forecast the following year's return of pink salmon (Tyler 1976 MS). The results of this research are also useful in understanding the timing and movements of juvenile salmonids after they enter the marine environment and are the basis for the following discussion.

Juvenile pink salmon that leave streams entering bays, fjords, and channels remain in these protected waters for several months. It is suspected that young salmonids that leave streams along unprotected shorelines move directly offshore. Those pinks that do enter protected areas, such as bays, move directly from river mouths to intermediate areas along the shorelines. Here the juvenile pinks remain in the surface waters and form large schools in the preferred areas. After approximately forty-five days the pinks gradually move to the open water areas in the bays where they remain for approximately another forty-five days. These movements are pictured in Fig. 35 (from Tyler 1976 MS), which shows that in the spring and early summer, juvenile pinks are concentrated at the heads of bays. By mid-summer, it can be seen from the figure, that juvenile pinks are distributed throughout the bays and that in August and September they are concentrated near the mouths of the bays. FRI research has also found that young pinks tend to leave from shorter bays earlier (e.g., Kaiugnak and Malina Bays) than from longer bays, especially those that have a network of arms (like Alitak Bay). Departure from these waters is gradual, beginning in late June, peaking in August, and lasting through September. After leaving the open waters of the protected areas, the juvenile pinks move offshore and begin their high seas period of life. There is some evidence to indicate that some pinks, after departing a particular bay, may move back into the open waters of adjacent bays. Small numbers of chum are also included in the catches made by tow-netting in the various bays. Walker (1968 MS) reported that juvenile chum salmon appeared to stay nearshore longer than the pinks, although a small percentage of chums were found in the open water catches of pinks. Chums were seen to remain in or near river mouths for up to several weeks.

Fisheries Research Institute has also conducted juvenile studies (using tow-netting)in Chignik lagoon. The studies, which were conducted from 1961-68, were intended to show various aspects of the distribution and abundance of the post-smolt sockeye salmon in the lagoon (Dahlberg 1968, Phinney 1968). These studies showed that juvenile sockeves behaved similarly to Kodiak pink salmon juveniles. The young sockeye were seen to delay their offshore migration and remain for a short period of time in the lagoon. Phinney (1968) reported that sockeye post-smolts initially inhabited the littoral areas of the lagoon gradually moving into deeper waters of the lagoon. He also noted that sockeye juveniles remained in the lagoon from four to six weeks before departing for offshore waters.

JUVENILE SALMONIDS IN OFFSHORE WATERS

Information on juvenile salmonids after they depart nearshore waters was nonexistent for many years except for fragmentary reports resulting from incidental catches made during attempts to sample older fish by researchers of the International North Pacific Fisheries Commission (Hartt 1966). However, FRI conducted research to fill this void from 1964-68 with a program aimed at determining the distribution, abundance, and migrations of juvenile salmonids during their first summer at sea. This research has been summarized by Royce et al. (1968), Sakagawa (1972), and Hartt and Dell (1976 MS).

Distribution and Abundance

A summary of the catch per unit of effort of juvenile salmonids in the waters of the *Kodiak region* is presented in Figs. 36-39 (from Hartt and Dell 1976 MS, Figs. 2-8). In the May-June period, it is evident that very few juvenile salmonids have entered the offshore sampling areas. The small catch of coho in the area immediately south of Kodiak Island indicates that offshore movement for this species has just begun. This is understandable as coho are larger than sockeye, pink, and chum juveniles and are therefore more able to cope with offshore existence. The lack of chinook or steelhead catches in May and June could reflect their small population sizes rather than later offshore movement. This is supported (for steelhead only) by catches made in the offshore waters of the *Kodiak region* in July (Fig. 37) in which steelhead were caught far offshore indicating the offshore movement of this species was well under way. Also evident from the catches in July is the appearance of juvenile sockeye indicating the initiation of this species' departure from nearshore waters. In August (Fig. 38) relatively high catches of all species were reported. Of note is the absence of sockeye, pink, and chum in the area farthest offshore. In the September-October period (Fig. 39) a picture similar to August is seen except that a few sockeye were caught in the area farthest offshore. It is important to note that these catches can be used only to indicate relative abundance and therefore attempts to make population estimates of juveniles in offshore waters cannot be undertaken. However, relative abundance is adequate to show the general features of distribution and timing of offshore migration, and to aid in understanding the outward migration from the bays as depicted in Fig. 35.

Vertical Distribution

The vertical distribution of young salmonids in coastal waters has not been studied in the *Kodiak region*, but tow-net catches and visual observations indicate that they are abundant in the near-surface waters. Drawing on information on juveniles outside the region provides some additional data. Data collected by the *Oshoro Maru* in outer Bristol Bay using small-meshed vertical gill nets indicated that juvenile sockeye are confined to the upper 10 m of water. However, LeBrasseur and Barner (1964) using trawl gear found age .0 chums as deep as 95 m in northern Hecate Strait. In summary, too little data exist to define the vertical distribution of juvenile salmonids.

Migration

Juvenile salmonids after entering the open sea were found to move in a counterclockwise direction close to shore along the Pacific Coast. This movement was found to be concentrated in a belt, the width of which appears to be related to that of the continental shelf. The width of the coastal belt along the British Columbia and Southeast Alaska coasts was estimated at approximately 37 km. Along the northern Gulf of Alaska coast, where the continental shelf is relatively wide, the coastal belt was found to be somewhat larger (Royce et al. 1968). The counterclockwise movement presumably is influenced by the surface currents known as the Alaska gyre.

Before ending the discussion of juveniles in the offshore waters, it is important to note the salmonid stocks that migrate through this area. Tag returns have indicated that juvenile sockeye from the Fraser River and coho and steelhead from streams as far south as the coast of Oregon are present in the *Kodiak region* by late August (Hartt and Dell 1976 MS).

Thus the *Kodiak region* apparently is an important feeding area for juvenile salmonids from distant as well as nearby production areas.

ADULT SALMONIDS IN OFFSHORE WATERS

Additional information on the distribution and migrations of salmon in the *Kodiak region* is available from high seas sampling by means of longline gear. Although other gears were also used, longline catches provided the most complete time - space coverage for present purposes. The research on which the following discussion is based was conducted by Canada and the United States for the International North Pacific Fisheries Commission (INPFC) whose objective is to determine the distribution and stock identity of salmonids in the North Pacific Ocean and Bering Sea. Much of this work has been summarized both on an individual species basis (French et al. 1976 MS; Godfrey 1965; Godfrey et al. 1973; Major et al. 1976 MS; Manzer et al. 1965; Mason 1964; Neave et al. 1967; Neave et al. 1976 MS; Shepard et al. 1968; Sutherland 1973; Takagi et al. 1976 MS) and also on a more general basis (Neave 1964; Royce et al. 1968).

The best information is that for sockeye, chum, and pink salmon because of their abundance. Catches of coho and chinook salmon and steelhead trout were too small for critical conclusions. It should be mentioned also, that longlines rarely catch age .0 salmon, or age .1 sockeye or chum salmon because of their small size. Thus, the catch data refer primarily to age .2 and older sockeye and chum salmon which will necessarily include some immature fish. All pinks and essentially all cohos caught by longline are maturing fish (age .1). The few chinooks and steelhead might be either mature or immature. For present purposes, maturity will be ignored, since the great majority of longline catches near Kodiak is of maturing fish.

The distribution, abundance and timing of salmonids in the offshore waters of the *Kodiak region* will be presented using longline catches for the years 1961-67. The abundance and distribution of salmonids are presented in Figs. 40-46 which present the catch per 1,000 hooks of longline gear in the *Kodiak region*. Although substantial differences between the oceanic distributions of salmonid species can be noted, their general patterns of occurrence and seasonal movements have much in common. The discussion of the pattern of salmonid movements will begin with the juveniles as they move offshore.

Distribution and Abundance

The winter distribution and relative abundance of salmonids in the *Kodiak region* are presented in Fig. 40. Somewhat surprising are the large catches of sockeye made in the *Kodiak region* at this time of year, a period when salmonids are concentrated at the southern limits of their offshore distribution. These fish which were caught in late January were primarily sockeye that had spent at least two or more winters in the ocean and indicate that at least some proportion of the sockeye stocks use the offshore waters of the *Kodiak region* to overwinter. The lack of catches for the other species may suggest that they do not overwinter in this area or that they are not available to longline gear because of vertical migration or feeding (INPFC Annual Report 1964).

The spring distribution of salmonids in the *Kodiak region* appears similar to that seen in the winter with the addition that chum are also seen in the longline catches (Figs. 41 and 42). In fact the CPUE for sockeye and chum indicates similar abundances in the *Kodiak region* through June (Fig. 43). Also apparent in June is the initial influx of large numbers of pink salmon and smaller numbers of both coho and steelhead in the *Kodiak region*. As to be expected, relatively large catches of all species continue through July (Fig. 44) as salmonids move through the *Kodiak region* on their spawning migration. Unfortunately, little sampling was done in August (Fig. 45) so that information on the abundance and distribution of salmonids is less complete than in June and July. However, comparatively large catches in the area immediately south of Kodiak Island indicate large numbers of most species are still present within the *Kodiak region*. The lack of catches in September (Fig. 45) reflects the fact that the peak of the spawning migration has passed, resulting in few fish being present in the Kodiak area.

In summary then, longline catches indicate that the relative abundance of salmonids in offshore areas of the Kodiak district increases in the early spring, peaks in July, and decreases gradually with few fish being present after August.

Vertical Distribution

Although more data exist on the vertical distribution of salmonids in the high seas than in any other area, the issue is still unclear. Early research (Barnaby 1952, Fukuhara 1953, Hanavan 1958) indicated the salmonids were concentrated in the upper 10 m in the high seas. Later research has shown a much deeper range of occurrence with sockeye and chum being caught up to 200 ft, pinks as deep as 80 ft, and coho as deep as 40 ft (Manzer 1964). In summary, the vertical distribution of adult salmonids is probably confined to the upper 200 m of offshore waters but more specific conclusions require new data.

Migration

Although little data exist on the winter migrations of young salmonids from the Kodiak area after they depart the coastal belt, their movement can be inferred from their distribution in the early spring when they are spread broadly throughout the southern Gulf of Alaska between about 45° and 50°N latitude. Their presence in this area dictates that the young salmonids must have migrated south sometime in the fall or winter where they intermingle with older fish. The older immatures and the mature fish tend to be distributed north of the age .1 immatures at this time. Probably in response to warming temperatures, mature and immature salmonids move northward in the spring, a movement that continues into the summer months. In June mature fish begin disappearing from the high seas catches as they enter nearshore waters in June and July, depending on species. The immature salmonids, after reaching the northern limit of their offshore distribution in the summer, which includes Kodiak and Shumagin Island coastal waters, turn westward and southwestward on a counterclockwise feeding migration. They are mixed with many stocks, including those from western Alaska and even Asia. As temperatures decrease in the fall, salmonids again move south where they are joined sometime during the winter by a new year class of juvenile salmonids. The cycle just described is repeated annually with mature fish leaving offshore grounds in the spring and early summer, and juveniles joining the offshore salmonid population sometime in the fall and winter.

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Table 1. Specific and common names of anadromous Pacific Coast[1] salmonids

Specific name	Common names
Oncorhynchus gorbuscha	pink or humpback salmon
O. keta	chum or dog salmon
O. kisutch	coho or silver salmon
O. nerka	sockeye or red salmon
O. tshawytscha	chinook or king salmon
Salmo clarki clarki	sea-run or coastal cutthroat trout
Salmo gairdneri	steelhead trout
Salvelinus malma	Pacific or dolly varden char

[1]Refers only to North American waters.

Table 2. Summary of general life history features of salmonids in Alaska

Species	Fresh-water habitat	Duration of time in fresh-water as juvenile	Duration of time in marine habitat (years)	Year of life at spawning	Average weight (pounds)	Average fecundity (eggs)
Pink	Short coastal streams	Less than 1 day	1	2	4.0	2,000
Chum	Short coastal streams and major rivers	Less than 1 month	2-6	3-7	8.0	3,000
Sockeye	Short streams and lakes	12-36 months	1-4	3-8	6.0	3,500
Coho	Short coastal streams, lakes and tributaries of major rivers	12-24 months	0-2	2-4	9.0	3,500
Chinook	Major rivers	3-12 months	1-6	2-8	20.0	4,000
Sea-run cutthroat	Short coastal streams	12-24 months	1-3	2-10	2.5	800
Steelhead	Short and long streams	12-48 months	1-5	2-7	8.0	8,000
Pacific char	Short streams	36-48 months	2-3	5-6	2.0	2,000

Sources: Armstrong (1963), Bailey (1969), Hart (1973), Jones (1974), Sheppard (1972).

Table 3. Value[1] of major Alaska natural resources production (Table 2 from Rogers 1973)

Calender year	Crude petroleum and natural gas	Fisheries products	Other minerals	Forest products	Furs	Commercial agricultural products	Total natural resource production
			Dollar value[2] (Millions)				
1950	--	100.2	17.7	6.1	4.4	2.2	130.6
1955	--	69.7	23.6	29.5	4.6	3.4	130.8
1960	1.5	96.7	20.4	47.3	4.8	5.4	176.1
1961	17.8	128.7	16.9	48.0	4.2	5.5	221.1
1962	31.7	131.9	22.5	52.3	4.3	5.8	248.5
1963	33.8	109.0	34.0	54.1	4.4	5.5	240.8
1964	35.5	140.9	30.6	61.0	4.4	5.5	278.0
1965	35.6	166.6	47.6	57.5	5.8	5.2	318.3
1966	50.4	197.3	35.9	73.7	7.0	5.5	369.8
1967	95.5	126.7	39.2	81.5	5.5	5.5	353.9
1968	191.1	191.7	30.6	94.8	6.0	5.3	519.5
1969	218.7	137.7	25.9	106.0	6.0	4.5	498.8
1970	250.0	150.0	30.0	108.0	6.0	5.0	549.0
1975	900.0	200.0	50.0	150.0	6.0	7.0	1,313.0
1980	2,200.0	200.0	80.0	160.0	6.0	8.0	2,654.0

Table 3. Value[1] of major Alaska natural resources production (Table 2 from Rogers 1973) - continued

Calendar year	Crude petroleum and natural gas	Fisheries products	Other minerals	Forest products	Furs	Commercial agricultural products	Total natural resource production

[1] *Fisheries products:* Wholesale market value, final stage of processing within Alaska.

Petroleum and natural gas: Crude oil and natural gas at well-heads price. Does not include estimate of value by manufacturing.

Other minerals: Average selling price of refined metals as computed by U.S. Bureau of Mines; land, gravel, stone at estimated value to construction industry.

Forest products: Value of pulp and lumber f.o.b. mill.

Furs: Raw fur value, includes U.S. share of sales of Pribilof furs at auction.

Commercial agricultural products: Wholesale market values.

[2] *All dollar values:* In unadjusted current dollars. 1970-80 estimates computed at 1968 unit values.

SOURCES: U.S. Department of the Interior agencies, Alaska Department of Natural Resources, Alaska Department of Fish and Game estimates by G. W. Rogers.

Table 4. Summary of catch statistics (1925-1972) in thousands of fish for the *Kodiak region* by district and by species

Area	Sockeye	Pink (odd year)	Pink (even year)	Chum	Coho	Chinook	Total[1]
a) Alaska Peninsula - South							
Average catch	990.0	2779.2	3179.6	1124.3	83.8	6.9	5184.4
95% Confidence interval	±231.6	±955.5	±1119.9	±166.4	±21.9	±1.7	
Peak catch[2]	3662.0 (1936)	9302.0 (1937)	9471.0 (1936)	2428.9 (1929)	284.5 (1936)	21.7 (1943)	15783.6
1975 catch	243.5	60.6	--	130.8	0.1	0.1	435.1
b) Chignik							
Average catch	724.3	463.0	586.4	152.0	17.1	0.9	1419.0
95% Confidence interval	±241.1	±217.1	±213.0	±30.3	±5.6	±0.2	
Peak catch[2]	2084.8 (1947)	1779.6 (1969)	1683.4 (1964)	464.6 (1970)	101.4 (1928)	3.4 (1969)	4385.7
1975 catch	399.6	66.2	--	25.2	53.3	0.6	544.9
c) Kodiak							
Average catch	1017.6	5946.8	6827.7	613.2	81.7	1.6	8102.3
95% Confidence interval	±203.3	±1851.5	±1463.9	±96.2	±18.2	±0.3	
Peak catch[2]	3015.4 (1926)	16787.1 (1937)	14113.9 (1962)	1514.4 (1971)	290.6 (1928)	4.9 (1930)	20275.8
1975 catch	136.4	1900.3	--	84.4	23.7	0.1	2144.9
d) Cook Inlet							
Average catch	1405.4	473.7	1770.1	406.9	289.7	60.6	3284.5
95% Confidence interval	±154.6	±160.6	±482.6	±98.1	±39.1	±11.7	
Peak catch[2]	2642.3 (1950)	1457.1 (1943)	4823.0 (1962)	1402.4 (1964)	644.8 (1942)	187.5 (1951)	8017.0
1975 catch	712.2	1239.5	--	962.1	233.4	4.9	3152.1
e) Resurrection Bay							
Average catch	14.9	25.9	75.2	2.5	1.9	<0.1	69.9
95% Confidence interval	±13.7	±30.0	±38.7	±1.4	±1.4	--	
Peak catch[2]	99.4 (1969)	119.7 (1971)	144.8 (1968)	40.9 (1973)	6.2 (1955)	1.0 (1957)	279.7
1975 catch	0.7	35.9	--	3.7	0.1	<0.1	40.4
					TOTAL:	Average catch	18060.1
						Peak catch	48741.8
						1975 catch	6317.4

[1]District totals determined by summing sockeye, chum, coho, chinook and the mean of even- and odd-year pink salmon average annual catches.

[2]Number in parentheses indicates year peak catch occurred.

Source: Tables 71, 73-73 INPFC Secretariat MS, Alaska Department of Fish and Game.

Table 5. Population[1] estimates of total run size of adult salmonids in the *Kodiak region* by district and by species in thousands of fish based on catch statistics, 1925-72

Area	Sockeye	Pink (odd-year run)	Pink (even-year run)	Chum	Coho	Chinook	Total
a) Alaska Peninsula - South							
Average run	1414.3	3970.3	4542.3	1606.1	119.7	9.9	7406.3[2]
Peak run	5231.4	13288.6	13530.0	3469.9	406.4	31.0	22547.7
b) Chignik							
Average run	1034.7	661.4	837.7	217.1	24.4	1.3	2027.1
Peak run	2978.3	2542.3	2404.9	663.7	144.9	4.9	6265.4
c) Kodiak							
Average run	1453.7	8498.3	9753.9	876.0	116.7	2.3	11574.7
Peak run	4307.7	23981.6	20162.7	2163.4	415.1	7.0	28965.3
d) Cook Inlet							
Average run	2007.7	676.7	2528.7	581.3	413.9	86.6	4692.2
Peak run	3774.7	2081.6	6890.0	2003.4	921.1	267.9	11452.9
e) Resurrection Bay							
Average run	21.3	37.0	107.4	3.6	2.7	0.1	99.9
Peak run	142.0	171.0	206.9	58.4	8.9	1.4	399.7
				TOTAL:	Average run		25800.2
					Peak run		69631.0

[1]Total run is based upon catches in Table 4 and is derived by assuming catch represents 70% of the total run.

[2]Area totals determined by summing sockeye, chum, coho, chinook, and mean of even- and odd-year pink salmon estimates.

Source: INPFC Secretariat MS.

Table 6. The percent contribution[1] of each species to the commercial catch within districts and for the entire *Kodiak region* based on catch statistics, 1925-72

Area	Sockeye	Pink (odd year)	Pink (even year)	Chum	Coho	Chinook	Total
a) Alaska Peninsula - South							
% individual district	19	54	61	22	2	<1	100
% *Kodiak region*	5	15	18	6	<1	<1	28
b) Chignik							
% individual district	51	33	41	11	1	<1	100
% *Kodiak region*	4	3	3	1	<1	<1	9
c) Kodiak							
% individual district	12	84	96	9	1	<1	100
% *Kodiak region*	6	33	38	3	<1	<1	44
d) Cook Inlet							
% individual district	43	14	54	12	9	2	100
% *Kodiak region*	8	3	10	2	2	<1	19
e) Resurrection Bay							
% individual district	21	37	99	4	3	1	100
% *Kodiak region*	<1	<1	<1	<1	<1	<1	3

[1]From Table 4.

Table 7. The percent contribution[1] of each statistical area to the commercial catch within each statistical district and within the entire *Kodiak region* by species based on catch statistics, 1956-72. The percent contribution to the *Kodiak region* is in parentheses

Statistical area	Sockeye	Pink (even year)	Pink (odd year)	Chum	Coho	Chinook	Total *Kodiak region*[2]
			a) Alaska Peninsula - South				
281	2 (1)	10 (4)	11 (5)	3 (1)	<1 (<1)	<1 (<1)	5
282	3 (1)	18 (7)	12 (5)	4 (2)	1 (<1)	<1 (<1)	6
283	1 (2)	31 (13)	30 (12)	10 (4)	<1 (<1)	<1 (<1)	12
284	13 (5)	4 (1)	2 (1)	5 (2)	<1 (<1)	<1 (<1)	5
			b) Chignik				
271	46 (5)	4 (<1)	2 (<1)	1 (<1)	<1 (<1)	<1 (<1)	4
272	5 (1)	25 (3)	3 (<1)	6 (1)	<1 (<1)	<1 (<1)	3
273	1 (<1)	9 (1)	12 (1)	4 (<1)	<1 (<1)	<1 (<1)	1
275	<1 (<1)	9 (1)	15 (2)	<1 (<1)	<1 (<1)	<1 (<1)	1
			c) Kodiak				
251	<1 (<1)	6 (4)	3 (2)	<1 (<1)	<1 (<1)	<1 (<1)	2
252	<1 (<1)	8 (5)	3 (2)	1 (<1)	<1 (<1)	<1 (<1)	3
253	1 (1)	11 (7)	7 (4)	1 (<1)	<1 (<1)	<1 (<1)	5
254	1 (1)	6 (4)	10 (7)	1 (1)	<1 (<1)	<1 (<1)	5
255	3 (2)	7 (4)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	3
256	2 (1)	10 (7)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	3
257	2 (1)	10 (7)	20 (13)	1 (<1)	<1 (<1)	<1 (<1)	7
258	<1 (<1)	16 (10)	26 (16)	1 (1)	<1 (<1)	<1 (<1)	9
259	<1 (<1)	9 (6)	9 (6)	1 (<1)	<1 (<1)	<1 (<1)	4
262	2 (1)	4 (3)	2 (1)	2 (1)	<1 (<1)	<1 (<1)	3

Table 7. The percent contribution[1] of each statistical area to the commercial catch within each statistical district and within the entire *Kodiak region* by species based on catch statistics, 1956-72. The percent contribution to the *Kodiak region* is in parentheses - continued

Statistical area	Sockeye	Pink (even year)	Pink (odd year)	Chum	Coho	Chinook	Total *Kodiak region*[2]
			d) Cook Inlet				
241	1 (<1)	9 (2)	2 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	1
242	<1 (<1)	10 (3)	10 (3)	1 (<1)	<1 (<1)	<1 (<1)	2
243	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1
244	32 (8)	28 (7)	<1 (<1)	7 (2)	3 (1)	1 (<1)	11
245	6 (1)	3 (1)	<1 (<1)	<1 (<1)	2 (<1)	<1 (<1)	2
246	2 (1)	<1 (<1)	<1 (<1)	<1 (<1)	1 (<1)	<1 (<1)	1
247	4 (1)	8 (2)	<1 (<1)	1 (<1)	3 (1)	1 (<1)	2
248	<1 (<1)	1 (<1)	1 (<1)	1 (<1)	<1 (<1)	<1 (<1)	<1
			e) Resurrection Bay				
231	12 (<1)	6 (<1)	71 (<1)	1 (<1)	9 (<1)	<1 (<1)	<1
232	8 (<1)	30 (<1)	33 (<1)	3 (<1)	44 (<1)	<1 (<1)	<1
233	<1 (<1)	1 (<1)	4 (<1)	<1 (<1)	5 (<1)	<1 (<1)	<1

[1]Percent contribution calculated by dividing average annual catch in each area by species by the total catch of all species in each district or in the *Kodiak region.*

[2]Totals do not add due to rounding errors.

Table 8. Population estimates of total run size of adult salmonids of the *Kodiak region* by statistical area and by species in thousands of fish. The peak population estimates are in parentheses

Statistical area	Sockeye	Pink (even year)	Pink (odd year)	Chum	Coho	Chinook	Total
			a) Alaska Peninsula - South				
281	113.1 (418.5)	772.2 (2300.1)	833.8 (2790.6)	208.8 (451.1)	23.9 (81.3)	0.9 (2.8)	1149.8 (3499.0)
282	254.6 (941.7)	1317.3 (3923.7)	873.5 (2923.5)	289.1 (624.6)	62.2 (211.3)	5.7 (18.0)	1707.0 (5219.2)
283	113.1 (418.5)	2317.1 (6900.3)	2223.4 (7441.6)	754.9 (1630.9)	35.9 (121.9)	0.9 (2.8)	3175.0 (9345.1)
284	961.7 (3557.4)	272.5 (811.8)	119.1 (398.7)	385.5 (832.8)	1.2 (4.1)	2.5 (7.7)	1546.7 (5007.2)
			b) Chignik				
271	931.2 (2680.5)	75.4 (216.3)	39.7 (152.5)	19.5 (59.7)	7.3 (43.5)	0.6 (2.2)	1016.1 (4044.0)
272	103.5 (297.6)	502.6 (1441.7)	66.1 (254.2)	115.1 (351.8)	0.5 (2.9)	0.1 (0.5)	503.6 (1501.0)
273	10.3 (29.8)	184.3 (528.6)	251.3 (966.1)	84.7 (258.8)	2.4 (14.5)	0.5 (2.1)	315.7 (1032.6)
275	<10.0 (<30.0)	175.9 (504.6)	297.6 (1144.0)	4.3 (13.3)	13.7 (81.1)	0.1 (0.4)	264.8 (1450.7)
			c) Kodiak				
251	58.1 (172.3)	687.4 (1411.4)	339.9 (959.3)	17.5 (43.3)	24.5 (87.2)	0.3 (0.8)	614.0 (2616.5)
252	58.1 (172.3)	883.6 (1814.6)	339.9 (959.3)	61.3 (151.4)	23.9 (83.0	0.4 (1.1)	754.8 (1794.7)
253	159.9 (473.8)	1276.3 (2621.1)	764.8 (2158.3)	87.6 (216.3)	14.0 (49.8)	0.4 (1.1)	1282.4 (3130.7)
254	145.4 (430.8)	687.3 (1411.4)	1189.8 (3357.4)	105.1 (259.6)	3.5 (12.5)	0.2 (0.7)	1192.7 (5219.3)
255	319.8 (947.7)	785.4 (1613.0)	<85.0 (<240.0)	17.5 (43.3)	25.7 (91.3)	0.7 (2.1)	798.9 (2010.9)
256	218.0 (646.2)	1178.2 (2419.5)	<85.0 (<240.0)	8.8 (21.6)	9.3 (33.2)	0.4 (1.1)	868.1 (2031.9
257	218.0 (646.2	1178.2 (2419.0	2294.5 (6475.0)	70.1 (173.1)	5.8 (20.8)	<0.1 (<0.1)	2030.3 (5287.2)
258	29.1 (86.2)	1865.4 (3830.9)	2974.4 (8393.6)	92.7 (475.9)	10.5 (37.4)	<0.1 (<0.1)	2552.3 (6711.9)
259	29.1 (86.2)	1080.0 (2217.9)	1019.8 (2877.8)	87.6 (216.3)	3.5 (12.5)	<0.1 (<0.1)	1170.2 (2862.9)
262	232.6 (689.2)	490.9 (1008.1)	254.9 (719.4)	262.8 (649.0)	4.7 (16.6)	<0.1 (<0.1)	873.1 (2218.7)
			d) Cook Inlet				
241	40.2 (75.5)	404.6 (1102.4)	88.0 (270.6)	23.2 (80.1)	4.1 (9.2)	0.9 (2.7)	314.7 (854.0)
242	<20.0 (<38.0)	480.4 (1309.1)	487.2 (1498.8)	58.1 (200.3)	<4.0 (<9.0)	<1.0 (<3.0)	566.9 (1654.2)
243	<20.0 (<38.0)	25.3 (68.9)	13.5 (41.6)	5.8 (20.0)	<4.0 (<9.0)	<1.0 (<3.0)	50.2 (125.3)
244	1485.7 (2793.0)	1340.2 (3651.7)	20.3 (62.4)	325.5 (1121.9)	165.6 (368.4)	32.9 (101.8)	2689.9 (6242.2)
245	261.0 (490.7)	126.4 (344.5)	13.5 (41.6)	18.8 (340.6)	74.5 (165.8)	16.5 (50.9)	440.7 (1241.0
246	100.4 (188.7)	25.3 (68.9)	<7.0 (<21.0)	5.8 (20.1)	29.0 (64.5)	3.5 (10.7)	154.9 (329.0)
247	200.8 (377.4)	379.3 (1033.5)	13.5 (41.6)	52.3 (180.3)	140.7 (313.2)	29.4 (91.1)	619.6 (1499.6)
248	<20.0 (<36.0)	50.5 (137.8)	54.1 (166.5)	29.1 (100.2)	<4.0 (<9.0)	<1.0 (<3.0)	106.4 (302.3)
			e) Resurrection Bay				
231	11.9 (79.5)	5.6 (25.6)	70.9 (136.5)	0.6 (9.3)	2.5 (8.2)	<0.1 (0.6)	53.2 (178.6)
232	8.5 (56.8)	30.0 (138.5)	33.3 (64.1)	2.7 (44.4)	0.2 (0.6)	<0.1 (0.6)	43.0 (203.7)
233	0.1 (5.7)	1.5 (6.8)	4.3 (8.3)	0.3 (5.2)	<0.1 (0.1)	<0.1 (0.3)	3.6 (18.8)
						TOTAL	25800.2 (69631.0)

[1]Estimates determined by assuming catch represents 70% of the total run and were calculated from Tables 5 and 7.

Source: INPFC Secretariat MS, INPFC Statistical Yearbooks 1956-72.

Table 9. A summary of the timing of salmonid runs to the Kodiak Island district as indicated by reports in the literature (see text for sources)

Species	Freshwater entry	Peak of run	End of run
Pinks	June 28 - July 22	Late July - early September	August 15 - September 18
Sockeye	May 13 - July 28	Early June - mid-August	August - early October
Chum	July 20	August 1 - 15	September 5
Coho	August 1	September 12	October 15
Chinook	June 6	June 21 - July 3	July 25
Steelhead	May - August	June	July - October
Char	July	Late August	September

Table 10. A summary of the timing of salmonid runs to the Cook Inlet district as indicated by reports in the literature (see text for sources)

Species	Freshwater entry	Peak of run	End of run
Pink	June - July	Late July - mid-August	August - September
Sockeye	June - July	Late June - mid-August	Late August
Chum	Early July	Late July	September
Coho	Late July - August	August	December
Chinook	Mid - May	Early - late June	July - August
Steelhead	May - early August	Late August - September	Mid-October
Char	Late June - mid-July	Late July - mid-September	September - October

Table 11. A summary of the timing of salmonid runs to the Resurrection Bay district as indicated by reports in the literature (see text for sources)

Species	Freshwater entry	Peak of run	End of run
Pink	July 14 - July 30	August 1 - 12	August 11 - September
Sockeye	May 23 - June 12	June 21 - June 24	July 20 - September 20
Chum	-	-	-
Coho	August 1 - September 11	Late August - September 30	October 14 - November 11
Chinook	August	-	-
Steelhead	Late May	-	-
Char	June 15 - July 15	September 10 - 23	Late October - November 20

Table 12. Population estimates[1] of juvenile salmonids in the *Kodiak region* by district and by species at the time of estuarine entry in millions of fish

Area	Sockeye	Pink (odd year)	Pink (even year)	Chum	Coho	Chinook	Total
a) Alaska Peninsula - South							
Average population size	7.4	59.6	68.1	36.1	0.6	<0.1	108.1[2]
Peak population size	27.5	199.3	202.9	78.1	2.1	0.2	309.0
b) Chignik							
Average population size	10.9	19.8	25.1	9.8	0.3	<0.1	43.4[2]
Peak population size	31.3	76.3	72.1	30.0	1.5	0.1	136.9
c) Kodiak							
Average population size	15.3	254.9	294.5	39.4	1.2	<0.1	330.7[2]
Peak population size	45.2	719.5	604.9	97.3	4.4	0.1	809.2
d) Cook Inlet							
Average population size	21.1	20.3	75.9	26.2	4.3	1.0	100.7
Peak population size	39.6	62.4	206.7	90.2	9.7	3.2	277.2
e) Resurrection Bay							
Average population size	0.2	1.1	3.2	0.2	<0.1	<0.1	2.6[2]
Peak population size	3.0	51.3	6.2	2.6	0.1	<0.1	33.0
			TOTAL:	Average population size			585.5
				Peak population size			1565.3

[1]Based upon estimates of spawners and survival - see text.

[2]Total calculated by summing estimated numbers of sockeye, chum, coho, and chinook salmon juveniles plus mean of the estimated numbers of even- and odd-year pink salmon juveniles.

Table 13. A summary of available information on the timing of estuarine entry of juvenile salmonids in the Kodiak region (see text for source)

Species	Beginning	Peak	End of entry
Sockeye	April - early June	May 17 - June 26	June - July 30
Pink	April - May	-	May - June
Chum	-	-	-
Coho	May - July 16	June 5 - August 20	July 15 - October 21
Chinook	June 24	June 15	July 20
Steelhead	May 23 - June 19	Early July	July 3 - September 11
Char	April 3 - June 6	May 11 - June 6	June 6 - late June

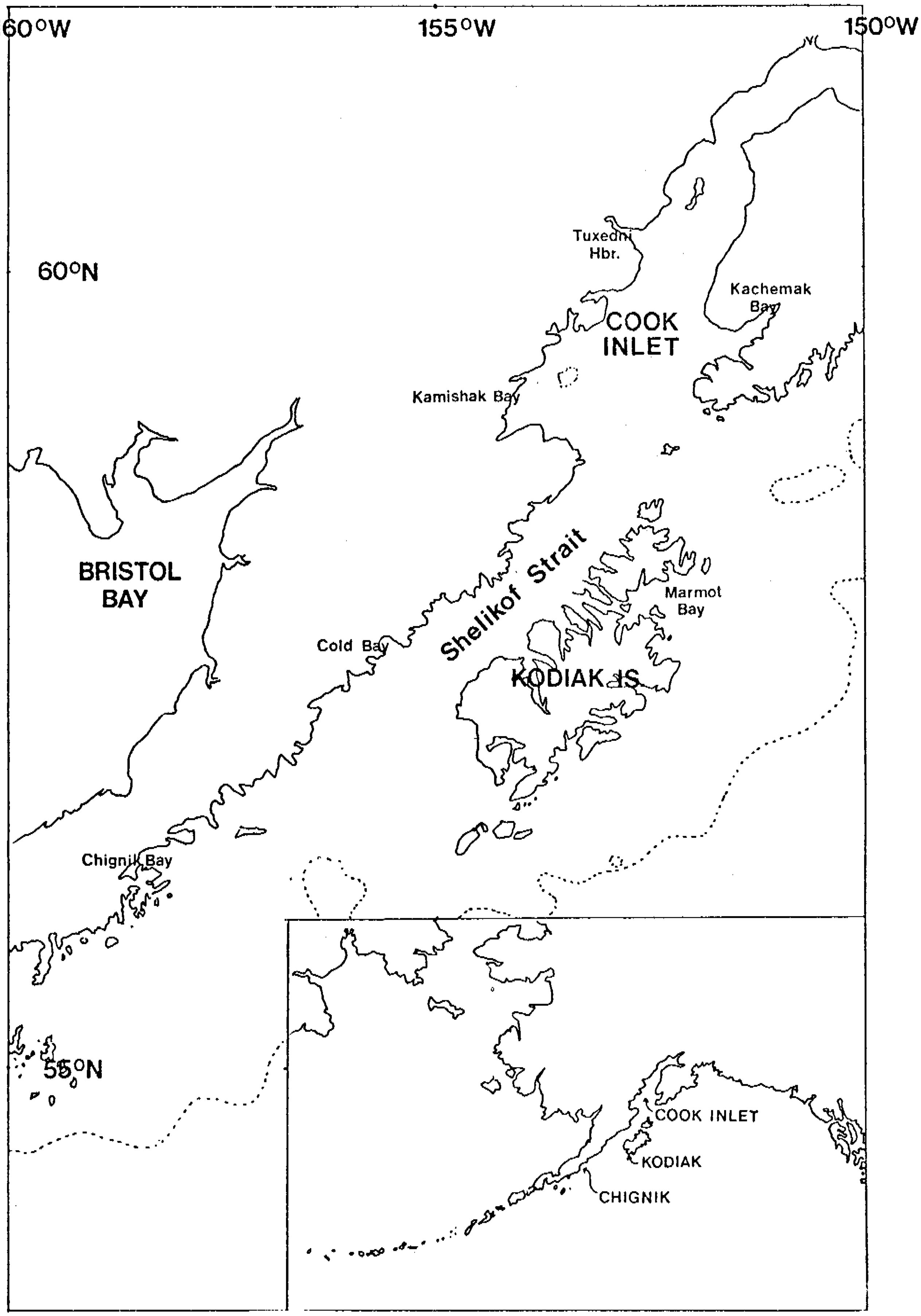


Fig. 1. Map of the area covered by the first interim report which includes marine waters as described in the text of the northern Gulf of Alaska (does not include Bristol Bay). The dotted line offshore indicates the hundred fathom depth line.

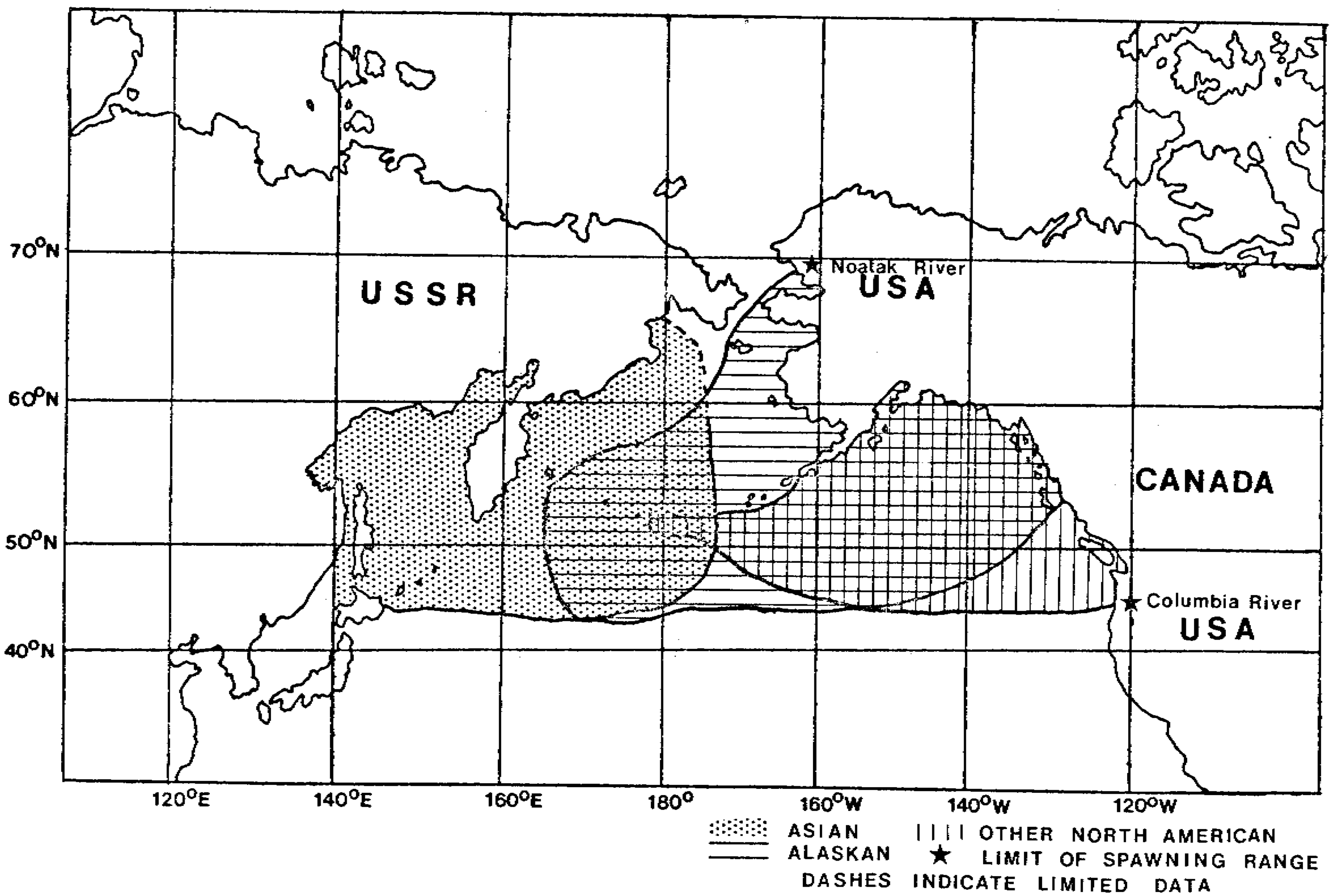


Fig. 2. The range of spawning stocks and offshore distribution of sockeye salmon.

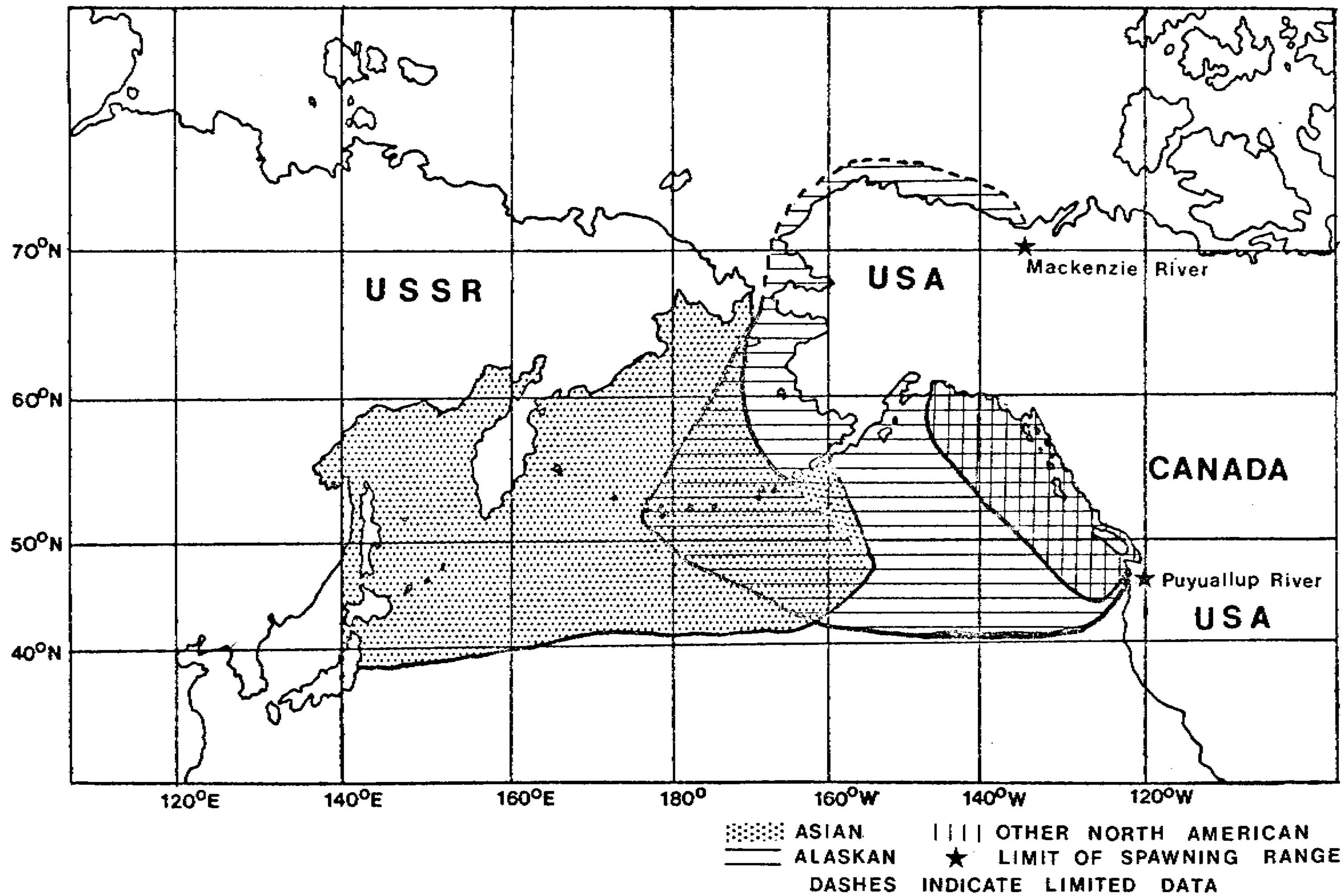


Fig. 3. The range of spawning stocks and offshore distribution of pink salmon.

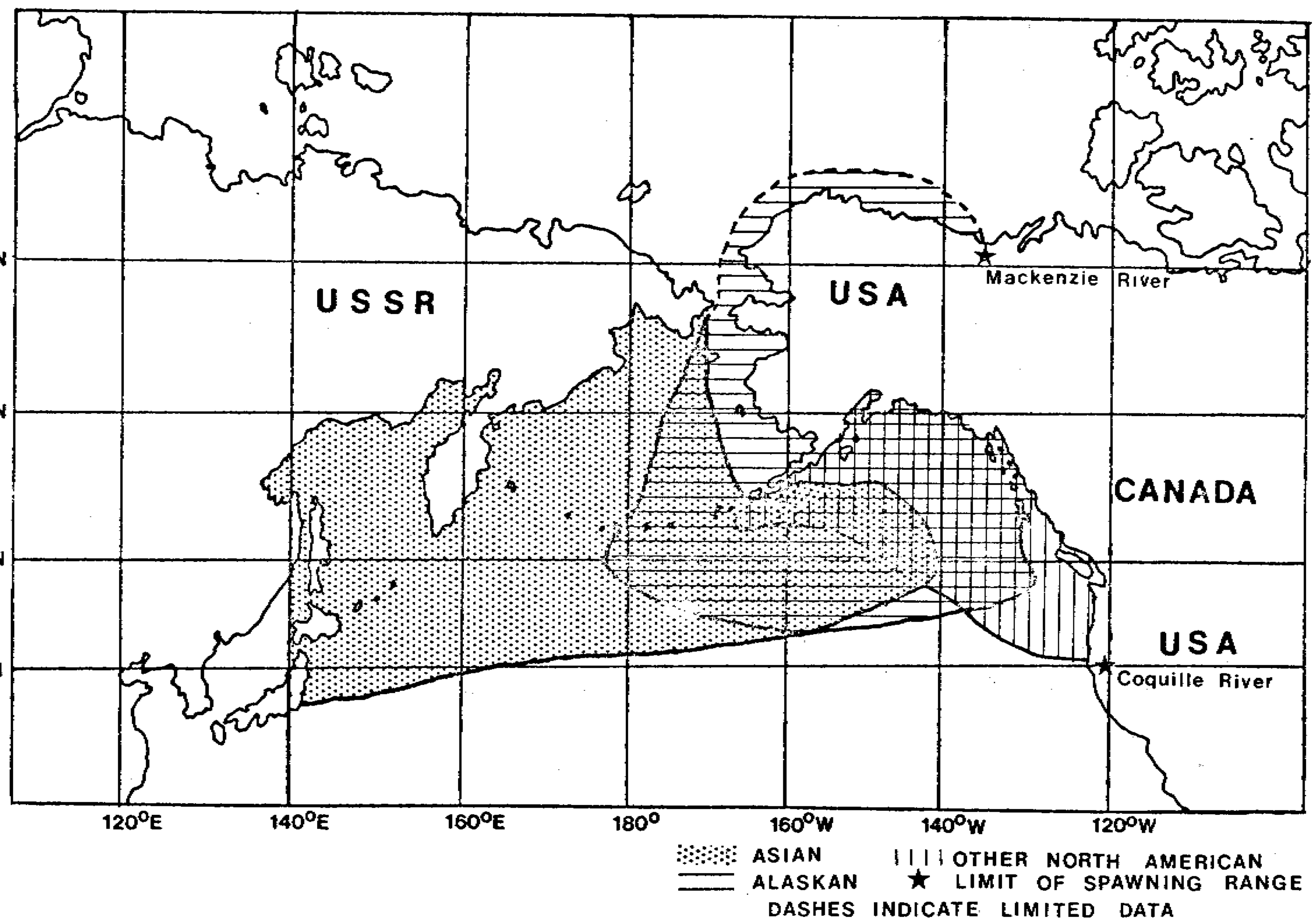


Fig. 4. The range of spawning stocks and offshore distribution of chum salmon.

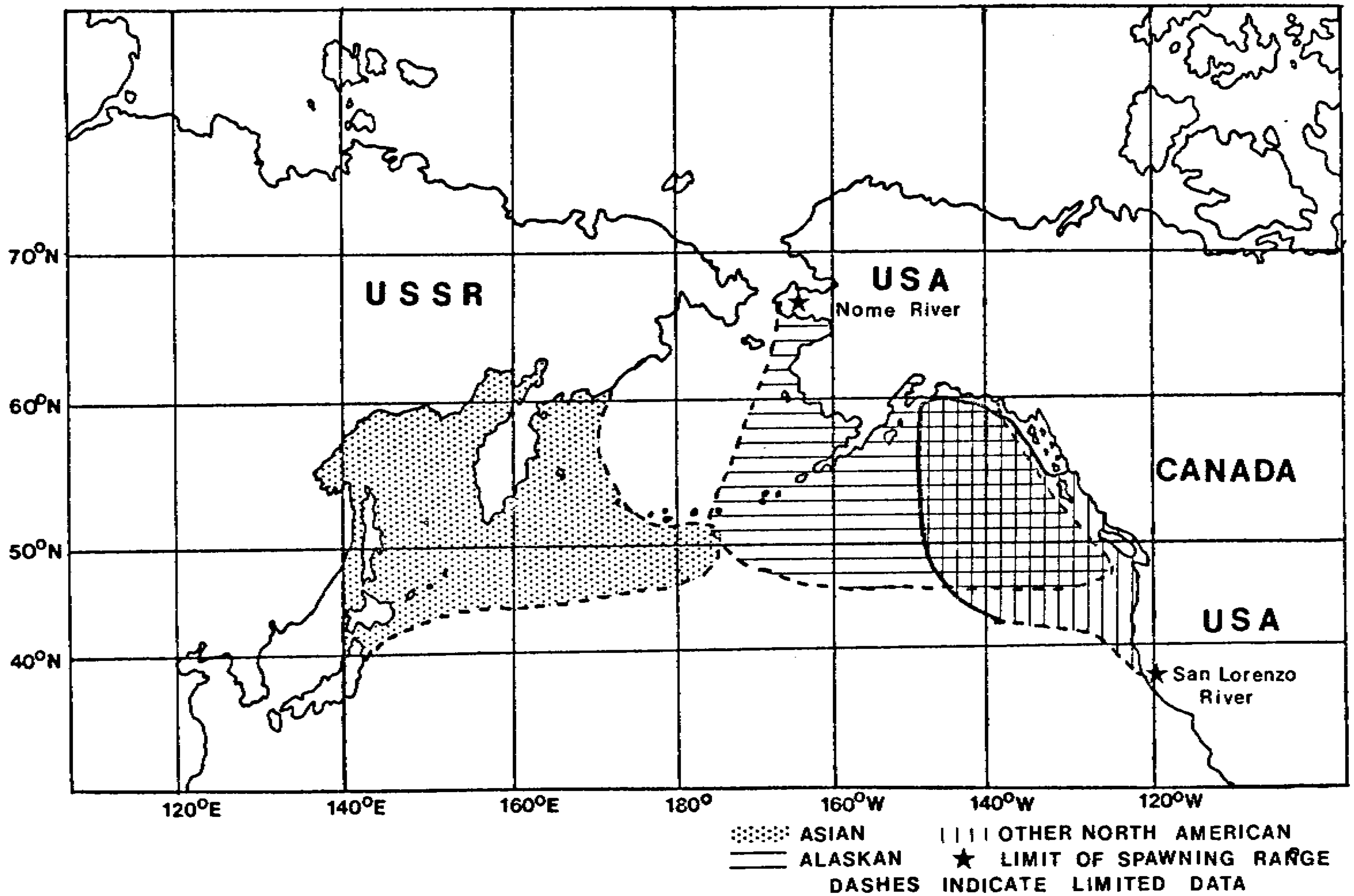


Fig. 5. The range of spawning stocks and offshore distribution of coho salmon.

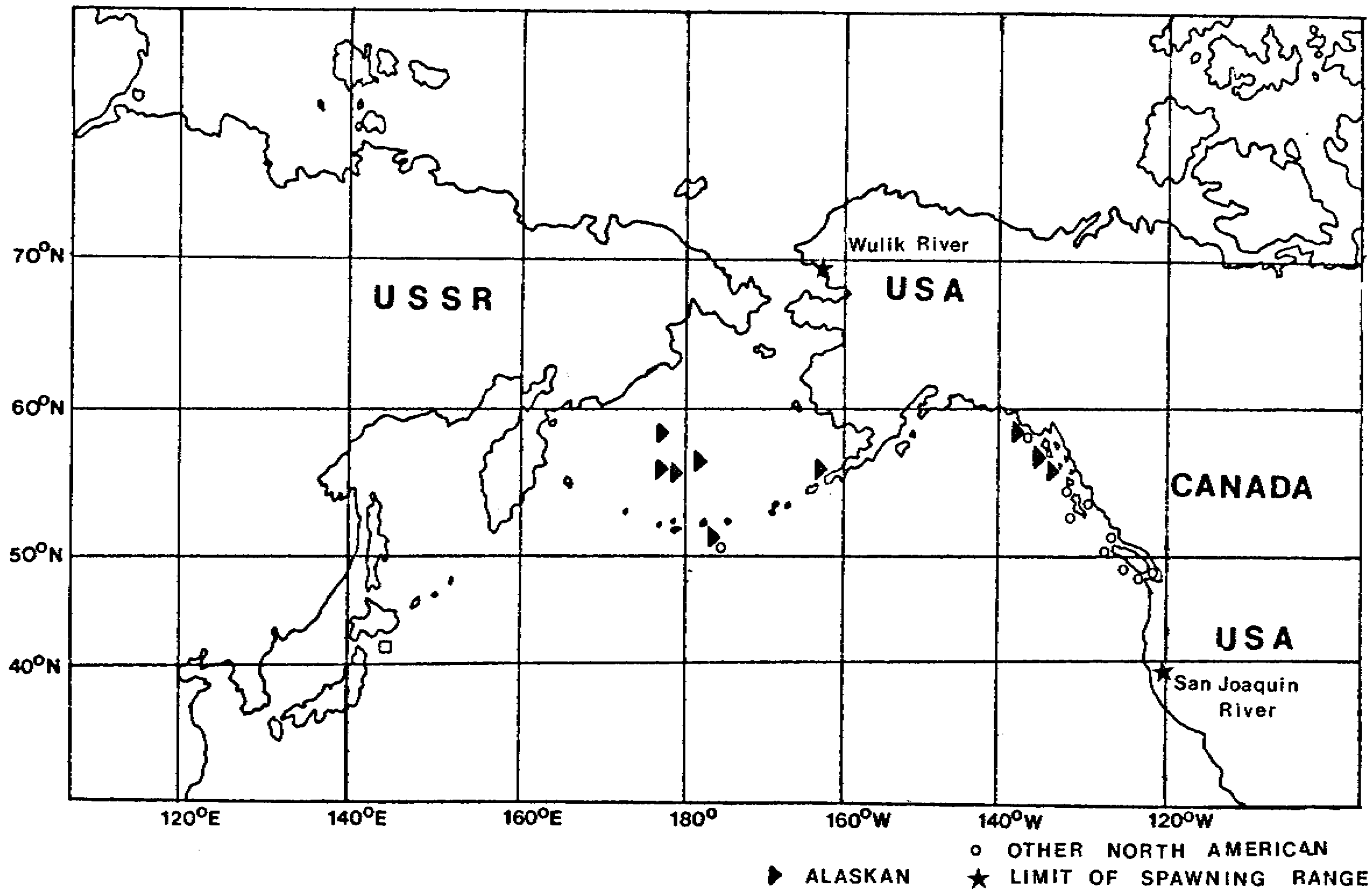


Fig. 6. The range of North American spawning stocks and offshore distribution of chinook salmon.

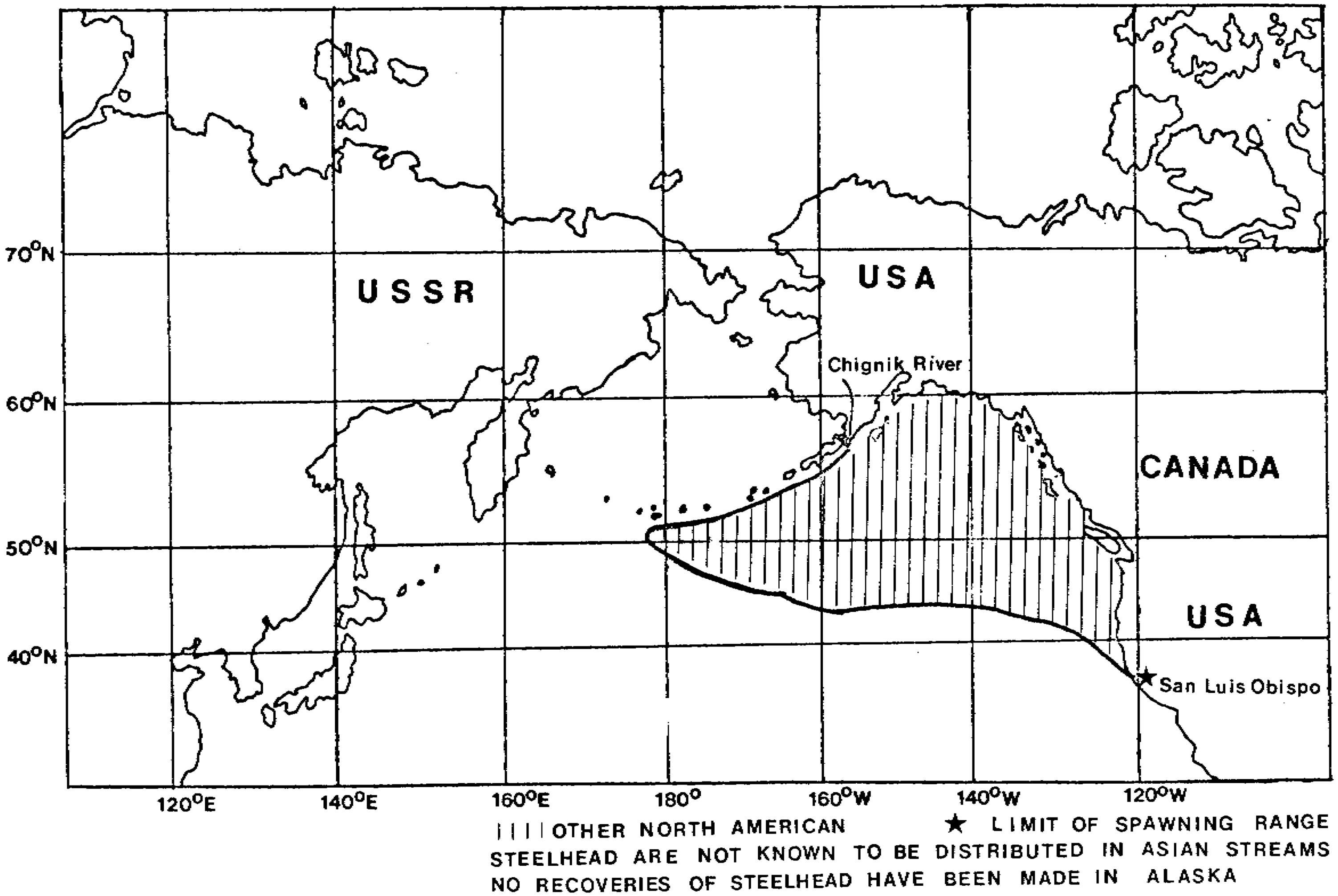


Fig. 7. The range of North American spawning stocks and offshore distribution of steelhead trout.

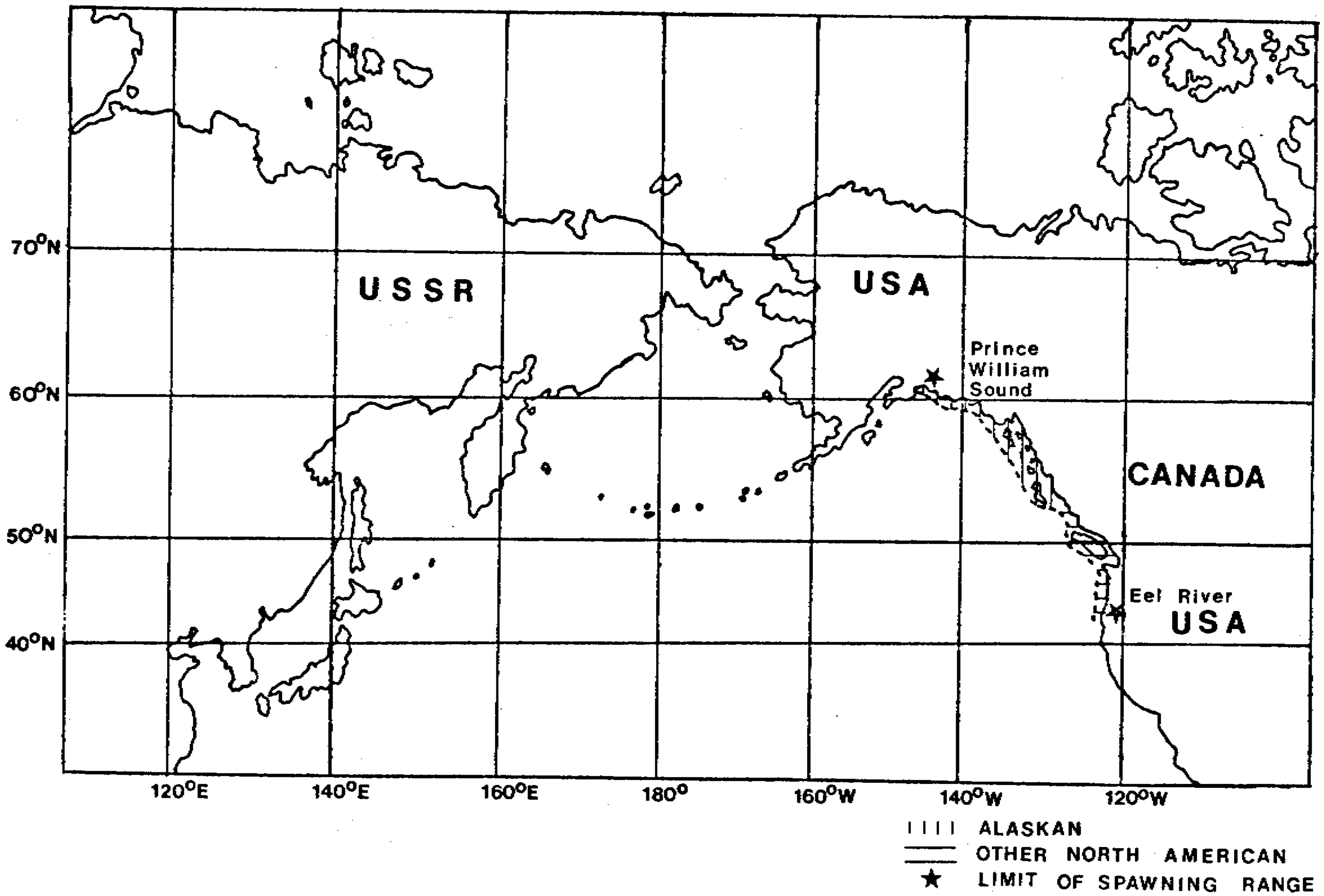


Fig. 8. The range of North American spawning stocks and offshore distribution of sea-run cutthroat trout.

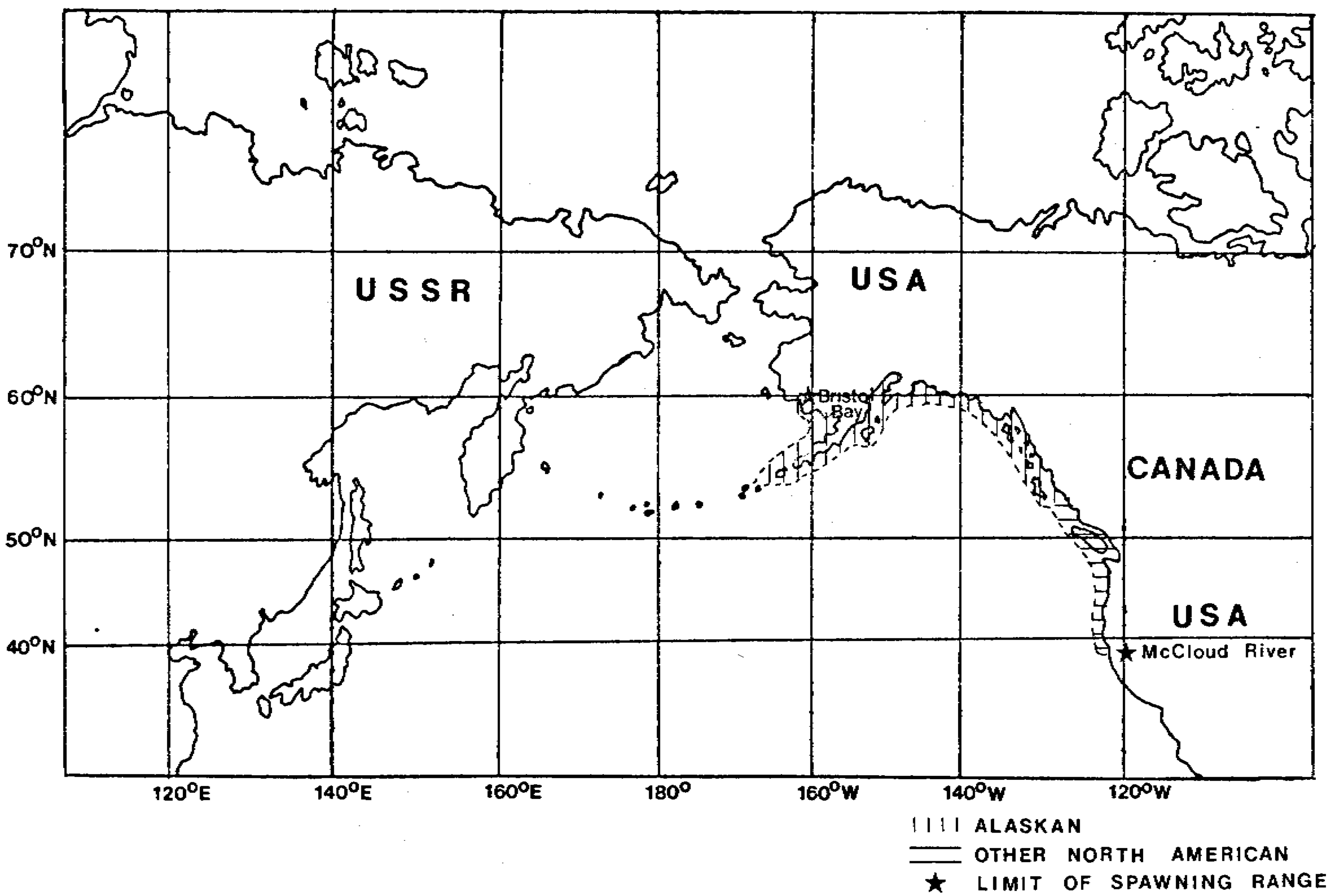


Fig. 9. The range of North American spawning stocks and offshore distribution of Pacific char.

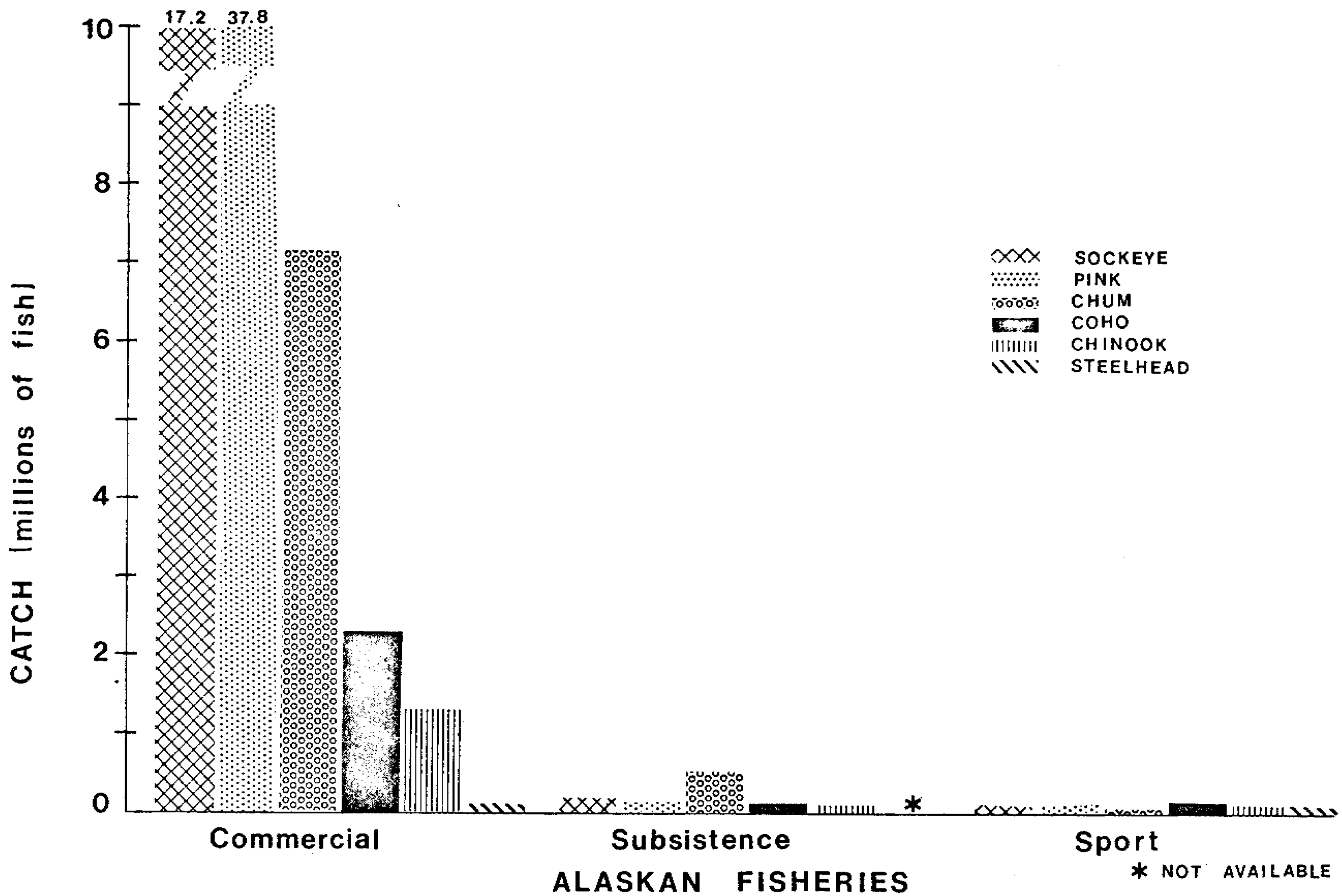


Fig. 10. The average annual catch of salmonids by the Alaskan commercial (1925-75), subsistence (1970-72, 1974, 1975), and sport (1965-72, 1974, 1975) fisheries.
Sources: INPFC Historical catch statistics MS; Costello (1972), Alaska Department of Fish and Game.

Fig. 11. Statistical districts of the Alaskan commercial salmon fishery.

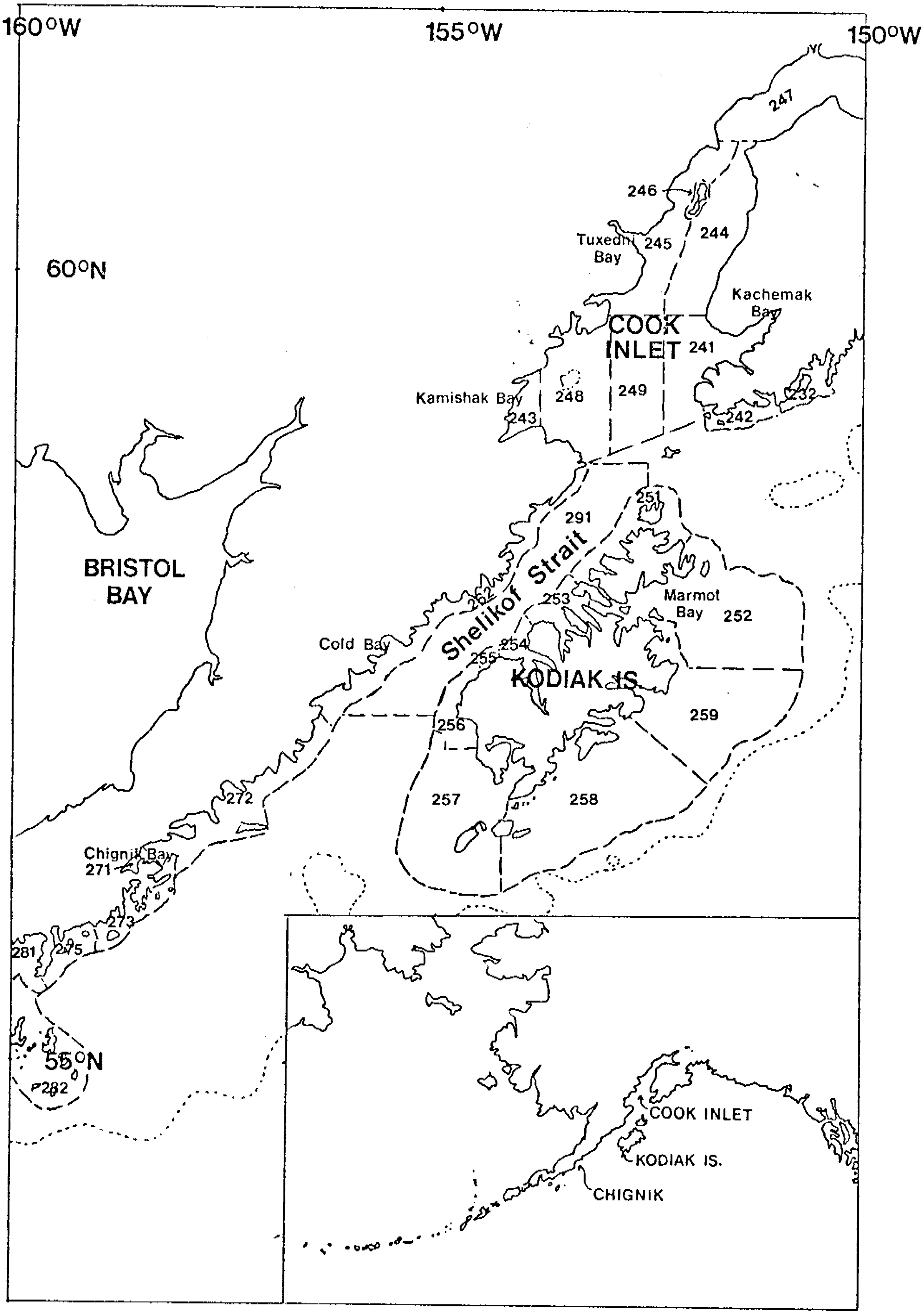


Fig. 12. Statistical areas (which are subdivisions of statistical districts) of the *Kodiak region* as used by the Alaska Department of Fish and Game for partitioning commercial salmon catches. Areas 283 and 284, lying west of 160°W are not shown.

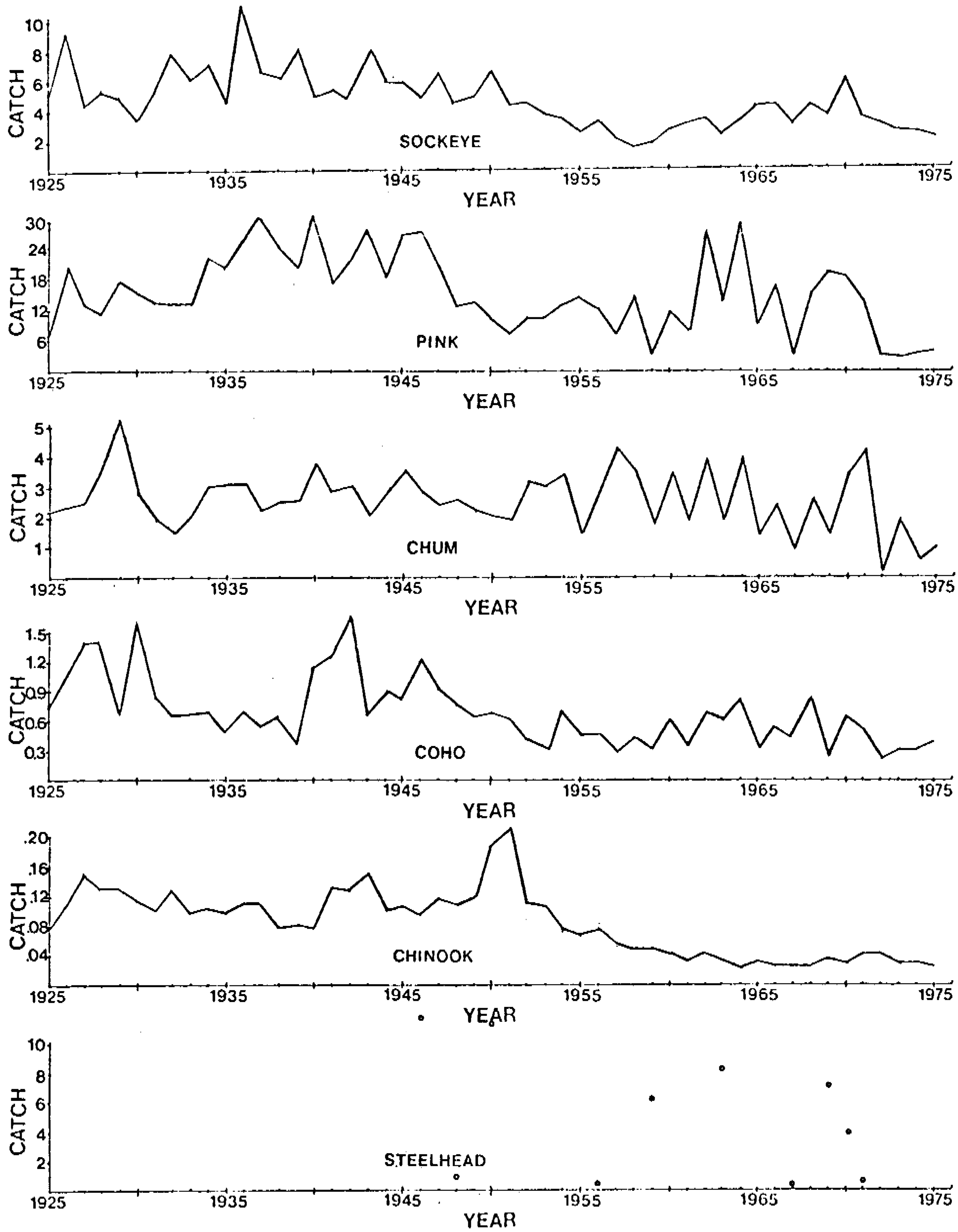
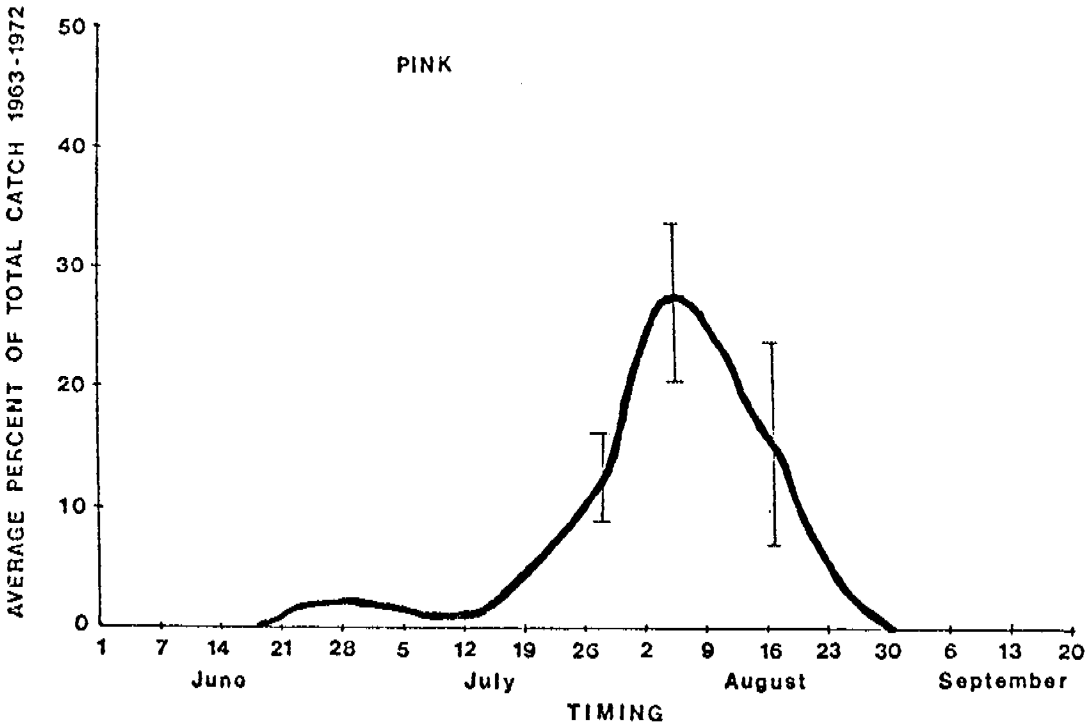


Fig. 13. Commercial catches of salmonids by year (1925-75) in Central Alaska. Units of catch for steelhead are thousands of fish. Units of catch for other species are millions of fish.
Sources: INPFC Secretariat (MS), INPFC Statistical Yearbooks (1972-74), NMFS Statistical Digest (1925-72), Alaska Department of Fish and Game.



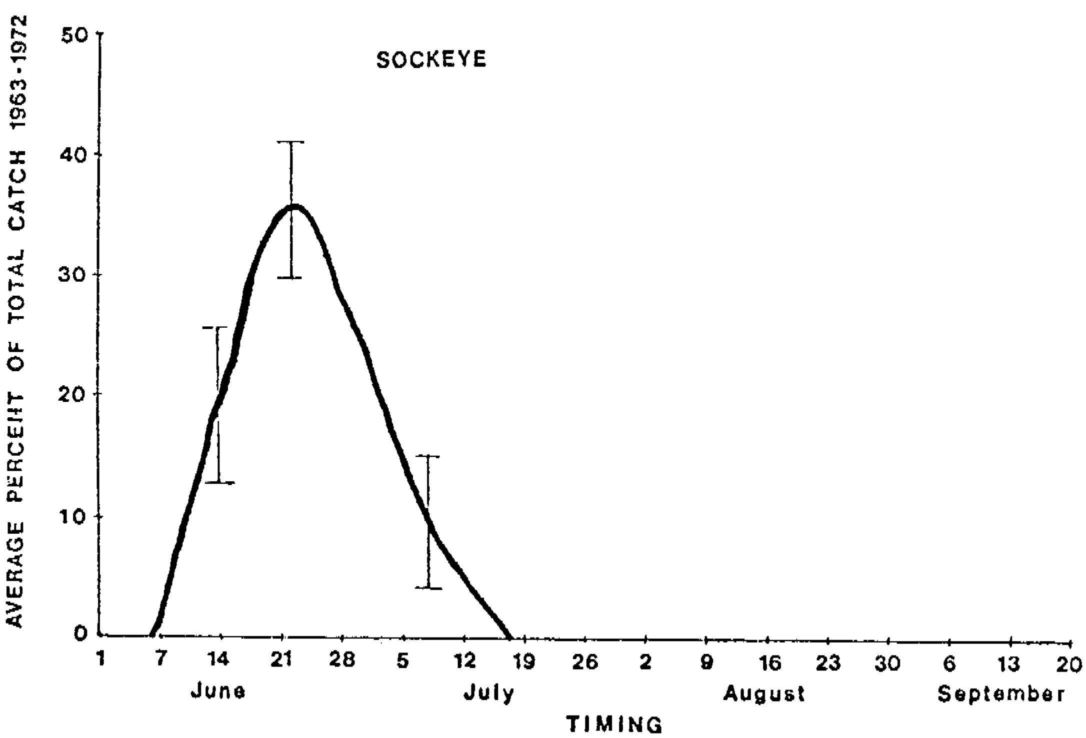
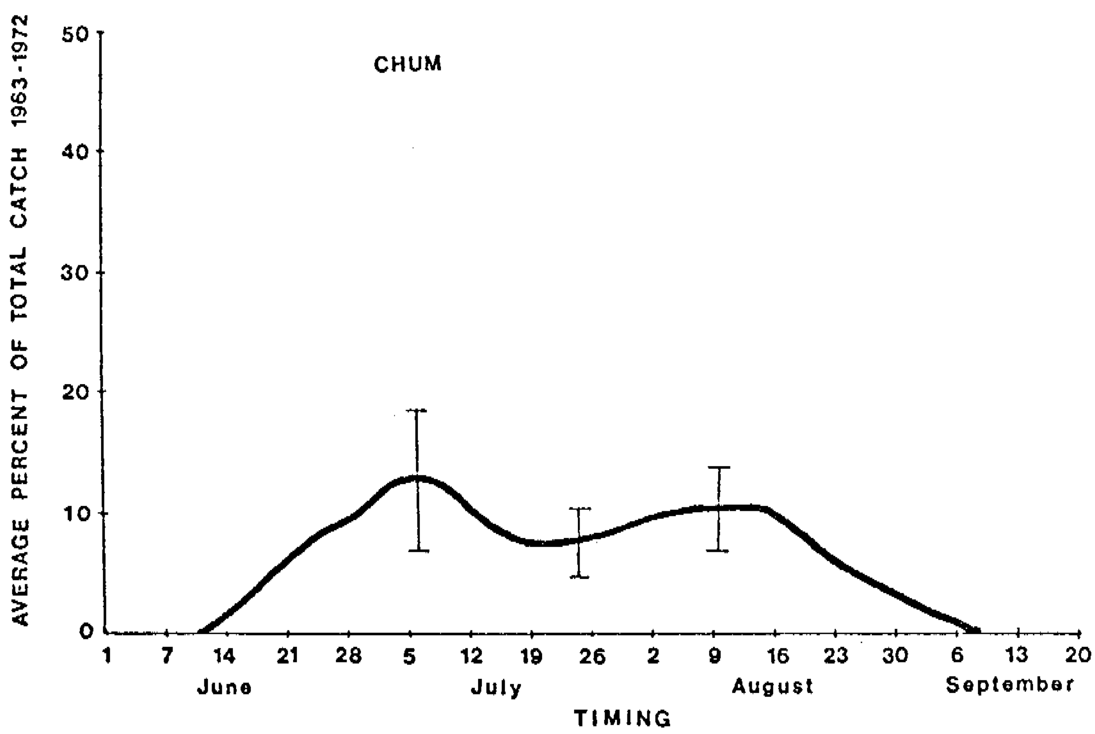


Fig. 14. The average timing of pink and sockeye runs to the South Alaska Peninsula district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



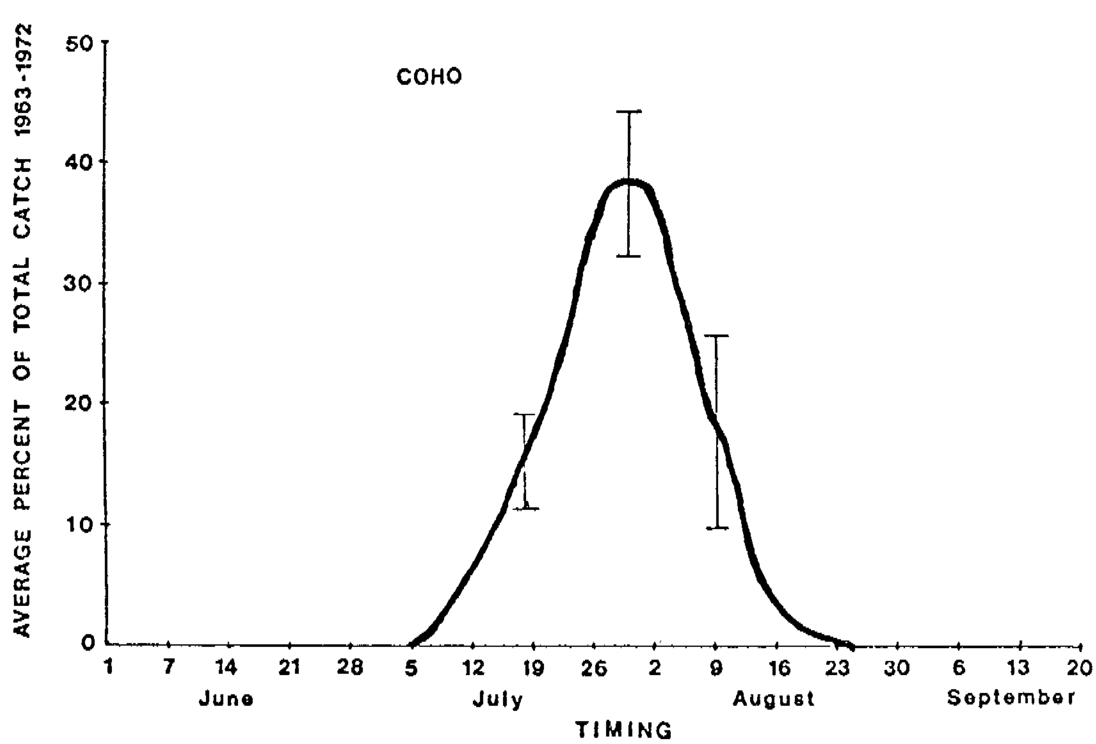


Fig. 15. The average timing of chum and coho runs to the South Alaska Peninsula district as derived from weekly statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.

