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FINAL REPORT

AN ECOLOGICAL ASSESSMENT OF THE LITTORAL ZONE ALONG THE OUTER COAST OF THE KENAI PENINSULA FOR STATE OF ALASKA, DEPARTMENT OF FISH & GAME

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FINAL REPORT

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AN ECOLOGICAL ASSESSMENT OF THE LITTORAL ZONE ALONG THE OUTER COAST OF THE KENAI PENINSULA FOR STATE OF ALASKA, DEPARTMENT OF FISH & GAME

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JANUARY 24, "1977

DAMES & MOORE

January 24, 1977

State of Alaska
Department of Fish & Game
Homer, Alaska 99603

Attention: Mr. Loren Flagg

Gentlemen:

Final Report
An Ecological Assessment
of the Littoral Zone Along
the Outer Coast of the
Kenai Peninsula for
State of Alaska,
Department of Fish & Game

We submit herewith the final progress report and final discussion for the littoral and sublittoral studies on the outer Kenai Peninsula. This report contains the qualitative and quantitative descriptions of the biota obtained during the summer surveys conducted in July and August 1976.

A major conclusion of the study is that the intertidal and subtidal biotic assemblages are rich, pristine and productive. Primary productivity is high on both rocky and soft substrates and macrophytes apparently contribute sizable quantities of plant material to offshore systems. The time of maximum contribution (Fall) and the probable stability of the material at low temperatures combine to support a hypothesis that these plant materials are very important food sources to offshore and nearshore benthic assemblages during the winter, when phytoplankton production is low.

Assuming that a major crude oil spill is the main threat arising from oil development in this area, the greatest danger would probably be to salmon stocks, sea otters and marine birds. An important consequence of disturbing sea otter and marine bird populations would be to reduce predation pressures on several major herbivore species (sea urchins, limpets and chitons). This could result in serious problems in the macrophyte assemblages. The most serious long-term effects of a major oiling would probably occur in the lagoons and estuaries, however. Heavy oil contamination in these areas could reduce natural salmon stocks in affected watersheds and seriously reduce plant production and the contribution of plant materials to offshore assemblages. On the other hand, rocky plant assemblages are probably fairly resistant to the effects of major contamination by crude oil.

Participation in this study has been a pleasure. Your assistance and cooperation have been appreciated. If you have any questions, please contact us at the Homer (235-8494) or Anchorage (279-0673) office.

Very truly yours,

DAMES & MOORE

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Associate

Dennis C. Lees
Marine Biologist

Richard J. Rosenthal
Marine Biologist

RCM:DCL:RJR:sed
Enclosure

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I. TASK OBJECTIVES

The main objective of this study is to assess some of the marine plant and animal communities in intertidal and adjacent shallow subtidal areas along the southern, or outer, Kenai Peninsula. This is to be accomplished by:

1. Gathering baseline information on species composition and relationships within supporting "characteristic" biotic assemblages;

2. recording seasonal changes within the habitats; and

3. collecting information leading to an understanding of the ecological functions within these assemblages, including data on population structure, food web relationships, and factors influencing distribution and abundance.

The objective of this study was to collect data on distribution, size structure and biomass of the dominant organisms at each site and to assess the condition of the assemblages during the early spring.

II. FIELD

Field Trip Schedule

The surveys described herein were conducted from 30 June to 10 July and 30 and 31 August 1976. The M.V. Humdinger, chartered out of Cordova, was used to transport personnel and equipment to and from the stations. It also served as a base of operations while in the field.

Scientific Party

The scientific party included:

1. Dennis Bishop, Dames & Moore, field assistant;
2. Dennis C. Lees, Dames & Moore, staff biologist;
3. Richard J. Rosenthal, Dames & Moore, staff biologist; and
4. Thomas M. Rosenthal, field assistant.

Methods

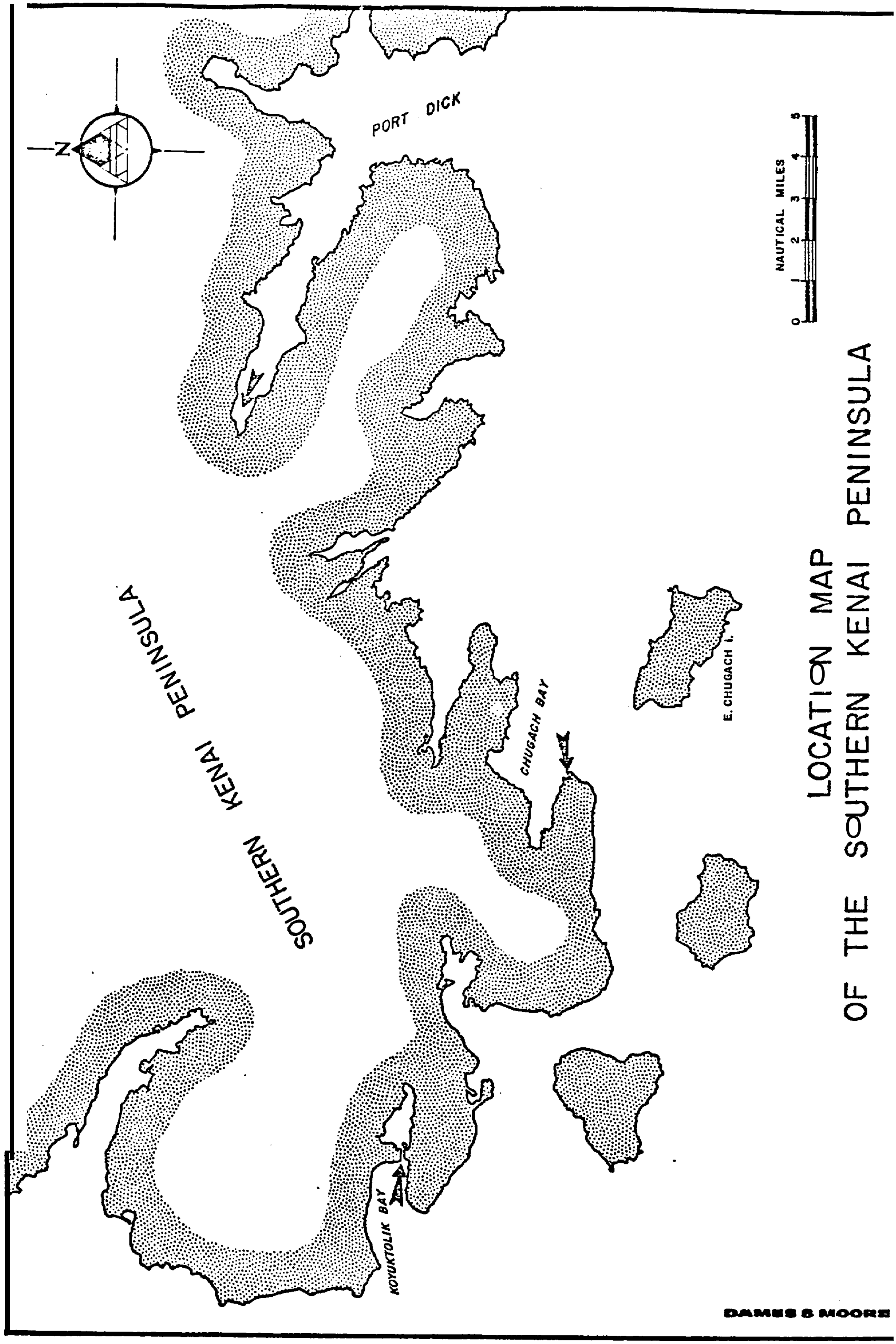
The mode of operation in the field was to combine qualitative and quantitative techniques in such a manner as to obtain a general description of the composition of the assemblages examined, the functional relationships characteristic of the sites surveyed, and the size structures, densities and biomasses of the organisms characterizing the various assemblages. This involved 1) taking random "nature walks" through the habitats, 2) examining large quadrats (25 m by 0.5, 1 or 2 m) for density estimates of macro-algae and large invertebrates such as starfish or gastropod, 3) medium quadrats (0.25 sq.m.) for species composition and relative cover estimates of smaller algae, encrusting and epifaunal forms, and 4) small quadrats (1/16 sq.m.) for density estimates and size distributions of dense organisms such as mussels and certain macrophytes (e.g., eelgrass) . In cases of extreme density, smaller quadrats or covers are used to collect more practical samples.

Laboratory analysis included measuring the size, wet and dry weight of certain organisms to permit examination of size and weight distributions at the study sites and estimation of biomass of certain species. Measurements used are described herein. Regression lines relating linear measurements with whole, wet or dry tissue weights have been developed for several organisms. Macrophytes were dried at 90°C for 24 hours to obtain dry weights. Densities of Zostera were determined by counting the turions in haphazardly cast 1/16 m2 quadrats. Only turions rooted within the quadrat were counted. Samples used for length and weight measurements were collected by hand by divers. Turions were collected either by removing all turions within the quadrats sampled, or by clearing small areas and placing all the turions in a bag. Length measurements were made from the uppermost node to the tip of the leaves. Turion heights were designated as the length of the longest leaf; turions were discarded if the tip of the longest leaf was broken off. Wet and dry weights were only measured for turions; roots and rhizomes were removed. Only turions on which the longest leaf was intact were utilized.

Densities of the blue mussel were estimated by counting the number of individuals in core samples (0.0046 m^2) or 1/16 m2 quadrat samples. Sampling size depended upon the general density level of the srea. Shell length is defined as the distance between the interior and the posterior margins, that is, the maximum length of the shell. Dry weights for mussels were obtained by drying 48 to 72 hours at 60°C. For larger specimens, wet tissue weights were obtained by removing the tissue from the shell and weighing it. For smaller specimens, the shell and tissue were dried and weighed, and then the meat was dissolved by Clorox and the empty shell weighed; dry tissue weight was obtained by subtraction.

Sample Localities

Specific habitats were examined at three locations on the outer Kemi Peninsula (Figure 1) during the summer of 1976. These are listed below:



LOCATION MAP OF THE SOUTHERN KENAI PENINSULA

FIGURE 1

A. **Koyuktolik** (Dogfish) Bay and Lagoon (Figure 2)

1a. North side of Bay

1b. South side of Bay

2a. Mussel bed on north side of entrance channel to lagoon (outer bed)

2b. Mussel bed or bar separating entrance channel from lagoon (inner bed)

3. Rock pinnacle in outer lagoon

4. Outer lagoon

5. Inner lagoon

B. **Chugach Bay** (Figure 3)

a. "Raft Cove

b. Shelf **and** lope north of Raft Cove

c* Northeast point of **Raft** Cove

d. West of Sea Otter Point

C. Port Dick (Figure 4.)

a. Subtidal eelgrass bed

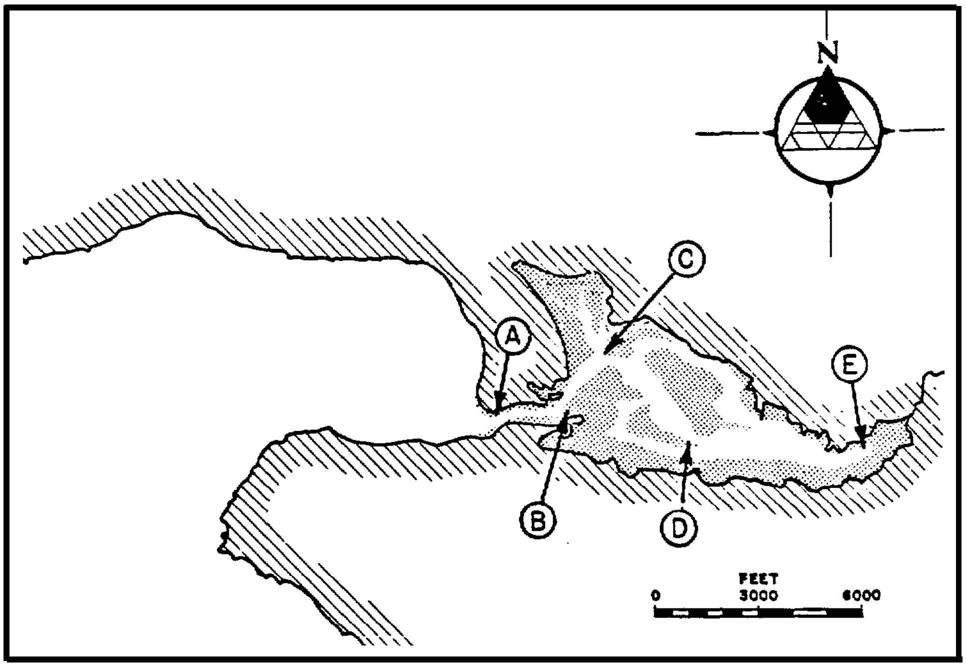
b. Intertidal mussel bed

c. **Rockweed** zone

d. Rock pinnacle (Dick's Head)

Data collection and Analysis

The data collected are presented as tables, figures and appendices in this report. Analysis and interpretation **of** data are included in final discussion section of this report.