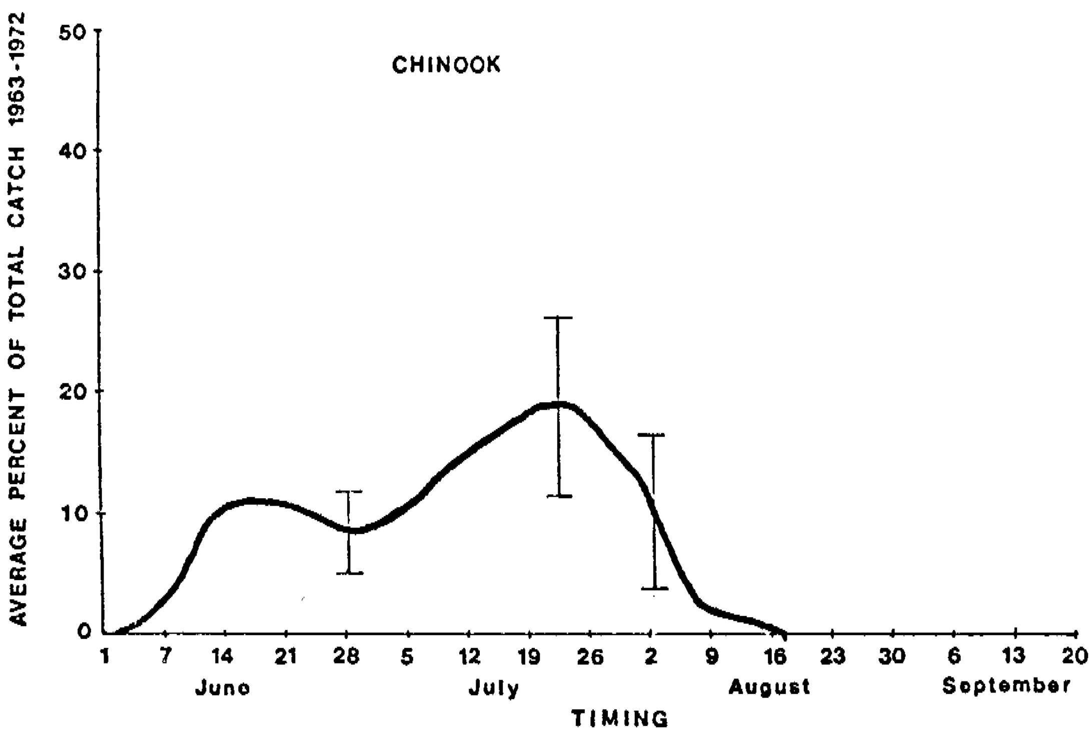
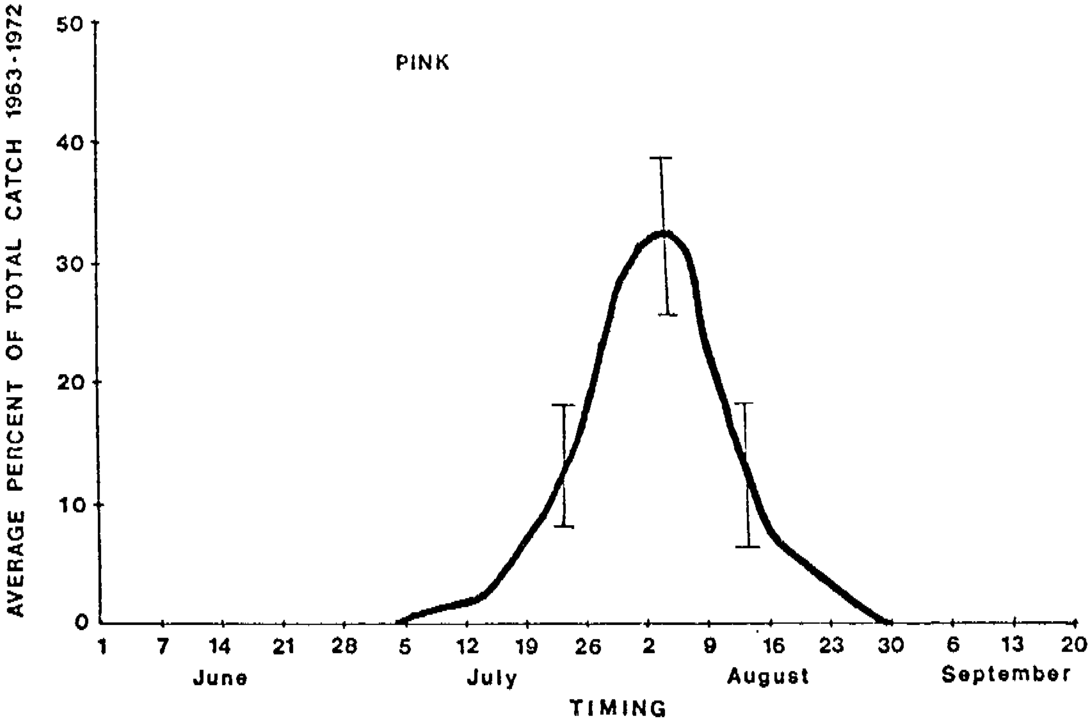


Fig. 16. The average timing of chinook salmon runs to the South Alaska Peninsula district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



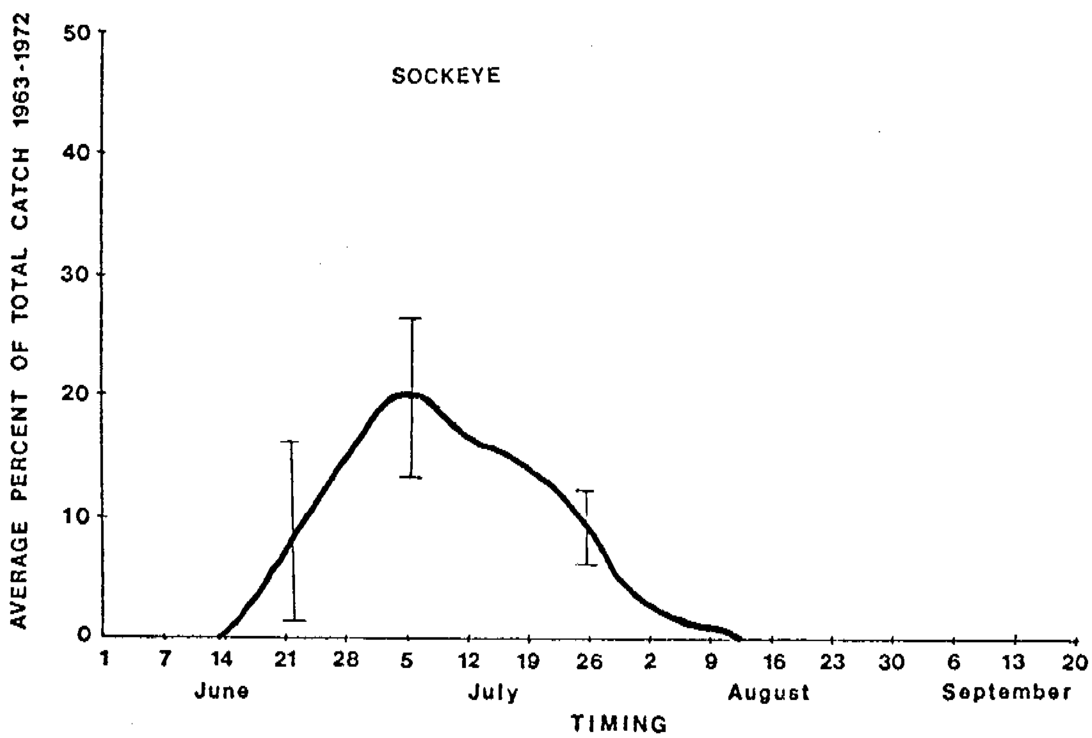
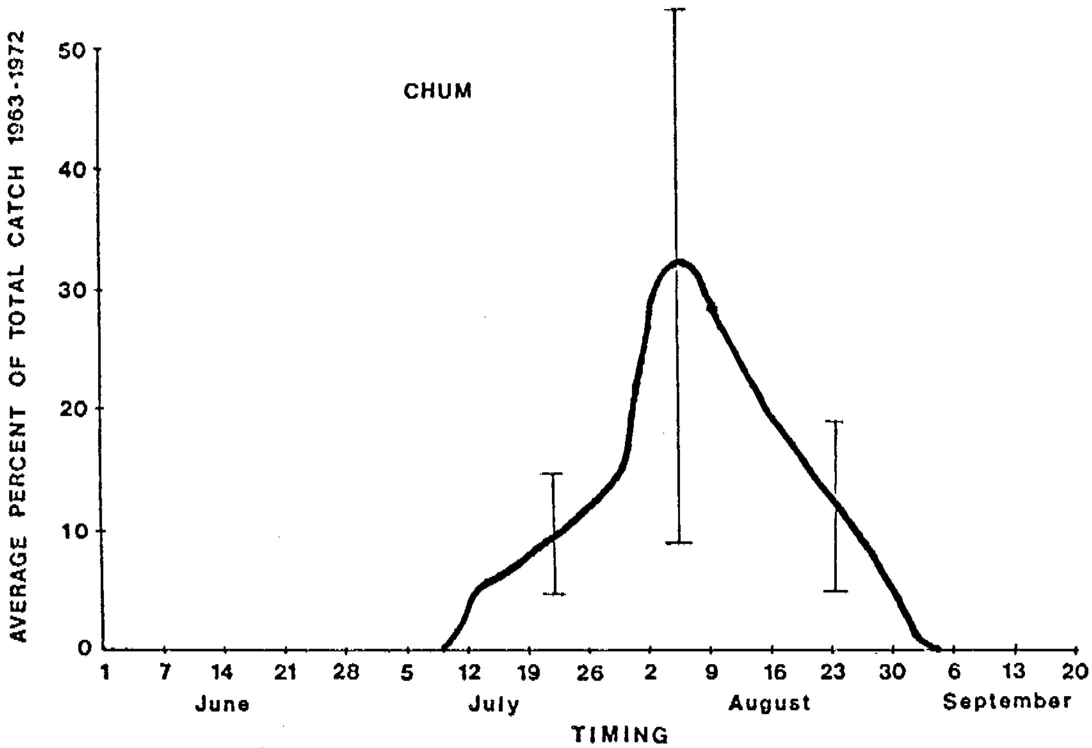


Fig. 17. The average timing of pink and sockeye runs to the Chignik district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate 95% confidence limits for the percent catch on selected dates.



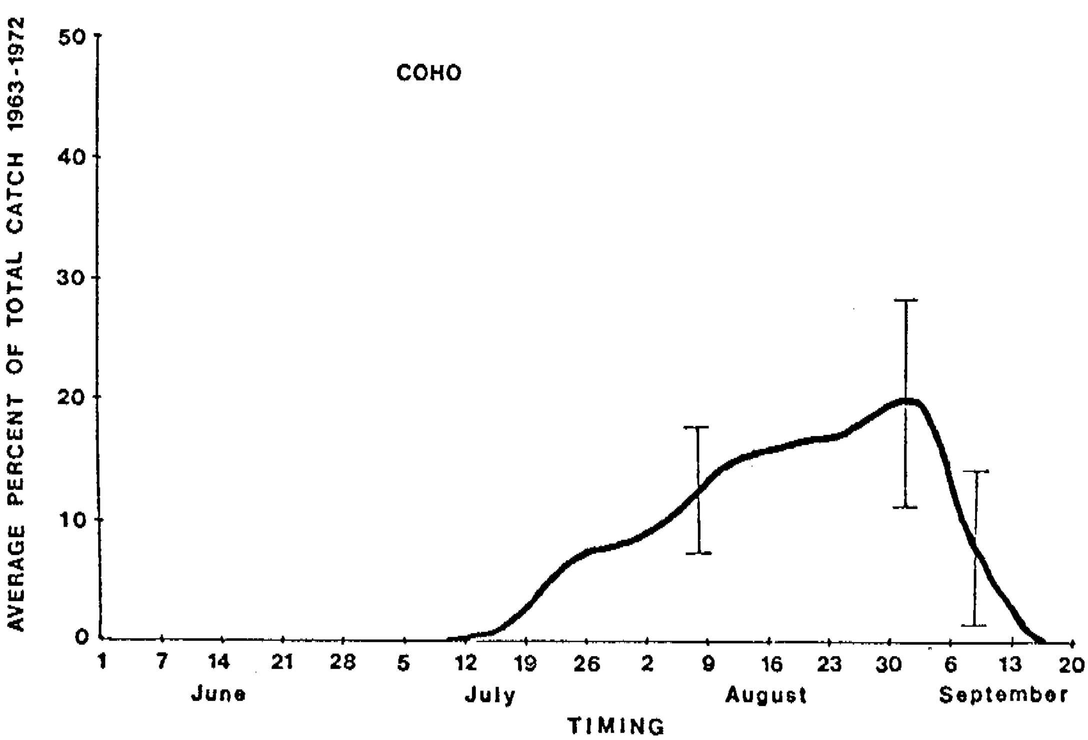


Fig. 18. The average timing of chum and coho runs to the Chignik district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate 95% confidence limits for the percent catch on selected dates.

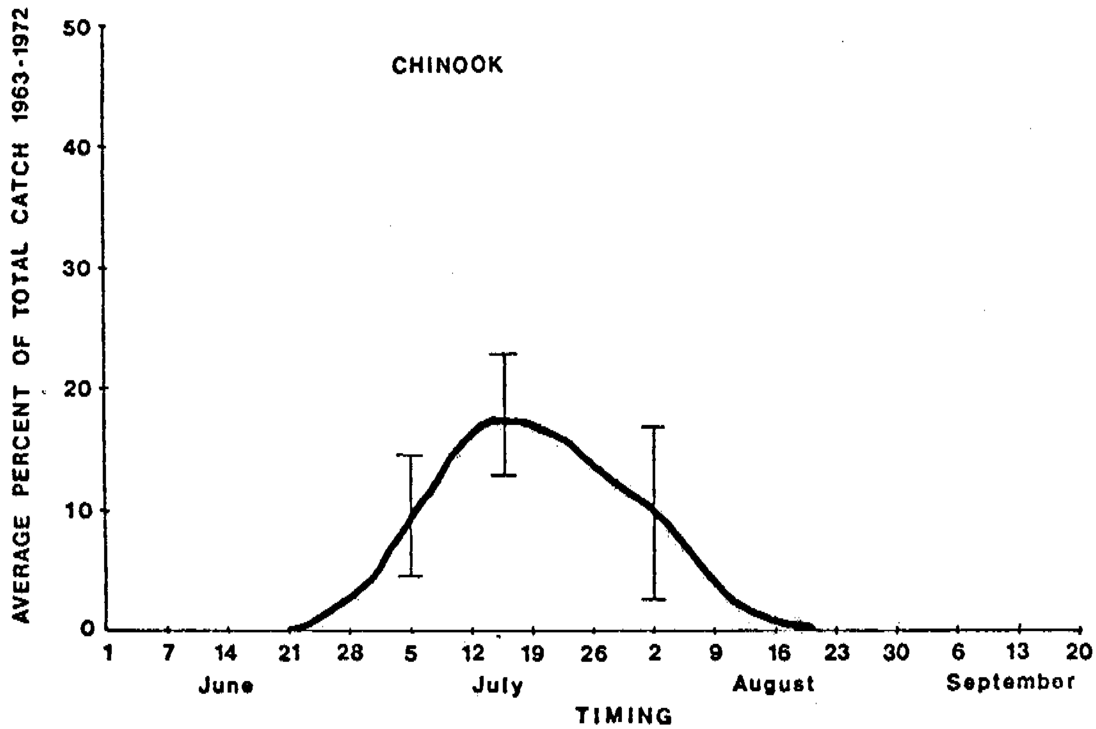
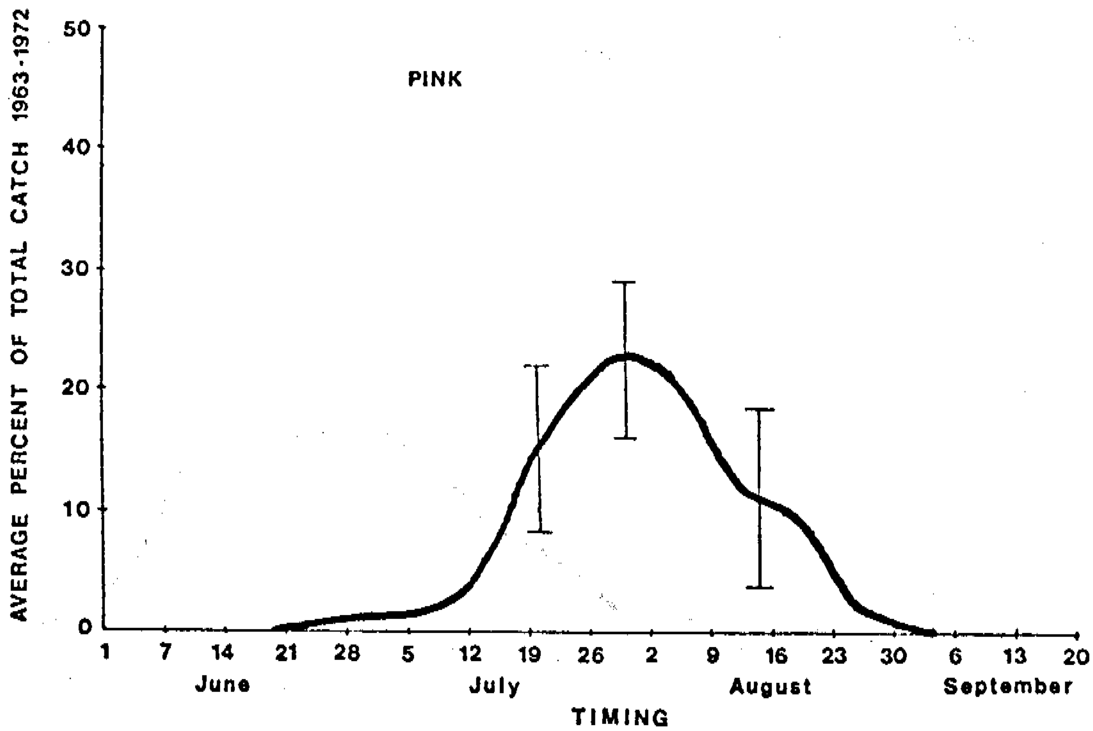


Fig. 19. The average timing of chinook runs to the Chignik district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



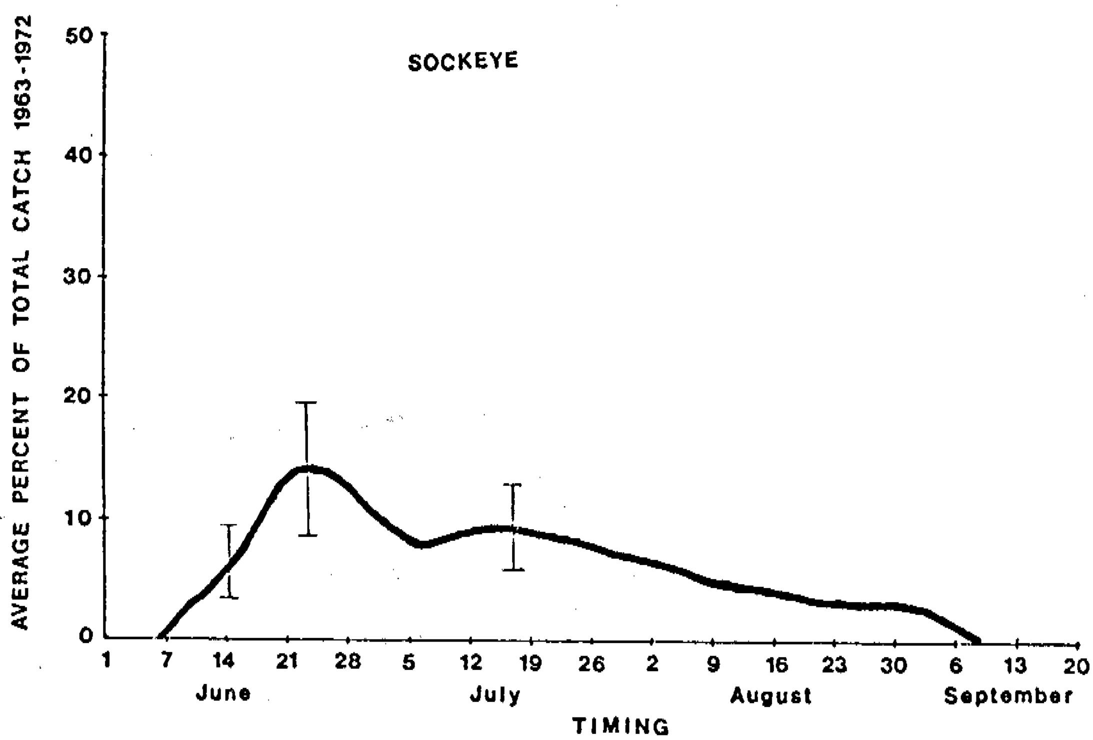
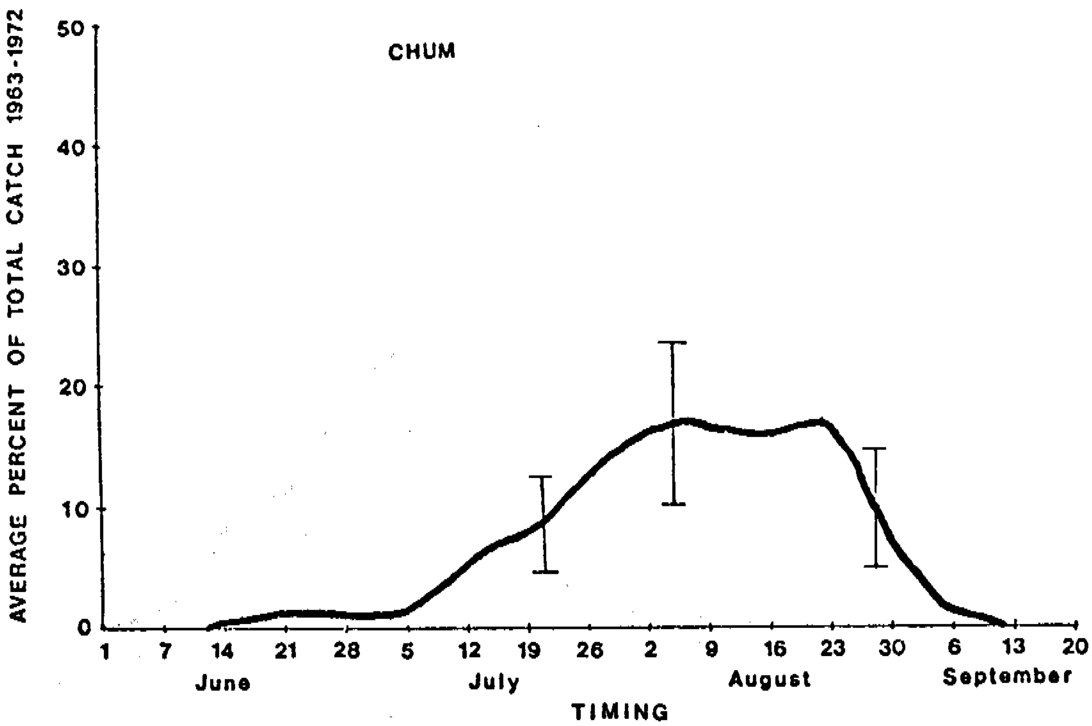


Fig. 20. The average timing of pink and sockeye runs to the Kodiak Island district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



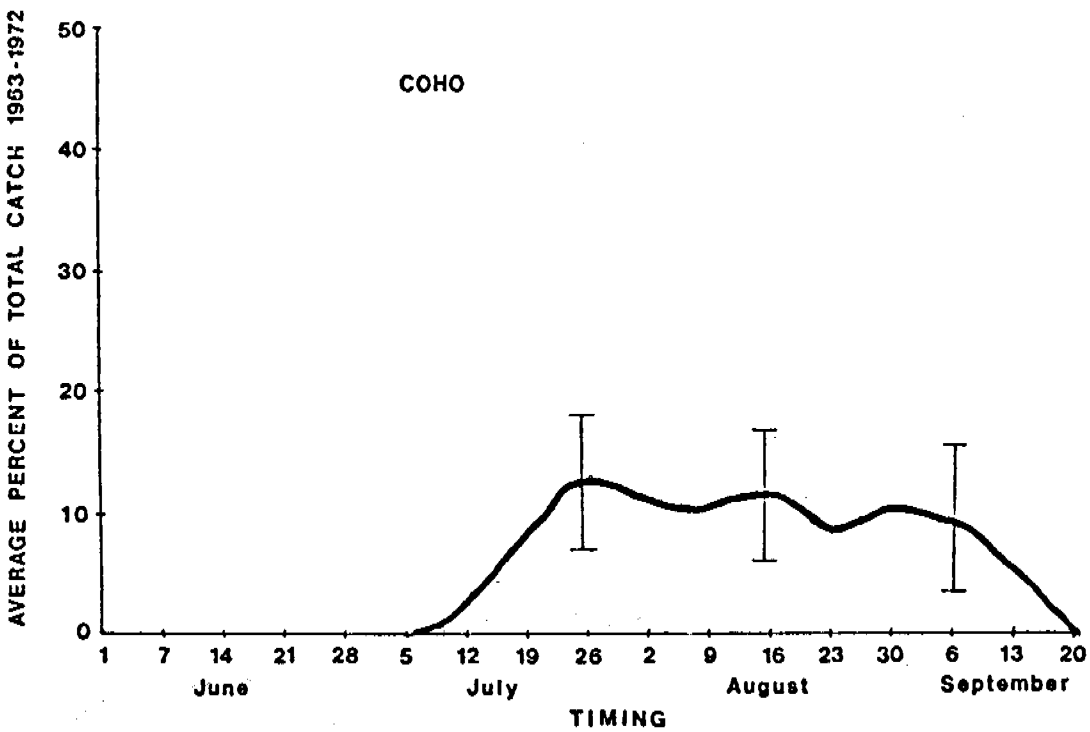


Fig. 21. The average timing of chum and coho runs to the Kodiak Island district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.

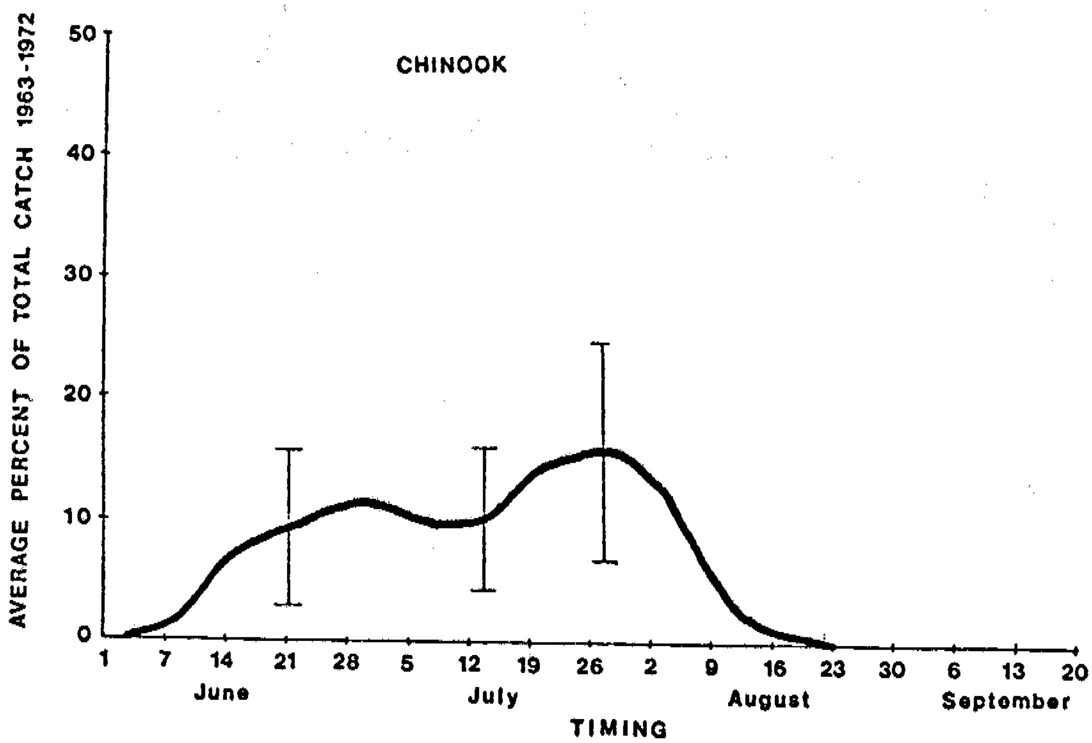
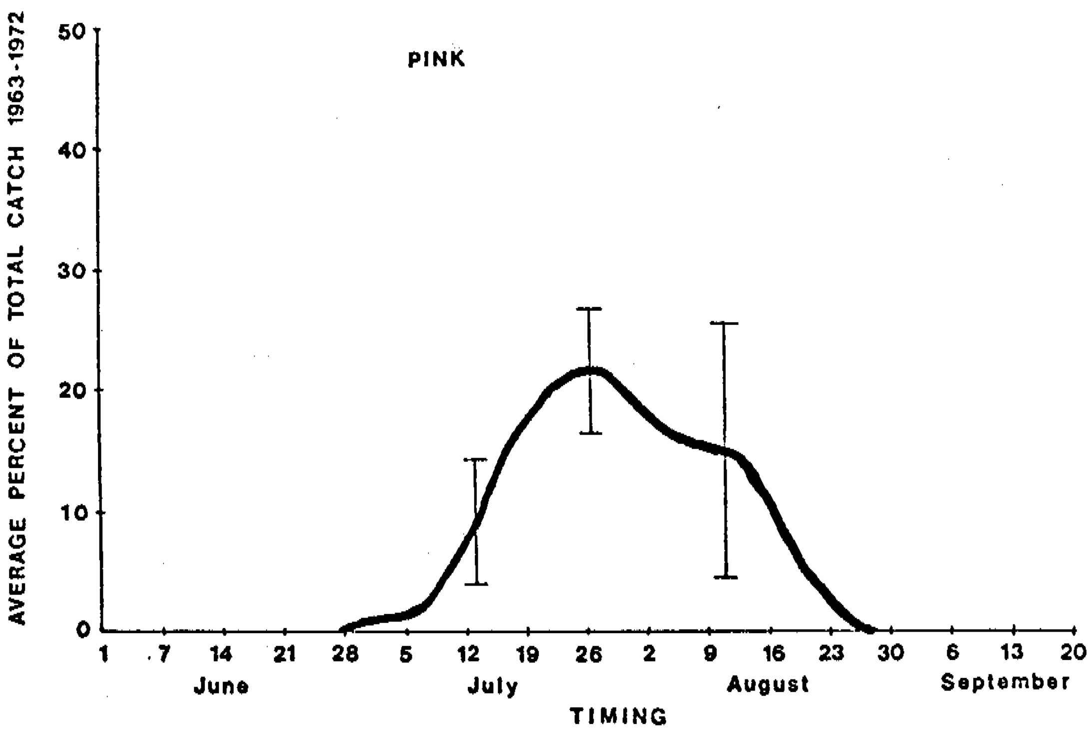


Fig. 22. The average timing of chinook runs to the Kodiak Island district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



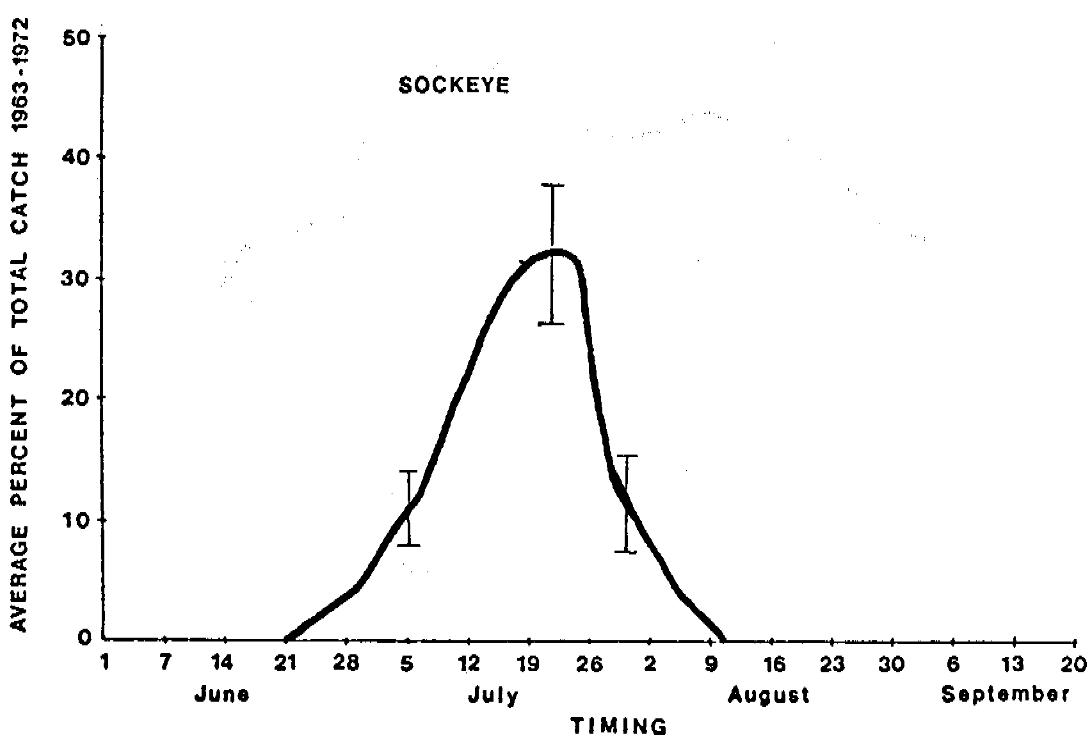
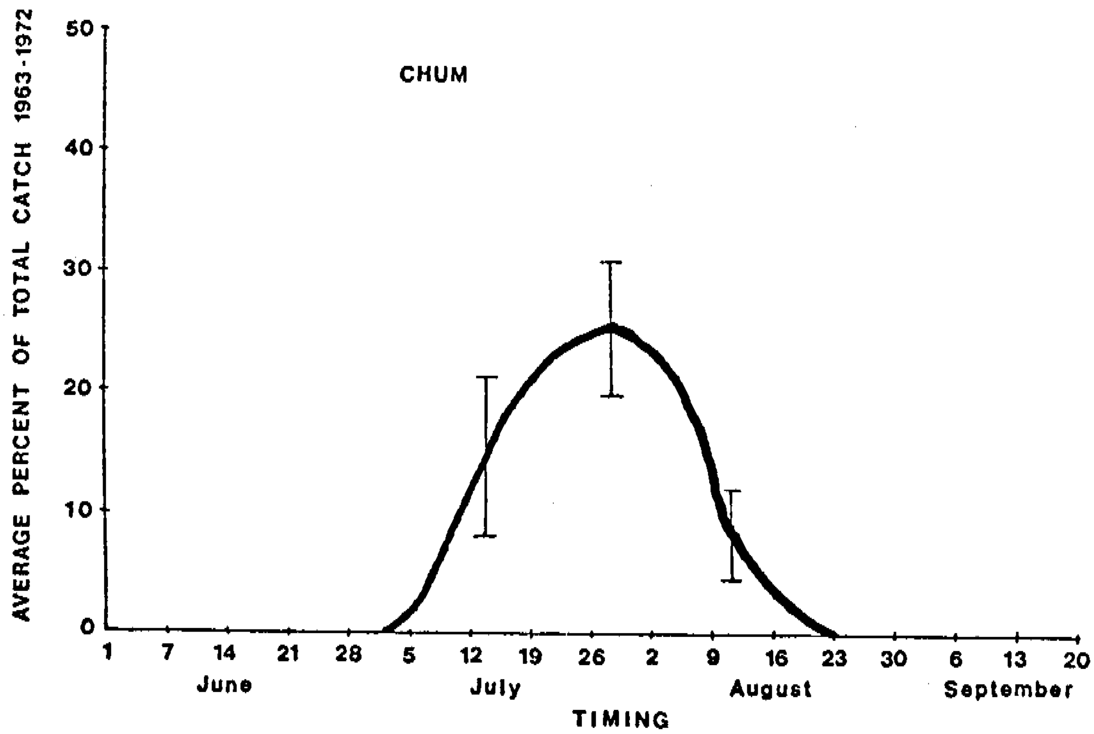


Fig. 23. The average timing of pink and sockeye runs to the Cook Inlet district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



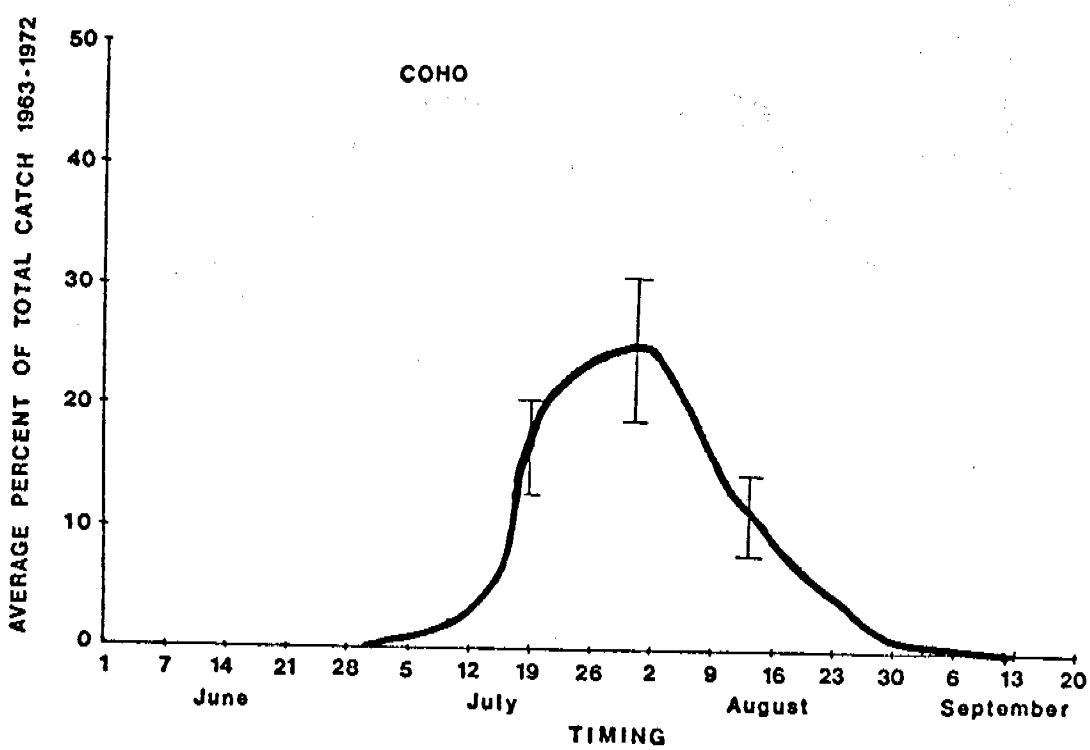


Fig. 24. The average timing of chum and coho runs to the Cook Inlet district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.

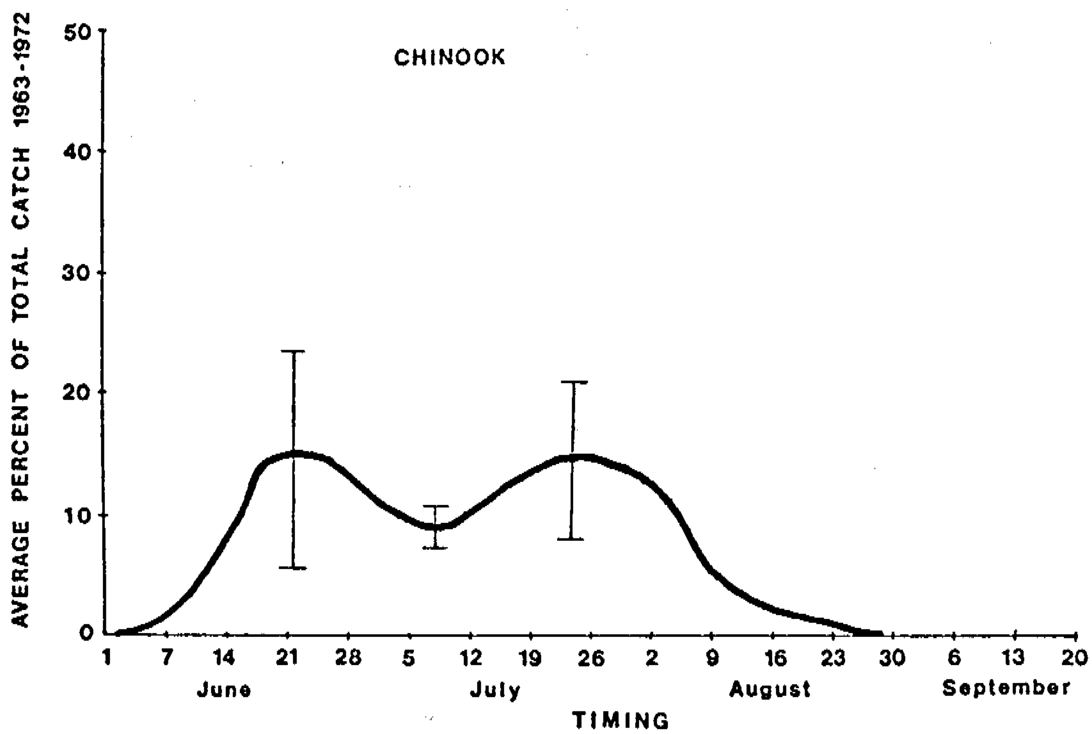
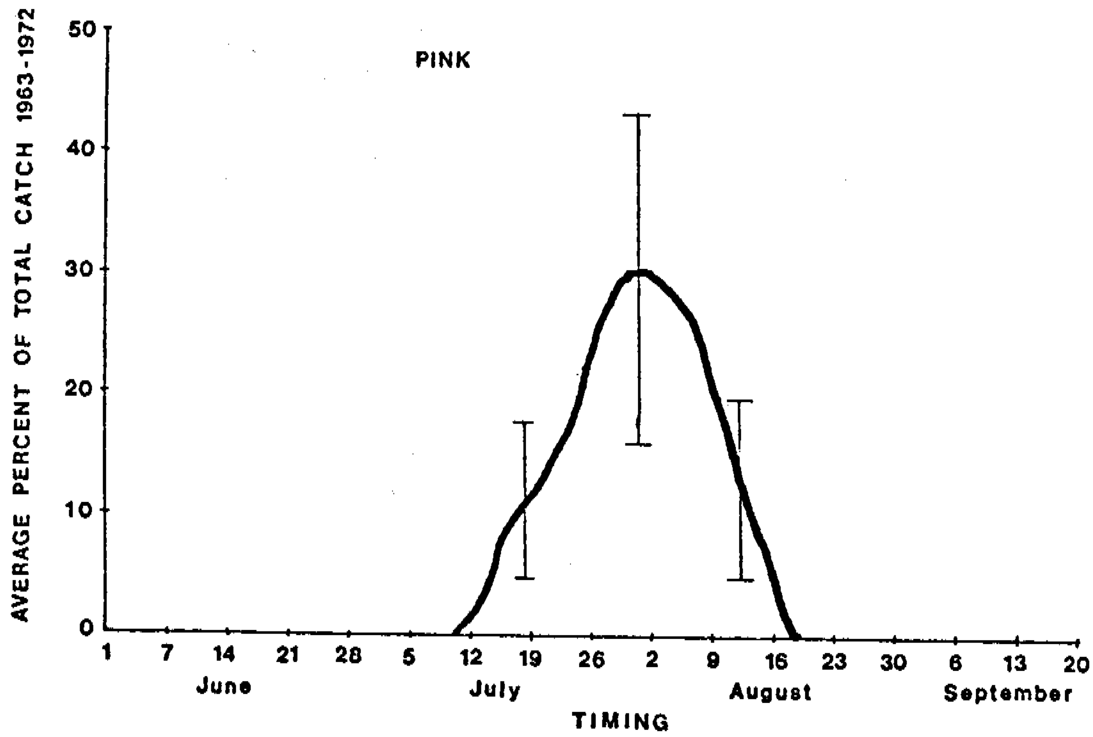


Fig. 25. The average timing of chinook runs to the Cook Inlet district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.



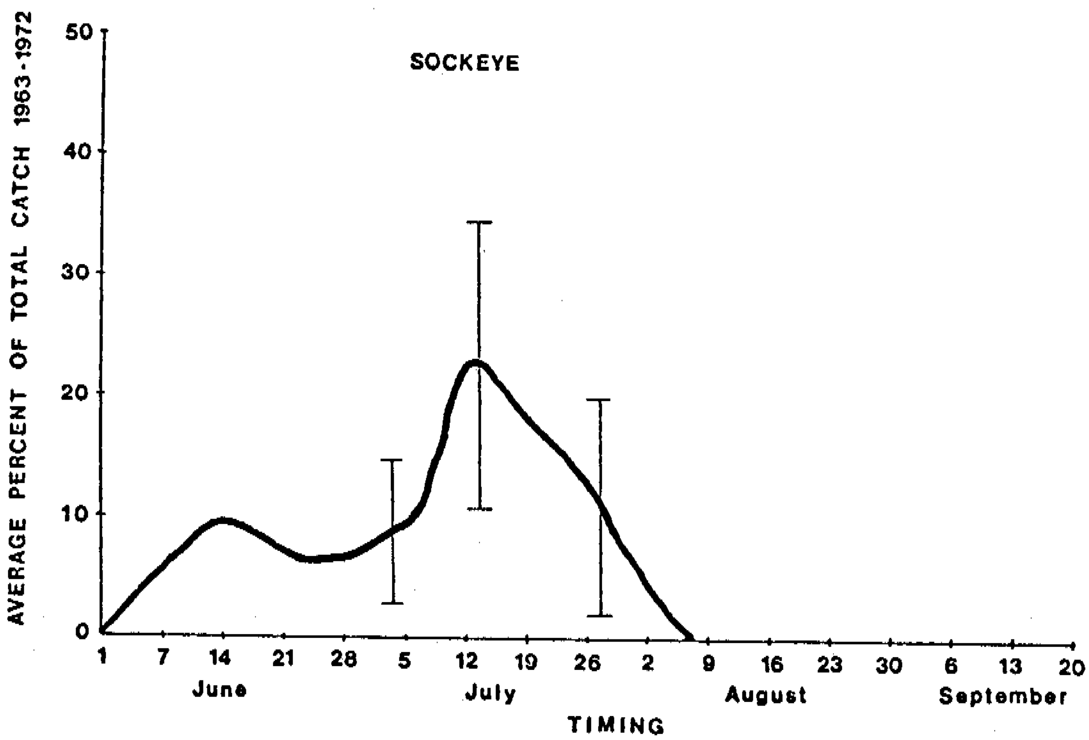


Fig. 26. The average timing of pink and sockeye runs to the Resurrection Bay district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.

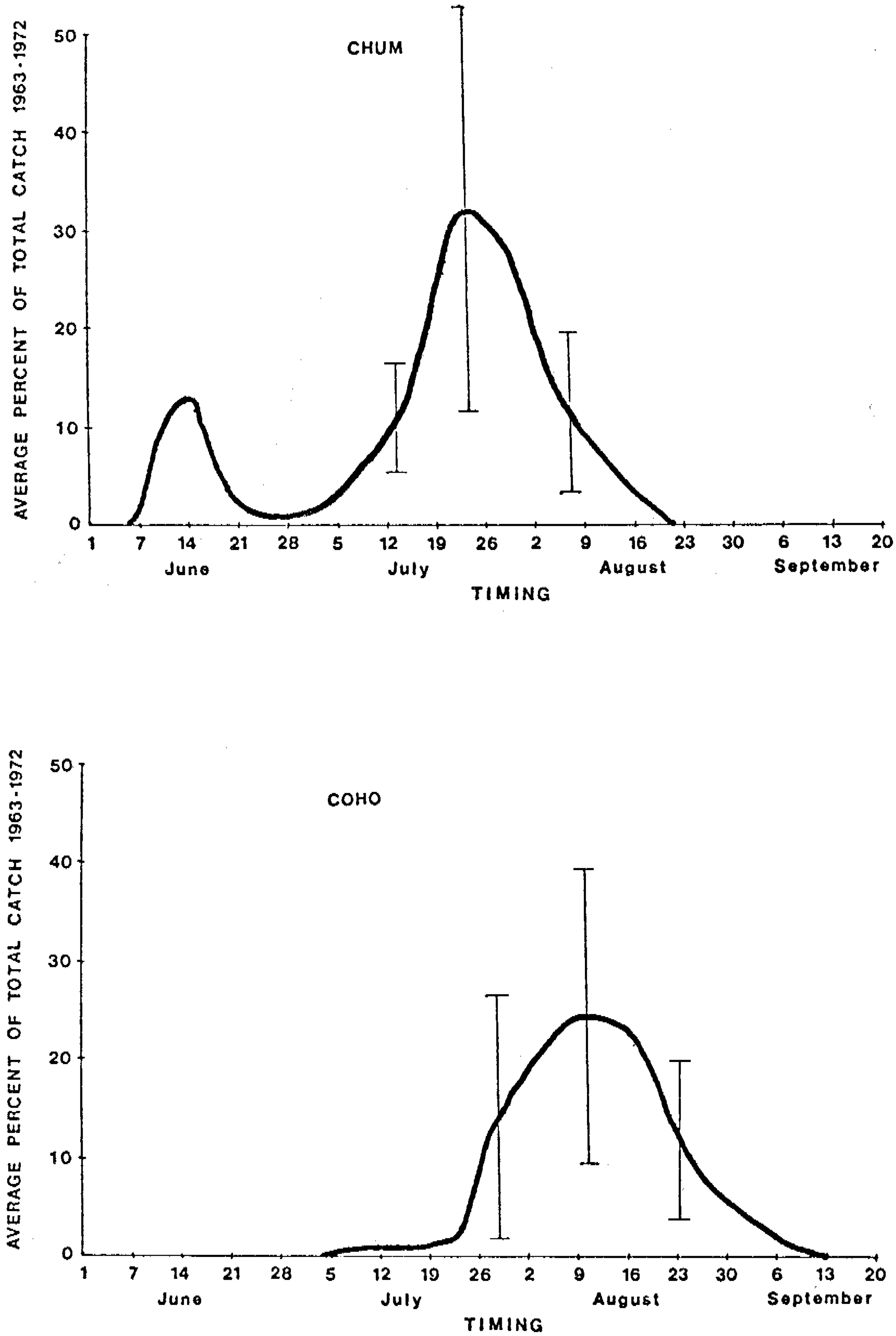


Fig. 27. The average timing of chum and coho runs to the Resurrection Bay district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates.

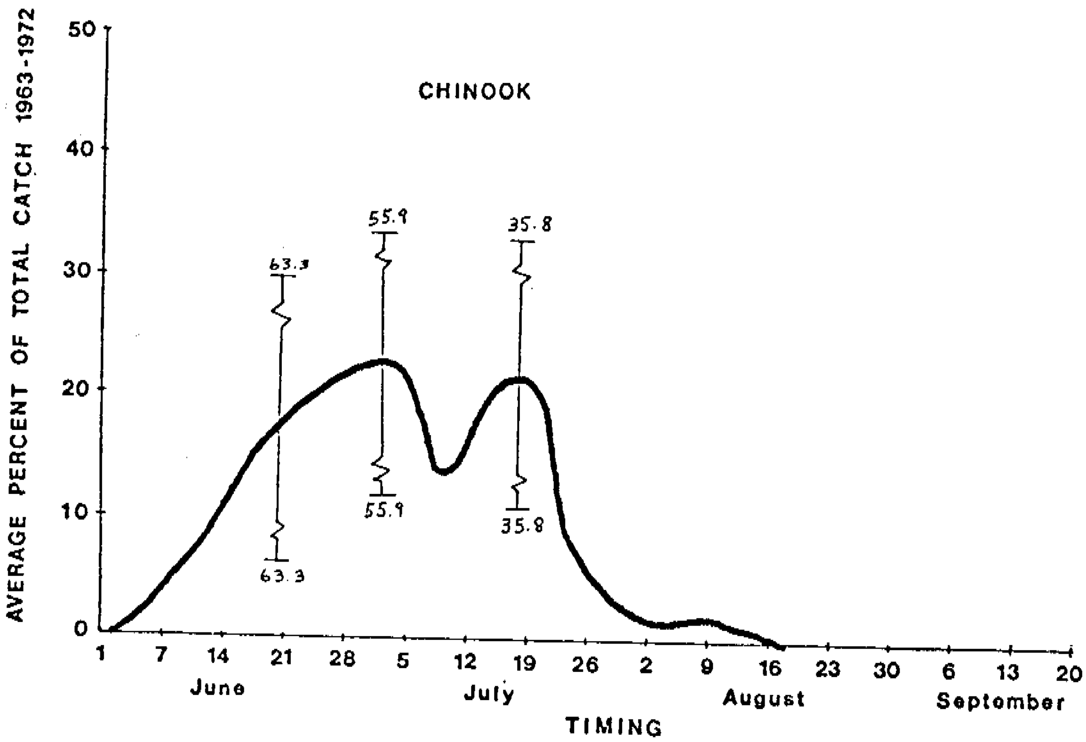


Fig. 28. The average timing of chinook runs to the Resurrection Bay district as derived from weekly catch statistics for the years 1956-72. The symbols along the curve indicate the 95% confidence limits for the percent catch on selected dates. The numbers associated with the symbols are the confidence limits.

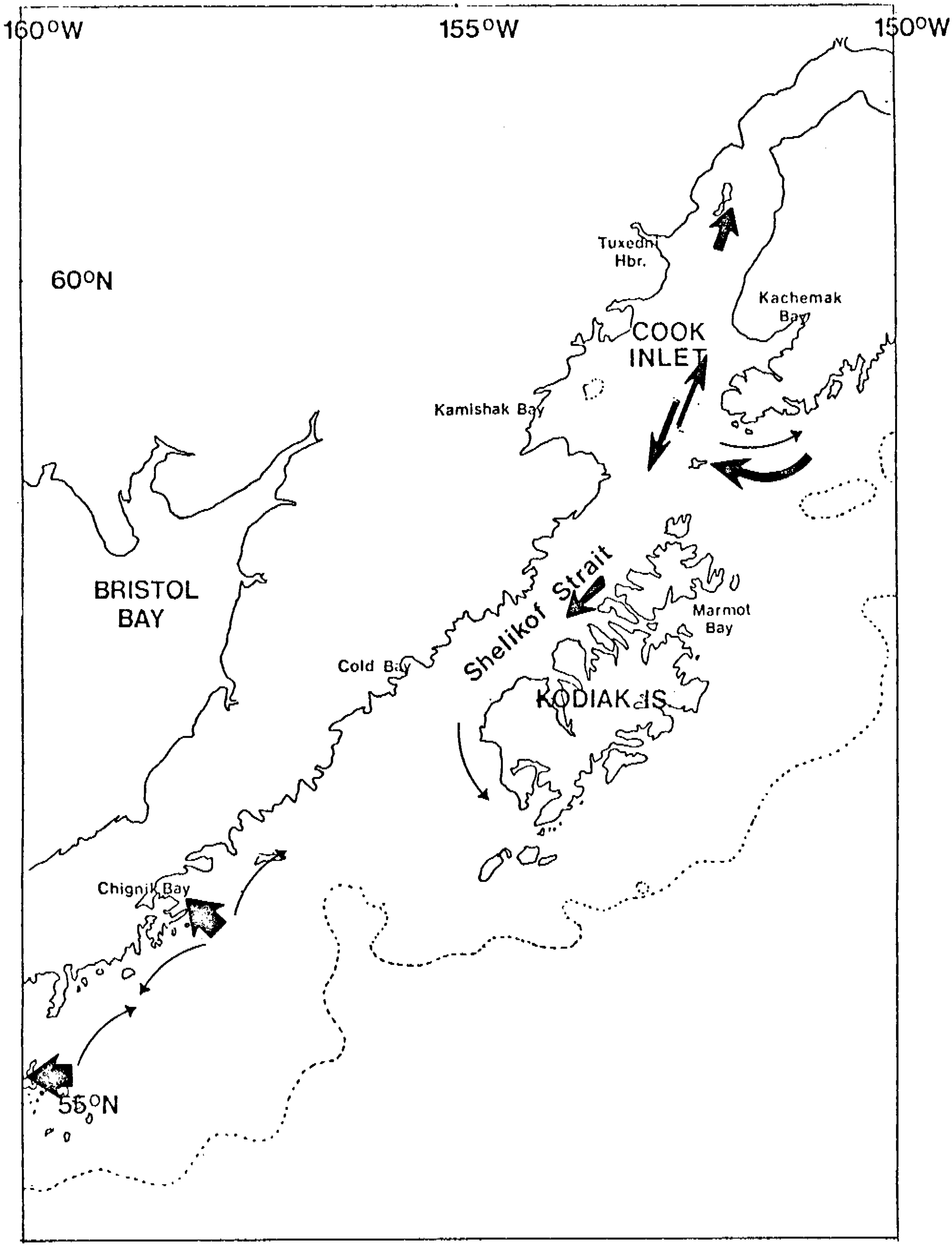


Fig. 29. Summary of coastal movements of adult salmonids in the *Kodiak region* as indicated by nearshore tagging.

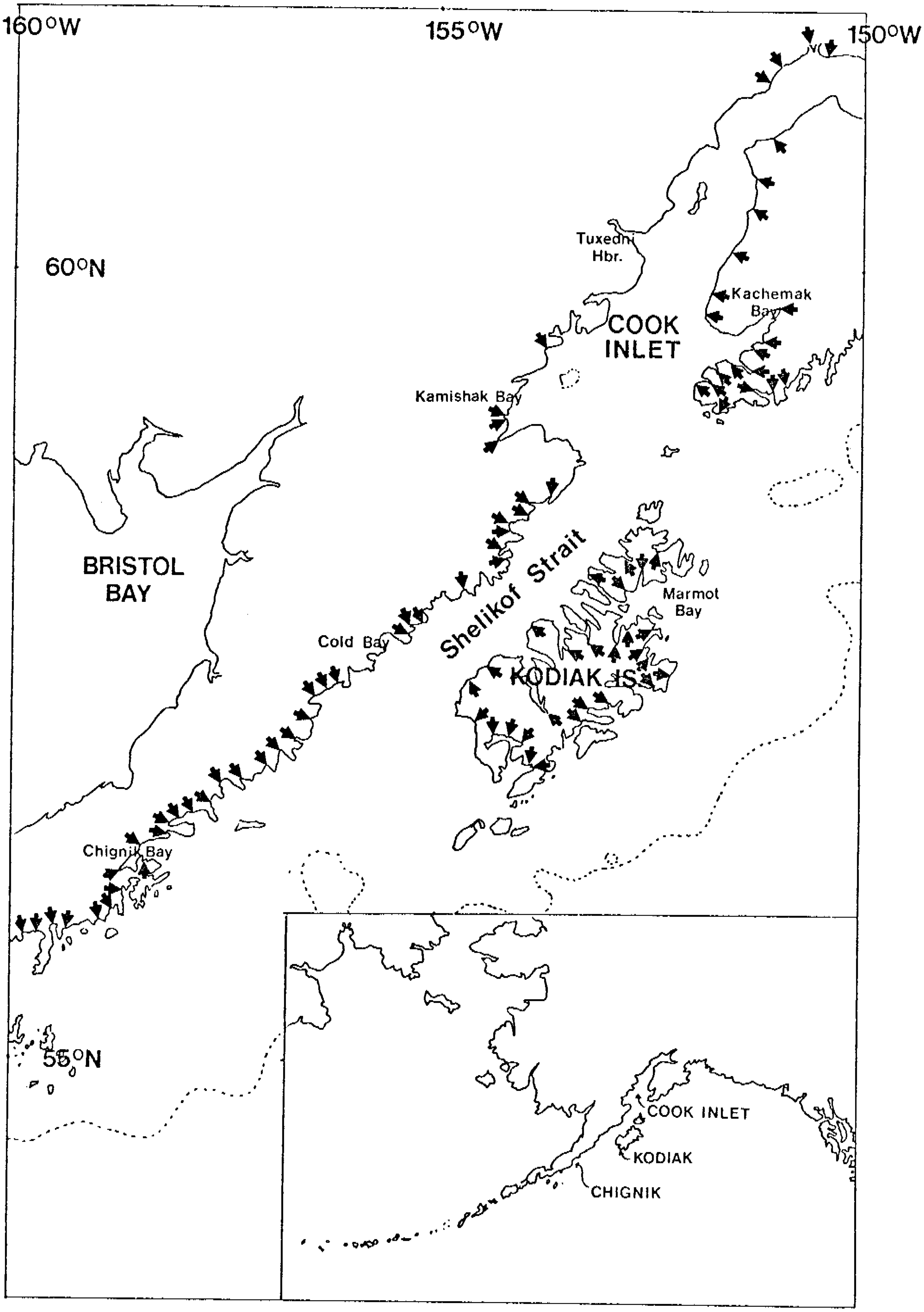


Fig. 30. Locations of juvenile pink salmon entry into marine waters of the *Kodiak region*.

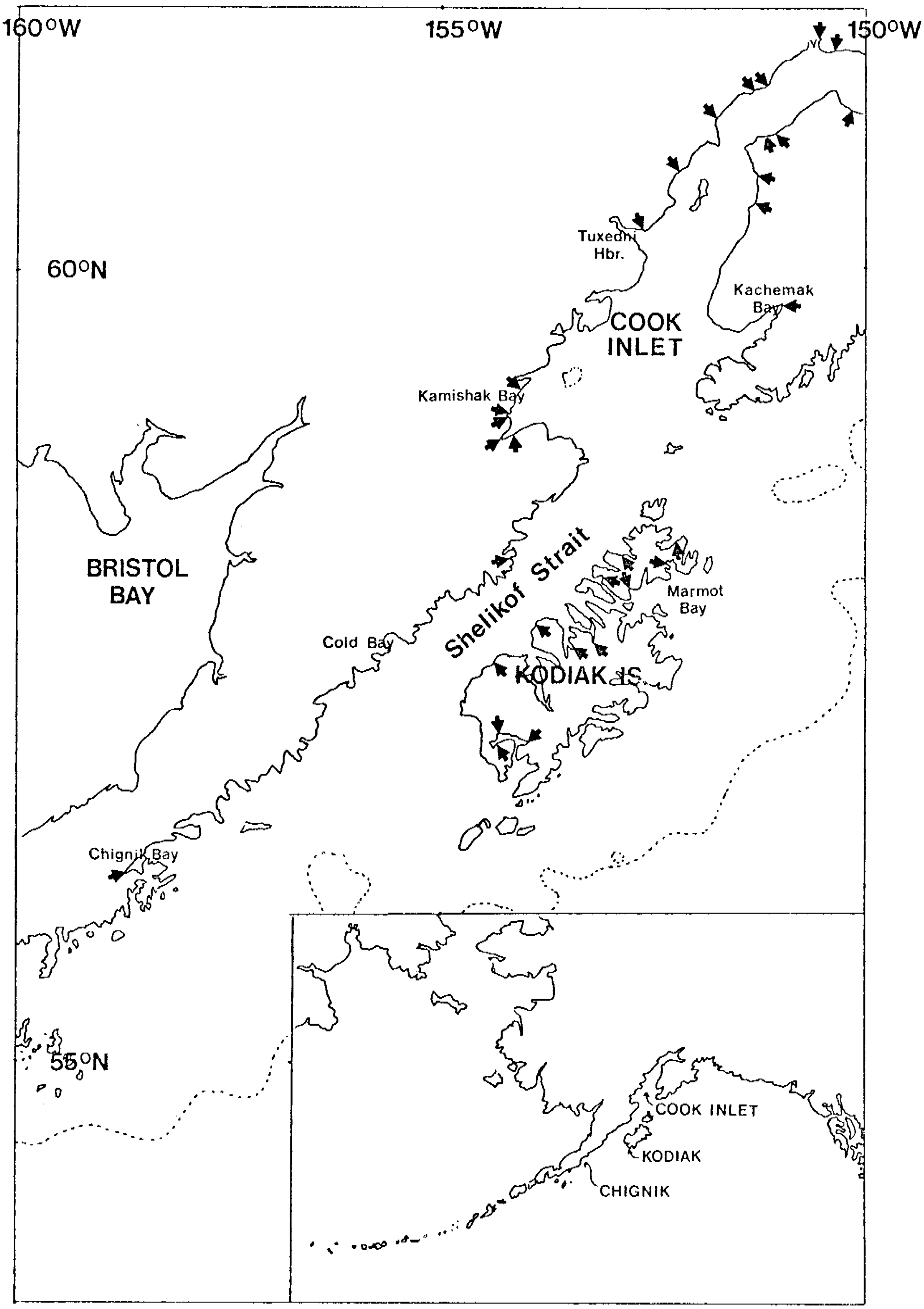


Fig. 31. Locations of juvenile sockeye salmon entry into marine waters of the *Kodiak region*.

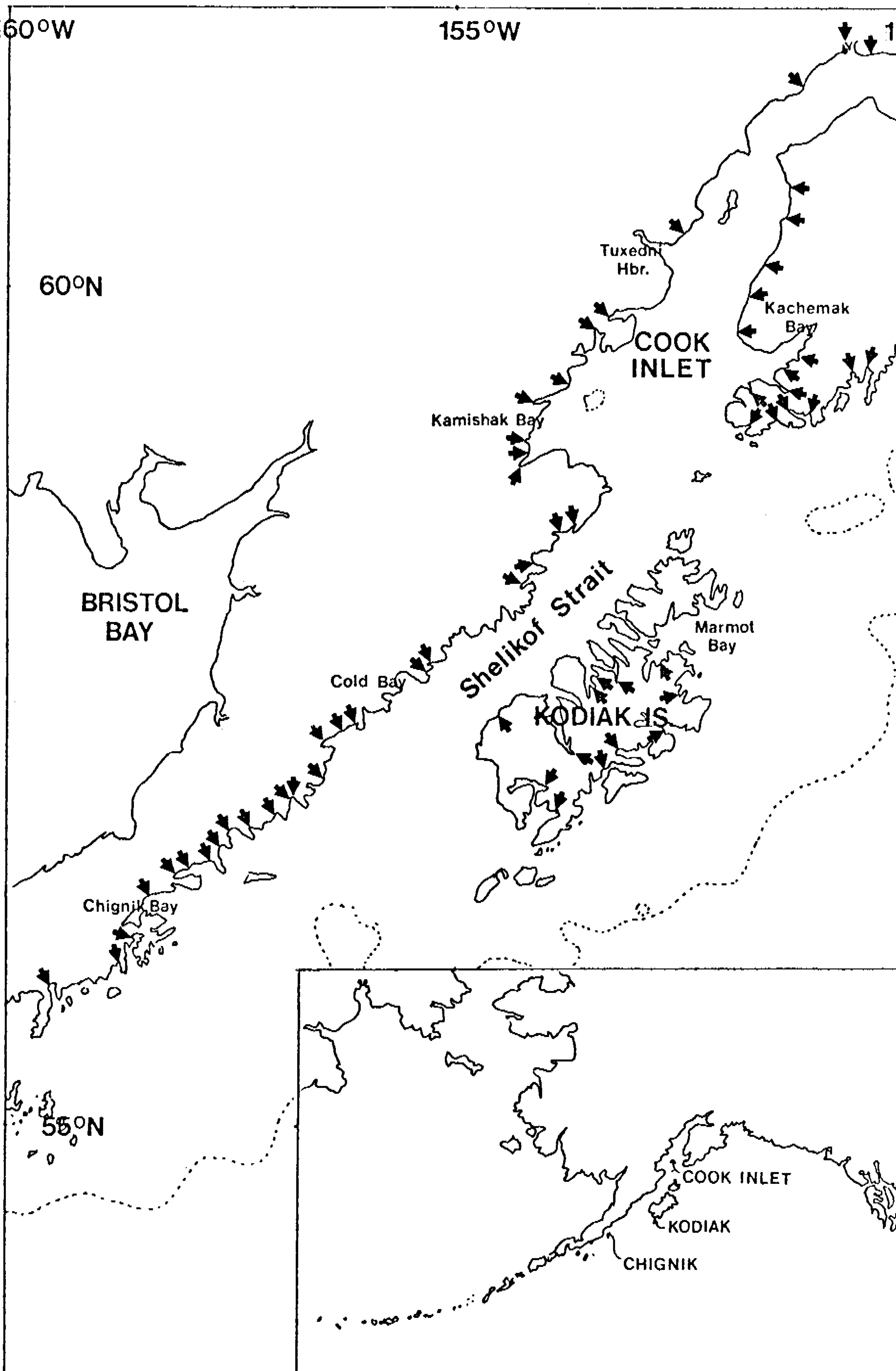


Fig. 32. Locations of juvenile chum salmon entry into marine waters of the *Kodiak region*.

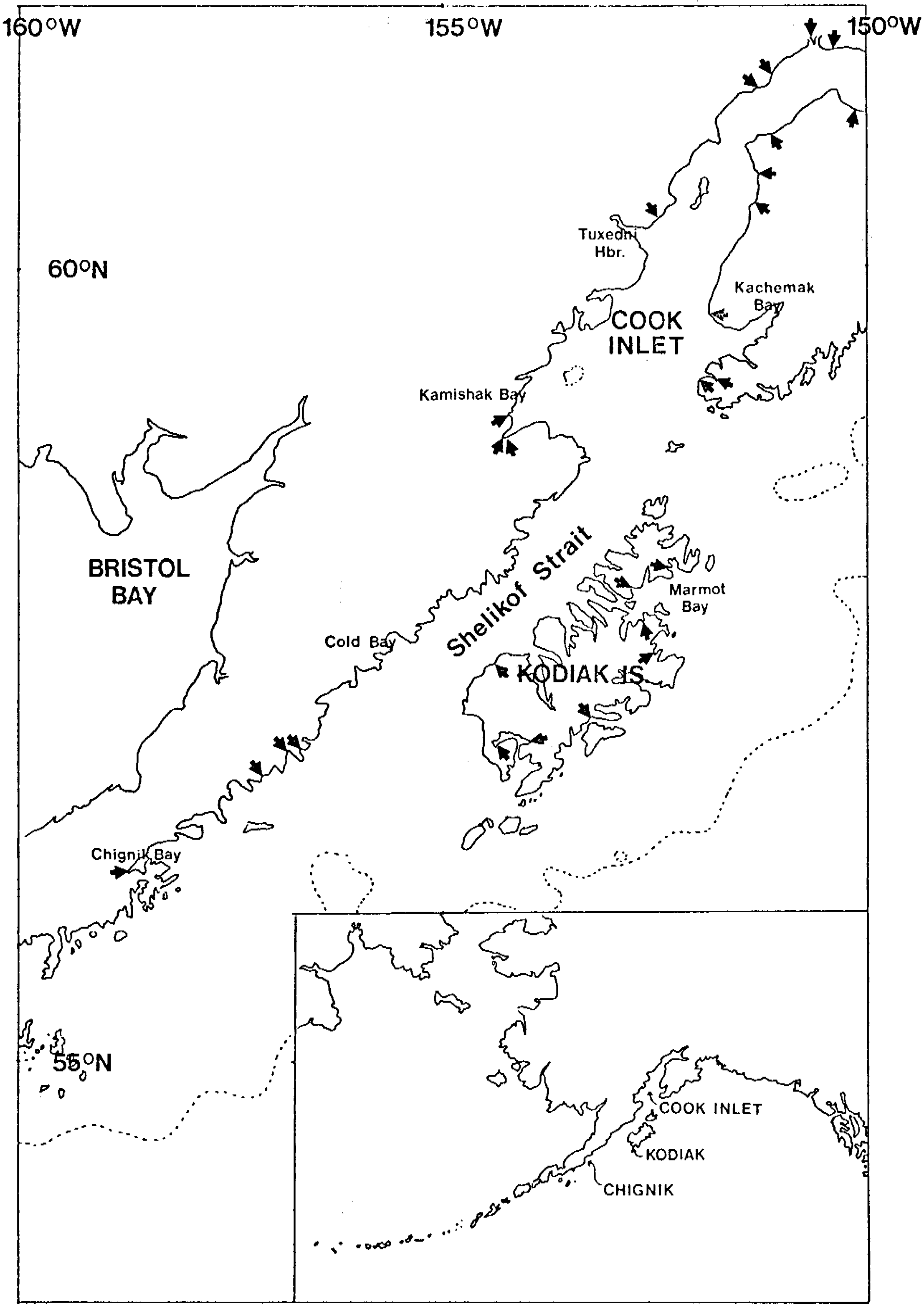


Fig. 33. Locations of juvenile coho salmon entry into marine waters of the *Kodiak region*.

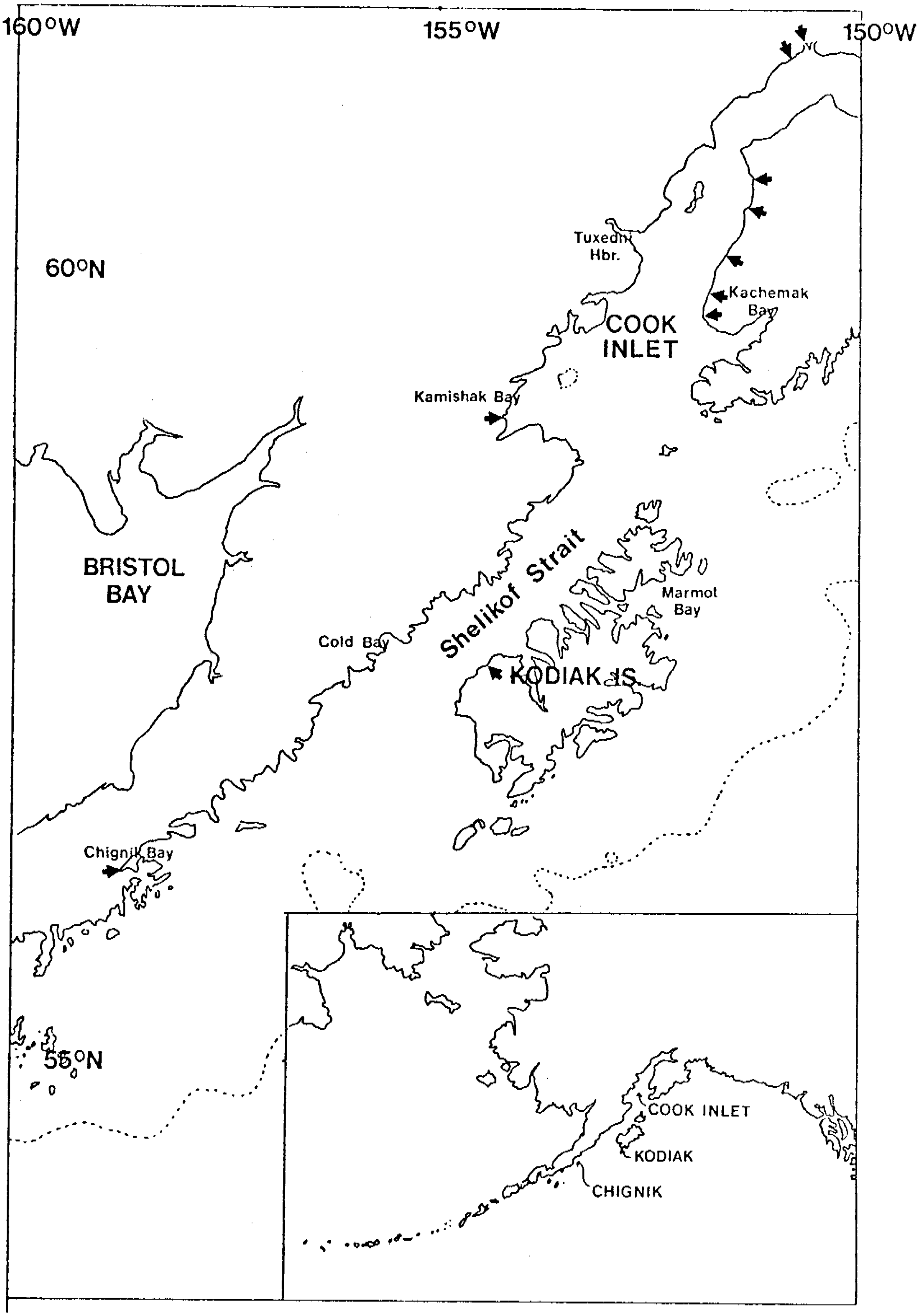


Fig. 34. Locations of juvenile chinook salmon entry into the marine waters of the *Kodiak region*.

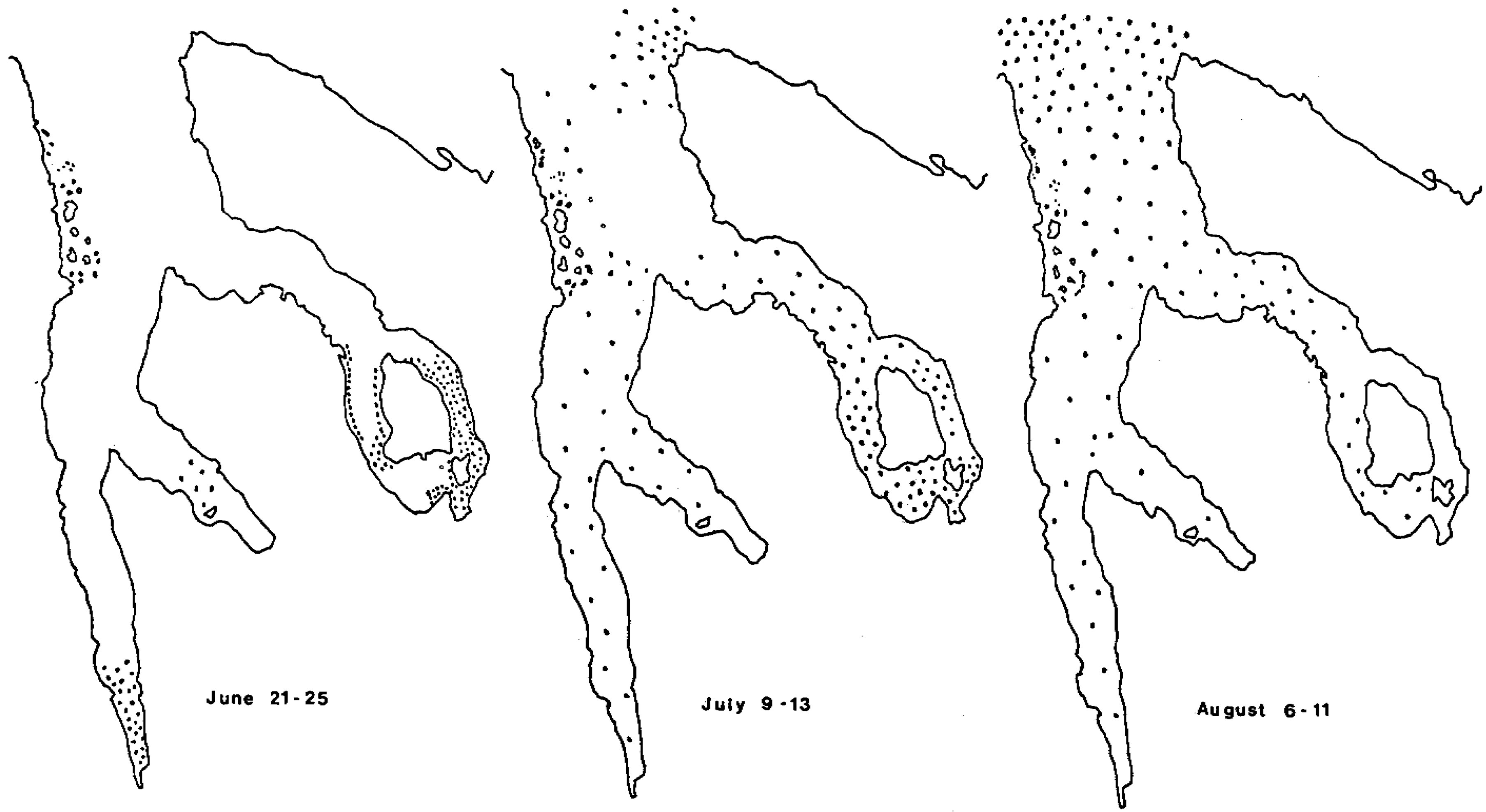


FIG. 35 Comparison of distribution of juvenile pinks from early, middle, and late surveys of Uganik Bay, 1963. Dots represent densities based on townet catches.

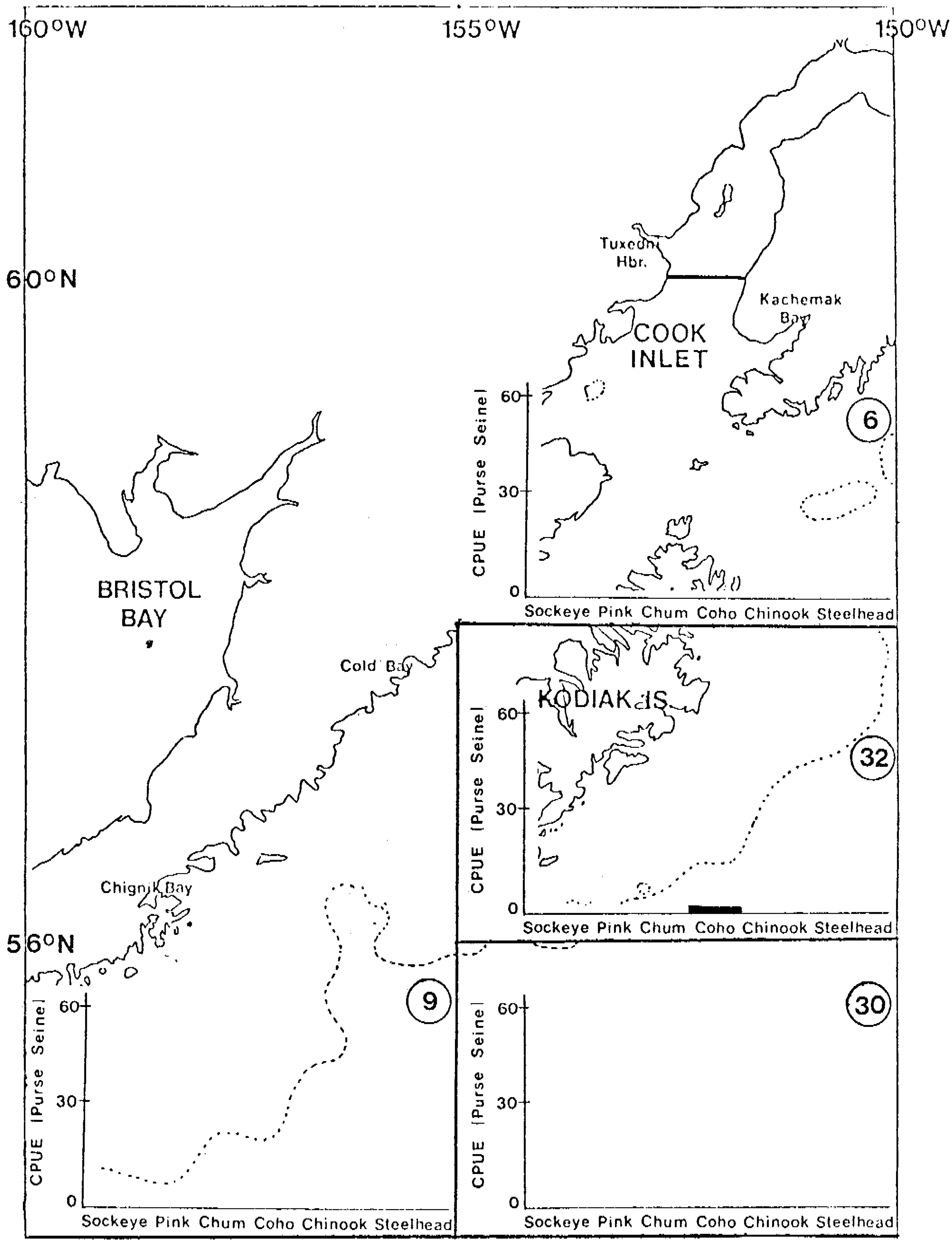


Fig. 36. The distribution and abundance of juvenile salmonids in offshore waters of the *Kodiak region* in May-June as determined from purse seining. The numbers circled indicate the number of purse seine sets made in the area.

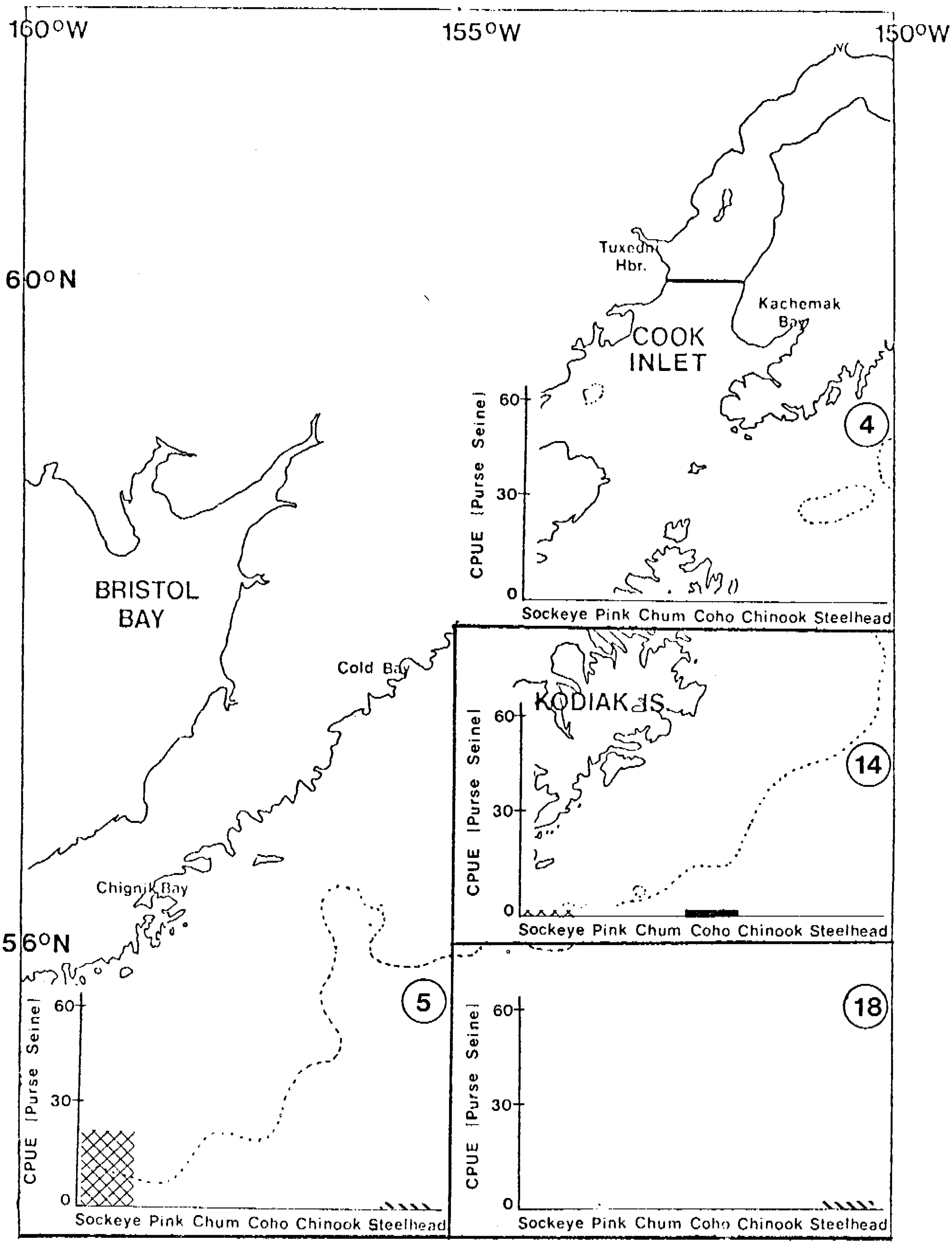


Fig. 37. The distribution and abundance of juvenile salmonids in offshore waters of the *Kodiak region* in July as determined from purse seining. The numbers circled indicate the number of purse seine sets made in the area.

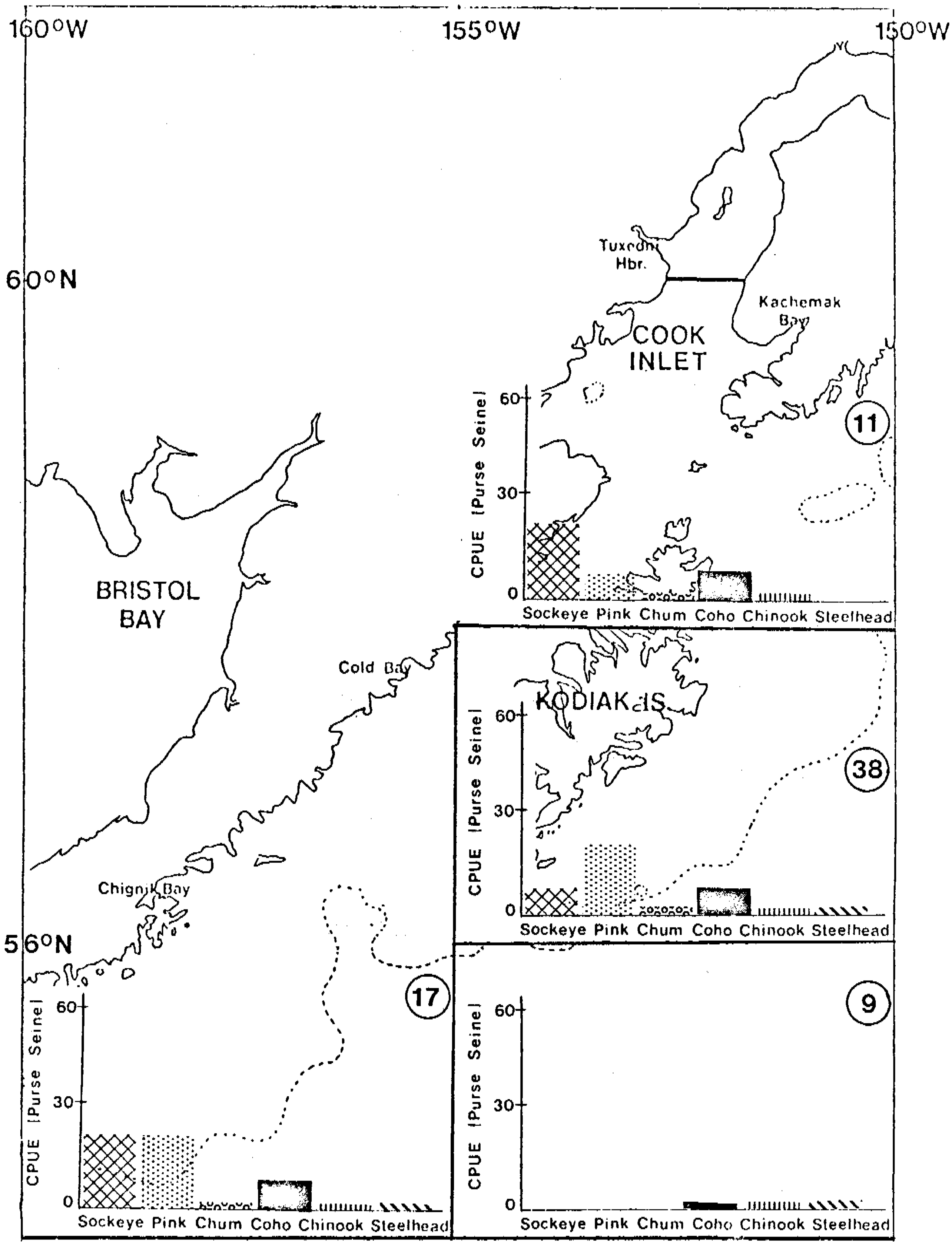


Fig. 38. The distribution and abundance of juvenile salmonids in offshore waters of the *Kodiak region* in August as determined from purse seining. The numbers circled indicate the number of purse seine sets made in the area.

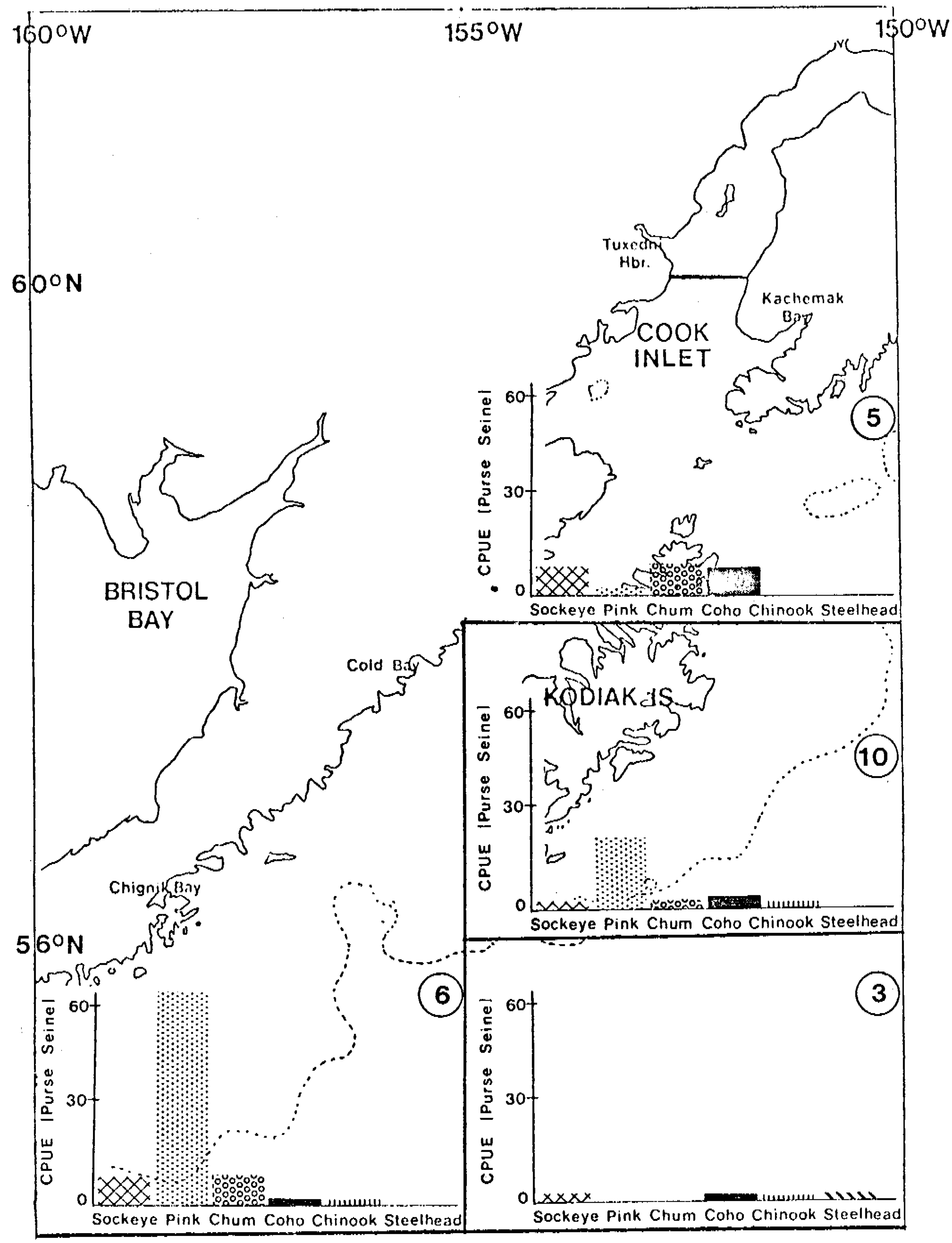


Fig. 39. The distribution and abundance of juvenile salmonids in offshore waters of the *Kodiak region* in September-October as determined from purse seining. The numbers circled indicate the number of purse seine sets made in the area.

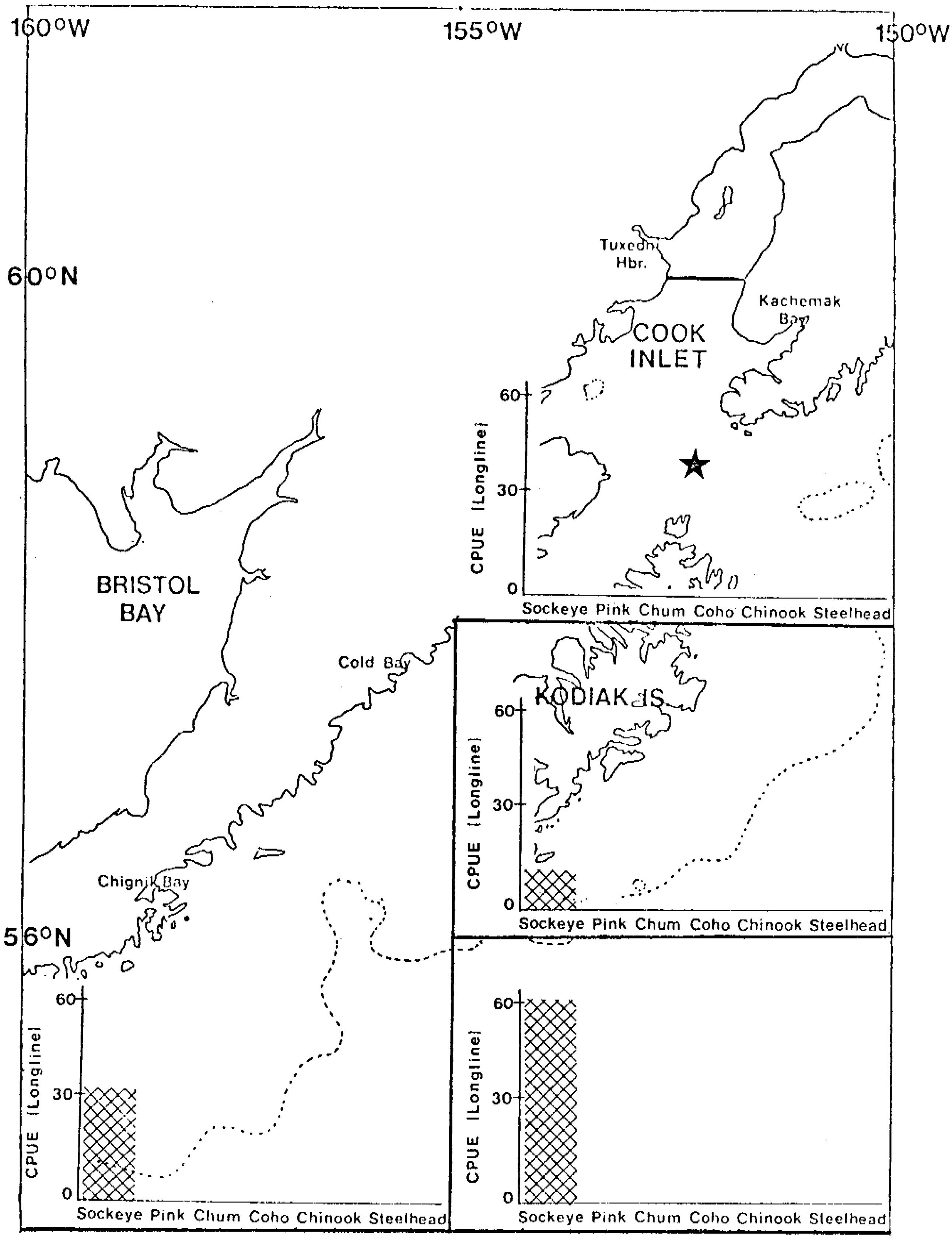


Fig. 40. The distribution and abundance of adult salmonids in the *Kodiak region* in winter (October-March) as determined by longline catches. The star indicates that no longlining was conducted in the area. A unit of effort equals one thousand hooks.