KEY:

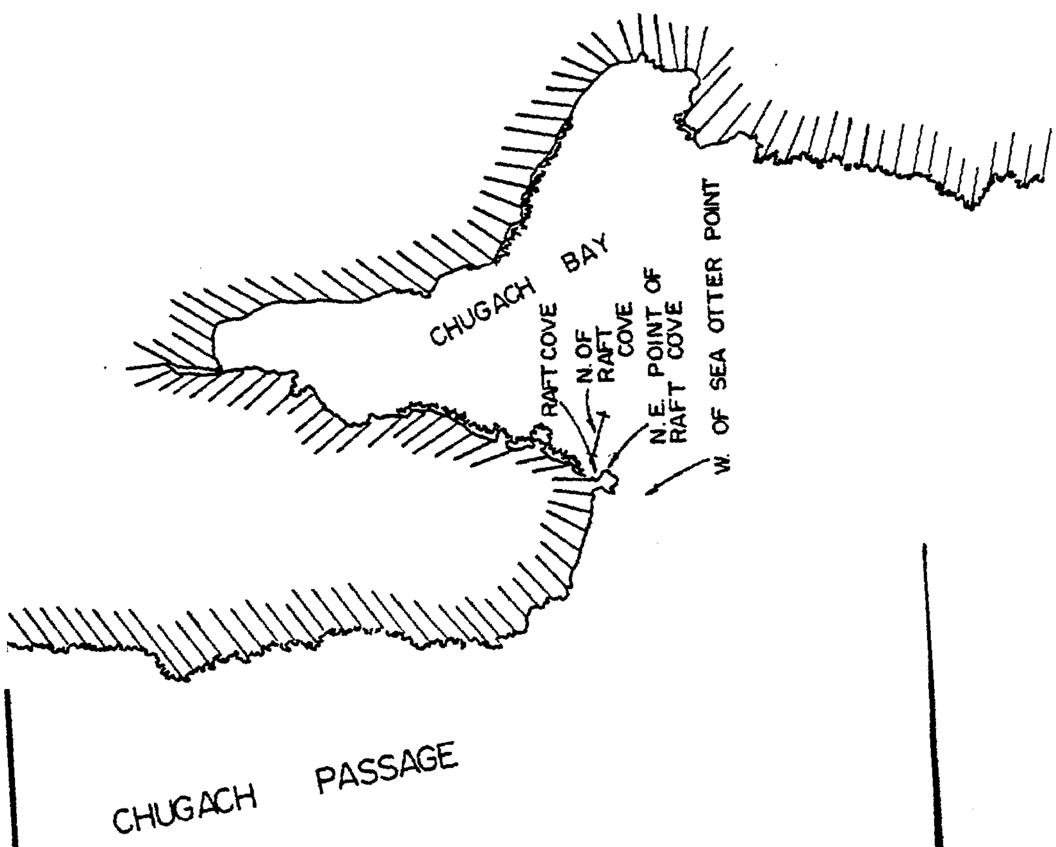
Ⓐ LETTERS CORRESPOND TO THOSE GIVEN IN THE TEXT

SHADED AREAS INDICATE MUD OR SAND FLATS

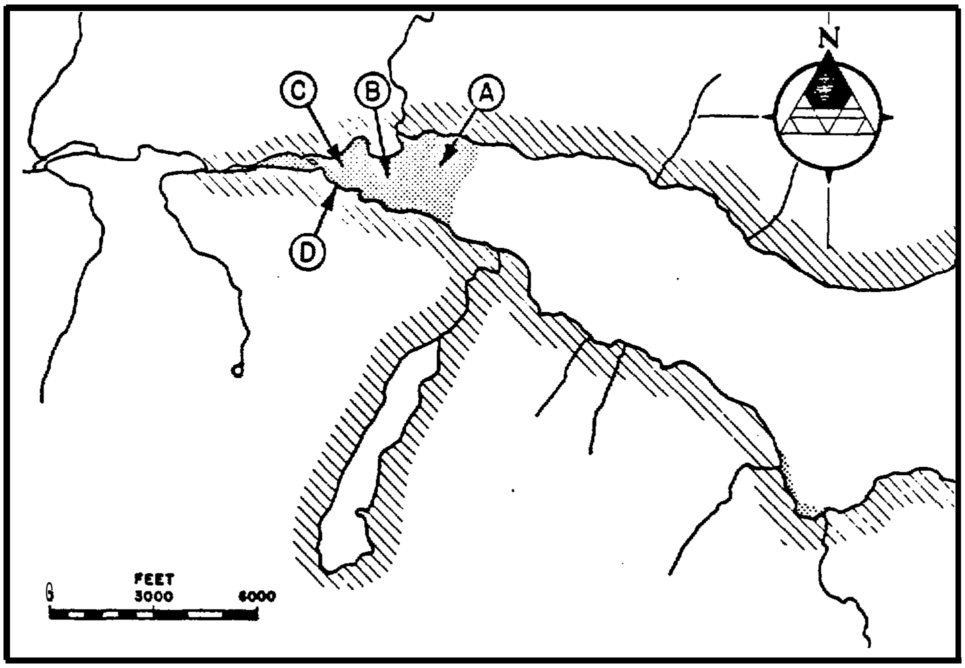
KOYUKTOLIK BAY AND LAGOON

DAMES & MOORE

FIGURE 2



LOCATION NAP FOR CHUGACH BAY



KEY:

A LETTERS CORRESPOND TO THOSE GIVEN IN THE TEXT

SHADED AREAS INDICATE MUD OR SAND FLATS

WEST ARM, PORT DICK

Types of Samples

Koyuktolik Bay - July

a. Qualitative diving observations from all sampling sites.

b. 0.0046 m^2 cores in mussel bed for estimating density, size structure and biomass - 12.

c. 1/16 m^2 quadrats for relative cover and abundance data for eelgrass from the transition zone and mid outer lagoon - 38.

d. Turion length, wet weight and dry weight data for estimating biomass and size structure of eelgrass from the inner lagoon, outer lagoon and transition zone - 210.

e. Food habit observations.

f. Relative cover of *Fucus* and *Mytilus* from 1/16 m^2 quadrats in the inner, outer and seaward mussel beds - 384.

g. Vertical series of 1/16 m^2 quadrats on rock pinnacle in entrance channel - 11.

h. 1/16 m^2 quadrats for density of *Katharina*, *Tonicella* and *Evasterias* on rock pinnacle in entrance channel - 22.

Koyuktolik Bay - August

a. Qualitative diving observations.

b. 1/16 m^2 quadrats for density and biomass estimates of eel-grass at the inner and outer edges of the eelgrass beds in the outer lagoon - 27.

c. Turion height and dry weight data for eelgrass from the eel-grass beds of the outer lagoon.

Chugach Bay - July

s. 1/4 m^2 quadrats for estimating abundance, density and relative cover of macrophytes and macrofauna - 50.

b. 5 x 1 m transects for Phaeophyta and grazers - 10.

c. 1/4 m^2 quadrats for estimating abundance of echinoids - 36.

d. Qualitative diving observations from all sampling sites.

e. Food habit observations.

Port Dick - July

a. 1/4 m^2 quadrats for estimating abundance and relative cover of macrophytes and macroinvertebrates - 80.

b. 1/4 m^2 quadrats for estimating relative cover of mussels - 60.

c* Size frequency data for Littorina sitkana - 333.

d. 1/4 m^2 quadrats for estimating abundance of limpets - 12.

e. Subtidal transects for estimating the abundance of asteriods:

5 x 1 m - 3

10 x 1 m - 6

30 x 1 m - 3

f. 30 m line intercept transects for estimating relative coverage of macrophytes - 9; of echinoids - 5.

g. Qualitative diving observations from all sampling sites.

h. Food habit observations.

i. Size, wet weight and dry weight of mussels for estimating biomass and size structure - 50.

j. 1/16 m2 quadrats for mussel size frequency data - 8.

k. 1/16 m^2 quadrats for estimating biomass of macrophytes - 12.

Port Dick - August

a. 1/16 m^2 quadrats for estimating density of eelgrass.

b. Turion length and dry weights for estimating biomass and size structure of eelgrass - 163.

Intended Use for Size and Density Data

Several types of quantitative data may be collected for some conspicuous species apparently occupying important roles in the natural economy of each study site. These include relative abundance (density-number of individuals per square meter), and some measurements of linear size (length, width, aperture width, etc.) and weight (wet or dry weight of soft tissue). These data will assist in describing variations in conditions at the study sites and will permit examination of differences between them. Specifically, we want to be able to compare population structure among different areas, or at the same site under different conditions, and to generate accompanying biomass estimates for selected species at the study sites. These data will provide information on temporal variations in population structure at specific sites and allow assessment of the effects of unnatural phenomena.

We employed several statistical techniques in data analysis. Size-frequency data were compared with the Kolmogorov-Smirnov two-sample test (Siegel, 1956). Most of the biomass data was reconstructed by using the size-weight regressions. This only produces first approximations but in view of the nature of the study and the poor understanding of the qualitative features of the various systems, we decided that the major Portion of our initial efforts would be more usefully spent in general endeavors such as describing species composition and the natural relationships (e.g., predator-prey and other trophic relationships).

Population structure was examined using a series of equations based on Brody-Bertalanffy growth curves (Ebert, 1973). This method, especially applicable to survey work, uses easily gathered size to produce useful first approximations of growth and mortality rates, and also generates a life table. The parameters required for computation are the means of the size distributions from two large samples (300 measurements; the means must closely estimate the parametric mean for the sampled population), times of sample collection relative to the time of "recruitment" in the sampled population, and maximum (asymptotic) size attained by the species at the collecting site.

111. RESULTS

KOYUKTOLIK LAGOON

Description of the Areas Examined

In July, five types of habitats were examined at Koyuktolik Bay. These included: (1) the sand bottom on the north side of the Bay, (2) the intertidal portion of the entrance channel, (3) a rock pinnacle in the entrance channel, (4) the outer lagoon and (5) the inner lagoon (Figure 2). These habitats differ significantly in hydrographical, geological, and biological characteristics. The north side of the Bay is exposed to moderate wave action, judging from the large ripplemarks in the well-sorted sand substrate. The south side and lagoon areas, however, appear well protected. Although the outer portion of the entrance channel may be exposed to considerable wave action from lower Cook Inlet, the lagoon areas are well protected. The entrance channel is. swept four times daily by strong tidal currents. Geologically, it appears that the lagoon was formed behind a moraine left by the glacier that excavated the Koyuktolik Bay and canyon complex. The narrow entrance channel winds through the moraine, permitting water movement into and from the Bay. The area of the lagoon is approximately 1,690,000 sq.m.

The substrate of the Bay, on its north side, was characterized by clean, gray medium sand with little shell debris. Wave action had created a microrelief of large ripple marks at a depth of 9.8 m (Appendix A-l). The biota was dominated by a maldanid polychaete (a deposit feeder), the clam _Tellina nuculoides_ (a suspension feeder), and a sand dollar _Echinarachnius parma_ (a suspension feeder). Major predators appeared to be sea ducks (probably scoters and common eiders), the olive shell (Olivella baetica) and the sunstar (Pyncopodia helianthoides; Appendix A-l).

On the south side of the Bay, the substrate was predominantly a cobble/sand matrix overlain with a thin dusting of silt. A large quantity of organic debris of terrestrial and marine origin was present (Appendix A-2) . Although shell debris was common, living clams were not observed. The most conspicuous alga was elephant ear kelp (Laminaria saccharin) , but it appeared possibly imported from shallower water. The predominant invertebrates were a chiton (Tonicella lineata), a hermit crab (Pagurus ochotensis) and the sunstar (Pycnopodia helianthoides).

The intertidal margins of the entrance channel to the lagoon was strongly dominated by two extensive beds of the blue mussel (Mytilus edulis). One bed was at the north side of the mouth and the other was on the gravel bar separating the entrance channel from the outer lagoon. Each mussel bed covered nearly four acres and comprised a considerable biomass of mussels. Additionally, outside the mussel beds, dense patches of the periwinkle (Littorina sitkana) were scattered throughout the intertidal zone in the entrance channels (Appendix A-3).

The flora of the mussel beds was dominated by rockweed (Fucus distichus), but several other sPecies were conspicuous- A large ribbon-like kelp (Alaria fistulosa) was a conspicuous dominant in the shallow subtidal zone. Another common intertidal form was the thin red alga Porphyra sp., which appeared to be an important pioneer species. In the ice-scoured furrows, it almost completely covered the exposed cobbles by mid-July, whereas in May these same furrows had been completely devoid of vegetation.

A large rock outcrop is located where the entrance channel joins the outer lagoon. The flora and fauna of this area is quite robust and diverse (Appendix A-4). The sides of this pinnacle supported moderate quantities of several large algae such as Fucus, Alaria sp. and Agarum cribrosum. The boulders around the pinnacle were heavily covered with a three-layered algal assemblage. The upper layer was dominated by Laminaria groenlandica and Alaria sp.; over much of the area, coverage by L. groenlandica was complete. Under the laminarian canopy, several foliose species of red algae were abundant, notably Rhodymenia palmata, Opuntiella californica and Iridaea lineare. Encrusting coralline algae formed a thin veneer on the rocks under the overlying algal canopy.

Vertical zonation on the pinnacle is indicated in Table 1. Rockweed and barnacles dominated the upper zone which is also occupied by several subdominant. These were mainly browsing molluscs (Littorina sitkana), some limpet species, a chiton (Katharina tunicata) and the blue mussel. Another chiton, Tonicella insignis, was common from mid-intertidal into the subtidal zone, under the kelp canopy (Table 1; Appendix A-5). The lower intertidal zone was largely dominated by algae (Table 1). Katharina was a dominant grazer in the mid-intertidal zone, and probably has a considerable influence on algal cover and the floral composition. Based on data collected in that zone, the estimated density for Katharina was about 44 individuals/m^2 (Appendix A-5).

Table 1. Distribution of organisms observed in a vertical series of 1/16 m^2 quadrats on a rock pinnacle in entrance channel to Koyuktolik Lagoon, 7/10/76.

	QUADRAT ORDER									
	Upper Intertidal								Low Intertid	
Species	1	2	3	4	5	6	7	8	9	10
Fucus distichus (C)	100%	20%	0	5%	5%	100%	100%	0	0	0
Balanus ? glandula (N)	0	5	46	0	0	0	0	0	0	0
Balanus ? glandula (C)	0	0	0	0	40%	75%	75%	50%	0	0
Littorina sitkana (N)	0	0	25	70	15	0	0	0	0	0
Acmaeidae, unid. (N)	0	0	0	6	5	0	0	0	0	0
Mytilus edulis (N)	0	0	0	20	0	0	0	0	0	0
Mytilus edulis (C)	0	0	0	5%	20%	0	0	0	0	0
Katharina tunicata (N)	0	0	0	0	0	2	3	0	0	0
Elassochirus gilli (N)	0	0	0	0	0	1	1	0	0	0
Serpulidae, unid. (N)	0	0	0	0	0	0	0	Numerous	0	Numerous
Encrusting bryozoan (N)	0	0	0	0	0	0	0	P	0	C
Alaria sp. (N)	0	0	0	0	0	0	0	0	3	0
Alaria sp. (C)	0	0	0	0	0	0	0	0	100%	0
? Monostroma sp. (C)	0	0	0	0	0	0	0	0	75%	50%
Encrusting coralline alga (C)	0	0	0	0	0	0	0	0	50%	25%
Pycnopodia helianthoides (N)	0	0	0	0	0	0	0	0	1	0
Tonicella ? insignis (N)	0	0	0	0	0	0	0	0	0	6
Laminaria sp.	0	0	0	0	0	0	0	0	0	0

(N) - Number
(C) - Relative cover
Dom - Dominant

Several mobile crustaceans were common on the sides of the pinnacle. These included the hermit crab Elassochirus gilli and two decorator crabs (Hyas lyratus and Oregonia gracilis).

The fauna on and under the boulders surrounding the pinnacle was dominated by suspension feeders such as the hydroid Abietinaria turgida, the sponge Halichondria panicea, the sea cucumber Cucumaria miniata and the brittlestar Ophiopholis aculeata. TWO herbivores, Tonicella lineata and Strongylocentrotus drobachiensis were common. The starfish Pycnopodia helianthoides and Evasterias troschelii were common. The discovery that juvenile king crab (Paralithodes camtschatica) were common under rocks was surprising in this estuarine habitat. Specimens with carapace widths of about 1 cm were observed under at least a third of the large boulders overturned during examination.

The outer lagoon was strongly dominated by macrophytes, mainly eelgrass (Zostera marina), and the seaweeds, Laminaria ? saccharin, Alaria sp., and Ahnfeltia plicata. The quantity of marine vegetation in the outer lagoon was very high. Major invertebrates included clams (Mya spp., Saxidomus gigantea and Tresus capax) and a crab (Telmessus cheiragonus; Appendix A-6). A total of 31 species was recorded in July.

The epibiota of the inner lagoon was generally representative of an impoverished area. only three species were recorded during a cursory examination, but extended observations probably would not have increased the number of macroscopic forms appreciably. Eelgrass was the dominant plant and the deposit feeding polychaete, Abarenicola ? pacifica was a common animal (Appendix A-7).

Biology of Eelgrass

The dominant primary producer in Koyuktolik Lagoon was eelgrass. The bed was best developed in the outer lagoon. Overall vegetative cover in the lagoon by eelgrass was not examined, but cover and density of turions (bundles of leaves) were measured in the transition zone between the inner and outer lagoon, and toward the middle of the outer lagoon. Turion density estimates are based on replicate counts in 0.0625 m^2 quadrats. In July, the density of eelgrass in the middle of the lagoon averaged about 485 turions per m2; relative cover averaged 81 percent (Appendix A-8). Plant height ranged from 38 to 142 cm, and averaged 107.9 ± 24.1 cm (Appendix A-9; Table 2). The distribution of plant height was unimodal, the mode being above the mean. In August, the estimated density of eelgrass in the same general area was about 612 turions/m^2; relative cover was not measured (Appendix A-10). Plant height at that time ranged from 31.5 to 248.0 cm, and averaged 160.0 ± 46.3 cm (Appendix A-n; Table 3); the distribution of plant height was again unimodal, but rather flatter than in July; the mode was again somewhat above the mean.

In the transition zone (Figure 2), eelgrass and a mat-forming red alga Ahnfeltia plicata co-dominated. Large patches of eelgrass were separated by wide channels of Ahnfeltia. In the area examined in July, relative cover by Ahnfeltia was about 54 percent. Relative cover by eelgrass was about 40 percent and the estimated overall density was 182 turions/m^2 (Appendix A-8). Density within the eelgrass bed was about 456 turions/m^2. Plant height ranged from 28-173 cm and averaged 95.5 ± 30.6 cm (Appendix A-12; Table 2). The distribution of plant height was basically bimodal in this location with the major mode located slightly above the

Table 2 . Turion height-frequency distributions of eelgrass (*Zostera marina*) in Koyuktolik Lagoon, 7/9/76.

Turion Height (cm) [1]	Inner Lagoon Frequency %		Transition Zone Inner & Outer Lagoon Frequency %		Middle of Outer Lagoon Frequency %	
20.0-29.9	1	2	1	1.6	0	0
30.0-39.9	10	20	0	.0	1	1
40-0.49.9	8	16	6	10.0	2	2
50.0-59.9	1	2	2	3.3	3	3
60.0-69.9	4	8	5	8.3	2	2
70.0-79.9	4	8	2	3.3	3	3
80.0-89.9	5	10	6	10.0	10	10
90.0-99.9	4	8	9	15.0	10	10
100.0-109.9	6	12	11	18.3	12	12
110.0-119.9	2	4	6	10.0	15	15
120.0-129.9	2	4	3	5.0	27	27
130.0-139.9	3	6	4	6.7	13	13
140.0-149.9	0	0	3	5.0	2	2
150.0-159.9	0	0	0	0	0	0
160.0-169.9	0	0	0	0	0	0
170.0-179.9	0	0	1	1.6	0	0
n	50		60		100	
$\bar{x}$ (cm) [2]	73.0		95*5		107 .9	
s (cm) [2]	33.2		30.0		24.1	

[1] Length of longest leaf from upper node.
[2] Based on unclassed data in Appendices A-9, A-12 and A-14.

mean. In August the estimated density of eelgrass within the bed in the same general area was 440 turions/m^2. Plant height ranged from 28.5-217.0 cm and averaged 130.5 ± 53.2 cm (Appendix A-13; Table 3). The distribution of plant height was irregularly bimodal with the major mode somewhat higher than the mean.

In the inner lagoon (Figure 2), although poorly developed and sparsely distributed, eelgrass was the dominant plant cover. Relative cover was probably less than 5 percent over the entire area, and density was estimated at less than 50 turions/m^2. Plant height ranged from 27.5-136.o cm and averaged 7.30 ± 33.2 cm.(Appendix A-14; Table 2). The distribution of plant height was basically bimodal with the major mode located somewhat below the mean. This area was not sampled in August.

Samples were collected for estimation of wet and dry weight of the standing stocks of eelgrass in July and August. The relationships between turion height and wet weight are shown for three locations in the lagoon in Figure 5; the basic data are included in Appendices A-12, A-14 and A-15. The relationships between turion height and dry weight for samples from the transition zone are shown in Figure 6 and the basic data are included in Appendices A-15 and A-16.

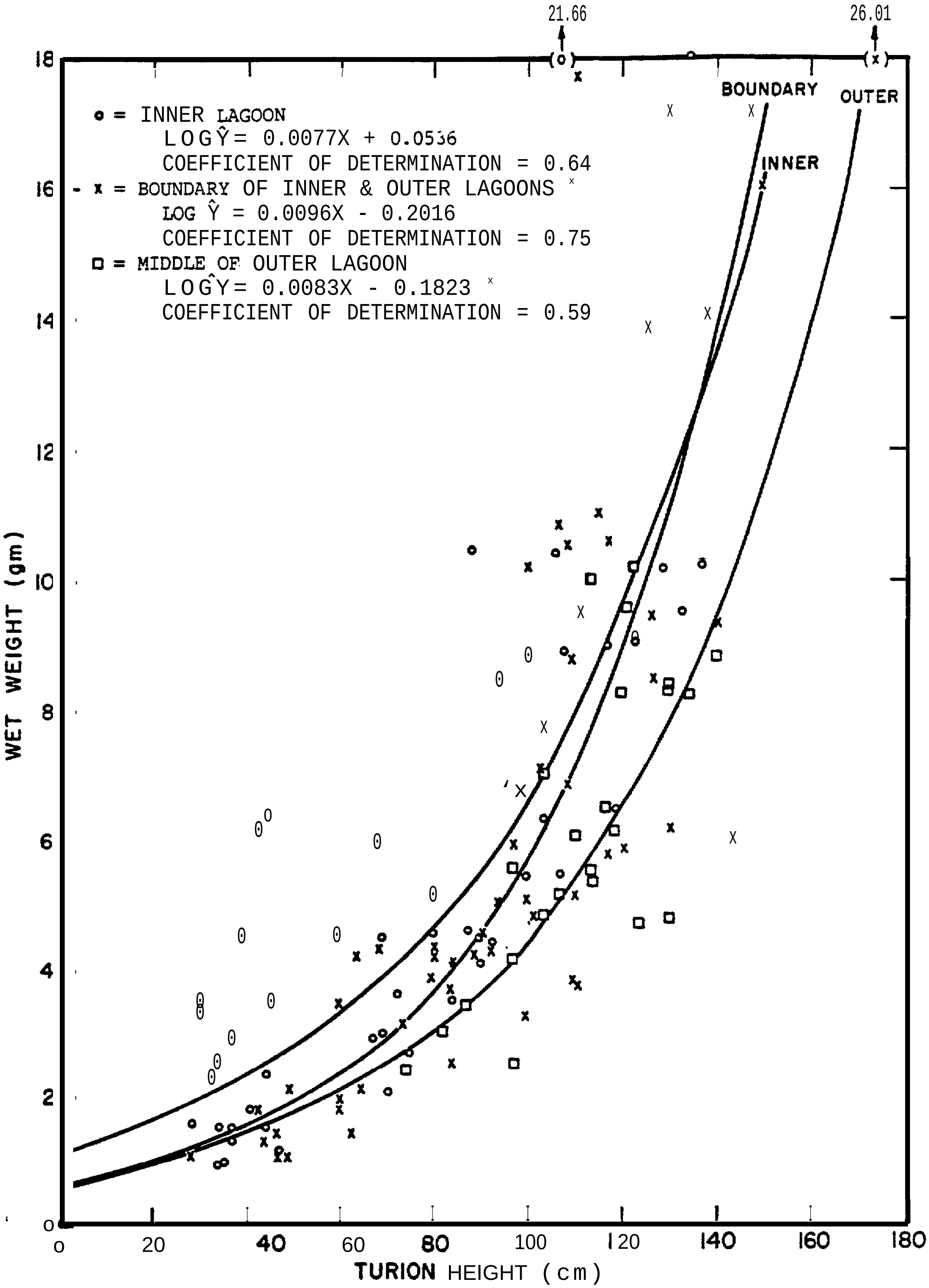
The turion height-wet weight regressions are fairly similar for all three beds sampled in July (Figure 5). However, it appears that the plants in the outer lagoon have a tendency to be lighter than plants of the same size from the inner beds. This is possible because the somewhat lower turion densities and relative cover within the beds of the transition

Table 3 . Turion height frequency distributions for eelgrass (Zostera marina in Koyuktolik Lagoon, 8/30/76.

Turion Height (cm) 1/	Transition Zone Between Inner & Outer Lagoon Frequency	%	Middle of Outer Lagoon Frequency	%	Total	Percent
20.0-29.9	1	1.5	0	0.0	1	0.6
30.0-39.9	2	3.0	2	2.0	4	2.4
40.0-49.9	2	3.0	0	0.0	2	1.2
50.0-59.9	2	3.0	0	0.0	2	1.2
60.0-69.9	2	3.0	1	1.0	3	1.8
70.0-79.9	6	9*0	2	2.0	8	4.8
80.0-89.9	5	7.5	1	1.0	6	3.6
90.0-99.0	3	4.5	4	4.0	7	4.2
100.0-109.9	5	7.5	4	4.0	9	5.4
110.0-119.9	2	3.0	7	7.1	9	5.4
120.0-129.9	1	1.5	7	7.1	8	4.8
130.0-139.9	5	7.5	3	3.0	8	4.8
140.0-149.9	1	1.5	7	7.1	8	4.8
150.0-159.9	6	9.0	6	6.1	12	7.2
160.0-169.9	3	4.5	9	9.1	12	7.2
170.0-179.9	5	7.5	7	7.1	12	7.2
180.0-189.9	7	10.4	10	10.1	17	10.2
190.0-199.9	2	3.0	9	9.1	11	6.6
200.0-209.9	4	6.4	7	7.1	11	6.6
210.0-219-9	3	4.5	6	6.1	9	5.4
220.0-229.9	0	0.0	2	2.0	2	1.2
230.0-239.9	0	0.0	4	4.0	4	2.4
240.0-249.9	0	0.0	1	1.0	1	0.6
n	67		99		166	
$\bar{x}$ (cm) 2/	130.5		160.0		148.1	
s (cm) 2/	53.2		46.3		49.0	

1/ Length of longest leaf from upper node.

2/ Based on unclassed data in Appendices A-n and A-13.

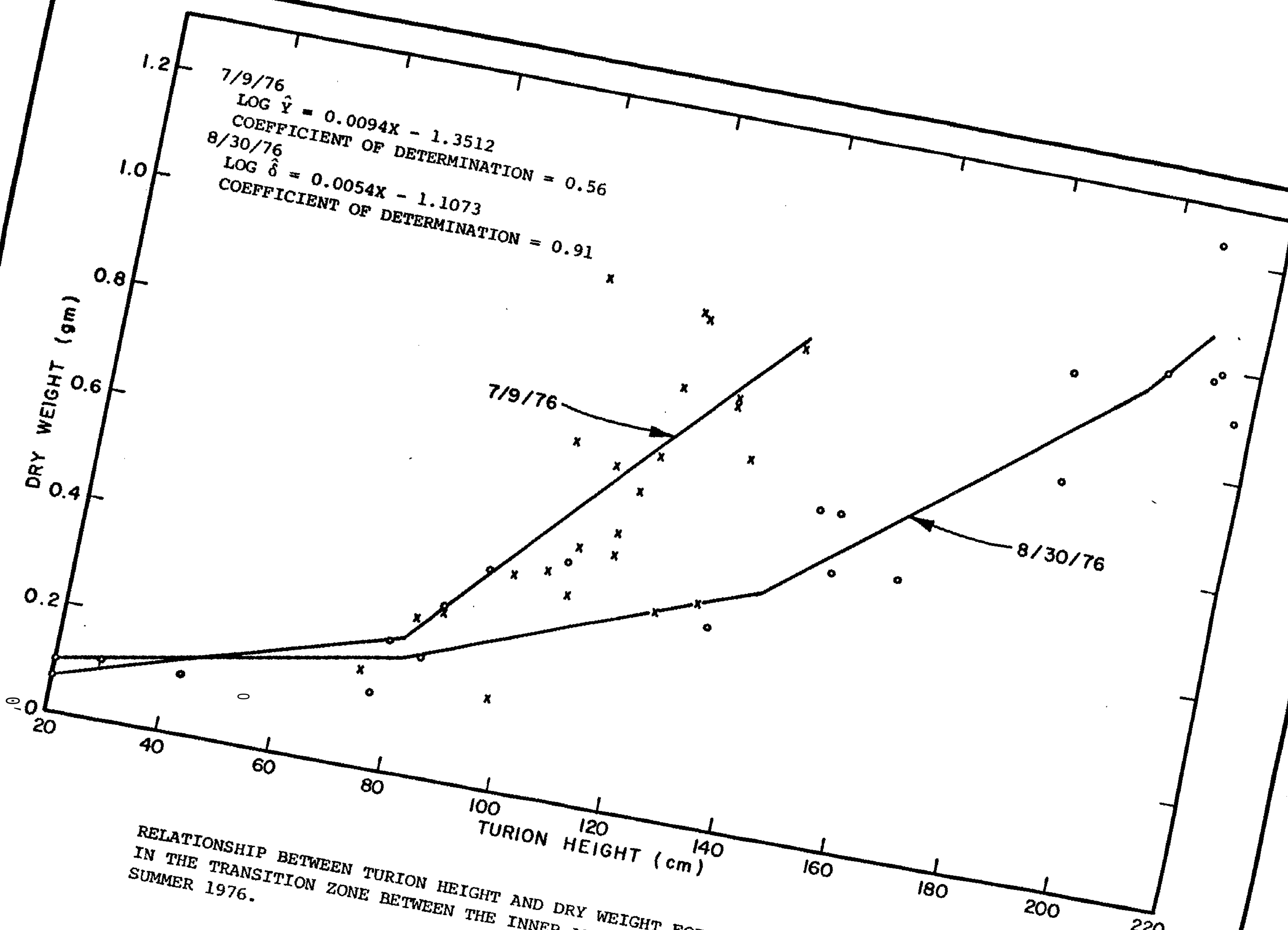


RELATIONSHIP BETWEEN TURION HEIGHT AND WET WEIGHT FOR EELGRASS (*ZOSTERA MARINA*) AT KOYUKTOLIK LAGOON, 7/9/76.