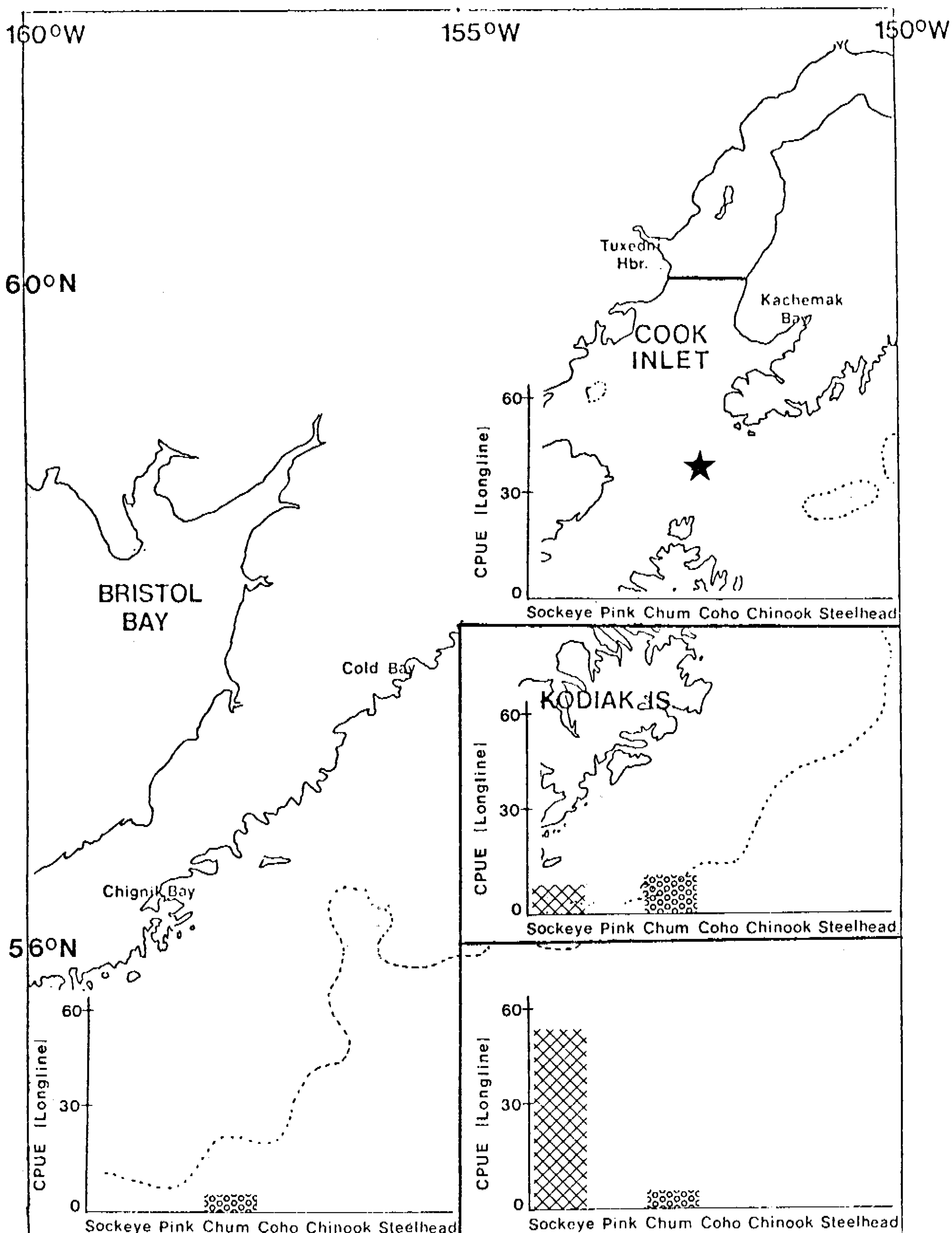


Fig. 41. The distribution and abundance of adult salmonids in the *Kodiak region* in April as determined by longline catches. The star indicates that no longlining was conducted in the area. A unit of effort equals one thousand hooks.

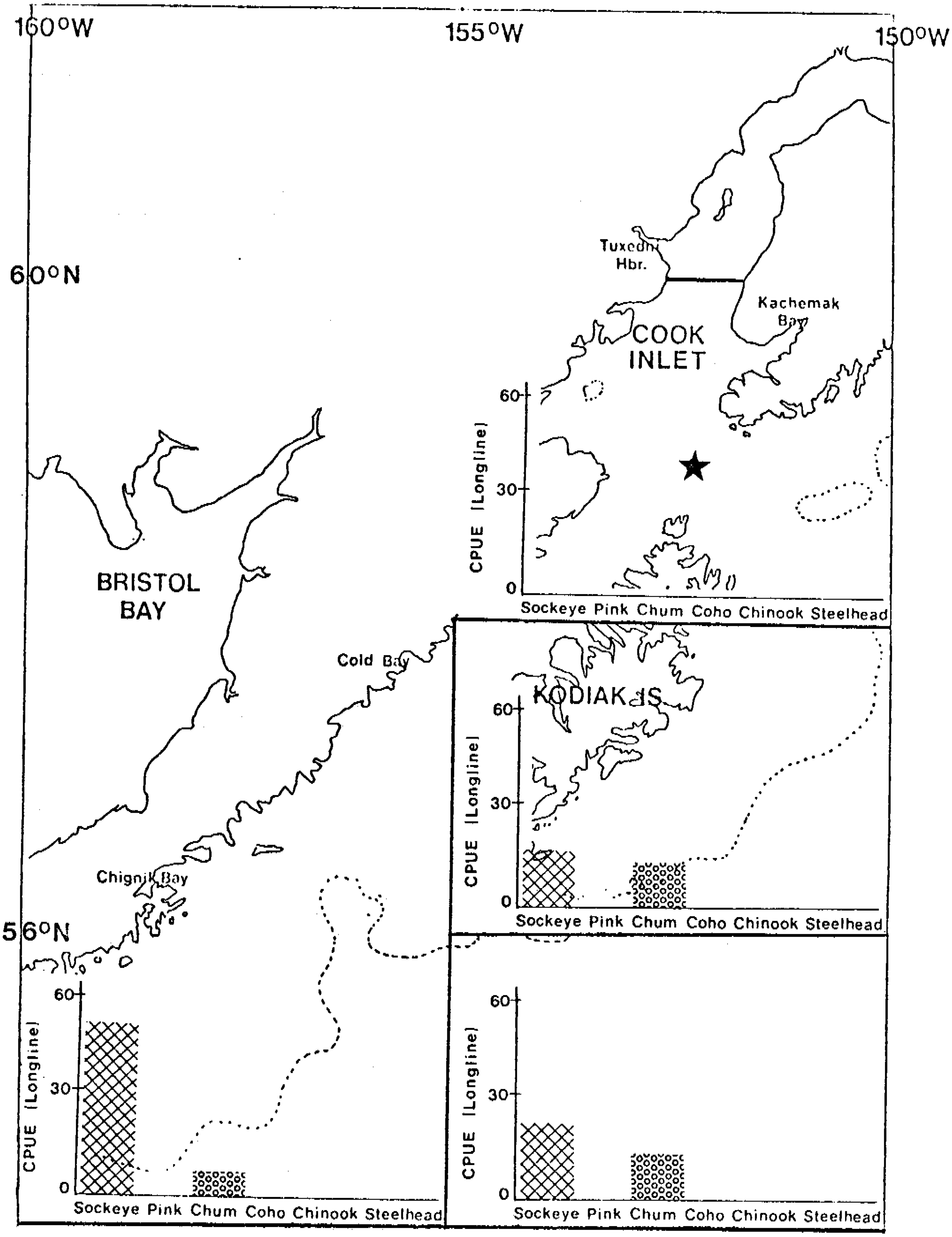


Fig. 42. The distribution and abundance of adult salmonids in the *Kodiak region* in May as determined by longline catches. The star indicates that no longlining was conducted in the area. A unit of effort equals one thousand hooks.

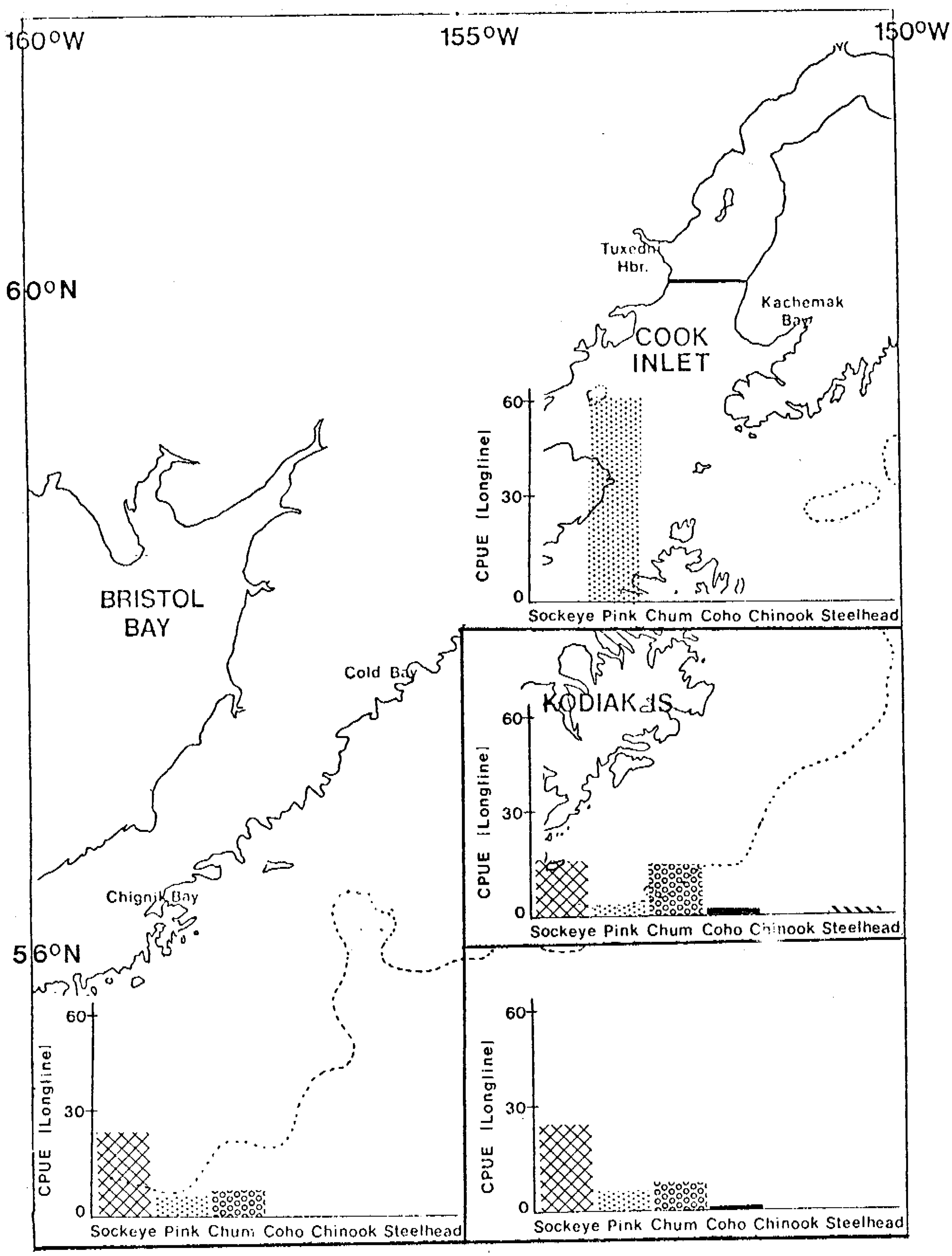


Fig. 43. The distribution and abundance of adult salmonids in the *Kodiak region* in June as determined by longline catches. A unit of effort equals one thousand hooks.

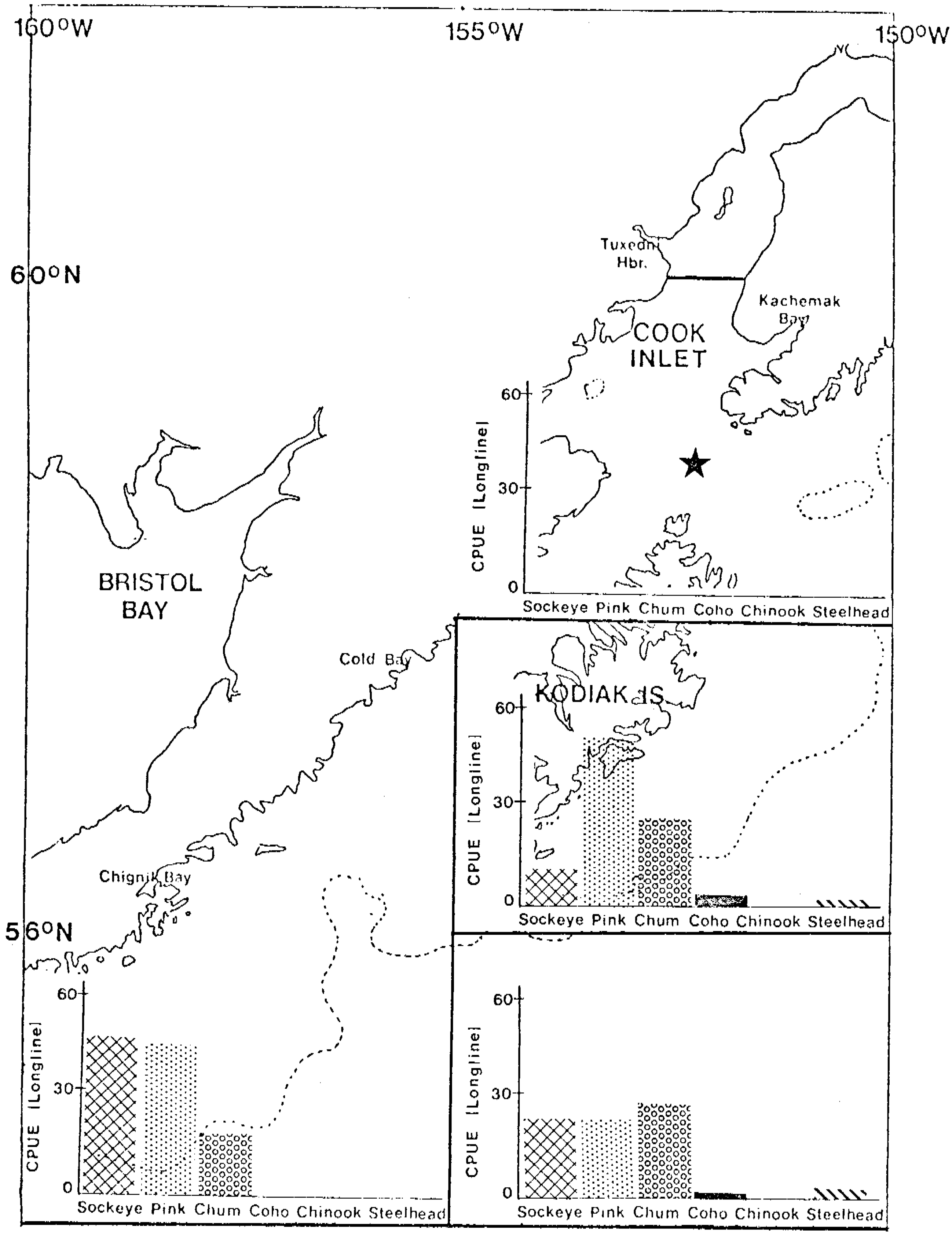


Fig. 44. The distribution and abundance of adult salmonids in the *Kodiak region* in July as determined by longline catches. The star indicates that no longlining was conducted in the area. A unit of effort equals one thousand hooks.

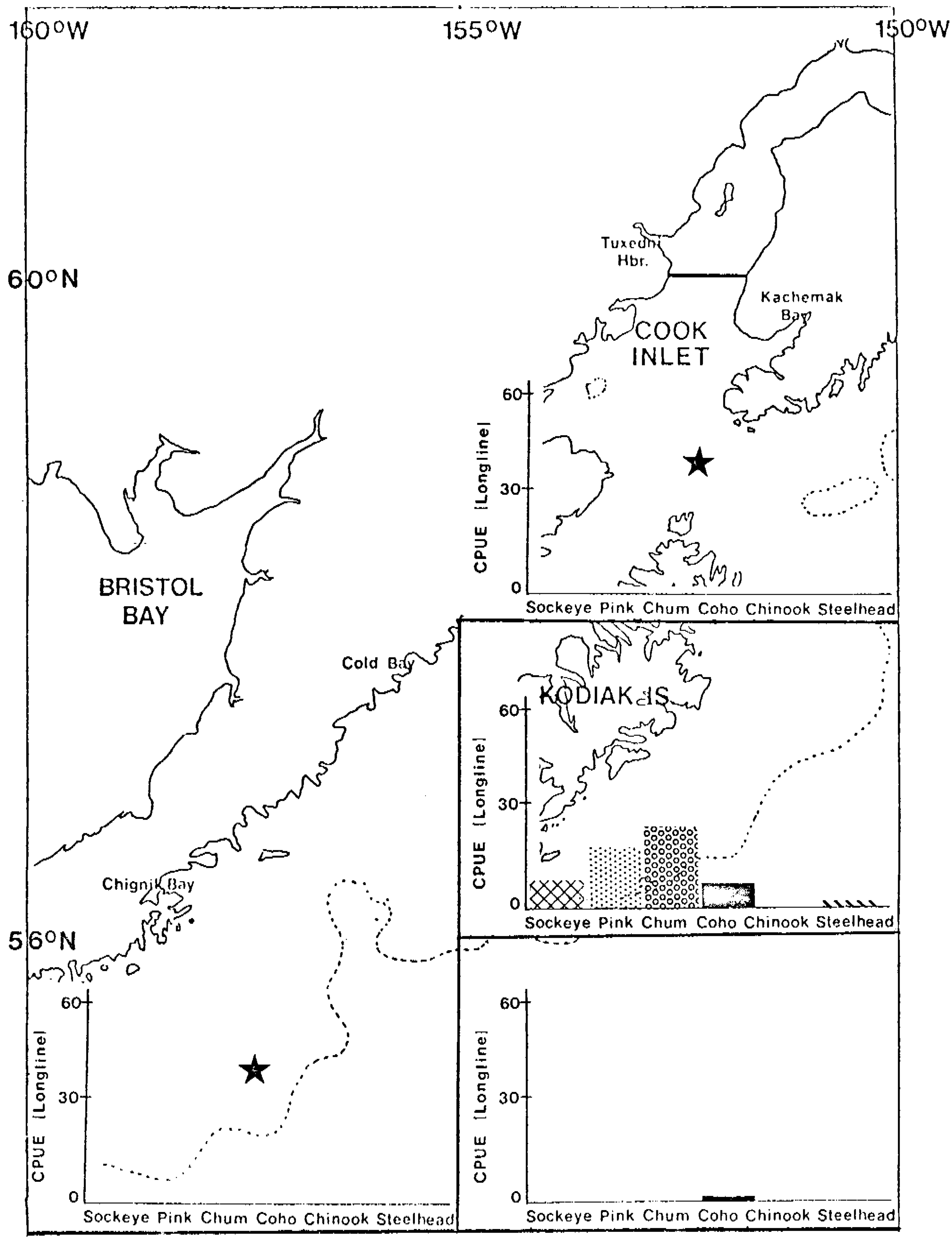


Fig. 45. The distribution and abundance of adult salmonids in the *Kodiak region* in August as determined by longline catches. Stars indicate areas where no longlining was conducted. A unit of effort equals one thousand hooks.

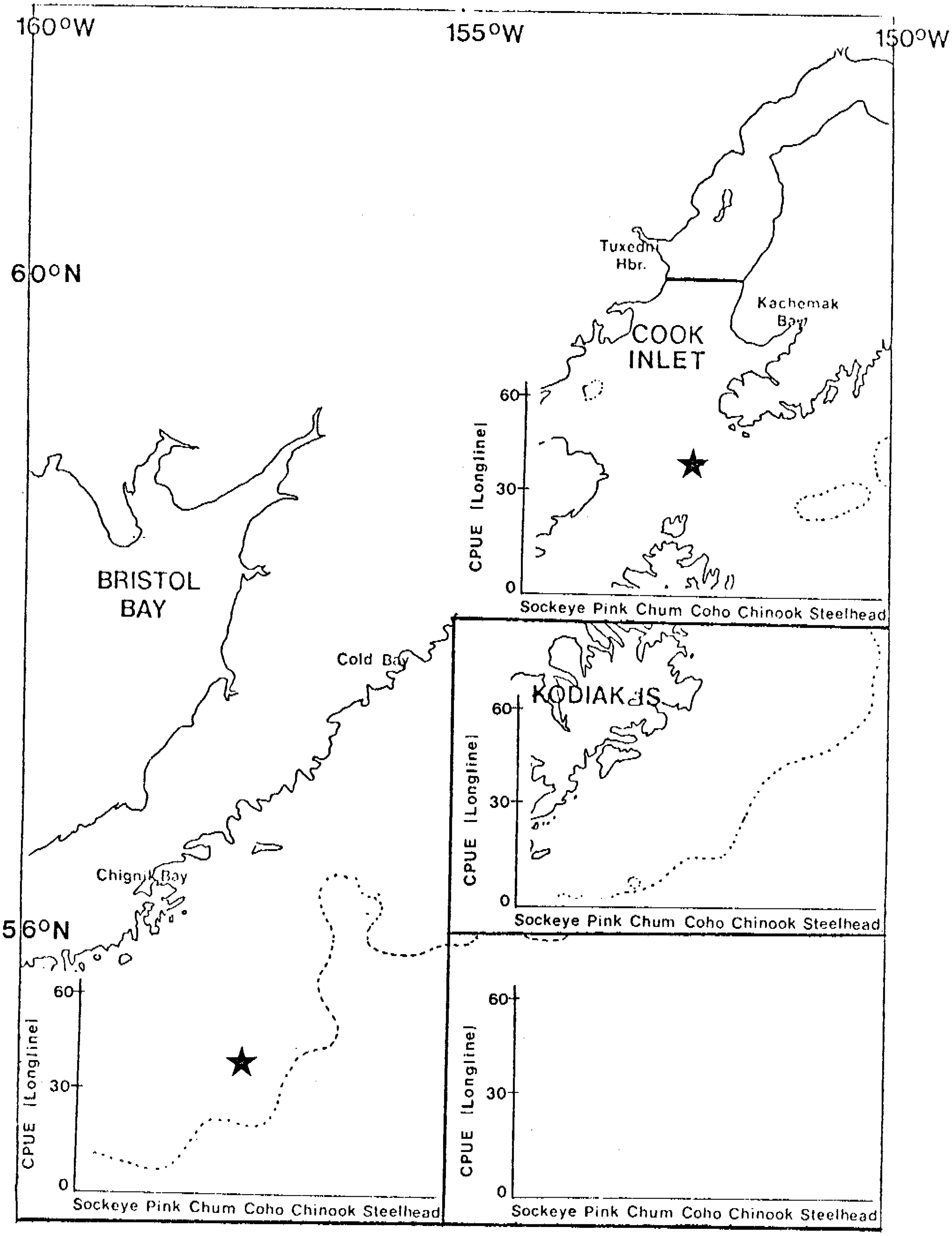


Fig. 46. The distribution and abundance of adult salmonids in the *Kodiak region* in September as determined by longline catches. Stars indicate areas where no longlining was conducted. A unit of effort equals one thousand hooks.

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RU #353

DETERMINATION AND DESCRIPTION OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE AND TIMING OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

SECOND INTERIM REPORT

April 15 - October 31, 1976

by

Loren J. Stern
Project Leader

Donald E. Rogers
Allan C. Hartt
Principal Investigators

A contribution to biological information needed by OCSEAP in making decisions with respect to offshore oil leases. Work performed under proposal number RU483-76 RFP Tasks A-7 and A-11.

Approved

Submitted November 2, 1976

Director

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INTRODUCTION

The objective of this report is to summarize information on the distribution, abundance, migration and timing of salmonids in waters of the eastern Bering Sea as defined below. It forms a portion of a background study designed to provide biological information needed by OCSEAP[1] in making decisions with respect to offshore oil leasing in the northern Gulf of Alaska and eastern Bering Sea. This is the second report from the literature survey on salmonids, the first covered northern waters of the Gulf of Alaska. A final report (due November 30, 1976) will interface the two interim reports and present relevant data not included in the earlier reports.

This report covers marine waters of the eastern Bering Sea bounded by longitudes 150°W and 175°W and latitudes 54°N and 58°30'N (Fig. 1). This area will henceforth be termed the *St. George Basin* region. Emphasis will be focused on the inshore area from the upper estuaries to the edge of the continental shelf. Total oceanic distributions will be briefly described to show their relation to inshore distributions.

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[1]Outer Continental Shelf Environment Assessment Program.

Six salmonid species are found in marine waters of the *St. George Basin* region (Figs. 2-7). Not enough data exist to describe the distribution, abundance, migration and timing of the Pacific char in this region. Consequently, the report will focus on sockeye, pink, chum, coho, and chinook salmon.

ADULT SALMONIDS IN NEARSHORE WATERS

The discussion will begin with mature adults as they enter nearshore waters at the culmination of the marine phase of their spawning migration. At this time the most accurate determinations of abundance can be made. Next, the juvenile salmonids will be discussed from the time they enter estuarine waters in the spring until they leave coastal waters for offshore feeding grounds. Lastly, information on adult salmon (age 0.1[2] and older) during their offshore phase of life will be presented, with emphasis on their return toward coastal waters.

Distribution and Abundance

It has generally been assumed that salmon were concentrated near the surface throughout their entire marine life. However, recent offshore experimental fishing (Manzer 1964, French et al. 1970) has shown that significant numbers of salmon occur at depths greater than 10 m. Consequently, more research is required to understand the vertical distribution of salmon.

Estimates of the annual abundance of adult salmon stocks were based on catch and escapement data. Catch data are relatively reliable for all species of salmon but reliable escapement data are only available for sockeye salmon.

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[2]Age designation proposed by Koo (1962) in which the number of ocean winter annuli on the scale is preceded by a decimal point and the number of freshwater winter annuli precedes the decimal point (e.g., a 2.1 age fish has spent two winters in freshwater and one at sea).

Therefore, the total population sizes of pink, chum, coho and chinook salmon stocks, which for sockeye salmon can be determined by summing catch and escapement, were estimated from catch-escapement relationships that were derived from sockeye salmon data.

Catch

The Japanese mothership fishery and the Alaskan commercial fishery account for the majority of the total catch of western Alaska stocks of salmon. Substantially fewer numbers are caught by subsistence and sport fisheries (Fig. 8). The Japanese mothership fishery operates as far east as 175°W longitude. Alaskan commercial salmon fisheries operate in bays and estuaries while subsistence and sport fisheries occur both in fresh-water and nearshore marine waters.

The Japanese mothership fishery, using surface gillnets, catches a mixture of both Asian and North American stocks of salmon. Estimates indicate that the percentage of Bristol Bay sockeye salmon caught by this fishery has varied annually from 3-37 percent with an average of 12 percent for the years 1956-73 (Fredin and Worlund 1974, Proc. 21st Annual Meeting INPFC 1974, Proc. 22nd Annual Meeting INPFC 1975) (Table 1). Insuffucent data exist to quantify the percentage of Bristol Bay stocks of pink, chum, and chinook salmon taken by the Japanese mothership fishery.

Alaskan commercial catch statistics from 1925-1975 were used to demonstrate historic levels of abundance which are measures of environmental carrying capacities. However, rates of exploitation were generally higher during the earlier years of this period; thus the historic decline in catches is somewhat greater than the actual decline in the abundances of the stocks.

Catch statisics are complicated by changes both in the fishery and in the procedure of recording data. Through 1954, catches were partitioned by districts (Fig. 9) which in 1955 were subdivided for greater geographic detail (Fig. 10).

Catch statisics from 1925-75 (Table 2, Fig. 11) show that sockeye salmon have historically been the most important species in Bristol Bay. The cyclic nature of individual runs are obscured by the grouping of different river systems. Sockeye salmon catches reached a peak of 24.7 million fish in 1938; before then catches over 20 million fish were not uncommon. After 1940 catches decreased although in 1947 a catch of 18.6 million fish occurred. Catches remained relatively low until 1965 when over 24 million fish were caught. Then, after another catch of over 20 million (20.7 million in 1970), the catch decreased to a low of only 0.8 million fish in 1973. Catches have risen gradually since then.

Currently, large numbers of pink salmon are caught in even years in Bristol Bay. Historically, low catches occurred in even and odd years until the mid-1950's. This probably reflects economic conditions rather than low levels of abundance because the more valuable sockeye salmon were very abundant in the earlier years. A catch of 2.5 million pink salmon was made in 1966. Since then catches have been lower, averaging less than 0.5 million fish.

Large numbers of chum salmon are caught annually in Bristol Bay. Peaks of nearly 1 million fish occurred in 1932 and 1939 with a low of only 0.07 million in 1935. Catches remained low through 1959, averaging less than 0.3 million fish but peaked in 1960 when 1.3 million chum salmon were caught. Since then catches have averaged approximately 0.5 million fish annually.

Catches of coho and chinook salmon are substantially less than those of sockeye, pink and chum salmon. Coho salmon catches averaged less than 0.02 million fish through 1950. After a low of 0.004 million in 1953, catches rose to a peak of 0.10 million in 1958 and since then have fluctuated greatly. A peak catch of 0.15 million chinook salmon was recorded in 1929, after which catches declined rapidly to less than 0.01 million in 1935. Since then catches have risen steadily and catches of 0.14 million fish occurred in 1964 and 1970.

Analysis of catch statisics for the 21-year period, 1955-75, yields an average annual catch of 9.5 million salmon by the Alaskan commercial fishery in the nearshore waters of the *St. George Basin* region (Table 3). Peak catches are composites of peak catches of individual species in different years.

Escapement

Over 90 percent of the runs of sockeye salmon to Bristol Bay come from five river systems (Royce 1965). Analysis of sockeye escapement data in these major river systems, available since 1952, yields an annual average of 9.1 million fish (Table 4). Similar data on the other salmon species are not available because of the relative magnitude of sockeye salmon runs in comparison to other species. Becker (1962) reported that sockeye predominate to such an extent in the Kvichak River that tower counts are considered to be all sockeye. Consequently, escapements of pink, chum, coho and chinook salmon were estimated by applying average catch-escapement ratios for sockeye to catches of pink, chum, coho and chinook salmon. A total of 11.0 million salmon were estimated to annually escape the fisheries (Table 5).

Population Estimates

The average total run of salmon (catch plus escapement) to the streams of the *St. George Basin* was estimated at 19.6 million for the years 1955-75 with a peak of 38.6 million fish (Table 6). This does not include salmon caught by the Japanese mothership fishery.

Alaska Peninsula North District. Total runs to this district averaged over 1.1 million salmon annually (1955-75) with a potential size of 3.7 million.

Sockeye salmon stocks comprise 60 percent of the total number of salmon in this district (Table 7). Chum salmon stocks are also important within the district constituting almost 30 percent of the average annual run of salmon. Pink, coho, and chinook salmon stocks are relatively small in relation to sockeye and chum stocks. The relative importance of this district within the whole region is small as it is estimated to produce only 5 percent of the total runs to the *St. George Basin* region.

Within the district statistical areas 315 and 313 are the most important as nearly 60 percent of the district's catch of salmon comes from this area. These two areas are important primarily as sockeye producers.

Bristol Bay District. Total runs to this district averaged over 18.3 million fish annually (1955-75) with a potential size of 32.4 million fish.

Sockeye salmon stocks predominate, constituting 86 percent of the total number caught in this district with even-year pink salmon and chum salmon comprising most of the remainder. This is the most important district within the *St. George Basin* region as over 86 percent of all salmon in this region are caught in Bristol Bay. In fact the Bristol Bay district is probably the most important salmon-producing area in North America.

Within Bristol Bay statistical areas 324 and 325 are most important as almost 80 percent of the district's catch comes from these areas. Statistical area 324, which includes salmon bound for the Kvichak, Naknek and Branch rivers, is extremely important as it provides 50 percent of all salmon caught in the *St. George Basin* region. The other statisical areas are also important on a region-wide basis.

Aleutian Islands District. Total runs to this district, which average less than 0.2 million fish, are much smaller than those of the other districts. The potential total run size is estimated to be 2.5 million fish.

Pink salmon predominate in the catches (especially in even years) when they constitute over 80 percent of the total catches in the district. Catches in this district come primarily from statistical area 302.

Timing

Salmonids enroute from their offshore grounds segregate into units, called races, bound for particular locations and regimes of timing within natal streams. As a result an environmental impact, although affecting only a small portion of the population, could devastate one or more of these races. Individual race timing is a function of the interplay of genetic and environmental factors. Despite environmental fluctuations, the timing of arrival of individual runs on the spawning grounds is amazingly consistent (Atkinson et al. 1967).

Catch statistics compiled on a weekly basis provide a reasonably accurate picture of run timing. However, because fishing periods are regulated by ADF&G[3] to insure adequate spawning escapements, catch does not fully indicate the entire shape or duration of the salmon runs. Escapement

[3] Alaska Department Fish and Game.

timing was used to supplement the use of catch statistics in describing the timing of salmon as they return to nearshore waters.

Aleutian Islands District (Fig. 12)

Catches of sockeye salmon begin in mid-June and continue through early August with multimodal peaks in between. Pink salmon catches begin three weeks later, peak in early August, and continue through at least late August. Chum salmon catches begin shortly after sockeye catches and continue through late August with bimodal peaks. Coho salmon catches do not begin until mid-July but continue through at least mid-September with a large peak in mid-August and a smaller one in early September. Chinook salmon catch data are not adequate to show timing.

Alaska Peninsula North District (Fig. 13)

Catches of sockeye salmon begin during the third week of June, peak 2-3 weeks later and continue through late August. Pink salmon catches in this district start slightly earlier than sockeye catches and continue into early September with bimodal peaks. Chum salmon catches have the longest duration, beginning in mid-June and continuing past mid-September with a peak in late July. Coho salmon catches begin in early August, latest of all species, and continue through at least late September. Chinook salmon catches begin in early June, and continue into late July.

Bristol Bay District (Fig. 14)

The large runs of Bristol Bay sockeye support a relatively short duration fishery, beginning in late June, peaking in early July and ending usually by late July. The majority of fish are caught within a three-week period. Pink salmon catches began the same time as sockeye salmon but last longer, peaking in late July and continuing into mid-August. Chum salmon catches begin slightly earlier than sockeye and pink catches, peak in mid to late July, and end in early September. Coho salmon catches start in late June, peak in mid to late August and continue into September. Chinook salmon catches begin in early June, peak in late June and are over by late July. Royce (1965) analyzed catch timing data supplemented by escapement timing data for individual rivers (Table 8) which indicates similar timing regimes for the Nushagak, Naknek-Kvichak, and Egegik systems with the Ugashik and Togiak sockeye salmon stocks running a few days later.

Migration

Sufficient tagging and experimental fishing data exist to show the migratory patterns of sockeye salmon stocks in the nearshore waters of the study area. Similar data on chum and pink salmon are adequate to show only the general migrations. Too little data on coho and chinook salmon migrations exist to describe them.

Pertinent to nearshore movements of adult salmon are reports indicating that such migrations include a large degree of 'wandering' (Neave 1964, Rearden 1965, Thorsteinson 1956, Verhoeven 1947). Also relevant are reports suggesting different migratory behaviors for different species (Milne 1957, Prakash 1962). Migration will be discussed by statistical district.

Aleutian Islands District

Tag returns indicate mature adult sockeye, chum, and pink salmon move through Aleutian passes in late May-July enroute to western Alaskan streams (Gilbert and Rich 1925, Royce et al. 1968, Thorsteinson and Merrell 1964). Significant numbers of immature sockeye salmon and lesser numbers of immature chum salmon bound for feeding grounds in the Bering Sea move through these passes in June-September (French et al. in press, Neave et al. in press).

Alaska Peninsula North District

The small number of Bristol Bay recoveries of fish tagged in this district indicate few, if any, sockeye bound for Bristol Bay enter the nearshore waters of this district (Gilbert 1923, Rich 1926). After moving through Aleutian passes adult sockeye salmon move in two belts offshore (Straty 1975) with only local sockeye salmon stocks entering the nearshore waters in significant numbers. Insufficient data exists to describe the migratory patterns of pink, chum, coho, and chinook salmon.

Bristol Bay District

Straty (1975) analyzed selected years of tagging data and concluded that Bristol Bay sockeye salmon stocks migrated in two offshore belts until approximately 158°W longitude where they enter nearshore waters. The main migration route in nearshore waters was found to be in the southern half of the bay. Straty also found that stock segration intensified toward the head of the bay, with Nushagak sockeye salmon stocks concentrated on the west side of the inner bay, Ugashik and Egegik stocks concentrated on the east side of inner Bristol Bay, and the Naknek-Kvichak sockeye salmon stocks most abundant centrally in the offshore waters until they reach Kvichak Bay. Similar data on pink, chum, coho, and chinook salmon are not available.

JUVENILE SALMONIDS IN NEARSHORE WATERS

Adequate data exist to describe the general patterns of abundance, distribution, timing, and migration of juvenile salmon upon their entry into the marine environment. However, there is little direct data to describe their initial movements upon entering estuarine waters.

Distribution and Abundance

The distribution and abundance of young salmon entering marine waters are roughly in proportion to the distribution and abundance of adults entering streams within the area. Analysis of this data, summarized by Atkinson et al. (1967), shows that juvenile salmon enter the marine environment throughout coastal waters of the *St. George Basin* region (Figs. 15-19).

Population Estimates

Direct counts or population estimates are available for a limited number of streams within the study area and in most cases were developed to aid in forecasting adult returns and as such provide indexes of relative abundance. Consequently, juvenile salmon abundance was based upon parent spawning stock size (Table 5) using average fecundities and survival rates to arrive at estimates of the number of downstream migrant salmon.

Fecundity varies inter- and intraspecifically among salmon necessitating the use of average values. Average fecundities of 2,000 eggs for pink, 3,000 eggs for chum, 3,500 eggs for sockeye and coho, and 4,000 eggs for chinook were used (Bailey 1969).

Survival rates from egg to downstream migrant also have great variability. Burgner (1962) reported that the rate of reproduction (defined as the number of smolt-index units per 1,000 parent spawners) varied twenty-fold for the years 1949-55 at Wood River. Foerster (1955) reported egg to seaward-migrating sockeye smolt survival rates as 1.8%, 2.8%, 2.6%, 1.2% for Port John, Cultus, Lakelse, and Babine Lakes, Canada, respectively. Donaldson (1963) stated that 2% approximates average egg to seaward migrant survival rates for sockeye, coho, and chinook salmon. Survival rates for the same period for pink and chum salmon are higher because these two species depart the freshwater environment soon after emergence while most sockeye, coho, and chinook salmon remain in freshwater for 1-3 years. Consequently, egg to seaward migrant survival rates for pink and chum salmon average approximately 10% (Foerster 1955, Mackinnon 1970). Thus survival rates of 2% for sockeye, coho, and chinook salmon and 10% for pink and chum salmon were used in subsequent population estimates.

Over 582 million juvenile salmon are estimated as an average year's production of juvenile salmon from streams within the *St. George Basin* region with sockeye smolts constituting the largest portion (Table 9).

Timing

Juvenile salmon enter estuarine waters in the spring and summer months, the precise timing depending on genetic and environmental factors, primarily climatic (Hartman et al. 1967), as well as travel distance to estuarine waters. Timing will be described based on catches of seaward migrant sockeye salmon. Too little data exist to describe the timing of pink, chum, coho, and chinook salmon juveniles although purse seine catches offshore suggest similar timing for sockeye, pink, chum, coho, and chinook salmon.[4]

[4]Hartt, Allan C. and Michael B. Dell. MS. 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA., unpublished manuscript.

Seaward migrating sockeye salmon reach estuarine waters usually one or two days after departing lake outlets. This migration occurs primarily mid-May through mid-July although small numbers of sockeye continue into September (Straty 1974). Fyke-net catches (Table 10) demonstrate that characteristics of the seaward migration vary in time and space. In general early migrants are primarily smolts of age 2.0,[5] whereas age 1.0 smolts are more prevalent in mid- to late summer.[6]

Migration

After entering estuarine waters of Bristol Bay sockeye salmon juveniles migrate in surface waters in a continuous band from the estuaries to at least 110 km offshore.[7] Similar data on pink, chum, coho, and chinook salmon juveniles are not adequate to describe their movements in near-shore waters.

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[5]Age designation proposed by Koo (1962).

[6]Hartman, Wilbur L., William R. Heard, Charles W. Strickland, and Robert Dewey. MS. 1963. Red salmon studies at Brooks Lake Biological Field Station, 1962. Manuscript Report No. 63-6. 36 pp.

[7]Hartt, Allan C., and Michael B. Dell. MS. 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA. Unpublished manuscript.

JUVENILE SALMON IN OFFSHORE WATERS

Adequate data exist to describe the distribution, abundance, timing, and migration of young sockeye salmon after they depart estuarine waters on their seaward migration. There are also adequate data to describe general features of the dynamics of pink, chum, coho, and chinook salmon juveniles in offshore waters of the *St. George Basin* region.

Distribution and Abundance

Straty (1972) concluded that sockeye salmon smolts were distributed in a belt from the estuaries to at least 56 km offshore extending to Port Moller through at least late summer. Analysis of unpublished purse seine data[8] extends this belt to 110 km offshore and illustrates the relative abundance of sockeye, pink, chum, coho, and chinook salmon juveniles in offshore waters of the *St. George Basin* (Fig. 20).

Timing

Juvenile sockey salmon are abundant in inner Bristol Bay (defined as east of Port Heiden) from late May through early August, a period of two and one-half months (Straty 1974). Straty noted that the time-space distribution of smolts depended on stock outmigration timing in addition to location of entry into Bristol Bay. Consequently, mixing of certain stocks of sockeye salmon in nearshore waters occurs enroute to offshore grounds. He found that Ugashik and Kvichak stocks of sockeye smolts were captured in early July off Port Moller. Naknek sockeye salmon smolts were not

[8] Hartt, Allan C., and Michael B. Dell. MS, 1976. Life history of Pacific salmon and ste-lhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA., unpublished manuscript.

captured there until July 17 and sockeye smolts from the Wood River were captured no further seaward than Port Heiden by mid-August. Further evidence indicates that early stocks and probably later ones as well move slower after passing Port Heiden. The timing of offshore movement of sockeye salmon juveniles is not known but probably occurs in the fall or early winter.[9]

Migration

Unpublished research using purse seines[9] and experimental fishing using a variety of gears (Straty 1974) demonstrate that stocks of sockeye, pink, chum, coho, and chinook salmon juveniles move along the southeast side of Bristol Bay and north side of the Alaska Peninsula in a belt up to 110 km offshore (Fig. 21). Juvenile salmon were most abundant in this belt from 18 to 55 km offshore.[9] Straty (1974) found that sockeye salmon smolts that enter along the north side of Bristol Bay (i.e., Wood River) move across the bay and then along the southeast shore. Echo sounding data (Straty 1974) and experimental gillnet catches (Japan, Hokkaido University, Faculty of Fisheries 1969) show that juvenile sockeye salmon are concentrated in the upper 2 m of the water column congregated in small schools. Gillnet catches in winter (French 1969) suggest that beyond Port Moller sockeye juveniles leave coastal waters and begin their high seas period of life.

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[9] Hartt, Allan C., and Michael B. Dell. MS. 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA., unpublished manuscript.

ADULT SALMONIDS IN OFFSHORE WATERS

Adequate data exist to describe the abundance, distribution, timing and migration of adult salmon in offshore waters of the *St. George Basin* region. The discussion will focus on sockeye (French et al. in press) and chum salmon (Neave et al. in press), the most abundant salmon species in the catches of both the high seas experimental fishing catches and in the nearshore commercial fishery.

Abundance, Distribution and Timing

Gillnet and longline catches on the high seas were used to describe the distribution and relative abundance of salmon. Fukuhara (1971) noted that the amount of high seas gillnet sampling was less than the minimum necessary to reflect sockeye abundance even at sampling sites. Consequently, relative abundance will be described. Not enough data exist to describe the fall-early spring distributions due to limited sampling.

Maturing age .3 sockeye salmon were caught in all areas fished with gillnets in the Bering Sea during winter sampling indicating a widespread distribution of this age class. No other age classes of sockeye salmon were intermixed in the gillnet catches. Little is known until June when high gillnet (Fig. 22) and longline (Fig. 23) catches of primarily mature fish reflect the spawning migration of stocks bound for Bristol Bay. Gillnet and longline catches in July of primarily immature fish indicate that sockeye are distributed as far east as 169°W longitude although in substantially fewer numbers than in June. August and September gillnet catches show that although some sockeye are still present in the offshore waters of the *St. George Basin* region, their center of abundance lies to the south in the North Pacific Ocean.

Not enough data exist to describe the distribution and abundance of chum salmon in the winter and spring. Gillnet catches in June and July show that chum salmon are distributed throughout the offshore waters of the region. (Fig. 22). Lower CPUE's in August gillnet catches are indicative of fewer numbers of fish and September catches suggest only a few chum salmon remain in the offshore waters of the *St. George Basin* region.

Migration

Royce et al. (1968) and French and Bakkala (1974) have summarized the migrations of western Alaskan stocks of sockeye salmon. Consequently, emphasis will be made on this species.

Age .0 sockeye from Bristol Bay, after moving offshore in the fall or winter, migrate into the North Pacific Ocean where they intermix with older age classes. By spring the young sockeye, now age .1, have reached the southern limit of their distribution (approximately 45°N latitude), south of the main concentration of age .2 and older sockeye salmon. In June age .1 fish commence a northward movement which continues into September, some fish moving as far north as the central Bering Sea. In the winter a southward movement occurs during which maturing and immature components separate with the maturing sockeye not migrating as far south as the fish that will not spawn in the next season. The maturing fish, now .2, remain in these waters until spring when they migrate through Aleutian passes enrout to spawning grounds. The immature age .2 sockeye are joined by a new year class of fish (age. 1) and the pattern just described is repeated.

There is much evidence to suggest that pink, chum, coho, and chinook salmon migrations in offshore waters are similar to that of sockeye salmon (Fig. 25). For example, age .0 sockeye, pink, chum, coho, and chinook salmon from western Alaska migrate along similar paths on the north side of the Alaska Peninsula and that western Alaskan stocks of sockeye, pink, chum, and coho salmon migrate into the North Pacific Ocean.

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Table 1. Estimated catches of Bristol Bay sockeye salmon by the Japanese mothership fishery in millions, 1956-73.

YEAR	CATCH[1]	EXPLOITATION RATE[1] (%)
1956	2.43	8.4
1957	7.35	38.7
1958	0.38	5.3
1959	0.60	4.1
1960	3.73	9.0
1961	6.13	24.5
1962	0.96	8.1
1963	1.00	11.9
1964	0.31	2.6
1965	6.94	11.5
1966	1.93	9.7
1967	0.92	7.8
1968	0.89	9.5
1969	2.03	9.3
1970	3.97	8.9
1971	1.43[2]	11.0[2]
1972	0.92[2]	18.4[2]
1973	0.88[3]	23.3[3]
$\bar{x}$	2.38	12.3

Sources: [1]Fredin and Worlund (1974)

[2]INPFC Secretariat (1974)

[3]INPFC Secretariat (1975)

Table 2. Summary of catch statistics (1925-72) in thousands of fish for western Alaska by statistical district and species.

District	Sockeye	Pink[3] (odd year)	Pink[3] (even year)	Chum	Coho	Chinook	Total
North Alaska Peninsula District							
Average catch	489.4	4.7	14.9	131.5	29.8	4.6	665.1
95% confidence interval	±78.6	±3.6	±11.1	±38.0	± 7.5	±1.7	
Peak catch[2]	1154.9(1956)	24.9(1953)	60.4(1958)	607.2	64.9(1968)	28.7(1959)	1898.3
1975 catch[2]	252.6	0.4	-	8.3	28.3	2.1	291.7
Bristol Bay District							
Average catch	10655.6	<0.05	479.6	424.3	28.0	68.0	11415.7
95% confidence interval	±1936.5	-	±285.3	±72.3	±7.6	±10.7	
Peak catch[2]	24700.0(1938)	1.9(1969)	2492.9(1966)	1316.0(1960)	135.8(1958)	150.7(1929)	27549.9
1975 catch[2]	1944.4	0.4	-	316.4	46.2	29.8	2337.2
Aleutian Islands District							
Average catch	14.1	77.1	500.9	2.3	<0.1	<0.1	305.4
95% confidence interval	±14.1	66.1	373.7	1.9	-	-	
Peak catch[2]	42.8(1952)	334.6(1927)	2001.7(1962)	94.5(1951)	0.8(1954)	2.3(1957)	1308.5
1975 catch[2]	19.4	0.7	-	1.9	-	-	22.0
Grand Totals							
Average catch							12408.2
Peak catch							30756.7
1975 catch							2650.9

Sources: [1]INPFC Secretariat 1976 MS

[2]Alaska Department of Fish and Game

[3]For 1928-50, Aleutian Island catches included with Alaska Peninsula (south side), or no catches reported.

Table 3. Summary of catch statistics[1] (1955-75) in thousands of fish for western Alaska by statistical divisions and species. The peak catch is enclosed in parentheses

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total	
ALASKA PENINSULA NORTH DISTRICT														
311	11.10	(31.80)	10.11	(60.40)	2.08	(7.90)	49.52	(242.40)	1.76	(4.70)	<0.05	(0.70)	68.55	(313.75)
312	8.24	(40.20)	<0.05	(0.10)	<0.05	(0.30)	62.19	(438.20)	<0.05	(9.30)	<0.05	(5.80)	70.60	(444.70)
313	68.09	(173.20)	<0.05	(0.20)	<0.05	(0.40)	5.92	(41.20)	24.60	(56.80)	3.47	(17.80)	102.00	(299.30)
314	7.44	(56.60)	<0.05	(0.20)	<0.05	(0.20)	17.86	(66.20)	<0.05	<0.05)	0.56	(2.70)	26.00	(125.70)
315	174.74	(452.70)	<0.05	(2.50)	<0.05	(0.40)	13.18	(34.30)	0.45	(1.50)	1.44	(9.50)	190.00	(500.05)
316	37.09	(81.00)	<0.05	(1.40)	<0.05	(1.40)	2.42	(8.90)	<0.05	(1.10)	0.11	(0.30)	40.30	(92.70)
317	5.85	(21.30)	*	(0.10)	<0.05	(<0.05)	1.99	(8.40)	7.51	(26.80)	1.04	(1.00)	15.40	(43.65)
318	*	(0.30)					*	(0.10)	*	(0.80)	<0.05	(<0.05)	0.15	(1.20)
Total	312.55	(857.10)	10.11	(64.90)	2.08	(10.60)	152.98	(840.50)	34.32	(32.00)	6.62	(38.70)	513.55	(1,256.05)
BRISTOL BAY DISTRICT														
321	331.38	(954.10)	<0.05	(<0.05)	<0.05	(0.10)	17.60	(51.40)	2.52	(5.80)	2.12	(3.40)	353.70	(1,015.75)
322	1,105.72	(3,190.70)	0.62	(4.00)	<0.05	(0.10)	23.00	(62.80)	3.13	(8.50)	2.53	(4.40)	1,134.70	(3,258.45)
323	*	(1,659.20)	--		--		*	(30.70)	--		*	(6.90)	--	(1,695.80)
324	4,563.63	(17,460.80)	118.57	(509.00)	0.05	(0.10)	110.98	(304.30)	1.69	(7.40)	8.23	(19.00)	4,743.80	(18,066.25)
325	997.11	(2,544.70)	879.74	(2,337.19)	0.14	(0.30)	248.55	(642.10)	26.76	(61.40)	66.22	(108.50)	1,778.60	(4,525.50)
326	149.86	(249.70)	6.36	(13.50)	0.39	(1.40)	101.96	(195.40)	10.77	(33.40)	10.90	(28.70)	276.80	(514.65)
320	*	(360.00)	--		--		*	(20.60)	--		*	(0.70)	--	(381.30)
Total	7,147.70	(26,439.20)	1,005.29	(2,863.60)	0.53	(2.00)	502.09	(1,307.30)	44.97	(116.50)	90.00	(173.70)	8,287.50	(29,469.50)
ALEUTIAN ISLAND DISTRICT														
300	--		--		*	(<0.05)	*	(0.80)	--		--		--	(0.80)
301	--		*	(8.70)	--		*	(1.50)	--		*	(1.60)	--	(7.55)
302	12.25	(12.25)	606.50	(1,976.80)	54.73	(242.10)	1.42	(11.40)	<0.05	(0.05)	<0.05	(0.70)	743.40	(2,243.25)
Total	12.25	(12.25)	606.50	(1,985.50)	54.73	(242.10)	1.42	(13.80)	<0.05	0.05	<0.05	(2.30)	743.40	(1,142.20)
GRAND TOTAL	7,472.50	(27,308.55)	1,621.90	(4,914.00	57.34	(254.70)	655.07	(2,161.60)	79.29	(198.60)	96.62	(214.70)	9,544.85	32,467.80)

*Sporadic reports only.

[1]Source: INPFC Statistical Yearbooks (1955-74).
Alaska Department Fish and Game.

Table 4. Summary of sockeye salmon escapement data[1] for the major sockeye rivers of western Alaska.

Area	North Side[4] Alaska Pen.	Ugashik	Egegik	Naknek - Kvichak				Nushagak			Togiak	St. George Basin Region
Year / River		Ugashik	Egegik	Naknek	Branch	Kvichak	Total	Wood	Other Systems	Total	Togiak	TOTAL
1952		0.65	0.76	0.10	-	5.97	6.07	0.23	0.21	0.44	0.18	8.10
1953	-	1.06	0.52	0.28	-	0.32	0.60	0.52	0.31	0.83	0.19	3.20
1954	-	0.46	0.51	0.80	-	0.24	1.04	0.57	0.12	0.69	0.20	2.90
1955	-	0.08	0.27	0.28	0.17	0.25	0.70	1.38	0.55	1.93	0.12	3.10
1956	-	0.42	1.10	1.77	0.78	9.44	11.99	0.77	0.44	1.21	0.22	16.43
1957	1.49	0.22	0.39	0.64	0.13	2.96	3.73	0.29	0.21	0.50	0.25	5.40
1958	0.31	0.28	0.25	0.28	0.09	0.54	0.91	0.96	0.32	1.28	0.07	3.23
1959	0.44	0.22	1.07	2.23	0.82	0.68	3.73	2.21	0.83	3.04	0.21	8.86
1960	0.59	2.34	1.80	0.83	1.24	14.63	16.70	1.02	0.66	1.68	0.18	23.10
1961	0.40	0.37	0.70	0.35	0.09	3.71	4.15	0.46	0.40	0.86	0.12	6.66
1962	0.46	0.27	1.03	0.72	0.09	2.58	3.39	0.87	0.64	1.51	0.07	6.54
1963	0.27	0.40	1.00	0.90	0.20	0.34	1.44	0.72	0.34	1.06	0.10	4.32
1964	0.32	0.48	0.85	1.35	0.25	0.96	2.56	1.08	0.26	1.34	0.09	6.32
1965	1.00	1.00	1.44	0.72	0.17	24.33	25.22	0.68	0.42	1.10	0.06	30.58
1966	1.76	0.72	0.80	1.02	0.17	2.78	4.97	1.21	0.42	1.63	0.08	8.47
1967	0.27	0.24	0.64	0.76	0.20	3.22	4.18	0.52	0.36	0.88	0.06	6.00
1968	-	0.27	0.34	1.02	0.19	2.56	3.77	0.65	0.33	0.98	0.05	5.21
1969	-	0.16	0.98	1.23	0.18	8.39	9.80	0.60	0.61	1.21	0.25	12.40
1970	-	0.73	0.92	0.73	0.18	13.94	14.85	1.16	0.80	1.96	0.19	18.72
1971	-	0.53	0.63	0.94	0.19	2.39	3.52	0.85	0.50	1.35	0.21	6.24
1972	-	0.08	0.55	0.59	0.15	1.01	1.75	0.43	0.10	0.53	0.09	3.00
1973	-	0.04	0.33	0.35	0.04	0.23	0.62	0.33	0.25	0.58	0.13	1.70
1974[2]	-	0.06	1.28	1.24	0.21	4.43	5.88	1.71	0.56	2.27	0.08	9.57
1975[3]	-	0.43	1.17	2.03	0.10	13.14	15.27	1.27	1.00	2.27	0.19	19.33
$\bar{x}$	0.66	0.47	0.81	0.88	0.27	5.00	6.12	0.85	0.44	1.30	0.14	9.14

Sources: [1]Rogers, Donald E. 1973.

[2]Krasnowski, Paul and Richard Randall, 1976.

[3]Anonymous, 1975.

[4]Ossiander, Frank J. 1967.

Table 5. Estimated average escapements[1] of salmon in western Alaska by statistical area and by species in thousands of fish.

Statistical area	Sockeye		Pink (even year)		Pink (odd year)		Chum		Coho		Chinook		Total	
ALASKA PEN. NORTH														
311	13.1	(37.4)	11.9	(71.1)	2.4	(9.3)	58.2	(285.2)	2.1	(5.5)	< 0.1	(0.8)	80.5	(113.6)
312	9.7	(47.3)	< 0.1	(0.1)	< 0.1	(0.3)	73.2	(515.5)	< 0.1	(0.3)	< 0.1	(6.8)	82.9	(570.1)
313	80.1	(203.8)	< 0.1	(0.2)	< 0.1	(0.5)	6.8	(48.5)	28.9	(66.8)	4.1	(20.9)	119.9	(340.3)
314	8.7	(66.6)	< 0.1	(0.2)	< 0.1	(0.2)	21.0	(77.9)	< 0.1	(< 0.1)	0.7	(3.2)	30.4	(147.9)
315	205.6	(532.6)	< 0.1	(2.9)	< 0.1	(0.5)	15.5	(41.1)	0.5	(1.8)	1.7	(11.2)	223.3	(583.4)
316	43.6	(95.3)	< 0.1	(1.6)	< 0.1	(1.6)	2.8	(10.5)	< 0.1	(1.3)	0.1	(0.4)	46.5	(109.1)
317	6.9	(25.1)	*	(0.1)	< 0.1	(< 0.0	2.3	(10.1)	8.8	(19.8)	1.2	(2.2)	19.2	(57.2)
318	*	(0.4)	--	--	--	--	*	(0.1)	*	(0.9)	< 0.1	(< 0.1)	--	(1.4)
Total	367.7	(1,008.5)	11.9	(76.2)	2.4	(12.4)	179.8	(988.9)	40.3	(96.4)	7.8	(46.5	602.7	(1,928.0)
BRISTOL BAY														
321	460.2	(1,325.1)	< 0.1	(< 0.1)	< 0.1	(0.1)	24.4	(11.4)	3.6	(8.1)	2.9	(7.5)	491.1	(1,412.1)
322	813.0	(2,346.1)	0.4	(2.9)	< 0.1	(0.1)	16.9	(46.2)	2.3	(6.2)	1.9	(3.2)	834.3	(2,403.2)
323	--	--	--	--	--	--	--	--	--	--	--	--	--	--
324	5,850.8	(22,411.3)	152.0	(652.6)	< 0.1	(0.1)	142.3	(390.1)	2.2	(9.5)	10.5	(24.3)	6,081.8	(23,161.5)
325	1,294.9	(3,304.8)	1,142.5	(3,035.2)	0.2	(0.4)	322.8	(833.9)	34.8	(79.7)	86.0	(141.0)	2,309.8	(5,872.2)
326	149.9	(249.7)	6.4	(13.5)	0.4	(0.3)	101.9	(195.4)	10.8	(33.4)	10.9	(28.7)	276.9	(514.1)
Total	8,568.8	(29,637.0)	1,301.3	(3,704.2)	0.6	(1.0)	608.3	(1,537.0)	53.7	(136.9)	112.2	(204.7)	9,993.9	(33,363.1)
ALEUTIAN IS.														
300	--	--	--	--	*	(< 0.1)	*	(0.9)	--	--	--	--	*	(0.9)
301	*	*	*	(10.2)	--	--	*	(1.9)	--	--	--	(1.9)	*	(8.9)
302	14.5	(--)	713.5	(2,325.6)	64.4	(284.8)	1.7	(13.4)	< 0.1	(< 0.1	< 0.1	(0.8)	405.1	(1,306.0)
303	--	(-)	--	--	--	--	--	--	--	--	--	--	--	--
309	-	(--)	--	--	--	--	--	--	--	--	--	--	--	--
310			--	--	--	--	--	--	--	--	--	--	--	--
Total	14.5	--	713.5	(2,335.8)	64.4	(284.8)	1.7	(16.2)	< 0.1	(< 0.1)	< 0.1	(2.7)	405.1	(1,315.8
Grand total	8951.0	(30821.0)	2026.7	(6146.3)	67.4	(334.0)	789.8	(2542.5)	94.0	(237.0)	120.0	(252.9)	11001.7	(36606.9)

[1] See text for source.
*Sporadic reports only.

Table 6. Estimates[1] of the average total runs of salmon in the nearshore waters of *St. George Basin* region by statistical area and species in thousands of fish (1955-75)

Statistical area	Sockeye		Pink (odd)		Pink (even)		Chum		Coho		Chinook		Total	
ALASKA PENINSULA NORTH														
311	24.2	(69.2)	22.0	(92.2)	4.4	(17.2)	107.7	(527.6)	3.8	(10.2)	<0.1	(1.5)	143.0	(518.2)
312	17.9	(87.5)	<0.1	(0.2)	<0.1	(0.6)	135.4	(953.7)	0.1	(0.6)	<0.1	(12.6)	197.1	(965.2)
313	148.1	(377.0)	<0.1	(0.4)	<0.1	(0.9)	12.6	(89.7)	53.5	(123.6)	7.5	(39.7)	221.8	(400.8)
314	15.1	(123.2)	<0.1	(0.4)	<0.1	(0.4)	38.8	(144.1)	<0.1	(<.1)	1.2	(5.9)	56.2	(273.6)
315	360.3	(985.3)	<0.1	(5.4)	<0.1	(0.9)	28.6	(76.0)	0.9	(3.3)	3.1	(20.7)	413.1	1,088.4
316	80.6	(176.3)	<0.1	(3.0))	<0.1	(3.0)	5.2	(19.4)	<0.1	(2.4)	0.2	(0.7)	85.1	(201.8)
317	12.7	(46.4)	*	(0.2)	<0.1	(<0.1)	4.2	(18.7)	16.3	(36.6)	2.2	(4.1)	35.5	(105.9)
318	*	(0.7)	--	--	--	--	*	(0.2)	*	(1.7)	<0.1	(<0.1)	*	(2.6)
Total	680.2	(1,911.9)	22.0	(101.8)	4.4	(23.0)	(332.7)	(1,829.4)	74.6	(178.4)	14.4	(84.2)	1,159.0	(3,676.6)
BRISTOL BAY														
321	791.5	(2,279.2)	<0.1	<0.1)	<0.1	(0.2)	42.0	(122.8)	6.2	(13.9)	5.0	(12.9)	844.8	(2,428.9)
322	1,918.7	(5,536.8)	1.0	(6.9)	<0.1	(0.2)	39.9	(109.0)	5.4	(14.7)	4.4	(7.6)	1,968.8	(5,671.6)
323	*	(1,659.2)	--	--	--	--	--	(30.7)	--	--	--	(6.9)	*	(1,696.8)
324	10,414.4	(39,892.1)	270.6	(1,161.6)	0.1	(0.2)	253.2	(694.4)	3.8	(16.9)	18.7	(43.3)	10,825.6	(10,825.7)
325	2,292.0	(5,849.5)	2,022.2	(5,372.3)	0.3	(0.7)	571.3	(1,476.0)	61.5	(141.1)	152.2	(249.6)	4,038.3	(10,402.7)
326	299.7	((499.4)	12.7	(27.0)	0.7	(1.7)	203.9	(390.8)	21.5	(66.8)	21.8	(57.4)	560.5	(1,028.7)
320	*	(360.0)	--	--	--	--	--	(20.6)	--	--	--	(0.7)	*	(391.3)
Total	15,716.4	(56,076.2)	2,305.9	(6,567.8)	1.1	(3.0)	1,110.4	(2,844.3)	98.6	(253.4)	202.1	(378.4)	18,288.1	(32,435.7)
ALEUTIAN ISLANDS														
300	--	--	--	--	*	(<0.1)	*	(1.7)	--	--	--	--	*	(1.7)
301	--	--	*	(18.9)	--	--	*	(3.5)	--	--	--	(3.5)	*	(15.4)
302	26.75	(26.7)	1,320.0	(4,302.4)	119.1	(526.9)	3.1	(24.8)	<0.1	<0.1	<0.1	(1.5)	155.4	(2,467.7)
Total	26.75	(26.7)	1,320.0	(4,321.3)	119.1	(526.9)	3.1	(30.0)	<0.1	<0.1	<0.1	(5.0)	155.4	(2,485.8)
GRAND TOTAL	16,423.4	(57,968.5)	6,078.56	(10,990.7)	124.7	(552.9)	1.446.3	(4,702.9)	173.2	(431.8)	216.6	(467.6)	19,602.6	(38,594.1)

[1] From Tables 3 and 5.

*Sporadic reports only

Table 7. The percent contribution[1] of each statistical area to the commercial catch within each statistical district and within the entire *St. George Basin* region by species based on catch statistics (1955-75). The percent contribution to the *St. George Basin* region is in parentheses.

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total	
ALASKA PENINSULA NORTH DISTRICT														
311	2.1	(0.1)	1.9	(0.1)	0.4	(<0.1)	9.6	(0.5)	0.3	(<0.1)	<0.1	(<0.1)	13.3	(0.7)
312	1.6	(0.1)	<0.1	(<0.1)	<0.1	(<0.1)	12.1	(0.6)	<0.1	(<0.1)	<0.1	(<0.1)	13.7	(0.7)
313	13.2	(0.7)	<0.1	(<0.1)	<0.1	(<0.1)	1.1	(<0.1)	4.8	(0.3)	0.7	(<0.1)	19.8	(1.1)
314	1.4	(<0.1)	<0.1	(<0.1)	<0.1	(<0.1)	3.4	(0.2)	<0.1	(<0.1)	0.1	(<0.1)	5.0	(0.3)
315	33.9	(1.7)	<0.1	(<0.1)	<0.1	(<0.1)	2.6	(0.1)	0.1	(<0.1)	0.3	(<0.1)	36.9	(2.0)
316	7.2	(0.4)	<0.1	(<0.1)	<0.1	(<0.1)	0.5	(<0.1)	<0.1	(<0.1)	<0.1	(<0.1)	7.8	(0.4)
317	1.1	(<0.1)	*	*	<0.1	(<0.1)	0.4	(<0.1)	1.5	(0.1)	0.2	(<0.1)	3.2	(0.2)
318	*	(<0.1)	--	--	--	--	*	(<0.1)	--	--	<0.1	(<0.1)	0.1	(<0.1)
Total	60.5	(3.0)	1.9	(0.1)	0.4	(<0.1)	29.7	(1.3)	6.7	(0.4)	1.3	(<0.1)	100	(5.4)
BRISTOL BAY DISTRICT														
321	4.0	(3.5)	<0.1	(<0.1)	<0.1	(<0.1)	0.2	(0.2)	<0.1	(<0.1)	<0.1	(<0.1)	4.3	(3.7)
322	13.3	(11.6)	<0.1	(<0.1)	<0.1	(<0.1)	0.3	(0.2)	<0.1	(<0.1)	<0.1	(<0.1)	13.7	(11.9)
324	55.0	(47.8)	1.4	(1.2)	<0.1	(<0.1)	1.3	(1.2)	<0.1	(<0.1)	0.1	(0.1)	57.2	(49.7)
325	12.0	(10.4)	10.6	(9.2)	<0.1	(<0.1)	3.0	(2.6)	0.3	(0.3)	0.8	(0.6)	21.5	(18.6)
326	1.8	(1.6)	<0.1	(<0.1)	<0.1	(<0.1)	1.2	(1.1)	0.1	(0.1)	0.1	(0.1)	3.3	(2.8)
Total	86.1	(74.9)	12.0	(10.4)	<0.1	(<0.1)	6.0	(5.3)	0.4	(0.4)	1.0	(0.8)	100	(86.7)
ALEUTIAN ISLAND DISTRICT														
302	1.6	(0.1)	81.6	(6.3)	7.4	(0.6)	0.2	(<0.1)	<0.1	<0.1	<0.1	(<0.1)	100	(7.8)
GRAND TOTAL	1.6	(0.1)	81.6	(6.3)	7.4	(0.6)	0.2	(<0.1)	<0.1	(<0.1)	<0.1	(0.1)	100	(7.8)

*Sporadic reports only.

[1]From Table 3.

Table 8. Timing of Bristol Bay stocks of sockeye salmon

District	River	10% Run	Peak Run	90% Run	Peak Catch	Peak Escapement
Nushagak		June 23-July 2	July 2-9	July 9-16	July 5	
	Igushik					July 10
	Snake					" 11
	Wood					" 8
	Nuyakuk					" 13
Naknek-Kvichak		June 24-July 3	July 2-9	July 8-17	July 5	
	Kvichak					July 12
	Alagnak					" 9
	Naknek					" 9
Egegik		June 23-July 2	July 3-9	July 9-17	July 5	
	Egegik					July 12
Ugashik		June 26-July 2	July 3-9	July 10-18	July 7	
	Ugashik					July 12
Togiak		June 23-29	July 8-12	July 20-27	July 10	
	Togiak					July 21

Source: Royce, 1965 (Tables 35-38)

Table 9. Population estimates of juvenile salmon by area and by species at the time of estuarine entry in millions of fish (1955-75) in the *St. George Basin* region. Peak estimates are in parentheses[1].

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total	
ALASKA PENINSULA NORTH DISTRICT														
311	0.5	(1.3)	1.2	(7.1)	0.2	(0.9)	8.7	(42.8)	0.1	(0.2)	<0.1	(<0.1)	10.0	(48.3)
312	0.4	(1.7)	<0.1	(<0.1)	<0.1	(<0.1)	11.0	(77.3)	<0.1	(<0.1)	<0.1	(0.3)	11.3	(79.3)
313	2.8	(7.1)	<0.1	(<0.1)	<0.1	(<0.1)	1.0	(7.3)	1.0	(2.3)	0.2	(0.8)	5.0	(17.5)
314	0.3	(2.3)	<0.1	(<0.1)	<0.1	(<0.1)	3.2	(11.7)	<0.1	(<0.1)	<0.1	(0.1)	3.5	(14.2)
315	7.2	(18.6)	<0.1	(0.3)	<0.1	(0.1)	2.3	(6.2)	<0.1	(0.1)	0.1	(0.4)	9.5	(25.5)
316	1.6	(3.3)	<0.1	(0.2)	<0.1	(0.2)	0.4	(1.6)	<0.1	(<0.1)	<0.1	(<0.1)	2.0	(5.1)
317	0.2	(0.9)	<0.1	(<0.1)	<0.1	(<0.1)	0.3	(1.5)	0.3	(0.7)	<0.1	(0.1)	0.9	(3.1)
318	*	(0.1)	--	--	--	--	*	(<0.1)	*	(<0.1)	<0.1	(<0.1)	*	(<0.1)
Total	12.9	(35.3)	1.2	(7.6)	0.2	(1.2)	27.0	(148.3)	1.4	(3.4)	0.3	(1.8)	42.3	(193.2)
BRISTOL BAY DISTRICT														
321	16.1	(46.4)	<0.1	(<0.1)	<0.1	(<0.1)	3.7	(10.7)	0.1	(0.3)	0.1	(0.3)	20.0	(57.7)
322	28.5	(82.1)	<0.1	(0.3)	<0.1	(<0.1)	2.5	(6.9)	0.1	(0.2)	0.1	(0.1)	31.2	(7.4)
324	204.8	(784.4)	15.2	(65.3)	<0.1	(<0.1)	21.3	(58.5)	0.1	(0.3)	0.4	(1.0)	233.3	(876.8)
325	45.3	(106.2)	114.2	(303.5)	<0.1	(<0.1)	48.4	(125.1)	1.2	(2.8)	3.4	(5.6)	155.5	(391.5)
326	5.2	(8.7)	0.6	(1.4)	<0.1	(<0.1)	15.3	(29.3)	0.4	<(1.2)	0.4	(1.1)	21.7	(41.0)
Total	299.9	(1,027.9)	130.1	(370.4)	<0.1	(<0.1)	91.2	(230.5)	1.9	(3.8)	4.4	(8.2)	461.6	(1,374.5)
ALEUTIAN ISLANDS DISTRICT														
300	--	--	--	--	*	(<0.1)	*	(0.1)	--	--	--	--	*	(0.1)
301	--	--	*	(1.0)	--	--	*	(0.3)	--	--	*	(0.1)	*	(0.9)
302	0.5	0.5	71.3	(232.6)	6.4	(28.5)	0.2	(2.0)	<0.1	(<0.1)	<0.1	(<0.1)	78.5	(132.6)
Total	0.5	0.5	71.3	(233.6)	6.4	(28.5)	0.2	(2.4)	<0.1	(<0.1)	<0.1	(<0.1)	78.5	(133.6)
GRAND TOTAL	313.3	981.0	203.4	(611.6)	6.7	(29.8)	118.4	(361.2)	3.3	(8.2)	4.8	(10.1)	582.5	(1,701.3)

[1]See text for source.

Table 10. The average timing of downstream migration of juvenile sockeye salmon based on fyke-net sampling at selected rivers.

River	Beginning	50%	Peak	End
Ugashik	May 5-23	May 30	May 23-June 7	June 18-26
Egegik	-	May 30	-	-
Naknek	May 23-June 6	June 16	June 5-14	July 7-15
Kvichak	May 10-June 4	June 2	May 23-June 11	June 10-22
Wood	May 30-June 8	June 22	June 15-July 11	July 2-July 15

Sources: Church (1963,1964), Hartman et al. (1967), Marriott (1965), McCurdy (1972a, 1972b), Nelson (1964,1965,1966), Paulus and McCurdy (1968), Paulus and Parker (1974), Pennoyer (1966), Pennoyer and Seibel (1965), Siedelman (1972), Van Valin (1968).

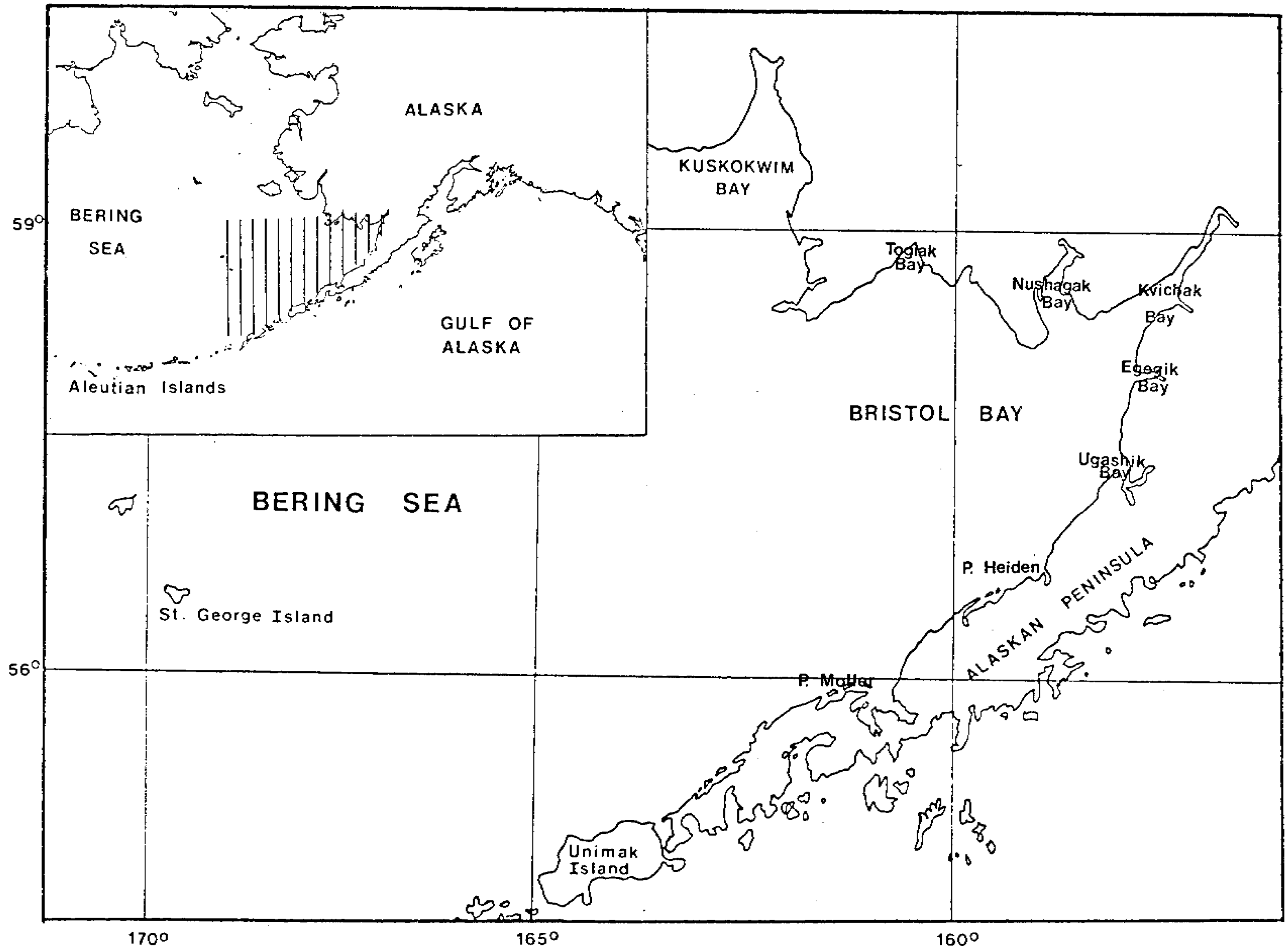

Fig. 1. Map of area covered in second interim report which includes marine waters of eastern Bering Sea to be referred to as the *St. George Basin* region.

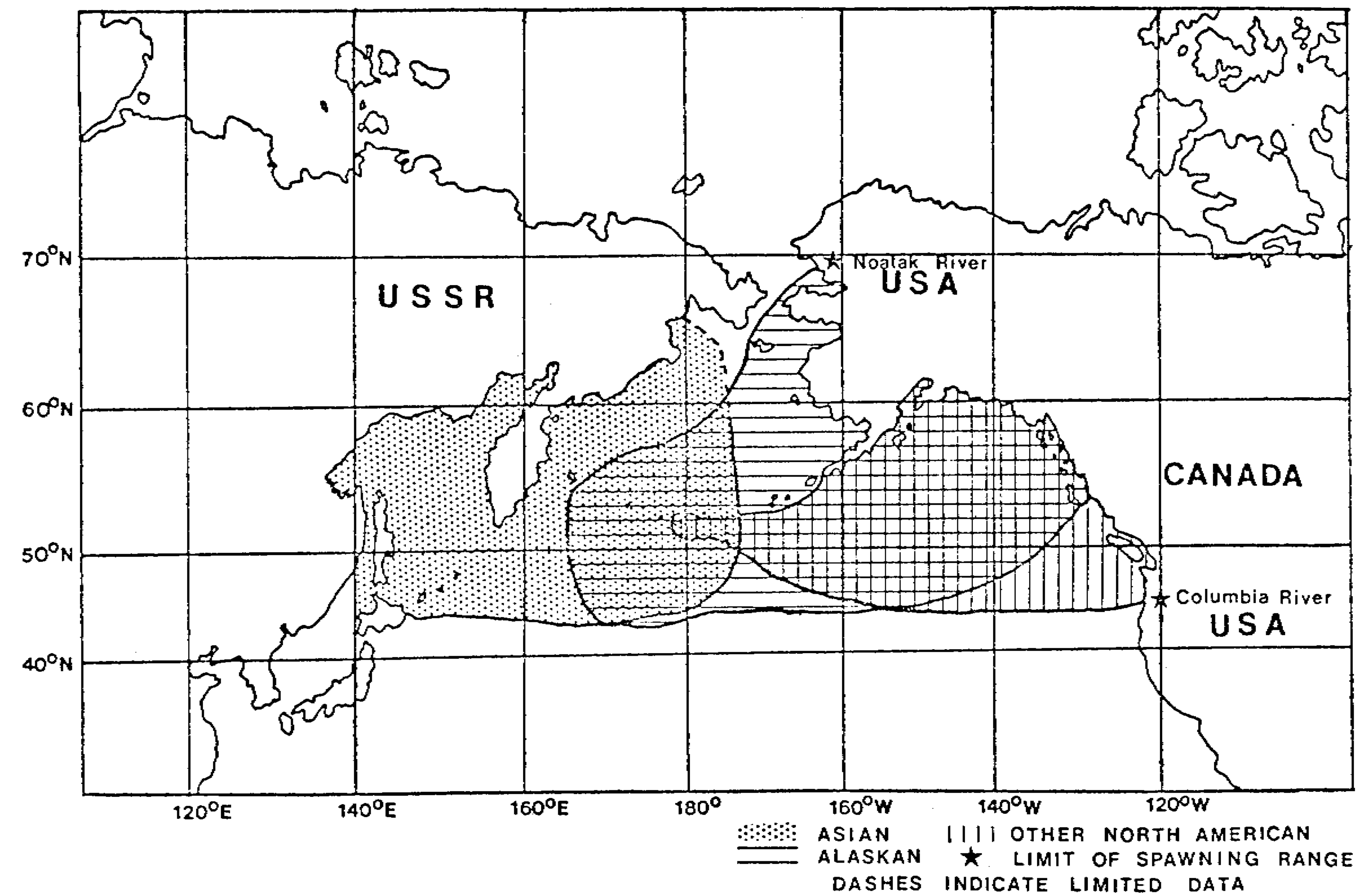

Fig. 2. The range of spawning stocks and offshore distribution of sockeye salmon.

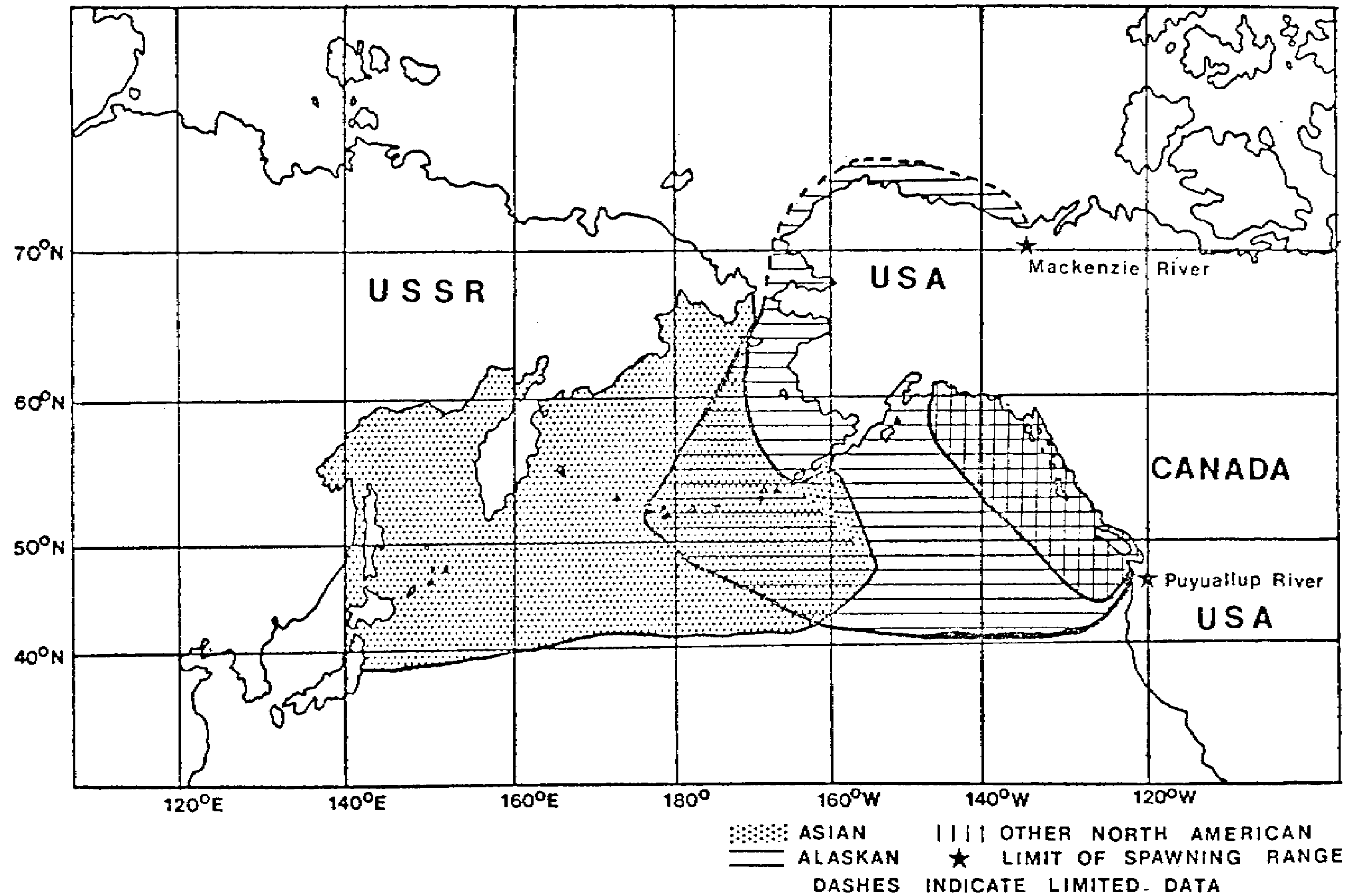

Fig. 3. The range of spawning stocks and offshore distribution of pink salmon.

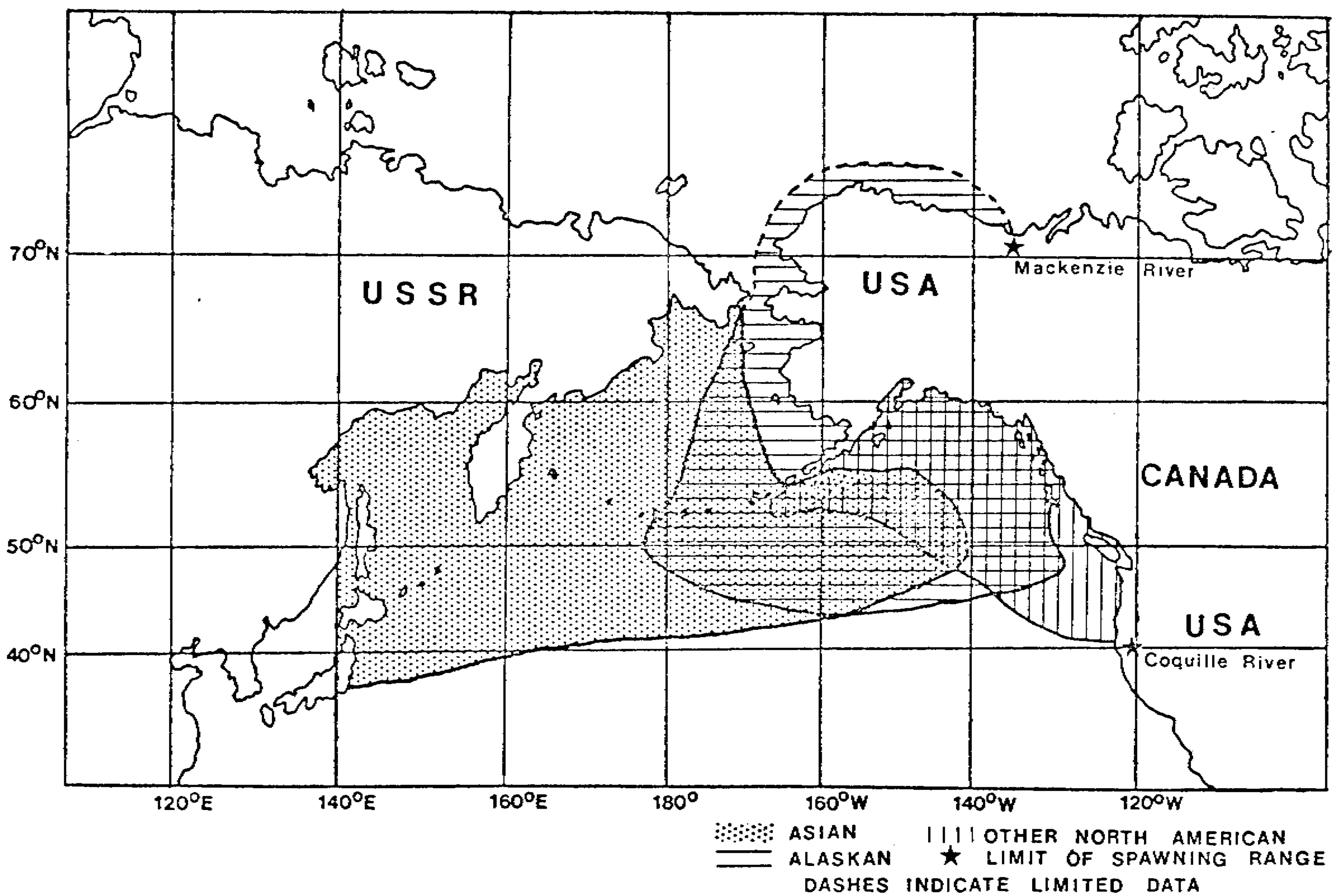

Fig. 4. The range of spawning stocks and offshore distribution of chum salmon.

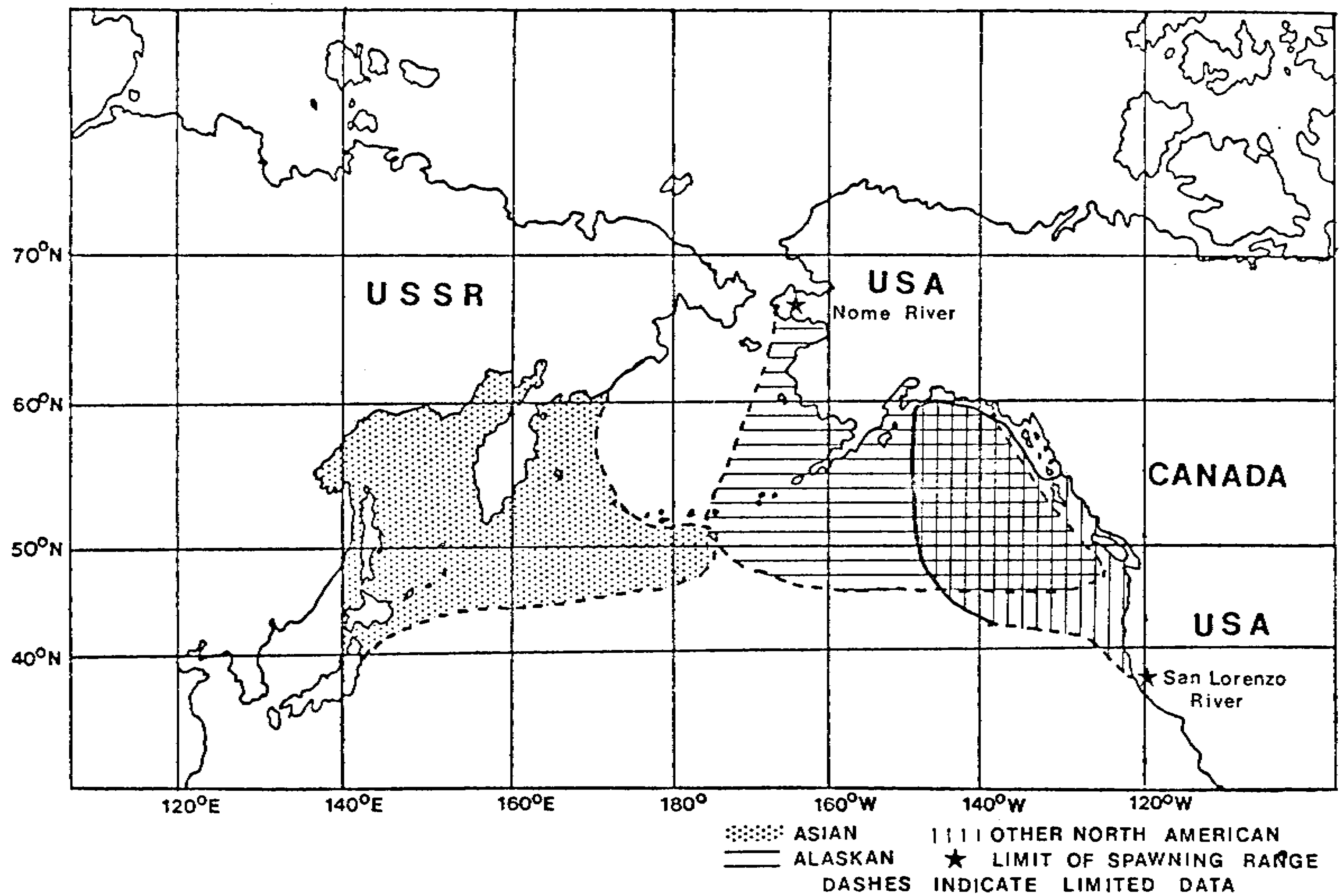

Fig. 5. The range of spawning stocks and offshore distribution of coho salmon.