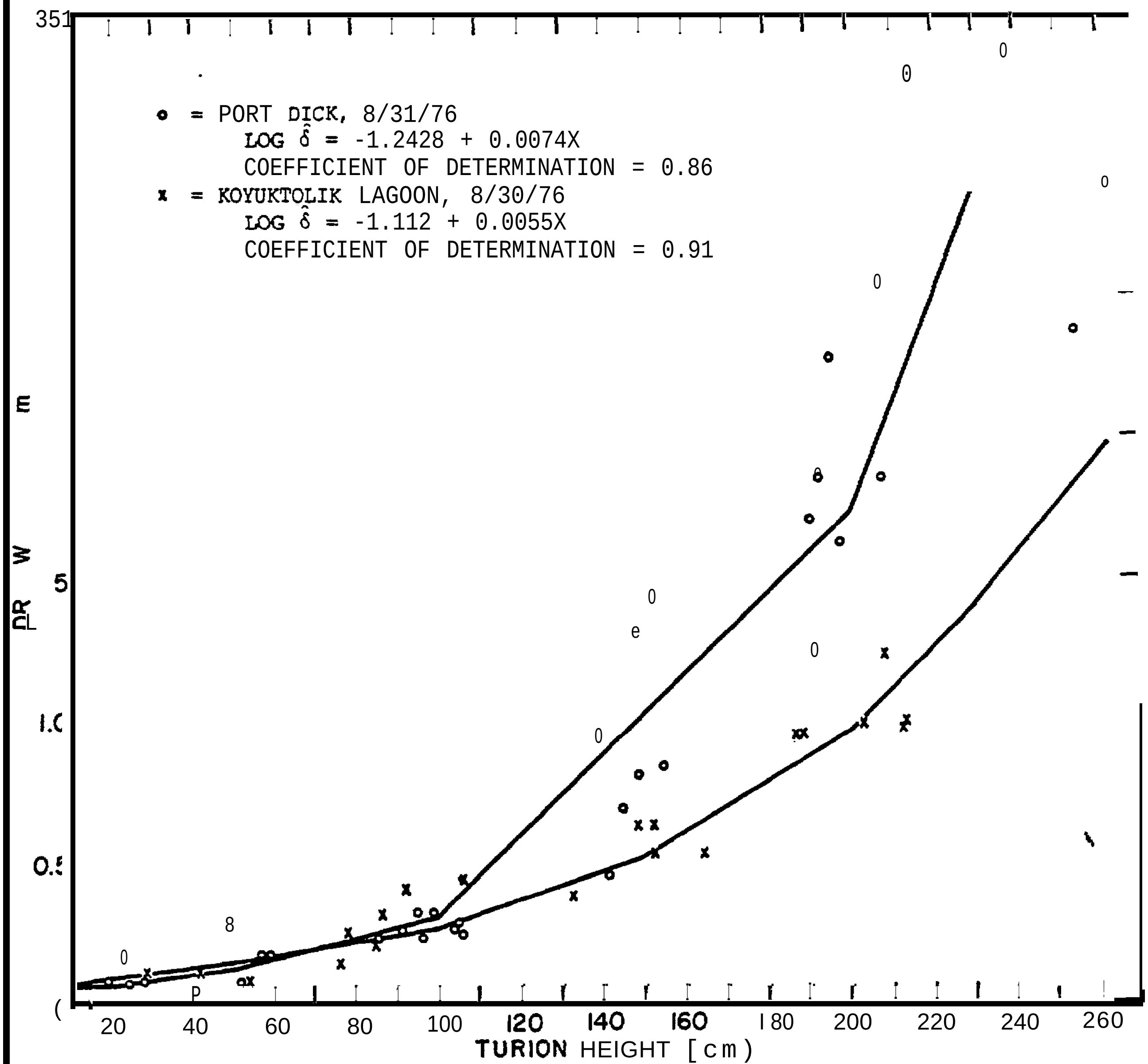
zone permit the plants to become more robust. However, it may also be a consequence of experimental error.

In August while examining the samples from the eelgrass meadows in Koyuktolik Lagoon, it seemed that the physical appearance of the plants was poorer than those observed in July. The plants were also somewhat poorer than those observed at Port Dick the next day. The characteristics of the plants that led to the initial subjective opinion were the number of frayed and broken leaves and the amount of deterioration and apparently dead tissue on the leaves. The first part of this hypothesis is supported by the data presented in Figure 6. A comparison of the regressions for turion height and dry weight suggests that, although average length was considerably lower in August (Tables 2 and 3), turions of equal size were considerably heavier in July (Figure 6). For example, the estimated dry weight of 140 cm long turion in July was 0.92 gm, but in August it had decreased to 0.45 gm. Furthermore, a comparison of the turion height-dry weight relationships for eelgrass from Port Dick and Koyuktolik Lagoon produced the same conclusion, namely plants of equal length were lighter at Koyuktolik {Figure 7). In fact, the details are quite similar; the estimated dry weight of a 140 cm long turion at Port Dick in August is about 0.88 gm, only slightly less than in the transition zone at Koyuktolik in July. These factors, in addition to a large quantity of loose and drifting leaves, made it appear that the eelgrass beds in Koyuktolik Lagoon had already peaked by late August. No flowering plants were observed during either survey.

To estimate biomass, the size distribution for each area was utilized to divide the number of turions per m^2 into size classes; then



RELATIONSHIP BETWEEN TURION HEIGHT AND DRY WEIGHT FOR EELGRASS (ZOSTERA MARINA) IN THE TRANSITION ZONE BETWEEN THE INNER AND OUTER LAGOONS, KOYUKTOLIK LAGOON. SUMMER 1976.



COMPARISON OF TURION HEIGHT-DRY WEIGHT RELATIONSHIPS FOR EELGRASS (*ZOSTERA MARINA*) FROM PORT DICK AND KOYUKTOLIK LAGOON, AUGUST 1976.

the number of individuals in each class was multiplied by the estimated weight of a turion of the average size for that class. The component weights were summed for the estimated biomass/m^2. These data are presented in Table 4.

Standing stocks of eelgrass are considerably lower in the inner lagoon than elsewhere (Table 4). In July the biomass of the beds of the outer lagoon and the transition zone were at least ten times greater than the biomass of the bed in the inner lagoon. Estimated wet weight at the outer areas averaged about 2,800 gm per m^2.

Because of the paucity of data, the main value of these data is that they provide general estimates of standing stocks of eelgrass and its distribution in the lagoon. It cannot be determined if the increase in density and biomass indicated for the middle of the outer lagoon are real or are due to sampling variation. Clearly, however, the outer lagoon supports a considerable standing crop. The poor condition of the plants and the large quantity of drifting eelgrass observed in August indicate that maximum values were not obtained.

Biology of the Mussel Beds

Beds of the blue mussel *Mytilus edulis* are an important and conspicuous feature in the ecology of the entrance channel and nearby lagoon system. These beds cover, in varying densities, at least 7.5 acres of the intertidal. All of the mussel beds examined here have been formed on a gravel/cobble substrate. With maturity, these beds incorporate a sizable quantity of cobble, gravel, sand and silt into the matrix formed by

Table 4. Estimates of size and weight distributions, density and biomass of eelgrass beds in Koyuktolik Lagoon in summer 1976.

	7/9/76						8/30/76			
	Inner Lagoon		Transition Zone		Outer Lagoon		Transition Zone		Outer Lagoon	
Turion Height (cm)	Approx. Frequency	Estimated Wet Tissue Weight (gin)	Approx. Frequency	Wet Tissue	Approx. Frequency	Wet Tissue	Approx. Frequency	Dry Tissue	Approx. Frequency	Dry Tissu
20.0- 29.9	1	1.8	8	8.3	0	0	7	0.7	0	0
30.0- 39.9	10	21.0	0	0	5	6.2	12	1.6	12	1.5
40.0- 49.9	8	20.1	46	77.5	9	15.1	13	1.8	0	0
50.0- 59.9	1	3.0	16	32.2	14	27.4	13	2.0	0	0
60.0- 69.9	4	14.3	39	100.5	9	22.1	13	2.3	6	1.1
70.0- 79.9	4	17.1	16	50.1	14	40.1	39	7.8	12	2.5
80.0- 89.9	5	2S.5	46	187.7	49	161.s	33	7.4	6	1.4
90.0- 99.9	4	24.4	68	3s1. 1	49	195.9	20	5.0	25	6.3
100.0-109.9	6	43.7	%5	535.3	58	284.5	33	9.5	25	7.1
110.0-119.9	2	17.4	46	364.2	73	430.6	13	4.3	43	14.1
3.20 .0-129.9	2	20.8	24	227.2	132	938.2	7	2.4	43	16.0
130.0-139.9	3	37.2	30	377.8	64	546.9	33	13.7	20	7.8
140.9-149.9	0	0	24	353.5	9	101.9	7	3.1	43	20.5
150.0-159.9	0	0	0	0	0	0	39	21.1	37	19.9
160.0-169.9	0	0	0	0	0	0	20	12.0	56	33.8
170.0-179.9	0	0	8	228.7	0	0	33	22.6	43	29.8
160.0-189.9	0	0	0	0	0	0	46	35.8	62	48.2
190.0-199.9	0	0	0	0	0	0	1.3	11.6	56	49.1
200.0-209.9	0	0	0	0	0	0	26	26.3	43	43.2
210.0-219.9	0	0	0	0	0	0	20	22.3	37	42.0
220.0-229.9	0	0	0	0	0	0	0	0	12	15.8
230.0 -239.9	0	0	0	0	0	0	0	0	25	35.9
240.0-249.9	0	0	0	0	0	0	0	0	6	10.2
Approx. No. per m^2	<50		456		485		440		612	
Estimated Biomass (gm wet wt./m^2)		<246		2894		2770		2133[2]		4061[2]
(gm dry wt./m^2)		<25[2]		289[2]		277[2]		213		406

[1] Calculated using the regression equation developed from the data for the transition zone eelgrass bed, which may cause an overestimate of biomass.

[2] Based on an average wet weight/dry weight ratio of 10:1.

the shells and byssus masses. Thickness of this mat ranged from abOut 1 cm near the upper edge of the beds to about 20 cm in some locations near the low tide mark. All beds examined have been located in areas subjected to fast tidal currents. The upper and lower margins are rather sharply defined. Connell (1961) pointed out that many intertidal organisms are limited by physical factors at their upper limits, and by biotic factors on their lower limits . The factors imposing upper limits for mussels in these beds are probably harsh temperatures, desiccation and limited feeding time. In some locations, the lower limits are probably imposed by the predatory activities of the slender starfish Evasterias troschelii, but overall, the rather sharp demarcation at the lower limit is unexplained at present. Other predators include glaucous-winged gulls, northwestern crows, sea ducks, and sea otters. To date, we have seen no evidence of other species competing strongly with mussels for food or space.

As indicated above, the majority of the mussels are concentrated into two beds. Within these beds, mean shell length seems largest near the lower edge of the bed and smaller at the top; densities are greater toward the middle of the bed and lowest near the lower edge; this numerical difference is probably a function of crowding and size.

Mussels and rockweed were the dominant organisms in both the outer and inner mussel beds. Relative cover by mussels in the outer bed averaged 80 percent (Table 5)- Rockweed (Fucus distichus) averaged less than 2 percent (Appendix A-17}, and was generally common only along the lower edge of the bed near MLLW. Mussel density and size structure varied

Table 5. summary of relative cover data for the blue mussel (*Mytilus edulis*) in mussel beds in the entrance to the lagoon, Koyuktolik Bay, 7/10/76.

Percent Cover*	Outer Bed	Inner Bed
0	0	15
1	0	1
5	1	4
10	2	4
15	3	1
20	1	3
25	4	4
30	3	1
35	2	1
40	9	7
45	3	6
50	8	11
55	1	9
60	5	18
65	5	11
70	11	14
75	14	17
80	11	13
85	13	8
90	24	10
95	25	9
97	3	0
9a	10	0
99	4	0
100	47	10
Number of quadrats	209	177
Mean cover ($\bar{x} \pm s$):	79.6 ± 23.9	58.9 ± 29.2

•In 1/16 m^2 quadrats

considerably with position within the bed. Near the channel (about 150 m from the upper edge of the bed), mussel density approached $13,000/m^2$, but 80 m from the upper edge, density was about $9,000/m^2$ (Appendix A-18). Size structures at these two levels were statistically similar. Average shell lengths were 25.5 ± 8.8 mm and 23.8 ± 7.4 mm, respectively, for the channel and the 80 m areas (Appendix A-18; Table 6). The size structures were basically unimodal; the modes were located very close to the means (Table 6). Unfortunately, samples for the upper levels of the bed were lost, but field observations indicated that the patterns were still similar to those reported previously. Generally, the density was very high but average shell length was small.