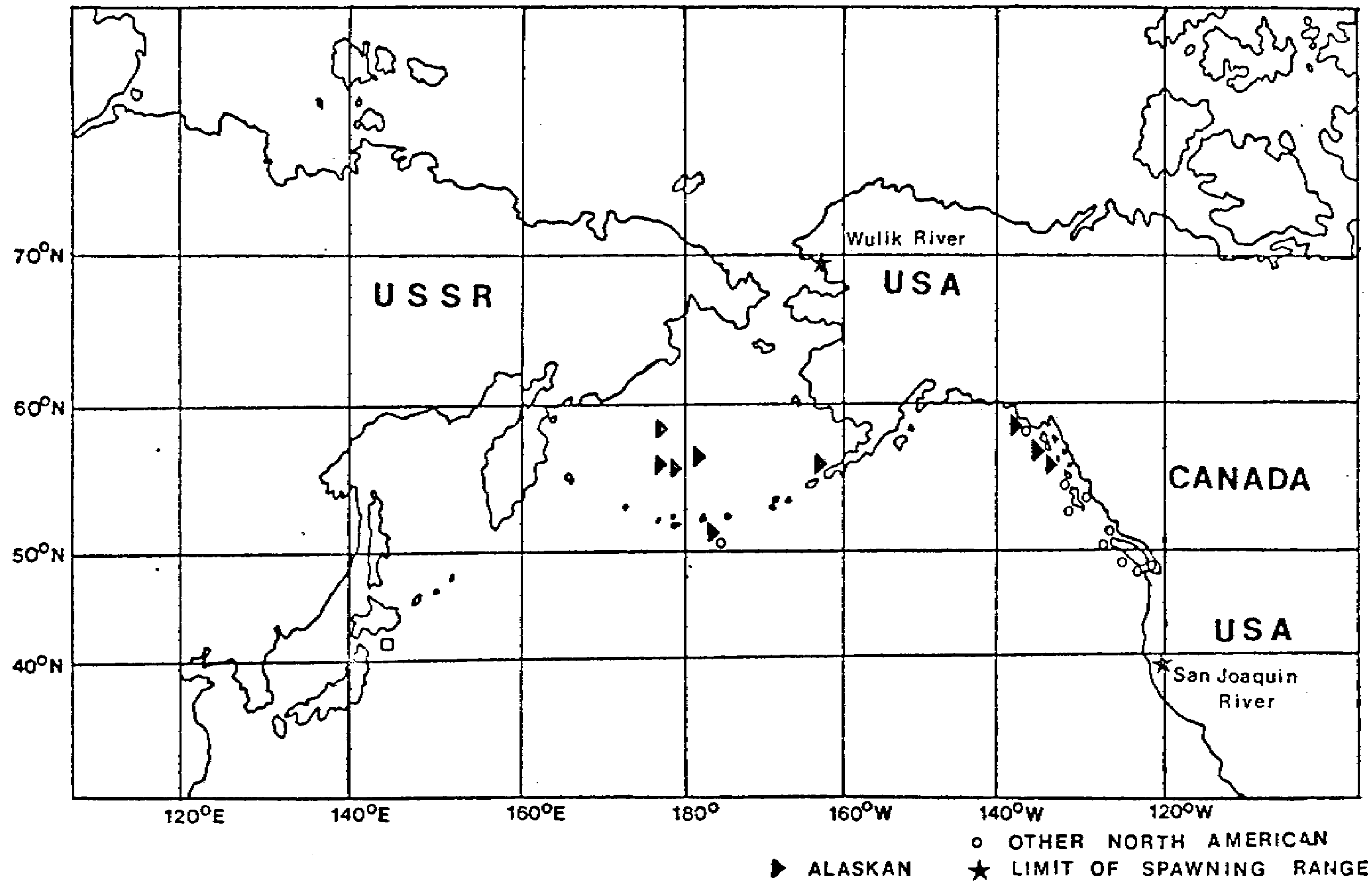

Fig. 6. The range of North American spawning stocks and offshore distribution of chinook salmon.

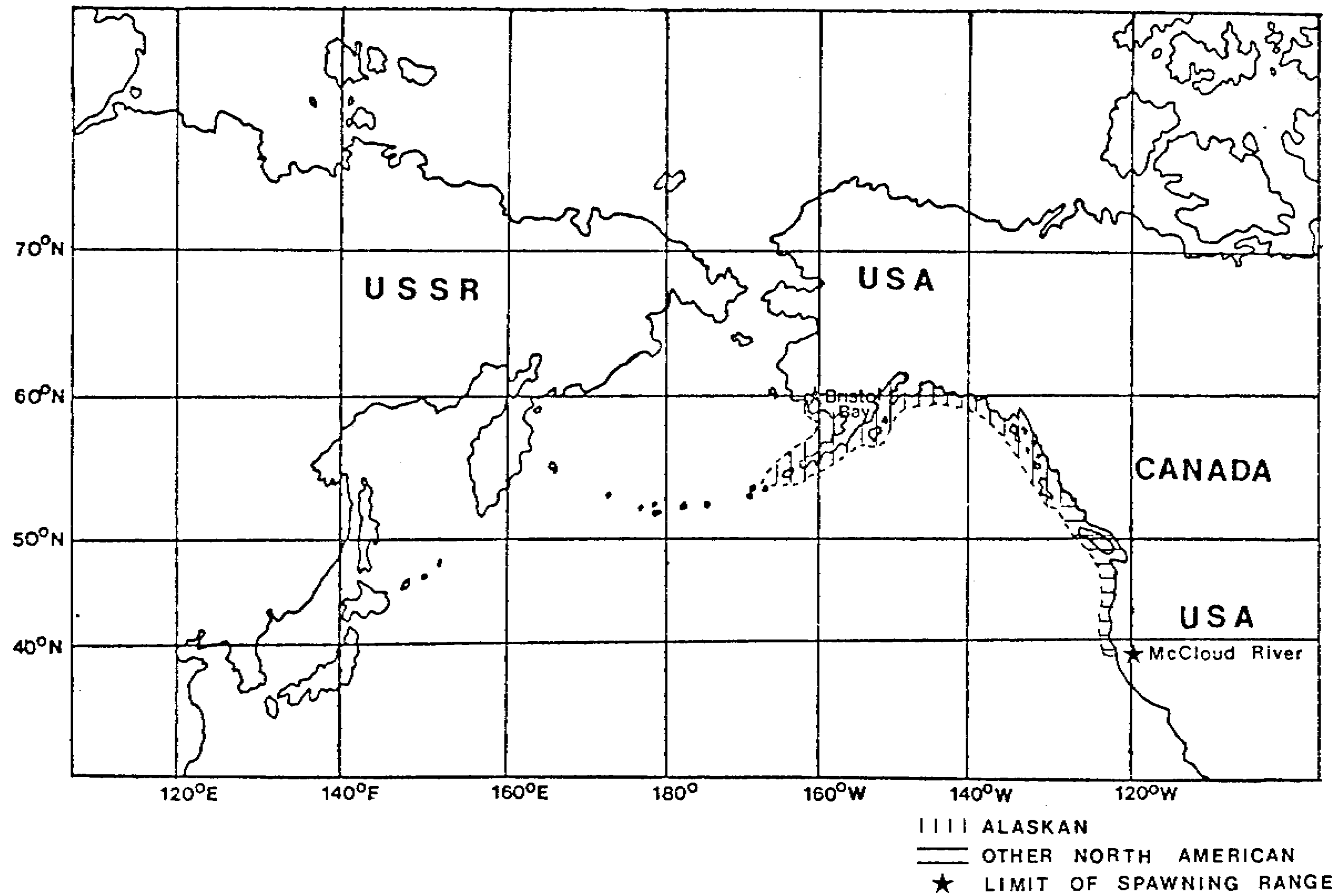

Fig. 7. The range of North American spawning stocks and offshore distribution of Pacific char.

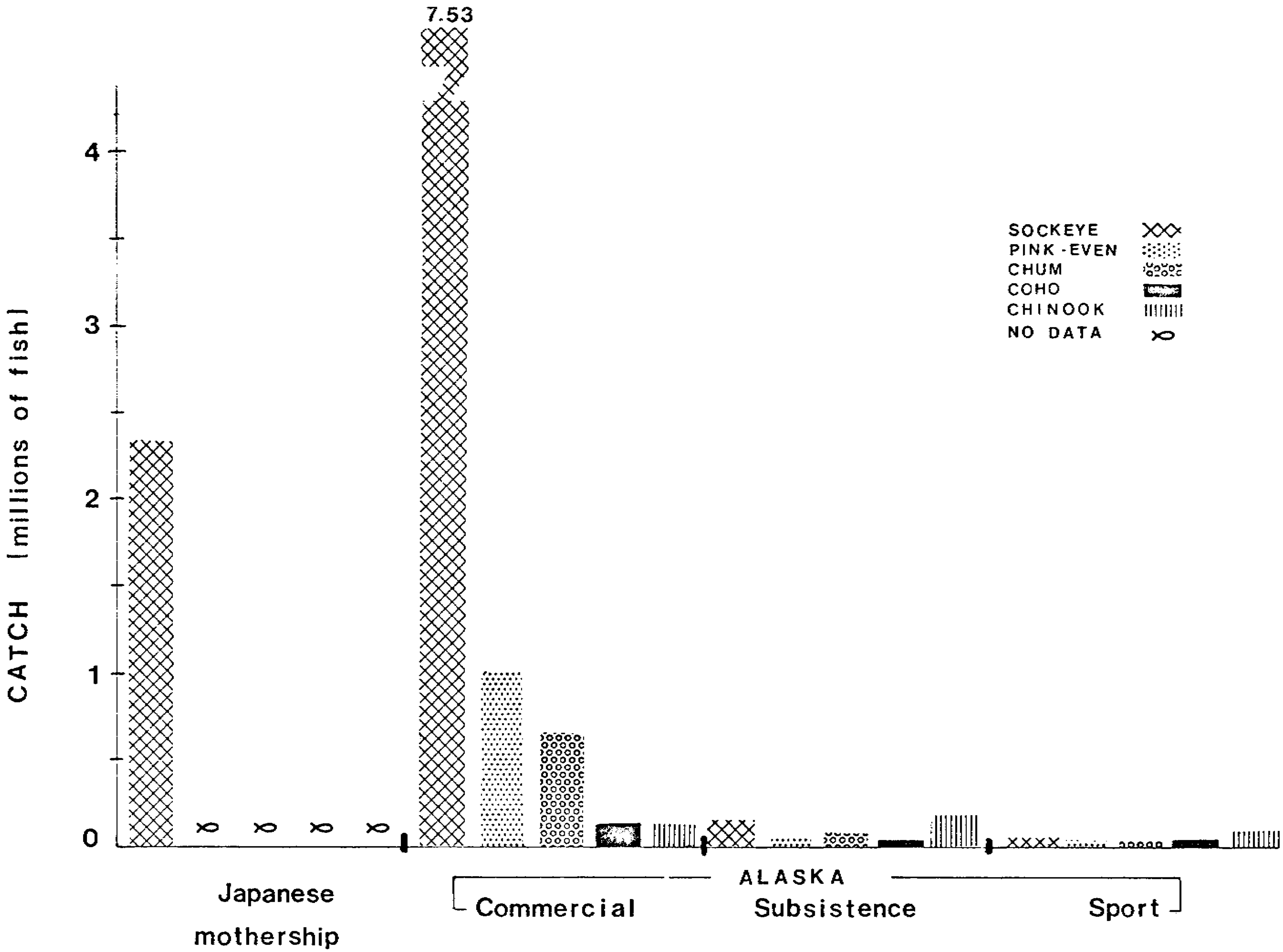

Fig. 8. Average annual catches of western Alaskan salmon by the Japanese mothership fishery (1956-72), Alaska commercial fishery (1955-75), Alaska subsistence fishery (1970-73), and Alaska sport fishery (1970-73).

Fig. 9. Statistical districts of the Alaskan commercial salmon fishery.

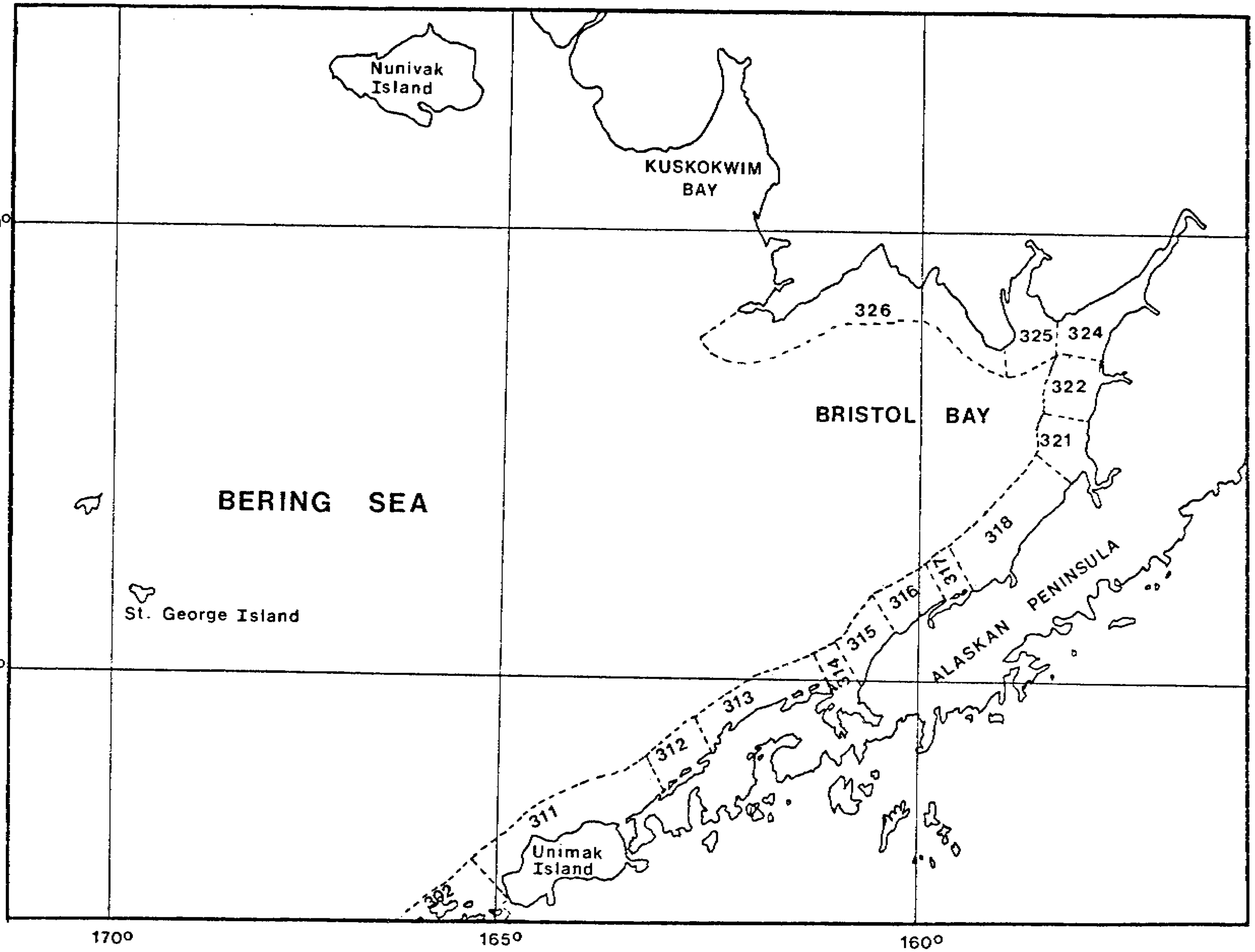

Fig. 10. Statistical areas (subdivisions of districts) of the Alaskan commercial salmon fishery in coastal waters of the *St. George Basin* region.

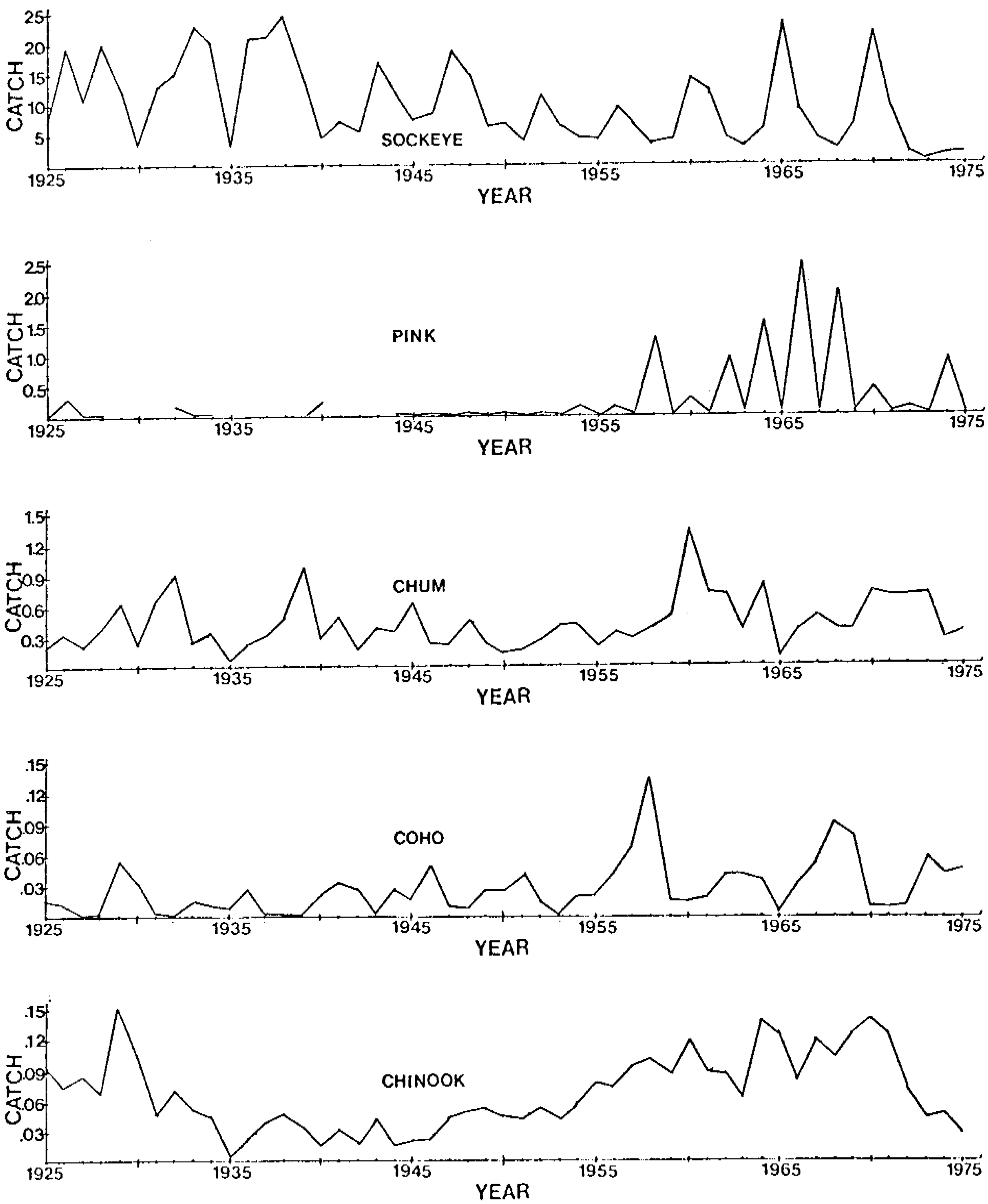

Fig. 11. Commercial catches of salmon by year (1925-75) in Bristol Bay in millions of fish.

Sources: INPFC Secretariat
INPFC Statistical Yearbooks 1972-74.
Alaska Department Fish and Game

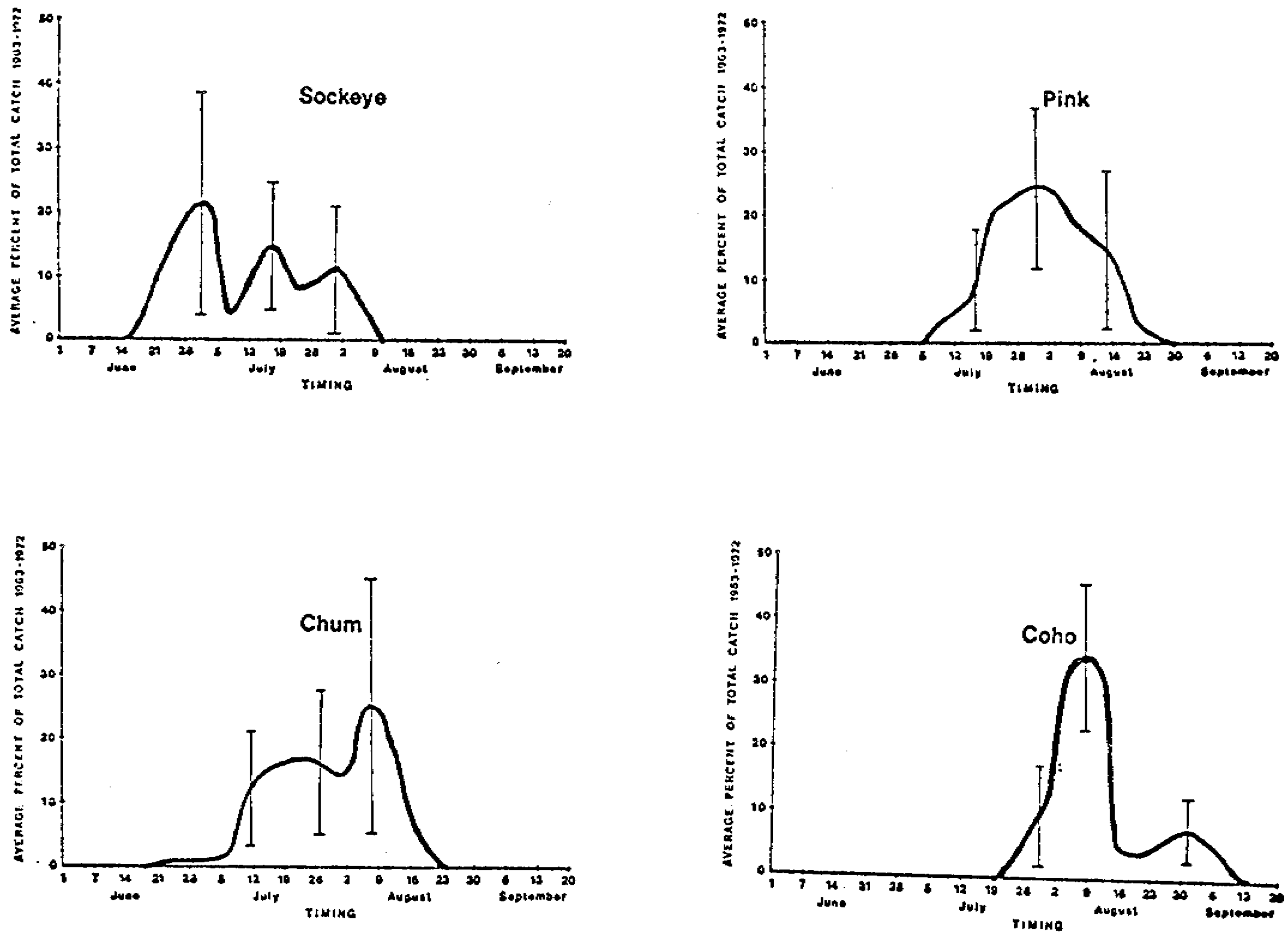

Fig. 12 The average timing of salmon runs to the Aleutian Islands District as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence limits for the percent catch on selected dates.

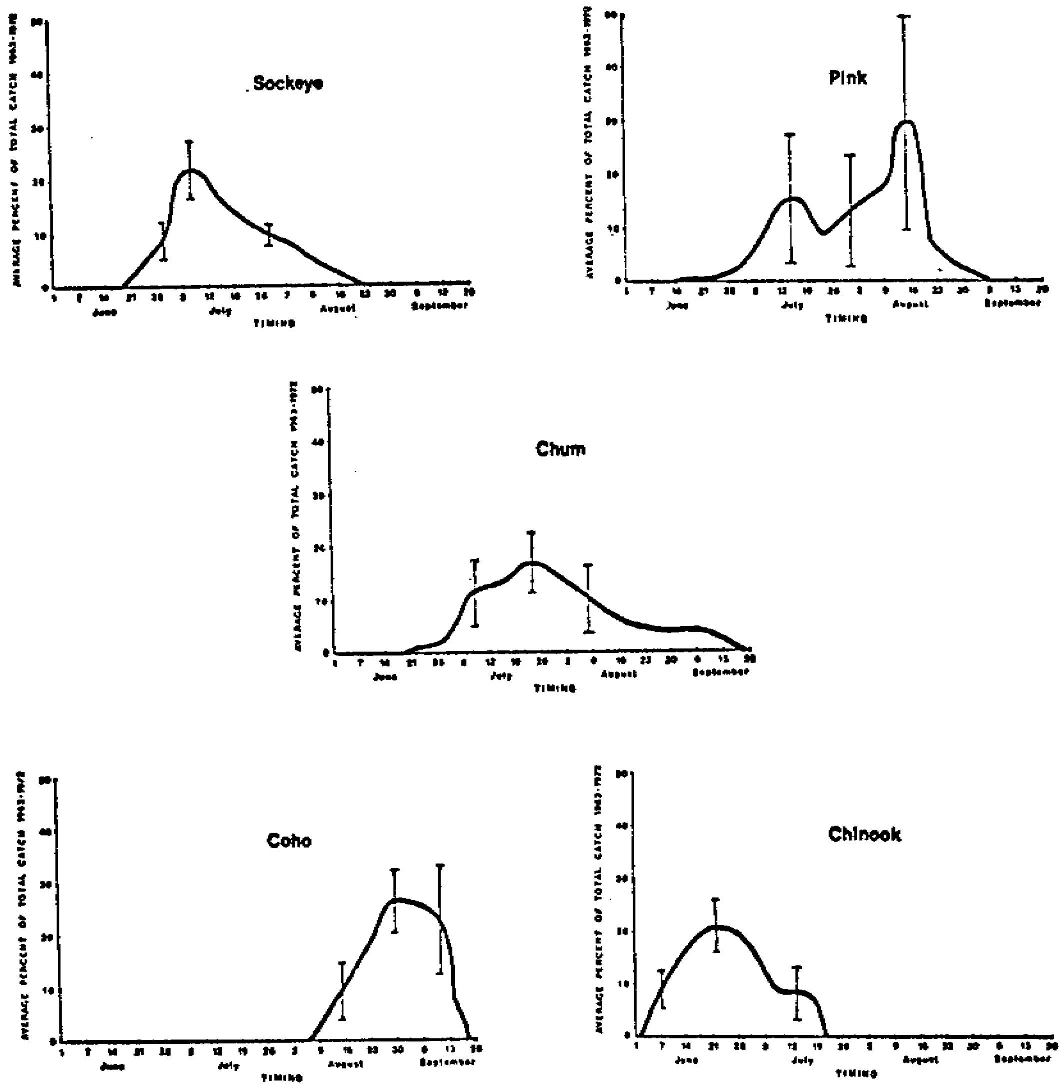

Fig. 13 The average timing of salmon runs to the Alaska Peninsula North District as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence limits for the percent catch on selected dates.

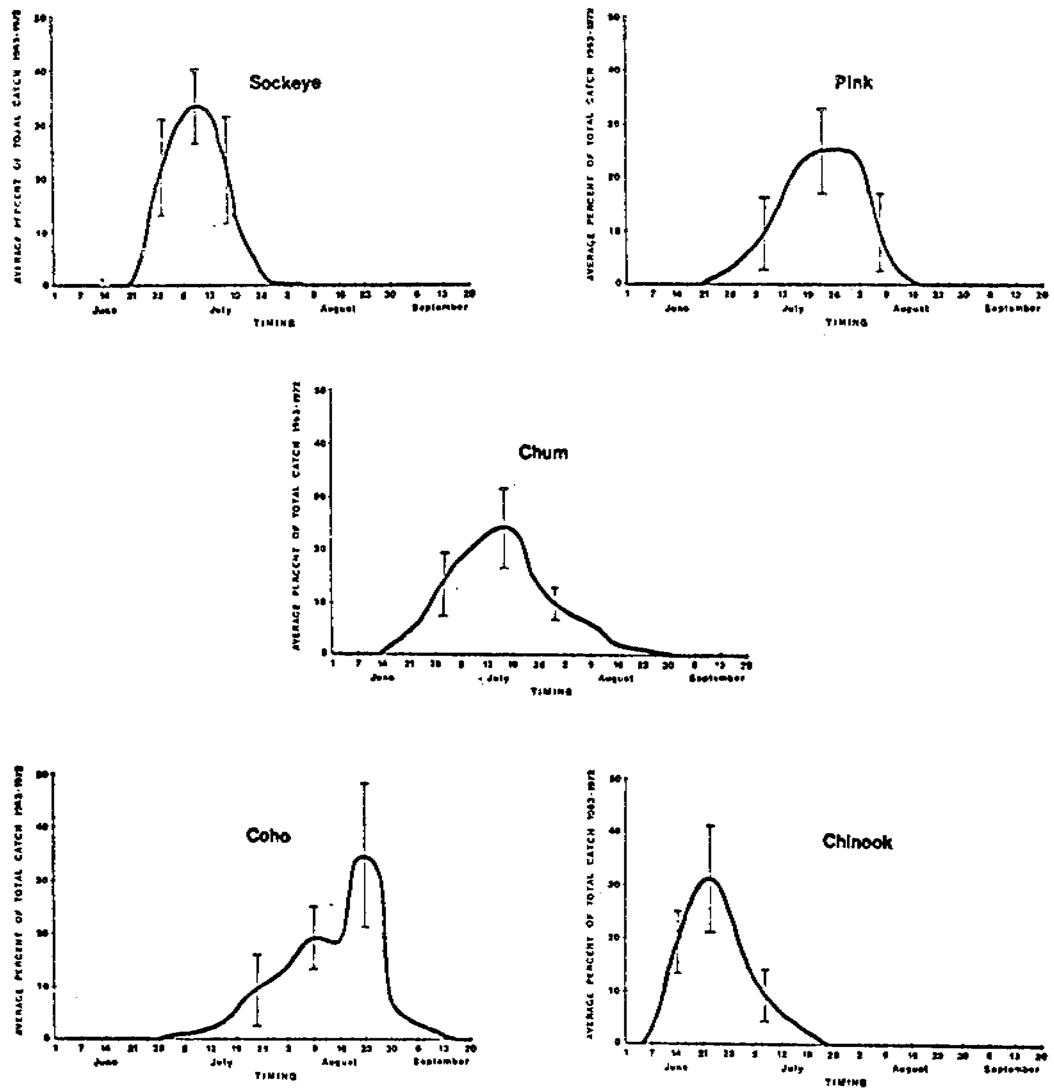

Fig. 14 The average timing of salmon runs to the Bristol Bay district as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence limits for the percent catch on selected dates.

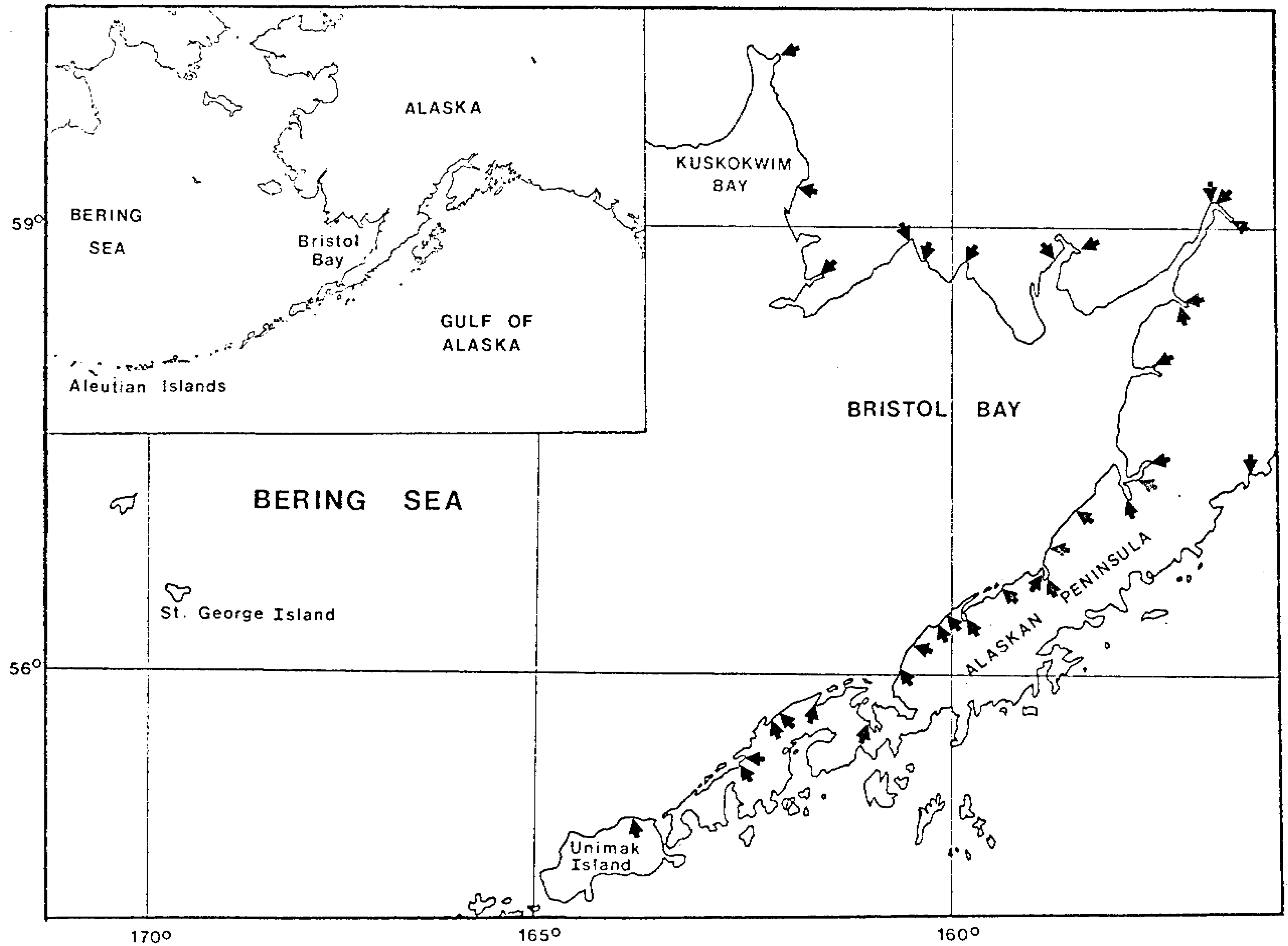

Fig. 15. Locations of juvenile sockeye salmon entry into nearshore waters of the *St. George Basin* region.

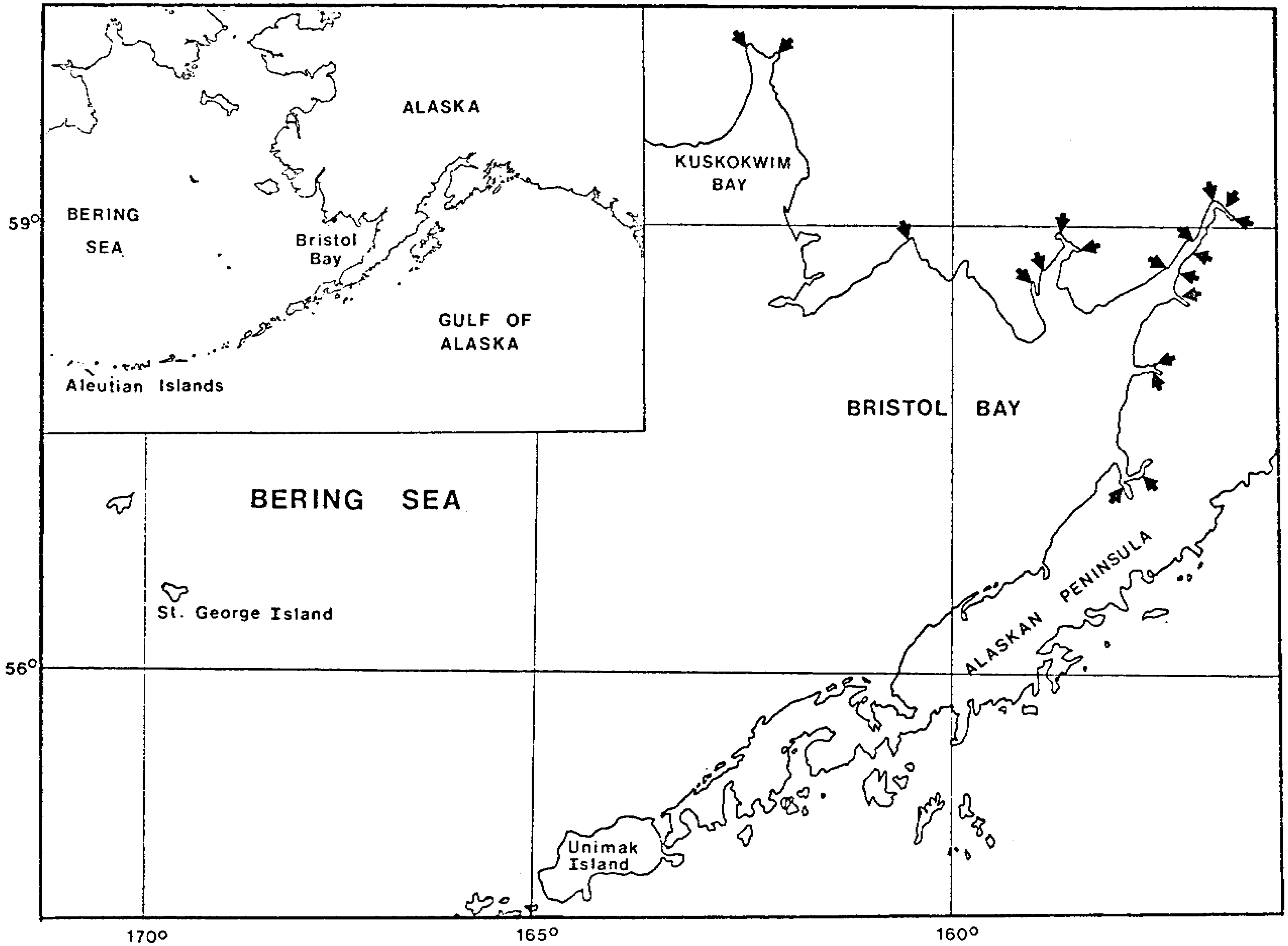

Fig. 16. Locations of juvenile pink salmon entry into nearshore waters of the *St. George Basin* region.

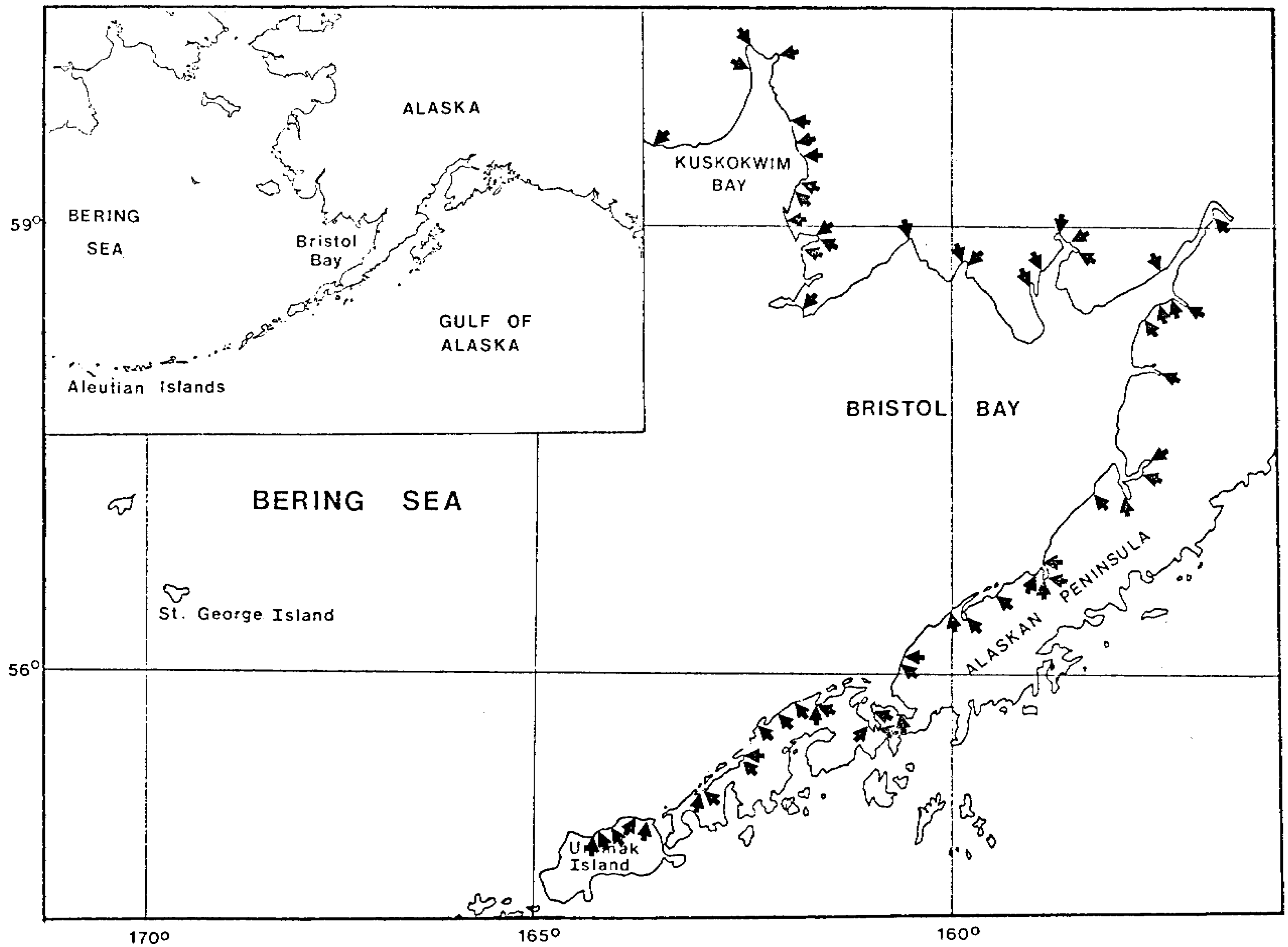

Fig. 17. Locations of juvenile chum salmon entry into nearshore waters of the *St. George Basin* region.

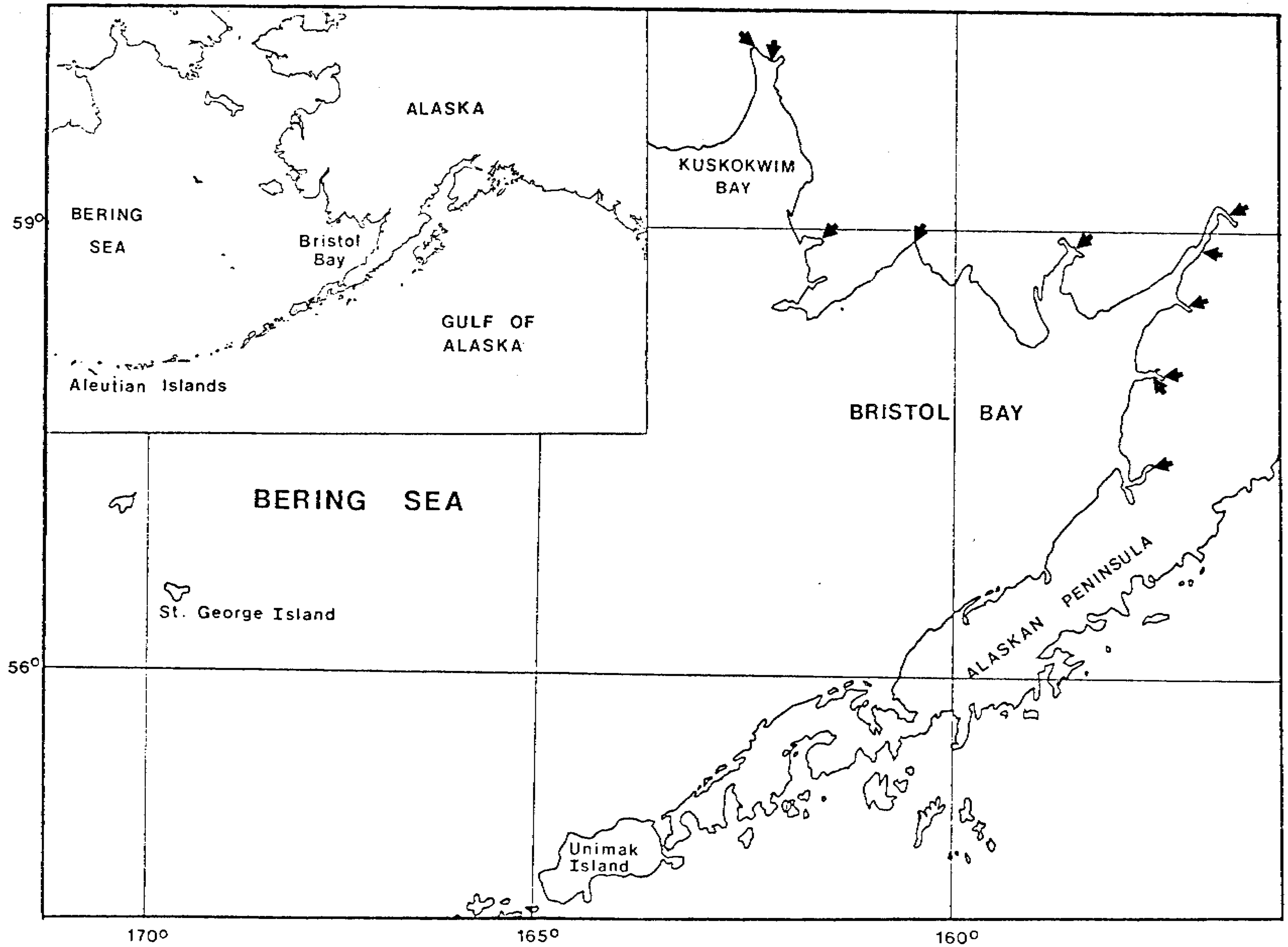

Fig. 18. Locations of juvenile coho salmon entry into nearshore waters of the *St. George Basin* region.

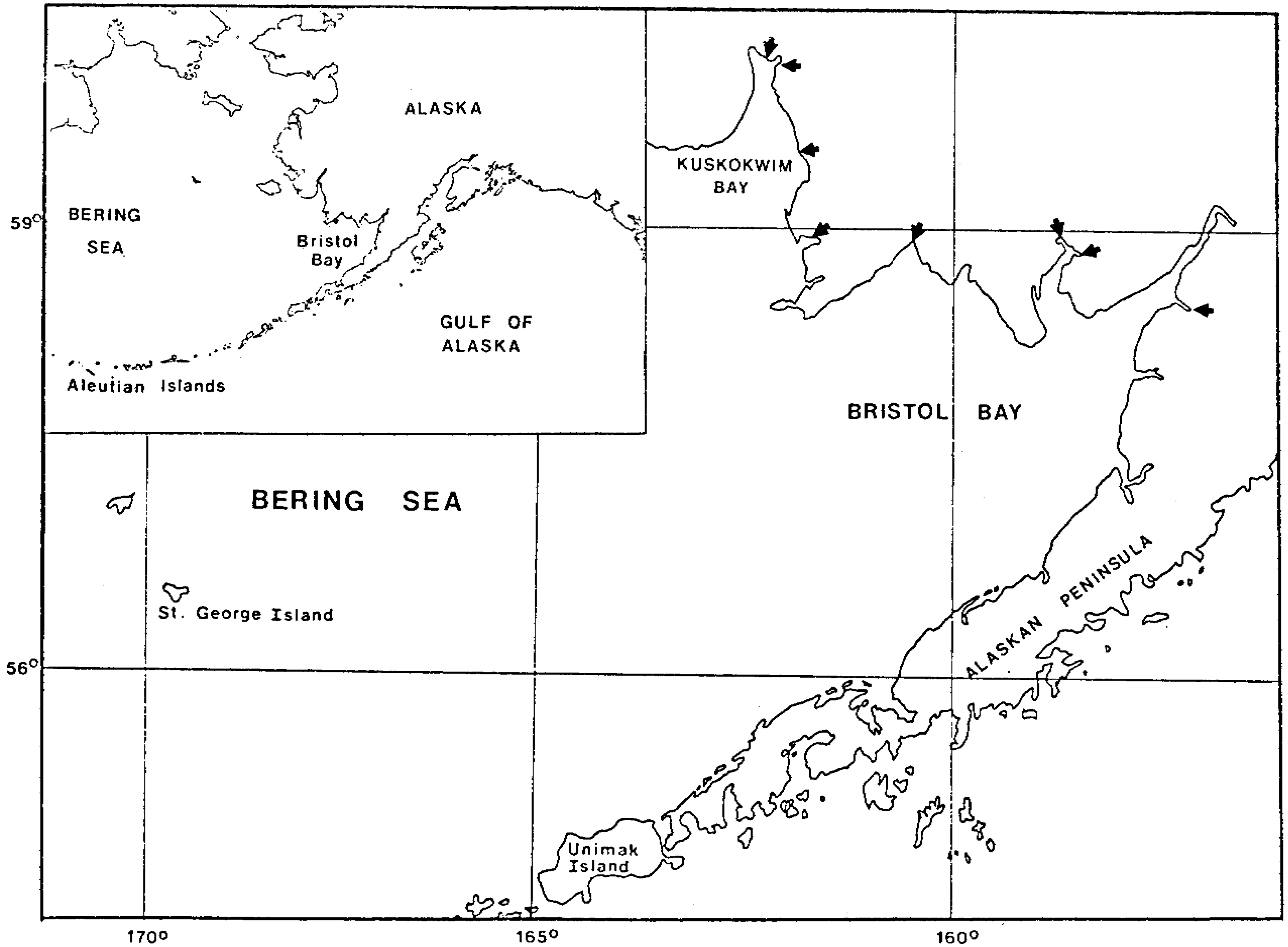

Fig. 19. Locations of juvenile chinook salmon entry into nearshore waters of the *St. George Basin* region.

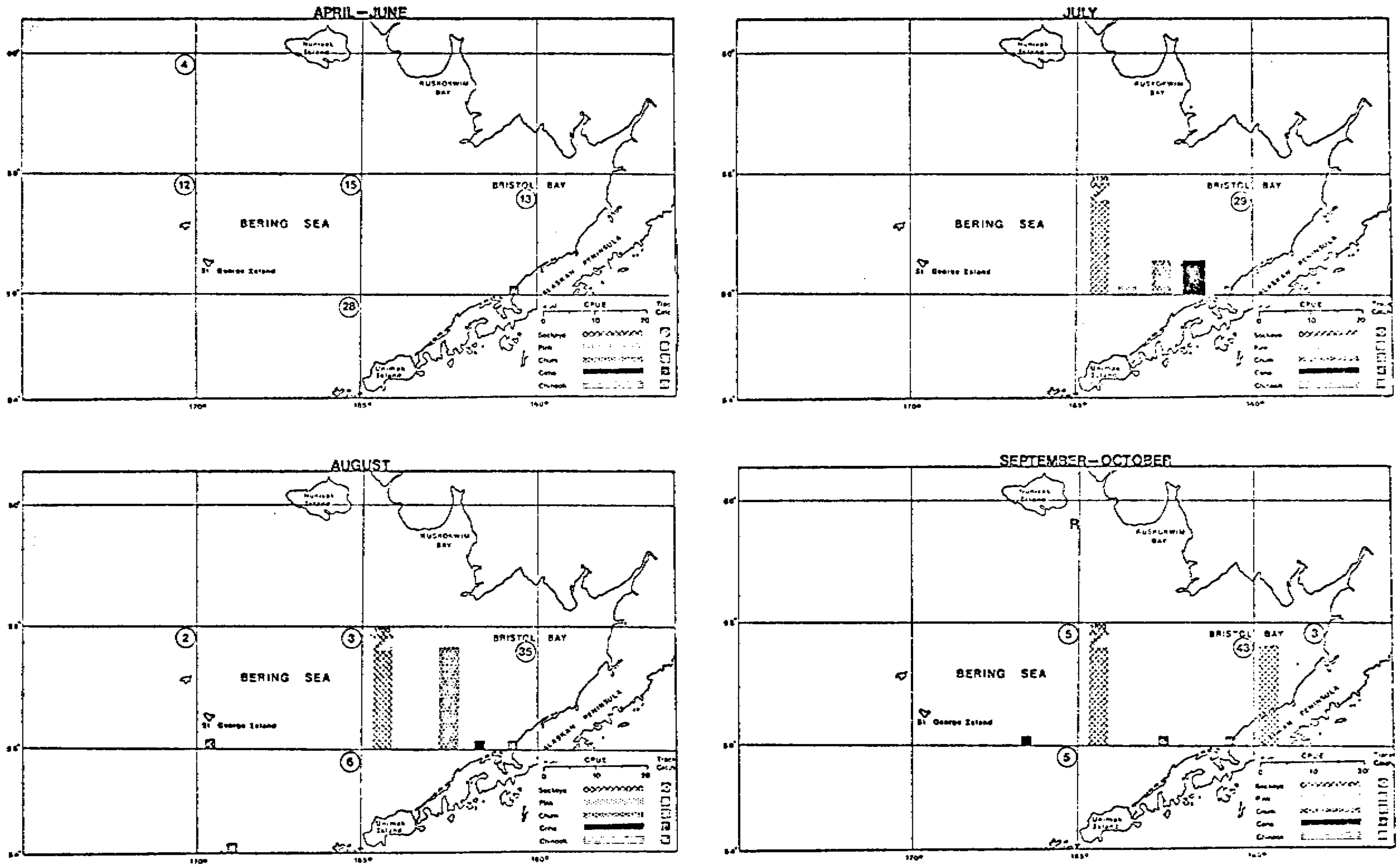

Fig. 20 The distribution and abundance of juvenile salmon in offshore waters of the *St. George Basin* region as indicated by purse seining.

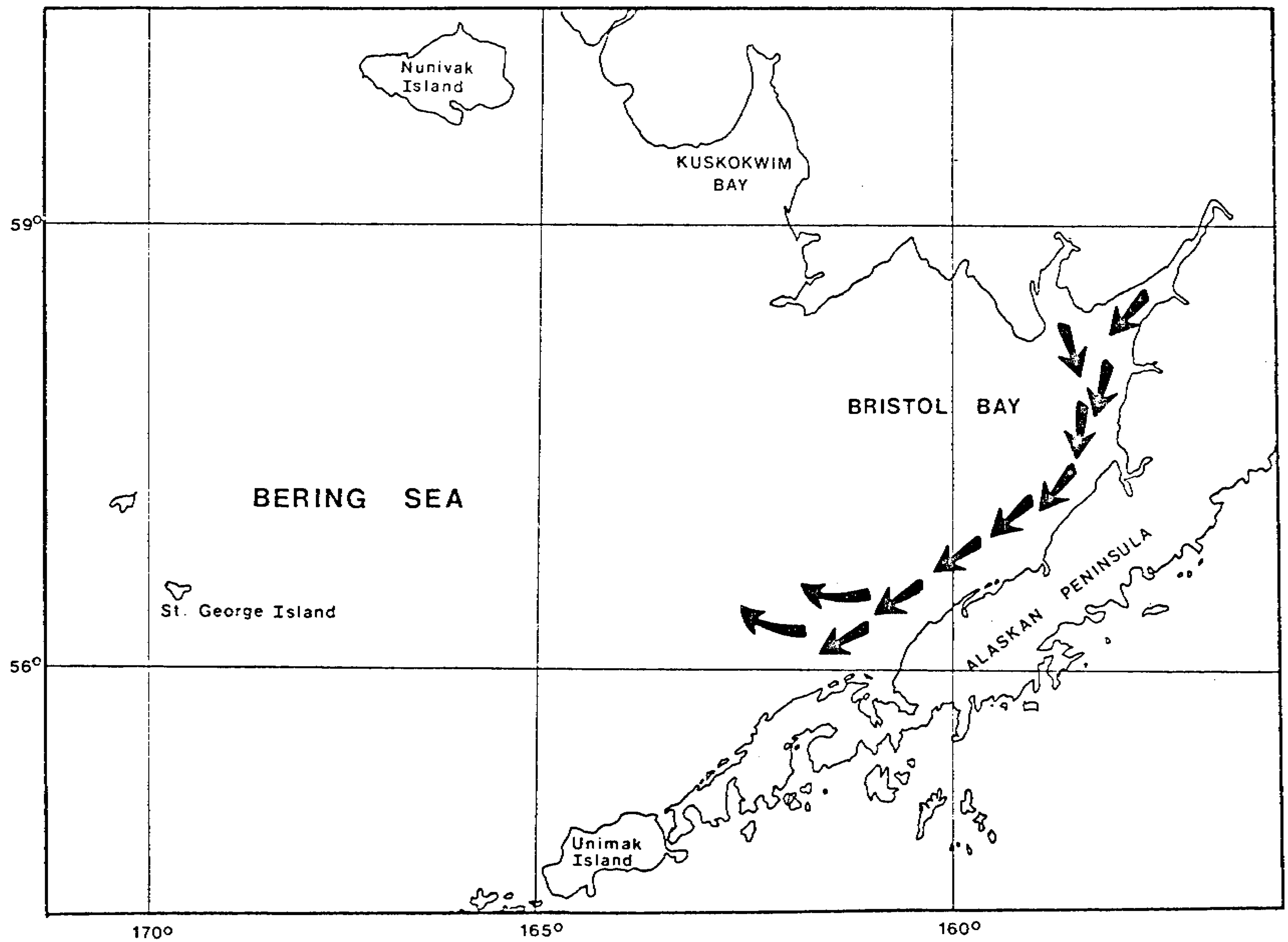

Fig. 21. The migration route of juvenile salmon in coastal waters of the *St. George Basin* region as determined by experimental fishing.

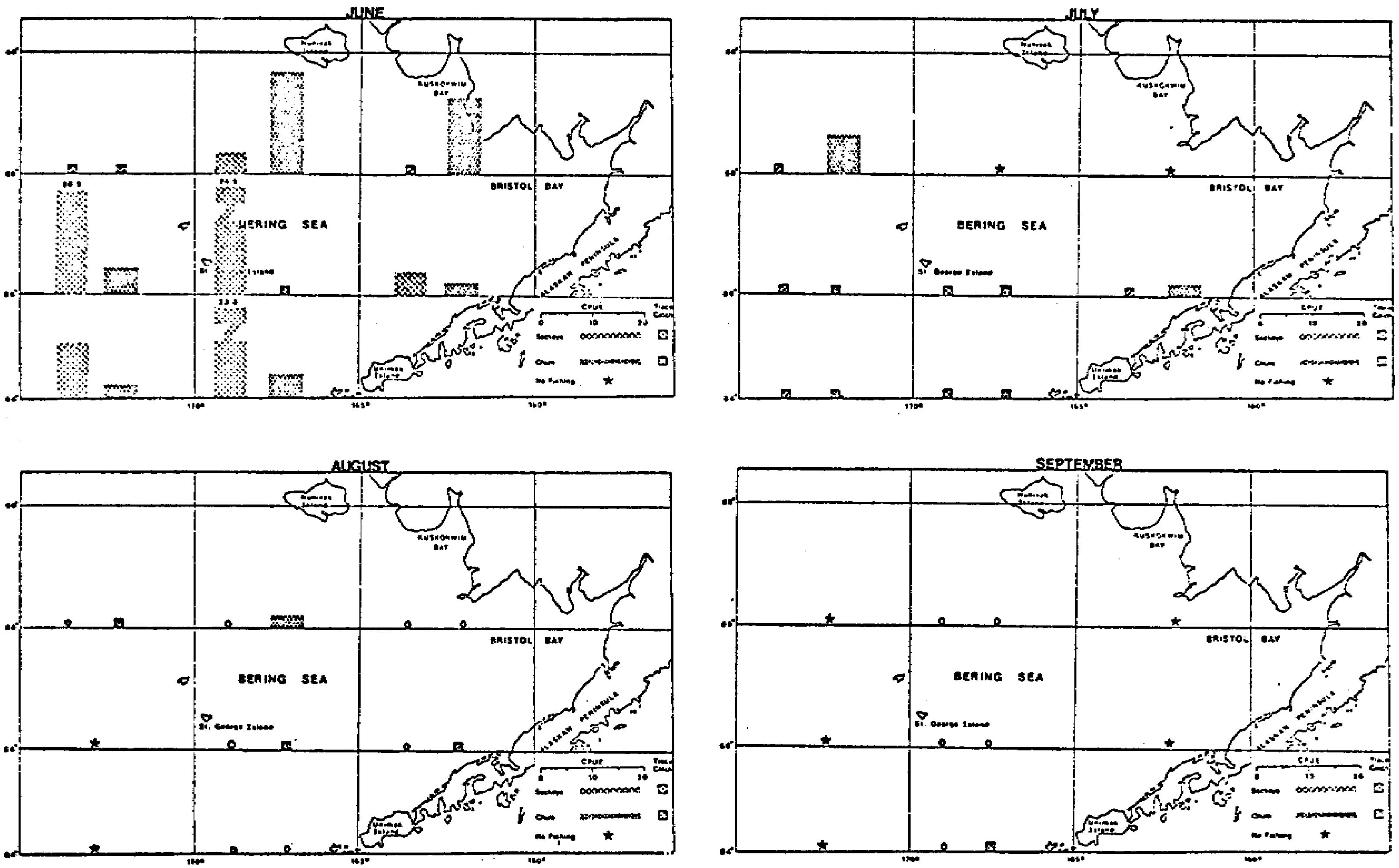

Fig. 22 The distribution and abundance of adult salmon in offshore waters of the *St. George Basin* region as indicated from gillnet catches. A unit of effort equals catch per shackle of gillnet.

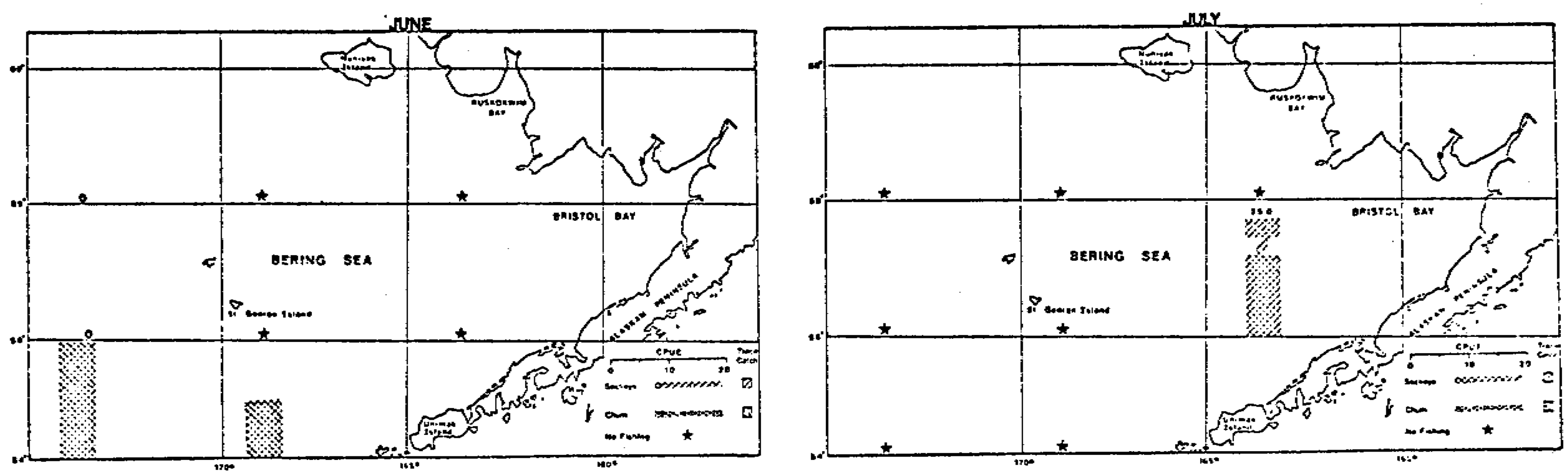

Fig. 23 The distribution and abundance of adult salmon in offshore waters of the *St. George Basin* region as indicated from longline catches. A unit of effort equals catch per one thousand hooks.

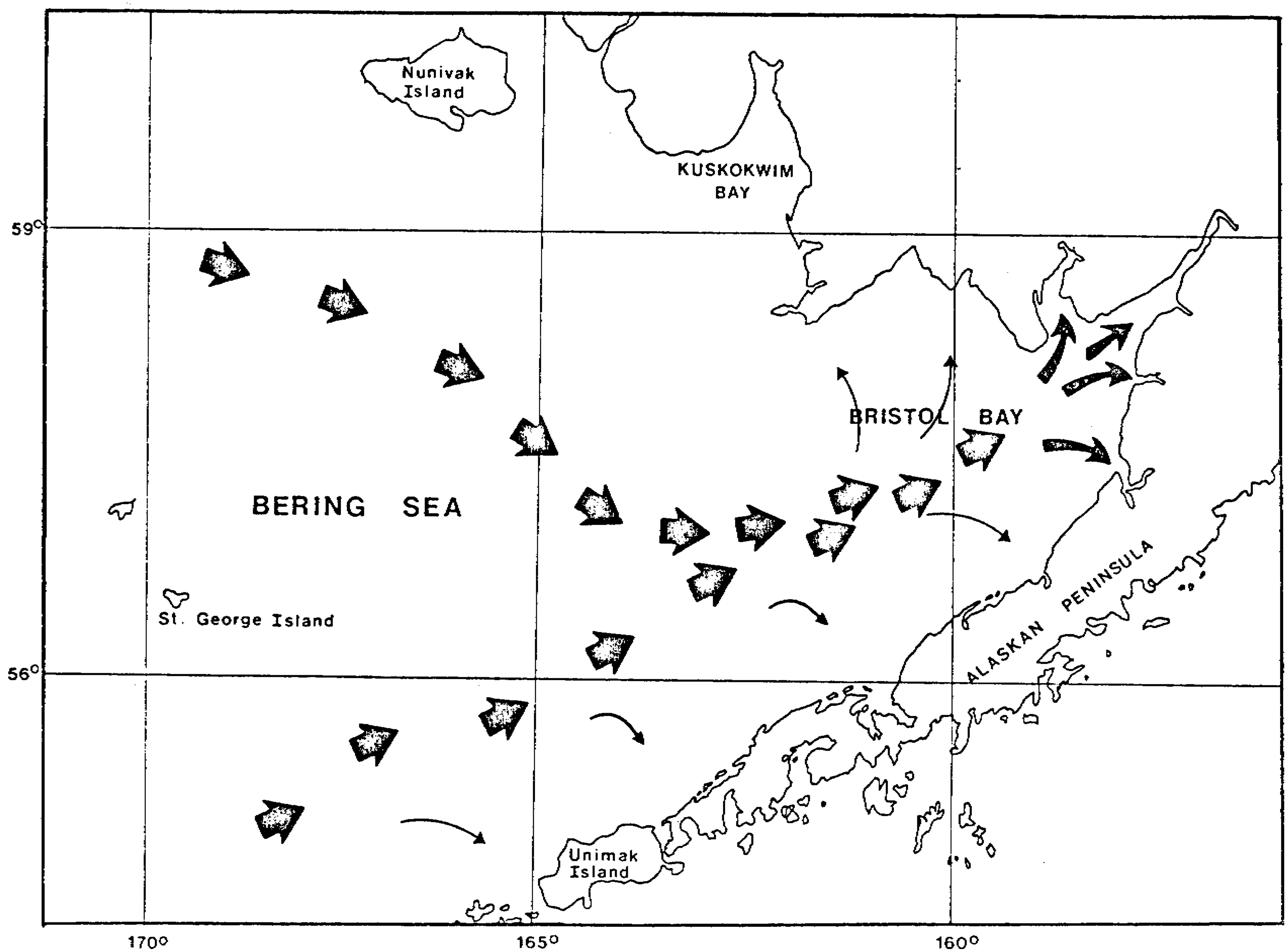

Fig. 24. Migration route of sockeye salmon bound for spawning grounds in western Alaska.

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December 1976

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RU #353

DETERMINATION AND DESCRIPTION OF THE STATUS OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE, AND MIGRATIONS OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

Third and Final Report Covering Prince William Sound, Copper River, Bering River, Yakutat, and Offshore Waters of the Northern Gulf of Alaska

by

Loren J. Stern
Project Leader

Allan C. Hartt
Donald E. Rogers
Principal Investigators

A contribution to biological information needed by OCSEAP in making decisions with respect to offshore oil leases. Work performed under proposal RU 353-76 RFP Tasks A-7 and A-11.

Approved:

Submitted 29 December 1976

[signature]
Director

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DETERMINATION AND DESCRIPTION OF THE STATUS OF KNOWLEDGE OF THE DISTRIBUTION, ABUNDANCE, AND MIGRATIONS OF SALMONIDS IN THE GULF OF ALASKA AND BERING SEA

Third and Final Report Covering Prince William Sound, Copper River, Bering River, Yakutat, and Offshore Waters of the Northern Gulf of Alaska

INTRODUCTION

This is the third and final report from the salmonid literature survey. It completes a summary of existing knowledge on the distribution, abundance, and migrations of salmonids in potential oil producing areas in the Gulf of Alaska and Bering Sea. The geographic area covered by this report is shown in Fig. 1 together with the geographic areas covered in the first report (Kodiak region) and the second report (St. George Basin region). The geographic coverage of the three reports is such that all three reports are needed for a description of knowledge of salmonid dynamics throughout the entire area. Because of the migratory nature of salmonids and in order that each report be complete within itself, there was necessarily some overlap of information in each report.

Like the first two reports, this report focuses on five species of Pacific salmon and covers steelhead and sea-run cutthroat trout and char secondarily. This is not to say these latter species are not important, but data on their marine life is much scarcer because of their minor importance in the commercial fishery. In fact, these species should be of particular concern because of their long residence in nearshore waters as compared to salmon which usually migrate far offshore (Figs. 2-9).

ADULT SALMONIDS IN NEARSHORE WATERS

This report, like the first two, begins with mature adult salmonids as they enter nearshore waters enroute to natal streams. Next juvenile salmonids (age .0)[1] are discussed from their entry into estuarine waters until they have moved to offshore feeding grounds. Lastly, the offshore phase of salmonid life history is discussed.

Distribution and Abundance

Estimates of annual abundance in coastal production areas were based on catch data supplemented by estimates of escapement. Escapement was estimated to be 30 percent of the total run (i.e. 0.43 times catch). Although the relationship between catch and escapement varies substantially between species, locations and years, both due to natural fluctuations and to management quotas established for optimum production, the total run figures provide satisfactory estimates for the purposes herein.

Catch

An intensive nearshore commercial fishery catches the largest proportion of salmon although sport and subsistence fisheries are also important in the case of chum, coho, and chinook salmon. The Japanese mothership fishery which operates west of 175°W catches only small numbers of sockeye and chum salmon bound for streams in the area covered by this report (Fredin and Worlund 1974; Shepard et al. 1968). Pink and coho salmon from the study area are not known to occur west of 175°W (Neave et al. 1967; Godfrey et al. 1973). Indirect evidence indicates that small numbers of chinook salmon and steelhead trout from the study area are probably caught by the mothership fishery (Sutherland 1973; Hartt 1962).

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[1] Age designation proposed by Koo (1962) in which the number of ocean winter annuli on the scale is preceded by a decimal point and the number of freshwater winter annuli precedes the decimal point.

In short, the oceanic distributions of salmonids bound for natal streams within the study area are such that relatively few are intercepted by high seas fisheries. Consequently, abundance estimates based upon nearshore catch data should not be greatly biased by high seas removals.

Salmon catch statistics are compiled by general districts (Fig. 10) and by detailed areas (Fig. 11). Catch statistics for the districts covered by this report (Prince William Sound, Copper River, Bering River, and Yakutat) for 1925-75 (Fig. 12, Table 1) show that pink salmon are the most abundant species on a region-wide basis. Runs of chum salmon to Prince William Sound and sockeye to the Copper River are also very important.

Sockeye (Fig. 12, Table 1) have historically been second only to pink salmon in abundance in this region. Catches of sockeye salmon averaged more than 0.9 million fish annually, and ranged from about 0.4 to 1.5 million fish.

Pink salmon catches declined from an average annual catch of 6.0 million fish for the period 1925-45 to slightly less than 3.0 million for the period 1946-75 (Fig. 12). The fishery is dominated by catches made in Prince William Sound (Table 1).

Chum salmon catches fluctuated greatly from a high of 1.7 million fish in 1945 to a low of only 0.02 million in 1954. Recent catches (1965-75) averaged approximately 0.3 million fish annually and like pink salmon are primarily from Prince William Sound.

Coho catches ranged from a high of 1.3 million fish in 1927 to a low of only 0.1 million in 1932. Recent catches are significantly lower than past catches primarily resulting from decreased levels of abundance in Prince William Sound. The Copper River and Yakutat districts currently provide most of the coho salmon catches.

Chinook salmon catches were significantly lower than those of other species. A peak catch of over 0.1 million fish occurred in 1930. Since then, catches ranged from about 0.01 to 0.03 million fish annually. During the past 6 years the catches were at or above the long-term average of about 0.03 million fish.

Although current levels of abundance are below historic levels, particuarly in the case of pink salmon, the stocks in the study area are substantial. Levels of abundance in the future can be expected to fluctuate as during the past 20 years and perhaps to maintain the average observed during that period. Enhancement programs may ultimately increase runs of some species substantially.

Catch statistics for the 21-year period 1955-75 are summarized by detailed statistical area in Table 2. For this period the annual average catch is 6.1 million salmon and the potential catch[2] is 14.9 million.

Population Estimates

Total run estimates (Table 3) were made by summing the average annual catch and estimated escapement (assumed to be 30 percent of the total run or 0.43 times catch). On this basis, the average annual runs to rivers in the area covered by this report totalled 8.5 million salmon during the period 1955-75. The percentage composition of the data in Table 3 are shown in Table 4. Pink salmon were most abundant, comprising 71 percent of the total (even and odd years averaged) with the remainder divided as follows: sockeye (14 percent), chum (9 percent), coho (5 percent), and chinook (< 1 percent).

Prince William Sound. This is the most important district in the region, accounting for 82 percent of the total (Table 4). Total runs of all species to this district averaged 6.9 million fish with a potential of 17.8 million

[2]Potential catch refers to the sums of peak catches of individual species for the 21 year period, 1955-75, for each statistical area.

(Table 3). Pink salmon stocks are very important both on a district and region-wide basis constituting 86 and 71 percent, respectively, of the total average annual catch (even and odd years averaged) (Table 4). Chum salmon stocks are also important as they comprise 9 percent of the region's total catch.

Over 50 percent of the Prince William Sound district's total catch and over 40 percent of the region's catch comes from statistical areas 221 and 226 (Table 4 and Fig. 11). Statistical area 221 also produced nearly 40% of the district's catch of chum salmon (Tables 3 and 4).

Copper River District. This district was estimated to provide 12 percent of the region's total salmon stocks (Table 4). Total runs to this district averaged 1.1 million salmon with a potential of over 2.0 million (Table 3). Sockeye salmon are the most abundant species in this district as they constitute almost 80 percent of the district's average annual salmon catch (Table 4). Significant runs of coho salmon also occur in the Copper River district.

Bering River District. This district was estimated to provide only 1 percent of the region's total salmon stocks (Table 4). Total runs were estimated at only 0.1 million salmon with a potential of twice that number (Table 3). Coho and sockeye salmon are the most abundant, constituting 63 and 35 percent of the total district catch, respectively.

Yakutat District. Runs to this district constitute only 5 percent of the region's total catch. Total runs to the Yakutat district were estimated at 0.4 million salmon with a potential of 1.3 million (Table 3). Sockeye and coho salmon are the most abundant species, consitituting 43 and 36 percent, respectively, of the total average catch (Table 4). Within the Yakutat district, statistical areas 182 and 185 are the most important salmon producing areas (Table 4, Fig. 11).

Timing of Migrations

The timing of salmonid migrations, both mature and immature in nearshore waters is of major importance in considering possible impacts by the petroleum industry.

Weekly catch statistics by district and species for the ten year period, 1963-72, were used to describe the timing of mature salmon migrations in nearshore waters. Catch statistics provide a satisfactory profile of the timing of salmon runs but are influenced to a degree by necessary regulation of fishing periods by management agencies. Consequently, escapement data where available were used to supplement the use of catch statistics.

Prince William Sound (Fig. 13). The fishery is such that fish are first intercepted in the outer areas (i.e., statistical areas 226, 227, and 228; Fig. 11) and then fished at various locations on their migration to natal streams. As a result, the timing curves shown represent a broad picture of the migration timing rather than what would be seen at a particular location within Prince William Sound.

Sockeye catches begin in mid-June, peak bimodally in early July (largest peak) and early August, and continue through late August. Pink salmon catches begin in early July, peak in early August, and continue through late August. Analyses of escapement data indicate that intertidal spawning continues through September (Helle et al. 1964) and that odd year pinks generally return earlier than even year runs (Noerenberg 1963). Chum salmon catches begin in late June, peak bimodally in late July and early August, and continue through the end of August. Sport catches of coho in Prince William Sound suggest that few coho remain after the first week of September (Williams 1972). Chinook catches begin in mid-June, peak bimodally in early July and early August, and continue through late August.

Copper River District (Fig. 14). Sockeye catches in this district begin in early June, peak soon thereafter, and continue into early August. Pink salmon catches begin almost 3 weeks later, peak bimodally in mid-July and early August, and end in late August. Chum catches like sockeye begin in early June and remain relatively constant through late August. Coho catches begin latest (in early August), peak in early September, and continue through the end of the month. Chinook catches begin in early June, peak in late June, and end in late July.

Bering River District (Fig. 15). Sockeye catches begin in early June, peak in early July, and continue through mid-August. Coho catches begin in mid-August, peak two weeks later, and end in late September. Chinook catches begin in mid-June peak in late June, and end by mid-July.

Yakutat District (Fig. 16). Sockeye catches begin in mid-June, peak in early July, and continue into September. Pink salmon catches begin almost a month later than sockeye, peak in late August, and end in mid-September. Chum catches begin in early August, peak in mid-September, and continue into early October. Coho catches begin in mid-July, peak in early September, and continue into October. Chinook catches begin in the spring and continue into late September. Weir count data in southeastern Alaska streams south of this district support the timing as shown from weekly catches and add information on char, sea-run cutthroat and steelhead trout timing (Table 5).

Migratory Routes

As discussed in the first two reports, maturing salmon approach natal streams over a broad front from high seas feeding areas, and as a result, often make extensive migrations along the coast. Thus, nearshore movements in opposite directions, characterized as "wandering," are quite common (Neave 1964; Verhoeven 1947). In addition, interspecific differences in migratory behavior have also been reported (Milne 1957; Prakash 1962).

Tagging studies in Prince William Sound have shown that a significant number of salmon caught in the outer waters are bound for Cook Inlet[2] (Noerenberg and Sevoie 1963). Also indicated are two main migration routes into Prince William Sound; fish bound for streams on the eastern shore generally migrate through the Hinchinbrook pass whereas fish bound for streams on the west shore move through passes near Knight Island (Thompson 1931; Noerenberg and Sevoie 1963). Superimposed on these routes are "to and fro" movements. Tagging only slightly offshore near the Copper River and Yakutat have yielded returns from southeastern Alaska (French et al. 1975). Thus, salmon approaching the coast in the northeast part of the Gulf of Alaska are a mixture of many stocks some of which are bound for areas other than those covered by this report.

JUVENILE SALMONIDS IN NEARSHORE WATERS

Distribution and Abundance

The abundance and species composition of young salmon upon their entry into marine waters are logically a function of the numbers of adults spawning

[3]Tyler, Richard W. and Wallace H. Noerenberg. 1959 MS. Salmon tagging in Cook Inlet and Prince William Sound, Fish. Res. Inst., Univ. Washington, Seattle, WA, unpublished manuscript.

in streams within the area. Data summarized by Atkinson et al. (1967), which presents detailed figures by species for individual stream, show that juvenile salmon enter the marine environment throughout nearshore waters covered by this report. The major contributing streams are presented in Figs. 17-21. The approximate numbers of spawners were presented in the foregoing section. Literature reports (Clemens and Wilby 1961) show that steelhead trout, char, and sea-run cutthroat trout also commonly occur in the nearshore waters of the area.

Population Estimate

Estimates of juvenile salmon abundance were based on parent spawning stock size and calculated using a 50/50 sex ratio, and average fecundity and survival (egg to downstream migrant) values. Average fecundities of 2,000 eggs for pink salmon, 3,000 eggs for chum, 3,500 eggs for sockeye and coho, and 4,000 eggs per female for chinook were used (Bailey 1969). Average survival rates to seaward migrant stage of 2% for sockeye, coho, and chinook and 10% for pink and chum salmon were used (Donaldson 1963; MacKinnon 1970). Even though fecundity and survival vary greatly in the natural environment, the use of average values provide a reasonably accurate picture of abundance.

Using the above rationale, over 231 million juvenile salmon were estimated to enter marine waters of this region in an average year and nearly 600 million in a peak year (Table 6). This does not include juvenile steelhead trout, Pacific char, and sea-run cutthroat trout for which there are no bases for abundance estimations.

Timing of Migrations

Juvenile salmon enter estuarine waters in the spring and summer, the precise timing depending on genetic and environmental factors (Hartman et al. 1967). Subsequent movements through the estuaries and protected bays and channels are a progression of actions related to the time of entry into the estuary. It is possible that salmon from adjacent rivers may enter Prince William Sound as part of their early marine migrations. Although most smolts reach estuarine waters in May small numbers continue through at least August (Table 7).

Migratory Routes

Juvenile salmon that enter protected estuarine waters generally remain near the surface, and gradually move offshore as the summer progresses (Healey 1969; Lagler and Wright 1962; Sakagawa 1972). Salmon smolts that enter the estuary along unprotected shores apparently move directly offshore.[4]

JUVENILE SALMONIDS OFFSHORE

Distribution and Abundance

Information on the distribution and abundance of juvenile salmon in offshore coastal waters was based primarily on the results of purse seine sampling which was done by the Fisheries Research Institute for the purposes of the International North Pacific Fisheries Commission. Analysis of these data indicates that juvenile salmonids are concentrated close to shore in a belt extending about 37 km offshore and apparently directly related to the width of the continental shelf[5] (Royce et al. 1968). Fig. 22 illustrates

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[4] Tyler, Richard W. MS 1976. Forecasts of pink salmon (Oncorhynchus gorbuscha) runs to the Kodiak Island area based on estuarine abundance of juveniles. Fish. Res. Inst., Univ. Washington, Seattle, WA, unpublished manuscript.

[5] Hartt, Allan C. and Michael B. Dell. MS 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA, unpublished manuscript.

the catches of juvenile salmonids by time periods and by 2° x 5° statistical areas. The general tendency for juvenile salmon to be concentrated nearshore during the summer is illustrated, but the scale of the figure is inadequate to show the actual narrow width of salmon distribution along the coast.

Timing of Migrations

Relatively small purse seine catches in April-June indicate that most age .0 fish have not migrated from nearshore protected waters. This is not the case in July and August when high CPUE's for all species indicate that movement from protected waters is underway. Catches in September-October indicate that relatively large numbers of juvenile pink and chum salmon and lesser numbers of the other species still occur in a narrow belt along the coast.

Migratory Routes

Information on the migration routes of age .0 salmon after departing the protection of nearshore waters were based on directional data from purse seine fishing, sizes of fish, and tag returns. These data indicate that age .0 salmonids move in a narrow band close to shore in a counterclockwise direction along the Pacific coast (Royce et al. 1968; Sakagawa 1972). The width of this band appears related to that of the continental shelf and averages approximately 37 km in width along the British Columbia and Southeast Alaska coasts and slightly wider along the northern Gulf of Alaska coast where the continental shelf is wider. Thus, the area along the coast of the northeastern part of the Gulf of Alaska is an area through which juvenile salmonids from as far south as California pass. All species are included, but sockeye, chum, and pink salmon far outnumber the other species and these originate as far south as Puget Sound. Thus, the actual population of juvenile salmonids is much larger than would be expected based upon the outmigration from rivers of the northeastern Gulf of Alaska.

ADULT SALMONIDS IN OFFSHORE WATERS

Abundance, Distribution, and Timing of Migrations

Gillnet (Fig. 23) and longline (Fig. 24) catches were used to describe the seasonal distribution and abundance of salmon in offshore waters adjacent to the study area. Fukuhara (1971) noted that the amount of sampling was less than that required to adequately reflect true abundance at sampling sites. Consequently, the figures may be viewed as showing only the general distributional pattern together with their seasonal migrations toward coastal waters of origin. Some older age immature fish are also included in the catches, thus accounting for chum salmon occurring far offshore in September.

Experimental fishing results in winter (Fig. 23, 24) suffer from small sample size but show that considerable numbers of sockeye and lesser numbers of pink and chum salmon overwinter in the offshore waters of the region covered by this report. Analysis of gillnet catches indicate that sockeye are most abundant in the western waters of the region. Seasonal changes in the availability of the salmon to the gear probably caused bias, particularly in winter sampling (Hartt 1962).

Results of fishing in spring (Fig. 23,24) demonstrate that larger numbers of sockeye, pink, and chum salmon have entered the study area than were present in winter or that they have become more vulnerable to the gear by changes in depth and/or feeding activity. Sockeye and chum salmon are distributed throughout the region. Pinks are most abundant in the eastern part of the study area. By June significantly more pink and chum salmon occurred in the catches whereas the CPUE's for sockeye were not changed significantly. As in spring sockeye and chum salmon are distributed throughout the study area, while pinks are most abundant in the eastern portion, probably indicative of inshore migrations for spawning. A high abundance of sockeye occurred in the north-central Gulf (Fig. 23), probably evidence of inshore migration of sockeye in this area.

Lower CPUE's for sockeye in July reflect the departure of Bristol Bay and other stocks from the sampling area. Increased CPUE's of sockeye in the coastal areas (Fig. 23) indicate migration toward spawning grounds in this vicinity. Increased CPUE's for chum salmon show that more fish of this species entered the study area or became more available to the gear. Pinks were still most abundant in the eastern portion of the study area although large numbers (probably reflecting Kodiak I. stocks) also occurred in the northwest portion. The large catches of sockeye in the southwest portion probably include mainly immature fish of age .2 and older.

The decrease in CPUE for sockeye continued into August and was evident for pink and chum as well. Gillnet data indicate that sockeye were most abundant in the south-central and southwest portion of the study area and chum were distributed evenly throughout the area.

A similar picture to that of August was seen in September. Again, the presence of immature age .2 fish probably distorted the picture of the distribution of maturing stocks in August and September.

Migratory Routes

The migratory routes of salmonids in offshore waters have been described from results of experimental fishing and tagging as follows: pinks - Royce et al. 1968, Takagi et al. (in press), sockeye - Royce et al. (1968), French and Bakhala (1974), French et al. (in press), chum - Neave et al. (in press), coho - Godfrey et al. 1973, chinook - Major et al. (in press), steelhead trout - Sutherland 1973.

After departing the coastal belt, juvenile salmonids move south probably in response to temperature, where they mix with older age classes. The juvenile salmon from the study area in the northwestern Gulf of Alaska apparently depart the coastal belt along the broad front extending from at least Yakutat to Unimak Island and the period of their departure probably continues from late summer through late fall. Sampling south of the eastern Aleutian Islands suggest that most of the juvenile sockeye, chum and pink salmon have moved offshore prior to reaching that far west. Pink salmon which spend only one winter at sea are more easily described and their general spring and summer migratory pattern is outlined in Fig. 25. The actual migrations and distribution and timing of their southward movement is known only from extrapolated data derived from late fall observations compared with early spring operations the following year. Pink salmon, however, migrate southward to at least 42° or 43° N. where they are found dispersed widely during the spring. They then migrate northward during spring and summer across a broad east - west front as diagrammed in Fig. 25. They then approach their coastal destinations via various approaches and perform the inshore migrations that were described in the earlier section of this paper. An important observation was made by Neave (1964) showing that frequently the late run fish tend to migrate well north of their final destination and then shift southward again along the coast toward their final purpose of origin in late summer or early fall.

Sockeye (Fig. 26) and chum salmon follow the same general pattern except that most individuals of these species remain two or three winters at sea before maturing and returning. Thus, they have opportunity to disperse much farther seaward than do the pink salmon. Some sockeye and chum salmon from the study area in the northeastern Gulf of Alaska migrate at least to the central Aleutian Island area (175°W) as part of their migration at either age .1 or age .2. Otherwise they tend to shift southward during the winter and then northward again during the spring during their feeding migrations as immature fish or during their homing migrations as maturing fish. Typically the maturing fish tend to be centered farther northward than the immature fish (French et al. in press).

Data of this sort for chinook salmon, coho salmon, steelhead trout are much fewer, but tag returns indicate that at least some individuals of these species do migrate well offshore and make a seasonal southward and northward migration. A large portion of coho and chinook salmon remain in coastal waters for their entire life, however. This does not seem to be the case for steelhead which tend to migrate offshore rather early[6] in their ocean migrations and tend to remain generally farther south than the other species (Sutherland 1973).

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[6]Hartt, Allan C. and Michael B. Dell. MS 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, WA, unpublished manuscript.

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Table 1. Summary of salmon catch statistics[1] for the 48-year period 1925-1972 in thousands of fish by species for Prince William Sound, Copper River, Bering River and Yakutat districts

District	Sockeye	Pink (odd)	Pink (even)	Chum	Coho	Chinook	Total[2]
Prince William Sound							
Average catch	120	4710	5414	501	57	2	5742
95% confidence interval	±20	±1336	±1402	±83	±14	±1	±1487
Peak catch	286	11632	11543	1754	259	12	13898
1975 catch	186	1201	--	80	3	2	1472
Copper River							
Average catch	624	2	2	1	196	17	840
95% confidence interval	±75	±1	±1	±1	±42	±3	±122
Peak catch	1136	11	10	10	710	47	1914
1975 catch	335	<1	--	1	54	20	410
Bering River							
Average catch	32	<1	<1	<1	56	<1	88
95% confidence interval	±8	<1	<1	<1	±11	<1	±19
Peak catch	72	<1	<1	<1	92	2	165
1975 catch	22	<1	--	--	24	2	48
Yakutat							
Average catch	161	36	29	11	143	9	356
95% confidence interval	±28	±22	±16	±6	±20	±6	±79
Peak catch	407	127	246	111	341	83	1128
1975 catch	73	80	--	4	38	6	200
Totals							
Average catch	937	4748	5445	512	451	28	7025
95% confidence interval	±131	±1359	±1419	±89	±88	±10	±1707
Peak catch	1901	11771	11799	1874	1401	143	17104
1975 catch	616	1282	--	85	119	29	2130

[1]Source: INPFC. MS 1974. Historical catch statistics for salmon of the North Pacific Ocean. Manuscript version (2nd draft) of compilation proposed for publication.

[2]Determined using mean of even- and odd-year pink catches.

Table 2. Summary of salmon catch statistics[1] for the 21-year period 1955-1975 in thousands of fish by detailed statistical area and species for the districts shown in Table 1

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total	
	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch		
Prince William Sound														
220	<1	(<1)	1*	(3)	<1*	(<1)	<1*	(<1)	1*	(1)	3*	(12)	6	(16)
221	3	(21)	870	(1666)	991	(1975)	197	(452)	6	(18)	<1	(<1)	1137	(2302)
222	14	(90)	411	(1275)	168	(666)	51	(155)	2	(14)	<1	(<1)	357	(1230)
223	51	(136)	255	(854)	168	(489)	52	(121)	1	(2)	<1	(1)	316	(932)
224	10	(21)	525	(1442)	319	(786)	68	(322)	2	(12)	<1	(1)	503	(1470)
225	20	(62)	112	(316)	33	(113)	19	(56)	1	(4)	<1	(<1)	113	(337)
226	19	(69)	1128	(1579)	1568	(3902)	41	(111)	7	(35)	<1	(<1)	1416	(2956)
227	5	(45)	479	(2030)	183	(896)	57	(227)	6	(26)	1	(3)	400	(1764)
228	<1	(1)	231	(570)	636	(1307)	34	(66)	2	(8)	<1	(1)	471	(1015)
229	2	(2)	463*	(823)	<1	(<1)	9*	(15)	1*	(1)	<1	(<1)	244	(430)
Total	124	(437)	4475	(10558)	4066	(10134)	528	(1525)	29	(121)	5	(20)	4963	(12452)
Copper River														
212	588	(1116)	3	(10)	2	(9)	1	(10)	137	(243)	14	(22)	743	(1401)
Total	588	(1116)	3	(10)	2	(9)	1	(10)	137	(243)	14	(22)	743	(1401)
Bering River														
200	30	(72)	<1	(<1)	<1	(<1)	<1	(<1)	54	(89)	<1	(1)	86	(163)
	30	(72)	<1	(<1)	<1	(<1)	<1	(<1)	54	(89)	<1	(1)	86	(163)
Yakutat														
181	11*	(39)	1	(3)	1	(6)	9	(36)	3	(9)	1	(4)	25	(93)
182	70	(175)	4	(18)	7	(26)	8	(49)	28	(105)	2	(3)	114	(354)
183	7	(16)	3	(22)	25	(77)	<1	(5)	14	(34)	2	(6)	38	(111)
184	3*	(7)	1	(4)	3*	(13)	2*	(12)	7	(23)	<1*	(1)	15	(52)
185	35	(48)	5	(13)	8*	(13)	<1*	(<1)	20	(64)	<1*	(<1)	63	(125)
191	<1*	(<1)	<1	(<1)	<1	(<1)	<1*	(<1)	1	(71)	1*	(3)	4	(76)
192	<1*	(<1)	<1	(<1)	<1*	(<1)	<1*	(<1)	33	(67)	<1	(<1)	34	(68)
Total	127	(286)	15	(61)	45	(136)	21	(104)	106	(373)	7	(18)	293	(880)
Grand total	869	(1911)	4494	(10630)	4114	(10280)	551	(1640)	326	(826)	27	(61)	6035	(14836)

[1]Source: INPFC Statistical Yearbooks (1955-74), Alaska Department of Fish and Game.
*Sporadic reports only.

Table 3. Estimates[1] of the average total runs of salmon (catch plus estimated escapements) in thousands of fish by statistical area and species for Prince William Sound, Copper River, Bering River, and Yakutat for the 21-year period 1955-1975

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total[2]	
	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch	Mean catch	Peak catch		
Prince William Sound														
220	<1	(<1)	2	(4)	<1	(<1)	<1	(<1)	2	(2)	4	(17)	7	(23)
221	4	(16)	1246	(2379)	1415	(2820)	281	(646)	8	(26)	<1	(1)	1624	(3289)
222	20	(128)	587	(1821)	240	(951)	72	(221)	2	(20)	<1	(1)	503	(1757)
223	73	(194)	364	(1220)	240	(699)	75	(172)	1	(3)	<1	(1)	451	(1331)
224	14	(29)	749	(2059)	27	(1122)	97	(460)	2	(18)	<1	(1)	501	(2100)
225	29	(88)	160	(451)	48	(162)	27	(80)	1	(5)	<1	(<1)	161	(461)
226	27	(99)	1610	(2254)	2239	(5571)	59	(158)	9	(50)	<1	(<1)	2029	(4223)
227	7	(65)	684	(2899)	262	(1280)	82	(324)	9	(36)	1	(4)	572	(2520)
228	<1	(1)	330	(814)	908	(1666)	48	(95)	3	(12)	<1	(1)	670	(1450)
229	3	(3)	662	(1175)	<1	(<1)	12	(21)	1	(2)	<1	(<1)	347	(614)
Total	177	(623)	6394	(15076)	5379	(14471)	753	(2177)	38	(174)	5	(26)	6861	(17788)
Copper River														
212	839	(1593)	5	(14)	3	(13)	2	(15)	196	(347)	20	(32)	1061	(2001)
Total	839	(1593)	5	(14)	3	(13)	2	(15)	196	(347)	20	(32)	1061	(2001)
Bering River														
200	42	(103)	<1	(<1)	<1	(<1)	<1	(<1)	77	(127)	<1	(1)	122	(233)
Total	42	(103)	<1	(<1)	<1	(<1)	<1	(<1)	77	(127)	<1	(1)	122	(233)
Yakutat														
181	16	(56)	2	(5)	2	(8)	13	(52)	4	(13)	1	(6)	36	(133)
182	70	(250)	5	(26)	11	(38)	12	(70)	40	(151)	3	(5)	163	(506)
183	9	(22)	4	(32)	35	(110)	1	(7)	19	(49)	3	(8)	54	(159)
184	4	(10)	2	(6)	5	(19)	3	(18)	11	(33)	1	(1)	21	(74)
185	50	(69)	7	(19)	11	(19)	<1	(<1)	29	(92)	<1	(1)	90	(180)
191	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	2	(101)	2	(4)	6	(109)
192	<1	(1)	<1	(<1)	<1	(<1)	<1	(<1)	47	(96)	<1	(<1)	49	(97)
Total	149	(408)	20	(88)	64	(194)	29	(147)	152	(535)	10	(25)	419	(1258)
Region total	1207	(2727)	6419	(15178)	5446	(14678)	784	(2339)	463	(1183)	35	(84)	8463	(21280)

[1]Calculated from Table 2.
[2]Pink salmon values are the mean of odd- and even-years.