Relative coverage of substrate by mussels averaged about 60 percent (Table 5), and Fucus averaged about 11 percent in the inner bed (Appendix A-19). The mussels were most dense in a 20 m wide band extending along the channel for approximately 200 m. Fucus was most abundant along the entrance channel, but was also abundant around several pools and drainage channels located within the bed. Mussel density and size structure varied considerably with position within the bed. At the southwestern corner of the bed, near the confluence of the entrance channel and a moderate sized feeder channel, densities were high, ranging from 18,000 to $22,000/m^2$. Moving north along the main channel, densities declined to about 12,500 at 30 m, and 7,000 at 75 m (Appendix A-20). Average shell length generally increased in the same direction, ranging from 16.7 mm at the southwest tip of the bed to 26.2 mm, 75 m north of that point (Appendix A-20; Table 7). Size generally appeared to decrease with increased distance from the channel (or increased tidal elevation). The size structures were basically unimodal in all samples except from 75 m north of the southwest tip; the modes were all

Table 6 . Size distributions for blue mussels (*Mytilus edulis*) from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	150 m from Upper Edge 10 m from Lower Edge		80 m from Upper Edge	
	Frequency	%	Frequency	%
1-4	1	0.9	0	0.0
5-8	4	3.4	1	1.2
9-12	2	1.7	4	4.8
13-16	9	7.6	11	13.1
17-20	20	17.0	12	14.3
21-24	15	12.7	14	16.7
25-28	23	19.5	18	21.4
29-32	20	17.0	16	19.1
33-36	12	10.2	5	6.0
37-40	7	5.9	3	3.6
41-44	4	3.4	0	0.0
45-48	0	0.0	0	0.0
49-52	1	0.9	0	0.0
n	118		84	
$\bar{x} \pm s$*	25.5		23.8	

* Based on unclassed data in Appendix A-18.

Table 7. Size distributions for blue mussels (*Mytilus edulis*) from inner bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	5 m from South End Frequency	%	10 m from South End Frequency	%	30 m from South End Frequency	%	75 m from South End Frequency	%
1-4	0	0.0	0	0.0	0	0.0	0	0.0
5-8	18	11.0	6	3.0	5	4.3	0	0.0
9-12	38	23.2	32	15.8	24	20.5	10	15.2
13-16	46	28.1	58	28.7	31	26.5	7	10.6
17-20	23	14.0	44	21.8	16	13.7	6	9.1
21-24	17	10.4	17	8.4	12	10.3	7	10.6
25-28	6	3.7	10	5.0	6	5.1	11	16.7
29-32	4	2.4	9	4.5	7	6.0	7	10.6
33-36	6	3.7	7	3.5	6	5.1	2	3.0
37-40	3	1.8	9	4.5	5	4.3	7	10.6
41-44	1	0.6	4	2.0	4	3.4	4	6.1
45-48	2	1.2	4	2.0	1	0.9	4	6.1
49-52	0	0.0	1	0.5	0	0.0	1	1.5
n	164		202		117		66	
$\bar{x} \pm s$*	16.7 ± 8.1 mm		19.7 ± 9.6 mm		19.6 ± 9.6 mm		26.2 ± 11.6	

*Based on unclassed data in Appendix .

fairly close to the means. The size distribution of the 75 m sample was somewhat bimodal but, because of the small sample size, the pattern is suspect.

Estimates of mussel biomass were developed for all sampling areas. These were generated utilizing the site specific density and size data and a shell length-wet weight regression equation for mussels from Port Dick in the same time period. Comparison of regression data collected from both Koyuktolik Bay and Port Dick in May indicated a close similarity and was considered as justification for this application (Dames & Moore, 1976).

The biomass of wet tissue in the outer bed was highest along the channel, where the estimate exceeded 9 kg/m^2. Although the size structure at the 80 m level was very similar, the lower density resulted in a biomass of only 5.5 kg/m^2 (Table 8). Biomass was generally higher in the inner bed, ranging from 6.6 to 11.5 kg/m^2 (Table 9). The average biomass for both beds" was about 7.7 kg/m^2. The overall biomass of the two mussel beds, adjusting for relative cover in both beds, is therefore estimated in the vicinity of 165,000 kg (about 165 metric tons).

Several feeding observations were made in the Bay, the mussel beds and the lagoon (Appendix A-21). Several species of birds were important predators on pelecypods. Evidence of sea otter predation was also common in the lagoon.

Table 8. Estimates of size and weight distributions, density and biomass of blue mussel (*Mytilus edulis*) for outer mussel bed, Koyuktolik Bay, 7/10/76.

	80 m from upper edge		150 m from upper edge	
Shell Length (mm)	Approximate Frequency	Estimated Wet Tissue Weight (gm)	Approximate Frequency	Estimated Wet Tissue Weight (gin)
1- 4	0	0	109	12.2
5- 8	109	16.2	434	65.0
9-12	435	86.8	217	43.4
13-16	1196	319.0	979	261.1
17-20	1304	465.2	2175	775.6
21-24	1522	725.4	1631	777.5
25-28	1956	1246.6	2501	1593.4
29-32	1739	1481.0	2175	1851.9
33-36	543	618.6	1305	1485.2
37-40	326	496.1	761	1158.0
41-44	0	0	434	884.4
45-48	.0	0	0	0
49-52	0	0	109	395.0
Approx. No. per m^2	9130		12830	
Estimated Biomass: (gm wet weight/m^2)		5455		9303

Table 9. Estimates of size and weight distributions, density and biomass of blue mussels (*Mytilus edulis*) for inner mussel bed, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	5 m from South End Frequency	5 m from South End Wet Tissue Wt.	10 m from South End Frequency	10 m from South End Wet Tissue Wt.	30 m from South End Frequency	30 m from South End Wet Tissue Wt.	75 m from South End Frequency	75 m from South End Wet Tissue Wt.
1 - 4	0	0	0	0	0	0	0	0
5 - 8	2002	292.2	655	156.1	543	81.2	0	0
9 - 12	3789	737.8	3496	694.4	2609	520.8	1079	217.0
13 - 16	5124	1334.2	6336	1682.3	3370	800.1	755	203.0
17 - 20	2463	891.6	4807	1705.8	1739	620.3	647	232.6
21 - 24	1895	880.9	1857	880.9	1304	621.8	755	362.7
25 - 28	669	415.5	1092	692.6	652	415.5	1188	761.8
29 - 32	446	370.3	983	833.1	761	648.0	755	648.0
33 - 36	669	642.4	765	866.1	652	742.3	269	247.5
37 - 40	334	496.1	982	1488.4	543	826.8	755	1157.6
41 - 44	112	221.0	437	884.2	435	884.1	432	884.2
45 - 48	223	590.9	437	1181.8	109	295.4	431	1181.8
49 - 52	0	0	110	394.9	0	0	108	394.9
Approx. No. per m^2	17,826		21,957		12,717		7,174	
Estimated Biomass: (gmWet Tissue Wt./m^2)		6,972.9		11,460.6		6,555.3		6,711.1

CHUGACH BAY

Five general locations were examined near the southern shoreline of Chugach Bay. The principal substrate in the sublittoral zone was bedrock with scattered boulders and patches of coarse sand. Depths surveyed ranged from 7.5-21 m. The general locations indicated in Figure 3 are 1) inside Raft Cove (9.1-10.7 m), 2) north of Raft cove (7.5-16 m), 3) near the northeast point of Raft Cove (8-11.5 m), 4) south of the southeast point of Chugach Bay (12-12.5 m) and 5) east of that point (21 m).

In all locations, the bottom was visually dominated by kelp species. However, the species composition, density and relative cover, varied markedly with location and depth. Inside Raft Cove, bull kelp (Nereocystis luetkeana) and elephant ear kelp (Laminaria groenlandica) were dominants (Table 10). Ribbon kelp (Alaria sp.) and Cymathere triplicate were common and only observed at this site. Juvenile kelps were abundant (Appendix B-l). North of Raft Cove, on a rock shelf and slope, Pleurophycus gardneri and elephant ear dominated (Table 11). Sieve kelp (Agarum cribrosum) became important at the deeper locations (Appendix B-2). Off the northeast point of Raft Cove, and south and east of the southeast point of Chugach Bay, elephant ear and sieve kelp dominated (Table 12, Appendices B-3 through B-10) .

Algal density and relative cover were generally higher at the shallower stations (Table 13, Appendix B-10) , but this pattern was not clear-cut throughout the area. In general, Laminaria, Nereocystis, Pleurophycus and Alaria were most abundant between the intertidal zone and 10 m depths. Agarum is most abundant between 10 m and 25 m. However, this varied greatly with microhabitat differences, turbulence and water clarity being particularly important factors.

Table 10 . Average density of principal macrophyte species in Raft Cove, Chugach Bay, 7/6/76.

	No. of plants per m^2	
Depth (m)	9.1	10.7
SPECIES		
Agarum cribrosum	0	0
Alaria sp.	0	5.6
Cymathere triplicate	6.7	4.8
Laminaria ? *groenlandica*	5.3	32.8
Nereocystis luetkeana	14.7	9.6

Table 11. Average density and relative cover of principal macrophytes on the shelf and slope north of Raft Cove, 7/6 and 7/8/76.

Depth (m)	7.5-9	9	10.5-11.5	12	12-13.5	15-16.5	16
	No. of plants per m² or relative cover (%)						
SPECIES							
Agarum cribrosum	0	0	3.4	4.0'	6.7	3.2	14.6
Constantinea sp.	-*	0.3%		2.3%		0	
Encrusting coralline alga		58.3%		78.3%		16%	
Laminaria ? groenlandica	21.2	5.2	3.4	5.3	0	1.6	16.9
L. yezoensis	0	0	0.6	0	0	0	0
Opuntiella californica		0.7%		9.7%		0	
Pleurophycus gardneri .	20.0 38.3%	10.8 48.3%	5.7 17.1%	6.7 45%	4.0 26.7%	4.0 11%	0.8
Rhodymenia pertusae		0		6.7%		2%	

* A dash (-) indicates that sampling method excluded that species in the respective sample.

Table 12 . Average density and relative cover of principal macrophytes of the northeast point Of Raft Cove, Chugach Bay, 7/5/76.

	No. of plants per m^2 or relative cover (%)			
Depth (m)	8-8.5	9-9.5	10.5	10.5-11.5
SPECIES				
Agarum cribrosum	5.2 12.3%	7.0 38.8%	2.0 15%	0.3 16. 5%
Constantinea sp.	*			5.6%
Encrusting coralline alga				21.5%
Hildenbrandia sp.				7%
Laminaria ? groenlandica	30.7	3.0	0	5.6
L. saccharin	0	0	40%	5.5%
L. yezoensis	0 0	0 0	0 0	0.8 2%
Pleurophycus gardneri	1.3 3.3%	0 0	0 0	0 0
Rhodymenia pertusae				3.4%

* A dash (-) indicates that sampling method excluded that species in the respective sample.

Table 13 . Relationship between depth, relative cover and density of major kelps in the vicinity of Raft Cove, Chugach Bay, July 1976.

Depth (mm)	Percent Cover	Moving Average for % Cover	No. of Plants per m^2	Moving Average for No./m^2	Location
7.5-9	8.3	--	41.2	--	North of Raft Cove
8-8.5	85.6	--	37.0	--	Northeast point of Raft Cove
9	101.6	79.9	16.0	26.2	North of Raft Cove
9-9.5	73.8	71.0	10.0	18.3	Northeat point of Raft Cove
9.1	--		26.7	12.3	In Raft Cove
10.5	55.0	68.9	2.0	11.7	Northeast point of Raft Cove
10.5 -11.5	39	68.9	6.7	20.4	Northeast point of Raft Cove
10.5-11.5	75.0	64.3	13.1	18.1	North of Raft Cove
10.7	--		52.8	19.4	Raft Cove
12	101.7	66.2	16.0	20.2	North of Raft Cove
12-12.5	50.7	66.4	8.6	19.4	South of Point
12-13.5	66.7	54.4	10.7	15.3	North of Raft Cove
15-16.5"	38	--	8.8	12.9	North of Raft Cove
16	--	--	32.3	--	North of Raft Cove
21	15	--	4.0	--	East of Point
Averages		65.5%		19.1 Plants/m^2	

The epifauna in the study site is quite rich; it was mainly dominated by a broad variety of suspension feeders. The general paucity of large clams and other large fleshy forms possibly reflects the predatory influence of the sea otters that inhabit Raft Cove. However, despite the presence of otters, sea urchins were common under rocks; even in Raft Cove, sea urchin density averaged 2 individuals/m^2 (Appendix B-1).

A broad variety of epifaunal forms was observed on the shelf and slope north of Raft cove (Appendices B-3 through B-5) . The macroherbivores included the sea urchins Strongylocentrotus drobachiensis and S. franciscanus. The former ranged in diameter from 7 to 40 mm and averaged 22.3 ± 7.2 mm (Table 14), and the latter ranged from 7 to 33 mm and averaged 19.9 ± 8.7 mm (Appendix B-11). These averages indicate small animals, particularly for S. franciscanus, suggesting rather young populations. The microherbivores included the snails Calliostoma ligature and Margaritas pupillus and the chitons Tonicella spp. (Table 15); combined densities approaches 13.5 individuals/m2. Major epifaunal suspension feeders included the tunicate ? Distaplia sp., the bryozoan Microporina borealis and hydroids of the family Sertulariidae; combined cover was over 20 percent. Hermit crabs (Paguridae) considered as scavengers and predators, were common. Three predatory species of starfish were common, namely, an unidentified species of Leptasterias (possibly L. leptalea), Crossaster papposus and Tosiaster arcticus. Average radii for these species were 17.0 ± 6.0 mm, 39.3 ± 17.7 mm and 23.3 ± 4.3 mm, respectively. The genus Henricia was also common in the area, but individuals were not identified to species. As a consequence, feeding type cannot be identified. The average size of the specimens observed was 29.6 ± 18.3 mm. Size data for several other asteroids in the area are presented in Appendix B-11.

Table 14 . Size distribution for the green sea urchin (*Strongylocentrotus drobachiensis*) from Raft Cove, Chugach Bay, 7/7/76.

Test Diameter (mm)	Frequency
6-10	4
11-15	6
16-20	17
21-25	17
26-30	13
31-35	3
36-40	1

n = 61
$\bar{x} \pm s$ = 22.3 ± 7.2 mm
Range = 7-40 mm

* Based on unclassed data in Appendix B-n.

Table 15. Abundance and relative cover of several common invertebrates north of Raft Cove, Chugach Bay, summer 1976.

	No. per m^2 or percent cover		
Date	7/6	7/8	7/6
Depth (m)	7.4-13.5	9.1	12-16.5
SPECIES			
Calliostoma ligatum		0	5.5
Crossaster papposus	0.4	0	0
? *Distaplia* sp.		0	6.3%
Henricia spp.	1.2	0	0.5
Leptasterias ? *leptalea*	0	2.7	0
Margaritas pupillus		2.7	2.0
Microporina borealis		6.7%	11.9%
Paguridae, unid.		14.7	2.5
Sertulariidae, unid.		8.7%	3.0%
Strongylocentrotus drobachiensis	2.0	0	2.5
S. franciscanus	0.8	0	0.5
Tonicella spp.		2.7	6.0
Tosiaster arcticus	0.8	0	0.5

Appendix B-11. Most numerous among these was Orthasterias koehleri, an active predator in the entire area.

Additional density data for echinoderm from depths between 12.2 and 18.3 m on the shelf and slope north of Raft Cove are presented in Appendix B-12. The green sea urchin S. drobachiensis was most common; its average density was 5.6 individuals/m2. Most of the individuals were relatively small and lived under boulders. The brittle star Ophiopholis aculeata, also found under rocks, averaged $3.7/m^2$, but this is probably a considerable underestimate.

Vertical faces usually support a broad variety of organisms, particularly suspension feeders. A detailed examination of a 2.5 m high pinnacle exemplifies this; over 50 percent of the species were suspension feeders (Appendix B-13). Dominant forms were the bryozoan Microporina borealis, and several species of hydroids and tunicates.

The epifaunal mat was not well developed under the algal canopy off the northeast point of Raft Cove (Appendix B-7). Only three species were common, namely the colonial tunicate ? Distaplia sp., hermit crabs (Paguridae) and chitons (Tonicella sp.). The olive snail (Olivella baetica) was common on sand (Appendix B-7).

The rock finger extending east of the southern headland of Chugach Bay supported an extremely rich, lush epibiota. An average of 19 species was observed per quadrat. A total of 71 taxa was observed in a single dive (about 1/2 hour). However, because of the small number of quadrats, the cover and density estimates are poor. The dominant species were the hydroids Abietinaria spp., Obelia ? loveni and Tubularia sp., an unidentified starfish (possibly Leptasterias leptalea), the bryozoan Microporina borealis, an orange encrusting tunicate, two species of hermit crabs, and the snail Trichotropis cancellata. Seventeen species of hydroids were particularly abundant, with a combined coverage of over 25%. Suspension feeders, with 56% of the species, dominated the epifauna.

A broad variety of feeding observations was recorded during this sampling period. The more active predators included the sea otter, and the starfish Dermasterias imbricata and Crossaster papposus (Table 16). The most remarkable observation was of the predatory chiton Placiphorella sp. feeding on a juvenile fish, which it had apparently captured. Three species appeared to be responding to reproductive maturity of their prey. Hermit crabs were eating the tops out of colonial tunicates to obtain the large eggs inside. The starfish Orthasterias koehleri was feeding on a small tunicate packed with numerous large eggs. The leather star Dermasterias imbricata was feeding on reproductively mature sertulariid hydroids, and possibly the bryozoans Microporina and Dendrobeania, upon which it was feeding, was mature also. The interesting aspect of this is the fact that these prey species, particularly hydroids, are not considered frequent prey species. However, the suspected pattern emerging from similar feeding observations is that some predators are able to sense reproductive maturity of potential prey species and that by preying on these species during such periods, they can capitalize on the concentrated nutrients available to them.

Table 16 . Observations of predation of Chugach Bay on 7/5 and 7/8/76.

Predator	Prey	Depth (mm)	No. of Feeding	Type of Evidence
Placiphorella sp.	Juvenile fish	9.1	1	Direct
Fusitriton oregonensis	Juvenile fish	--	1	Direct
Pagurus sp.	Orange, social, colonial tunicate ? (tops eaten out of groups)	--	1	Direct
Enhydra lutris	Molluscus	12.0	Numerous	Indirect
Orthasterias koehleri	Can-of-corn tunicate	15.8	1	Direct
Leptasterias ? leptalea	Musculus vernicosus	18.3	1	Direct
Dermasterias imbricata	Microporina borealis	15.8	1	Direct; gut out
Dermasterias imbricata	Dendrobeania ? murrayana	15.2	1	Direct; gut out
Dermasterias imbricata	Sertulariid hydroids	16.8	Numerous	Direct; gut out
Crossaster papposus	Calliostoma ligature	16.8	1	Direct; gut out
Crossaster pappOsus	Placiphorella sp .	--	1	Direct

PORT DICK

General Description of Areas Examined

The areas examined at the head of the West Arm of Port Dick included the outer edge of the shelf, a small rock islet near the slope on the southern side of the shelf, and the slope at the outer edge of the shelf. The shelf is a depositional mudflat at the mouth of Port Dick Creek. Quantitative data were collected in the rockweed and mussel assemblages, the eelgrass bed and on the slope (Figure 4).

Intertidal Zone

The rocky intertidal zone on Dick's Head was dominated by rockweed, sea lettuce and blue mussels (Table 17). RockWeed dominated in the high, middle and low intertidal zones on the north side. The high zone was characterized by barnacles and mussels, the middle zone by sea lettuce and a rope-like green alga (Spongomorpha sp.), and the low zone by sea lettuce and a ribbon-like brown alga (Alaria sp.; Table 17). With the exception of the species mentioned, most of the organisms observed in the intertidal zone were relatively uncommon (Appendix C-l). The biota was fairly diverse (Appendix C-2).

Plant biomass in the intertidal zone was quite high, averaging about 5.5 kg/m^2; rockweed (Fucus) composed over 90% of the wet weight (Appendix c-3). The estimated biomass of rockweed in the 12 m location is extraordinary and probably is a consequence of sampling variability. Even adjusting for relative cover at that level (68%) reduces the biomass to 12.6 kg/m^2. However, it is apparent from these data that the intertidal zone on Dick's Head supports a high algal standing crop.

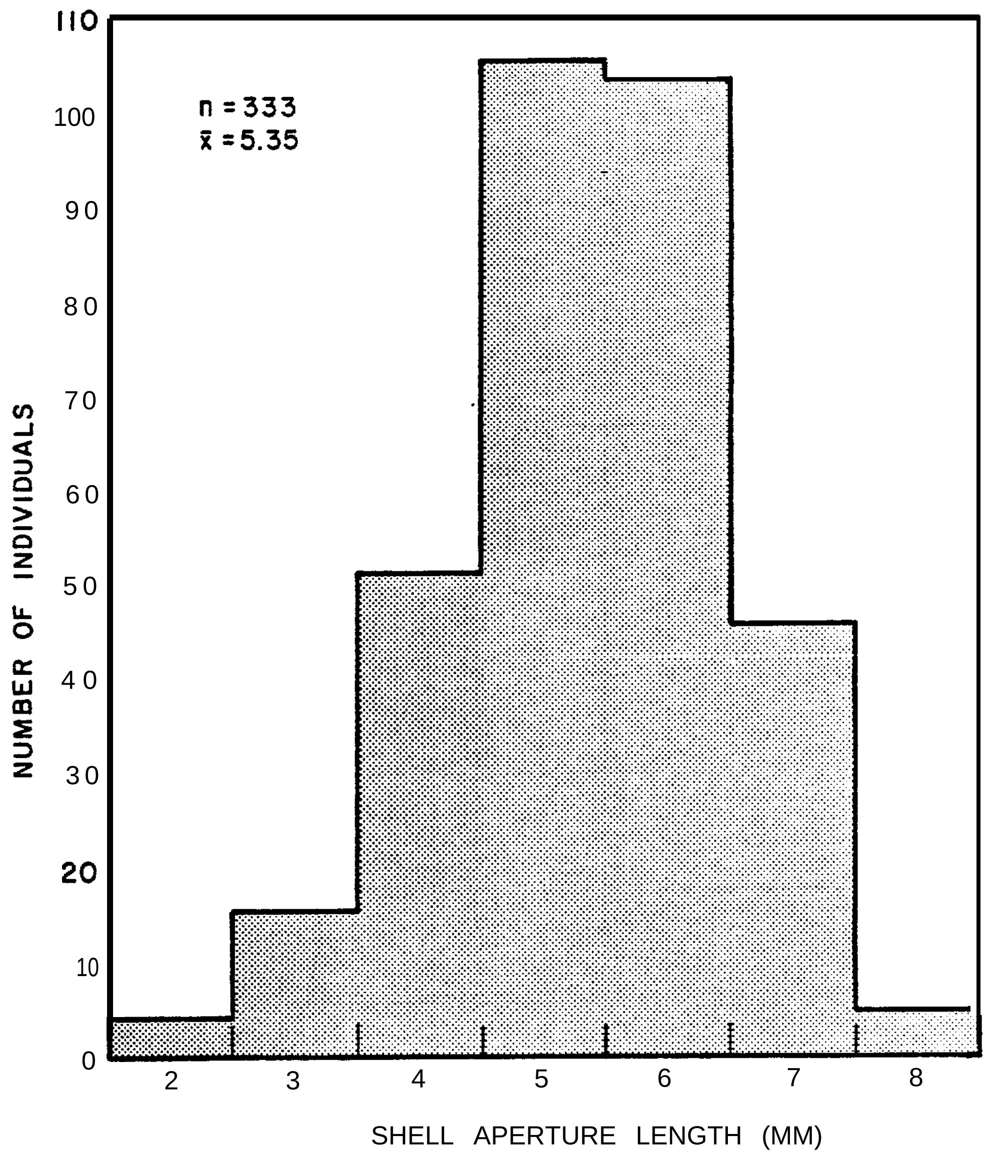
Table 17 . Relative cover by major organisms in intertidal zones on Dick's Head, at the head of West Arm, Port Dick, 6/30/76.

Species	Lower Intertidal	Middle Intertidal	Upper Intertidal	Mean Cover $\bar{x} \pm s$
	PERCENT COVER			
Alaria sp.	8.2	1.3	0	3.8 ± 12.8
Balanus ? *glandula*	0	3.8	10.4	4.6 ± 9.7
Callophyllis sp.	0	0.2	0	0.1 ± 0.4
Costaria costata	0.5	0	0	0.2 ± 1.2
Cryptosiphonia woodii	0.3 "	0.5	0	0.3 ± 1.4
Enteromorpha sp.	0*4	0.2	1.7	().8 ± 3.3
Fucus distichus	66.4	38.8	68.2	57.8 ± 32.1
Gigartina papillata	0	2.4	0	1.0 ± 3.2
Gloiopeltis furcata	0	1.2	0.1	0.4 ± 2.5
Halosaccion glandiforme	1.5	4.7	0	2.0 ± 5.6
Littorina sitkana	0	0.1	1.7	0.6 ± 1.3
Mytilus edulis	0	6.6	18.5	8.5 ± 23.8
Rhodophyta, unid. (Filamentous)	7.6	3.2	1.9	4.2 ± 10.1
Rhodymenia palmata	0.1	0.5	0.1	3.7 ± 4.8
Scytosiphon lomentaria	0	0.2	0	0.1 ± 0.3
Spongomorpha sp.	5.2	10.4	0.2	5.3 ± 10.5
? *Ulva* sp.	24.9	11.4	2.3	12.8 ± 16.9

Several herbivores were common in this area. The periwinkle Littorina sitkana, a microherbivore, was abundant in the high intertidal (Table 17). Aperture length, used as a measure of size, averaged 5.4 ± 1.2 mm (Figure 8). The size structure was strongly unimodal. Limpets (family Acmaeidae) were another microherbivore common in the intertidal zone. Highest densities were observed in the mid-intertidal zone (Appendix c-4).

On the south side of Dick's Head, the blue mussel strongly dominated the intertidal zone. Relative cover exceeded 70% (Table 18) and overall density was over 4,600 mussels/m^2. Density was generally higher at the lower levels (Table 19). However, at the highest level sampled, the elevated density appears to be due to a strong O-year class there. Average shell length was generally larger at the lower levels, except for the population at the lowest level (Table 19; Appendix C-5). The modes of the size distributions follow the same general pattern. All except the upper population had basically unimodal distribution; while the upper population was clearly bimodal. Young mussels (O-year class) were uncommon in the mid-intertidal populations, but dominated in the highest population and common in the lowest population. The abundance of young mussels in the lower population is not completely responsible for its smaller average size; however, the mode for that population is also considerably smaller than for the population at the next higher level (Table 19).

A series of mussels were weighed and measured to determine the relationship between shell length, whole wet weight, wet tissue weight and dry tissue weight. On the average, wet weight was about 44% of whole wet weight and dry weight is about 19% of wet tissue weight (Appendix C-6). The



SIZE FREQUENCY HISTOGRAM FOR THE PERIWINKLE *LITTORINA SITKANA* FROM DICK'S HEAD, WEST ARM, pORT DICK, 6/30/76.

FIGURE 8

Table 18. Relative cover data for the blue mussel (*Mytilus edulis*) in 1/4 m^2 quadrats on Dick's Head, at the head of West Arm, Port Dick, 7/1/76.

Percent Cover	Number of Quadrats
30	2
35	2
40	2
4s	0
50	2
55	0
60	2
65	4
70	6
75	9
80	7
85	6
90	7
95	1
Total	50

Mean Percent Cover: $\bar{x} \pm s = 71.6 \pm 17.0\%$

Table 19 . Summary of size distribution data for the blue mussel (*Mytilus edulis*) fr the intertidal zone, on Dick's Head at the head of West Arm, Port Dick, July 1976.