Table 4. The average percent contribution[1] of each detailed statistical area to the commercial salmon catch within districts and within the whole region (1955-1975). The percent contributions to the entire region are enclosed in parentheses

Statistical area	Sockeye		Pink (even)		Pink (odd)		Chum		Coho		Chinook		Total	
	District catch	Region catch	District catch	Region catch	District catch	Region catch	District catch	Region catch	District catch	Region catch	District catch	Region catch		
Prince William Sound														
220	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)
221	<1	(<1)	18	(14)	20	(16)	4	(3)	<1	(<1)	<1	(<1)	23	(19)
222	<1	(<1)	8	(7)	3	(3)	1	(1)	<1	(<1)	<1	(<1)	7	(6)
223	1	(1)	5	(4)	3	(3)	1	(1)	<1	(<1)	<1	(<1)	6	(5)
224	<1	(<1)	11	(9)	6	(5)	1	(1)	<1	(<1)	<1	(<1)	10	(8)
225	<1	(<1)	2	(2)	1	(1)	<1	(<1)	<1	(<1)	<1	(<1)	2	(2)
226	<1	(<1)	23	(19)	32	(26)	1	(1)	<1	(<1)	<1	(<1)	29	(23)
227	<1	(<1)	10	(8)	4	(3)	1	(1)	<1	(<1)	<1	(<1)	8	(7)
228	<1	(<1)	5	(4)	13	(10)	1	(1)	<1	(<1)	<1	(<1)	10	(6)
229	<1	(<1)	9	(8)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	5	(4)
Total	2	(2)	90	(74)	82	(67)	11	(9)	1	(<1)	<1	(<1)	100	(82)
Copper River														
212	79	(10)	<1	(<1)	<1	(<1)	<1	(<1)	18	(2)	2	(<1)	100	(12)
Total	79	(10)	<1	(<1)	<1	(<1)	<1	(<1)	18	(2)	2	(<1)	100	(12)
Bering River														
200	35	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	63	(1)	<1	(<1)	100	(1)
Total	35	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	63	(1)	<1	(<1)	100	(1)
Yakutat														
181	4	(<1)	<1	(<1)	<1	(<1)	3	(<1)	1	(<1)	<1	(<1)	9	(<1)
182	24	(1)	1	(<1)	2	(<1)	3	(<1)	10	(<1)	1	(<1)	39	(2)
183	2	(<1)	1	(<1)	9	(<1)	<1	(<1)	5	(<1)	1	(<1)	13	(1)
184	1	(<1)	<1	(<1)	1	(<1)	1	(<1)	2	(<1)	<1	(<1)	5	(<1)
185	12	(1)	2	(<1)	3	(<1)	<1	(<1)	7	(<1)	<1	(<1)	22	(1)
191	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	1	(<1)
192	<1	(<1)	<1	(<1)	<1	(<1)	<1	(<1)	11	(<1)	<1	(<1)	12	(1)
Total	43	(2)	5	(<1)	15	(1)	7	(<1)	36	(2)	2	(<1)	100	(5)
Region total	--	(14)	--	(74)	--	(68)	--	(9)	--	(5)	--	(<1)	--	(100)

[1]Calculated from Table 2.

Table 5. Run timing of adult salmonids in selected southeastern Alaska streams

Species	River	Beginning	Peak	End	Source
Sockeye	Petersburgh Creek	May	July	September	Jones 1974, 1975
Pink	Petersburgh Creek	June	August	September	Jones 1973, 1974, 1975
Chum	Petersburgh Creek	June	July	October	Jones 1973, 1974, 1975
Coho	Petersburgh Creek	August	--	November	Jones 1973, 1974, 1975
Steelhead	Petersburgh Creek	March	May	June	Jones 1973, 1974, 1975
	Peterson Creek	March	May	June	Jones 1972
Char	Petersburgh Creek	June	August	October	Jones 1973, 1974, 1975
Sea-run cutthroat	Petersburgh Creek	July	September	October	Jones 1973, 1974, 1975
	Peterson Creek	August	September	October	Jones 1972

Table 6. Population estimates[1] of juvenile salmon in millions of fish by district and species based on parent spawning stock size

District	Sockeye	Pink (even)	Pink (odd)	Chum	Coho	Chinook	Total
Prince William Sound							
Average	1.9	191.8	161.4	33.9	0.4	0.1	212.8
Peak	6.5	452.3	434.1	98.0	1.8	0.3	549.8
Copper River							
Average	8.8	0.2	0.1	0.1	2.1	0.2	11.4
Peak	16.7	0.4	0.4	0.7	3.6	0.4	21.8
Bering River							
Average	0.4	<0.1	<0.1	<0.1	0.8	<0.1	1.2
Peak	1.1	<0.1	<0.1	<0.1	1.3	<0.1	2.4
Yakutat							
Average	1.6	0.6	1.9	1.3	1.6	0.1	5.9
Peak	4.3	2.6	5.8	6.6	5.6	0.3	21.0
Region total							
Average	12.7	192.6	163.4	35.3	4.9	0.4	231.3
Peak	28.6	455.3	440.3	105.3	12.3	1.0	595.0

[1]*See* text for calculation.

Table 7. The timing[1] of downstream migration of juvenile salmonids in selected locations in the northeastern Gulf of Alaska

Species	Location	Beginning	Peak	End
Sockeye	Taku River	April	May	June
Pink	Prince William Sound (8 bays)	April	May	June
	Sashin Creek	--	April	June
Chum	Prince William Sound (8 bays)	April	May	June
	Sashin Creek	--	May	--
Coho	Petersburgh Creek	March	May	August
	Sashin Creek	--	May	--
	Taku River	April	May	June
Chinook	Taku River	April	May	June
Steelhead	Petersburgh Creek	April	June	August
	Peterson Creek	May	June	July
Char	Taku River	April	May	June
Sea-run cutthroat	Petersburgh Creek	May	May	July
	Peterson Creek	May	July	July

[1]Source: Jones 1972, 1973, 1974, 1975.
Lagler and Wright 1962.
Meehan and Siniff 1962.
Tait and Kirkwood 1957.

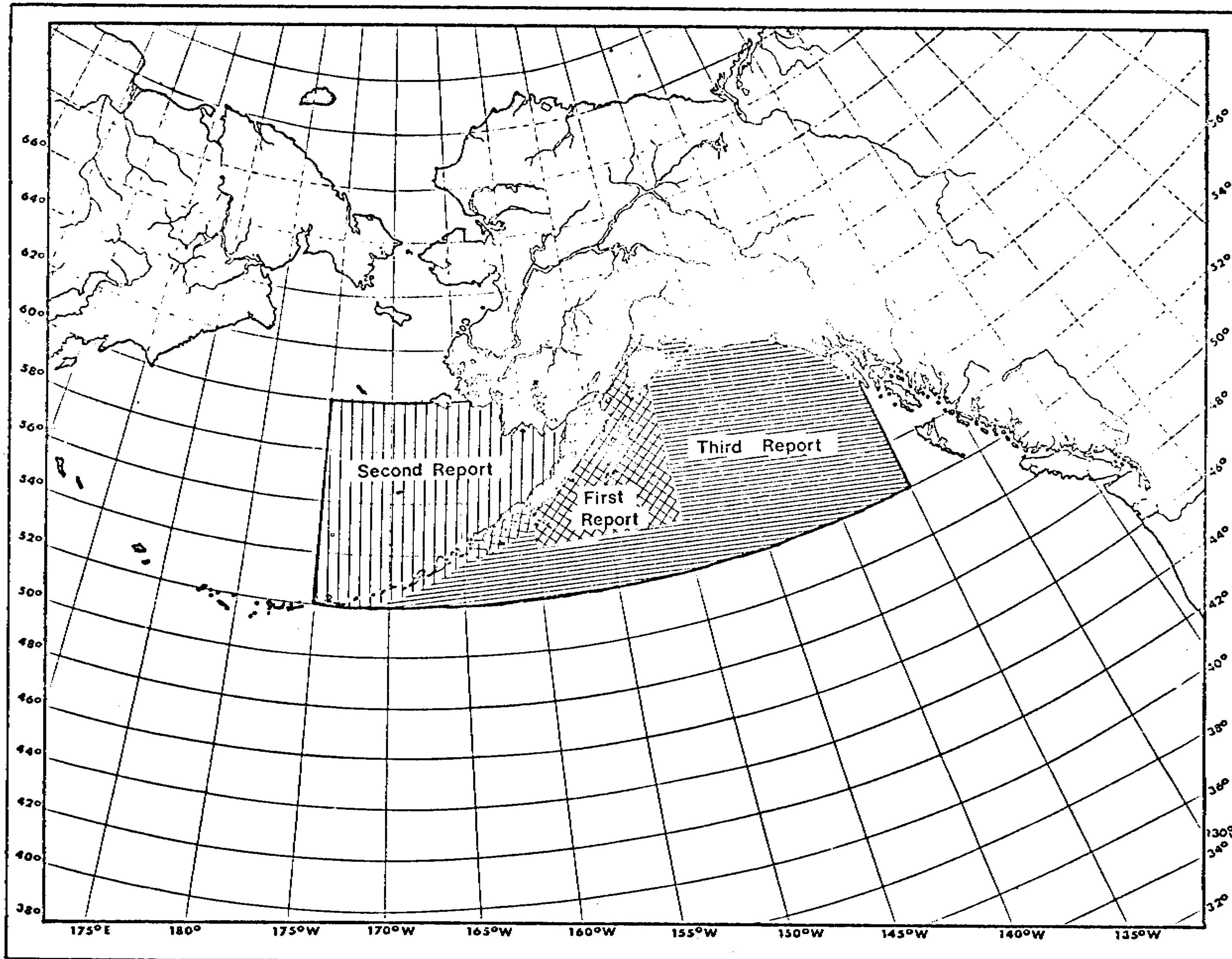


Fig. 1. Map of study area showing geographic coverage of each report.

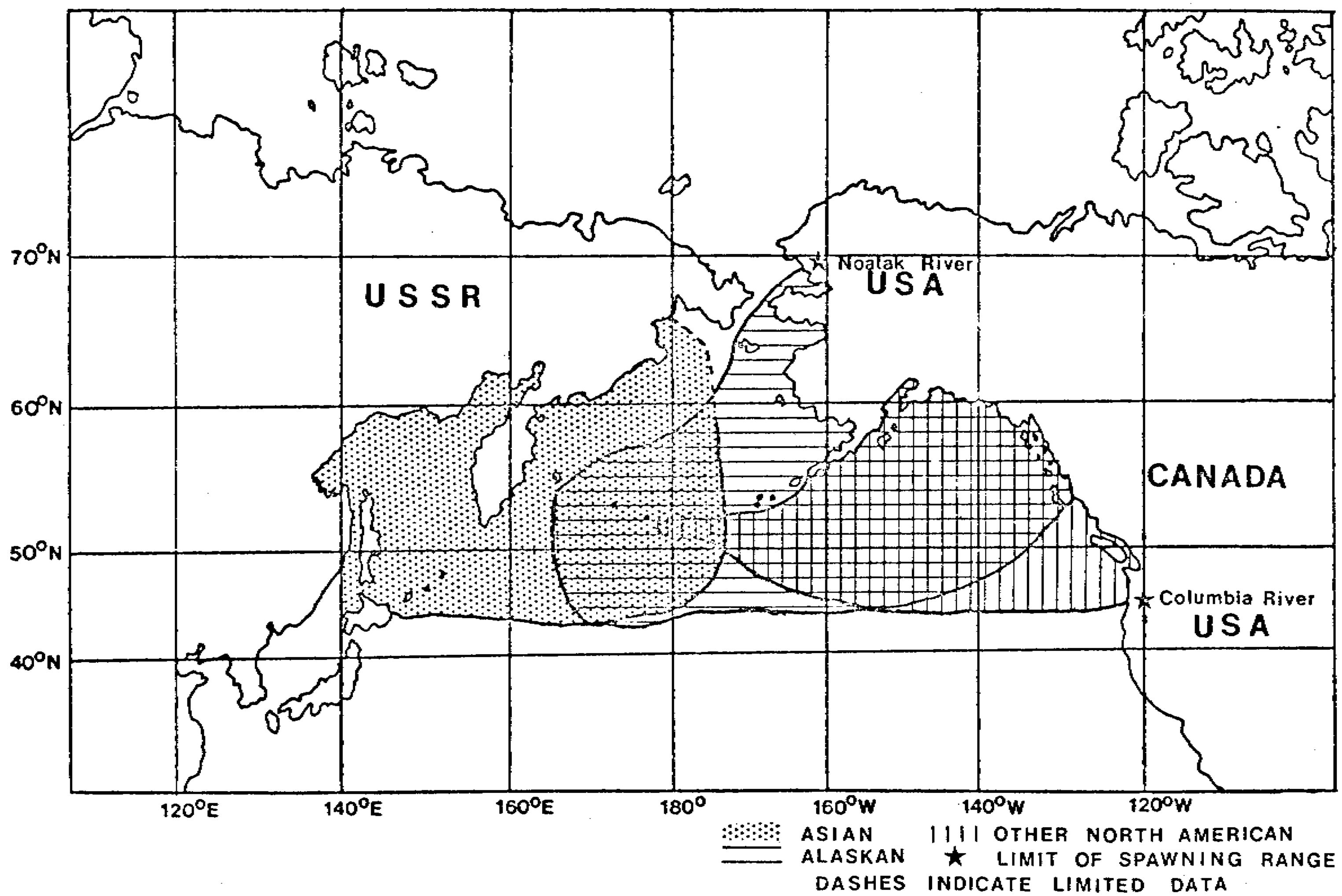


Fig. 2. The range of spawning stocks and offshore distribution of sockeye salmon. (From Hart 1973.)

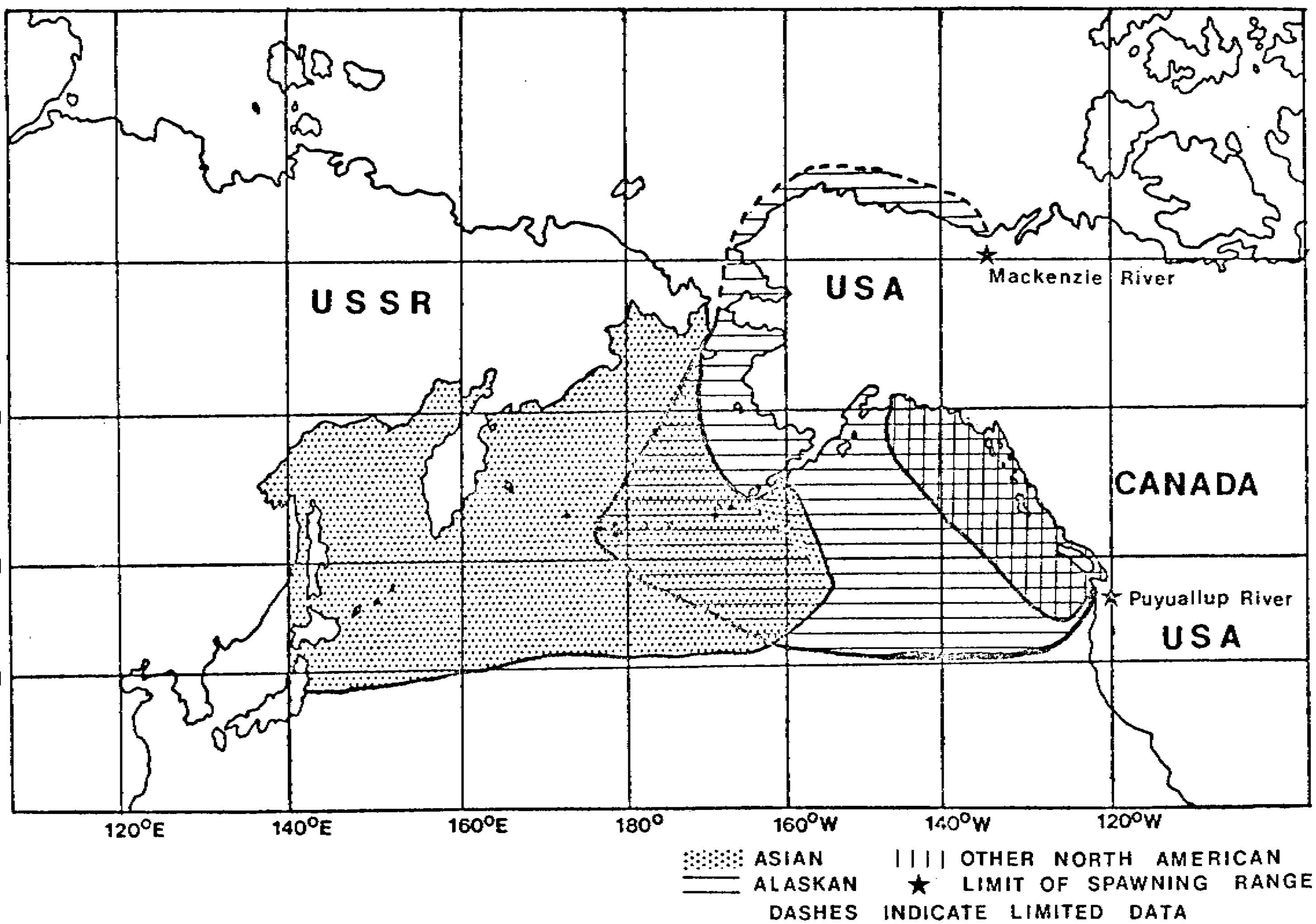


Fig. 3. The range of spawning stocks and offshore distribution of pink salmon. (From Hart 1973.)

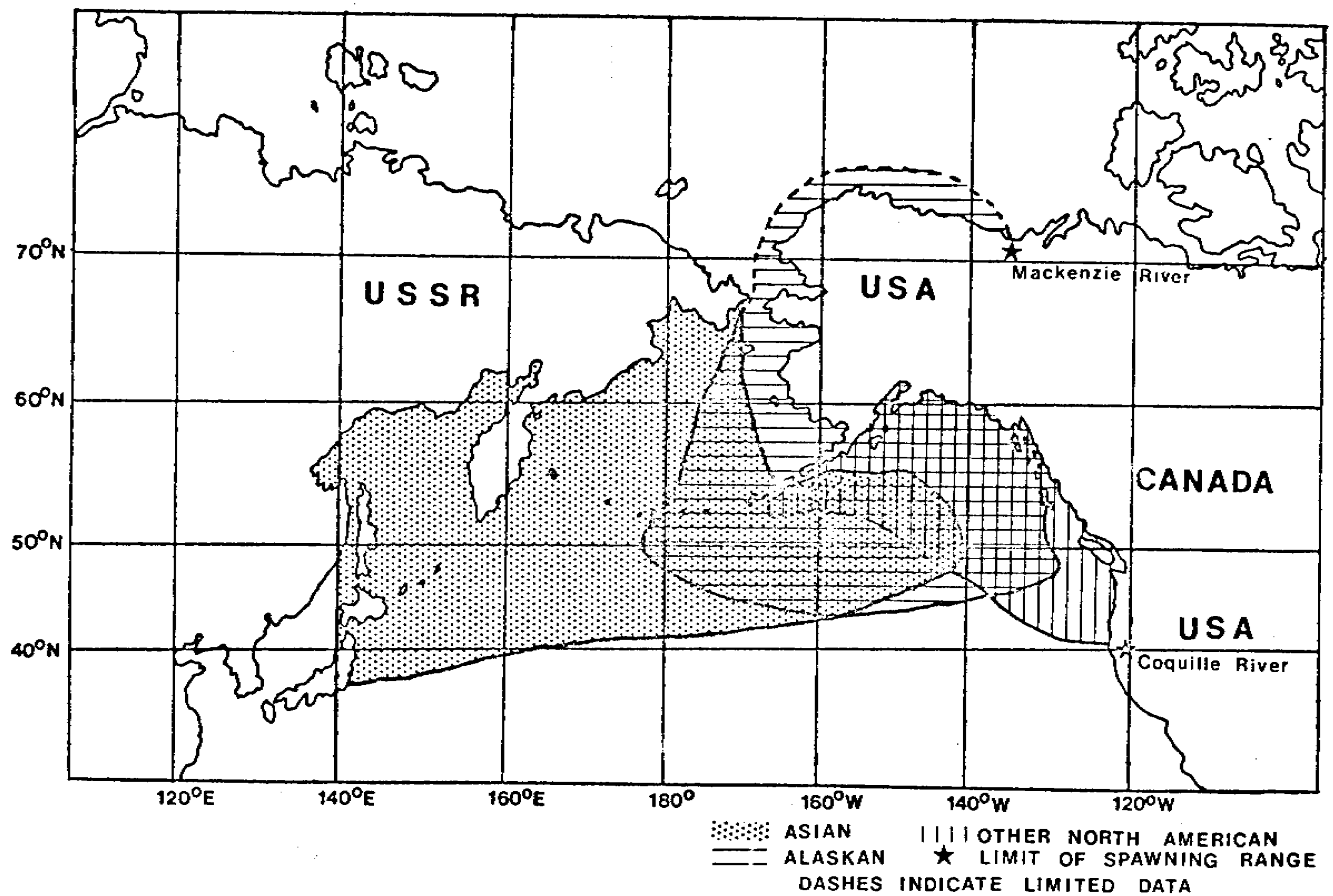


Fig. 4. The range of spawning stocks and offshore distribution of chum salmon. (From Hart 1973.)

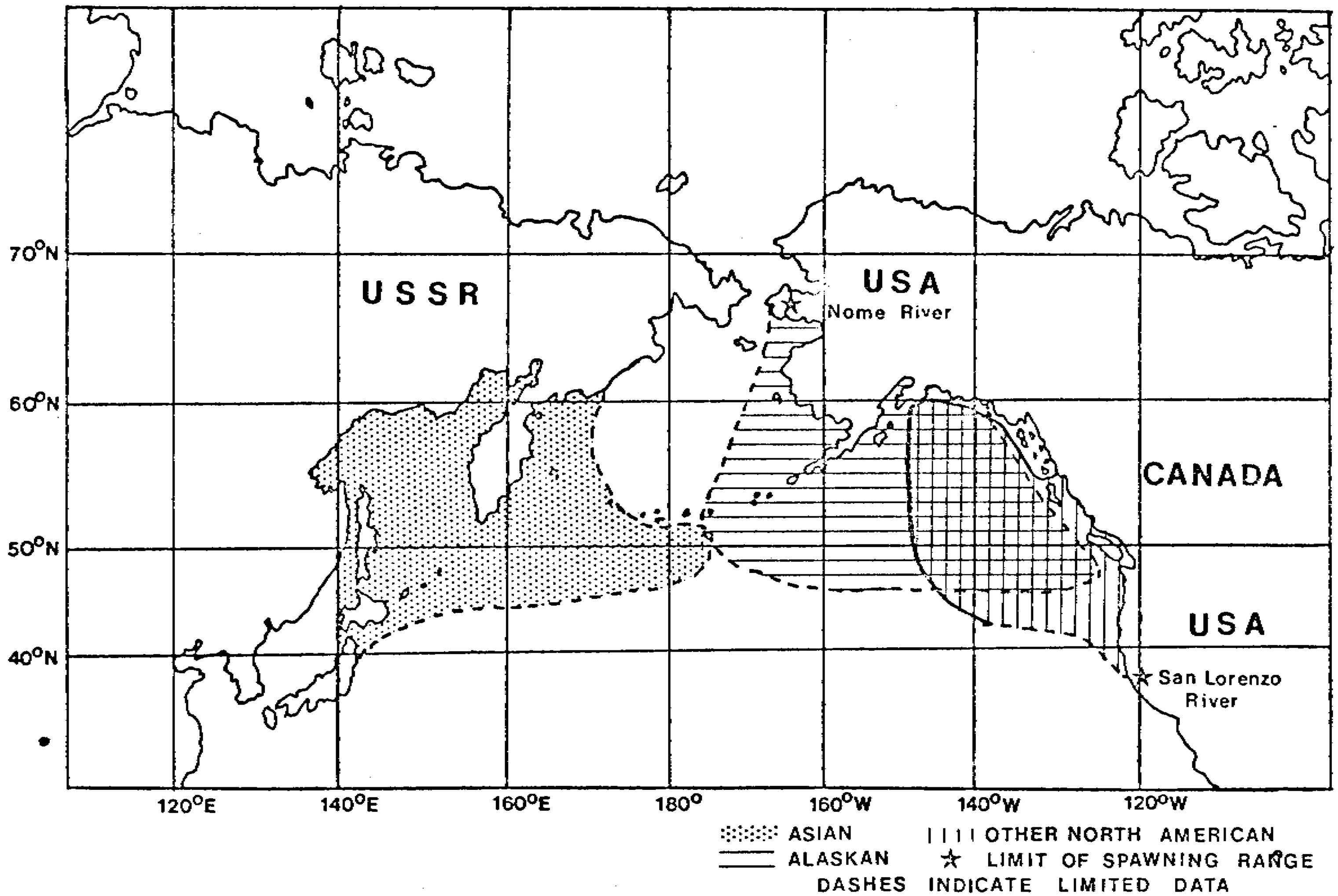


Fig. 5. The range of spawning stocks and offshore distribution of coho salmon. (From Hart 1973, and French et al. 1975.)

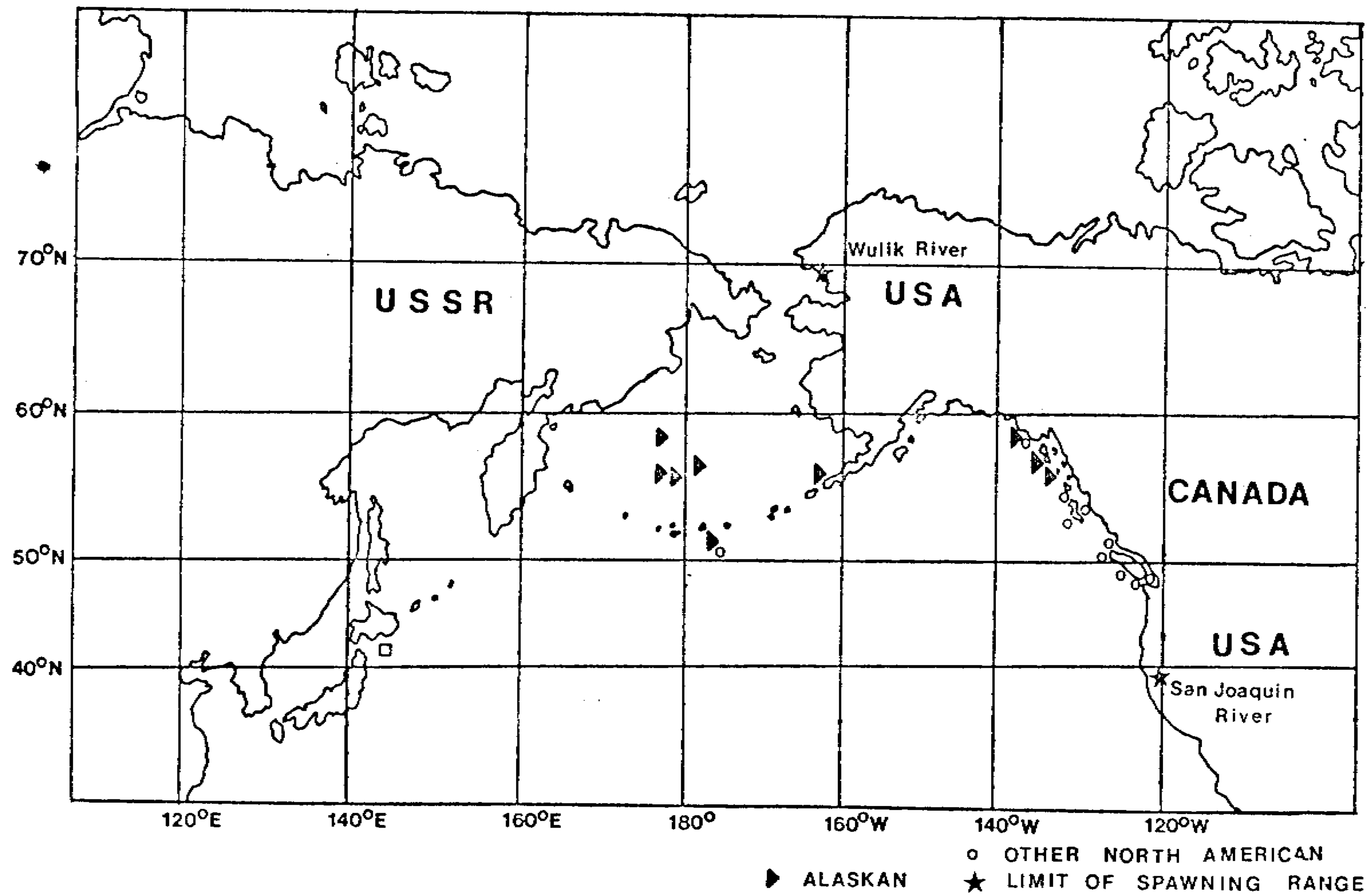
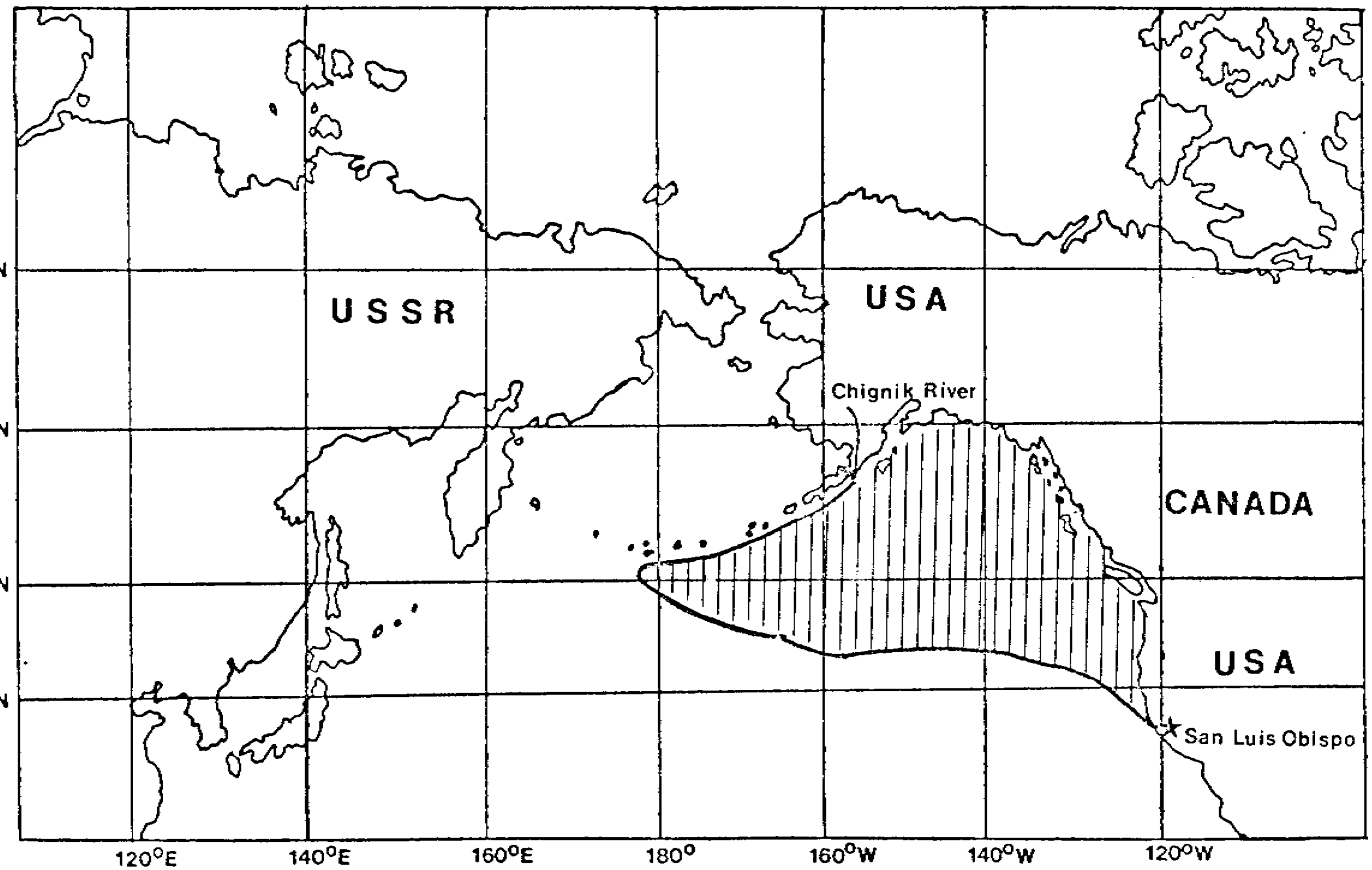


Fig. 6. The range of North American spawning stocks and offshore distribution of chinook salmon. (From Major et al., in press.)



|||| OTHER NORTH AMERICAN ★ LIMIT OF SPAWNING RANGE
STEELHEAD ARE NOT KNOWN TO BE DISTRIBUTED IN ASIAN STREAMS
NO RECOVERIES OF STEELHEAD HAVE BEEN MADE IN ALASKA

Fig. 7. The range of North American spawning stocks and offshore distribution of steelhead trout. (From Hart 1973.)

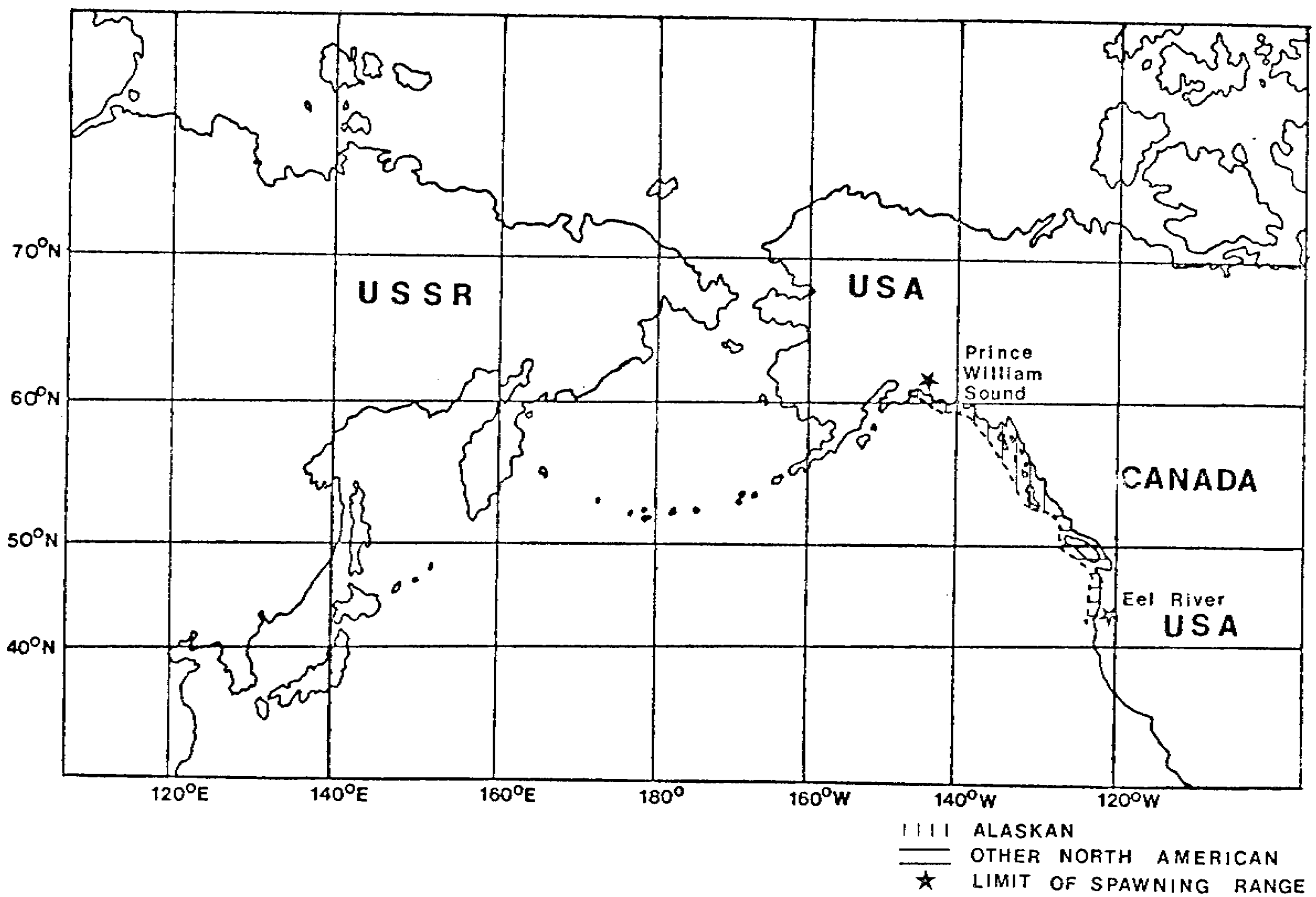


Fig. 8. The range of North American spawning stocks and offshore distribution of sea-run cutthroat trout. (From Hart 1973.)

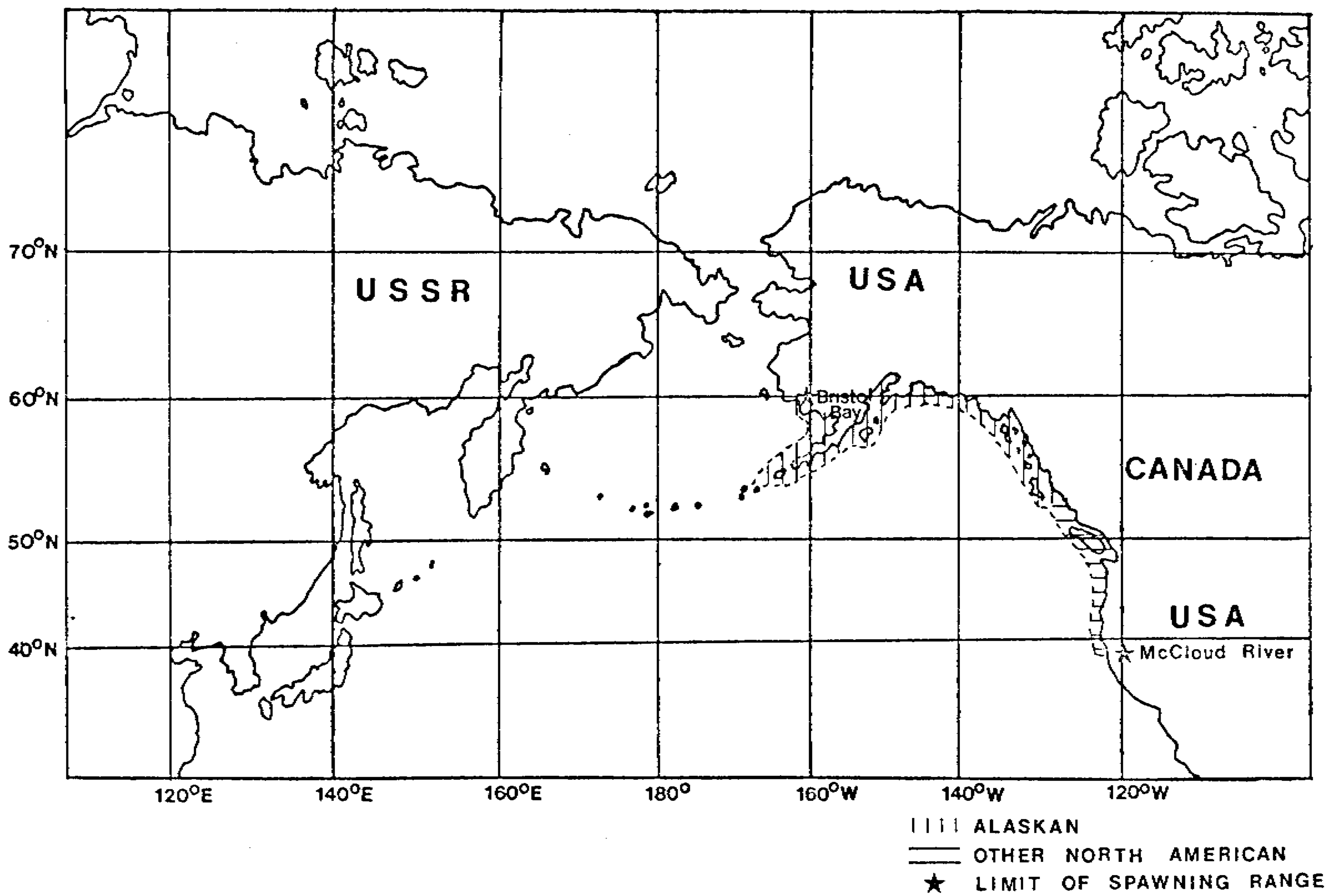


Fig. 9. The range of North American spawning stocks and offshore distribution of Pacific char. (From Hart 1973.)

Fig. 10. Statistical districts of the Alaskan commercial salmon fishery.

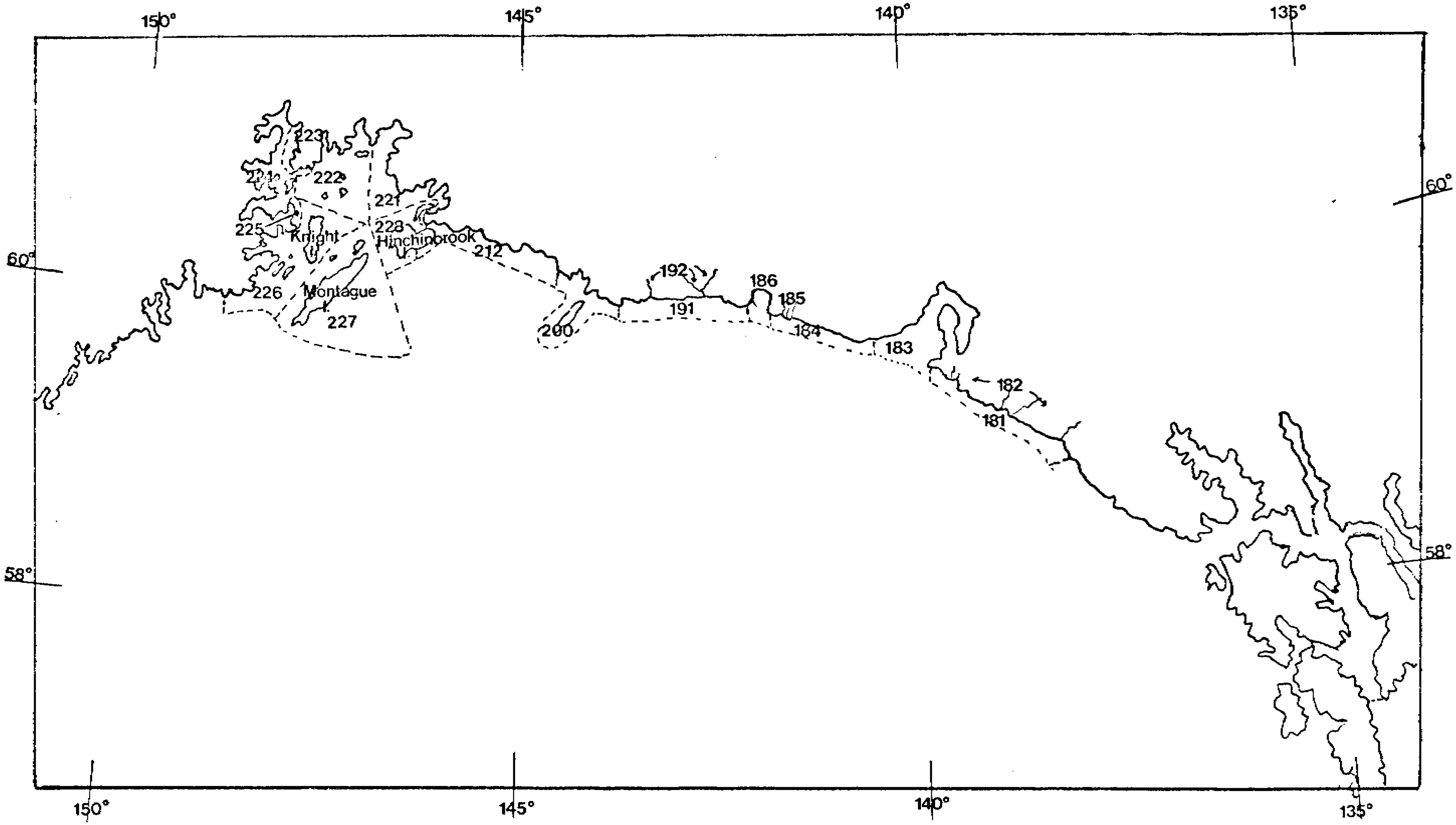


Fig. 11. Alaska Department of Fish and Game statistical areas covered by the third report.

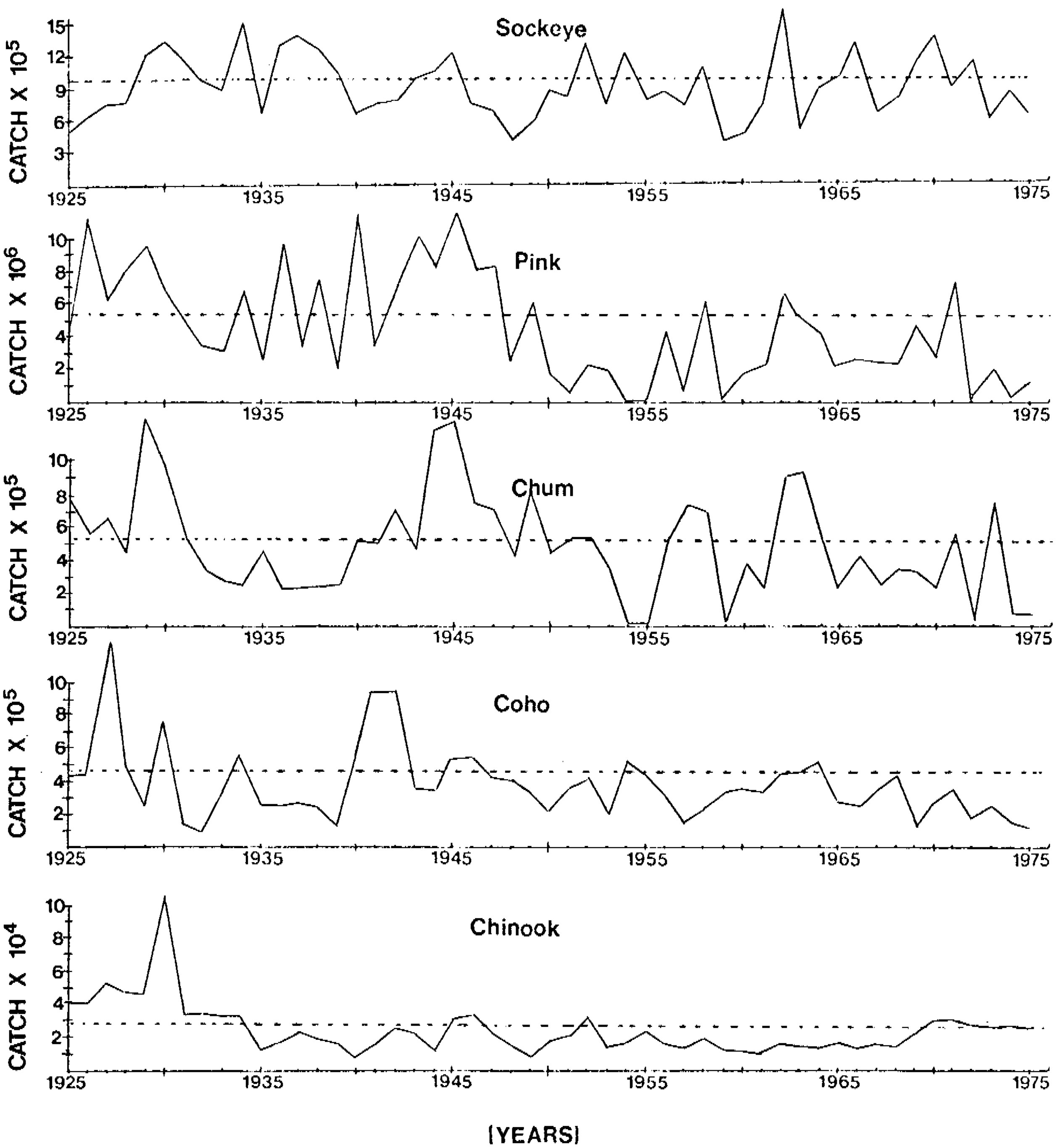


Fig. 12. Commercial catches of salmon[1] by species and year (1925-75) in numbers of fish for the Prince William Sound, Copper River, Bering River, and Yakutat districts. The dotted lines show the 51-year average (1925-75).

[1]Source: INPFC. MS 1974. Historical catch statistics for salmon of the North Pacific Ocean. Manuscript version of compilation proposed for publication in INPFC bulletin series. INPFC Statistical Yearbooks (1972-74), Alaska Department Fish Game Preliminary Data (1975).

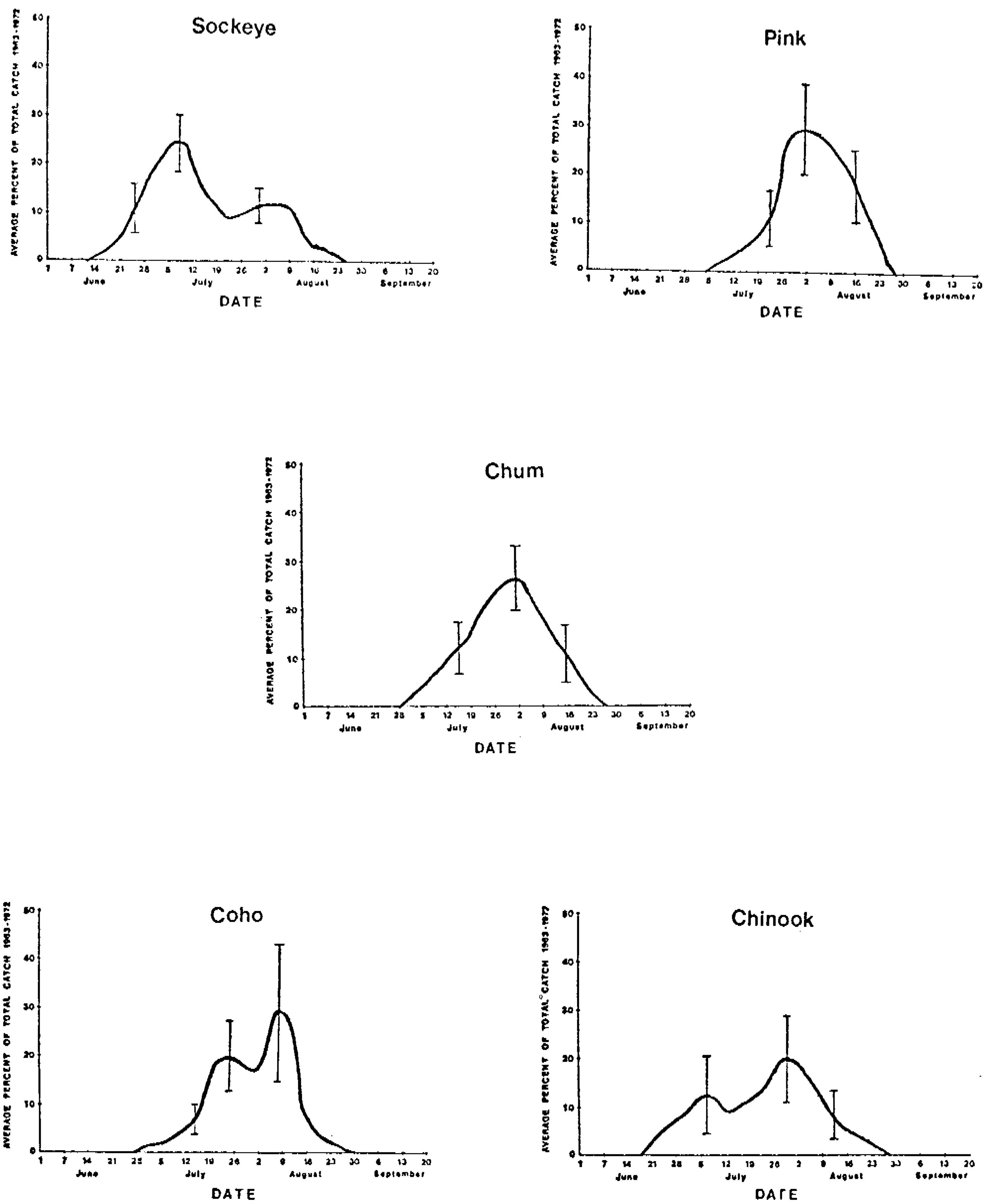


Fig. 13. The average timing of salmon runs to the Prince William Sound district as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence intervals for the percent catch on selected dates.

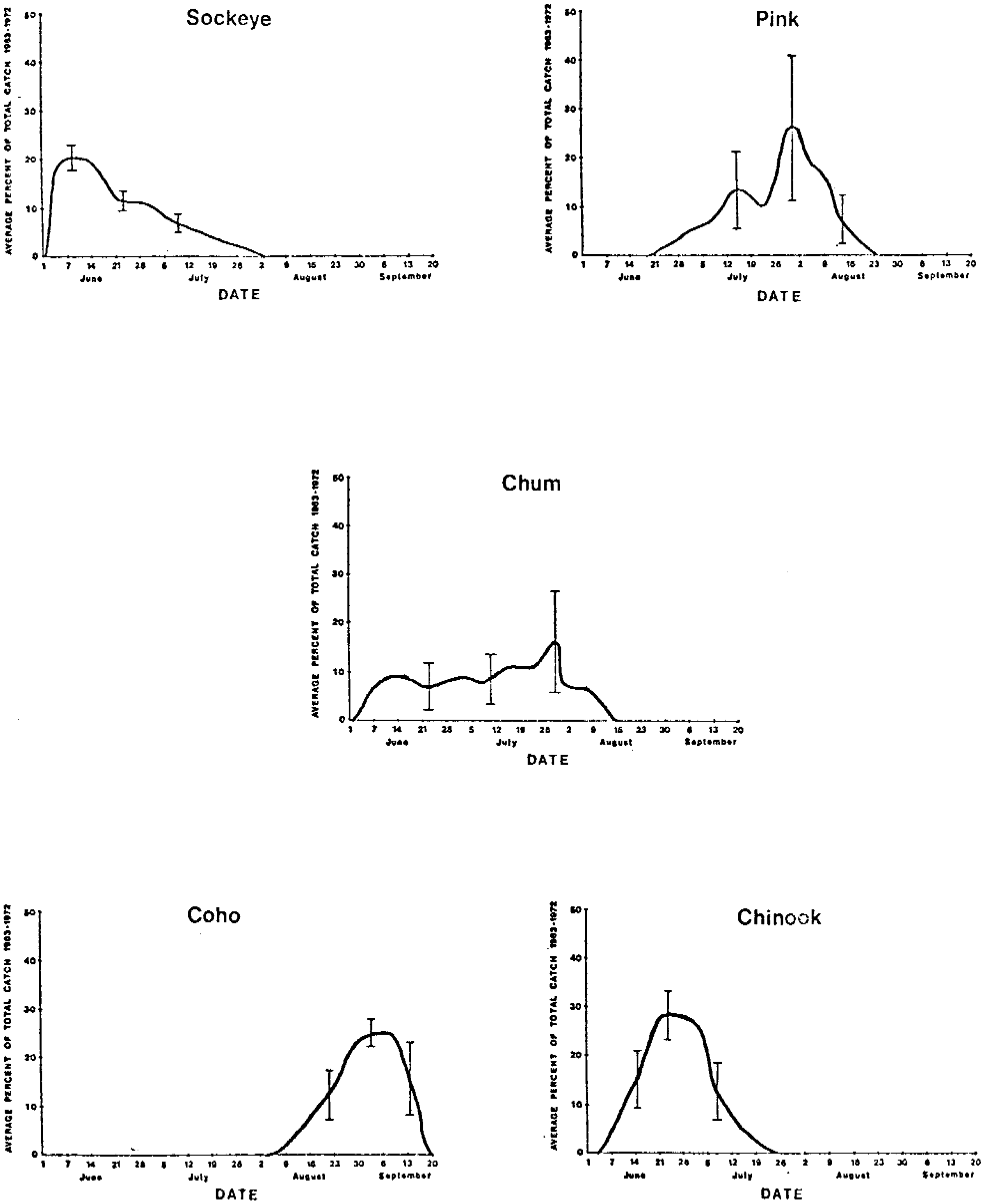


Fig. 14. The average timing of salmon runs to the Copper River district as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence intervals for the percent catch on selected dates.

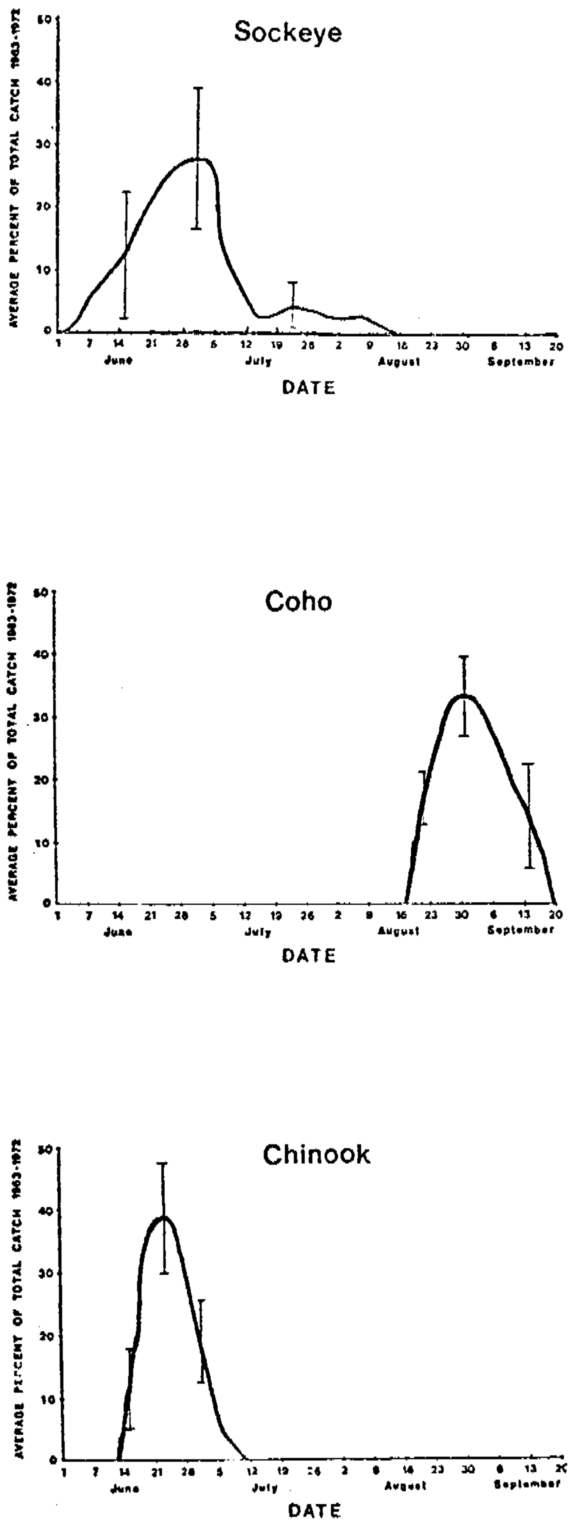


Fig. 15. The average timing of salmon runs to the Bering River district as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence intervals for the percent catch on selected dates.

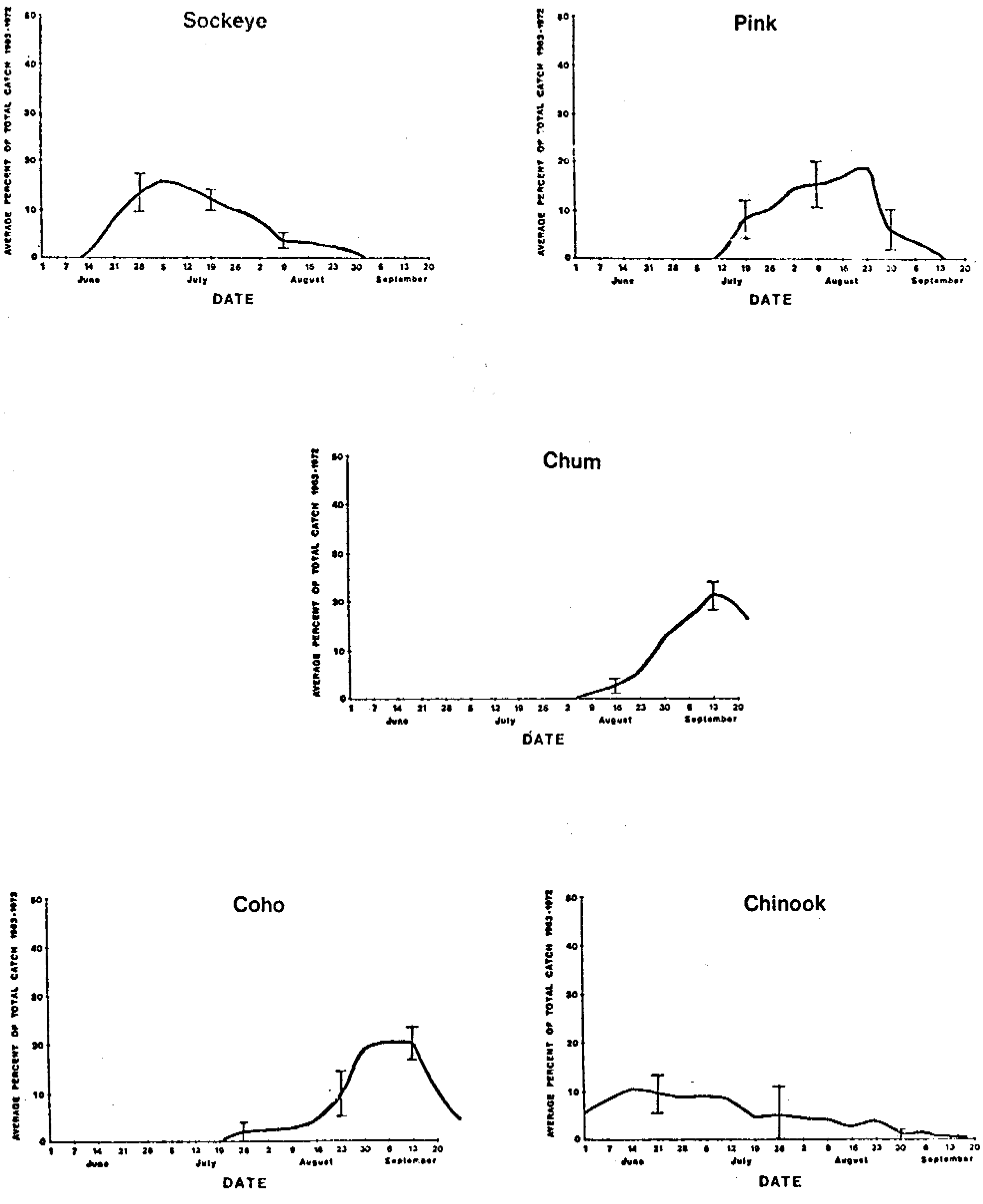


Fig. 16. The average timing of salmon runs to the Yakutat district as derived from weekly catch statistics (1963-72). The symbols along the curve indicate 95% confidence intervals for the percent catch on selected dates.

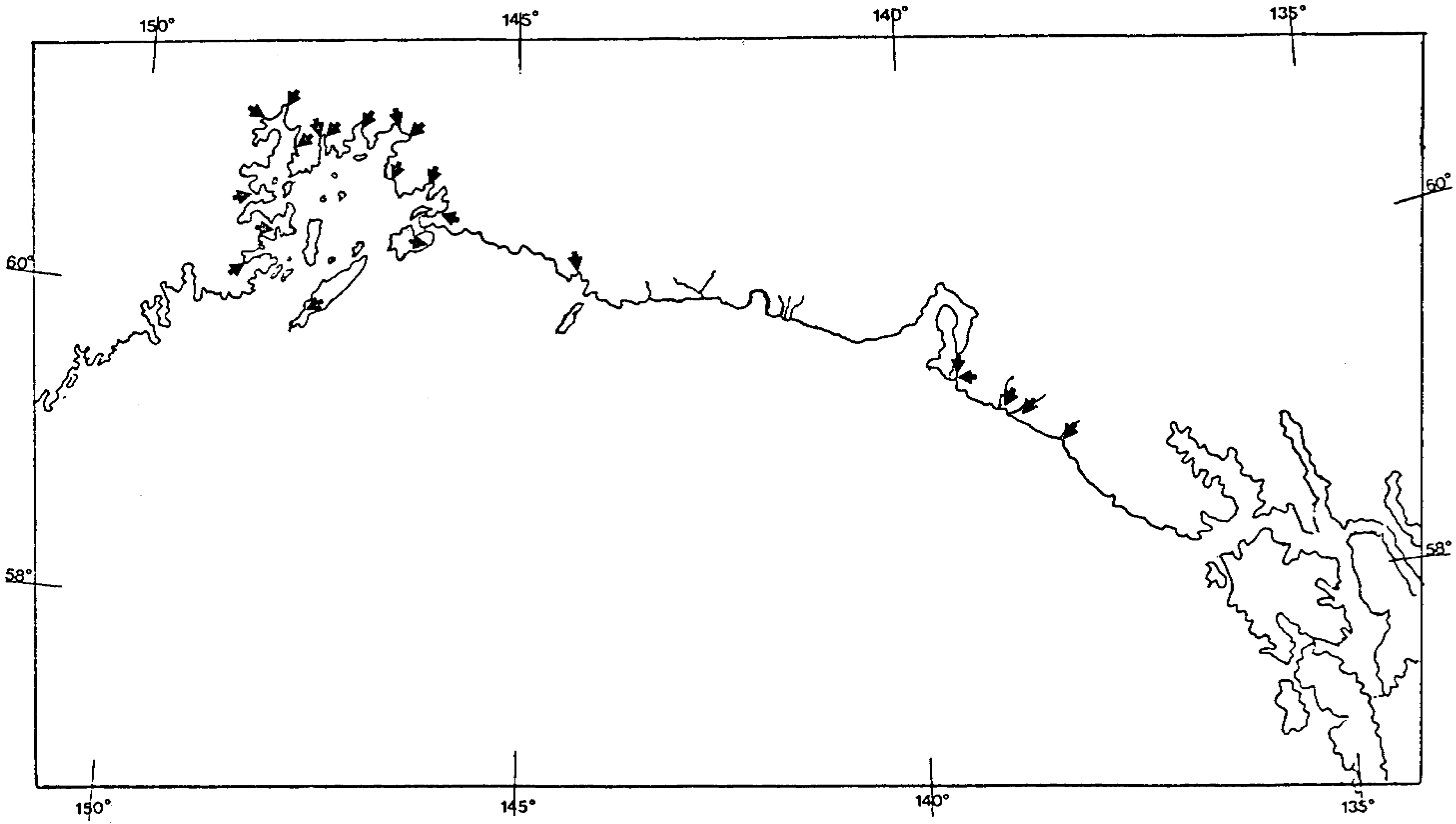


Fig. 17. Locations[1] of juvenile sockeye salmon entry into nearshore waters.
[1]Source: Figs. 53, 55, 59, Atkinson et al. 1967.

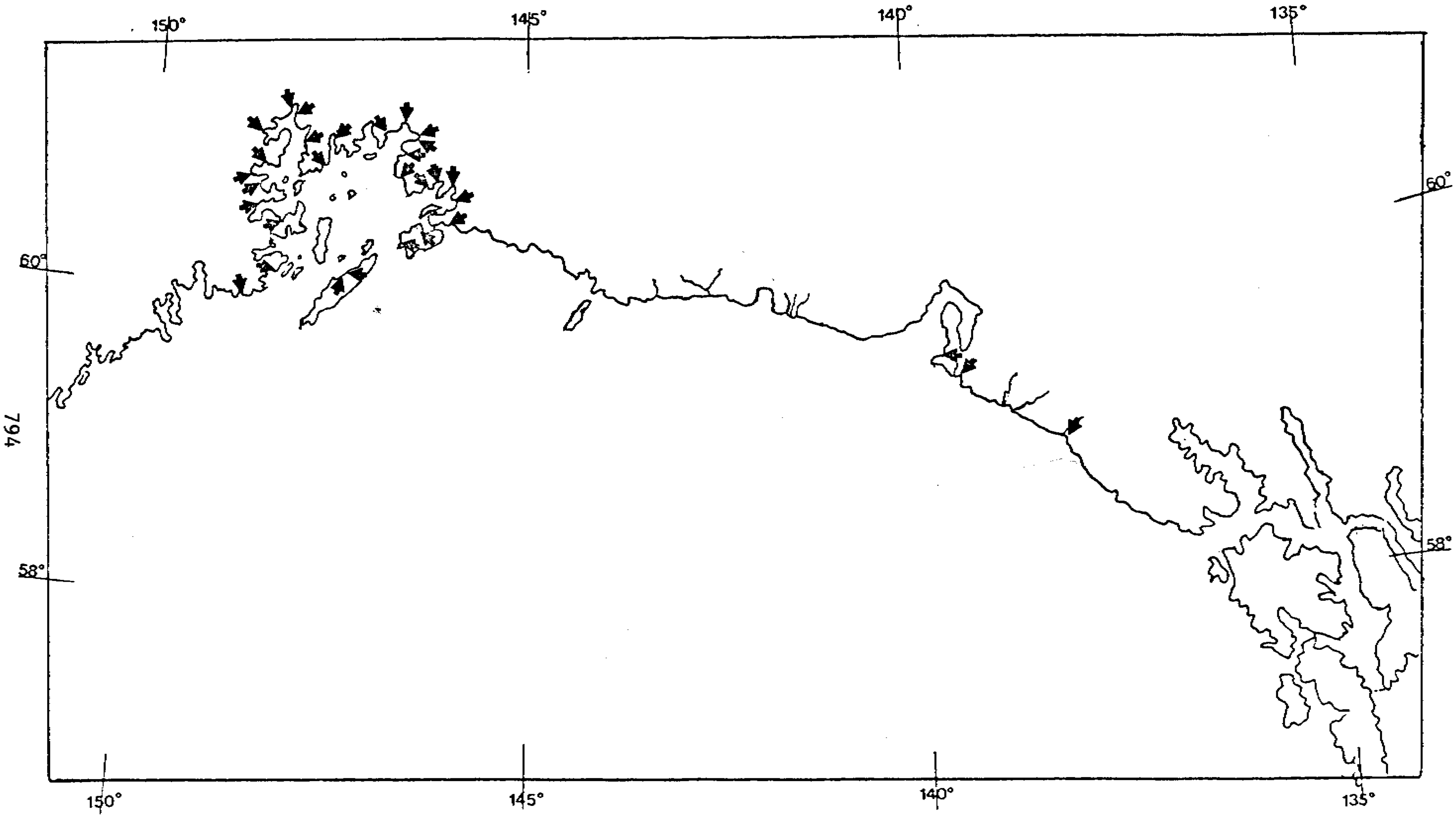


Fig. 18. Locations[1] of juvenile pink salmon entry into nearshore waters.

[1]Source: Figs. 52, 58, Atkinson et al. 1967.

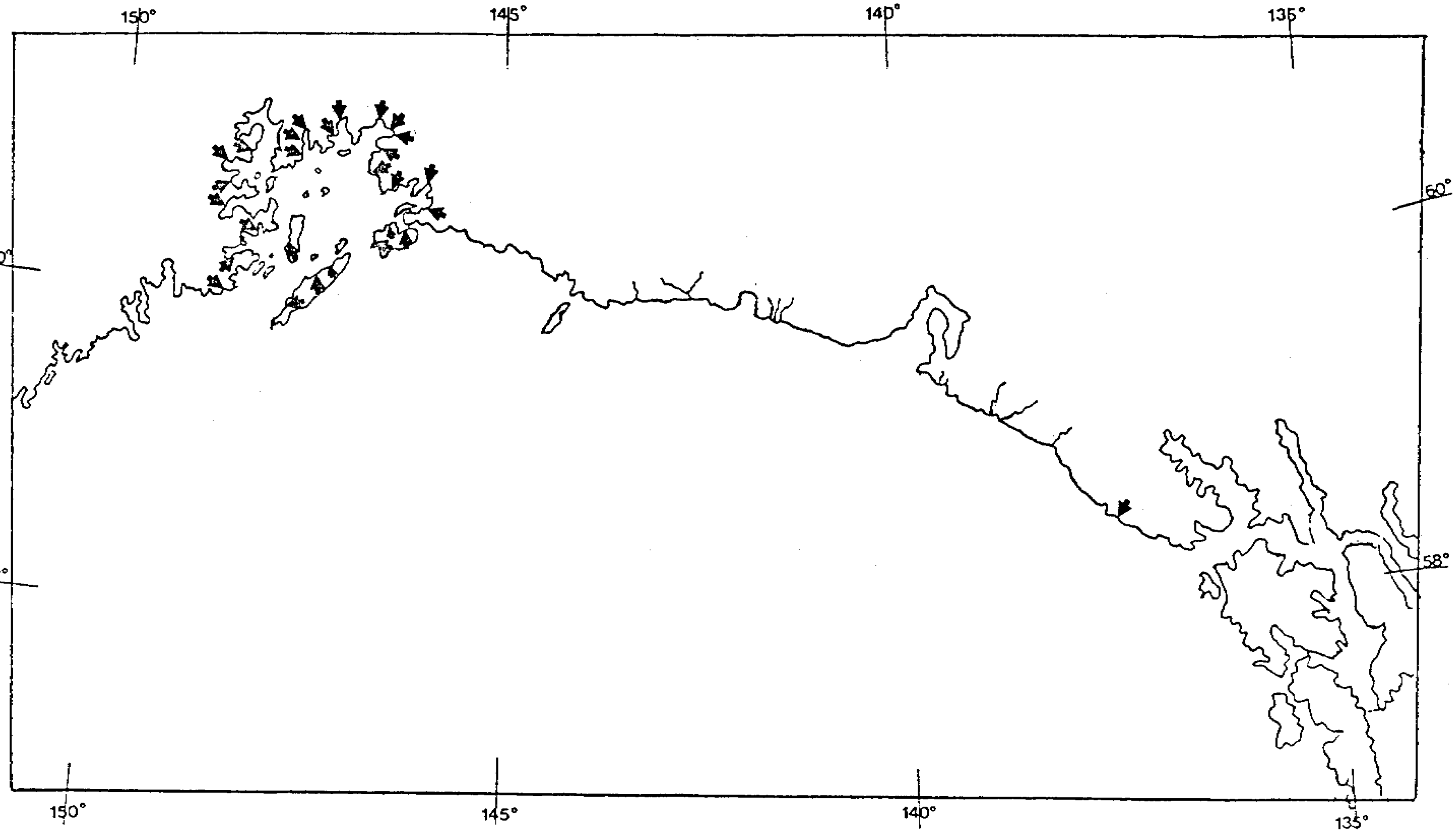


Fig. 19. Locations[1] of juvenile chum salmon entry into nearshore waters.
[1]Source: Figs. 50, 56, Atkinson et al. 1967.

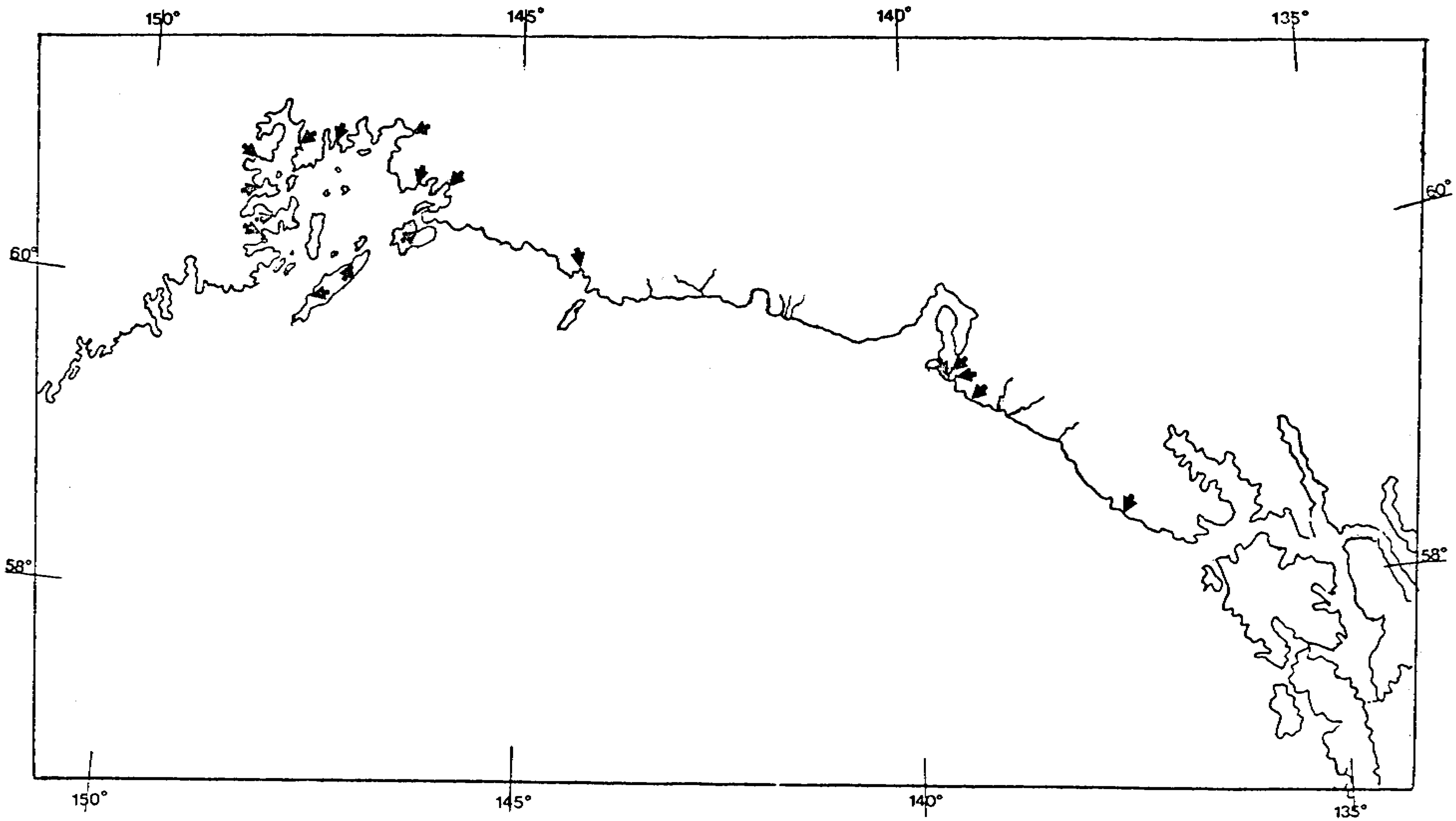


Fig. 20. Locations[1] of juvenile coho salmon entry into nearshore waters.

[1]Source: Figs. 51, 54, 57, Atkinson et al. 1967.

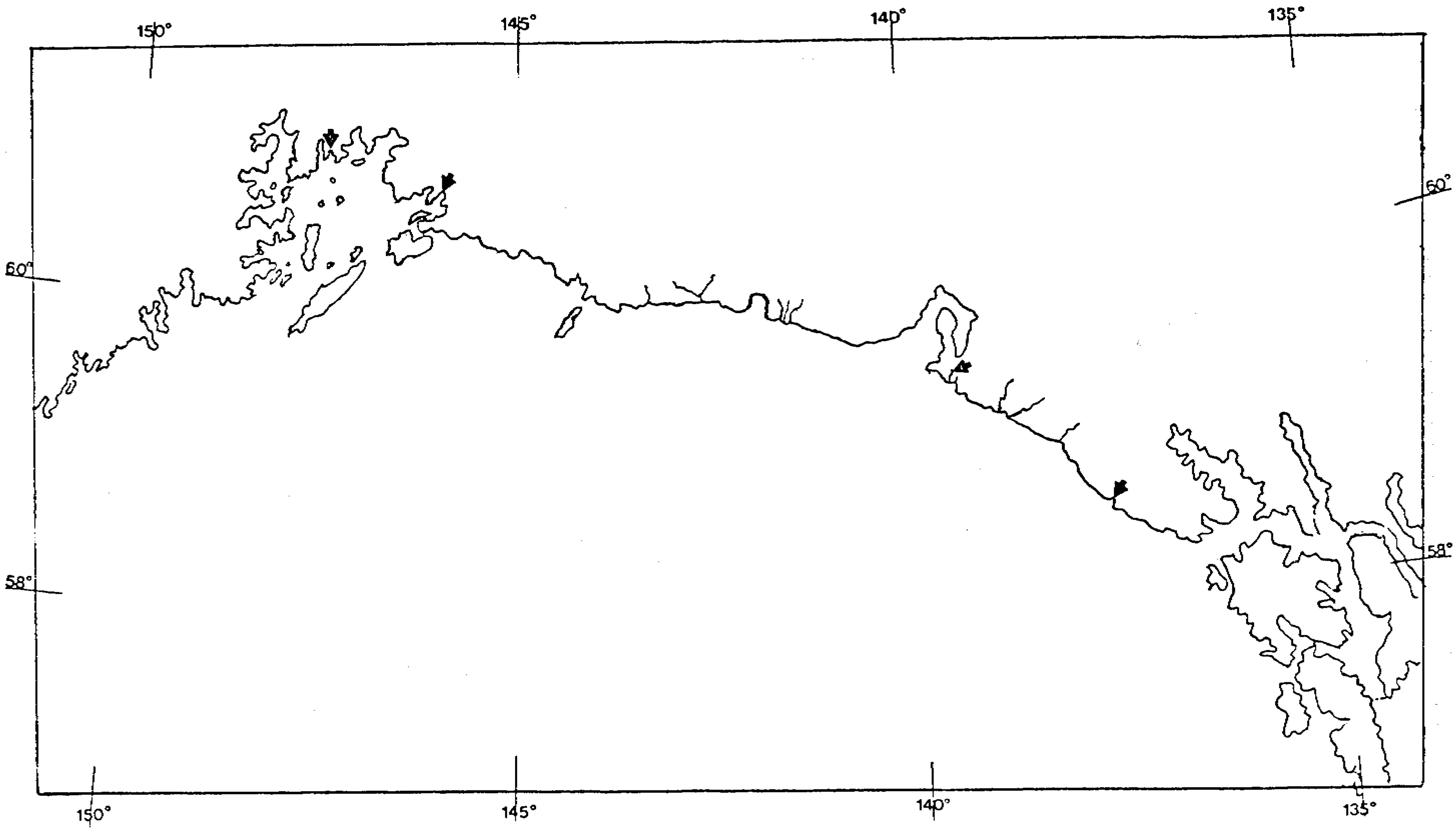


Fig. 21. Locations[1] of juvenile chinook salmon entry into nearshore waters.

[1]Source: Fig. 49, Atkinson et al. 1967.

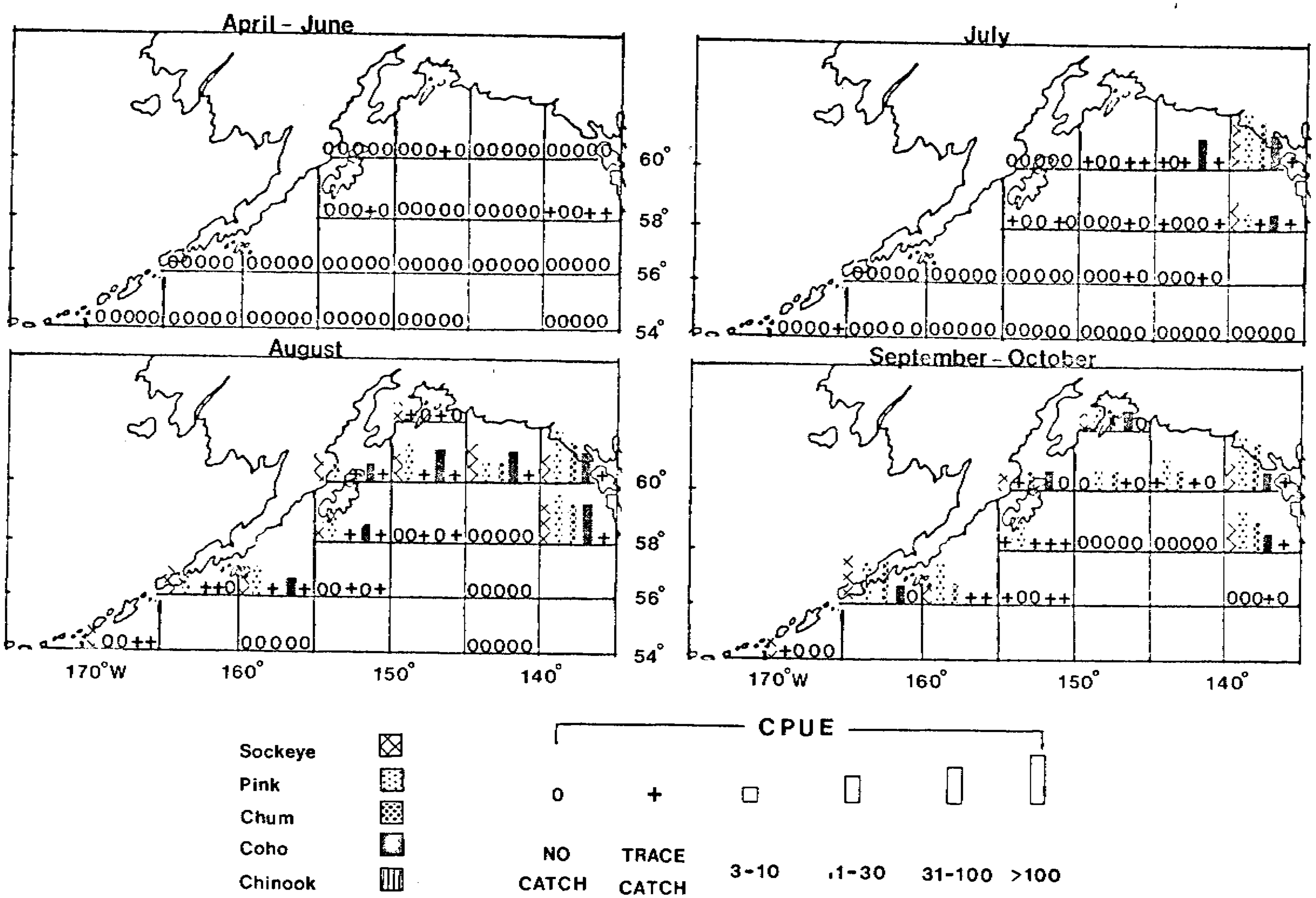


Fig. 22. The distribution and abundance of juvenile salmon in offshore waters as indicated by purse seine data[1] (1956-70). Units of catch are catch per set.

[1]Source: Hartt, Allan C., and Michael B. Dell. MS 1976. Life history of Pacific salmon and steelhead trout during their first summer in the open sea. Fish. Res. Inst., Univ. Washington, Seattle, Washington.

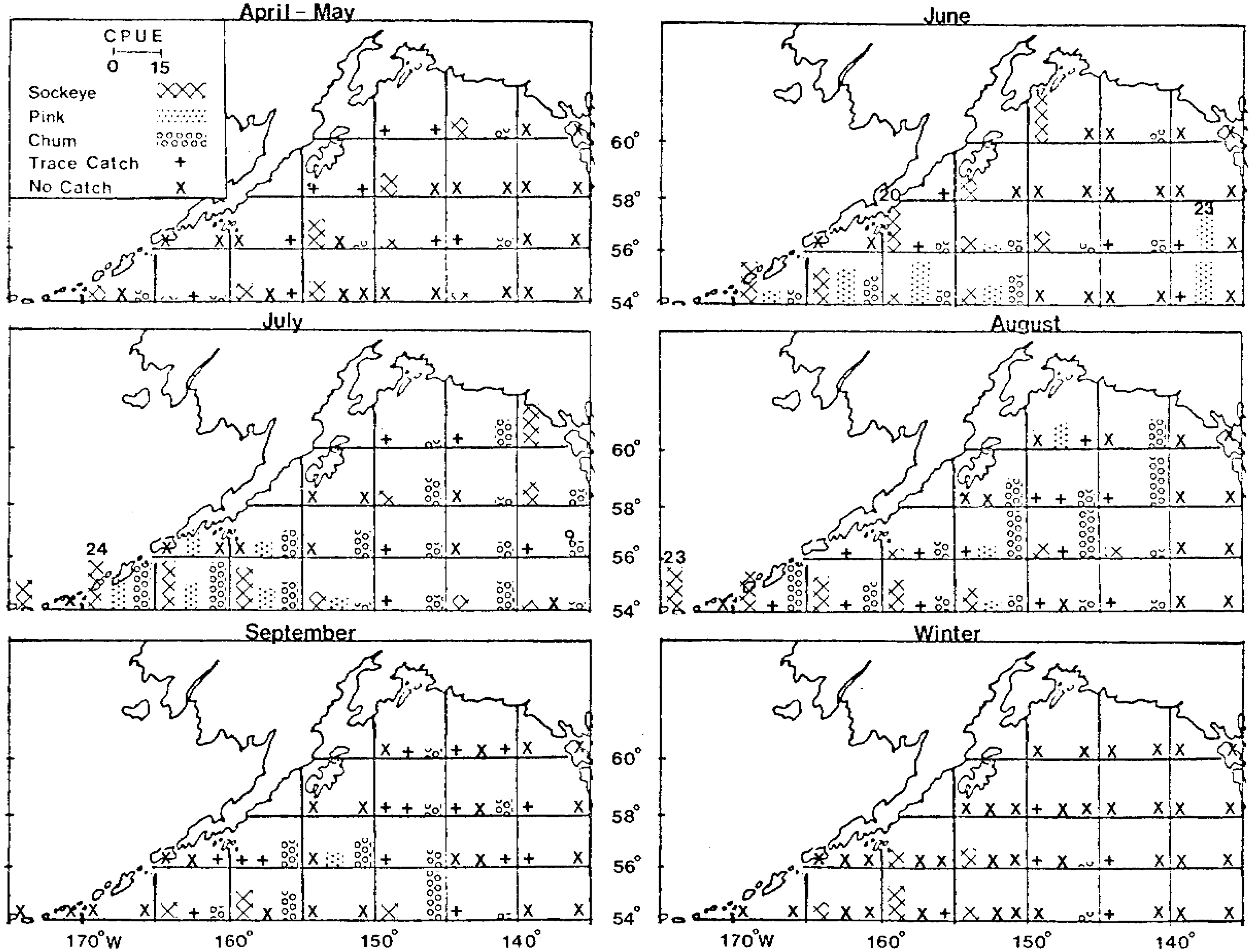


Fig. 23. The distribution and abundance of adult sockeye, pink, and chum salmon in offshore waters as indicated by gillnet catches.[1] Sockeye data: Canada 1956-60 and 1967, Japan 1960-71, U.S. 1956-71. Winter sockeye data: Canada 1963, U.S. 1962-65, 1967, 1969-71. Pink data: Canada, Japan, and U.S. 1961-71. Chum data: Canada, Japan, and U.S. 1956-71. Winter chum data: Canada, Japan, and U.S. 1962-71.

[1] Source: French et al. (in press), Neave et al. (in press), Takagi et al. (in press).

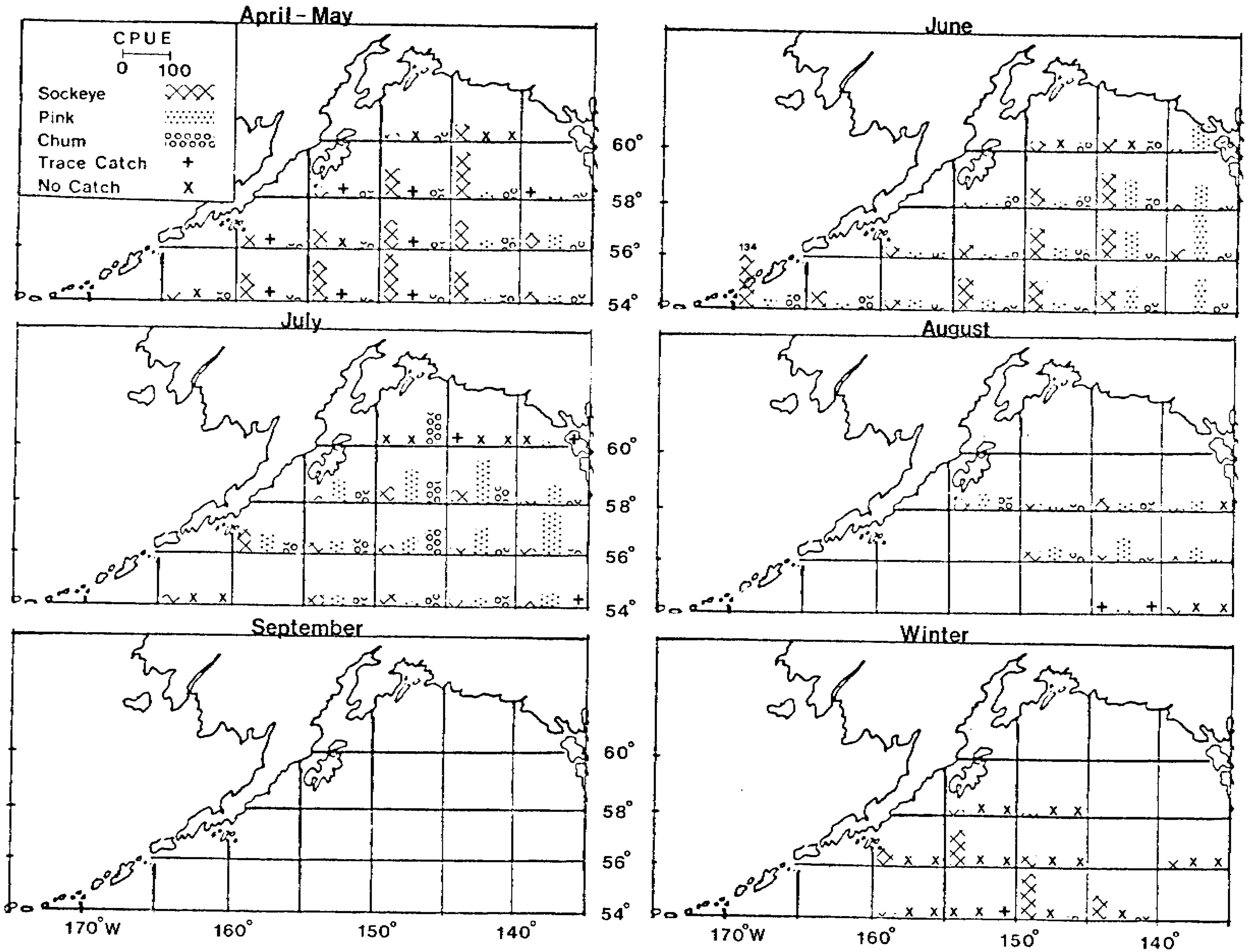


Fig. 24. The distribution and abundance of adult sockeye, chum, and pink salmon in offshore waters as indicated by longline catches[1] (1961-67). A unit of effort equals catch per thousand hooks.

[1]Source: Turner and Aro (1968).

Pink Salmon

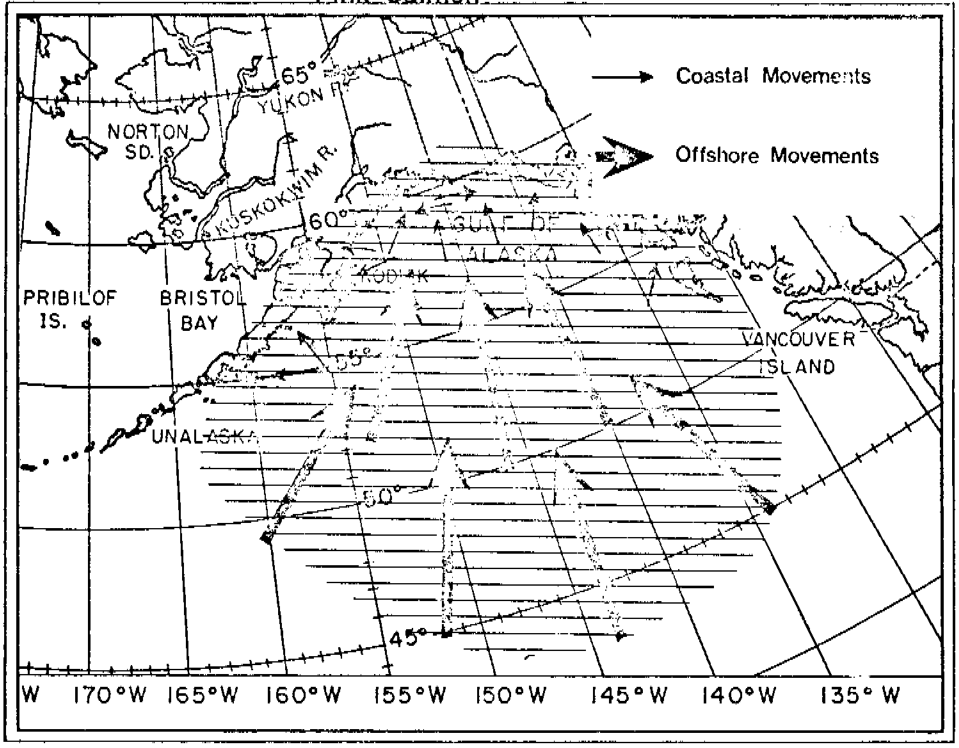


Fig. 25. Spring and summer migrations of northeastern Pacific stocks of pink salmon enroute to spawning grounds. (Adapted from Fig. 91, Takagi et al., in press.)

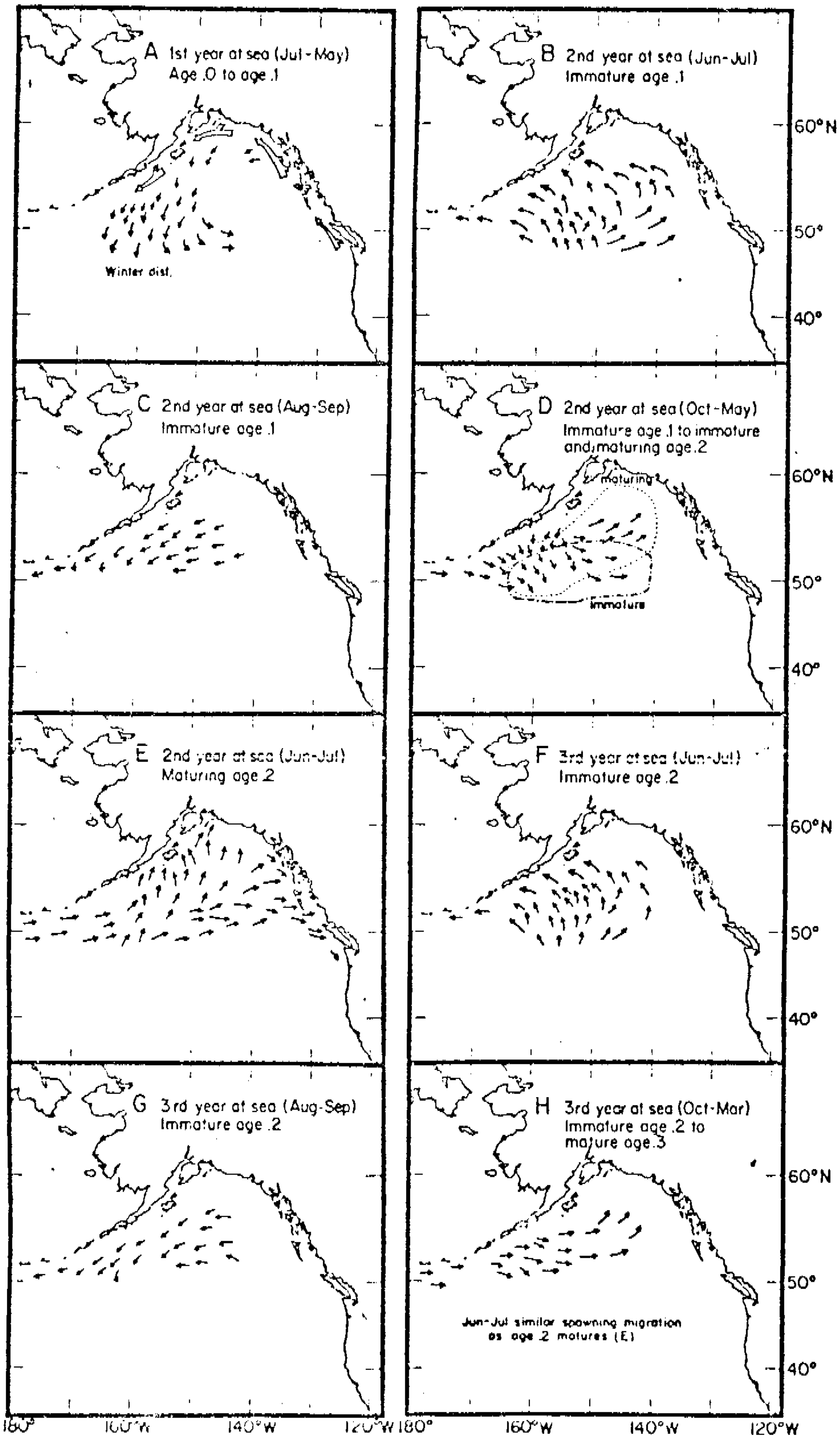


Fig. 26. The migratory routes of northeastern Pacific stocks of sockeye salmon. (From Fig. 94, French et al., in press.)

Contract 03-5-022-81

Research Unit 356

October 1 to December 31, 1976

5 Pages

QUARTERLY REPORT

Reconnaissance Characterization of Littoral Biota,

Beaufort and Chukchi Seas

and

Environmental Assessment of Selected Habitats in the

Beaufort and Chukchi Sea Littoral System

December 30, 1976

INTRODUCTION

The title of this contract was changed at the start of fiscal 1977 to reflect the changing emphasis of the contract. On September 30, 1976, this contract was extended through September 30, 1977 with additional cost reimbursement authorization of $164,000 by modification number 6. This modification was accepted by Western Washington State College on October 4, 1976.

I. Task Objectives

The work during this quarter was on our task 5 (analysis of samples and data processing) of our Reconnaissance Characterization of Littoral Biota, Beaufort and Chukchi Seas (also incorporated in Environmental Assessment of Selected Habitats on the Beaufort and Chukchi Sea Littoral System, task statement 1) and task statements 2 and 3 (selection of representative sites for intensive study and design of studies to be carried out in 1977) of the Environmental Assessment technical proposal.

Laboratory analysis of Beaufort and Chukchi littoral samples collected in 1976 continues and is now more than 1/3 completed. The 1975 data are ready for reporting in the common format that we, R.U. 79, and others have agreed to use, but we still lack some codes for plant species that are necessary before the final tapes can be prepared.

Our currently-favored sites for intensive study are:

1. Wales: one rocky, sea beach; one sandy, sea beach; one lagoon beach.
2. Baldwin Peninsula: one beach on Kotzebue Sound; one beach on Hotham Inlet.

3. Cape Krusenstern: sandy, sea beach

4. Cape Lisburne: rocky, sea beach

5. Wainwright: sandy, sea beach; lagoon beach

6. Barrow: gravel sea beach; experimental work in laboratories at NARL.

7. Colville River Delta (Helmerick's camp): sand-mud beach in river delta

8. Between Points Storkersen and McIntyre (abandoned DEW Line site): marsh

9. Barter Island: marsh

10. Nuvagapak Point: barrier beach; lagoon beach

Among these sites there are more sampling stations than originally planned. Selection was based on a combination of geography, biota and logistics.

II. Field or Laboratory Activities

A. Ship and field trip schedule: none

B. Scientific Party (all with Western Washington State College)

1. Principal Investigator

A. C. Broad, on salary December 15-31.

2. Laboratory Supervisor

Helmut Koch, October 1 - December 31.

3. Computer Programmer

Gregg Petrie, hourly wages

4. Laboratory Assistants (all on hourly wages)

Susan Broad

Mark Childers

David Cormany

Crystal Driver

Patricia Jackson

Wendy Pounds

C. Methods: See item 4 on page 6 of September 30, 1976, quarterly report.

D. Sample localities: none

E. Data collected or analyzed

1. no data collected
2. 422 biological samples analyzed
3. no miles of trackline

F. Milestone Chart and Data Submission Schedules

1. Update of Schedules

a. The schedule for laboratory analysis of samples collected in 1976 originally submitted on January 15, 1976 (Revised Work Statement) called for samples to be analyzed by September 15, 1976. We now plan to have completed the laboratory analysis of 1976 data by June 15, 1977.

b. The January 15, 1976, Revised Work Statement called for a final report on Reconnaissance Characterization of Littoral Biota, Beaufort and Chukchi Seas, at the end of September, 1976. We will submit an annual report on April 1, 1977, which will be based on all the 1975 and most of the 1976 data. The 1976 data will be submitted in processed form by September 30, 1977.

c. Otherwise, we are on schedule.

2. Justification of slides in schedule

a. My original estimate of sample analysis and report completion in September, 1976, was hopeful rather than realistic, and was based on an interpretation of deadlines later revised. The completion dates proposed herein are realistic and are in accordance with present reporting practices.

III. Results

Results of this quarter's work are summarized above (item II D 2) but, in themselves do not constitute a reportable whole.

IV. Preliminary interpretation of results

The fauna of the Chukchi Sea littoral zone north of Point Hope is similar to that of the Beaufort Sea in species diversity and numbers of individuals encountered. South of Point Hope, species not characteristic of the Arctic (many of which have Pacific Northwest affinities) have been encountered and there is a corresponding increase in species diversity. We have found 9 additional mysiid species, 7 bivalves, 7 polychaetes, 4 amphipods, 4 gastropods, and 8 others but this listing is still very incomplete (about 2/3 of the 1976 samples remain unsorted and unidentified).

V. Problems encountered/recommended changes.

Our principal problems during the quarter have been those that have concerned us in the past: the data management program is needlessly cumbersome for our data and, while having the advantage to the Project Data Manager's office of a common format used by several units, has required extra effort on our part. There is a long turn-around time between submitting species names and receiving code designators for them. Finally, the problem of laboratory analysis of samples is always more time-consuming and more costly than it was estimated to be. The first of these two problems certainly should take care of themselves as the work progresses. The third must be dealt with in our own laboratory.

VI. Estimate of funds expended.

	Amount Budgeted	Amount Spent	Amount Remaining
Salary, P. I.	25,000	12,834	12,166
Salaries, Associates	56,000	32,226	23,774
Salaries, Other	90,000	50,050	39,950
Fringe	18,000	9,745	8,255
Travel & Freight	30,500	15,857	14,643
Chukchi logistics	28,000	20,940	7,060
Supplies	6,000	3,990	2,010
Equipment	15,765	1,284	14,481
Computer Costs	5,800	49	5,751
Overhead	68,000	14,597	53,403
	$343,065	$161,572	$181,493

QUARTERLY REPORT

Contract #: 03-5-022-67-TA2 #4
Research Unit #: 359
Report Period: 1 Oct - 31 Dec 1976
Number of Pages: 13

BEAUFORT SEA PLANKTON STUDIES

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Seattle, Washington 98195

1 January 1977

Departmental Concurrence: [signature]
Francis A. Richards
Associate Chairman for Research

REF: A76-67

I. Task Objectives

The primary objectives of this project are to determine the seasonal density distribution and environmental requirements of principal species of phytoplankton, zooplankton, and ichthyoplankton, and to determine seasonal indices of phytoplankton production. The secondary objective is to summarize existing literature, unpublished data, and archived samples.

II. Field and Laboratory Activities

A. There has been no field work this quarter.

B. Laboratory activities

Samples collected during the August-September cruise of the USCGC *Glacier* are being analyzed.

C. Methods

Temperatures, obtained using reversing thermometers, are being corrected using the calibration factors provided by the Coast Guard and following the procedure outlined in U.S. Naval Oceanographic Office Publ 607 (1968).

Carbon-14 uptake was determined using a Packard Tri-Carb Liquid Scintillation Spectrometer with Aquasol (New England Nuclear) as the scintillation cocktail. Primary productivity was calculated using the equation

$$Ps(\text{mg C m}^3 \cdot \text{hr}^{-1}) = \frac{(L-D) \times w \times 1.05}{R \times T}$$

where (L-D) = light-dark bottle disintegrations per min
w = carbonate carbon
1.05 = ^{14}C isotope factor
R = activity of the ^{14}C used
T = incubation time

Chlorophyll and phaeopigments were determined using the fluorometric technique (Strickland and Parsons 1968). Calculations were done using the equations

$$\text{Chl } a = \frac{\frac{F_o/F_{a_{max}}}{F_o/F_{a_{max}-1}} (K_x)(F_o - F_a)}{\text{vol. filtered}}$$

$$\text{Phaeo} = \frac{\left[\frac{F_o/F_{a_{max}}}{F_o/F_{a_{max}}-1}\right](K_x)\left[F_o(F_a/F_{o_{max}}) - F_a\right]}{\text{vol. filtered}}$$

where F_o = fluorometer reading before acidification

F_a = fluorometer reading after acidification

K = fluorometer door calibration factor

vol. filtered = volume of water filtered

Salinity determinations were done on board *Glacier* using a Bissit Berman Hytech salinometer Model 6220.

Zooplankton samples are being split in a Folsom plankton splitter, sorted by broad taxonomic group, and identified to species where possible or to the lowest possible taxonomic category.

Phytoplankton standing stock samples are being analyzed using the Utermöhl (1931) inverted microscope technique and Zeiss counting chambers. Five and 50-ml settling chambers are set up for each sample. Rare organisms and cells larger than 50 μm are counted at 10x in the 50-ml chambers and small, abundant organisms are counted at 25x in the 5-ml chambers. Each chamber is scanned quickly to estimate the abundance of cells present. From this estimate, the portion of the chamber to be counted is determined. Usually 1/5 of the chamber is counted.

D. The cruise track and station locations are given in Fig. 1 and Table 1. Chart depths for stations 13, 23, 25, and 26 have been corrected from Table 4 in the 1 Oct 1976 Quarterly report.

E. Data collected and analyzed

	Number Collected	Number Analyzed
Phytoplankton standing stock	172	15
Chlorophyll *a*	165	165
Primary productivity	158	158
Temperature	87	87
Salinity	172	172
Zooplankton net tows		
Bongo net	10	0
Ring net	51	10
Echosounder records	10	0

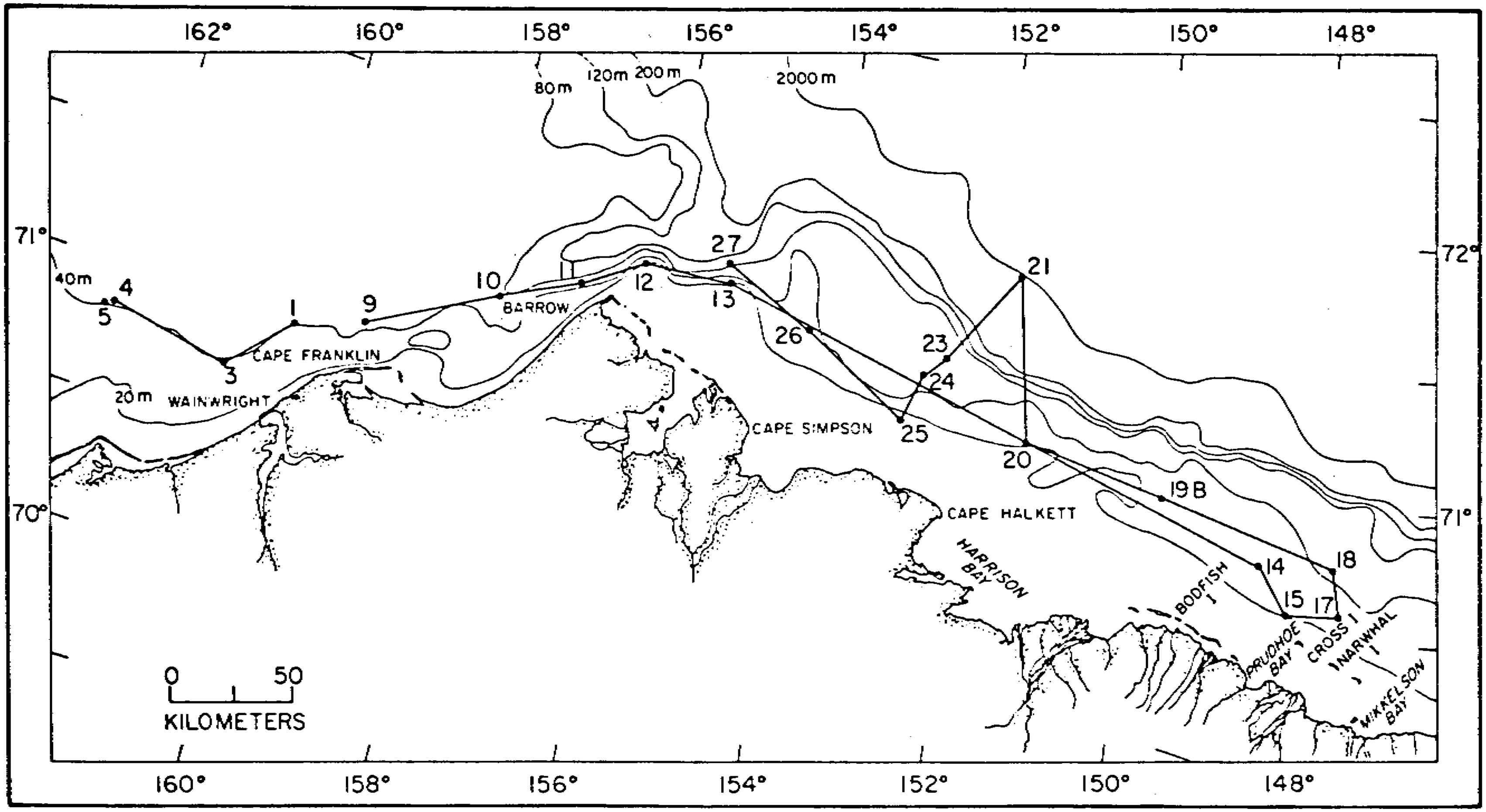


Fig. 1. Cruise track and station locations, USCGC *Glacier*, 7 Aug - 4 Sep 1976. Stations 6, 7, and 8 are off the chart to the west and are not given. Stations 2, 16, and 22 were not taken by us.

Table 1. Station locations, USCGC *Glacier*, 7 Aug - 4 Sep 1976

Station	Latitude (N)	Longitude (W)	Chart Depth (m)	Location
1	70° 54'	160° 04'	54	Chukchi Sea
3	70° 43'	160° 40'	20	Chukchi Sea
4	70° 50'	162° 09'	40	Chukchi Sea
5	70° 47'	162° 14'	36	Chukchi Sea
6	70° 39'	162° 16'	36	Chukchi Sea
7	70° 28'	163° 26'	40	Chukchi Sea
8	70° 34'	162° 50'	27	Chukchi Sea
9	71° 03'	159° 17'	61	Chukchi Sea
10	71° 16'	157° 43'	70	Chukchi Sea
11	71° 25.5'	156° 54.8'	106	Chukchi Sea
12	71° 31.5'	156° 09'	139	Chukchi Sea
13	71° 31'	155° 05'	31	Beaufort Sea
14	71° 11'	153° 09'	25	Beaufort Sea
15	70° 36'	148° 12'	16	Beaufort Sea
17	70° 32'	147° 33'	25	Beaufort Sea
18	70° 39'	147° 37'	25	Beaufort Sea
19B	70° 57'	149° 33'	30	Beaufort Sea
20	71° 08'	151° 19'	34	Beaufort Sea
21	71° 43'	151° 47'	1700	Beaufort Sea
23	71° 22'	152° 20'	75	Beaufort Sea
24	71° 19'	152° 32'	52	Beaufort Sea
25	71° 08'	152° 57'	22	Beaufort Sea
26	71° 23'	154° 21'	30	Beaufort Sea
27	71° 36'	155° 32'	171	Beaufort Sea

F. Milestone Chart and Data Submission Schedule

We will submit all data on schedule with our final report on 1 April 1977.

III. Results

Results are listed in Table 2. Salinity ranged from 5.05 to 32.67°/₀₀ in the upper 50 m at stations located in the Beaufort Sea (stations 12-27). The lowest salinities were found at the surface at stations located in pack ice. Temperature ranged from 3.46 to -1.60°C in the upper 50 m.

Chlorophyll *a* ranged from 0.12 to 5.38 mg m^{-3} and phaeopigments ranged from 0.02 to 0.75 mg m^{-3}. Primary productivity ranged from 0.066 to 5.979 mg C $m^{-3} \cdot hr^{-1}$. In general, high chlorophyll concentrations and high primary productivity occurred at the same depth and station.

Phytoplankton standing stock has been determined only for stations 13-15. Small species of the genus *Chaetoceros* are the most abundant organisms. The category *Chaetoceros* spp. includes *Ch. fragilis* Meunier, *Ch. furcellatus* Bailey, *Ch. socialis* Lauder, *Ch. wighami* Brightwell and possibly other species in the same size range. These species have been lumped together because they are difficult to separate when only short chains or solitary cells are present and no resting spores are present.

Zooplankton standing stocks will be given in the final report for this project.

IV. Preliminary Interpretation of Results

Interpretation of the results will be given in the final report.

V. Task Objectives

The basic objective of the Beaufort Plankton Project at the AIDJEX camp in 1975 was to collect information on standing stocks and seasonal changes in the environment under the pack ice, including primary production and response of herbivores to production.

VI. Laboratory Activities

Analysis of the zooplankton samples, data reduction, and synthesis of the data are continuing and will be included in the final report, 1 April 1977.

Table 2. Hydrographic data for OCS stations taken during Aug-Sep 1976, USCGC *Glacier*, in the Chukchi and Beaufort seas

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/₀₀	Temp. (°C)	Chl *a* (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3}\cdot hr^{-1}$)
01	09 Aug	0635	70°54.0'	160°04.0'	54	000	28.54	0.93	0.17	0.03	0.170
						005	30.09	-0.33	0.14	0.32	1.603
						010	31.82	-1.32	0.95	0.19	--
						015	32.15	-1.72	1.94	0.12	6.793
						020	32.25	-1.85	5.96	0.09	5.135
						025	32.67	-1.72	0.63	0.25	2.835
						030	32.97	-1.25	3.19	0.28	0.610
						045	33.01	-1.27	0.70	0.34	0.426
02	No hydrographic station										
03	09 Aug	2300	70°43.0'	160°40.0'	20	000	29.27	2.06	0.18	0.04	0.068
						005	29.25	1.96	0.12	0.04	0.113
						010	29.20	1.95	0.16	0.04	0.076
						015	31.65	-1.17	0.18	0.09	0.180
						020	32.49	-1.47	0.83	0.38	0.715
						035	32.93	-1.19	0.29	0.22	0.452
04	10 Aug	1800	70° .0'	162°09.0'	40	000	29.88	3.97	0.19	0.04	0.105
						005	29.90	4.04	0.16	0.03	0.096
						010	29.91	3.90	0.16	0.04	0.120
						015	31.57	3.01	0.30	0.05	0.436
						020	31.86	0.66	0.22	0.05	0.580
						025	32.63	-0.57	0.66	0.27	0.698
						035	32.59	MALF	0.48	0.25	0.425

Table 2. (continued)

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/₀₀	Temp. (°C)	Chl a (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3} \cdot hr^{-1}$)
05	11 Aug	1453	70°47.0'	162°14.0'	36	000	29.19	5.02	0.18	0.02	0.131
						005	29.42	4.77	0.23	0.02	0.139
						010	29.98	3.78	0.20	0.06	0.244
						015	30.94	1.94	0.25	0.09	0.251
						020	32.16	-0.20	0.41	0.19	0.266
						025	32.49	-0.85	0.49	0.28	0.471
						030	32.66	-1.07	0.71	0.54	0.488
						035	32.64	-1.04	0.66	0.44	0.589
06	11 Aug	2308	70°39.0'	162°16.0'	36	000	32.48	4.78	0.22	0.03	0.154
						005	32.48	5.45	0.31	0.04	0.189
						010	32.28	5.91	0.24	0.03	0.210
						015	32.23	1.65	0.26	0.05	0.239
						020	32.06	0.12	1.69	0.38	1.721
						025	31.00	-0.84	2.59	0.34	3.012
						030	30.90	-1.03	0.47	0.29	0.615
						035	29.66	-1.00	0.57	0.42	0.647
07	12 Aug	1510	70°28.0'	163°26.0'	40	000	30.30	4.82	0.27	0.03	0.172
						005	30.27	4.82	0.26	0.03	0.226
						010	30.32	4.90	0.17	0.32	0.148
						015	no sample	4.81			
						020	30.62	5.01	0.22	0.02	0.128
						025	32.44	-0.85	0.94	0.12	1.034
						030	32.44	-0.09	1.34	0.11	1.573
						040	32.44	-0.13	1.64	0.02	1.412
08	13 Aug	0745	70°34.0'	162°50.0'	27	000	29.34	3.78	0.23	0.04	0.111
						005	29.57	2.95	0.18	0.03	0.129
						010	no sample				
						015	30.74	-0.09	0.25	0.04	0.205

Table 2. (continued)

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/°°	Temp. (°C)	Chl *a* (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3}\cdot hr^{-1}$)
09	14 Aug	1843	71°03.0'	159°17.0'	61	000	29.81	2.08	0.19	0.03	0.082
						005	29.81	1.94	0.17	0.03	0.038
						010	31.73	-1.08	0.20	0.07	0.090
						015	32.67	-1.33	8.00	0.32	4.528
						020	32.79	-1.29	2.71	0.22	1.990
						025	32.81	-1.28	3.00	0.17	1.684
						035	32.71	-1.27	2.55	0.17	1.484
						055	32.77	-1.26	2.49	0.30	1.605
10	15 Aug	1843	71°16.0'	157°43.0'	70	000	29.10	2.42	0.24	0.04	0.144
						005	29.42	2.20	0.28	0.03	0.284
						010	30.68	-1.08	0.81	0.18	0.942
						015	32.67	-1.24	2.69	0.21	2.022
						020	32.70	-1.26	2.54	0.44	2.954
						025	32.70	-1.25	3.43	0.24	2.762
						045 no	sample	-1.33			
						065	32.94	-1.47	3.30	0.14	2.527
11	16 Aug	1538	71°25.5'	156°54.8'	106	000	28.57	3.26	0.37	0.07	0.375
						005	28.76	2.54	0.33	0.05	0.397
						010	28.90	2.26	0.29	0.06	0.394
						015	32.51	-1.38	14.20	0.28	0.955
						025	32.74	-1.32	1.72	0.18	1.557
						050	32.79	-1.38	1.99	0.24	1.742
						075	32.94	-1.51	2.38	0.25	1.697
						100	33.03	-1.58	2.65	0.38	1.912

Table 2. (continued)

Sta. No.	Date (1976)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/₀₀	Temp. (°C)	Chl *a* (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3} \cdot hr^{-1}$)
12	17 Aug	1545	71°31.5'	156°09.0'	139	000	29.09	3.23	0.31	0.04	0.145
						005	29.06	3.23	0.27	0.02	0.198
						010	29.25	3.46	0.31	0.04	0.163
						015	29.64	2.54	0.54	0.23	0.447
						025	31.88	-0.72	0.56	0.19	0.448
						050	32.67	-1.33	3.10	0.25	2.812
						075	32.69	-1.29	2.90	0.40	1.753
						100	32.74	-1.34	2.60	0.37	1.812
13	18 Aug	1555	71°31.0'	155°05.0'	31	000	15.35	1.03	0.62	0.09	0.359
						005	28.22	2.54	0.49	0.10	0.516
						010	29.44	2.82	0.59	0.13	0.427
						015	29.63	2.53	0.51	0.08	0.544
						020	29.90	2.09	0.54	0.10	0.538
						025	30.56	0.72	0.47	0.10	0.622
14	21 Aug	0100	71°11.0'	153°09.0'	25	000	07.84	1.78	0.29	0.06	0.164
						005	27.72	-0.80	0.81	0.02	0.550
						010	29.67	-0.67	0.18	0.06	0.070
						015	31.29	-0.67	0.15	0.11	0.094
						020	31.46	-0.87	0.12	0.12	0.066
15	24 Aug	0053	70°36.0'	148°12.0'	16	000	10.04	-0.21	0.32	0.03	0.224
						005	28.48	-0.91	5.07	0.18	4.362
						010	28.23	-1.41	5.20	0.08	3.936
						015	30.32	-1.43	5.38	0.14	4.198
16	No hydrographic data										

Table 2. (continued)

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/∘∘	Temp. (°C)	Chl *a* (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3} \cdot hr^{-1}$)
17	26 Aug	0518	70°32.0'	147°33.0'	25	000	06.02	-1.34	0.48	0.06	0.194
						005	28.88	-1.56	3.22	0.51	4.334
						010	30.06	-1.48	3.80	0.25	5.979
						015	30.72	-1.54	2.93	0.36	3.400
						020	31.72	0.67	1.64	0.18	1.672
18	26 Aug	1808	70°39.0'	147°37.0'	25	000	05.05	0.33	0.36	0.05	0.094
						005	25.90	-0.84	2.00	0.08	2.364
						010	29.70	-1.56	3.36	0.34	3.947
						015	30.21	-1.60	3.08	0.21	3.366
19A	Salinity at 0 & 20 m only from this station					000	10.75				
						020	31.90				
19B	27 Aug	0900	70°57.0'	149°33.0'	30	000	07.64	0.43	0.43	0.08	0.335
						005	24.63	-1.15	0.71	0.07	0.447
						010	30.01	-1.12	0.38	0.07	0.144
						015	31.44	-1.16	0.23	0.13	0.183
						020	30.43	-1.01	0.32	0.21	0.037
						025	31.62	-1.05	0.20	0.15	0.123
20	28 Aug	2327	71°08.0'	151°19.0'	34	000	19.05	MALF	0.30	0.03	0.098
						005	22.81	0.78	1.76	0.06	0.861
						010	32.25	-1.36	3.90	0.75	2.449
						015	30.73	-0.57	0.50	0.12	0.465
21	30 Aug	0035	71°43.0'	151°47.0'	1700	000	10.18	0.28	0.18	0.03	0.095
						005	25.63	-0.98	0.48	0.10	0.356
						010	28.06	-1.02	0.65	0.02	0.493
						015	29.54	-0.96	0.53	0.04	0.377
						020	30.04	0.54	0.74	0.10	0.718
						025	30.58	0.53	0.63	0.03	0.375

Table 2. (continued)

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/°°	Temp. (°C)	Chl *a* (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3} \cdot hr^{-1}$)
21 (cont.)	29 Aug	2355	71°43.0'	151°47.0'	1700	030	30.85	MALF	0.22	0.03	0.131
						040	31.33	-0.12	0.25	0.10	0.174
						050	32.04	-0.77	0.24	0.18	0.134
						060	32.44	-1.19	0.39	0.26	
						075	32.62	-1.30	0.39	0.25	0.119
						100	32.74	-1.49	0.62	0.20	0.318
	29 Aug	2300				500	no sample	0.33			
						510	34.79	0.34	0.11	0.14	
						700	34.84	0.05	0.35	0.30	
						800	34.84	-0.04	0.09	0.11	
						900	34.85	-0.09	0.19	0.30	
						1000	34.85	-0.18	0.18	0.28	
22	No hydrographic data										
23	31 Aug	0112	71°22.0'	152°20.0'	75	000	15.71	0.54	0.53	0.04	0.232
						005	25.52	1.45	0.67	0.08	0.318
						010	27.43	1.91	0.83	0.06	0.599
						015	28.84	2.67	1.98	0.83	0.756
						020	30.98	0.92	0.41	0.09	0.315
						025	31.25	0.52	0.38	0.11	0.271
						030	24.05	1.33	0.73	0.14	0.363
						040	28.34	2.34	1.00	0.06	0.972
						050	31.10	-0.12	0.36	0.12	0.250
						060	31.59	-0.66	0.27	0.13	0.166
						075	32.22	-0.94	0.77	0.35	0.546

Table 2. (continued)

Sta. No.	Date (1976) (GMT)	Time (GMT)	Latitude (N)	Longitude (W)	Sonic Depth (m)	Sample Depth (m)	S°/∘∘	Temp. (°C)	Chl a (mg m^{-3})	Phaeo (mg m^{-3})	Primary Prod. (g $Cm^{-3} \cdot hr^{-1}$)
24	31 Aug	1715	71°19.0'	152°32.0'	52	000	17.36	0.27	0.58	0.07	0.233
						005	25.83	1.68	0.75	0.09	0.422
						010	27.87	3.18	0.89	0.12	0.583
						015	28.55	2.78	1.03	0.09	0.767
						020	29.42	2.32	0.74	0.06	0.527
						025	30.09	1.91	0.49	0.05	0.364
						030	30.60	2.05	0.34	0.07	0.217
						045	31.47	-0.30	0.46	0.16	0.206
25	01 Sep	1625	71°08.0'	152°57.0'	22	000	20.47	1.79	0.19	0.03	0.123
						005	26.24	-0.26	0.47	0.07	0.353
						010	28.99	-0.41	2.20	0.60	2.250
						015	30.09	0.30	1.08	0.14	0.734
26	02 Sep	1420	71°23.0'	154°21.0'	30	000	17.40	1.15	0.22	0.03	0.063
						005	25.27	0.19*	0.44	0.08	0.286
						010	27.55	2.95	0.69	0.10	0.380
						015	28.77	2.73	0.62	0.09	0.479
						020	29.15	2.15	0.66	0.09	0.372
						025	29.38	2.13	0.36	0.06	0.168
27	02 Sep	2158	71°36.0'	155°32.0'	171	000	08.35	0.14	1.00	0.20	0.298
						005	25.79	2.31	0.54	0.05	0.315
						010	27.73	2.12	0.46	0.05	0.344
						015	28.48	-0.67	0.53	0.04	0.299
						020	31.05	-1.34	1.28	0.01	1.240
						025	31.92	0.23	0.69	0.12	0.361
						030	32.00	0.19	0.51	0.15	0.334

* One thermometer malfunctioned; this temperature based on only one thermometer.

VII. Literature Review: Phytoplankton, Zooplankton, Ichthyoplankton

The phytoplankton references have been put on computer cards and the first listing run (Quarterly Report for 1 Oct 1976). Key punching of the zooplankton references is continuing with approximately one-third (200) of the references on cards and preliminary listings run. Ichthyoplankton references are being compiled and will be key punched in January.

References Cited

Strickland, J. D. H., and T. R. Parsons. 1968. A Practical Handbook of Seawater Analysis. Fish. Res. Bd Can. Bull. 167. 311 pp.

U.S. Naval Oceanographic Office. 1968. Instruction Manual for Obtaining Oceanographic Data. 3rd ed. Publ. 607.

Utermöhl, H. 1931. Neue Wege in der quantitativen Erfassung der Plankton. Verh. int. Verein. theor. angew. Limnol. 5: 567-5.

QUARTERLY REPORT

Contract No.	: None
Research Unit No.	: RU-380
Reporting Period	: Oct. 1 - Dec. 31, 1976
Number of Pages	: 8

ICHTHYOPLANKTON OF THE EASTERN BERING SEA

Co-Principal Investigators

Kenneth D. Waldron and Felix Favorite
National Marine Fisheries Service
Northwest and Alaska Fisheries Center

I. Task Objective:

Collect and analyze ichthyoplankton samples from a portion of the eastern Bering Sea during the spring of 1976.

II. Field or Laboratory Activities:

A. Ship Schedule: No field activity.

B. Scientific Party

1. Laboratory Personnel:

Kenneth D. Waldron	NMFS	Co-principal investigator
Beverly Vinter	NMFS	Ichthyoplankton specialist
Donald M. Fisk	NMFS	Technician

C. Methods

Sorting of plankton samples collected during April-May 1976 was completed by the contractor. Fish larvae and fish eggs were identified at the Northwest Fisheries Center.

D. Sample Localities: See Figures 1 and 2.

E. Data Collected

1. No field collections.

2. Number and type of analyses: Preliminary sorting completed for all samples. Identification of fish larvae from the 505 bongo net samples has been completed and fish larvae from the neuston net samples have been identified and are being checked. Fish eggs from all the 505 bongo and the neuston samples have been counted and those of pollock have been identified. Tentative identification has been made of some of the remaining eggs. Various computations have been made, e.g., standard haul factors, and summary tables have been prepared. Using the OCSEAP ADP formats parts of the data have been transferred to coding sheets preparatory to punching cards.

3. Miles of trackline: Not applicable.

III. Results:

Data concerning the volume of zooplankton and the counts of certain zooplankton groups from aliquots of the 33 bongo net samples were received during early October. As was expected, the dominant organisms in these samples were copepods. The samples have been returned to Seattle and can be made available to persons interested in zooplankton. No further examination of the 333 bongo samples will be made at this laboratory.

Fish larvae from the 505 bongo and the neuston samples have been identified to various taxonomic levels. For certain groups identification was only to family, but for others we were able to make a specific identification. A preliminary listing of the groups is shown in Table 1. Numerically the most abundant larvae were those of the walleye pollock (*Theragra chalcogramma*).

Eggs of walleye pollock were identified in the 505 bongo and in the neuston samples. Numbers per sample ranged from 0 to over 13 eggs per cubic meter in the bongo samples and from 0 to over 10,000 eggs for total neuston samples. Distribution of pollock eggs in the surface layers (neuston samples) is shown in Figure 1, while Figure 2 shows the distribution in the total water column (i.e., that part of the water column sampled by the bongo nets). Although pollock eggs were absent from many stations in the northeastern portion of the survey area, eggs of other species were present. Distribution patterns for the two sets of data are very similar, with major concentrations of eggs along the outer edge of the continental shelf, generally over depth greater than 100 meters.

IV. Preliminary Interpretation of Results:

No interpretations can be made at this time.

V. Problems Encountered/Recommended Changes:

Delays by NASO in awarding the sorting contract caused us to fall behind our time schedule by about one month.

VI. Estimate of Funds Expended:

As of 31 December 1976 an estimated $11,500 will have been expended for RU-380.

TABLE 1

PRELIMINARY LIST OF FISH LARVAE COLLECTED DURING CRUISE MF 76A IN THE EASTERN BERING SEA, APRIL - MAY, 1976

Osmeridae
- Unidentified species
- Mallotus villosus - capelin

Bathylagidae
- Bathylagus pacificus - slender blacksmelt
- Leuroglossus schmidti - northern smoothtongue

Mycthophidae
- Protomyctophum thompsoni - bigeye lanternfish

Gadidae
- Unidentified species
- Gadus macrocephalus - Pacific cod
- Theragra chalcogramma - walleye pollock

Zoarcidae
- Unidentified species - eelpouts

Scorpaenidae
- Sebastes sp. - rockfish

Hexagrammidae
- Hexagrammos sp. greenling
- Hexagrammos stelleri - white-spotted greenling
- Pleurogrammus monopterygius - Atka mackerel

Cottidae
- Unidentified species
- Hemilepidotus sp. - Irish lords
- Hemilepidotus jordani - yellow Irish lord
- Triglops sp. - sculpin

Agonidae
- Unidentified species - poachers

Cyclopteridae
- Unidentified species - snailfish

Bathymasteridae
- Unidentified species - searchers

Stichaeidae
- Unidentified species A - pricklebacks
- Unidentified species B
- Unidentified species C

Pholidae
- Unidentified species - gunnels

TABLE 1 (con't.)

Ammodytidae
Ammodytes hexapterus - sand lance

Pleuronectidae
Atheresthes sp. - arrowtooth flounder
Hippoglossoides sp.- flathead sole
Hippoglossus stenolepis - Pacific halibut
Lepidopsetta bilineata - rock sole
Reinhardtius hippoglossoides - Greenland halibut

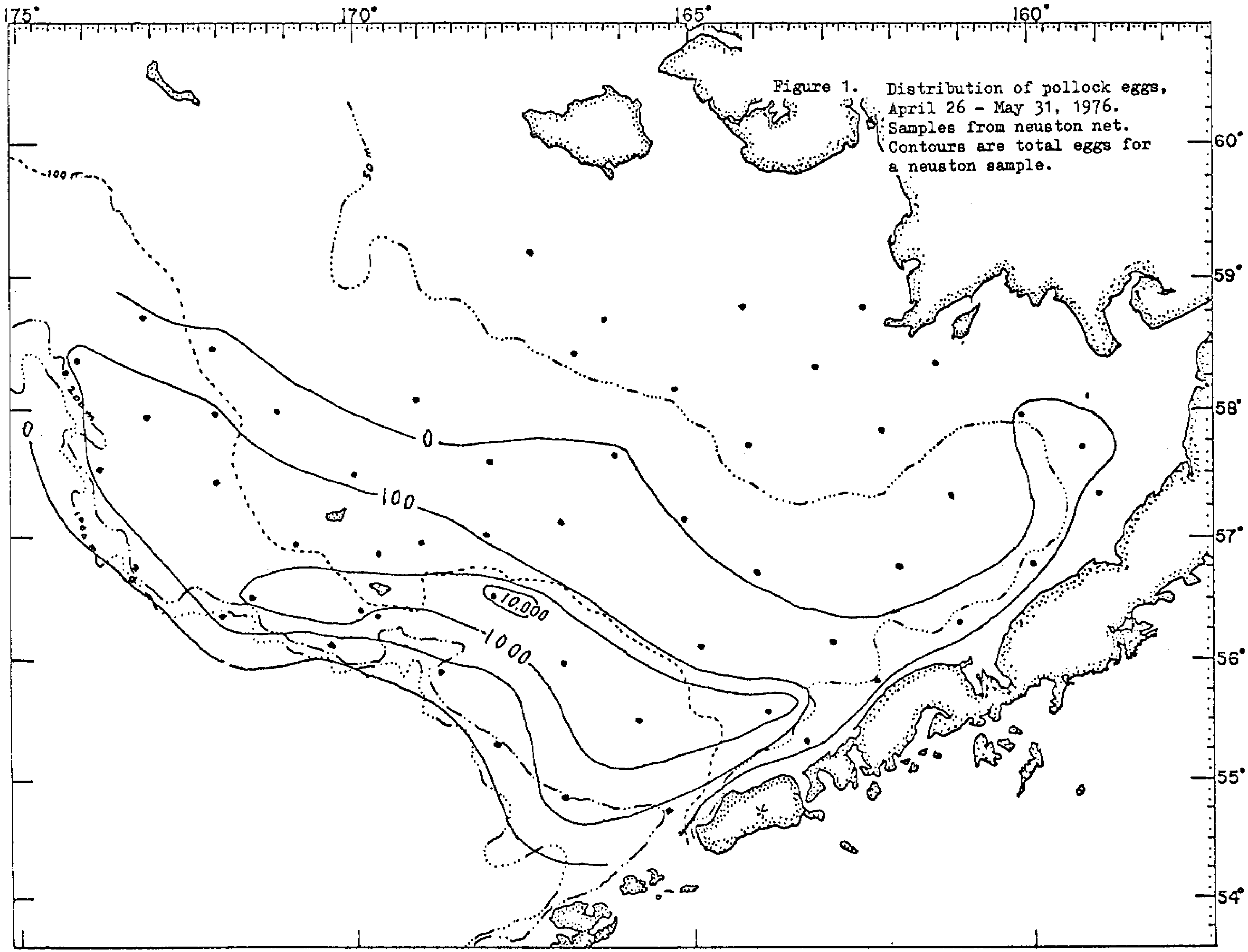


Figure 1. Distribution of pollock eggs, April 26 - May 31, 1976. Samples from neuston net. Contours are total eggs for a neuston sample.

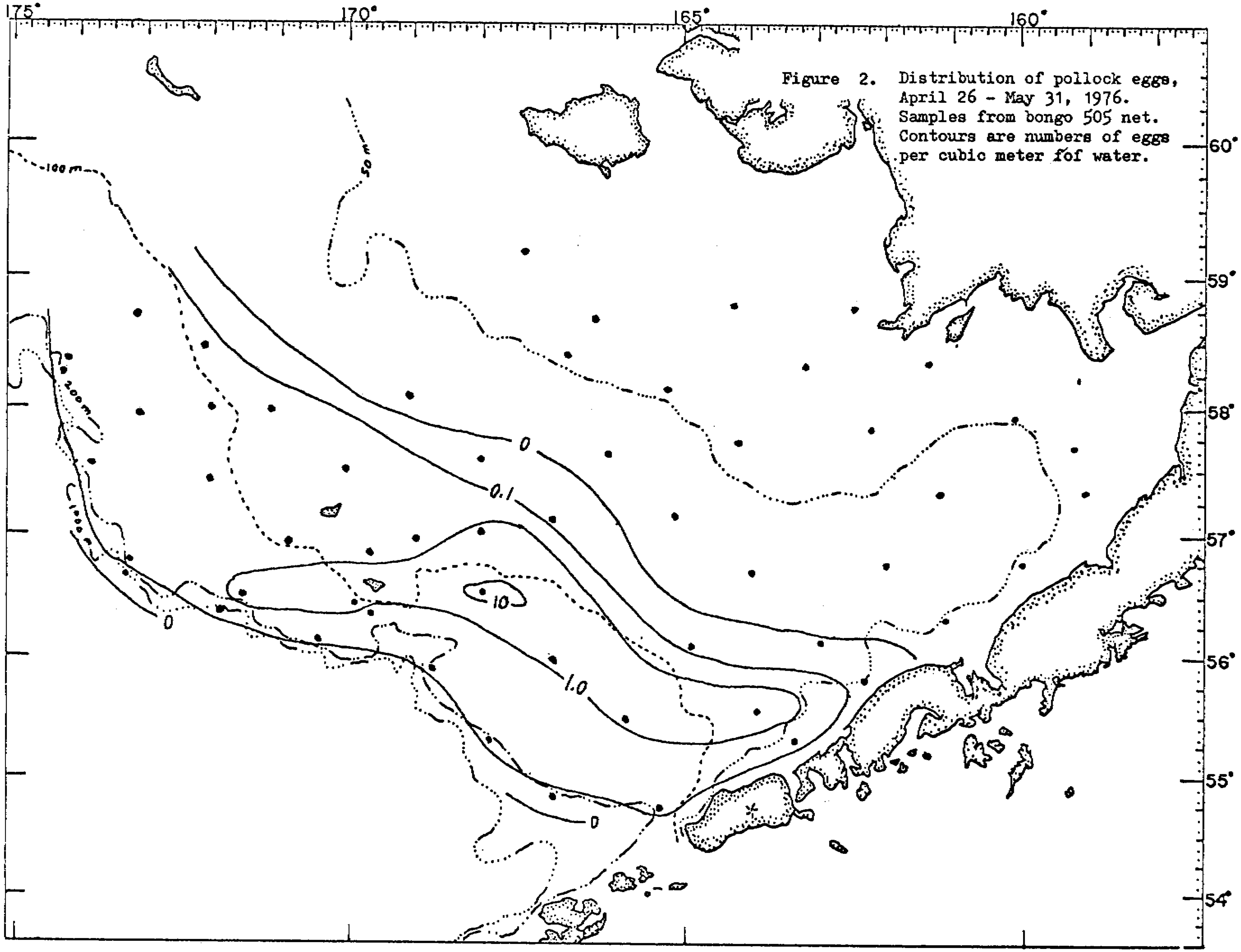


Figure 2. Distribution of pollock eggs, April 26 - May 31, 1976. Samples from bongo 505 net. Contours are numbers of eggs per cubic meter fof water.

PROJECT RU-380 Ichthyoplankton, Eastern Bering Sea - NWFC

DATE 15 December 1976

PRINCIPAL INVESTIGATORS Dr. F. Favorite and Mr. K. Waldron

	MAJOR MILESTONES/ ACTIVITIES	QUARTERS FY76 A	FY77 J	O	J	A
1	Miller Freeman Cruise 76A, Collect Plankton Samples					
2	Samples returned to Seattle aboard Freeman					
3	Award sorting contract					
4	Sort plankton for ichthyoplankton & major taxa					
5	Identification of ichthyoplankton					
6	Analysis of data					
7	Final Report: (a) Start					
8	(b) Submit for internal review					
9	(c) Final draft preparation					
10	(d) Submit to NOAA					
11	Quarterly Reports					
12	Transcription to OCSEAP format and submit mag tape					
13						
14						
15						
16						
17						
18						

Milestone: Start ├── Estimated Completion △ Actual Completion ▲

PROGRESS REPORT

RECONNAISSANCE EPIBENTHIC
INTERTIDAL BIOTA
RESEARCH UNIT #417
LOWER COOK INLET ALASKA
U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ASSOCIATION

EO
AN
Dennis C. Lees - AN
Richard C. Miller - AN
Richard J. Rosenthal - AN

DAMES & MOORE
JOB NO: 6797-004-20
December 8, 1976

December 8, 1976

Dr. Herb Bruce, Director
National Oceanic & Atmospheric
Administration
OCSEAP Office
P.O. Box 1808
Juneau, Alaska 99802

Gentlemen:

Fifth Quarterly Progress Report
Lower Cook Inlet
Reconnaissance Survey
R. U. # 417

This correspondence is a revision of the progress report submitted 4 October 1976. The purpose is to update the schedules for submission of the final report and completion of data processing. Furthermore, since that correspondence was not in the required format, it was necessary to add additional information and comply with the format.

If you have any questions concerning this program, please feel free to contact us at either the Anchorage (279-0673) or the Homer (235-8494) office.

Yours very truly,

DAMES & MOORE

Richard C. Miller

Richard C. Miller, Associate

Dennis C. Lees

Dennis C. Lees, Marine Biologist

RCM/DCL/eq

I. TASK OBJECTIVES

In order to promote adequate planning and implementation of the forthcoming lease sales and potential offshore exploratory drilling, Department of Interior has directed that appropriate research be conducted to increase the information available for agencies involved in decision-making activities.

As a part of this effort, the objective of this study has been to conduct reconnaissance of the habitats and biological assemblages in the intertidal areas of Lower Cook Inlet. This has been accomplished by means of an aerial reconnaissance of the Lower Inlet to determine the distribution of coastal habitats, and a series of cursory intertidal surveys to determine the nature of the biological assemblages associated with the habitats observed.

II. FIELD OR LABORATORY ACTIVITIES

A. Field Trip Schedule:

The dates, areas and nature of the field activities, since 1 July, are as follows:

Dates	Areas	Vessel or Aircraft	Nature of Work
9-10 July	Koyuktolik Bay	M.V. Humdinger	Intertidal & Subtidal Reconnaissance
11 July	Whiskey Gulch & Deep Creek		Beach Profile
13 July	Amakdedori Beach & Polly Creek	Cook Inlet Aviation-charter	Intertidal Reconnaissance

A. Field Trip Schedule Continued:

Dates	Areas	Vessel or Aircraft	Nature of Work
14 July	Seafair Beach, Homer Spit & Mud Bay		Intertidal Reconnaissance & Beach Profile
20-22 July	Troublesome Creek & Anchor Point	M.V. Humdinger	Subtidal Reconnaissance
3 August	Troublesome Creek & Archimandritof Shoals	M.V. Humdinger	Subtidal Reconnaissance
21-24 August	Chinitna Bay & Iniskin Bay	M.V. Humdinger	Subtidal & Intertidal Reconnaissance
30 August	Koyuktolik Bay	M.V. Humdinger	Subtidal & Intertidal Reconnaissance

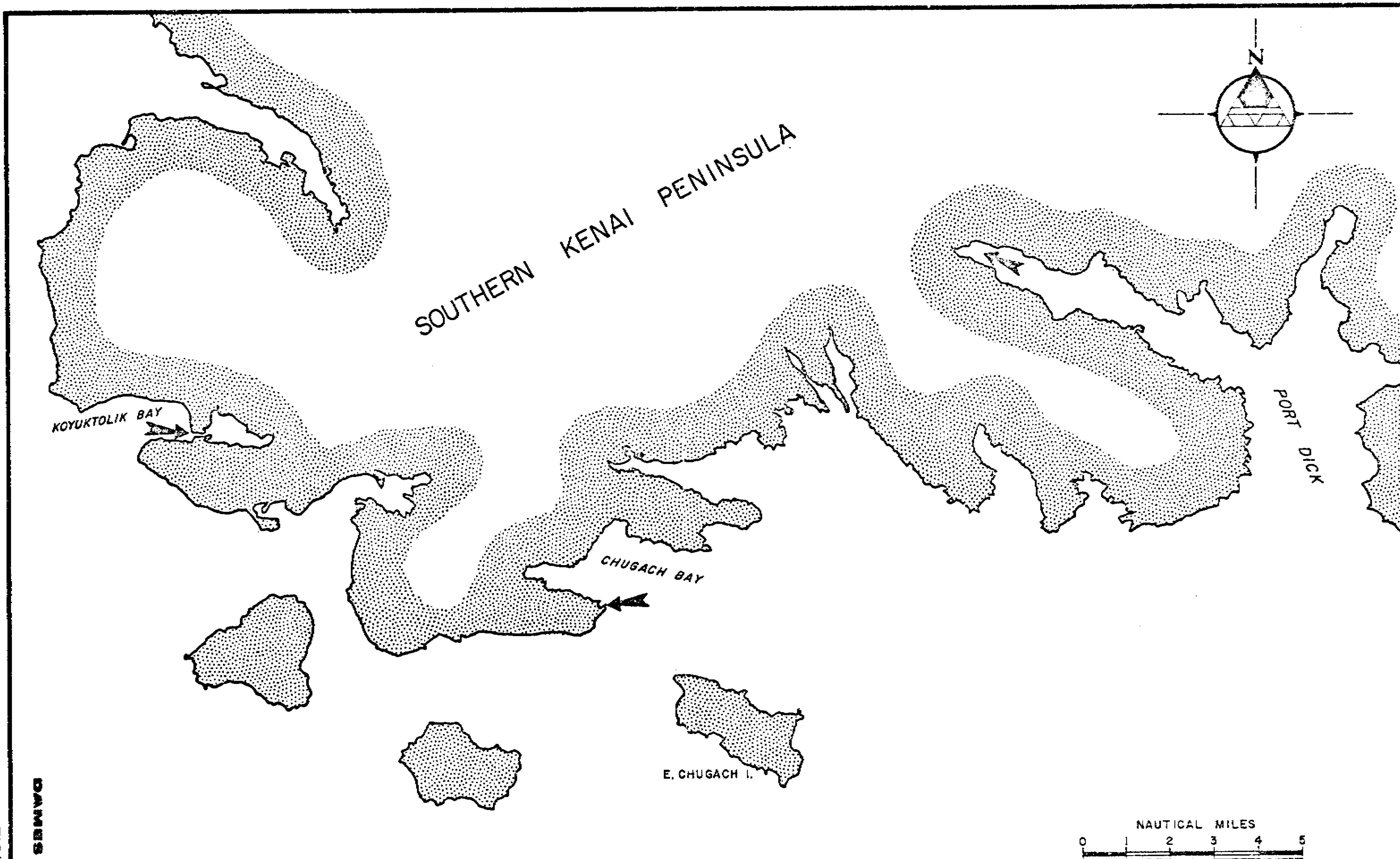
B. Scientific Party:

1. Robert Bennett, Dames & Moore, Field Assistant
2. Dennis Bishop, Dames & Moore, Field Assistant
3. Dennis C. Lees, Dames & Moore, Project Manager, Biologist
4. Dr. Jon Houghton, Dames & Moore, Biologist
5. Richard J. Rosenthal, Dames & Moore, Biologist
6. Thomas Rosenthal, Dames & Moore, Field Assistant

C. Methods:

1. Study Area Selection:

Intertidal study areas were selected on the basis of characteristic substrate type, vulnerability to environmental disturbance and accessibility. Eight areas were examined on the east shore of Lower Cook Inlet and Kachemak Bay. Ten areas were examined on the west shore of the Inlet and in Kamishak Bay (Figure 1). Several habitats were examined at some of these areas.



LOCATION MAP
OF THE SOUTHERN KENAI PENINSULA

FIGURE I

2. Procedures:

Field work was accomplished during low tide periods in May, June, July and August, 1976. Each area was visited only once during the study. Access to study areas on the east shore of Cook Inlet was by four-wheel drive vehicle. Access to areas on the west shore was by fixed-wing aircraft landing on floats or wheels as appropriate. An inflatable boat was used for additional mobility to some study areas on the west shore. During the field visits, major emphasis was placed on qualitative description of the study area and collection of representative specimens for each habitat for later identification. A minimum of two Dames & Moore biologists were present for each visit.

The following were accomplished at each study area where feasible:

a. The general physical characteristics of the intertidal area were described.

b. Epiflora and epifauna were described over the full tide range.

c. Quantitative measurements of organism densities, percent cover, etc., were made using random 0.0625 (1/16), 0.25 or 1.0 sq. m. quadrat casts or line transects.

d. Organisms living on and among other organisms were sought out and described.

e. Unconsolidated substrates (gravel, sand, and mud) were excavated and examined for infauna.

f. Quantitative measurements of infaunal densities were made using haphazard casts of hand operated beach corers. Material from a large corer (30 cm. deep by 79 sq. cm.) was sieved through a 4-mesh Tyler screen (4.75 mm. openings). Material from a small corer (10 cm. deep by 44 sq. cm.) was sieved through a 20-mesh Tyler screen (0.85 cm. openings).

g. Organisms taken in the cores and other organisms of questionable identity were either preserved in the field or collected live and returned to the field laboratory in Anchor Point for identification.

h. Approximate beach profiles were surveyed where possible.

3. Taxonomy:

As expected, many problems were encountered in attempting to identify organisms found in this study with standard taxonomic references for the northeast Pacific Ocean. Intertidal and shallow subtidal organisms of Lower Cook Inlet have not been previously studied in a systematic way and few extensive collections from this area have been examined by taxonomists. Thus, many organisms were encountered with characters intermediate to or outside the ranges of those considered definitive for separate species in standard keys. In some cases, it was possible to clear up these questions by reference to the original literature. In others, questions remain which must await a rigorous investigation by taxonomic specialists. Problematic individuals of some groups have bene submitted to such specialists for examination.

D. Sample Localities:

The survey was conducted at thirty specific locations within Lower Cook Inlet. These are listed below:

1. East Side of Inlet:

   a. Koyuktolik Bay:

      (1) Outer Bay - subtidal.
      (2) Entrance channel to lagoon - intertidal & subtidal.
      (3) Outer lagoon - subtidal.
      (4) Inner lagoon - subtidal.

   b. Base of Homer Spit, east side (Mud Bay) - intertidal.

   c. Base of Homer Spit, west side - intertidal.

   d. Seafair Beach, Homer - intertidal.

   e. One mile west of Seafair Beach - intertidal & subtidal.

   f. Troublesome Creek - Mutnaia Gulch - subtidal.

   g. Anchor Point - subtidal.

   h. Whiskey Gulch - intertidal.

   g. Deep Creek - intertidal.

   h. Clam Gulch - intertidal.

   i. Mouth of Kasilof River - intertidal.

2. West Side of Inlet:

   a. Mouth of Douglas River - intertidal.

   b. Amakdedori Beach - intertidal.

   c. Brain Bay - intertidal.

      (1) Entrance channel.
      (2) Mud/gravel flats.
      (3) Eelgrass beds.

   d. Iniskin Bay:

      (1) Iniskin Rock - subtidal.
      (2) Scott Island - Intertidal.
      (3) Rocky Point, east side of entrance to bay - intertidal and subtidal.
      (4) Keystone Creek area, inside bay - intertidal.

e. Chinitna Bay:

(1) Glacier Spit - intertidal.
(2) Gull Island - intertidal.
(3) Clam Cove Reef - subtidal.
(4) E. Glacier Creek Beach - intertidal.
(5) Spring Point - intertidal and subtidal.

f. Polly Creek Beach - intertidal.

Additionally, a detailed aerial reconnaissance was conducted to assess distribution of the geological facies, habitats and associated biological assemblages on the Barren Islands and on the west side of Lower Cook Inlet.

E. Data Collected or Analyzed:

1. Number and types of samples/observations:

a. Intertidal reconnaissance observations in 14 areas.

b. Subtidal reconnaissance observations in five areas.

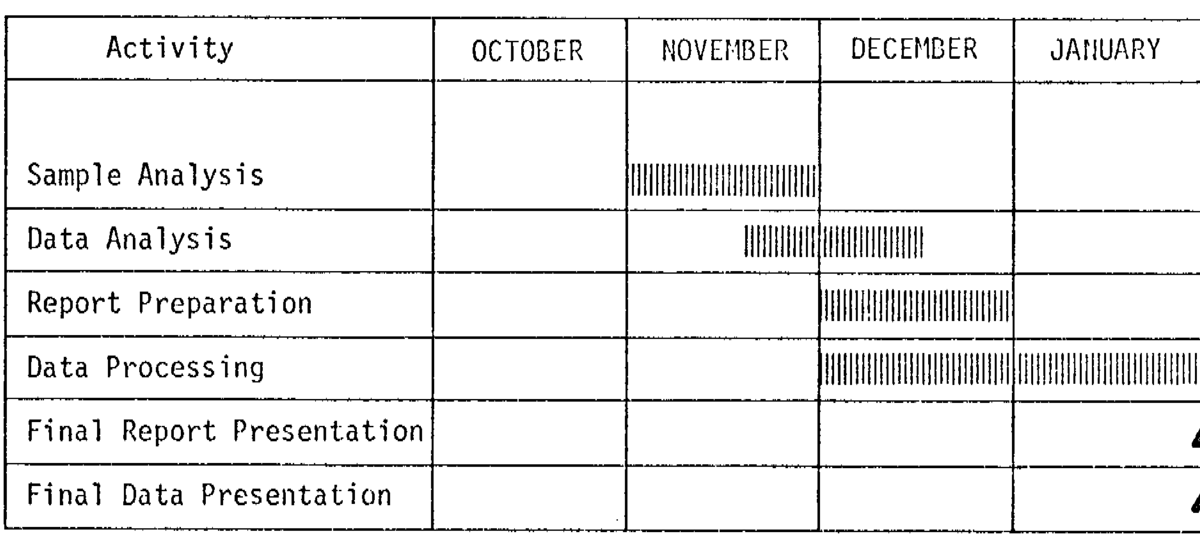
c. Replicate quantitative core samples in eight areas.

2. Types of Analyses:

a. Length-frequency distributions for mussels, starfish, snails, sea urchins and eelgrass.

b. Length-weight regressions for mussels and eelgrass.

F. Milestone (▲) Chart and Data Submission Schedules:



This revision in report and data submission schedules is a consequence of a more realisitic appraisal of the work load and available personnel. Also, communication with taxonomic specialists indicates that their schedules will create delays.

III. RESULTS

None to be submitted at this time. A detailed preliminary report was submitted in mid-August covering data collected until 14 July. Additional analysis is in progress.

IV. PRELIMINARY INTERPRETATION OF RESULTS

See Preliminary Report.

V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

Additional time is required to complete data analysis.

VI. ESTIMATE OF FUNDS EXPENDED - $86,000.00

QUARTERLY REPORT

Contract #: 03-5-022-67-TA8 #4
Research Unit #: 424
Reporting Period: 1 Oct - 31 Dec 1976
Number of Pages: 33

Lower Cook Inlet Meroplankton

T. Saunders English
Department of Oceanography
University of Washington
Seattle, Washington 98195

1 January 1977

Departmental Concurrence: [signature]
Francis A. Richards
Associate Chairman for Research

REF: A76-68

I. Task Objective

Our main objective is to conduct a quantitative survey to determine the seasonal distribution of commercially or ecosystem important species of ichthyoplankton and shrimp and crab larvae in Lower Cook Inlet, Alaska.

II. Field Activities

A. Ship Schedule

Miller Freeman - RP-4-MF-76B, Leg III
Lower Cook Inlet, 17-29 October

This cruise was aboard the NOAA ship *Miller Freeman* (FRS-21). The vessel has an overall length of 215 feet, a beam of 42 feet, an average depth of 18 feet and a displacement of 1920 tons. She has a retractable bowthruster capable of delivering 11,000 lbs thrust, and a 12-foot retractable centerboard which makes her a very stable and maneuverable platform. The main engine is a geared diesel, turning at 800 RPM and rated at 2150 shaft HP. The speed ranged from 1 to 16 knots, with a cruising speed of 13 knots. The bongo net was deployed from the starboard main deck. The Marco winch, used for the net tows, was located on the above deck. This winch was equipped with 19,685 feet of 7/16 in. wire with a load capability of 10,000 lbs.

B. Scientific Party

1. Kendra Daly, Assistant Oceanographer
2. Leanne Legacie, Assistant Oceanographer

Department of Oceanography
University of Washington
Seattle, Washington 98195

C. Methods

Nine stations were located in Lower Cook Inlet (Fig. 1, Table 1). Station 10 in the Gulf of Alaska was not sampled due to adverse sea conditions. Station 11, also located in the Gulf of Alaska, was not sampled due to the shortage of cruise time available. The stations were not sampled in order, having to fit in with the other scientific programs and the cruise time available. All UW stations were occupied for an average of 0.5 to 1 hr depending on the length of the bongo tow and the weather. The station sampling order for only the UW stations is given in Figure 1. The weather was variable from fair to snowing. The temperature ranged between 50° to -15°F. We encountered calm to 10 ft seas and 5 to 60 kt winds. The inclement weather was a problem and caused the loss of 2 working days and slowed down operations considerably on other days.

The acoustic surveys were conducted using a Ross 200A Fine Line Echosounder system operating with a frequency of 105 kHz. A 10° beam

Ross transducer, mounted in a plywood towed body, was lowered approximately 2 m below the surface while on station. The incoming signals were recorded on a paper chart marked with station number, date, time (GMT), and other pertinent information. Acoustic scattering layers were of particular interest. The incoming signal was recorded on magnetic tape for at least 5 min at every station for later digitizing and analysis at the University of Washington.

Zooplankton and ichthyoplankton were sampled with a bongo net in a double oblique tow. The bongo net consisted of a double-mouthed frame (each mouth with an inside diameter of 60 cm and a mouth area of 0.2827 m^2) made of fiberglass and weighing 95 lbs. A 100-lb weight was attached below the frame. A 505-μm mesh net with an open area ratio (OAR) of 8:1 and a 333-μm mesh net, 8:1 OAR, were attached to the frame. A TSK flowmeter was mounted in the mouth of each net to estimate the volume of water filtered. A bathykymograph (BKG) was attached to the frame to determine the depth of tow. Double oblique tows required deployment at 50 m/min, a 30 sec soaking time, and retrieval at 20 m/min. An inclinometer, with a readout on the ship's bridge, was used to adjust the ship's towing speed in order to maintain a 45° wire angle.

Samples were placed in 1000-ml bottles and preserved with a stock solution of formalin, propylene glycol, propylene phenoxetol and sea water in a 2:8 ratio. The solution was changed and the sample represerved 24 hrs later. A label was filled out and inserted in the jar. The jar was capped and sealed with plastic electrical tape for storage.

D. Sample localities and UW station sampling order

For sample localities and UW trackline, see Fig. 1 and Table 1.

E. Data collected or analyzed

1. The number and kinds of net hauls are given in Table 2 for the *Miller Freeman* cruise.

2. The number and kinds of net hauls analyzed from the *Discoverer*, Leg V, 05-09 May 1976 are reported in Tables 3 and 5. Table 4 describes the possible fish egg identification for the egg size categories. The analyzed samples for the *Discoverer*, Leg VII, 22-30 May 1976, are reported in Tables 6 and 7; the *Acona*, Leg II, 8-15 July 1976 are reported in Tables 8 and 9; and the *Surveyor*, Leg II, 24-31 August 1976 are reported in Tables 10-12.

Figures 2 through 5 show the four size categories of fish eggs (in Table 4) that were caught at each station for the following cruises:

7-10 APR 76	*Discoverer*, Leg III RP-4-DI-76A
6-7 MAY 76	*Discoverer*, Leg V RP-4-DI-76A
24-27 MAY 76	*Discoverer*, Leg VII RP-4-DI-76A
10-13 JUL 76	*Acona*, Leg II RP-4-AC-231
25-28 AUG 76	*Surveyor*, Leg II RP-4-SU-76B
18-28 OCT 76	*Miller Freeman*, Leg III RP-4-MF-76B

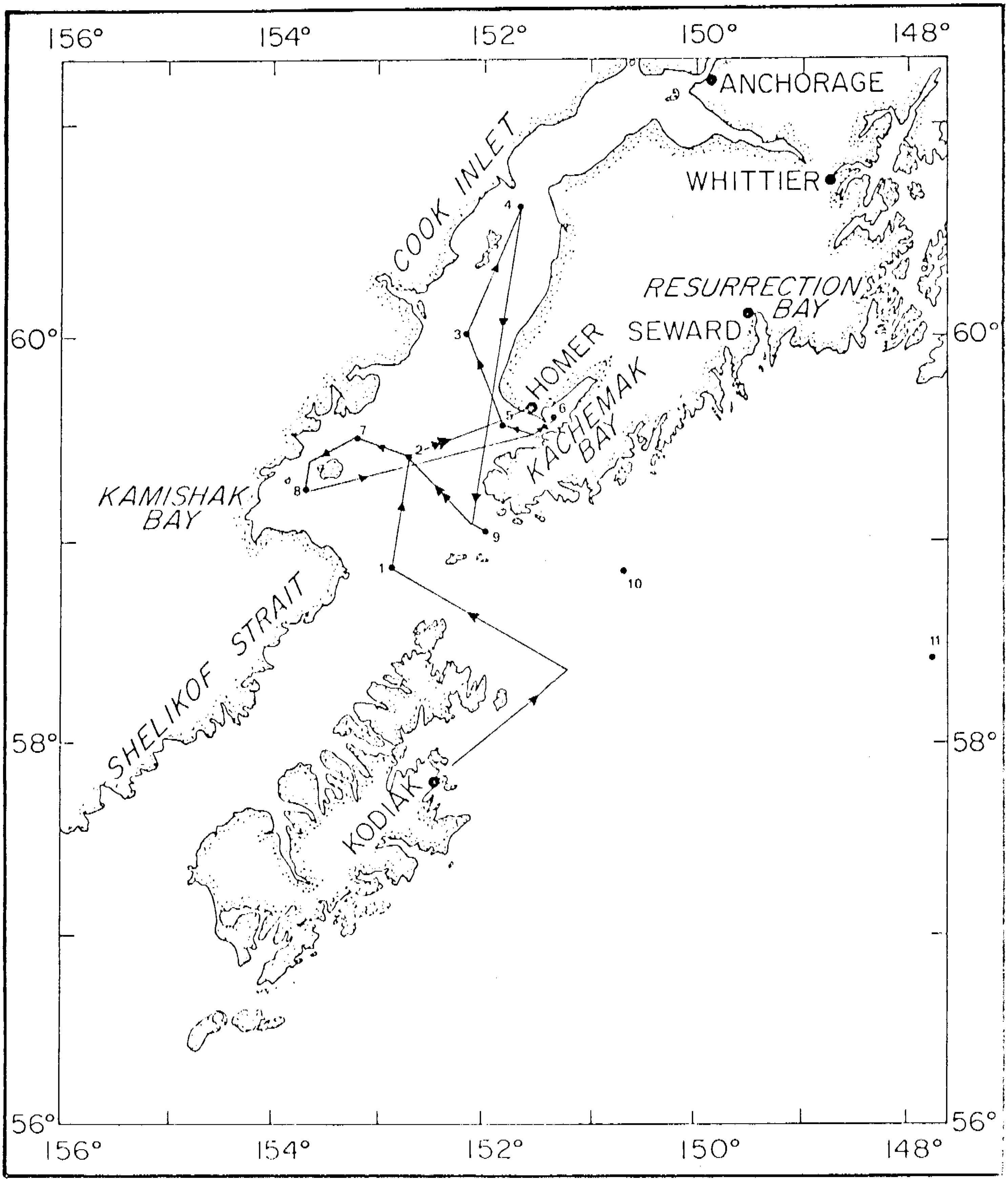


Fig. 1. Station sampling order, *Miller Freeman*, Leg III.

with the exception of 18-28 OCT 76 *Miller Freeman*, Leg III cruise. Data for that cruise has not yet been analyzed. Figure 6 show the total of all fish egg size categories.

F. Milestone Chart and Data Submission Schedules

1. For updated milestone/data submission schedule see Table 13.

2. The data submission for the *Discoverer*, Leg III, 06-13 April 1976, cruise has been delayed due to unforeseen problems in taxonomy. We have just recently corrected the problem and can now expect a submission date of 1 April 1977. A letter to this effect has been sent to the proper authorities.

III. Results

A. *Miller Freeman*, Leg III

Nine stations were surveyed acoustically with a total of 60 min of chart records and 45 min of magnetic tapes. The chart recorder revealed large numbers of target organisms in the water column at all stations.

B. Tables 14-18 illustrate the abundance and distribution of different egg size categories from April to August 1976 at stations 1-10.

IV. Preliminary Interpretations of Results

Miller Freeman, Leg III

Ichthyoplankton was caught at 7 stations. Shrimp were caught at all stations and crab larvae at stations 2 and 5. Large numbers of copepods were found at stations 5 and 6.

Table 1. Station locations, *Miller Freeman*, Leg III

Station	Latitude (N)	Longitude (W)	Chart Depth (m)	Location
1	58° 54.3'	152° 51.1'	174	Shelikof Strait
2	59° 22.8'	152° 40.8'	66	Lower Cook Inlet
3	60° 00.8'	152° 13.6'	57	Lower Cook Inlet
4	60° 38.4'	151° 39.0'	84	Cook Inlet
5	59° 35.1'	151° 49.2'	38	Outer Kachemak Bay
6	59° 36.7'	151° 16.8'	98	Inner Kachemak Bay
7	59° 29.9'	153° 10.0	39	Kamishak Bay
8	59° 15.9'	153° 41.8'	28	Kamishak Bay
9	59° 02.6'	151° 59.4'	200	Lower Cook Inlet

Table 2. UW Haul Summary Sheet, *Miller Freeman*, Leg III

Bongo Tows

(1976) (GMT)	Time (GMT)	Station	Haul	Latitude (N)	Longitude (W)	Depth (m)	Volume Filtered† (m^3)	Jars from mesh size (µm) 505	333
19 Oct	0400	1	1	58° 54.3'	152° 51.1'	172	243.6	1	1
19 Oct	2057	2	1	59° 24.3'	152° 41.5'		- - - - - - - ABORT - - - - - - - -		
28 Oct	0845	2	2	59° 22.8'	152° 40.8'	66	129.8	1	-
23 Oct	1935	3	1	60° 00.8'	152° 13.6'	57	115.2	1	1
24 Oct	1004	4	1	60° 38.4'	151° 39.0'	50	161.7	1	1
23 Oct	1006	5	1	59° 35.1'	151° 49.2'	32	110.2	1	1
22 Oct	1758	6	1	59° 36.7'	151° 16.8'	75	162.4	1	1
21 Oct	0907	7	1	59° 29.9'	153° 10.0'	31	44.9	1	1
22 Oct	0403	8	1	59° 15.9'	153° 41.8'	27	152.6	1	1
28 Oct	1244	9	1	59° 02.6'	151° 59.4'	199	706.0	1	1

† averaged

Table 3. Summary of taxonomic categories of fish eggs, larvae, young and adults found in Bongo net samples collected on Lower Cook Inlet *Discoverer* cruise, Leg V, 05-09 May 1976

A total of 11 samples were collected. Summaries of samples from stations 1 through 6 appear in the Quarterly Report dated 1 October 1976. Samples from stations 7 through 9 are identified and summarized below. The fish are distributed into 8 families, 8 genera and 3 species. The eggs are distributed into 3 size categories.

Family Ammodytidae

39 larvae sandlance[1] *Ammodytes hexapterus* Pallas

Family Bathymasteridae

4 larvae blacksmelt *Bathylagus* spp.

Family Cottidae

2 larvae genus? species?

Family Gadidae

46 larvae genus? species?

Family Gonostomidae

4 larvae bristlemouth *Cyclothone* sp.?

Family Pleuronectidae

4 larvae rock sole *Lepidopsetta bilineata* (Ayres)
1 larva butter sole *Isopsetta isolepis* (Lockington)

Family Scorpaenidae

2 larvae rockfish *Sebastes* sp.

Family Stichaeidae

10 larvae cockscomb *Anoplarchus* sp.
4 larvae prickleback *Lumpenus* spp.

24 larvae unidentified

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[1] The common name is presented for the first time for each species; thereafter only the scientific name is recorded.

Table 3. (cont.)

837 eggs categorized (see Table 4, List of Possible Fish for Egg Size Categories):

808 eggs ∿ 1 mm (0.90-1.26 mm)

15 eggs ∿ 2 mm (1.30-2.54 mm)

14 eggs ∿ 3 mm (2.56-3.90 mm)

Table 4. List of Possible Fish for Egg Size Categories

< 1 mm category (0.74-0.88 mm)

Limanda aspera
Limanda proboscidea

∿ 1 mm category (0.90-1.26 mm)

Gadus macrocephalus
Isopsetta isolepis
Parophrys vetulus
Platichthys stellatus
Psettichthys melanostictus

∿ 2 mm category (1.30-2.54 mm)

Eopsetta jordani
Glyptocephalus zachirus
Lyopsetta exilis
Microstomus pacificus
Pleuronectes quadrituberculatus
Pleuronichthys coenosus
Pleuronichthys decurrens
Theragra chalcogramma

∿ 3 mm category (2.56-3.90 mm)

Hippoglossoides elassodon
Hippoglossoides robustus
Hippoglossus stenolepis

Table 5. Identification of Fish Eggs and Larvae by Station
Lower Cook Inlet Bongo Tows, *Discoverer*, Leg V

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
8 May	0402	7	1	333	27[a]	2[a]	27 eggs ∿ 1 mm (1.00-1.20 mm)[b] 1 larva ∿ 8.4 mm *Ammodytes hexapterus* Pallas 1 larva ∿ 10 mm *Lumpenus* sp.
8 May	0402	7	1	505	60	2	56 eggs ∿ 1 mm (1.06-1.24 mm) 4 eggs ∿ 2 mm (1.36 mm) 2 larvae unidentified due to extensive damage (1 elongate and 1 non-elongate)
8 May	0734	8	1	333	360	17	358 eggs ∿ 1 mm (0.92-1.30 mm) 2 eggs ∿ 2 mm (1.36 mm) 17 larvae (6.9-9.0 mm) *Ammodytes hexapterus* Pallas

[a] All specimens are classified into four main categories: eggs include all stages of eggs prior to hatching; larvae include newly hatched and all stages prior to metamorphosis; young include fish after metamorphosis to acquisition of adult fin rays and adult body configuration; adults include fish that are sexually mature.

[b] Eggs are measured to the nearest hundredths of a millimeter in diameter. Fish or larvae, if less than 10 mm in length, are measured to the nearest tenth of a millimeter under a microscope using a calibrated micrometer eye piece. If 10 mm or greater in length, the fish or larvae are measured by a metric ruler to the nearest millimeter. When there are more than three eggs, fish or larvae, the largest and the smallest are measured. Larvae are measured by standard length.

Table 5. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
8 May	0734	8	1	505	353	20	346 eggs ∿ 1 mm (0.94-1.24 mm)
							7 eggs ∿ 2 mm (1.34-1.64 mm)
							18 larvae 3.4-4.5 mm *Ammodytes hexapterus* Pallas
							1 larva 9.7 mm *Lumpenus* sp.
							1 larva 3.7 mm *Lepidopsetta bilineata* (Ayres) (?)
8 May	1315	9	1	333	19	15	9 eggs ∿ 1 mm (0.94-1.16 mm)
							1 egg ∿ 2 mm (1.40 mm)
							9 eggs ∿ 3 mm (3.46-3.84 mm)
							4 larvae 5.8-6.0 mm *Anoplarchus* sp.
							2 larvae 3.3, 3.9 mm *Lepidopsetta bilineata* (Ayres) (?)
							2 larvae 5.1, 6.3 mm Cottidae
							1 larva 4.4 mm Gadidae
							1 larva 5.3 mm unidentified (intense body pigment)
							5 larvae unidentified due to extensive damage (all elongate)
8 May	1315	9	1	505	18	16	12 eggs ∿ 1 mm (0.94-1.20 mm)
							1 egg ∿ 2 mm (1.60 mm)

Table 5. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
8 May	1315	9	1	505	18	16	5 eggs ∿ 3 mm (3.36-3.56 mm)
							3 larvae 4.6, 5.5, 9.5 mm *Ammodytes hexapterus* Pallas
							6 larvae 5.0-6.2 mm *Anoplarchus* sp.
							1 larva 3.5 mm *Isopsetta isolepis* (Lockington)
							1 larva 11 mm *Lumpenus* sp.
							5 larvae unidentified due to extensive damage (all elongate)
9 May	0145	11	1	333	11	44	11 eggs < 1 mm (0.67-0.83 mm)
							3 larvae 7.9, 11, 21 mm *Bathylagus* spp. (?)
							4 larvae 3.4-4.1 mm *Cyclothone* sp. (?)
							1 larva 29 mm *Lumpenus* sp.
							32 larvae 3.4-4.4 mm Gadidae
							1 larva 8.8 mm unidentified (elongate)
							2 larvae 3.7, 6.0 mm unidentified (non-elongate)
							1 larva 12 mm unidentified (w/large ellipsoidal eyes extending to the articulation of the jaws)

Table 5. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
9 May	0145	11	1	505	11	24	11 eggs ∿ 2 mm (1.36-2.56 mm)
							1 larva 7.4 mm *Bathylagus* sp. (?)
							1 larva 3.3 mm *Lepidopsetta bilineata* (Ayres) (?)
							2 larvae 5.5, 6.1 mm *Sebastes* sp.
							13 Larvae 3.5-4.6 mm Gadidae
							7 larvae unidentified due to extensive damage (all elongate)

Table 6. Summary of taxonomic categories of fish eggs, larvae young and adults found in Bongo net samples collected on Lower Cook Inlet *Discoverer* cruise, Leg VII, 22-30 May 1976.

A total of 24 samples were collected. Summaries of samples from stations 2 and 5a appear in the Quarterly Report dated 1 October 1976. Samples from stations 1 and 3 are identified and summarized below for larvae. Samples from stations 1, 3, 4, 6, 7, 8, and 10 are sized and summarized for fish eggs. The fish are distributed into 8 families, 11 genera, and 6 species. The eggs are distributed into 4 size categories.

Family Ammodytidae

13 larvae sandlance[1] *Ammodytes hexapterus* Pallas

Family Cottidae

15 larvae sculpin genus? species?
1 larva northern sculpin *Icelinus borealis* Gilbert?
3 larvae *Myoxocephalus* sp.?

Family Cyclopteridae

1 larva genus? species?

Family Gadidae

3 larvae genus? species?
3 larvae Pacific cod *Gadus* sp.
1 larva Alaska pollock *Theragra chalcogramma* (Pallas)

Family Gonostomidae

2 larvae bristlemouth *Cyclothone* sp.?

Family Pleuronectidae

5 larvae rock sole *Lepidopsetta bilineata* (Ayres)
3 larvae slender sole *Lyopsetta exilis* (Jordan and Gilbert)
34 larvae *Hippoglossoides* sp.

Family Ptilichthydae

1 larva quillfish *Ptilichthys goodei* Bean

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[1] The common name is presented for the first time for each species; thereafter only the scientific name is recorded.

Table 6. (cont.)

Family Stichaeidae

4 larvae cockscomb *Anoplarchus* sp.

7 larvae unidentified due to extensive damage

122 larvae unidentified

4612 eggs categorized (see Table 4, List of Possible Fish for Egg Size Categories):

149 eggs < 1 mm (0.74-0.88 mm)

4305 eggs ∿ 1 mm (0.90-1.26 mm)

39 eggs ∿ 2 mm (1.30-2.54 mm)

104 eggs ∿ 3 mm (2.56-3.90 mm)

Table 7. Identification of Fish Eggs and Larvae by Station

Lower Cook Inlet Bongo Tows, *Discoverer*, Leg VII

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
24 May	0732	1	1	333	60[a]	106[a]	1 egg ∿ 2 mm (2.16 mm)[b] 59 eggs ∿ 3 mm (2.74-3.60 mm) 7 larvae 4.7-6.5 mm *Ammodytes hexapterus* Pallas 2 larvae 8.1, 8.7 mm *Anoplarchus* sp. 1 larva 5.4 mm *Cyclothone* sp. (?) 16 larvae 4.7-6.9 mm *Hippoglossoides* sp. 4 larvae 6.8-8.7 mm *Lepidopsetta bilineata* (Ayres)(?) 3 larvae 3.6, 4.2, 5.2 mm *Lyopsetta exilis* (Jordan and Gilbert) 1 larva 36 mm *Ptilichthys goodei* Bean

[a] All specimens are classified into four main categories: eggs include all stages of eggs prior to hatching; larvae include newly hatched and all stages prior to metamorphosis; young include fish after metamorphosis to acquisition of adult fin rays and adult body configuration; adults include fish that are sexually mature.

[b] Eggs are measured to the nearest hundredths of a millimeter in diameter. Fish or larvae, if less than 10 mm in length, are measured to the nearest tenth of a millimeter under a microscope using a calibrated micrometer eye piece. If 10 mm or greater in length, the fish or larvae are measured by a metric ruler to the nearest millimeter. When there are more than three eggs, fish or larvae, the largest and the smallest are measured. Larvae are measured by standard length.

Table 7. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (µm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
24 May	0732	1	1	333	60	106	1 larva 3.3 mm *Icelinus borealis* Gilbert? 2 larvae 8.9, 9.9 mm *Myoxocephalus* sp. 1 larva 7.7 mm Cottidae 2 larvae 4.4, 4.2 mm Gadidae 63 larvae 3.9-6.7 mm unidentified (elongate) 1 larvae 5.8 mm unidentified (non-elongate) 2 larvae unidentified due to extensive damage (1 elongate and 1 non-elongate)
24 May	0732	1	1	505	46	97	1 egg ∿ 2 mm (2.08 mm) 45 eggs ∿ 3 mm (2.74-3.60 mm) 4 larvae 8.8-14.0 mm *Ammodytes hexapterus* Pallas 2 larvae 8.0, 8.5 mm *Anoplarchus* sp. 1 larvae 4.3 mm *Cyclothone* sp. (?) 3 larvae 5.3, 7.4, 9.0 mm *Gadus* sp. 18 larvae 4.0-5.6 mm *Hippoglossoides* sp. 1 larva 8.0 mm *Lepidopsetta bilineata* (Ayres) (?) 1 larva 4.1 mm Cottidae (*Myoxocephalus* sp. (?))

Table 7. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
24 May	0732	1	1	505	46	97	1 larva 6.4 mm Cottidae ("Cottid 2" from Blackburn 1973)
							3 larvae 3.8, 3.9, 5.0 mm Cottidae
							1 larva 4.8 mm Cyclopteridae
							1 larva 5.5 mm Gadidae
							56 larvae 5.5-6.4 mm unidentified (elongate)
							1 larva 8.9 mm unidentified (non-elongate)
							4 larvae unidentified due to extensive damage
25 May	1607	3	1	333	85	7	80 eggs ∿ 1 mm (0.96-1.24 mm)
							5 eggs ∿ 2 mm (1.30-1.50 mm)
							1 larva 13 mm *Ammodytes hexapterus* Pallas
							5 larvae 3.4-4.0 mm Cottidae
							1 larva unidentified due to extensive damage
25 May	1607	3	1	505	86	8	85 eggs ∿ 1 mm (0.90-1.20 mm)
							1 egg ∿ 2 mm (1.54 mm)
							1 larva 6.2 mm *Ammodytes hexapterus* Pallas

Table 7. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
25 May	1607	3	1	505	86	8	1 larva 5.9 mm *Theragra chalcogramma* (Pallas) 5 larvae 3.4-4.0 mm Cottidae 1 larva 5.5 mm unidentified (non-elongate)
25 May	2217	4	1	333	3		2 eggs ∿ 1 mm (1.10-1.16 mm) 1 egg ∿ 2 mm (1.70 mm)
25 May	2217	4	1	505	1		1 egg ∿ 1 mm (1.10 mm)
26 May	0835	6	1	333	663		4 eggs < 1 mm (0.86 mm) 659 eggs ∿ 1 mm (0.94-1.10 mm)
26 May	0835	6	1	505	615		5 eggs < 1 mm (0.86 mm) 610 eggs ∿ 1 mm (0.90-1.06 mm)
26 May	1928	6	3	333	380		378 eggs ∿ 1 mm (0.90-1.06 mm) 2 eggs ∿ 2 mm (1.34 mm)
26 May	1928	6	3	505	284		2 eggs < 1 mm (0.84 mm) 281 eggs ∿ 1 mm (0.94-1.06 mm) 1 egg ∿ 2 mm (1.36 mm)
27 May	0056	6	4	333	169		168 eggs ∿ 1 mm (0.94-1.16 mm) 1 egg ∿ 2 mm (1.40 mm)

Table 7. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
27 May	0056	6	4	505	181		180 eggs ∿ 1 mm (0.94-1.10 mm) 1 egg ∿ 2 mm (1.40 mm)
27 May	0708	6	7	333	17		16 eggs ∿ 1 mm (0.94-1.10 mm) 1 egg ∿ 2 mm (1.40 mm)
27 May	0708	6	7	505	37		36 eggs ∿ 1 mm (0.94-1.16 mm) 1 egg ∿ 2 mm (1.40 mm)
27 May	1300	7	1	333	767		22 eggs < 1 mm (0.84-0.86 mm) 744 eggs ∿ 1 mm (0.90-1.10 mm) 1 egg ∿ 2 mm (1.30 mm)
27 May	1300	7	1	505	731		39 eggs < 1 mm (0.82-0.86 mm) 692 eggs ∿ 1 mm (0.90-1.10 mm)
27 May	1701	8	1	333	189		38 eggs < 1 mm (0.80-0.88 mm) 150 eggs ∿ 1 mm (0.90-1.14 mm) 1 egg ∿ 2 mm (1.40 mm)
27 May	1701	8	1	505	256		36 eggs < 1 mm (0.80-0.86 mm) 220 eggs ∿ 1 mm (0.90-1.14 mm)

Table 7. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
30 May	1813	10	1	333	22		1 egg < 1 mm (0.84 mm)
							2 eggs ∿ 1 mm (0.90-0.94 mm)
							9 eggs ∿ 2 mm (1.26-2.26 mm)
							10 eggs ∿ 3 mm (3.06-3.80 mm)
30 May	1813	10	1	505	18		2 eggs < 1 mm (0.74-0.84 mm)
							1 egg ∿ 1 mm (0.96 mm)
							12 eggs ∿ 2 mm (1.50-2.54 mm)
							3 eggs ∿ 3 mm (2.70-3.90 mm)

Table 8. Summary of size categories of fish eggs found in Bongo net samples collected on Lower Cook Inlet *Acona* cruise, Leg II, 8-15 July 1976.

The eggs are distributed into 2 size categories.

2579 eggs are categorized (see Table 4, List of Possible Fish for Egg Size Categories):

2424 eggs < 1 mm (0.74-0.88 mm)

155 eggs ∿ 1 mm (0.90-1.26)

Table 9. Identification of Fish Eggs and Larvae by Station

Lower Cook Inlet Bongo Tows, *Acona*, Leg II

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
12 July	1619	1	1	505	0		
12 July	1133	2	1	333	24		24 ∿ 1 mm (0.90-0.96 mm)
12 July	1133	2	1	505	16		16 eggs ∿ 1 mm (0.94 mm)
10 July	0901	3	1	505	0		
10 July	1556	4	1	505	0		
11 July	0018	5	1	333	63		51 eggs < 1 mm (0.74-0.84 mm) 12 eggs ∿ 1 mm (0.90-0.94 mm)
11 July	0018	5	1	505	169		133 eggs < 1 mm (0.74-0.88 mm) 36 eggs ∿ 1 mm (0.90-1.00 mm)
11 July	1009	6	2	333	123		123 eggs < 1 mm (0.74-0.86 mm)
11 July	1009	6	2	505	68		67 eggs < 1 mm (0.76-0.86 mm) 1 egg ∿ 1 mm (1.14 mm)
11 July	1031	6	3	333	104		103 eggs < 1 mm (0.74-0.86 mm) 1 egg ∿ 1 mm (1.04 mm)
11 July	1031	6	3	505	112		111 eggs < 1 mm (0.76-0.90 mm) 1 egg ∿ 1 mm (1.00 mm)

Table 9. (cont.)