Shell Length (mm)	0 m Zone Frequency	%	3 m Zone Frequency	%	9 m Zone Frequency	%	12 m Zone Frequency	
1-4	6	1.2	1	0.4	0	0.0	0	0.
5-8	101	19.7	0	0.0	1	0.2	28	2.
9-12	111	21.6	2	0.8	7	1.5	56	5
13-16	63	12.3	7	2.7	9	2.0	97	8.
17-20	75	14.6	13	5.0	20	4.3	107	9.
21-24	81	15.8	23	8.8	19	4.1	109	10.
25-28	43	8.4	49	22.3	29	6.3	168	15
29-32	15	2.9	65	25.0	23	5.0	140	12
33-36	10	1.9	39	15.0	58	12.6	148	13.
37-40	7	1.4	33	12.7	93	20.1	128	11.
41-44	1	0.2	10	4.0	101	21.9	58	5.
45-48	0	0.0	7	2.7	74	16.0	40	3
49-52	0	0.0	2	0.8	24	5.2	6	0.
53-56	0	0.0	0	0.0	4	0.9	1	0.
n	513		260		462		1,086	
$\bar{x}$ (cm)*	16.0		30.4		37.3		27.7	
s (cm)*	8.0		7.4		9.4		10.1	
No. /m^2	4,104		2,080		3,696		8,688	

*Based on unclassed data in Appendix C-5.

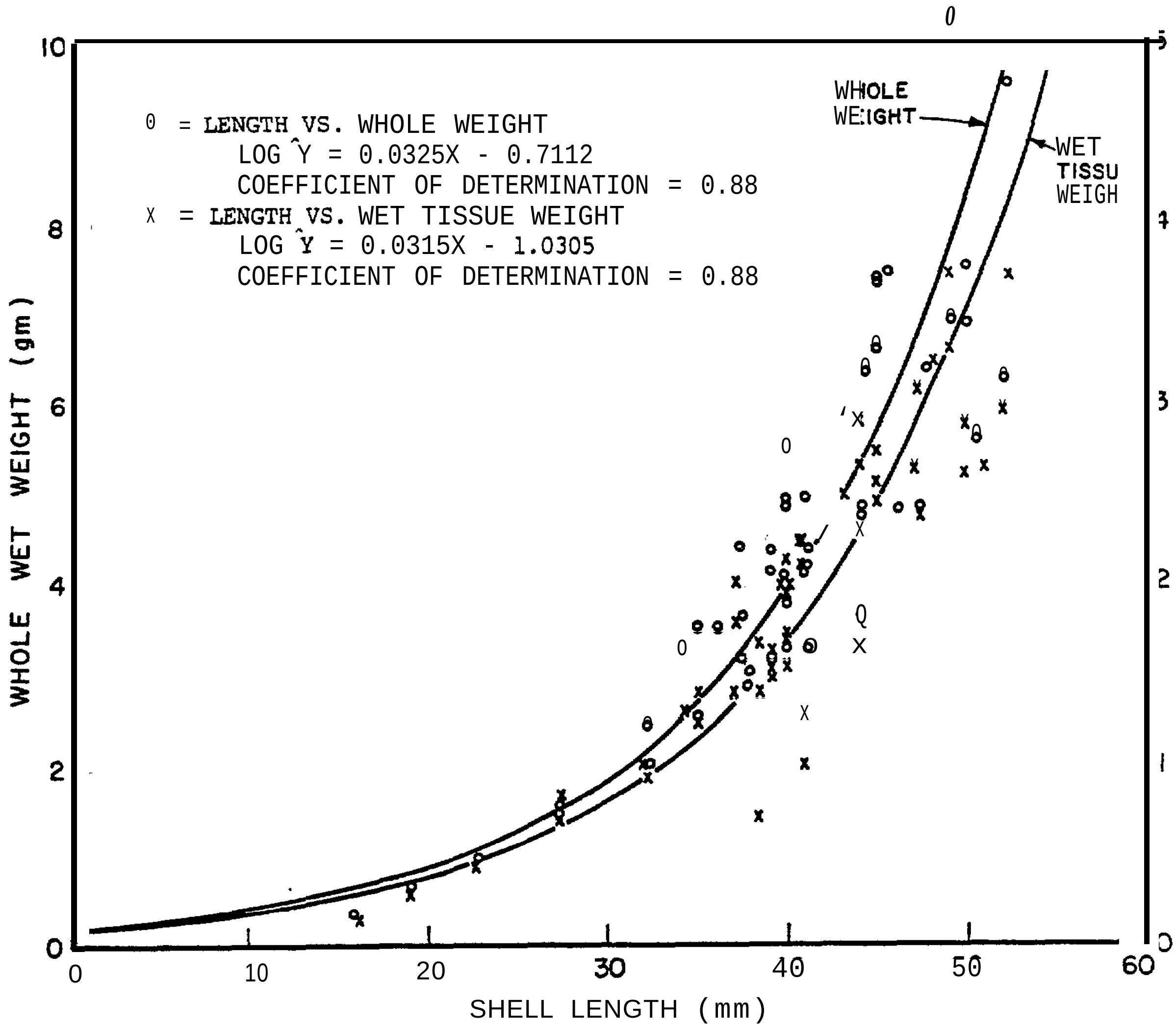
relationship between shell length, whole wet weight and wet tissue weight are shown in Figure 9, along with the respective regression equations.

The data for density, size distributions and the length-weight regressions were used to develop biomass estimates for the mussel populations at the various tidal levels. Wet tissue weight increased dramatically from the higher to the lower levels (Table 20). The overall average was about 4.4 kg/m^2.

Subtidal Areas

The subtidal area in the vicinity of Dick's Head was no more diverse than the intertidal zone (Appendix c-7). The rocky portions were dominated by Laminaria spp. and Alaria sp. and the soft substrate by eelgrass (Zostera marina). Few macroinvertebrates were observed on the rock substrate (Appendix c-7). These were limited mainly to the green sea urchin (Strongylocentrotus drobachiensis) and the slender star (Evasterias troschelii) (Appendix C-8). Macrophytes covered about 75% of the soft substrate in the vicinity of Dick's Head; ? Ulva was the dominant plant, but eelgrass, distributed in small patches, was somewhat important (Appendix c-9). Mussels covered nearly 25% of the soft substrate.

The slender star (Evasterias troschelii) was an important predator around Dick's Head, feeding mainly on Mytilus edulis and Littorina sitkana (Table 21). Its density averaged about 1.1/m^2. Radius averaged 41.2 ± 27.0 mm; the size structure was basically unimodal with the mode located substantially below the mean (Table 22). Sizes ranged from 15-130 mm (Appendix C-10). These data indicate that the population is dominated by relatively young individuals and that recruitment has been successful recently. Sea otters also seemed to be feeding in the area (Table 21).



RELATIONSHIP BETWEEN SHELL LENGTH, WHOLE WET WEIGHT AND WET TISSUE WEIGHT FOR BLUE MUSSELS (*MYTILUS EDULIS*) FROM DICK'S HEAD, PORT DICK, 7/1/76.

Table 20. Estimates of size and weight distribution, density and biomass for blue mussels (*Mytilus edulis*) from the intertidal zone of Dick's Head at the head of West Arm, Port Dick, July 1976.

	0 m Zone		3 m Zone		9 m Zone		12 m Zone	
Shell Length (mm)	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.	Frequency	Wet Tissue Wt.
1- 4	48	5.4	8	1.1	0	0	0	0
5- 8	808	120.7	0	0	8	1.2	224	33.4
9-12	888	177.3	16	3.2	56	11.2	448	89.4
13-16	504	134.5	56	14.9	72	19.2	776	207.1
17-20	600	214.0	104	37.1	160	57.1	856	305.3
21-24	648	308.9	184	87.7	152	72.5	872	415.7
25-28	344	219.2	464	295.6	232	147.8	1344	856.3
29-32	120	102.2	520	442.8	184	156.7	1120	953.8
33-36	80	91.1	312	.355.1	464	528.2	1184	1347.7
37-40	56	85.2	264	401.7	744	1131.9	1024	1557.9
41-44	8	16.3	80	162.7	808	1643.1	456	927.3
45-48	0	0	56	152.2	592	1609.1	320	869.8
49-52	0	0	16	58.1	192	697.5	56	203.4
53-56	0	0	0	0	32	155.4	8	38.8
Density	4104		2080		3696		8688	
Estimated Biomass: (gm wet weight/m^2)		1475		2012		6231		7809

Table 21. Observations for predation at Port Dick 7/1-7/3/76.

Predator	Prey	No. of Feedings	Type o Eviden
Evasterias troschelii	Mytilus edulis	7	Direc
Hexagrammos stelleri-juv.	Juv. Mytilus on eelgrass		Direc
Hermissenda crassicornis	Hydroid	1	Direc
Telmessus cheiragonus	Zostera marina	1	Direc
Enhydra lutris	clams	Numerous	Indir
Phalacrocorax auritus	Fish	4	Direc

Table 22. Size distribution for the slender star (Evasterias troschelii) near outer edge of shelf at head of West Arm, Port Dick, '/1/76.

Radius (mm)[1]	Frequency
10-19	12
20-29	38
30-39	19
40-49	14
50-59	9
60-69	3
70-79	3
80-89	2
90-99	6
100-109	0
110-119	4
120-129	1
130-139	1

n = 112
Mean radius[2] = 41.2 ± 27.0 mm
Range = 15-130 mm

[1] Measured from center of mouth to tip of longest arm.
[2] Based on unclassed data in Appendix C-10.

Closer to the center of the shelf, the flora was more diverse and covered about 65% of the bottom (Table 23) . Dominant species were Laminaria saccharin, Zostera marina and Desmarestia viridis. Laminaria and Desmarestia were more "abundant in the shallower areas examined. All species were distributed in a patchy manner (Appendix C-n). Algal debris, composed largely of sea lettuce, was common throughout most of the area. Epibenthic invertebrates were uncommon.

Eelgrass formed a more uniform bed toward the middle of the shelf. Estimated densities at the inner and outer edges of the bed were 109 and 108 turions/m^2, respectively (Appendix C-12). Turion height ranged from 35.5 - 274.0 cm, at the inner edge, and averaged 164.1 ± 58.3 cm (Appendix C-13) . The shape of the size distribution is not clear, but may be bimodal (Table 24). The major mode is somewhat higher than the mean. At the outer edge of the bed, turion height ranged from 13.5 - 267.0 cm and averaged 126.4 ± 63.9 cm (Appendix C-14). The shape of the distribution is basically unimodal with the mode fairly close to the mean (Table 24) . Except for the conspicuous mode, the distribution is rather flat; a broad range of sizes are well represented.

The relationship between turion height and dry weight (Appendix C-15), shown for August in Figure 7, indicates that the plants are in good condition. As discussed previously, the condition of the plants from Port Dick was superior to that of those from Koyuktolik Lagoon. Flowering plants were common in the bed.

Table 23. Relative cover and abundance of major epibiotic organisms on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

SPECIES	6 m	8-9 m	12.5-13.0 m	Overall $\bar{x} \pm s$
Algal debris (C)	10%	0	23%	13.5 ± 24.3%
Costaria costata (C)	10%	0.8%	0	2.3 ± 8.0%
Desmarestia viridis (C)	5%	36. 2%	1.5%	12.6 ± 23.7%
Laminaria saccharin (N)	0	0.3	0	0.1 ± 0.3
Laminaria saccharin (N)	31.2%	41. 7%	10%	23.8 ± 25.1%
Pycnopodia helianthoides (N)	0	0	0.1	0.05; $0.2/m^2$
Rhodophyta, unid. (Filamentous) (C)	0	0	1%	0.5%
Telmessus cheiragonus (N)	0	0	0.2	0.1; $0.4/m^2$
? Ulva sp. (C)	0	0	5%	2.5 ± 7.2%
Zostera marina (C)	0	5%	47%	13.8 ± 12.1%
Total percent cover by attached macrophytes	56.2%	83. 7%	64.5%	

Table 24. Turion height-frequency data for eelgrass (*Zostera marina*) from West Arm, Port Dick, 8/31/76.

Turion Height (cm)[1/]	Inner Edge of Bed	Outer Edge of Bed	Total	Percent
10.0 - 19.9	0	3	3	1.5
20.0 - 29.9	0	6	6	3.0
30.0 - 39.9	0	5	5	2.5
40.0 - 49.9	2	3	5	2.5
50.0 - 59.9	2	5	7	3.5
60.0 - 69.9	0	6	6	3.0
70.0 - 79.9	2	5	7	3.5
80.0 - 89.9	4	5	9	4.5
90.0 - 99.9	4	8	12	6.0
100.0 - 109.9	2	3	5	2.5
110.0 - 119.9	1	5	6	3.0
120.0 - 129.9	3	4	7	3.5
130.0 - 139.9	1	13	14	7.0
140.0 - 149.9	7	7	14	7.0
150.0 - 159.9	4	5	9	4.5
160.0 - 169.9	3	4	7	3.5
170.0 - 179.9	1	10	11	5.4
180.0 - 189.9	7	1	8	4.0
190.0 - 199.9	8	7	15	7.4
200.0 - 209.9	8	3	11	5.4
210.0 - 219.9	8	4	12	6.0
220.0 - 229.9	5	2	7	3.5
230.0 - 239.9	5	3	8	4.0
240.0 - 249.9	0	0	0	0.0
250.0 - 259.9	1	2	3	1.5
260.0 - 269.9	0	2	2	1.0
270.0 - 279.9	1	0	1	0.5
n	81	121	202	
$\bar{x}$ (cm)[2/]	164.1	126.4	141.5	
s (cm)[2/]	48.3	63.9	61.6	

[1/] Length of longest leaf from upper node.
[2/] Based on unclassed data in Appendices c-13 and c-14.

Estimates of standing stocks were computed using the information for density, the distribution of turion heights and the length-weight regression from late August. Biomass was higher near the inner edge of the bed, mainly as a consequence of the larger average turion size. The overall average was about 120 gms dry weight/m^2 (Table 25). Based on an estimate that eelgrass covers about 300,000 m2 on this shelf, the dry weight of this plant may approach 35 metric tons.

The slope between the shallow shelf at the head of West Arm, and the deeper basin was dominated by the brown alga Laminaria saccharin. Highest density was observed along the lip (Appendix C-16) . Overall density exceeded 2.o plants/m^2.