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
11 July	2051	6	4	333	164		164 eggs < 1 mm (0.76-0.90 mm)
11 July	2051	6	4	505	816		808 eggs < 1 mm (0.76-0.86 mm) 8 eggs ∿ 1 mm (1.00 mm)
10 July	0010	7	1	333	330		278 eggs < 1 mm (0.74-0.87 mm) 52 eggs ∿ 1 mm (0.90-1.04 mm)
10 July	0010	8	1	505	920		864 eggs < 1 mm (0.76-0.86 mm) 56 eggs ∿ 1 mm (0.90-1.04 mm)
13 July	0548	9	1	505	7		1 egg < 1 mm (0.77 mm) 5 eggs ∿ 1 mm (1.00-1.20 mm) 1 egg ∿ 3 mm (lost)
13 July	1230	10	1	505	2		2 eggs ∿ 1 mm (lost)

Table 10. Number of fish eggs and larvae at each station

Lower Cook Inlet Bongo Tows, *Surveyor*, Leg II

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae
25 Aug	1206	2	1	333	0	109
25 Aug	1206	2	1	505	0	128
26 Aug	1040	5	1	333	44	476
26 Aug	1040	5	1	505	25	536
26 Aug	2203	6	1	333	21	856
26 Aug	2203	6	1	505	17	332
27 Aug	1000	6	2	505	48	1568

Table 11. Summary of size categories of fish eggs found in Bongo net samples collected on Lower Cook Inlet *Surveyor* cruise, Leg II, 24-31 August 1976.

The eggs are distributed into 2 size categories.

51 eggs categorized (see Table 4, List of Possible Fish for Egg Size Categories):

50 eggs $<$ 1 mm (0.74-0.88 mm)

1 egg $\sim$ 1 mm (0.90-1.26 mm)

Table 12. Identification of Fish Eggs and Larvae by Station
Lower Cook Inlet Bongo Tows, *Surveyor*, Leg II

Date (1976) (GMT)	Time (GMT)	Station	Haul	Mesh Size (μm)	Eggs	Fish or Larvae	Identification of Fish Eggs and Larvae
25 Aug	0840	1	1	505	0		
25 Aug	1206	2	1	333	0		
25 Aug	1952	3	1	505	0		
26 Aug	0400	4	1	505	0		
26 Aug	1040	5	1	333	34		33 eggs $<$ 1 mm (0.74-0.88 mm) 1 egg $\sim$ 1 mm (0.90-1.26 mm)
26 Aug	2203	6	1	333	17		17 eggs $<$ 1 mm (0.76-0.84 mm)
28 Aug	0650	7	1	333	0		
28 Aug	0330	8	1	505	0		
28 Aug	1919	9	1	505	1		1 egg $\sim$ 1 mm (0.87 mm)
29 Aug	0459	10	1	505	1		1 egg $<$ 1 mm (0.74 mm)

SMALL FISH EGGS (0.74-0.88 mm diameter) PER BONGO NET TOW

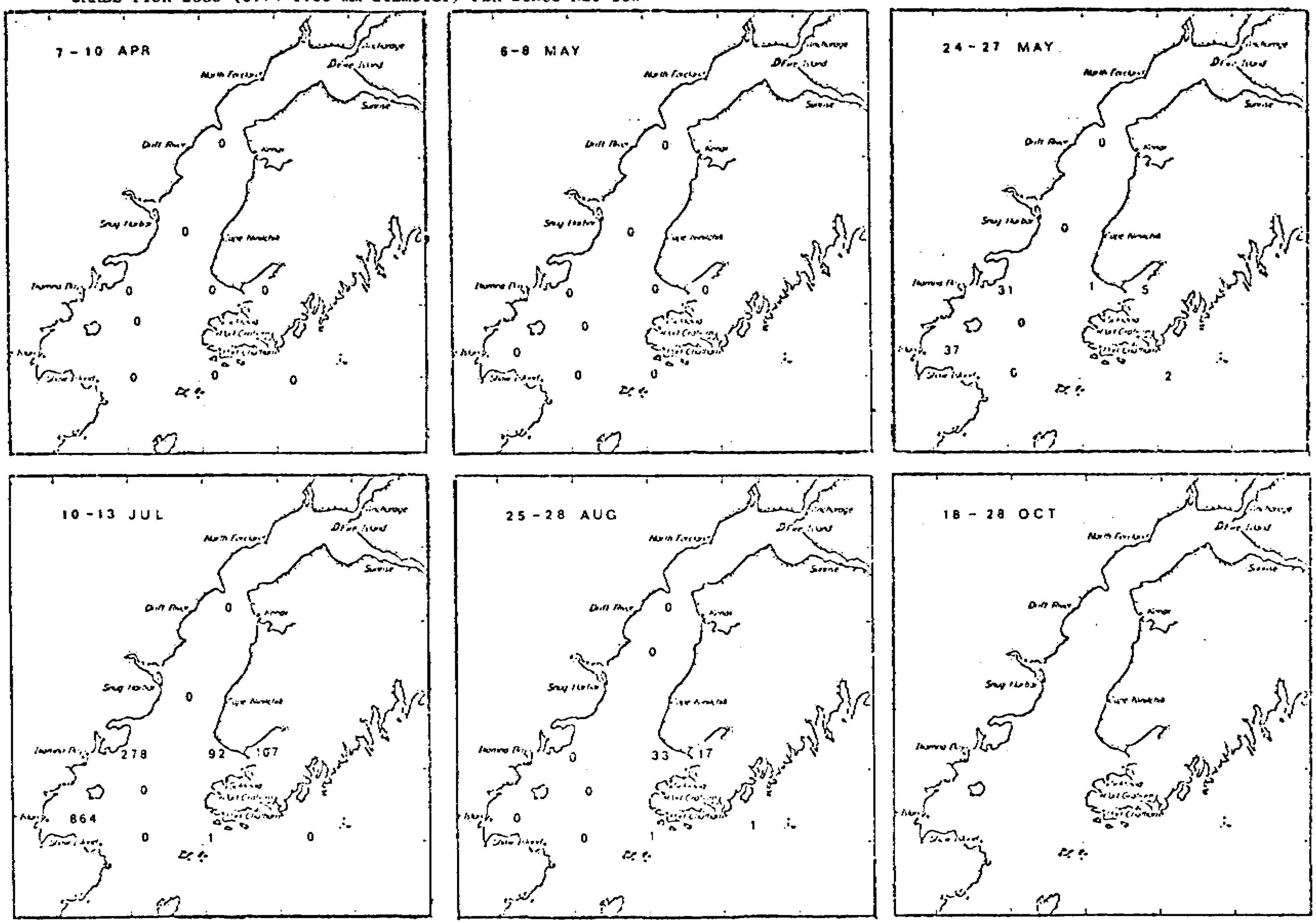


Fig. 2. Totals of fish eggs per station for five cruises.

1-mm FISH EGGS (0.90-1.26 mm diameter) PER BONGO NET TOW

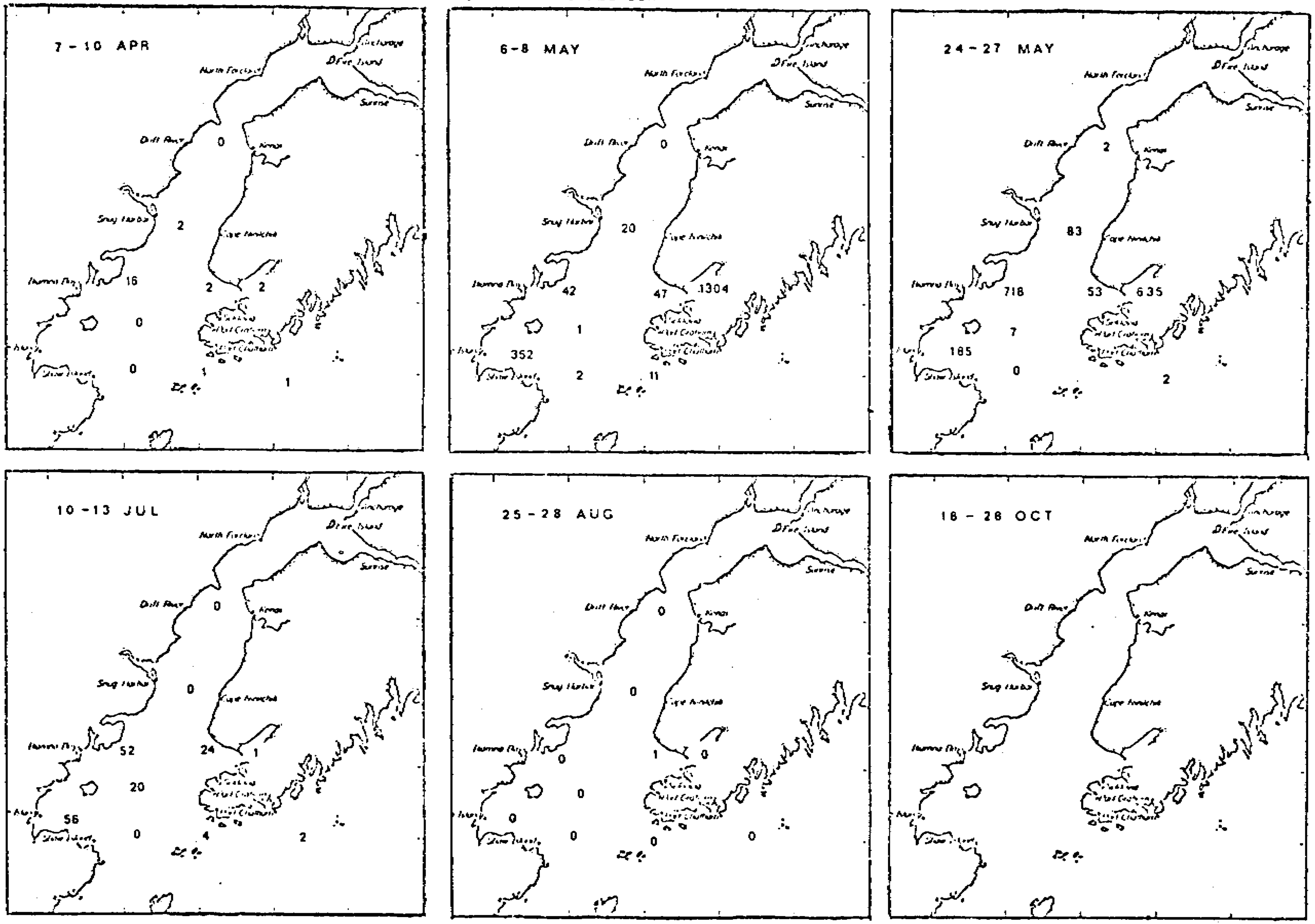


Fig. 3. Totals of fish eggs per station for five cruises.

INTERMEDIATE FISH EGGS (1.30 -2.54 mm diameter) PER BONGO NET TOW

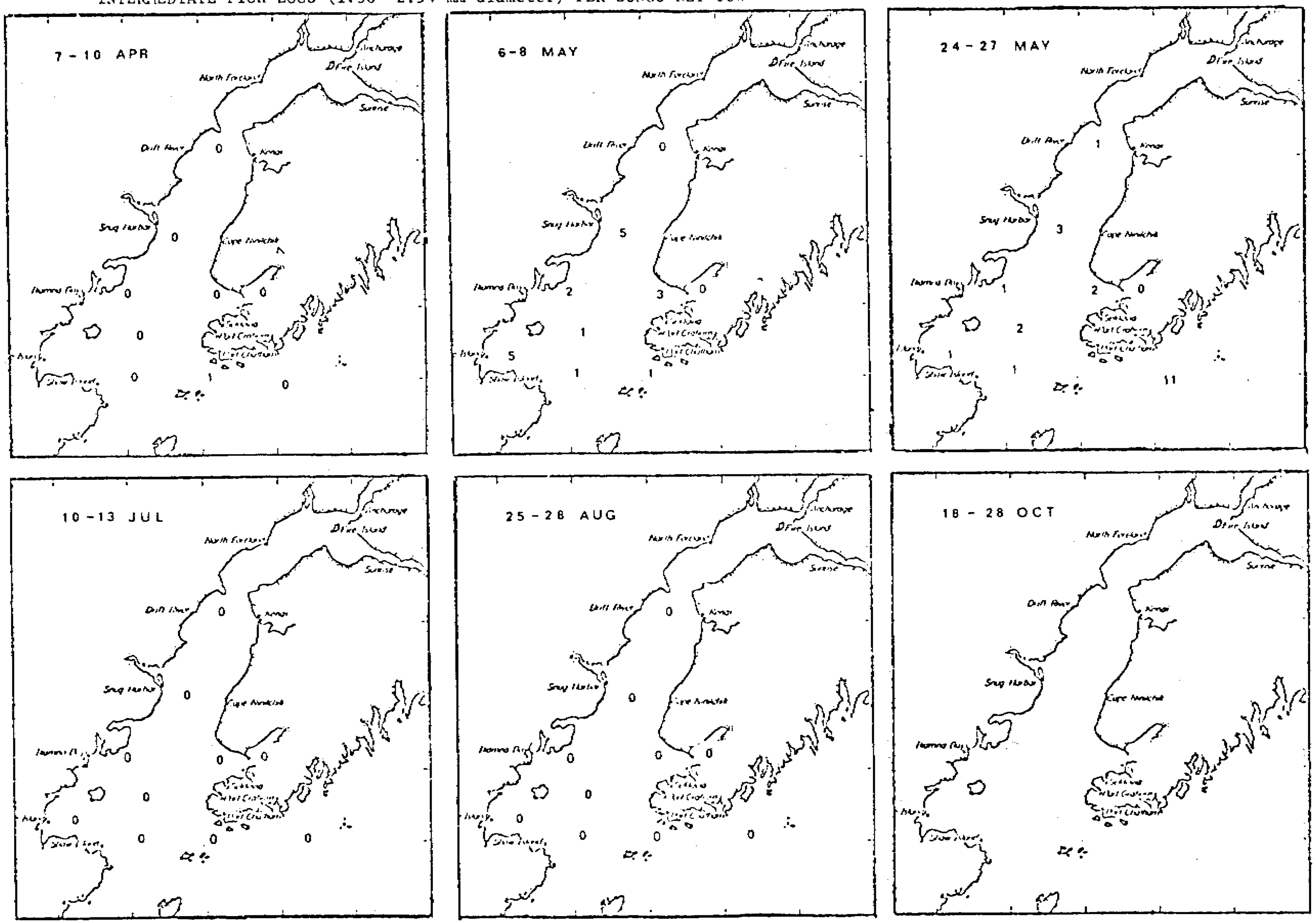


Fig. 4. Totals of fish eggs per station for five cruises.

LARGE FISH EGGS (2.56-3.90 mm diameter) PER BONGO NET TOW

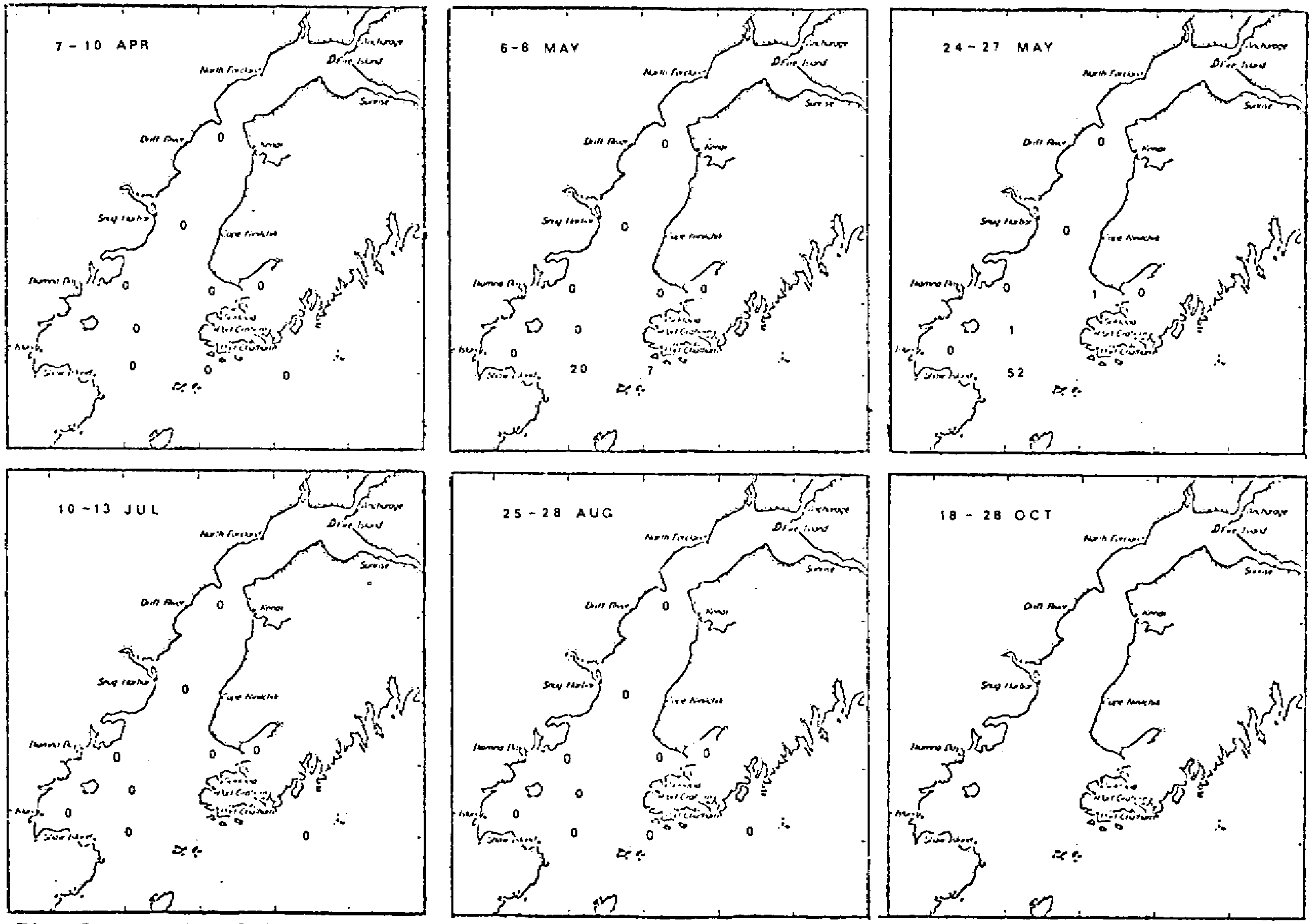


Fig. 5. Totals of fish eggs per station for five cruises.

TOTAL FISH EGGS PER BONGO NET TOW

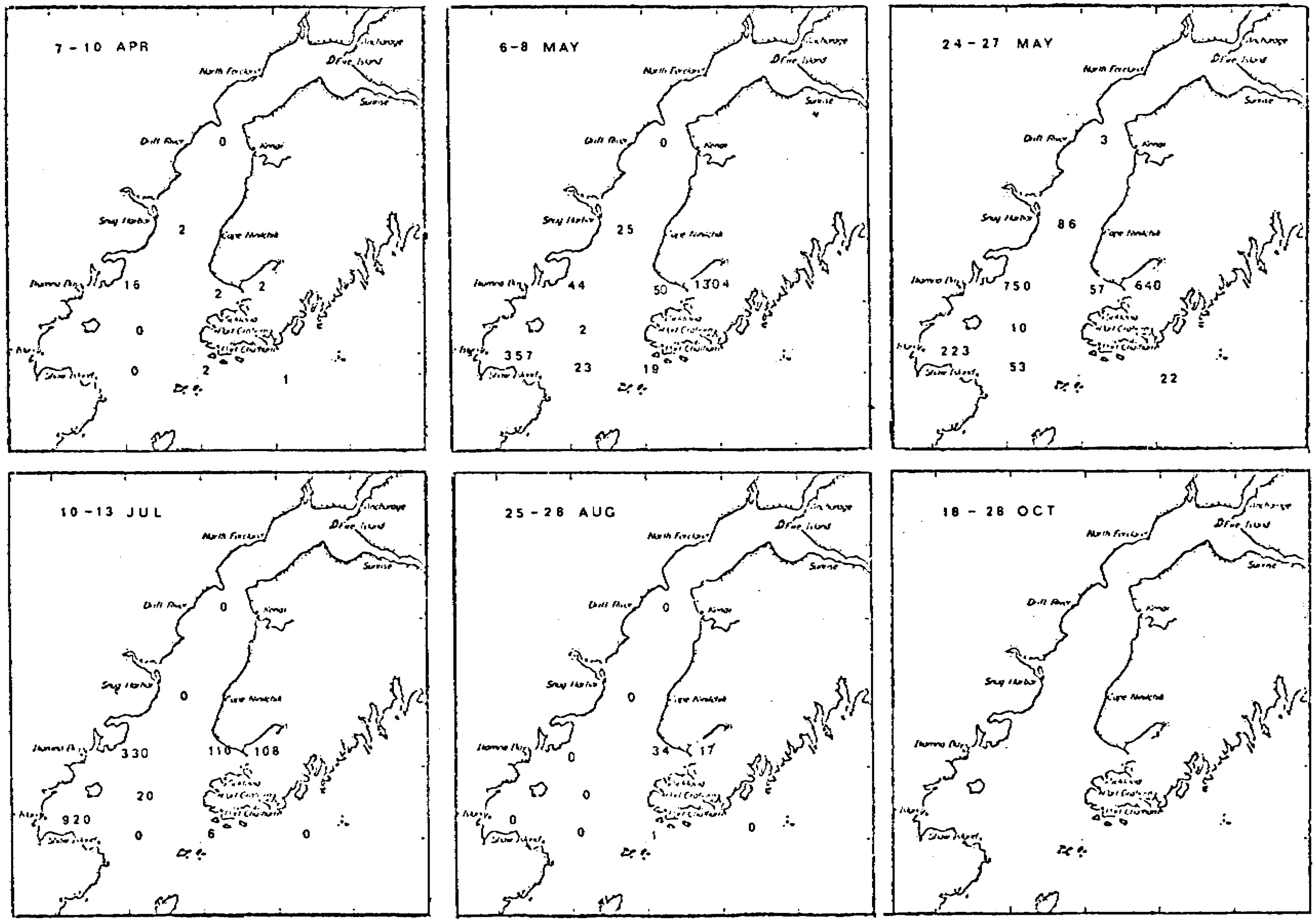


Fig. 6. Totals of fish eggs per station for five cruises.

Table 13. ACTIVITY / MILESTONE / DATA MANAGEMENT

Project Lower Cook Inlet Meroplankton (RU (156) 424) FY 1977

PI T. SAUNDERS ENGLISH

	ACTIVITY / MILESTONE / DATA MANAGEMENT	OCT 1	JAN 2	APR 3	JUL 4
1	AUTUMN SAMPLING	├─┤			
2	QUARTERLY REPORT 1		△		
3	SUBMIT SUMMER 76 CRUISE DATA (4[illegible] BONGO HAULS)			△	
4	WINTER-EARLY SPRING SAMPLING		├─┤		
5	QUARTERLY REPORT 2			△	
6	SUBMIT FALL 76 DATA (44 BONGO HAULS)				△
7	QUARTERLY REPORT 3				△
8	SUBMIT WINTER-EARLY SPRING 77 DATA (44 HAULS)				△
9	FINAL REPORT				△
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					

QUARTERLY REPORT

Research Unit #425
Reporting Period:
1 Oct 1976 - 31 Dec 1976
16 Pages

INITIAL ZOOPLANKTON INVESTIGATIONS IN LOWER COOK INLET

Dr. David M. Damkaer

Principal Investigator

Pacific Marine Environmental Laboratory

National Oceanic and Atmospheric Administration

3711 15th Avenue N.E.

Seattle, Washington 98105

(Report prepared by D. B. Dey and D. M. Damkaer)

28 December 1976

I. TASK OBJECTIVES

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, especially Lower Cook Inlet. 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.

II. FIELD AND LABORATORY ACTIVITIES

A. Field Studies

This project was first directed into Lower Cook Inlet in April of this year, and in subsequent months a total of five cruises were taken to Cook Inlet:

Cruise I	6 - 13 April 1976	NOAA DISCOVERER
Cruise II	5 - 9 May 1976	NOAA DISCOVERER
Cruise III	24 - 30 May 1976	NOAA DISCOVERER
Cruise IV	8 - 15 July 1976	U. of Alaska ACONA
Cruise V	24 - 31 Aug 1976	NOAA DISCOVERER

The cruises included transects across the open continental shelf, for comparative purposes. Cruises I, III, and V also included a transect into another inshore area. Station locations are shown in Figure 1.

Since this project has been terminated, there will be no additional field work. A final report will be submitted in March, 1977.

B. Methods

On the five cruises, zooplankton was sampled at noon and midnight with closing ring nets of 60 cm diameter and 211 μm mesh. These nets were hauled vertically through strata of varying thicknesses, obtaining discrete samples, depth permitting, as follows: 25-0 m; 50-25 m; 100-50 m; 300-100 m; 500-300 m; the bottom-500 m. In addition, at each station samples were obtained with a bongo net, mesh sizes of 333 and 505 μm, towed obliquely between the surface and 200 m.

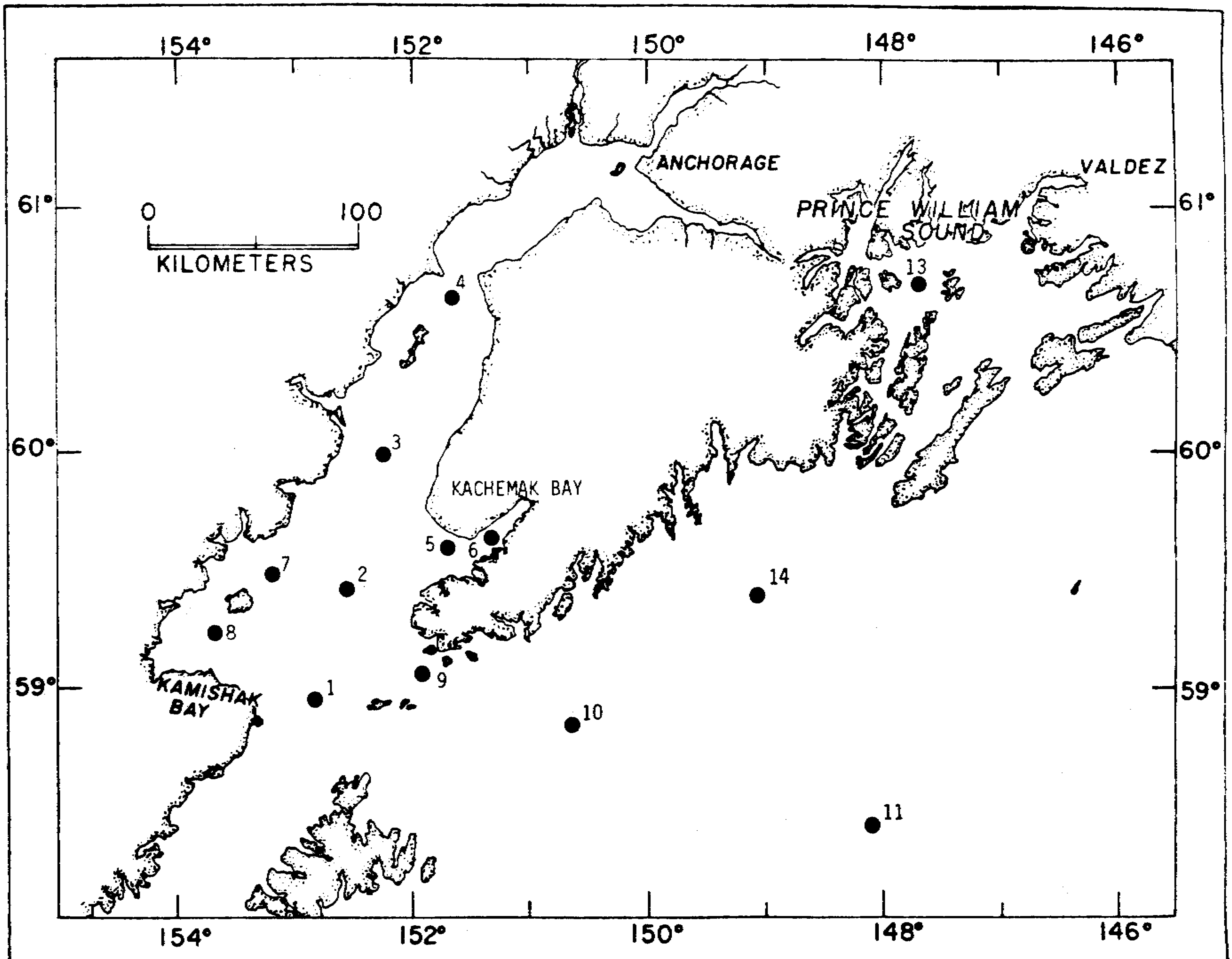


FIGURE 1. Station locations for Cook Inlet Cruises I-V, April - August 1976

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 little evidence of mesh clogging by phytoplankton, except in Kachemak Bay on Cruise II.

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. Displacement plankton volumes were determined on board during Cruises IV and V.

Laboratory analyses have proceeded primarily on the samples from the vertically-hauled nets from the five cruises. During this past quarter, work was concentrated on the Lower Cook Inlet samples collected on Cruises IV and V. The settled volumes and biomass concentrations were determined for a total of 38 samples, major groups were enumerated and species identified for 15 of the samples.

Data Processing: Data derived from laboratory analyses are recorded on easily read forms from which the key punching of data cards is done. The data are punched, the cards systematically verified and a duplicate copy is made of each deck of data cards to be submitted.

During the recent quarter, over 4,250 data cards covering five cruises from October 1975 - May 1976 were processed and submitted (Table 1).

Cruise	File I.D. #	Area Covered	# Samples
Surveyor, 3 Oct-10 Oct 1975	SU7501	Prince William Sound	142
Discoverer, 20 Oct-10 Nov 1975	DI7501	Gulf of Alaska	24
Discoverer, 6 Apr-13 Apr 1976	CI7601	Lower Cook Inlet Gulf of Alaska Prince William Sound	24 (LCI)
Discoverer, 5 May-9 May 1976	CI7602	Lower Cook Inlet Gulf of Alaska	12 (LCI)
Discoverer, 24 May-30 May 1976	CI7603	Lower Cook Inlet Gulf of Alaska Prince William Sound	17 (LCI)

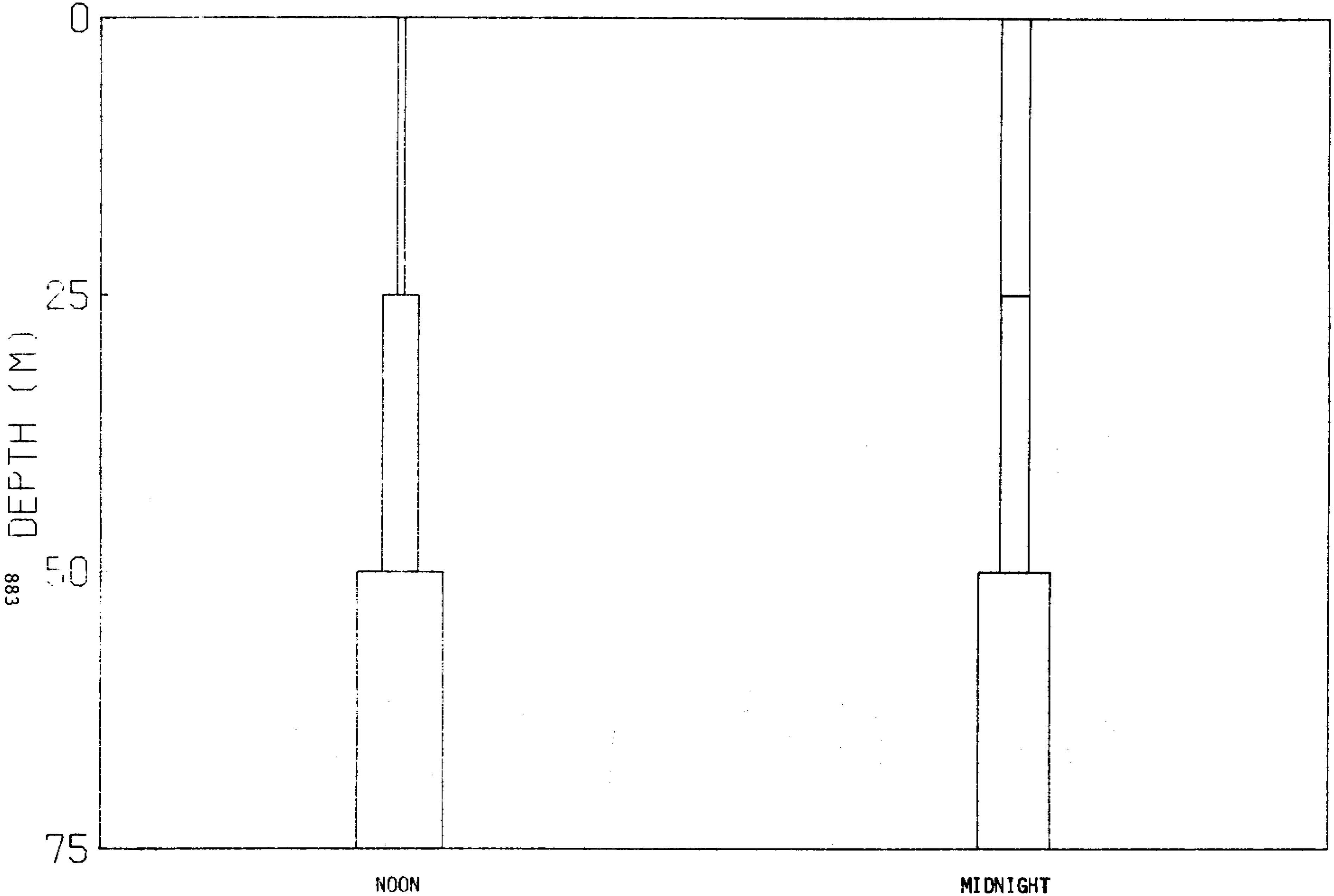
Table 1. Summary of Data Submitted on Punched Cards

III. RESULTS AND DISCUSSION

The plankton volumes for the entire water column at Kachemak Bay (Station 6), Lower Cook Inlet, as a measure of zooplankton biomass indicate that sometime after an apparent peak in spring a gradual decline occurred throughout the summer months (Figures 2-6).

Because of significant depth differences, it is perhaps most useful to compare plankton surface values (0-25 m) at Kachemak Bay with those of the more exposed stations of open Lower Cook Inlet (Figure 7). The general pattern of plankton standing stock with time at these stations contrasts noticeably with that of Kachemak Bay while comparing rather favorably with the Gulf of Alaska Station 11. No doubt the physical conditions found at the open Lower Cook Inlet stations more closely parallel what one finds at Station 11 and this situation clearly reflects the difficulties encountered in any attempt to generalize about the biology of an area as diverse and dynamic as Lower Cook Inlet.

The interpretations of zooplankton volumes, though obtained relatively quickly and simply, are complicated by the irregular occurrence of phytoplankton. Some phytoplankters form long intertwining chains and do not settle from the sample, but entangle zooplankton and other phytoplankton and give the appearance of a large plankton volume. For this reason, it is often easier and more revealing to compare the zooplankton of different times or areas by the kinds of plankton and their relative numerical abundance.

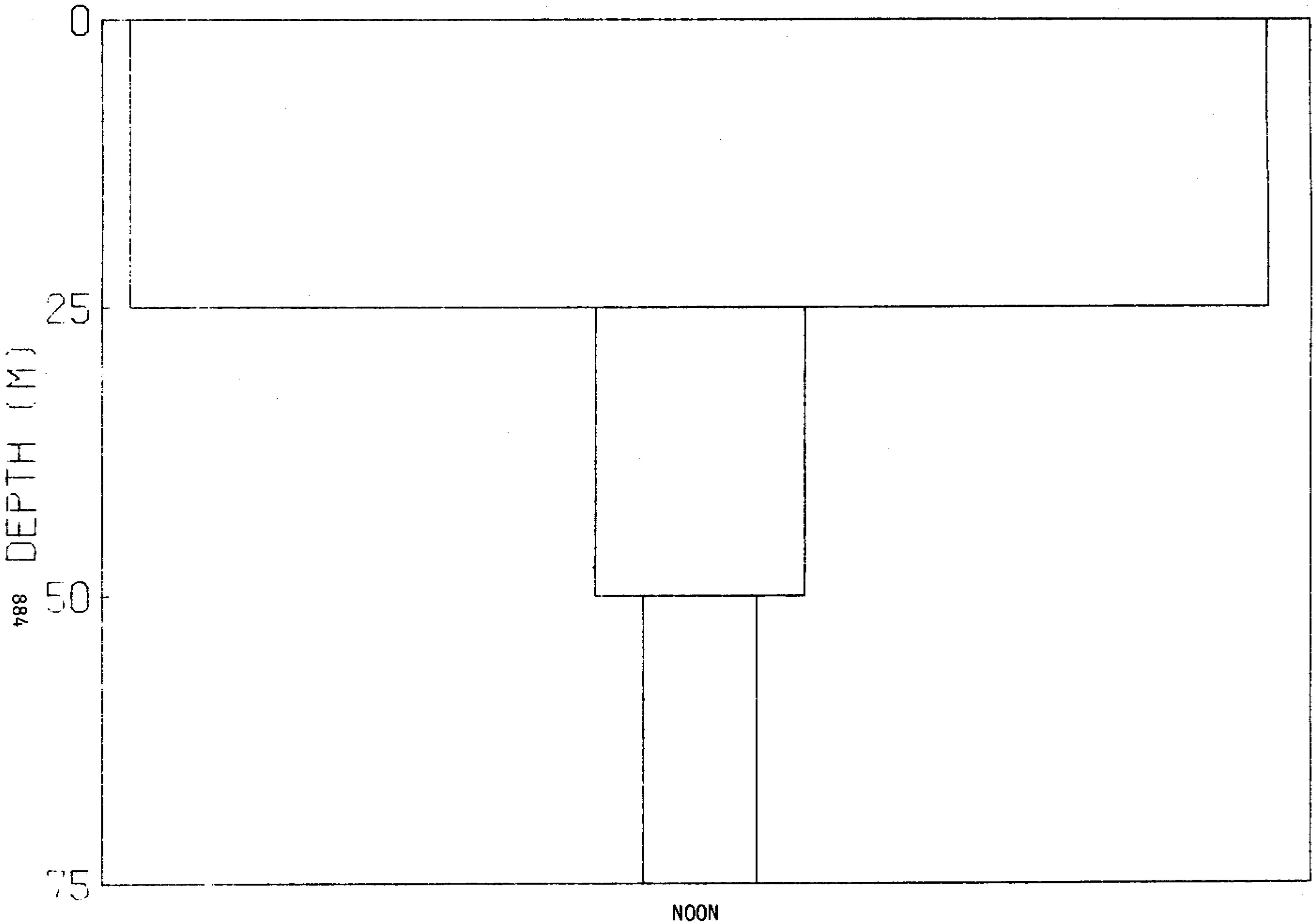


PLANKTON BIOMASS

FIGURE 2. KACHEMAK BAY, ALASKA

8-9 APRIL 1976

1 INCH = 2 ml/m^3

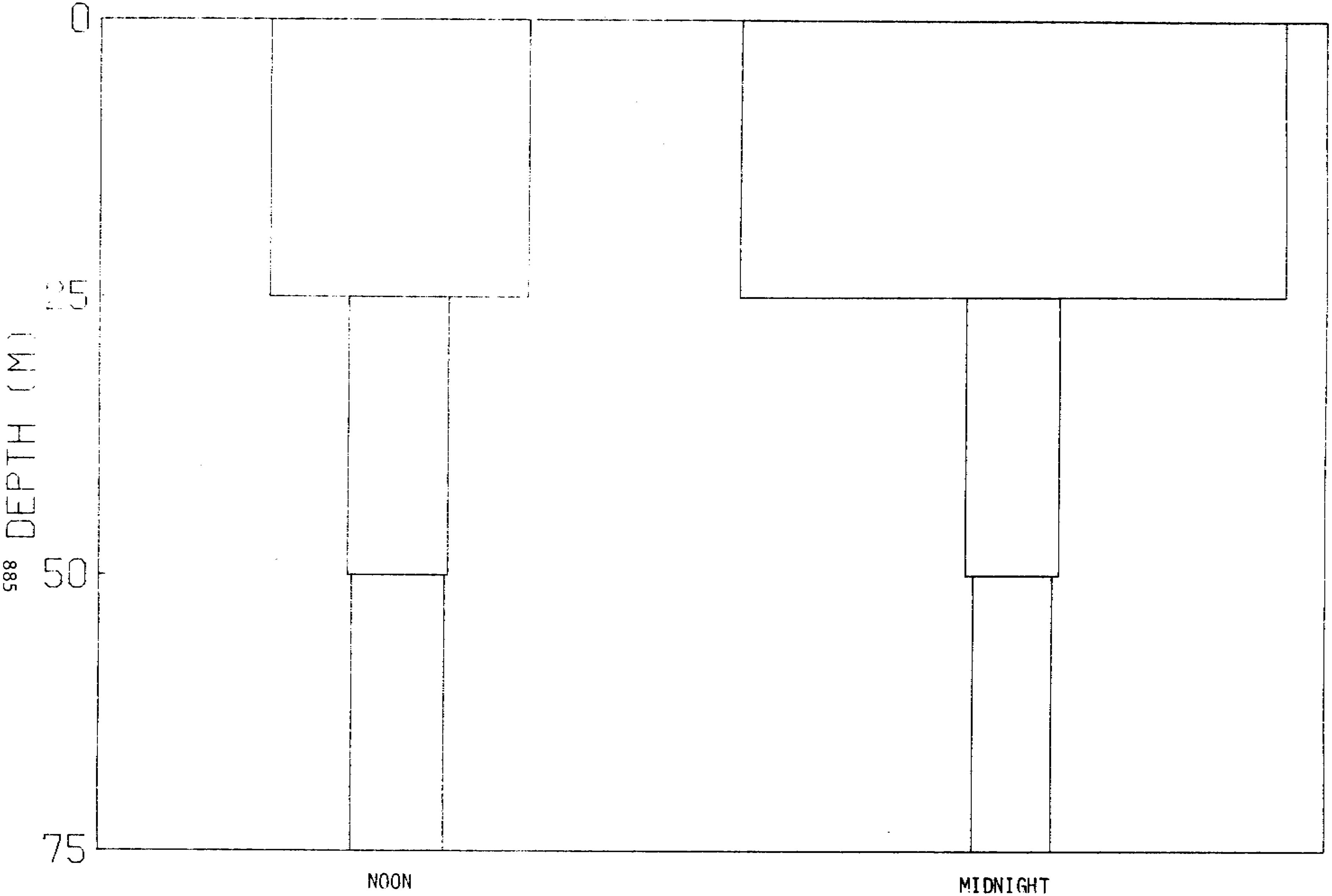


PLANKTON BIOMASS

FIGURE 3. KACHEMAK BAY, ALASKA

7 MAY 1976

1 INCH = 4 ml/m^3



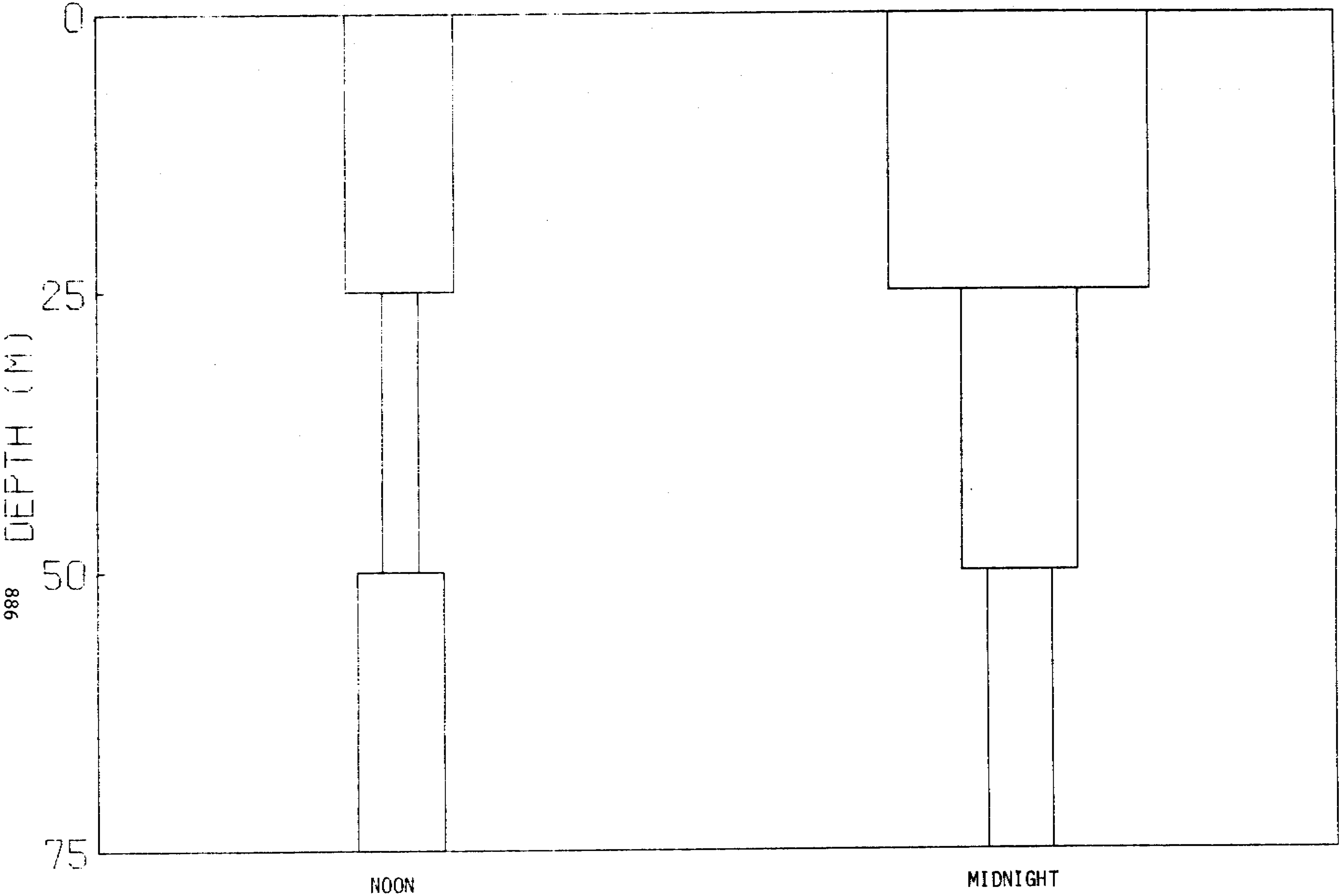
PLANKTON BIOMASS

FIGURE 4. KACHEMAK BAY, ALASKA

26 MAY 1976

1 INCH = 2 ml/m^3

988

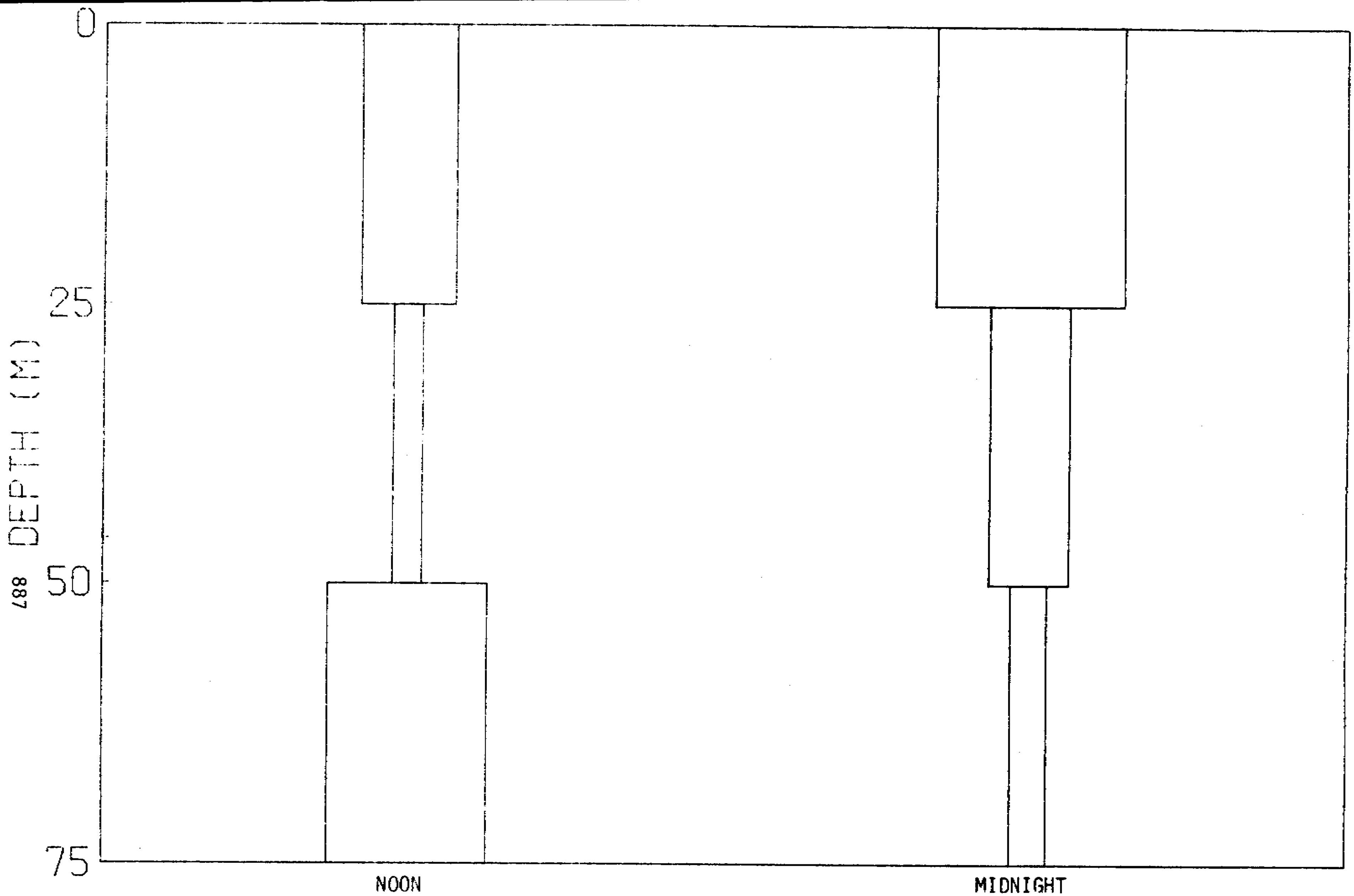


PLANKTON BIOMASS

FIGURE 5. KACHEMAK BAY, ALASKA

11 JULY 1976

1 INCH = 2 ml/m^3



PLANKTON BIOMASS

FIGURE 6. KACHEMAK BAY, ALASKA

26-27 AUGUST 1976

1 INCH = 2 ml/m^3

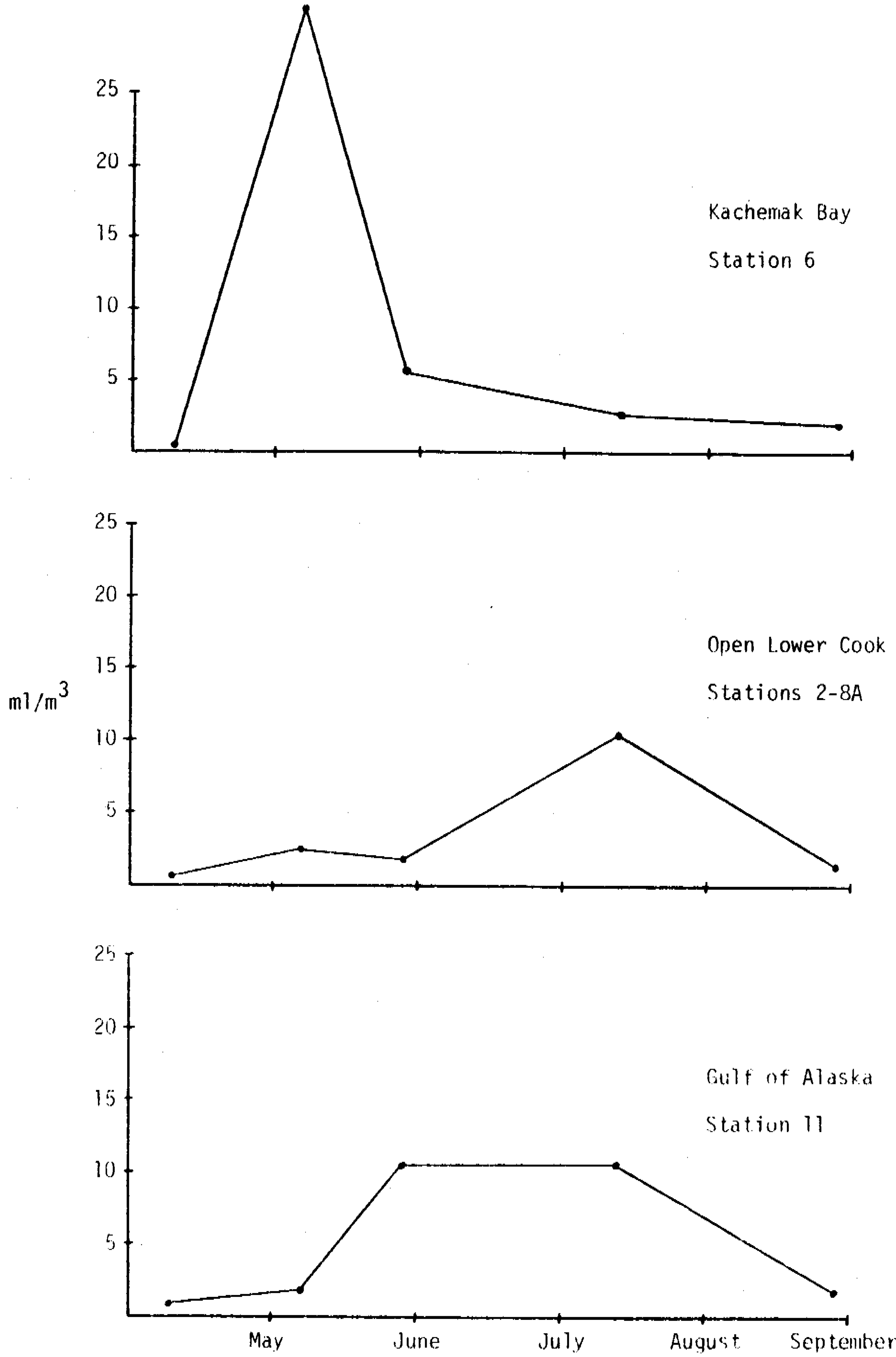


FIGURE 7. ZOOPLANKTON SETTLED VOLUMES, MEAN OF ALL SAMPLES. APRIL - AUGUST 1976; UPPER 25 m.

In Kachemak Bay, the largest numerical component of the zooplankton collected during these cruises was, throughout, the Copepoda. Within this group the three most abundant animals, Pseudocalanus spp., Acartia longiremis and Oithona similis, showed trends of increasing their numbers from spring through summer despite what appears to be an overall decline in total plankton volumes (Table 2). Also, analysis of samples from the last two cruises has resulted in the addition to the species list of two important but previously undetected species of copepod, Centropages abdominalis and Tortanus discaudatus, as well as several other species usually associated with the benthos and of less significant concentrations (Table 3). Additionally, the presence of Calanus glacialis was noted in samples from the two summer cruises, again confirming the extreme southern distribution of this Arctic species.

Chaetognaths were represented in Kachemak Bay by Sagitta elegans in July and August and after maintaining fairly constant concentrations from April to the end of May, sharp increases were recorded during these latter two cruises. The pattern for the group Euphausiacea somewhat paralleled that of Chaetognatha though the sharp summer increase was considerably less in magnitude and concentration values fell off again rather quickly by late August (Table 2).

Cirripede (barnacle) nauplii, which undoubtedly form an important food source for plankton-feeding animals, were very abundant in Kachemak Bay in early April, were replaced by smaller numbers of the more advanced larval form (cyprid) by early May, and by late May there were no specimens of either form collected in the vertical tows. Six weeks later, however, another generation was apparently well on its way as again the barnacle nauplii were found to be quite abundant and the concentration of the cyprid form was several times greater than recorded in early May. By late August, the nauplii and cyprids in the

	I (6-13 Apr)	II (5-9 May)	III (24-30 May)	IV (8-15 July)	V (24-31 Aug)
COPEPODA					
Pseudocalanus spp.	55.2	61.1	113.3	435.3	386.2
Acartia longiremis	38.2	109.4	13.4	374.0	731.7
Oithona similis	27.4	48.1	54.3	194.9	508.1
CHAETOGNATHA					
Sagitta elegans	3.7	2.8	3.3	47.2	101.6
CIRRIPEDIA					
Nauplii	372.6	0	0	118.8	650.4
Cyprids	0	2.8	0	9.8	20.3
Crab Larvae (Zoeae)	0.1	2.6	3.3	2.4	0
AMPHIPODA	0	0.1	0.02	0.1	0
EUPHAUSIACEA	1.7	1.9	4.0	25.4	0.6
Larval Fish	0	0.5	0.04	0.02	0.8
Fish Eggs	0	0.7	0	0.03	0

Table 2. Abundant Zooplankton Species and Important Groups, #/m^3 in Water Column; mean values. Kachemak Bay, Alaska, April - August 1976

Table 3. Zooplankton species and major groups, Kachemak Bay, Alaska April - August 1976

COPEPODA

Calanoida

- *Calanus cristatus*
- *C. glacialis*
- *C. marshallae*
- *Eucalanus* juveniles
- *Microcalanus* spp.
- *Pseudocalanus* spp.
- *Aetideus* sp.
- *Metridia lucens*
- *Centropages abdominalis*
- *Acartia clausii*
- *A. longiremis*
- *A. tumida*
- *Tortanus discaudatus*

Cyclopoida

- *Oithona similis*
- *Cyclopina* sp.
- *Oncaea borealis*

Harpacticoida

- *Tegastes* sp.
- *Tisbe gracilis*

Monstrilloida

CHAETOGNATHA

- *Sagitta elegans*

POLYCHAETA

MEDUSAE

GASTROPODA

CLADOCERA

- *Podon leuckarti*

CIRRIPEDIA

ANOMURA

BRACHYURA

ISOPODA

AMPHIPODA

MYSIDACEA

CUMACEA

EUPHAUSIACEA

- *Thysanoessa longipes*
- *T. raschii*

DECAPODA (misc.)

LARVACEA

- *Oikopleura* sp.

Larval fish

Fish eggs

water column had become extremely abundant and maxima for the five cruises were recorded (Table 2).

Crab larvae (zoeae), while not found in great numbers during Cruise I, reached moderate concentrations in the water column at Station 6 by Cruise II. These values fluctuated somewhat through Cruises III and IV (at stations in and near Kachemak Bay including Stations 2, 5, and 6) and by late August, no zoeae were found in the zooplankton samples (Table 2).

The Amphipoda of Kachemak Bay first showed their presence in the vertical hauls in early May, but in relatively low concentrations. The subsequent values found for this group remained less than $1/m^3$ in the water column in late May and early July. None was collected in the August samples (Table 2).

The highest ichthyoplankton concentrations were found in early May, during the apparent plankton biomass maximum in Kachemak Bay, and late August, with very low values found during the two cruises between these dates (Table 2).

Finally, from April through August at Station 6 in Kachemak Bay, there was a definite and consistent nighttime increase in total zooplankton volume in the surface layer (0-25 m). It is believed this is due to daily vertical migrations of zooplankton, particularly copepods. There was probably also some avoidance of the net during the daylight tows. The night volumes in the 0-25 m layer ranged from four times the day volumes in early April to approximately two times the day volumes in May, July and August (Figs. 2, 4-6).

Quarterly Report

Contract #03-5-022-56
Research Unit # 426
Task Order #13
Reporting Period 10/1 - 12/31/76
Number of Pages 2

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

Dr. R. Ted Cooney
Associate Professor of Marine Science
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

January 1, 1977

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 samples with bongo nets and NIO Tucker mid-water trawls.

B. A-22; summarize the existing literature and unpublished data on the transfer of synthesized organic matter of 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.

II. Field and Laboratory Activities

A. There was no field activity scheduled during this quarter.

B. Most samples reported as taken on Leg II, NOAA vessel Discoverer have been processed.

C. Dr. Conney participated in the Southern Bering Sea Workshop, Salishon Lodge, Oregon, October 3-6, 1976.

III. Results

Our effort this quarter has been spent entirely on sample processing. Until the data set is complete, there is little use in running the complex statistical and numerical analyses planned for these observations. I expect to begin the formal treatment of data and the development of the descriptions of the animal plankton and micronekton baseline immediately.

IV. Preliminary Interpretation of Results

Not applicable.

V. Problems Encountered/Recommended Changes

None.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 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 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	submitted		
Discoverer Leg II #808	6/2/75	6/19/75	submitted		
Discoverer Leg I #810	8/9/75	8/28/75	submitted		
Miller Freeman #815	11/10/75	11/26/75	submitted		
Contract #03-5-022-34	Last	Year	submitted		
Surveyor 001/2	3/76	4/76	submitted		
Discoverer 002	8/3/76	8/17/76	3/30/77[a]		

Notes: [1] Data Management Plan has been approved and made contractual. Format has been received and approved by all parties.

[a] Date of submission is dependent upon continuation and funding of this project in FY '77.

FISHERIES RESEARCH INSTITUTE
College of Fisheries
University of Washington
Seattle, Washington 98195

RU #485

ASSESSMENT OF PELAGIC AND NEARSHORE FISH IN THREE BAYS ON SOUTHEAST KODIAK ISLAND

Quarterly Progress Report
October 1 - December 31, 1976

by

Colin K. Harris
Project Leader

Allan C. Hartt
Principal Investigator

A contribution to biological information needed by OCSEAP in making decisions with respect to offshore oil leases. Work performed under proposal RU 485-76 Tasks A-7, A-8, A-9, A-11.

Date: 27 December 1976

Approved:

Robert L. Burgner, Director
Fisheries Research Institute

ASSESSMENT OF PELAGIC AND NEARSHORE FISH IN THREE BAYS ON SOUTHEAST KODIAK ISLAND

INTRODUCTION

This is the quarterly progress report for the period October 1 to December 31, 1976 on our pelagic and nearshore fish survey of Ugak, Kaiugnak, and Alitak bays on southeast Kodiak Island. It is the fourth report of the study; the preceding reports, two of which were monthly, together covered the period May 15 to September 30, 1976. The present report is a review of laboratory work and data analysis accomplished during the quarter, plus a brief analysis of catch data from the fourth and final cruise.

TASK OBJECTIVES

The objectives of this survey (Task Nos. A-7, A-8, A-9, and A-11) are to determine (1) the species composition of the pelagic and nearshore ichthyofauna of the three bays, (2) relative abundance by species, (3) age composition of abundant species by means of length frequency analysis, (4) food habits of abundant or otherwise major species, and (5) seasonal and diel migrations and changes in distribution. The purpose of this study is to provide baseline information on the pelagic and nearshore fish biota of southeast Kodiak Island for use by OCSEAP in making decisions with respect to petroleum resource development.

FIELD ACTIVITIES

Methods

Because field sampling ended immediately before the end of the last quarter, data from the fourth cruise was being keypunched and was not available for tabulation when the last progress report was in preparation. However, it is tabulated and briefly interpreted herein to aid NOAA/OCSEAP in its attempt to update and condense project results for BLM as frequently as feasible.

The fourth cruise of this study was conducted from August 26 through September 16, 1976 on the charterered R/V Commando, a 20.4 m fisheries research vessel maintained by the College of Fisheries, University of Washington. Personnel consisted of the three permanent crewmen of the Commando and four biologists: Colin Harris, FRI Biologist, Project Leader, Santiago Etchevers, FRI Biologist, and Steve Quinnell and Jeff Osborn, U of W fisheries student helpers.

Five types of gear were employed according to a predetermined sampling strategy. These were:

1. A 5 x 6 x 27 m Marinovitch midwater herring trawl with 2.1 x 1.5 m steel V-doors, and 5 cm body and 1.2 cm stretch cod end mesh.
2. A standard 6.1 x 3.1 x 15 m surface tow net with 7.6 cm outside, 1.9 - 3.8 cm body, and 0.6 cm stretch cod end mesh.
3. A 3 x 9.8 x 6 m try net (small otter trawl) with 3.3 cm stretch mesh in the body, 0.5 cm stretch mesh in the cod end, a cod end liner and tickler chain.
4. Two 46 x 2 m trammel nets with 51 cm stretch mesh in the outer panels and 5 cm stretch mesh in the inner panel.
5. A 47 x 3 m beach seine with 3.2 cm wing, 1 cm body, and 0.2 cm stretch inner mesh.

The midwater trawl was usually fished in the deeper midwater zone (5 - 27 m from the bottom), although several shallower hauls were made in each bay as well. The bathypelagic zone was emphasized as it consistently yielded larger and more diverse catches than did shallower waters. Tows were ten minutes long and covered about 1.3 km.

Townetting was done by towing the net on the surface between the Commando and a diesel-powered purse seine skiff so as to keep the net away from both propeller washes. The net was attached to two 3.7 m vertical steel poles which kept it open, and these poles were in turn attached to the 9 m bridles. At the end of a ten minute tow, covering about .74 km, the entire net was hoisted on board the Commando for emptying. To allow valid comparison of our results with past FRI tow net data from these bays, we duplicated past methods closely. This included using many of the transects and stations of past projects, and sampling exclusively at night in Ugak and Kaiugnak bays and in daytime in Alitak Bay. In the fourth cruise, a few experimental nighttime tows were made around Cape Hepburn in Alitak Bay as will be described.

Trynetting was done from the diesel-powered purse seine skiff with help from a model 8274 12-v Warn winch. Try net sites were selected in the second cruise on the basis of smooth and workable substrate, habitat type, and location in the bays. Trawl depths of 4, 9, and 13 m were maintained by a sounding line. Tows were ten minutes long and covered about .46 km depending on the force and direction of wind and current. Catches were bagged and labelled for processing on board the Commando.

The trammel nets and beach seine were set from a 4.6 m Delta Marine fiberglass skiff. The trammel nets were set off rocky points and bluffs and in kelp beds to sample littoral areas unworkable by the try net. The two nets were set together, one attached to and perpendicular to shore, and the second continuing from the first but parallel to shore. The sets were 2.5 or 5 hours long, and catches from the perpendicular and parallel nets were processed separately to allow inference about littoral movements. The beach seine was set by anchoring one end to shore and laying the net out from the skiff to form a semicircle. As the arc was closed, the seine was pulled to shore manually, and the catches were bagged and/or preserved for processing later.

Figures 1 - 3 show sampling transects and stations for all gear types. We attempted to sample exactly the same trammel net, beach seine, and try net sites during various cruises. However, adverse sea and/or weather conditions sometimes precluded replication at a site or necessitated replicate effort at another but proximate and similar site.

Our pelagic sampling and beach seining frequently yielded large catches of small, usually juvenile fish. If one or more species were abundant in the catch, a single random subsample was chosen to make a volume of 200, 500, or 1000 ml, depending on the size of the fish. This subsample was enumerated by species and usually retained for length measurements. The volume of the total catch was then found by water displacement, and thereby catch in numbers of each species could be estimated proportionately. Species represented in small numbers were first separated and counted directly. This volumetric estimation procedure was also used when fish were so mixed with large quantities of jellyfish or shrimp that separation and direct counting would have been impractical.

With very few exceptions, length measurements were recorded for all fish or a subsample of fish from every haul. A total of about 4718 individual measurements were recorded and 421 stomach samples from several species were preserved during the fourth cruise.

In most cases we recorded the predominant life history stage of each species caught. "Larvae" was recorded for any stage up to and including acquisition of postlarval traits, and "juvenile" usually signified young-of-the-year beyond the postlarval stage (as for Clupeidae, Salmonidae, Osmeridae, Gadidae, Gasterosteidae, Hexagrammidae, Ammodytidae, and Trichodontidae). Pleuronectids under about 150 mm were arbitrarily called "juvenile", however, as we could not distinguish with certainty young-of-the-year, and 150 mm was the size above which sexes were usually distinguishable. This length may not be attained until the third or even fourth year, depending on the species. For most other species, including cottids, scorpaenids, agonids, stichaeids, pholids, bathymasterids, liparids, and zaprorids, "juvenile" was recorded for fish in the smallest one or two apparent length classes.

The three bays were divided into various regions appropriate for the different gear types to permit inferences regarding distributional trends. These regions were selected to correspond to major ecological or hydrographic features such as head of bay, protected inlets, fjord, and so on (Figures 1-3), These regions have been redefined since the last progress report. While any distributional trends are not exactly comparable between these two reports, they will be in the final analysis of all four cruises.

To calculate the catch per unit of effort (CPUE) values used in the following section, a standard haul was defined for each type of gear. Within each combination of region, bay, and cruise, the total catch of a species was divided by the appropriate number of standard hauls. No attempt was made to adjust the data from the various gear types to make them comparable; that is, data from the various gear are analyzed and discussed separately. For the midwater trawl, tow net, and try net a standard haul was defined as one ten minute tow. A single set comprised one standard beach seine haul, and one 2.5 hour set of both trammel nets comprised a standard trammel net haul. Occasionally the trammel nets were set for longer periods, usually 5.0 hours, in which case the number of hauls was just the number of multiples of 2.5 (e.g., a 5.0 hour set becomes 2 standard hauls). Sets exceeding 2.5 hours were infrequent, so we consider insignificant any error accrued from the integrating effect of longer sets or from likely reduction of catchability as the nets fill with fish.

The fourth cruise resulted in 218 hauls, and consisted of six, three, and eight sampling days in Ugak, Kaiugnak, and Alitak bays, respectively (Table 1).

Results

Table 2 provides a checklist of all species caught during the fourth cruise, their occurrence by bay and gear type, and their relative abundance in terms of total catch in numbers. With this checklist as a reference, generic names will be abbreviated in subsequent tables and text. Also, species lists will be in order of decreasing abundance.

Consistent with results of the first three cruises, the Pacific sandfish (*T. trichodon*) and capelin (*M. villosus*) were by far the dominant surface and midwater species in the study area (Tables 3-8). The sandfish was the most abundant species in the surface waters of Ugak and Kaiugnak bays, and the capelin had mean CPUE values, respectively, about 10 and 35 times that of the pink salmon (*O. gorbuscha*), the third rank species (Tables 3 and 4). In the chiefly diurnal tow net catches from Alitak Bay, the capelin had a mean CPUE about 400 times that of the second most abundant resident, and the sandfish was not represented at all. In the midwater zone sandfish and capelin dominated the catches by a factor of at least 40, except in Alitak Bay where, again, the sandfish population is considerably depressed relative to the other bays (Tables 6 and 8). Sandfish and capelin were represented almost exclusively by juvenile forms in all depth strata.

Contrasting the earlier pelagic catches, juvenile greenling (*Hexagrammos* spp.; suspected Age I, that is, hatched the previous late summer) were only incidental region while the sandfish was principally found in the outer sector, in agreement with earlier findings. In the surface layer the capelin was most abundant in the easternmost part of the inner region. Juvenile pink salmon were by far most abundant in the middle region of Ugak Bay in the third cruise, while in the fourth cruise they were found in increasingly greater abundance toward the outer region of the bay (Table 3). This probably demonstrates their moving to the outer bay as part of their seaward migration. The capelin was found mostly in the outer half of Kaiugnak Bay in surface and midwater strata, and the sandfish was most abundant in surface waters in the inner region, as found earlier. Midwater sandfish catches, however, were greatest in the outer region. As before, the capelin was most abundant in the lower Deadman and/or Hepburn region(s) in both midwater and surface strata of Alitak Bay. Pink salmon catches in Alitak Bay were too small to permit interpretation regarding distribution.

The beach seine samples included several species also abundant in the pelagic zone, plus many generally benthic or littoral species as well (Tables 9-11). By far the most abundant intertidal species in all three bays was the Pacific sand lance (A. hexapterus), although the vast majority of the total catch came from relatively few hauls. This pattern of catch suggests that sand lance have a very patchy distribution, either closely associated with the bottom or schooling in dense aggregations along shore. Larval herring were caught in two hauls in Ugak Bay and in one haul in Alitak Bay. Juvenile masked and white-spotted greenlings (H. octogrammus and H. stelleri) were the most consistently abundant intertidal forms. Other species frequent in seine catches included great sculpin (M. polyacanthocephalus), rock sole (L. bilineata), silverspotted sculpin (B. cirrhosus), tubenose poacher (P. barbata), crescent gunnel (P. laeta), and Gymnocanthus spp. (comprised of G. galeatus and G. pistilliger which could not be separated in the field).

Trynetting yielded a greater number of species than did beach seining despite the constant problem of kelp clogging the opening of the trawl. The most common species in the subtidal zone were the rock sole (L. bilineata), yellowfin sole (L. aspera), masked greenling, whitespotted greenling,, Gymnocanthus spp., snake prickleback (L. sagitta), silverspotted sculpin, sturgeon poacher (P. acipenserinus, and rock greenling (H. lagocephalus) (Tables 12-14). The Pacific sand lance (A. hexapterus) was most abundant strictly by number, but the entire catch was from a single haul at 9 m depth along the northeast shore of the bay (Fig. 3). Interestingly, this haul was just offshore from the nearly simultaneous beach seine haul which yielded half of the total seine catch of sand lance from Alitak, indicating 1) that the aggregation was quite large, and 2) that the subtidal segment of the aggregation was, at least in part, closely associated with the bottom. There are several apparent distributional trends in the nearshore zone by depth and location within the respective bays. These will be reported after more thorough analysis. Species of zoogeographical interest caught incidentally by the try net are the Alaskan ronquil (B. caeruleofasciatus), Bering poacher (O. dodecaedron), Aleutian alligatorfish (A. bartoni), plain sculpin (M. jaok), antlered sculpin (E. diceraus), lingcod (O. elongatus), arctic shanny (S. punctatus), and manacled sculpin (S. gilli).

The trammel net catches again indicated a preponderance of greenlings in the nearshore rocky areas and kelp beds (Tables 15-17). The striking reversal in the relative abundances of flatfishes and greenlings between try net and trammel net catches perhaps reflects not only the respective habitat preferences of the two forms, but, in a synergistic fashion, respective gear avoidance abilities as well. In Ugak and Kaiugnak bays the rock greenling (H. lagocephalus) was the most abundant hexagrammid, followed in order by the masked greenling (H. octogrammus), whitespotted greenling (H. stelleri), and kelp greenling (H. decagrammus). Interestingly, the totals of 4 and 2 kelp greenling caught in the fourth cruise in the exposed nearshore zone of Ugak and Kaiugnak bays, respectively, comprised the only occurrences of the species in the entire study. Because the catches are so small, it is impossible to ascertain whether the resident kelp greenling population in each bay is very small so that finding the species only in the fourth cruise in two bays is a statistically reasonable result of our sampling effort, or whether the species has a more oceanic or at least outer-coastal distribution which fringes on the bays in late summer. In Alitak Bay the masked greenling was over three times as abundant as the other two common hexagrammid species in trammel net catches. In all bays the rock and masked greenlings were ending their spawning as evinced by the loss of spawning color in the males. The whitespotted greenling, however, was still in its spawning season as males were typically very dark and many females had ripe and running eggs. Notable incidental catches in the trammel net were the decorated warbonnet (C. polyactocephalus), Atka mackerel (P. monopterygius), and antlered sculpin (E. diceraus).

LABORATORY ACTIVITIES

To date all of the stomach samples from the first three cruises have been examined and the resulting data have been keypunched and verified. Fourth cruise samples are presently under examination and should be completed by the middle of January.

Analysis of fish specimens for purposes of identification has been completed, except for specimens of Sebastes mystinus which are receiving special scrutiny.

We are finishing our literature review of non-salmonid pelagic and nearshore fishes from the Gulf of Alaska and Bering Sea. Our attempt has been to emphasize zoogeographical, ecological, and life history aspects of various species to provide a background of information from which to interpret our own results. The salmonid literature is huge, and we are limiting our literature review of that group to avoid duplication of other efforts. Mainly we are relying on the findings of the FRI OCSEAP-sponsored salmonid literature review, R.U. 353, and unpublished data from past FRI tow net projects around Kodiak Island.

Much of our laboratory work in the last quarter has included these phases of data management and analysis: 1) keypunching and verifying raw data, 2) finishing a FORTRAN mapping program to convert our data from 80-column format to EDS 104-column tape format, and to make all format and/or code changes resulting from NODC's review of our data management plan, 3) writing several FORTRAN programs to scan data for keypunching or coding errors, 4) using CDC software facilities to edit data files when errors are found, and 5) using FORTRAN and SPSS programs to tabulate physical and catch data.

PROBLEMS ENCOUNTERED

Problems arising in this quarter have mainly involved data editing and analysis. Most of the analysis will of course involve EDS File Type 023 records 4 and 6, the catch data and individual measurement data. However, almost all of the pertinent key sort and analytical variables, including time of haul, temperature, salinity, tide stage, depth of tow, and habitat type, lie on records 1 and 2. It has required some effort in file manipulation and software programming to restructure the data files so that all pertinent variables lie on each case (i.e., card image) of records 4 and 6.

ESTIMATE OF FUNDS EXPENDED

By December 13, 1976 we have completely spent the original contract funds, and approximately $9,340 of the second contract additional allotment of $30,000. There is a balance of $20,680. Our major expenditures in this quarter have been salaries and wages, computer and data punching services, secretarial services, and indirect costs.

Table 1. Distribution of Cruise 4 sampling by bay and gear type.[1/]

Bay	Gear type and number of hauls					Total
	Midwater trawl	Tow net	Beach seine	Try net	Trammel net	
Ugak	19	20	13	20	4	76
Kaiugnak	7	10	9	12	2	40
Alitak	18	36	21	21	6	102
Total	44	66	43	53	12	218

[1/] A standard trammel net haul has been redefined as a 2.5-hr set of both net panels, and hence the number of hauls for this gear is exactly half of that reported earlier.

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance[1,2].

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Clupeidae									
Pacific herring *Clupea harengus pallasi*		x	x		x	x		x	A
Salmonidae									
Pink salmon *Oncorhynchus gorbuscha*	x		x			x	x	x	C
Chum salmon *Oncorhynchus keta*	x		x		x	x			I
Coho salmon *Oncorhynchus kisutch*	x		x			x		x	I
Sockeye salmon *Oncorhynchus nerka*	x					x			I
Dolly Varden *Salvelinus malma*			x		x	x	x	x	I
Osmeridae									
Surf smelt *Hypomesus pretiosus*			x			x			I
Capelin *Mallotus villosus*	x	x	x			x	x	x	V
Gadidae									
Pacific cod *Gadus macrocephalus*	x		x	x	x	x		x	I
Pacific tomcod *Microgadus proximus*	x			x		x	x		R

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance (cont'd)

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Walleye pollock *Theragra chalcogramma*		x		x		x	x	x	I
Zoarcidae									
Alaska eelpout *Bothrocara pusillum*		x						x	I
Gasterosteidae									
Threespine stickleback *Gasterosteus aculeatus*	x		x			x	x	x	I
Aulorhynchidae									
Tube-snout *Aulorhynchus flavidus*				x			x		R
Scorpaenidae									
Blue rockfish[3] *Sebastes mystinus*	x		x	x	x	x	x	x	I
Tiger rockfish *Sebastes nigrocinctus*	x							x	R
Hexagrammidae									
Kelp greenling *Hexagrammos decagrammus*				x	x	x	x		I
Rock greenling *Hexagrammos lagocephalus*			x	x	x	x	x	x	C
Masked greenling *Hexagrammos octogrammus*			x	x	x	x	x	x	A

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance (cont'd)

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Whitespotted greenling *Hexagrammos stelleri*	x	x	x	x	x	x	x	x	A
Lingcod *Ophiodon elongatus*	x							x	R
Atka mackerel *Pleurogrammos monopterygius*					x			x	R
Cottidae									
Unidentified Cottidae			x				x		
Padded sculpin *Artedius fenestralis*			x			x		x	I
Crested sculpin *Blepsias bilobus*	x	x		x	x	x		x	I
Silverspotted sculpin *Blepsias cirrhosus*			x	x		x	x	x	C
Buffalo sculpin *Enophrys bison*			x	x		x	x		R
Antlered sculpin *Enophrys diceraus*				x	x	x		x	R
Soft sculpin *Gilbertidia sigalutes*		x				x			R
Gymnocanthus spp. (suspected *G. galeatus* and *G. pistilliger*)			x	x		x	x	x	C

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance (cont'd)

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Red Irish Lord *Hemilepidotus hemilepidotus*				x			x		R
Yellow Irish Lord *Hemilepidotus jordani*	x	x	x	x	x	x	x	x	I
Pacific staghorn sculpin *Leptocottus armatus*			x	x	x	x		x	I
Plain sculpin *Myoxocephalus jaok*				x		x		x	I
Great sculpin *Myoxocephalus polyacanthocephalus*			x	x	x	x	x	x	C
Shorthorn sculpin *Myoxocephalus scorpius*			x	x	x	x	x	x	I
Manacled sculpin *Synchirus gilli*				x			x		R
Ribbed sculpin *Triglops pingeli*				x		x		x	R
Agonidae									
Aleutian alligatorfish *Aspidophoroides bartoni*				x		x			R
Bering poacher *Occella dodecaedron*				x		x			R

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance (cont'd)

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Tubenose poacher *Pallasina barbata*	x		x	x		x	x	x	C
Sturgeon poacher *Podothecus acipenserinus*	x			x	x	x	x	x	I
Cyclopteridae									
Smooth lumpsucker *Aptocyclus ventricosus*		x						x	R
Ribbon snailfish *Liparis cyclopus*				x		x			R
Trichodontidae									
Pacific sandfish *Trichodon trichodon*	x	x	x	x		x	x	x	V
Bathymasteridae									
Alaskan ronquil *Bathymaster caeruleofasciatus*				x		x			R
Searcher *Bathymaster signatus*				x		x			R
Stichaeidae									
High cockscomb *Anoplarchus purpurescens*				x		x			R
Decorated warbonnet *Chirolophis polyactocephalus*					x			x	R

Table 2. List of all species caught in Cruise 4, by gear type, location, and relative abundance (cont'd)

Species	Gear type					Location			Relative abundance
	Tow net	Midwater trawl	Beach seine	Try net	Trammel net	Ugak Bay	Kaiugnak Bay	Alitak Bay	
Butter sole *Isopsetta isolepis*				x		x	x		I
Rock sole *Lepidopsetta bilineata*			x	x	x	x	x	x	A
Yellowfin sole *Limanda aspera*				x	x	x	x	x	A
Starry flounder *Platichthys stellatus*			x	x	x	x	x	x	I
Sand sole *Psettichthys melanostictus*			x	x		x	x	x	I

[1]Relative abundance categories were arbitrarily defined on the basis of total catch in numbers over the entire cruise: R = rare (1-5), I = infrequent (6-100), C = common (101-450), A = abundant (451-15000), V = very abundant (>15001).

[2]Nomenclature is standardized according to Bailey, R.M., 1970, A list of common and scientific names of fishes from the United States and Canada, AFS Spec. Pub. No. 6, 3rd edition.

[3]See footnote on page 6 of the text regarding this identification.

Table 3. Cumulative tow net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (7 hauls)		Middle (7 hauls)		Outer (6 hauls)		Total (20 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
T. trichodon	1009	144.14	393	56.14	1271	211.83	2673	133.65
juveniles	1009	144.14	393	56.14	1271	211.83		
M. villosus	875	125.0	50	7.1	192	32.0	1117	55.85
larvae	300	42.86						
juveniles	575	82.14	50	7.1	192	32.0		
O. gorbuscha	5	.71	44	6.29	65	10.83	114	5.70
juveniles	5	.71	44	6.29	65	10.83		
S. mystinus			5	.71	5	.83	10	.50
juveniles			5	.71	5	.83		
O. keta	1	.14	5	.71			6	.30
juveniles	1	.14	5	.71				
O. nerka	2	.29	3	.43	1	.17	6	.30
juveniles	2	.29	3	.43	1	.17		
G. aculeatus	3	.43	2	.29			5	.25
juveniles	3	.43	2	.29				
O. kisutch			4	.57			4	.20
juveniles			4	.57				

Table 3. Cumulative tow net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (7 hauls)		Middle (7 hauls)		Outer (6 hauls)		Total (20 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
L. sagitta			2	.29	2	.33	4	.20
juveniles			2	.29	2	.33		
A. hexapterus	3	.43					3	.15
juveniles	3	.43						
T. chalcogramma	1	.14						
juvenile							1	.05
Hexagrammos sp.	1	.14						
juvenile							1	.05
B. bilobus	1	.14					1	.05
juvenile								
H. jordani					1	.17	1	.05
juvenile								
P. barbata			1	.14			1	.05
juvenile								
P. acipenserinus					1	.17	1	.05
juvenile								

Table 4. Cumulative tow net catches of all species from two regions of Kaiugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (4 hauls)		Outer (6 hauls)		Total (10 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
T. trichodon	341	85.25	12	2.0	353	35.30
juveniles	341		12	2.0		
M. villosus	15	3.75	125	20.83	140	14.00
juveniles	15	3.75	125	20.83		
O. gorbuscha	2	.50	2	.33	4	.40
juveniles	2	.50	2	.33		
Z. silenus			3	.50	3	.30
juveniles			3	.50		
G. aculeatus			2	.33	2	.20
juveniles			2	.33		
H. elassodon	1	.25	1	.17	2	.20
juveniles	1	.25	1	.17		

Table 5. Cumulative tow net catches of all species from five regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Deadman (10 hauls)		Hepburn (12 hauls)		Westside (3 hauls)		Middle (5 hauls)		Outer (6 hauls)		Total (36 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
M. villosus	2	.20	6697	558.08			1	.20			6700	186.11
larvae			6200	516.67								
juveniles	2	.20	497	41.42			1	.20				
G. aculeatus	1	.10	11	.92			2	.40	3	.50	17	.47
juveniles			11	.92			2	.40	1	.17		
adults	1	.10							2	.33		
O. gorbuscha	4	.40	3	.25	1	.33					8	.22
juveniles	4	.40	3	.25	1	.33						
S. mystinus							1	.20	1	.17	2	.06
juveniles							1	.20	1	.17		
O. kisutch			1	.08							1	.03
juvenile												
G. macrocephalus			1	.08							1	.03
juvenile												
S. nigrocinctus									1	.17	1	.03
juvenile												
H. lagocephalus							1	.20			1	.03
juvenile												
O. elongatus							1	.20			1	.03
juvenile												
B. bilobus					1	.33					1	.03
adult												

Table 5. Cumulative tow net catches of all species from five regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Deadman (10 hauls)		Hepburn (12 hauls)		Westside (3 hauls)		Middle (5 hauls)		Outer (6 hauls)		Total (36 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
H. jordani juvenile			1	.08							1	.03
P. barbata adult			1	.08							1	.03
A. hexapterus adult							1	.20			1	.03

Table 6. Cumulative midwater trawl catches of all species from three regions of Ugak Ba,, Cruise 4. CPUE values are mean catches per unit effort (cumulative catch/number of hauls).

Species	Inner (7 hauls)		Middle (6 hauls)		Outer (6 hauls)		Total (19 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
T. trichodon	980	140.00	597	99.50	11558	1926.33	13135	691.32
juveniles	930	140.00	597	99.50	11558	1926.33		
M. villosus	455	65.00	4670	778.33	177	29.50	5302	279.05
juveniles	455	65.00	4670	778.33	177	29.50		
L. sagitta	4	.57					4	.21
adults	4	.57						
T. chalcogramma	2	.29					2	.11
juveniles	2	.29						
B. bilobus	2	.29					2	.11
adults	2	.29						
G. sigalutes	2	.29					2	.11
juveniles	2	.29						

Table 7. Cumulative midwater trawl catches of all species from two regions of Kaiugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (3 hauls)		Outer (4 hauls)		Total (7 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
M. villosus			1742	435.50	1742	248.86
juveniles			1742	435.50		
T. trichodon	26	8.67	721	180.25	747	106.71
juveniles	26	8.67	721	180.25		
T. chalcogramma	2	.67	16	4.00	18	2.57
juveniles	2	.67	16	4.00		

Table 8. Cumulative midwater trawl catches of all species from four regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Deadman (6 hauls)		Hepburn (3 hauls)		Middle (4 hauls)		Outer (5 hauls)		Total (18 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
M. villosus	5688	948.00	754	251.33	217	54.25	162	32.40	6821	378.94
juveniles	396	66.00	103	34.33	217	54.25	88	17.60		
adults	2078	346.33	651	217.00			74	14.80		
Lumpenus spp.[1]	100	16.67	225	75.00					325	18.06
larvae	100	16.67	225	75.00						
L. medius	321	54.00			72	18.00	100	20.00	496	27.56
larvae	321	54.00			72	18.00	100	20.00		
C. h. pallasi							128	25.60	128	7.11
adults							128	25.60		
T. trichodon					1	.25	121	24.20	122	6.78
juveniles							121	24.20		
adults					1	.25				
A. hexapterus							64	12.80	64	3.56
juveniles							56	11.20		
adults							8	1.60		
B. pusillum	32	5.33							32	1.78
adults	32	5.33								
T. chalcogramma							2	.40	2	.11
juveniles							2	.40		
Z. silenus							2	.40	2	.11
juveniles							2	.40		

Table 8. Cumulative midwater trawl catches of all species from four regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Deadman (6 hauls)		Hepburn (3 hauls)		Middle (4 hauls)		Outer (5 hauls)		Total (18 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
H. stelleri juvenile							1	.20	1	.06
B. bilobus adult							1	.20	1	.06
H. jordani adult							1	.20	1	.06
A. ventricosus adult	1	0.17							1	.06

[1]These are probably mostly *L. medius*.

Table 9. Cumulative beach seine catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner	(7 hauls)	Middle	(2 hauls)	Outer	(4 hauls)	Total	(13 hauls)
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
C. h. pallasi	1200	171.43					1200	92.31
larvae	1200	171.43						
A. hexapterus			649	324.5	480	120.00	1129	86.85
juveniles					19	4.75		
adults			649	324.5	412	103.00		
M. villosus	200	28.57					200	15.38
larvae	200	28.57						
H. pretiosus					55	13.75	55	4.23
juveniles					55	13.75		
L. bilineata	3	.43	11	5.50	31	7.75	45	3.46
juveniles					2	.50		
adults	3	.43	4	2.00				
P. barbata	35	5.00	8	4.00	1	.25	44	3.38
juveniles	6	.86			1	.25		
adults			8	4.00				
T. trichodon			1	.50	41	10.25	42	3.23
juveniles			1	.50	41	10.25		
H. octogrammus	29	4.14					29	2.23

Table 9. Cumulative beach seine catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Inner	(7 hauls)	Middle	(2 hauls)	Outer	(4 hauls)	Total	(13 hauls)
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
M. polyacanthocephalus	11	1.57	12	6.00	4	1.00	27	2.08
juveniles	3	.43			1	.25		
adults	3	.43			3	.75		
B. cirrhosus	10	1.43	12	6.00	1	.25	23	1.77
juveniles	10	1.43	12	6.00	1	.25		
H. lagocephalus	8	1.14	10	5.00	2	.50	20	1.54
juveniles	8	1.14	10	5.00				
P. stellatus	1	.14			12	3.00	13	1.00
adults	1	.14			12	3.00		
S. malma	7	1.00			5	1.25	12	.92
juveniles	5	.71						
adults	2	.29			5	1.25		
Gymnocanthus spp.	4	.57	8	4.00			12	.92
juveniles	4	.57						
H. stelleri	6	.86	5	2.50			11	.85
juveniles	6	.86	5	2.50				
P. laeta	10	1.43					10	.77
adults	10	1.43						
O. keta	6	.86					6	.46
juveniles	6	.86						

Table 9. Cumulative beach seine catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Inner (7 hauls)		Middle (2 hauls)		Outer (4 hauls)		Total (13 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
G. macrocephalus					5	1.25	5	.38
juveniles					5	1.25		
G. aculeatus	3	.43					3	.23
juveniles	3	.43						
S. mystinus	1	.14			2	.50	3	.23
juveniles	1	.14			2	.50		
A. fenestralis	3	.43					3	.23
juveniles	3	.43						
L. armatus	2	.29			1	.25	3	.23
juveniles					1	.25		
adults	2	.29						
P. melanostictus					2	.50	2	.15
adults					2	.50		
O. kisutch	1	.14					1	.08
juvenile								
H. jordani	1	.14					1	.08
juvenile								
M. scorpius	1	.14					1	.08
juvenile								

Table 10. Cumulative beach seine catches of all species from two regions of Kaiugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (5 hauls)		Outer (4 hauls)		Total (9 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
A. hexapterus	3067	613.40	125	31.25	3192	354.67
juveniles			125	31.25		
adults	3067	613.40				
H. octogrammus	23	4.60	85	21.25	108	12.00
juveniles	6	1.20	1	.25		
B. cirrhosus			28	7.00	28	3.11
juveniles			28	7.00		
M. polyacanthocephalus	21	4.20	5	1.25	26	2.89
juveniles	9	1.80	1	.25		
adults	4	.80				
H. lagocephalus	23	4.60	1	.25	24	2.67
juveniles	22	4.40	1	.25		
adults	1	.20				
H. stelleri	11	2.20	12	3.00	23	2.56
juveniles	11	2.20	10	2.50		
P. barbata	3	.60	9	2.25	12	1.33
adults	3	.60				
P. laeta			11	2.75	11	1.22
adults			11	2.75		
M. scorpius			4	1.00	4	.44
juveniles			1	.25		
adults			3	.75		
P. stellatus	4	.80			4	.44
juveniles	4	.80				
L. bilineata	2	.40			2	.22
adults	2	.40				
S. malma adult	1	.20			1	.11
Unidentified Cottidae juvenile	1	.20			1	.11

Table 11. Cumulative beach seine catches of all species from four regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Deadman	(7 hauls)	Eastside	(5 hauls)	Westside	(6 hauls)	Tannerhead	(3 hauls)	Total	(21 hauls)
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
A. hexapterus	6312	901.71	20008	4001.60	77	12.83	18	6.00	26415	1257.86
juveniles			13346	2669.2						
adults	72	10.29			77	12.83				
H. stelleri	74	10.57	8	1.60	127	21.17			209	9.95
juveniles	24	3.43	8	1.60	127	21.17				
H. octogrammus	95	13.57	1	.20	67	11.17			163	7.76
juveniles			1	.20	9	1.50				
adults	18	2.57								
C. h. pallasi	2	.29	108	21.60					110	5.24
larvae	2	.29	108	21.60						
M. polyacanthocephalus	25	3.57			37	6.17	1	.33	63	3.00
juveniles	25	3.57					1	.33		
adults					3	.50				
L. bilineata	1	.14	27	5.40	2	.33	28	9.33	58	2.76
juveniles	1	.14			2	.33	27	9.00		
adults			2	.40			1	.33		
S. malma	29	4.14							29	1.38
adults	13	1.86								
Gymnocanthus spp.			17	3.40	2	.33	5	1.67	24	1.14
juveniles			17	3.40	2	.33	5	1.67		
L. armatus					2	.33	13	4.33	15	.71
juveniles					1	.17				
adults					1	.17	13	4.33		

Table 11. Cumulative beach seine catches of all species from four regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Deadman (7 hauls)		Eastside (5 hauls)		Westside (6 hauls)		Tannerhead (3 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
O. gorbuscha	4	.57			10	1.67			14	.67
juveniles	4	.57								
adults					10	1.67				
P. stellatus					2	.33	12	4.00	14	.67
juveniles							7	2.33		
adults					2	.33				
O. kisutch	11	1.57	1	.20					12	.57
juveniles	9	1.29	1	.20						
adults	2	.29								
M. scorpius	1	.14			11	1.83			12	.57
juveniles	1	.14			3	.50				
adults					8	1.33				
P. barbata	2	.29			5	.83	1	.33	8	.38
juveniles	2	.29			5	.83	1	.33		
P. laeta	2	.29			6	1.0			8	.38
adults	2	.29			6	1.0				
B. cirrhosus	1	.14			5	.83	1	.33	7	.33
juveniles	1	.14			5	.83	1	.33		
P. melanostictus							7	2.33	7	.33
juveniles							7	2.33		

Table 11. Cumulative beach seine catches of all species from four regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Deadman (7 hauls)		Eastside (5 hauls)		Westside (6 hauls)		Tannerhead (3 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
T. trichodon							6	2.00	6	.29
juveniles							6	2.00		
H. jordani	3	.43			2	.33			5	.24
juveniles	3	.43								
adults					2	.33				
A. fenestralis					3	.50			3	.14
juveniles					3	.50				
S. mystinus					1	.17			1	.05
juvenile										
H. lagocephalus					1	.17			1	.05
juvenile										
L. sagitta	1	.14							1	.05
adult										

Table 12. Cumulative try net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (3 hauls)		Middle (9 hauls)		Outer (8 hauls)		Total (20 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
L. aspera	207	69.00	170	18.89	5	.63	382	19.10
juveniles	42	14.0	50	5.56	5	.63		
L. bilineata	11	3.67	112	12.44	118	14.75	241	12.05
juveniles			72	8.00	15	1.88		
adults	11	3.67	5	.56	43	5.38		
Gymnocanthus spp.	77	25.67	13	1.44			90	4.50
adults	57	19.00	5	.56				
L. sagitta	1	.33	5	.56	75	9.38	81	4.05
juveniles			3	.33	65	8.13		
adults	1	.33	2	.22				
P. barbata			14	1.56	28	3.50	42	2.10
juveniles			14	1.56	28	3.50		
P. acipenserinus			14	1.56	20	2.50	34	1.62
juveniles					12	1.50		
adults			14	1.56	8	1.00		
H. stelleri	8	2.67	16	1.78	5	.63	29	1.45
juveniles	3	1.00	11	1.22	5	.63		
adults	5	1.67	2	.22				

Table 12. Cumulative try net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (3 hauls) No.	Inner CPUE	Middle (9 hauls) No.	Middle CPUE	Outer (8 hauls) No.	Outer CPUE	Total (20 hauls) No.	Total CPUE
B. cirrhosus			20	2.22	5	.63	25	1.25
juveniles			13	1.44	5	.63		
adults			7	.78				
T. trichodon			2	.22	19	2.38	21	1.05
juveniles			2	.22	19	2.38		
P. melanostictus			12	1.33	7	.88	19	.95
juveniles					1	.13		
adults			12	1.33	6	.75		
H. octogrammus	4	1.33	14	1.56			18	.90
juveniles			12	1.33				
adults	4	1.33	2	.22				
P. stellatus			11	1.22	6	.75	17	.85
adults			11	1.22	6	.75		
L. armatus	5	1.67	7	.78	1	.13	13	.65
adults	5	1.67	7	.78	1	.13		
M. jaok	10	3.33	2	.22			12	.60
juveniles	10	3.33						
adults			2	.22				

Table 12. Cumulative try net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (3 hauls) No.	Inner CPUE	Middle (9 hauls) No.	Middle CPUE	Outer (8 hauls) No.	Outer CPUE	Total (20 hauls) No.	Total CPUE
H. jordani	7	2.33	2	.22			9	.45
juveniles	3	1.00	2	.22				
adults	4	1.33						
H. elassodon	7	2.33	1	.11			8	.40
juveniles	7	2.33						
adults			1	.11				
H. lagocephalus			5	.56			5	.25
juveniles			3	.33				
adults			2	.22				
P. laeta	1	.33	1	.11	2	.25	4	.20
juveniles					1	.13		
adults	1	.33	1	.11	1	.13		
S. mystinus	2	.67	1	.11			3	.15
juveniles	2	.67	1	.11				
M. scorpius	2	.67	1	.11			3	.15
adults	2	.67	1	.11				
O. dodecaedron					3	.38	3	.15
adults					3	.38		

Table 12. Cumulative try net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (3 hauls)		Middle (9 hauls)		Outer (8 hauls)		Total (20 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
H. stenolepis			3	.33			3	.15
juveniles			3	.33				
I. isolepis			1	.11	2	.25	3	.15
adults			1	.11	2	.25		
M. proximus					2	.25	2	.10
adults					2	.25		
T. chalcogramma			1	.11	1	.13	2	.10
juveniles			1	.11	1	.13		
L. cyclopus					2	.25	2	.10
juveniles					2	.25		
B. signatus			1	.11	1	.13	2	.10
juveniles					1	.13		
G. macrocephalus			1	.11			1	.05
adult								
E. bison			1	.11			1	.05
juvenile								

Table 12. Cumulative try net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (3 hauls)		Middle (9 hauls)		Outer (8 hauls)		Total (20 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
M. polyacanthocephalus juveniles					1	.13	1	.05
T. pingeli juvenile			1	.11			1	.05
A. bartoni juvenile	1	.33					1	.05
B. caeruleofasciatus juvenile	1	.33					1	.05
A. purpurescens adult	1	.33					1	.05
L. medius adult	1	.33					1	.05

Table 13. Cumulative try net catches of all species from two regions of Kaiugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (3 hauls)		Outer (9 hauls)		Total (12 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
L. bilineata	2	.67	77	8.56	79	6.58
adults	2	.67	6	.67		
H. octogrammus	24	8.00	20	2.22	44	3.67
juveniles	2	.67	9	1.00		
adults			1	.11		
H. lagocephalus			40	4.44	40	3.33
juveniles			7	.78		
adults			4	.44		
H. stelleri	10	3.33	26	2.89	36	3.00
juveniles	1	.33	19	2.11		
adults						
B. cirrhosus	10	3.33	22	2.44	32	2.67
juveniles	2	.67	20	2.22		
L. aspera	6	2.00	1	.11	7	.58
juveniles	6	2.00	1	.11		
Gymnocanthus spp.	2	.67	4	.44	6	.50
juveniles			3	.33		
adults	2	.67	1	.11		
P. melanostictus			6	.67	6	.50
juveniles			1	.11		
adults			1	.11		
M. polyacanthocephalus	1	.33	4	.44	5	.42
juveniles			2	.22		
adults	1	.33	2	.22		
P. stellatus	3	1.00	1	.11	4	.33
adults	3	1.00	1	.11		
H. jordani	2	.67	1	.11	3	.25
juveniles	2	.67	1	.11		

Table 13. Cumulative try net catches of all species from two regions of Kalugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Inner (3 hauls)		Outer (9 hauls)		Total (12 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
P. barbata			3	.33	3	.25
juveniles			3	.33		
I. isolepis			3	.33	3	.25
juveniles			3	.33		
L. sagitta			2	.22	2	.17
juveniles			2	.22		
Aulorhynchus flavidus			1	.11	1	.08
juvenile						
H. decagrammus			1	.11	1	.08
adult						
H. hemilepidotus			1	.11	1	.08
adult						
M. scorpius			1	.11	1	.08
adult						
S. gilli			1	.11	1	.08
adult						
P. acipenserinus			1	.11	1	.08
adult						
S. punctatus	1	.33			1	.08
adult						
H. elassodon	1	.33			1	.08
juvenile						
H. stenolepis			1	.11	1	.08
juvenile						

Table 14. Cumulative try net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Eastside (8 hauls)		Westside (7 hauls)		Tannerhead (6 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
A. hexapterus	948	118.5			3	.50	951	45.29
juveniles					3	.50		
adults	948	118.5						
L. bilineata			6	.86	221	36.83	227	10.81
juveniles			6	.86	70	11.67		
H. octogrammus	99	12.38	8	1.14			107	5.10
juveniles	9	1.13						
adults	7	.88	4	.57				
H. stelleri	7	.88	47	6.71	28	4.67	82	3.90
juveniles	4	.50			28	4.67		
adults	3	.38	2	.29				
L. aspera	1	.13	55	7.86	6	1.0	62	2.95
juveniles	1	.13			6	1.0		
H. stenolepis					51	8.5	51	2.43
juveniles					51	8.5		
Gymnocanthus spp.	2	.25	19	2.71	21	3.5	42	2.00
juveniles	1	.13			19	3.17		
adults	1	.13	12	1.71	2	.33		

Table 14. Cumulative try net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Eastside (8 hauls)		Westside (7 hauls)		Tannerhead (6 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
P. acipenserinus					17	2.83	17	.81
juveniles					17	2.83		
H. jordani	2	.25	8	1.14	4	.67	14	.67
juveniles	2	.25			4	.67		
adults			6	.86				
Unident. Pleuronectidae					12	2.0	12	.57
juveniles					12	2.0		
B. cirrhosus	5	.63			1	.17	6	.29
juveniles	5	.63			1	.17		
P. melanostictus					6	1.0	6	.29
juveniles					2	.33		
adults					4	.67		
M. polyacanthocephalus	3	.38	1	.14	1	.17	5	.24
juveniles	3	.38						
adults			1	.14	1	.17		
H. lagocephalus	4	.50					4	.19
adults	4	.50						

Table 14. Cumulative try net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Eastside (8 hauls)		Westside (7 hauls)		Tannerhead (6 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
M. scorpius	1	.13	3	.43			4	.19
juveniles			2	.29				
adults	1	.13	1	.14				
P. barbata	2	.25			2	.33	4	.19
juveniles	2	.25			2	.33		
T. chalcogramma					3	.50	3	.14
juveniles					3	.50		
T. pingeli	3	.38					3	.14
S. punctatus	3	.38					3	.14
adults	3	.38						
P. stellatus	3	.38					3	.14
adults	3	.38						
G. macrocephalus	1	.13			1	.17	2	.10
juveniles	1	.13			1	.17		
P. laeta			2	.29			2	.10
adults			2	.29				

Table 14. Cumulative try net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls). (cont'd)

Species	Eastside (8 hauls)		Westside (7 hauls)		Tannerhead (6 hauls)		Total (21 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
O. elongatus juvenile					1	.17	1	.05
B. bilobus adult	1	.13					1	.05
E. diceraus juvenile	1	.13					1	.05
M. jaok juvenile			1	.14			1	.05

Table 15. Cumulative trammel net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (1 haul)		Middle (1 haul)		Outer (2 hauls)		Total (4 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
H. lagocephalus	14	14.00	13	13.00	43	21.50	70	17.50
adults	14	14.00	13	13.00	43	21.50		
H. octogrammus	18	18.00	9	9.00	8	4.00	35	8.75
adults	18	18.00	9	9.00	8	4.00		
H. stelleri	4	4.00	11	11.00	15	7.50	30	7.50
adults	4	4.00	11	11.00	15	7.50		
P. acipenserinus	1	1.00	5	5.00	22	11.00	28	7.00
adults	1	1.00	5	5.00	22	11.00		
L. bilineata			13	13.00	15	7.50	28	7.00
juveniles					1	.50		
adults			13	13.00	14	7.00		
C. h. pallasi					19	9.50	19	4.75
adults					19	9.50		
G. macrocephalus	1	1.00	10	10.00			11	2.75
adults	1	1.00	10	10.00				
H. decagrammus					4	2.00	4	1.00
adults					4	2.00		

Table 15. Cumulative trammel net catches of all species from three regions of Ugak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Inner (1 hauls) No.	Inner (1 hauls) CPUE	Middle (1 hauls) No.	Middle (1 hauls) CPUE	Outer (2 hauls) No.	Outer (2 hauls) CPUE	Total (4 hauls) No.	Total (4 hauls) CPUE
M. polyacanthocephalus					3	1.50	3	.75
adults					3	1.50		
S. malma	1	1.00			1	.50	2	.50
adults	1	1.00			1	.50		
L. armatus			1	1.00	1	.50	2	.50
adults			1	1.00	1	.50		
O. keta	1	1.00					1	.25
adult								
E. diceraus	1	1.00					1	.25
adult								
M. scorpius					1	.50	1	.25
adult								
L. aspera	1	1.00					1	.25
adult								
P. stellatus					1	.50	1	.25
adult								

Table 16. Cumulative trammel net catches of all species from two regions of Kaiugnak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Inner (2 hauls)		Outer (1 haul)		Total (3 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE
H. lagocephalus	15	7.50	46	46.00	61	20.33
adults	15	7.50	46	46.00		
H. octogrammus	12	6.00			12	4.00
adults	12	6.00				
H. stelleri	5	2.50	1	1.00	6	2.00
adults	5	2.50	1	1.00		
S. mystinus			1	1.00	1	.33
adult						
H. decagrammus			1	1.00	1	.33
adult						
M. polyacanthocephalus	1	.50			1	.33
adult						
L. bilineata	1	.50			1	.33
adult						

Table 17. Cumulative trammel net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls).

Species	Deadman	(2 hauls)	Eastside	(2 hauls)	Westside	(3 hauls)	Total	(7 hauls)
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
H. octogrammus	16	8.0	40	20.00	128	42.67	184	26.29
adults	16	8.0	40	20.00	128	42.67		
H. stelleri	31	15.50	8	4.00	20	6.67	59	8.43
adults	31	15.50	8	4.00	20	6.67		
H. lagocephalus			53	26.50	1	1.00	54	7.71
adults			53	26.50	1	1.00		
G. macrocephalus	4	2.0	3	1.50	3	1.00	10	1.43
juveniles	4	2.0			3	1.00		
adults			3	1.50				
M. scorpius					10	3.33	10	1.43
adults					10	3.33		
P. stellatus	1	.50			2	.67	3	.43
adults	1	.50			2	.67		
M. polyacanthocephalus			1	.50	1	.33	2	.29
adults			1	.50	1	.33		
P. monopterygius	1	.50					1	.14
adult								

Table 17. Cumulative trammel net catches of all species from three regions of Alitak Bay, Cruise 4. CPUE values are mean catches per unit of effort (cumulative catch/number of hauls) (cont'd)

Species	Deadman (2 hauls)		Eastside (2 hauls)		Westside (3 hauls)		Total (7 hauls)	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
B. bilobus adult					1	.33	1	.14
H. jordani adult					1	.33	1	.14
C. polyactocephalus adult	1	.50					1	.14
L. aspera adults					1	.33	1	.14

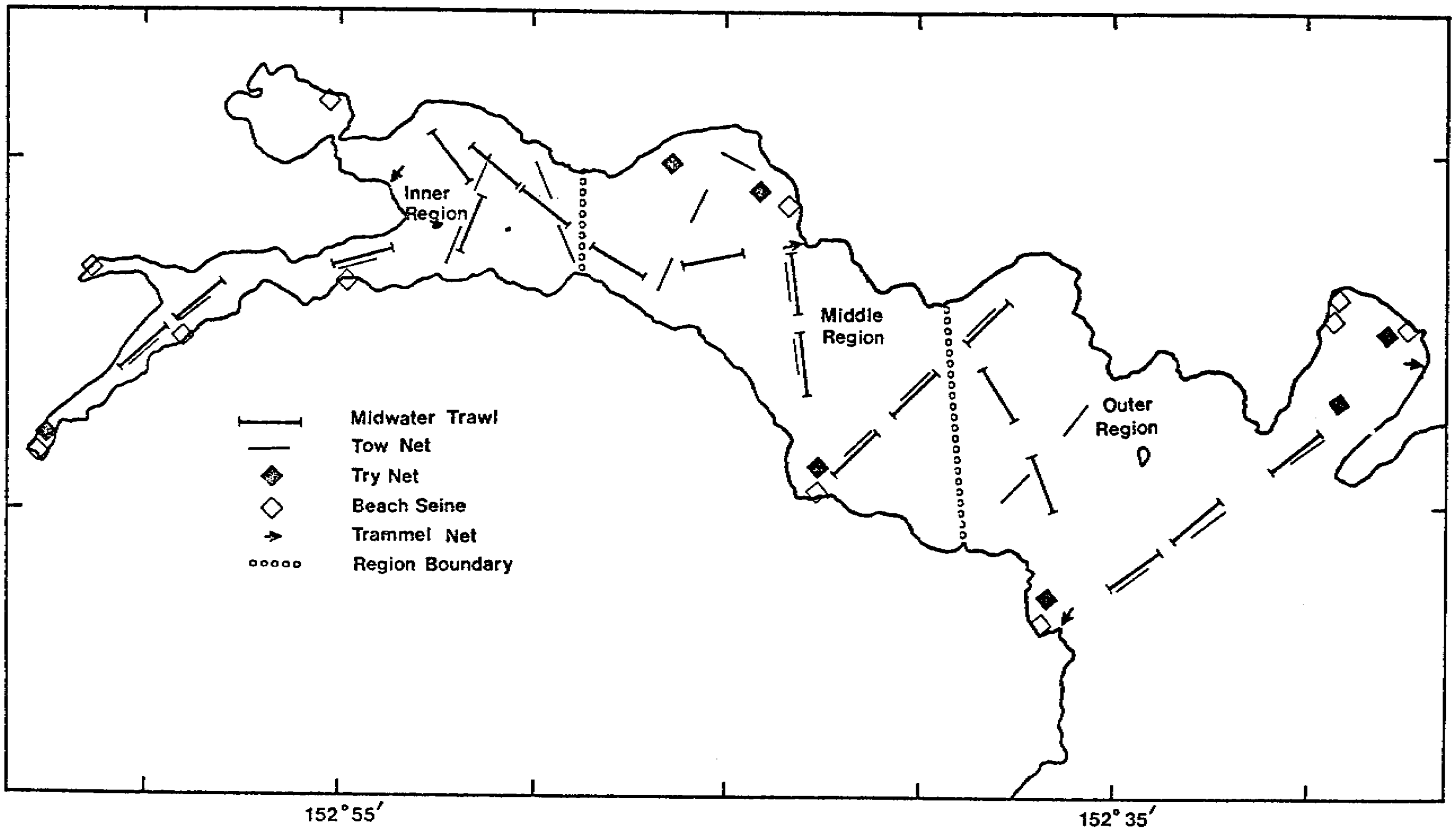


Figure 1 - Sampling sites and transects, and regions referred to in distributional analysis, Ugak Bay, Cruise 4.

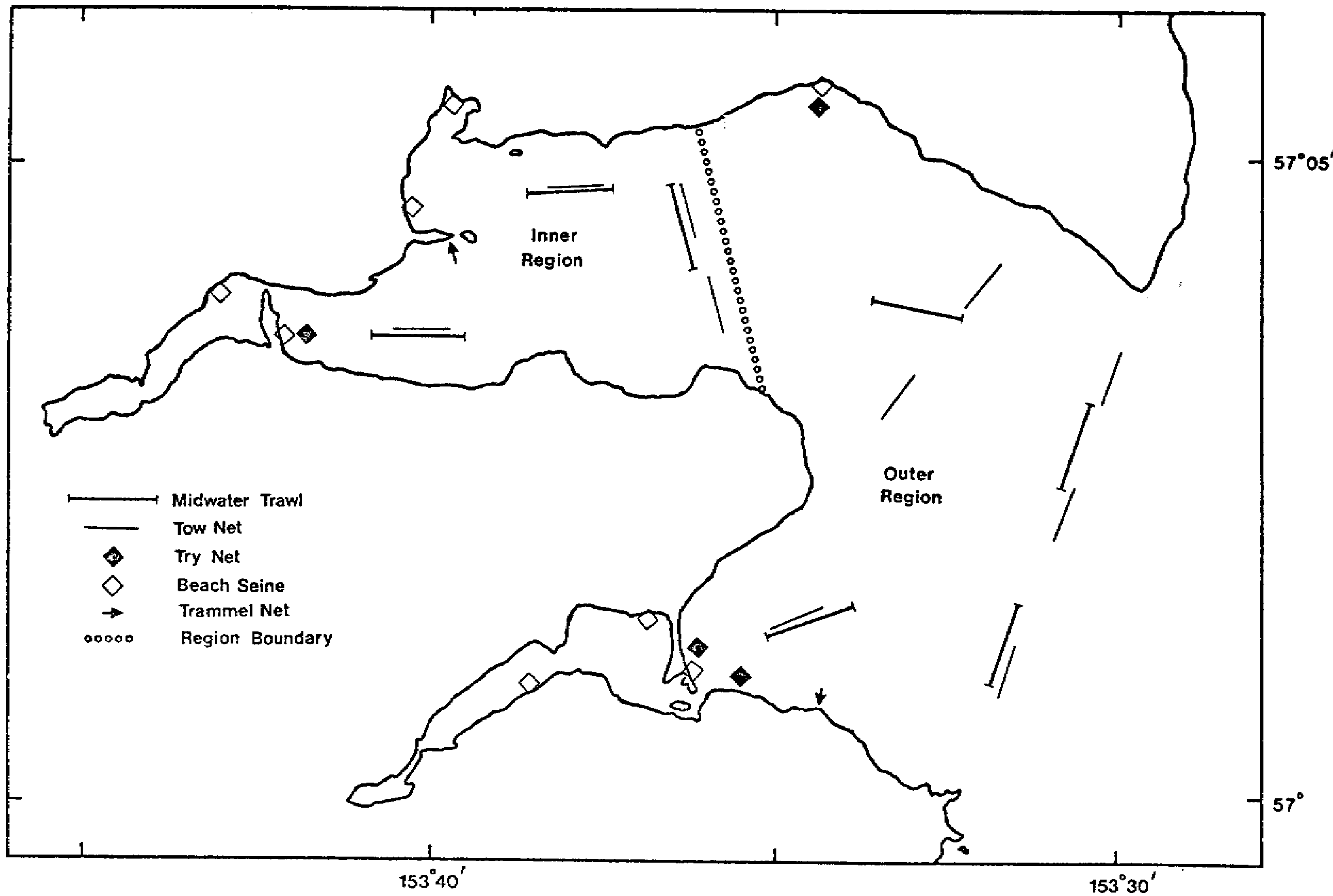


Figure 2 - Sampling sites and transects, and regions referred to in distributional analysis, Kaiugnak Bay, Cruise 4.

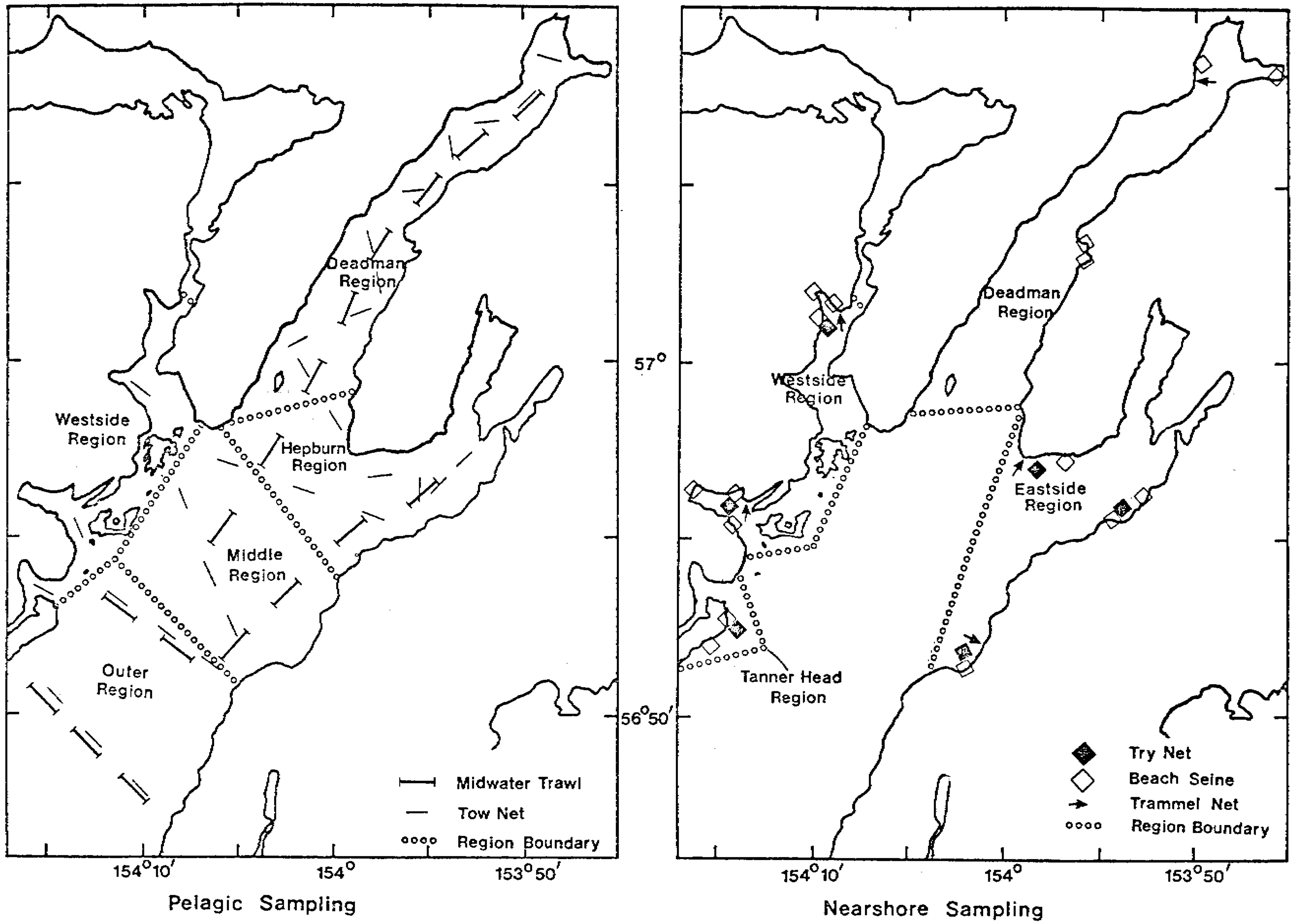


Figure 3 - Sampling sites and transects, and regions referred to in distributional analysis, Alitak Bay, Cruise 4.

Research Unit # 486

Demersal Fish and Shellfish Assessment in Selected Estuary Systems of Kodiak Island

Principal Investigator
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Alaska Department of Fish and Game
P.O. Box 686
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December, 1976

Completion Report for Period Oct. 1 - Dec. 1, 1976

Prepared for:

National Oceanic and Atmospheric Administration
Environmental Research Laboratories
Boulder, Colorado

Introduction

This report presents the activities from October 1 through December 31,1976 on Demersal Fish and Shellfish Assessment in Selected Estuary Systems of Kodiak Island, Research Unit 486-76. This project was initiated during the spring quarter 1976 and results have been previously reported in quarterly reports on June 30 and September 30, 1976. This project is complimentary to R.U. 485, Assessment of Pelagic and Nearshore Fish in Three Bays on Southeast Kodiak Island.

The study area for this project is inside of a line drawn between headlands and deeper than ten fathoms (18 M) in Ugak and Alitak bays on Kodiak Island (Figure 1).

Task Objectives

A. Determine the spatial and temporal (June-September) distribution, relative abundance and inter-relationships of the various demersal finfish and shellfish species in the study area.

B. Determine the growth rate and food habits of selected demersal fish species.

C. Conduct literature survey to obtain and summarize an ordinal level documentation of commercial catch, stock assessment data, distribution as well as species and age group composition of various shellfish species in the study area.

D. Obtain basic oceanographic and atmospheric data to determine any correlations between these factors and migrations and/or relative abundance of various demersal fish and shellfish species encountered.

Field or Laboratory Activities

During this quarter samples were examined in the laboratory and reference specimens assembled. Data was proofed, punched onto diskettes, and is now being placed on magnetic tape. Data summarization and literature review were continued. Arrangements are being made to examine the contents of stomachs collected during the field season.

Results

The otter trawl catch in September is presented in Table 1. The catch was similar to that captured and reported in previous reports. Catch was predominantly tanner crab (*Chionoecetes bairdi*), king crab (*Paralithodes camtschatica*), yellowfin sole (*Limanda aspera*), shrimp, great sculpin (*Myoxocephalus polyacanthocephalus*), Pacific halibut (*Hippoglossus stenolepis*), starry flounder (*Platichthys stellatus*), and walleye pollock (*Theragra chalcogramma*).

Further results will be presented in the annual report at the end of March 1977.

Preliminary Interpretation of Results: None

Problems Encountered/Recommended Changes : None

Preliminary Audit of Expenses to Date

A.	Personnel		11.8[1]
	Permanent -		
	Temporary 11.8		
B.	Travel and Subsistence		1.3
C.	Contractual Services		35.2
D.	Commodities[2]		3.1
E.	Equipment		3.2
		Total	54.6
		10% overhead	5.1
		GRAND TOTAL	59.7

[1]Includes benefits
[2]Includes expendable fishing gear, i.e. trawls and seines

Table 1. Preliminary tabulation of otter trawl catch in kilograms per 20 minute haul in Ugak and Alitak bays on Kodiak Island, June, July, August and September, 1976.

	Ugak Bay				Alitak Bay			
	June	July	August	Sept.	June	July	August	Sept.
Crustaceans	50.7	84.4	78.3	80.17	95.6	132.4	69.2	109.2
Flounders	55.3	76.5	68.1	48.5	34.5	45.1	29.8	37.5
Sculpins	51.0	35.2	16.0	18.9	13.0	19.5	9.8	13.6
Cod	17.1	31.4	0.5	0.8	3.9	16.4	4.8	8.5
King crab	7.9	41.7	39.1	38.2	12.3	39.4	19.9	29.46
Tanner crab	35.4	36.9	18.5	28.0	71.1	61.0	28.0	47.2
Shrimp	7.4	5.4	21.1	12.2	12.2	31.7	21.2	32.4
Yellowfin sole	26.7	42.8	38.0	24.4	18.5	25.8	19.9	24.3
Irish Lord	33.0	11.0	2.4	2.5	0.4	1.7	0.5	0.6
Flathead sole	22.5	17.7	12.9	3.1	2.3	4.3	2.9	3.4
Great sculpin	11.2	14.8	8.6	11.9	12.2	16.8	9.2	13.29
Halibut	7.3	3.5	5.0	7.8	7.5	9.2	4.0	3.9
Pacific cod	16.7	30.5	0.3	0.7	T[1]	1.8	0.4	0.1
Rock sole	2.6	7.5	2.7	4.7	1.6	2.8	0.7	0.5
Butter sole	2.5	0.5	1.7	1.8	0.1	0.2	T[1]	T[1]
Starry flounder	0.4	0.2	0.7	4.5	2.9	1.2	1.8	5.0
Walleye pollock	0.2	0.6	0.1	0.1	3.9	14.6	4.0	8.4
Total Catch	186.5	252.0	133.1	162.6	151.3	219.5	118.5	182.4

[1] Trace, less than 0.1 kilogram per 20 minute haul.

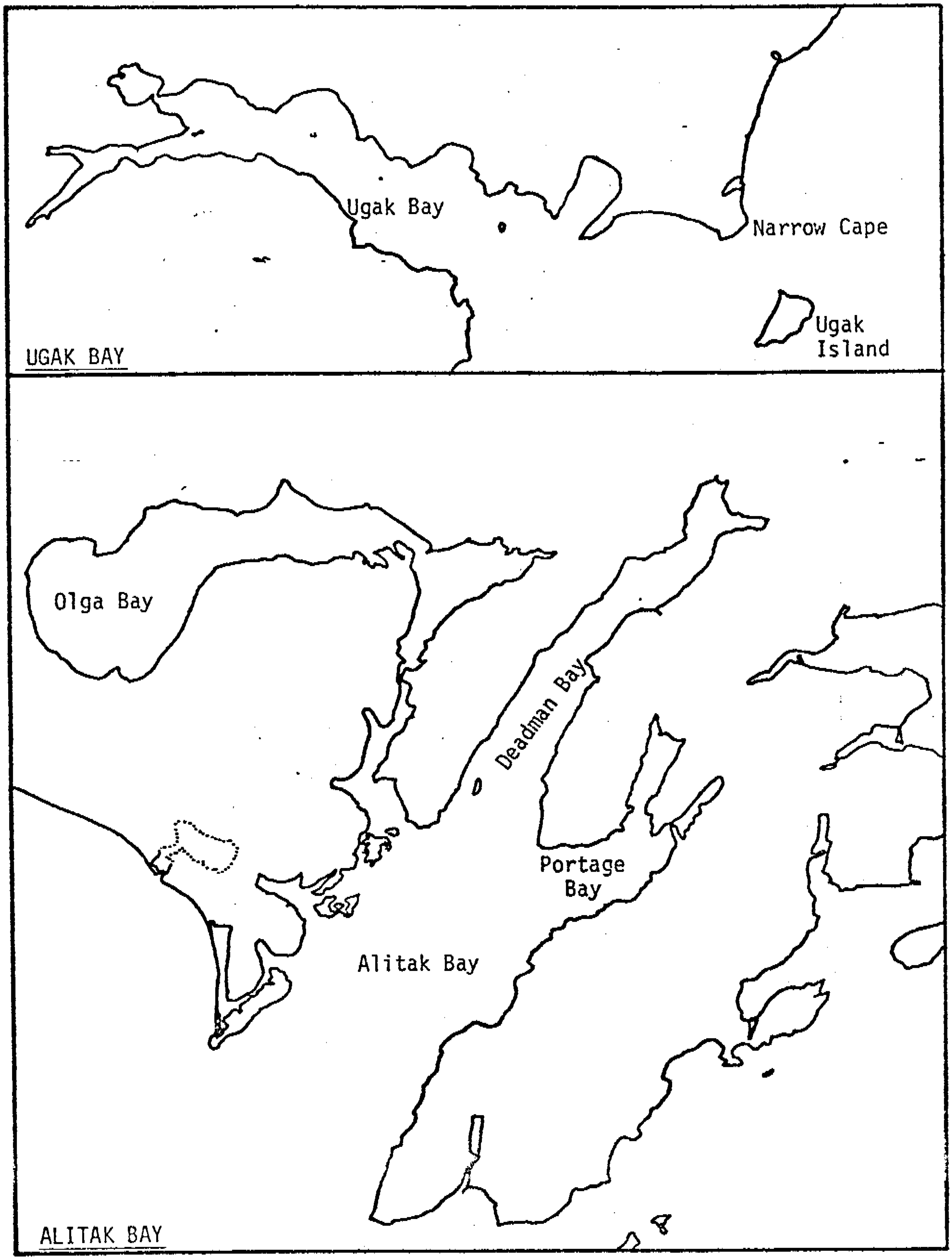

Figure 1. Diagram of the study areas, Ugak and Alitak bays on Kodiak Island.

Quarterly Report

Contract #03-5-022-56
Research Unit #502
Task Order #30
Reporting Period 10/1 - 12/31/76
Number of Pages 4

TRAWL SURVEY OF THE BENTHIC EPIFAUNA OF THE CHUKCHI SEA AND NORTON SOUND

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January 1, 1977

I. Task Objective

To conduct a survey of the benthic epifaunal invertebrates of the Chukchi Sea/Norton Sound Areas.

II. Field and Laboratory Activities

A. The second leg of the trawl survey cruise aboard the Miller Freeman was completed for the period September 27 to October 13, 1976.

B. Scientific party on Leg II of Miller Freeman cruise was:

Mr. Max Hoberg, IMS, University of Alaska
Mr. John Hilsinger, IMS, University of Alaska

C. The material collected and the notes compiled on Leg I and Leg II of this investigation are currently being examined and verification of field identification is underway.

D. Species lists, distribution, and abundance are being processed prior to development of computer listings to be used for future data analysis.

III. Results

A. See summary, Leg II, enclosed.

B. Feeding notes for sea stars, the king crab, the starry flounder and several other fishes were again carefully collected by way of stomach analyses whenever material and time warrented.

C. Additional reproductive notes were compiled.

D. Sea urchins (Strongylocentrotus droebachiensis) were measured and weighed for preliminary size comparisons for areas trawled.

E. Adult specimens of the clam, Sempes groenlandicies (an important food for several marine mammal species) was collected for return to the laboratory where preliminary growth studies will be initiated.

IV. Preliminary Interpretation of Results

Although an abundance of invertebrate material was collected, no economically important species were found in commercial quantities. The invertebrate biomass was dominated by sea-star species (see attached summery of Leg II for names of species).

An intensive survey of sea-star and starry flounder stomachs have developed a good basis for a more comprehensive study of trophic interactions of species in the study area.

CRUISE REPORT
NOAA SHIP MILLER FREEMAN FRS-21
RP-4-MF-76B Leg II

Epibenthic Invertebrates
Norton Sound - Northern Bering Sea
9/27/76 - 10/13/76

Enumeration, speciation and weights of epifaunal invertebrates of the Northern Bering Sea and portions of Norton Sound were made on Leg II of the MILLER FREEMAN cruise 76B. Invertebrate data were obtained from 64 stations, including one additional station to the cruise plan off the southeastern shore of St. Lawrence Island during inclement weather. Not included in the above total are two stations (in sub area 5) between St. Lawrence Island and Nunivak Island, also station D/E-3/4 north of Unimak Pass.

Numerous concentrations of invertebrates were encountered, however, no economically significant species were found in commercial quantities during Leg II. The invertebrate biomass was dominated by four Asteroid (sea star) species: Leptasterias polaris ascervata, Asterias amurensis, Evasterias echinosoma and Lethasterias nanimensis. Commonly encountered animals include: Hydrozoa, Scyphozoa, Anthozoa, Polynoida, Nereidae, Gastropoda, Bivalvia, Cirripedia, Malacostraca, Echiurida, Bryozoa, Brachiopoda, Echinoidea and Ascidiacea.

In addition to qualitative and quantitative aspects of the benthic invertebrates, preliminary observations of biological interrelationships between sections of the benthic community were made, i.e. feeding, reproduction, and parasitism.

No problems occurred during Leg II other than snagged trawls. The officers and crew assisting in the sorting of trawl material were greatly appreciated. Forty three 5-gallon buckets containing invertebrates are stored in the port-side formalin bin. Five 5-gallon buckets are stored in the walk-in freezer. The specimens will remain onboard until the conclusion of Leg III (Lower Cook Inlet), at which time they will be off-loaded at Seward.

Feeding Observations

Frequency of occurance index
R - Rare (<5 observations)
C - Common (>5 observations)

Predator	Prey	
Leptasterias polaris ascervata	Echinarachnius parma (sand dollar)	- R
	Unidentified Polychaeta (worm)	- R
	Balanus sp. (barnacle)	- R
	Macoma sp. (clam)	- R
	Unidentified gastropod (snail)	- R
	Serripes groenlandicus (cockle)	- R
	Bryozoa	- R

Evasterias echinosoma	– Serripes groenlandicus (cockle)	– R
	Margarites sp. (snail)	– R
	Echinarachnius parma (sand dollar)	– R
Lethasterias nanimensis	– Serripes groenlandicus (cockle)	– C
	Natica aleuticus (clausa) (snail)	– R
	Echinarachnius parma (sand dollar)	– R
Plathichthys stellatus	– Echiurus echiurus (Echiurida)	– R
	Serripes groenlandicus (cockle)	– C
	Brittle star – Type 3	– C
	Yoldia sp. (clam)	– C
	Polynoidae (scale worm)	– R
	Synidothea bicuspida (isopod)	– R
	Bispira polymorpha (tube worm)	– R
	Priapulus caudatus (priapulid worm)	– R
	Oenopota sp. (snail)	– R
	Labidochirus splendescens (hermit crab)	– R
	Unidentified fish	– R
	Stegophiura sp. (brittle star)	– R
Paralithodes camtschatica	Shell fragments	– R
	Brittle star Type 3	– C

Parasitism:

Parasitic barnacles (Rhizocephala): white, orange, green and dark brown were attached to the abdomen of Pagurus capillatus and P. trigonocheirus.

Parasitic gastropod (Entocolax sp.?) forming galls were attached internally to the disc and rays of Leptasterias polaris ascervata and Leptasterias sp.

Hirudinae egg cases were on the pleopods and eggs of Sclerocrangon boreas.

The shrimp Argis lar with the parasitic isopod (Bopyridae) under the carapace.

Pollutants: 3% of invertebrate stations contained pollutants such as blue monofilment line and a 1-gallon tin can.

Reproductive data:

The sea star Leptasterias sp. brooding light to bright orange eggs around the oral area.

The sea star Leptasterias polaris ascervata brooding young. Young are attached to pelecypod (Astarte borealis) or gastropod shells which are held in the oral area by the tube feet.

No ovigerous Telmessus cheiragonus (crab) were observed. Most females had orange eggs internally.

Most female Hyas coarctatus alutaceus (crab) were gravid with orange eggs.

Argis lar nearly always contained aqua, blue or green eggs, also green ovary. Maximum percentage with eggs/station was 33%.

The anemone Stomphia coccinea brooding young internally, the latter resembling small onions.

The shrimp Crangon dalli located mainly in Norton Sound and the Bering Sea, had a maximum percentage with eggs/station of 90%.

Five species of Pagurid crabs were carrying black or dark purple eggs. The maximum percentage of gravid females of any one species/station was 57%.

Miscellaneous data collection:

Voucher specimens were collected for providing later comparisons of taxonomic identifications.

Thirty-six Paralithodes camtschatica, stomachs were preserved for later examination. Preliminary results found brittle star-Type 3 to be the primary food item, with unidentified shell fragments.

Three hundred-seventy-nine sea urchins, Strongylocentrotus droebachiensis were measured and weighed for area growth comparisons. The spine density of the urchins increased as the cruise proceeded west from Norton Sound to the Northern portion of St. Lawrence Island.

Serripes groenlandicus were frozen for age-growth studies (4 5-gallon containers). Also several dozen are maintained in an aerated salt water system for toxicity studies.

Comments: Porifera species, noted in previous cruise reports for the Eastern Bering Sea; as ~~the present~~ provide substrate and boring sites for numerous invertebrates to attach and immerse themselves into. Specificly, Tow 259 Station C-34 is an excellent example of this relationship, where approximately 40 invertebrates were found either attached to the surface or concealed within the approximately six species of Porifera.

Ascidians (approximately 5 species) and abondoned pelcypod and gastropod shells provided substrate in the same manner as the sponge.

Personnel:

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OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 30 R.U. NUMBER: 502

PRINCIPAL INVESTIGATOR: O.C.S. Coordination Office/H. M. Feder
University of Alaska

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		
Miller Freeman	9/1/76	10/15/76	(a)		

Note: [1] Data management plan was submitted on 8/30/76, approved by M. Pelto on 9/13/76; we await approval by the contracting officer.

(a) Raw field data was submitted at the end of the cruise. Verified and formated data will be submitted in accordance with the management plan of the FY '77 proposal (modified) providing the proposal is approved and funded.

Research Unit # 512

Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System

James E. Blackburn
Alaska Department of Fish and Game
P.O. Box 686
Kodiak, Alaska 99615

December, 1976

Completion Report for Period Oct. 1 - Dec. 31, 1976

Prepared for:

National Oceanic and Atmospheric Administration
Environmental Research Laboratories
Boulder, Colorado

Introduction

This report describes activities, progress and some preliminary results of Cook Inlet Pelagic and Demersal Fish Studies, Research Unit 19E, from October 1 through December 31, 1976. This project was initiated during spring quarter 1976 and results have been previously reported in quarterly reports on June 30, and September 30, 1976; in an interim report on August 15, 1976 and in a synthesis meeting on Cook Inlet in Anchorage in Novemer. The contributions to the synthesis meeting are contained here and expanded. Other contributions are generally not duplicated.

The study area for this project includes lower Cook Inlet from the Forelands to 59 N latitude and west of 152 west longitude, south of Pt. Bede on the Kenai Peninsula.

Task Objectives

A. Determine the spatial and temporal (May-September) distribution, relative abundance and inter-relationships of the various pelagic and demersal finfish and shellfish species in the study area.

B. Determine when, where, at what rate and in what relative abundance pelagic fish species (primarily salmonids) migrate into and through the study area.

C. Determine the growth rate and food habits of selected pelagic and demersal fish species.

D. Survey the literature to obtain and summarize an ordinal level documentation of commercial catch, stock assessment data, distribution, as well as species and age group composition of various shellfish species in the study area.

E. Survey the literature to inventory and characterize salmon spawning streams as well as timing of fry and smolt migrations.

F. Obtain basic oceanographic and atmospheric data to determine any correlations between these factors and migrations and/or relative abundance of various pelagic and demersal fish and shellfish species encountered.

Activities

Field activities during this quarter were limited to six successful beach seine hauls between the Kenai River and East Forelands from October 8 to 13, 1976 at the site of an oil spill (JP-4). Personnel involved were Wesly Bucher, Assistant Principal Investigator and Dave Anderson, staff member.

Laboratory and office activities included assembling reference specimens, examining preserved samples, data summarization, literature review, and preparation of data for placement onto magnetic tape. Arranqments are being made to examine the contents of stomachs collected during the field season.

Results

The sampling at the oil spill site resulted in capture of fish at the site of the spill (Table 1). Catches before and after the spill are similar, however, more species were caught in fewer hauls before the spill; and both saffron cod (*Eleginus gracilis*) and longfin smelt (*Spirinchus thaleichthys*) catches tended to be greater after the spill. These trends could be random, related to seasonality, or they may be related to effect of oil on the fish and on the catchability of those fish. Saffron cod, longfin smelt, one pink salmon (*Oncorhynchus gorbuscha*) and one Dolly Varden (*Salvelinus malma*) were captured in a visible oil slick and they appeared to be unusually sluggish, that is they did not flop around much when captured.

The otter trawl catch in September averaged 92.6 Kg/tow (Table 1), less than in August but greater than in June or July. Predominant species in September were, in order of decreasing weight captured per tow, yellowfin sole (*Limanda aspera*), rock sole (*Lepidopsetta bilineata*), tanner crab (*Chionoecetes bairdi*), butter sole (*Isopsetta isolepis*), king crab (*Paralithodes camtschatica*), great sculpin (*Myoxocephalus polyacanthocephalus*) and Pacific halibut (*Hippoglossus stenolepis*).

Preliminary distribution information is prepared for several species. Tanner crab (Figure 1) and king crab (Figure 2) occurred in greatest biomass at one station near Seldovia and in the western half of lower Cook Inlet south of the latitude of Mt. Augustine. King crab did not extend as far south as did tanner crab and king crab occurred sporodically in Kennedy Entrance, where tanner crab were not captured.

Walleye pollock (Figure 3) occurred in greatest abundance in the southern portion of Cook Inlet. The greatest biomass was taken in August, with lesser catches in both July and September, suggesting a seasonal influx of this species into Cook Inlet.

Pacific cod (Figure 4) occurred in greatest abundance in two separate areas: the southern portion of Cook Inlet and in the central inlet at the latitude of Homer to Anchor Point. The more northerly area contained large biomass only in June; since this is near the reproductive season, the distribution suggests a spawning aggregation.

Butter sole (Figre 5) occurred in greatest biomass in the western inlet at the level of Augustine Island and across the inlet at the level of Kachemak Bay. Distribution in June, however, was exclusively at the level of Kachemak Bay, with none in the area east of Augustine Island. Since the June samples are near the reproductive season, the distribution suggests that spawning occurs in the general vicinity of the eastern half of the inlet at the latitude of Kachemak Bay.

Pacific halibut (Figure 6) were most numerous nearer shore, in the mouth of Kachemak Bay and in Kamishak Bay but modest numbers occurred in mid-inlet north of 59°10'N. Only 3 individuals were captured south of this latitude. There was a tendency for smaller individuals to occur near shore, especially on the west side of the inlet.

Irish Lords (*Hemilepidotus* sp., Figure 7) were strikingly more abundant at a few locations in the southeast portion of Cook Inlet.

Saffron cod (Figure 8) occurred in three discreet locations: north of Cape Ninilchik on the eastern shoreline, on the south side of Kachemak Bay from Sadie Cove west, and in Kamishak Bay. They were in most samples taken north of the Kenai River with frequency decreasing toward the east Forelands and they occurred frequently south of the Kenai River to Cape Ninilchik. They occurred occasionally in Kachemak Bay and only one individual was captured in Kamishak Bay, on Amakdedori Beach. Young-of-the-year through adult fish were captured.

Longfin smelt (Figure 9) occurred, as did saffron cod, very frequently north of Cape Ninilchik. It occurred also at one station south of Snug Harbor and at two locations in Illiamna Bay. Late stage larvae, juveniles, and adults of this species were captured.

Fishing effort with beach seine and townet, the gear that captured saffron cod and longfin smelt, was most intense in Kachemak Bay but covered the entire eastern shoreline of Cook Inlet between Port Graham and the east Forelands. The western shoreline was covered with slightly less density of stations between about Snug Harbor and Amakdedori Beach. Thus the infrequence of these taxa in Kachemak Bay and in the west side south of Snug Harbor is significant.

Preliminary Interpretation of Results

None at this time.

Problems Encountered/Recommended Changes

None during this quarter.

Preliminary Audit of Expenses to Date

A.	Personnel		63.9[1]
	Permanent	24.7	
	Temporary	39.2	
B.	Travel and Subsistence		3.5
C.	Contractual Services		75.8
D.	Commodities[2]		30.1
E.	Equipment		14.2
		Total	187.5
		10% overhead	17.3
		GRAND TOTAL	204.8

[1] Includes benefits
[2] Includes expendable fishing gear, i.e. trawls and seines

Table 1. Beach seine catch at the area of an oil spill in Cook Inlet at East Foreland with comparative before spill catches.

	E. Forelands 60°43'10"N 151°24'30"W	Between Forelands and Kenai River 60°37'30"N 151°20'45"W	Near Kenai River 60°34'45"N 151°19'25"W
Before Spill			
Date of haul	9-27	9-28	9-28
Time of haul, Zulu	2345	0150	0245
Saffron cod	1	5	4
Longfin smelt	14	13	
Coho salmon, Juv.	1	1	2
Dolly Varden	1		
Bering cisco		2	
Starry flounder	1		
Snailfish sp.			1
Pacific herring	1	2	

	E. Forelands 60°43'10"N 151° 24'30"W			Between Forelands and Kenai River 60°37'30"N 151° 20'45"W		Near Kenai River 60°34'45"N 151° 19'25"W
After Spill						
Date of haul	10-9	10-9[1/]	10-13	10-9	10-14	10-10
Time of haul, Zulu	2140	2205	2330	2335	0100	0015
Saffron cod	4	4	7	10	7	23
Longfin smelt	11	23	45	20	20	14
Pink salmon, Juv.		1				
Dolly Varden		1				
Bering cisco						1
Unidentified larval fish				+		

[1/] Oil was observed in shallow water and saffron cod and longfin smelt were abnormally sluggish when captured.

Table 2. Preliminary tabulation of otter trawl catch in kilograms per haul in lower Cook Inlet in June, July, August, and September 1976.

	June	July	August	Sept.
Flounders	19.8	25.1	40.1	60.0
Crustacea	14.7	27.3	32.5	18.6
Cod	10.1	20.5	31.2	4.9
Sculpins	7.5	11.1	23.8	6.7
Tanner crab	9.9	23.2	23.2	10.8
Pacific cod	9.4	6.2	7.0	2.4
Halibut	8.6	5.2	8.6	5.1
Butter sole	5.7	6.4	4.1	7.4
King crab	4.4	4.1	8.6	6.9
Yellowfin sole	1.9	7.0	4.7	22.1
Rock sole	1.8	2.6	10.4	11.4
Walleye pollock	0.7	10.0	24.2	2.4
Arrowtooth flounder	0.4	3.0	7.6	2.3
Great sculpin	3.7[1]	3.3[1]	7.2	5.2
Irish Lord[2]	0.9[1]	5.2[1]	15.2	1.2
Total Catch	53.4	84.6	137.4	92.6

[1] Conservative figures; all individuals may not have been identified

[2] Originally identified as brown Irish Lord, now believed to be yellow Irish Lord

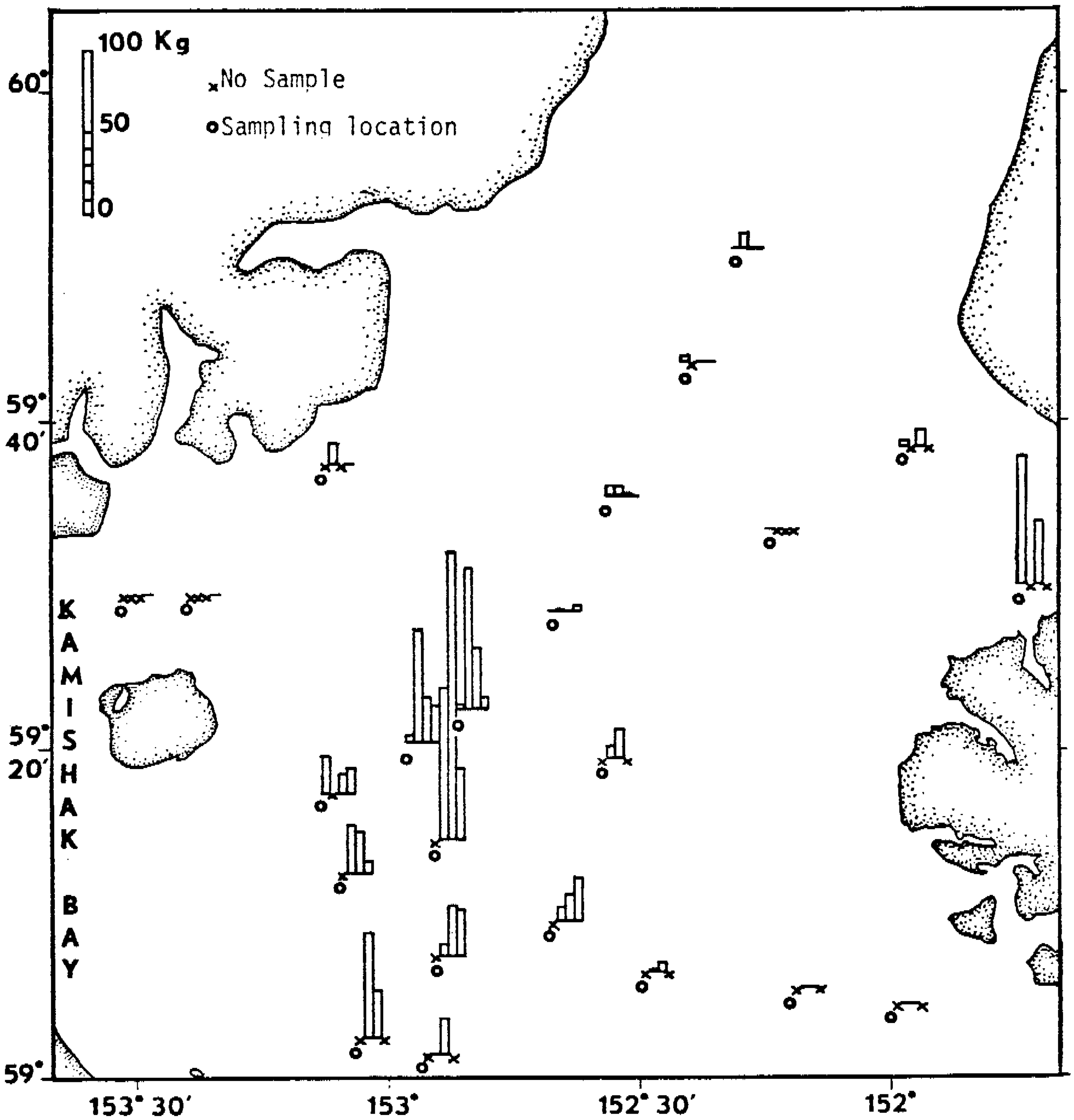

Figure 1. Preliminary presentation of 20 minute otter trawl catch of tanner crab (*Chionoecetes bairdi*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

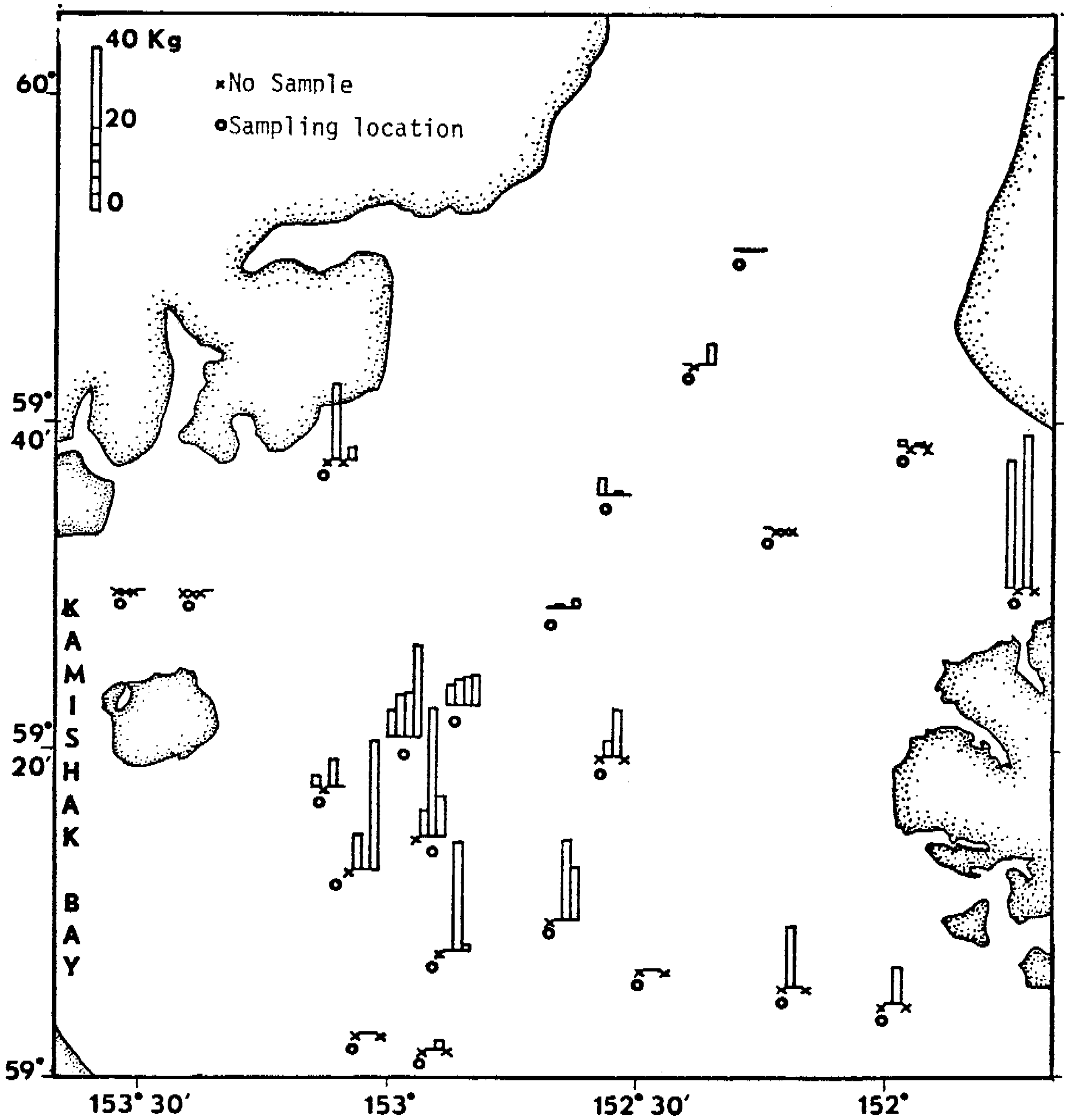

Figure 2. Preliminary presentation of 20 minute otter trawl catch of king crab (*Paralithodes camtschatica*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

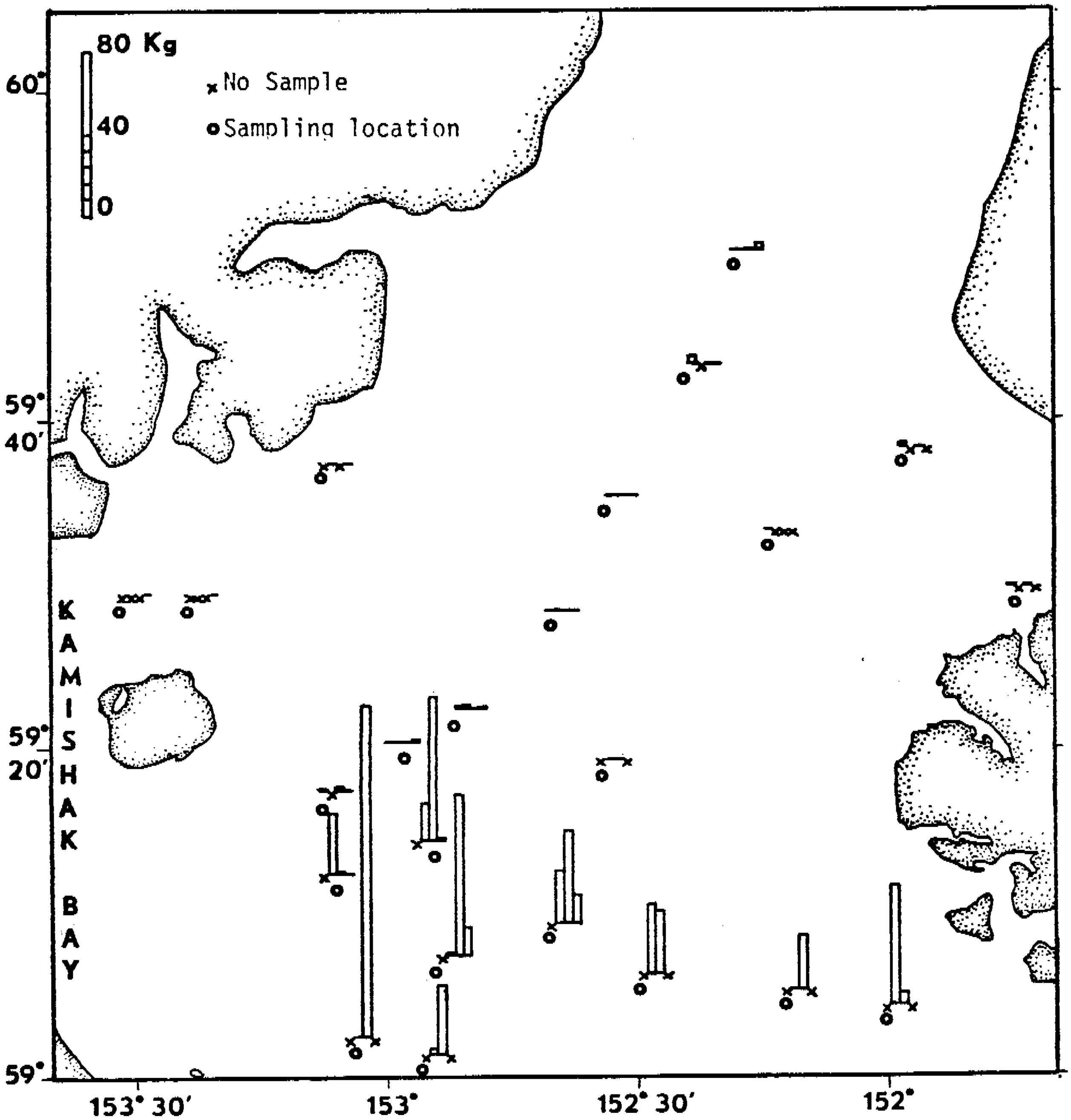

Figure 3. Preliminary presentation of 20 minute otter trawl catch of walleye pollock (*Theragra chalcogramma*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

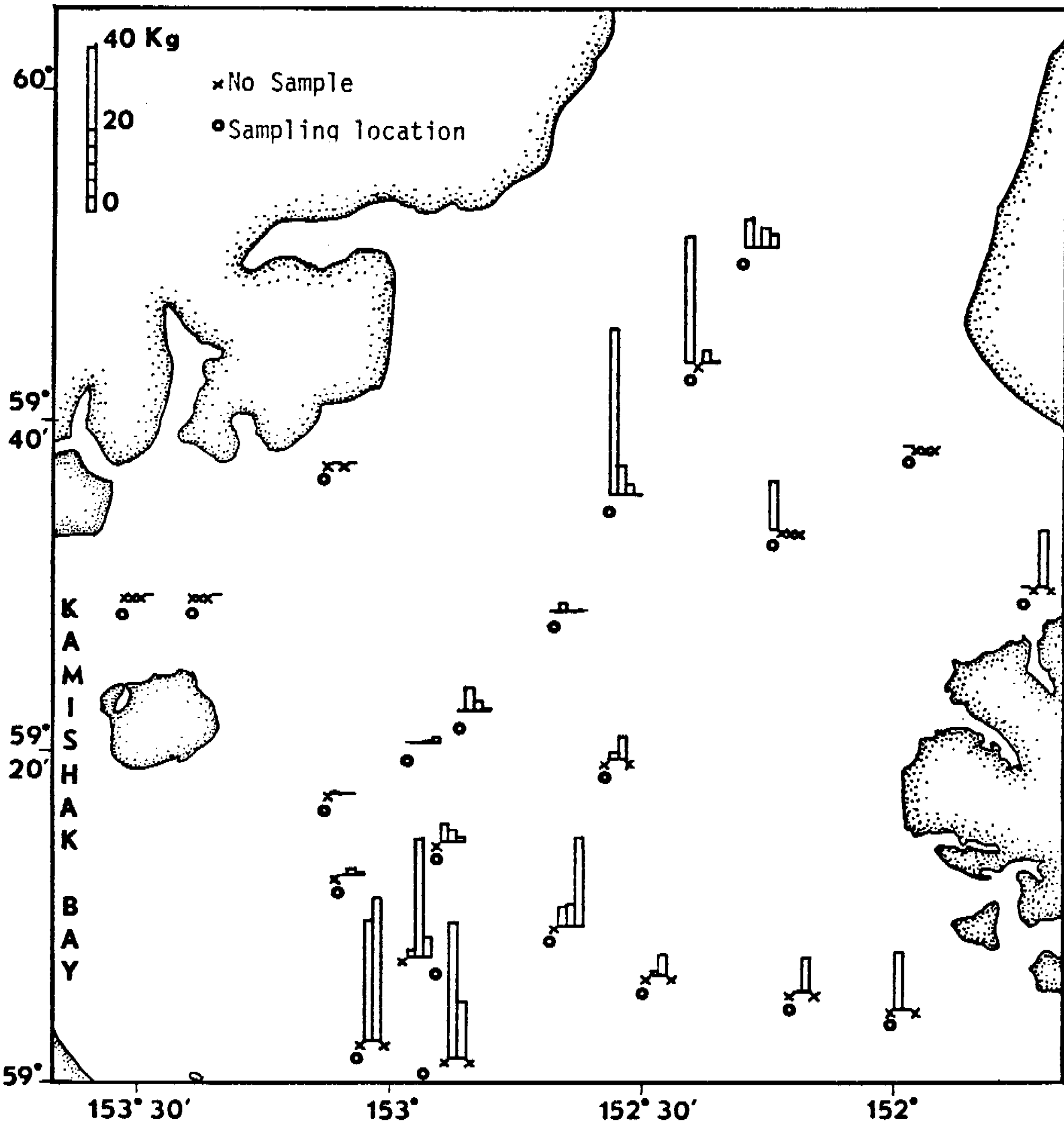

Figure 4. Preliminary presentation of 20 minute otter trawl catch of Pacific cod (*Gadus macrocephalus*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

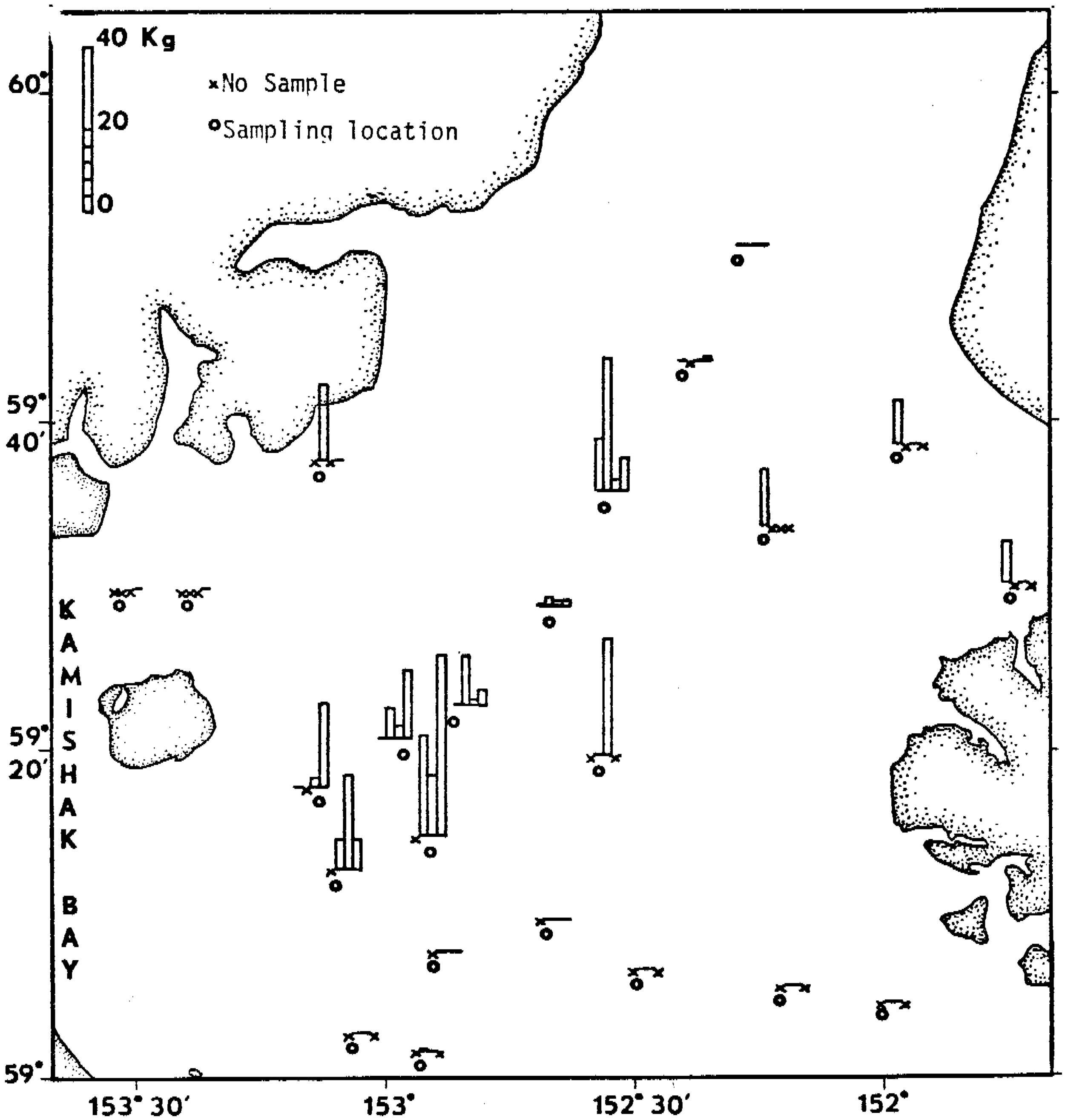

Figure 5. Preliminary presentation of 20 minute otter trawl catch of butter sole (*Isopsetta isolepis*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

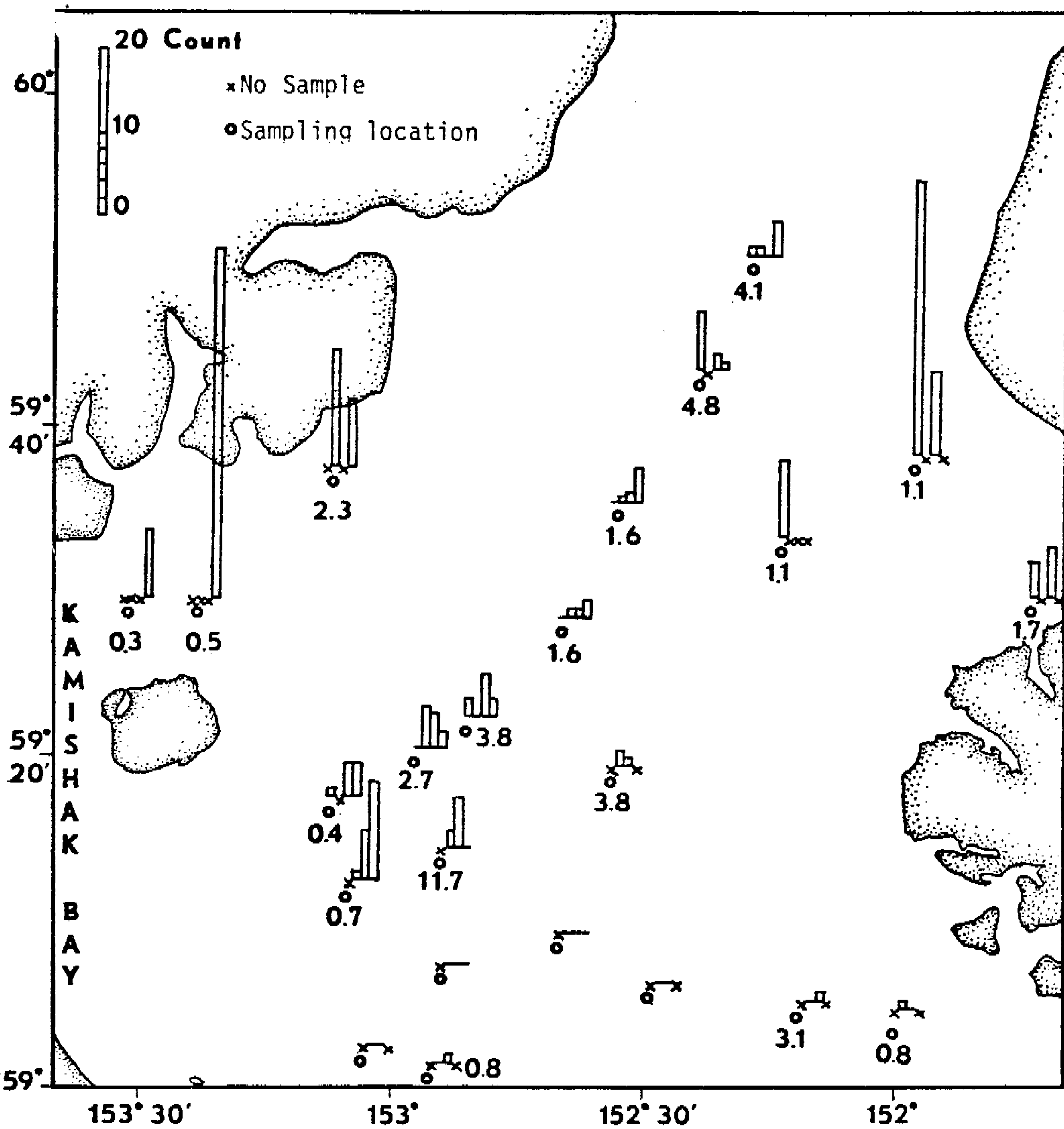

Figure 6. Preliminary presentation of 20 minute otter trawl catch of Pacific halibut (*Hippoglossus stenolepis*) numbers by location and month. Catches in early June, July, August and September are shown left to right respectively and mean weight in Kg is given for each location.

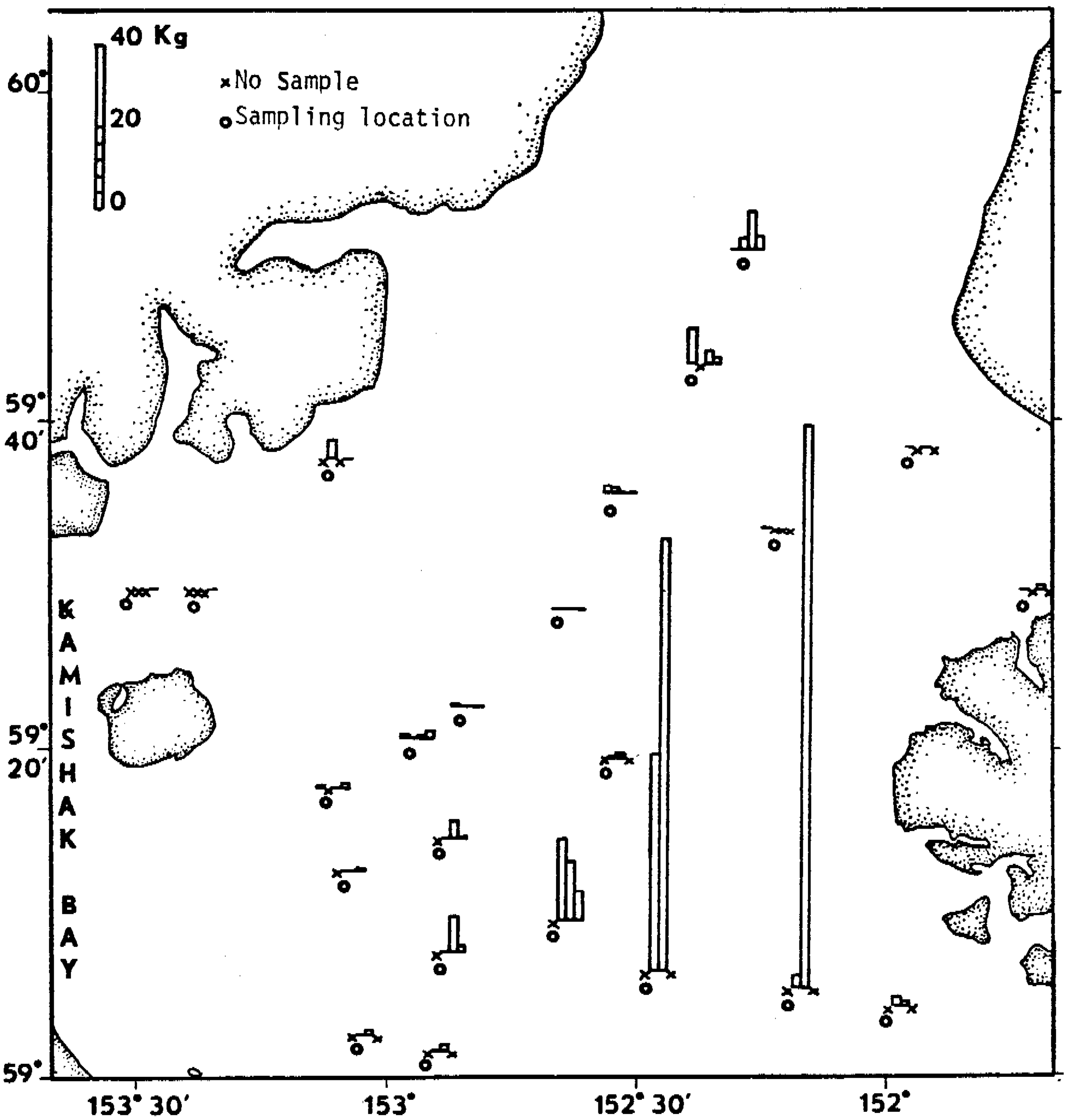

Figure 7. Preliminary presentation of 20 minute otter trawl catch of Irish Lord (*Hemilepidotus sp*) in Kg by location and month. Catches in early June, July, August and September are shown left to right respectively for each location.

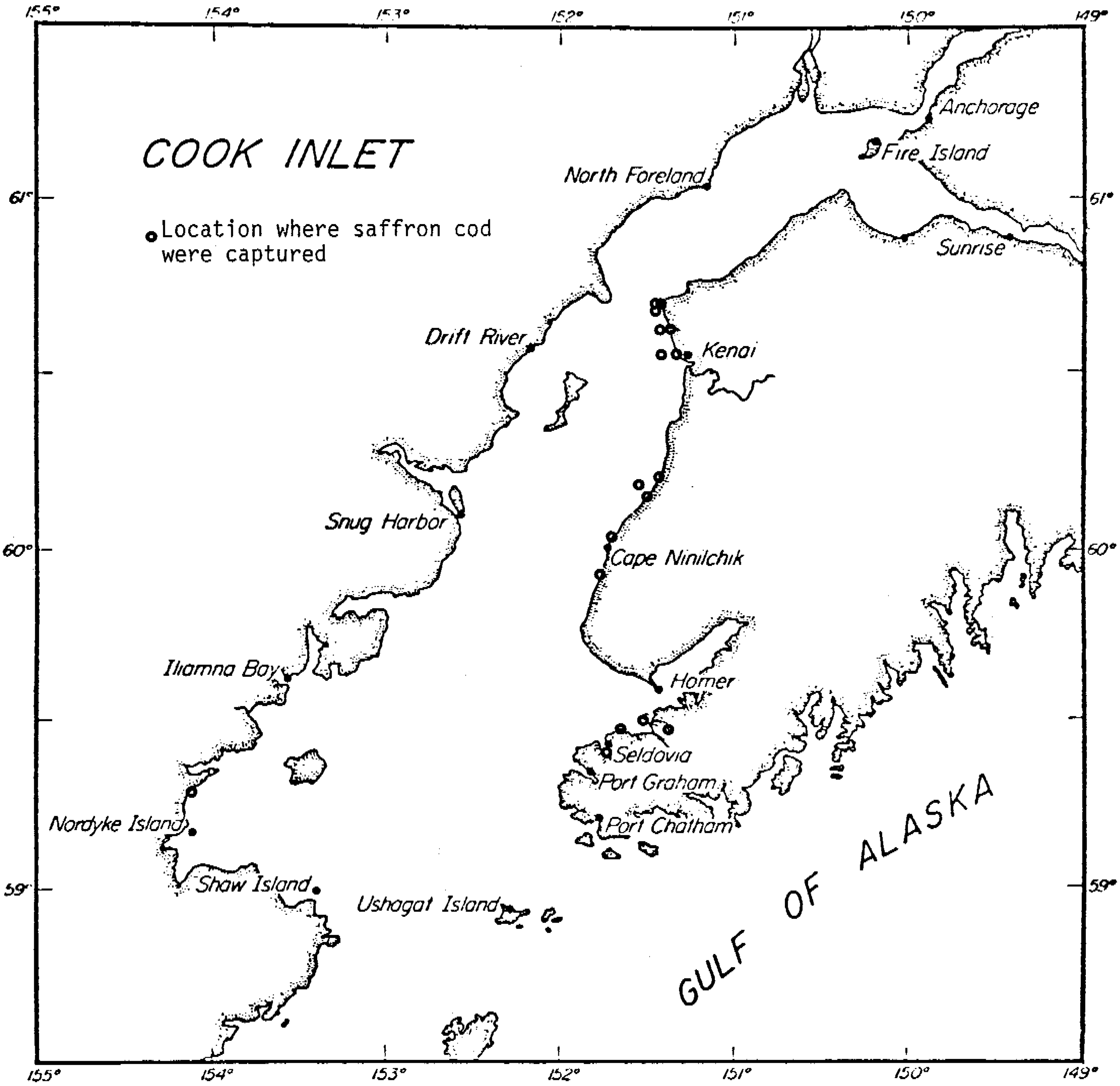

Figure 8. Locations of capture of saffron cod (*Eleginus gracilis*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

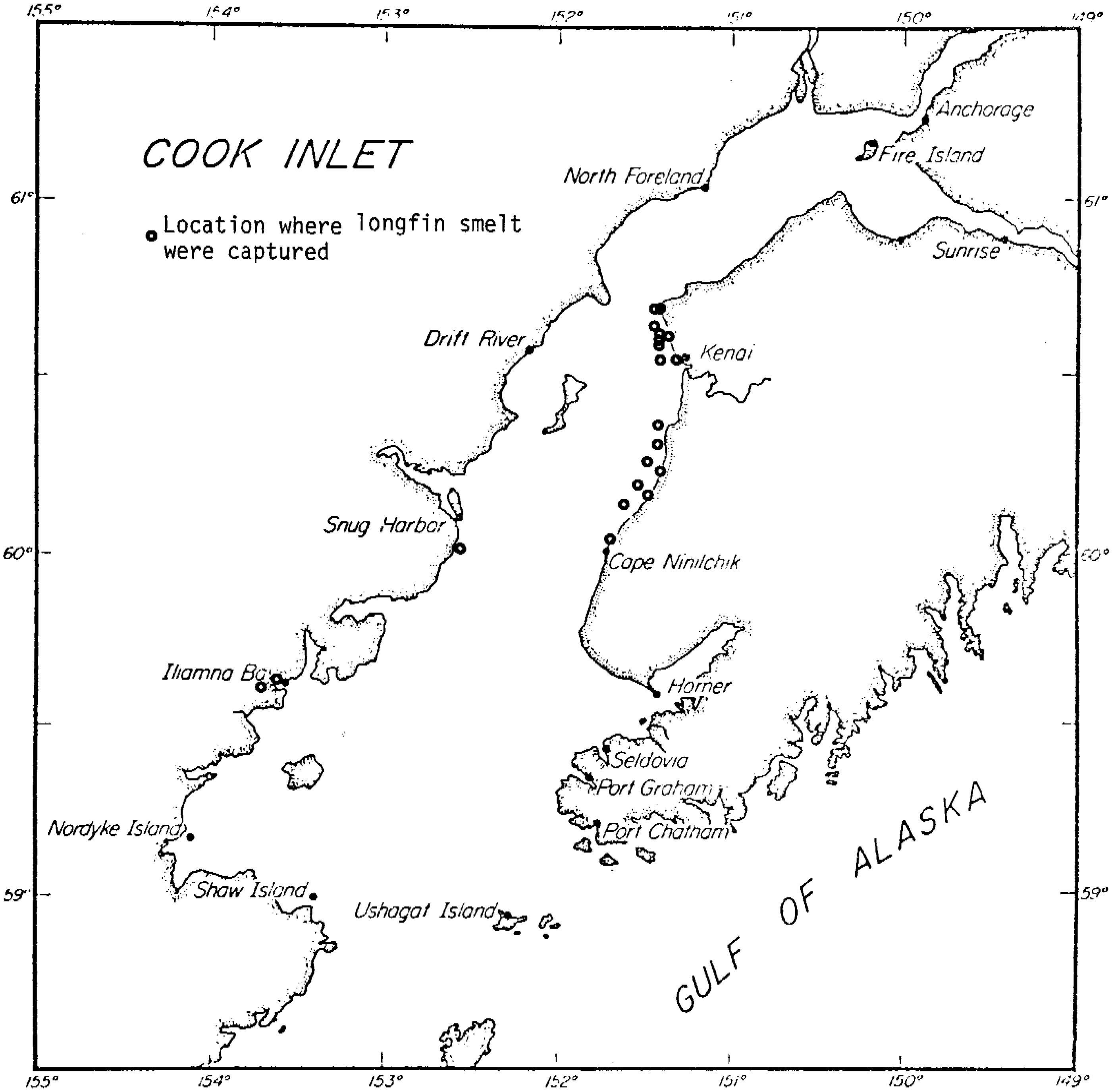

Figure 9. Locations of capture of longfin smelt (*Spirinchus thaleichthys*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

Quarterly Report

Contract #03-5-022-56
Research Unit #517
Task Order #29
Reporting Period 10/1 - 12/31/76
Number of Pages 7

THE DISTRIBUTION, ABUNDANCE, AND DIVERSITY OF THE EPIFAUNAL BENTHIC ORGANISMS IN TWO (ALITAK AND UGAK) BAYS OF KODIAK ISLAND, ALASKA

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University of Alaska
Fairbanks, Alaska 99701

January 1, 1977

I. Task Objectives

A. A qualitative inventory census of dominant benthic invertebrate epifaunal species within the study sites (Alitak and Ugak Bays).

B. A description of spatial distribution patterns of selected benthic invertebrate epifaunal species in the designated study sites.

C. Observations of biological interrelationships between segments of the benthic biota in the designated study areas.

II. Field and Laboratory Activities

A. Ship schedules and names of vessels:

1. 18 July - 28 July, 1976 F/V Big Valley

2. 19 August - 29 August 1976 F/V Big Valley

B. Scientific party:

Max Hoberg - on both cruises listed above.

C. Methods:

Data will be obtained in conjunction with the trawling activities of the Alaska Department of Fish and Game on three cruises to be taken in June, July and August. The invertebrates will be separated, enumerated, and weighed according to methodology developed by Feder in his OCS investigations of the Gulf of Alaska and the Bering Sea. All invertebrates will be sorted on shipboard, given tentative identifications, counted, weighed, and representative samples of individual species preserved and labeled for final identification at the Institute of Marine Science, University of Alaska in Fairbanks. All species will be assigned Taxon Code numbers after final identification.

Biological data (food studies, growth, reproductive notes, recruitment, and parasite observations) will be collected and the data assessed.

D. Data Collected:

1. Cruise of 18 July - 28 July, 1976 - 53 stations occupied (28 - Alitak Bay; 25 - Ugak Bay).

2. Cruise of 19 August - 29 August, 1976 - 47 stations were sampled (22 - Alitak Bay; 25 - Ugak Bay).

III. Results

A. All data is summarized in the three cruise reports attached.

B. Approximately 95% of the invertebrate species and biomass in all three cruises (i.e., 17 June - 22 June; 18 July - 28 July; and 19 August - 29 August) consisted of crustaceans. *Chionoecetes bairdi*, *Paralithodes camtschatica*, *Pandalus borealis*, and *Pandalus hypsonotus* predominated the samples.

D. Identified and unidentified specimens were preserved for later confirmation and identification in the laboratory.

E. Biological data was collected as time permitted (i.e., reproductive, parasitic, and feeding data).

IV. Preliminary Interpretation

No new preliminary interpretations for this quarter - see Quarterly Report for October 1, 1976.

V. Problems Encountered, Recommended Change

Insufficient time was available on all cruises to fully assess trophic interrelationships in Alitak and Ugak Bays. It is highly recommended that several other short trawl collections be made to permit more intensive examination of invertebrate and fish stomachs to establish "baseline" feeding data.

CRUISE REPORT

17 June -- 22 June 1976

Alitak and Ugak Bays -- Kodiak Island, Alaska

R/V Big Valley

Personnel -- Steve Jewett

Fifty-three (53) stations were sampled during six days of benthic trawling (400-mesh Eastern otter trawl) in Alitak and Ugak Bays. The number of stations that were trawled in Alitak Bay was 28, one station less than was planned. This station was untrawlable due to the presence of crab gear. Only 25 stations were occupied in Ugak Bay since five stations were eliminated due to rocky bottom conditions. Generally stations were occupied for 20 minutes bottom time covering a distance of one nautical mile.

Invertebrate were identified to the lowest taxon with numbers and weights normally assigned to each taxon. Approximately 95% of the invertebrate biomass and species consisted of *Chionoecetes bairdi*, *Paralithodes camtschatica*, *Pandalus borealis* and *Pandalus hypsinotus*.

Unidentified organisms were preserved for later identification. Some observations of biological interrelationships between segments of the benthic biota were made, i.e., feeding observations on sea stars and Pacific cod. Also, reproductive conditions of selected species was noted.

Problems Encountered

In order to completely fulfill the objectives of this study more time at each station must be utilized for observations of biological interrelationships between segments of the benthic biota, specially, exaimination of stomach contents of fishes and crabs.

There is some question concerning which agency (A.D.F.& G. or I.M.S.) is to collect information on investebrate organisms. This matter should be clarified before the July cruise.

CRUISE REPORT
18 July - 28 July
Alitak and Ugak Bays - Kodiak Island, Alaska
R/V Big Valley

Personnel - Max Hoberg

Fifty-three stations were sampled during eight days of benthic trawling (400-mesh Eastern otter trawl) in Alitak and Ugak Bays. Twenty-eight stations were occupied in Alitak Bay, while twenty-five were occupied in Ugak Bay. Stations were trawled for 20 minutes bottom time covering one nautical mile or less depending on bottom conditions. Pollutants were noted at five locations in each bay, varying from tin cans to plastics.

The invertebrates were identified, with weights and numbers assigned to each taxon. Approximately 95-100% of the invertebrate biomass and species were crustacean species. *Chionoecetes bairdi, Paralithodes camtschatica, Pandalus borealis,* and *Pandalus hypsinotus* predominated the samples. Parasites (isopods) were confined to the *Crangon* and *Argis* species, specifically under the carapace.

Identified and unidentified specimens were preserved for later confirmation and identification. Biological interrelationships between benthic species were noted, i.e., reproductive condition of shrimp and crab species. Also, feeding notes on *P. camtschatica, C. bairdi,* and several demersal fish species stomachs were collected for later analysis.

No difficulties occured during the second cruise. The trawl study was smooth, with only 1.5 days delay due to inclement weather.

CRUISE REPORT

19 August - 29 August 1976

Alitak and Ugak Bays - Kodiak Island, Alaska

R/V Big Valley

Personnel Max Hoberg

Forty-seven stations were sampled during eight days of benthic trawling (400-mesh Eastern otter trawl) in Alitak and Ugak Bays. Twenty-two stations were occupied in Alitak Bay. Seven stations were eliminated due to storage of crab gear. Twenty-five stations were occupied in Ugak Bay. Stations were trawled for 20 minutes bottom time covering one nautical mile or less depending on bottom conditions. Pollutants, varying from plastics to cardboard, were noted at four locations in each bay. All invertebrates were identified, weighed and counted. Approximately 95% of the invertebrate biomass and species were crustaceans. Parasitic isopods were noted under the carapace of *Pandalopsis dispar, Argis sp., and Crangon communis. Balanus sp.* was also noted embedded in sponge and attached to the carapace of *Pandalus hypsinotus.*

Specimens were preserved for verification. Biological interrelationships between benthic species were noted i.e., reproductive condition of shrimp and crab species. Feeding notes were made and stomachs obtained on *Paralithodes camtschatica, Chionoecetes bairdi* and several demersal fish species. No difficulties occurred during the third cruise. The study progressed quite smoothly, with no delays.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 29

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	3	4
Big Valley 001	6/17/76	6/23/76	2/28/77[a]			
Big Valley 002	7/18/76	7/28/76	2/28/77[a]			
Big Valley 003	8/19/76	8/29/76	2/28/77[a]			

NOTE: 1 Data Management Plan submitted August 16, 1976, we await formal approval.

a Data submission is dependent on approval and funding of proposed work statement for FY '77, and reflects the Milestone dates of said proposal.

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