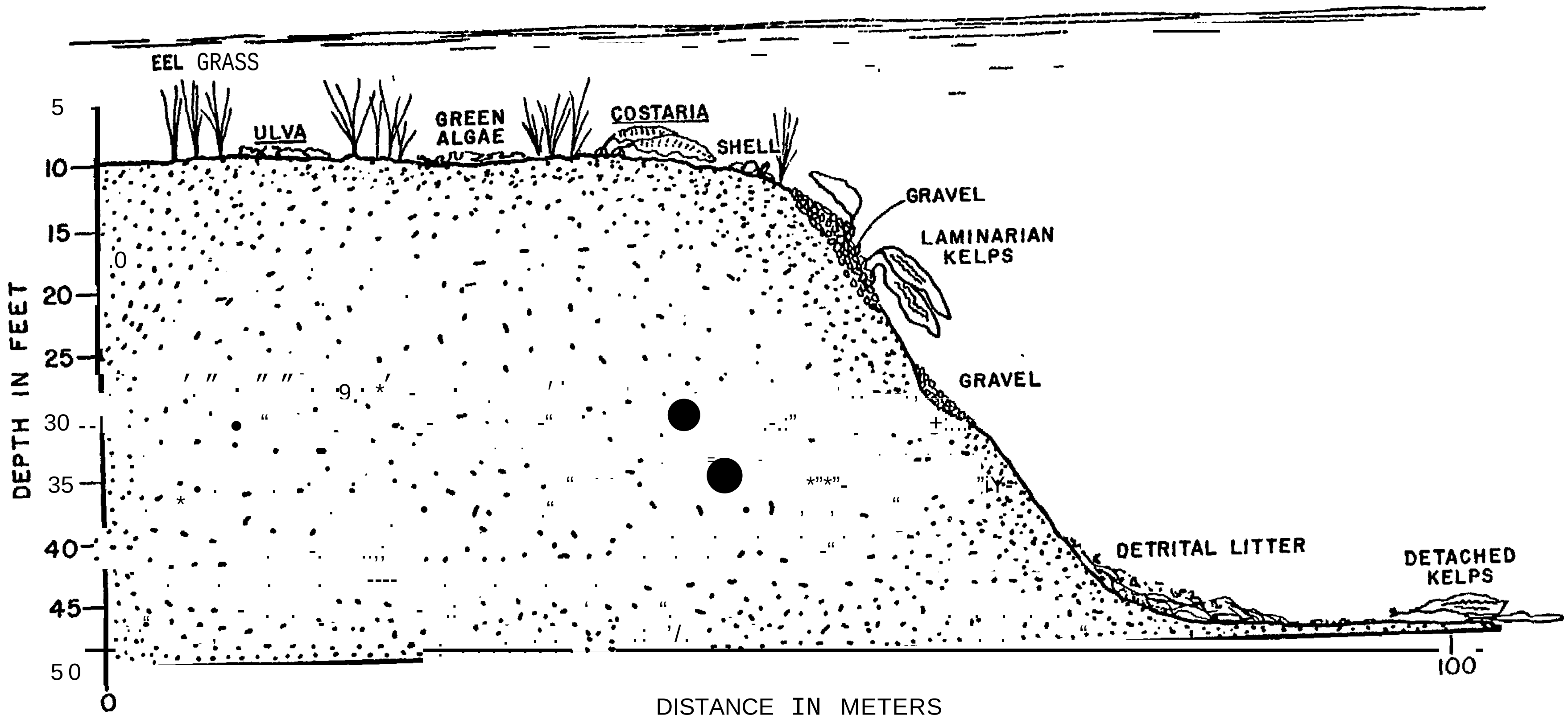
The sunstar (Pyncopodia helianthoides) was a dominant predator on the slope, its overall density was 0.14/m^2. The population was composed of moderate sized individuals with an average radius of 141.7 ± 85.8 mm (Appendix c-17). Other less common species observed on the slope are listed in Appendix C-18.

A considerable quantity of plant material is produced in the rocky intertidal zone and on the shallow subtidal shelf, but attached plants are not common more than a short distance down the outer slope (Figure 10). A great deal of the plant material produced in shallow water is torn loose and transported into the basin by tidal activity and storm induced turbulence. The resulting large accumulations of detrital material in the basin are probably very important to the food budget of organisms that generally remain in the deeper portions of the fjord.

Table 25. Estimate of size and weight distribution, density and biomass for eelgrass (Zostera marina) from West Arm, Port Dick, 8/31/76.

Turion Size Class (cm)	Inner Edge of Bed Frequency	Inner Edge of Bed Dry Weight	Outer Edge of Bed Frequency	Outer Edge of Bed Dry Weight
10.0- 19.9	0	0	3	0.20
20.0- 29.9	0	0	4	0.47
30.0- 39.9	0	0	4	0.46
40.0- 49.9	3	0.33	3	0.33
50.0- 59.9	3	0.39	4	0.65
60.0- 69.9	0	0	5	0.93
70.0- 79.9	3	0.55	4	0.92
80.0- 89.9	6	1.31	4	1.09
90.0- 99.9	6	1.55	7	2.06
100.0-109.9	3	0.92	3	0.92
110.0-119.9	1	0.55	4	1.81
120.0-129.9	4	1.94	4	1.72
130.0-139.9	1	0.77	11	6.62
140.0-149.9	10	6.37	6	4.23
150.0-159.9	6	4.32	4	3.58
160.0-169.9	4	3.84	4	3.40
170.0-179.9	1	1.52	9	10.07
180.0-189.9	10	12.60	1	1.19
190.0-199.9	10	17.07	6	9.91
200.0-209.9	11	20.24	3	5.03
210.0-219.9	11	24.00	4	7.96
220.0-229.9	7	17.79	2	.4.72
230.0-239.9	7	21.09	3	8.39
240.0-249.9	0	0	0	0
250.0-259.9	1	5.93	2	7.87
260.0-269.9	0	0	2	9.33
270.0-279.9	1	8.34	0	0
No./m^2	109		108	
Estimated biomass:				
(gmdryweight/m^2)		151.42,		93.63
(gmwetweight/m^2)		1514′		936*

* Estimate wet weight based on an estimated wet weight/dry weight ratio of 10:1.



PROFILE OF VEGETATIVE PATTERNS AT THE OUTER EDGE OF WEST AR&!, PORT DICK, JUNE 1976.

DISCUSSION

The importance of nearshore assemblages to marine systems and, specifically, to ocean fisheries, is due in large part to their plant production. This appears to be particularly true of nearshore areas on the southern Kenai Peninsula. Macrophyte production of the kelp and eelgrass beds contributes large quantities of plant material to the benthic assemblages of both the north Gulf of Alaska and lower Cook Inlet. The timing of the major contribution of plant material to nearshore waters is important. The main plant assemblages shed a large proportion of their biomass during autumnal storms, at a time when phytoplankton stocks are declining rapidly. Drifting plant materials from macrophyte assemblages are distributed widely within Cook Inlet. Dense mats of macerated algal debris are frequently observed in the middle Inlet, at least 60 miles from appreciable algal stocks (personal communication, Rick Wright, State of Alaska). Large quantities of bull kelp have been observed stranded at Amakdedori Beach, in Kamishak Bay, at least 40 miles from the nearest bed (personal communication? Tina Cunnings, ADF&G). In fact, it appears from the paucity of large herbivorous species that most of the plant material produced in the nearshore assemblages is exported and utilized elsewhere.

Macerated kelp is apparently a relatively stable food material. Zobell (1959) showed that, "for finely chopped seaweeds, about half of the organic content is oxidized within 5 days at 20°C . . . . [they are] almost completely mineralized within a month." Furthermore, "decomposition takes place only about half as fast at 10°C." Assuming an average temperature of about 5°C in deeper waters in this area, one can extrapolate that the organic content of finely chopped seaweeds would be half oxidized in about 20 days. Zobell (1959) also stated that decomposition rates are much slower for living plants or larger pieces, so algal debris from fall shedding may remain available for several months during the winter.

Nearshore areas are also important as forage and nursery areas for numerous important sport and commercial species. Rocky areas are important for juvenile king crab, some shrimp species, herring and probably salmon. The areas of soft substrate are important to the fry of several species of salmon, dungeness crabs, and as feeding areas to several species of ducks and geese. Such areas also support important clam resources.

GENERAL COMPOSITION OF MAJOR BIOTIC ASSEMBLAGES

One of the major objectives of this study was to begin to describe major features in the ecology of nearshore assemblages of the outer Kenai Peninsula. Three general areas, each representing an important nearshore assemblage, were selected as study sites. Exposed rocky shoreline is the dominant substrate of the coastline along the southern Kenai Peninsula. This type of habitat, typified by offshore beds of bull (Nereocystis) and ribbon kelp (Alaria), was examined at Chugach Bay and E. Chugach Island. Protected rocky areas and soft substrates are also important substrate types, especially in the numerous bays and fiords penetrating into the Peninsula. Such habitats, characterized by beds of mussels and eelgrass, were examined at Koyuktolik Bay and in the West Arm of Port Dick. Data from surveys in summer 1975 and spring 1976 are presented in earlier reports (Dames & Moore 1975 and 1976).

Hard Substrates

The rock habitats supported more diverse benthic assemblages than the soft substrates, regardless of whether they were protected from or exposed to waves and strong currents. The stability of the substrate allows organisms to attach firmly. On rock habitats, exposure generally acted to increase diversity; this is a response to several factors. Exposed rocky habitats are generally free of resuspendable inorganic deposits which act to discourage development of lush epibenthic assemblages. The turbulent nature of exposed areas has additional beneficial effects. By causing the resuspension of organic particles, it increases food availability to suspension feeders and also, by macerating organic debris, it accelerates the decomposition process upon which suspension feeders depend. Finally, by agitating the upper algal canopies, turbulence increases light penetration through them, thus promoting better development of vegetative undergrowth.

At Chugach Bay, the degree of exposure of the sites examined varies moderately. The most exposed sites were west of "Sea Otter" Point (Figure 3). The structural complexity and species diversity of the epibenthic assemblage off this site was great, particularly with regard to the suspension feeders. At locations farther inside the Bay, complexity was somewhat reduced. Also, algal species characteristic of less turbulent, darker habitats were found in shallower water.

The species composition of the nearshore assemblage at Chugach Bay was typically diverse; approximately 200 species were identified (Appendix D-l). Hydroids, bryozoans, tunicates and starfish were disproportionately abundant (Table 26). This reflects the diversity of the suspension feeding assemblage

Table 26. Comparison by major taxa of the species observed on the southern Kenai Peninsula.

	Chugach Bay	E. Chugach Bay	Koyuktolik Bay	Port Dick
ALGAE-total	45	26	39	47
Chlorophyta	1		7	6
Rhodophyta	27	17	18	25
Phaeophyta	17	9	14	16
ANGIOSPERMAE	0	0	1	1
PROTOZOA	0			1
PORIFERA	7	1	3	1
CNIDARIA-total	29	17	8	3
Hydrozoa	25	15	3	1
Anthozoa	4	2	5	2
SIPUNCULA		1		
ANNELIDA-Polychaeta	4		7	6
ARTHROPODA-Crustacea	14	9	17	17
MOLLUSCA-tots 1	40	21	37	34
Pelecypoda	11	4	13	15
Gastropoda	21	13	19	19
Polyplacophora	8	4	5	
ECTOPROCTA	15	8	5	1
BRACHIOPODA	1		1	
ECHINODERMATA-tots 1	20	10	11	5
Holothuroidea	2	0	3	1
Echinoidea	3	1	2	1
Asterozoa	15	9	6	3
CHORDATA				
Tunicata	12	5	1	
Pisces	10	4	8	22
Aves			4	5
Mammalia	1	2	2	2
Total	198	104	144	145

and the concomitant diversification of predators. Twelve species of large kelps were observed (Appendix D-1); six of these were dominant in one or more areas during the summer. Elephant ear kelp (Laminaria groenlandica) dominated the bottom between low intertidal and 6 m deep. Between 6 m and 12 m, bull kelp (Nereocystis luetkeana) formed a dense surface canopy. This was particularly well developed in the vicinity of Raft Cove and on its outlying shelf. Under the canopy was a dense mixed stand of L. groenlandica and Pleurophycus gardneri. Several other species of Laminaria were also commonly encountered within this lower canopy. At about 12 m, sieve kelp (Agarum cribrosum) began to appear in the lower canopy and, at about 17 m, was the dominant alga, replacing Laminaria spp. and Pleurophycus which had gradually disappeared. Sieve kelp was abundant on down past 23 m deep.

The major herbivores were the green sea urchin (Strongylocentrotus drobachiensis), several chitons (Tonicella spp. and Mopalia spp.) and snails (Margaritas pupillus and Callistoma ligature). The densities and sizes of the sea urchin species indicate that their influence on the plant community was small. Densities of microherbivores such as chitons and small snails, that feed on gametophytes and juvenile sporophytes of the kelps, were great enough to suggest that they may have had an influence on the composition and density of the algal assemblages. About 20 species of herbivores were identified.

The appearance of the suspension feeding assemblage was dominated by bryozoans (Microporina borealis), hydroids (Abietinaria spp. and Campanularia verticillata) and colonial tunicates (? Aplidium spp., ? Distaplia sp., ? Synoicum sp., and Didemnum sp.). This epifaunal assemblage was not well developed under the dense algal canopies. However, where the algal canopy thinned out, the epifaunal mat was well developed, commonly covering more than 50% of the available substrate. About 90 species of suspension feeders were identified.

The major predators at Chugach Bay appeared to be sea otters and starfish, particularly Orthasterias koehleri, Dermasterias imbricata, Crossaster papposus and Leptasterias ? leptalea. A group of additional species #at act equally well as predators or scavengers was particularly characterized by crustaceans (Appendix D-l). About 50 species of predators and scavengers were identified at Chugach Bay. These included several common fish species, namely white-spotted, kelp and rock greenling, northern ronquil, and some unidentified cottids and flatfish. Also, although marine birds were not surveyed, several species were common and active in the area.

Generally, the size data collected suggests that the fauna was composed of young to moderately old animals. None of the species measured were very large for their species, implying either slow growth, high mortality, or both. Because of the abundance of food, slow growth does not seem too probable. A high mortality rate seems fairly predictable, however, considering the density and variety of predators and the exposure of the area to winter storms .

Seasonal changes at Chugach Bay were not examined, but can be predicted based on observation in similar locations (Kachemak Bay and western Prince William Sound). The most obvious and important changes concern the algal assemblages. Bull kelp is an annual, germinating in late winter and early spring and forming dense surface canopies by late spring or early summer. The plants are senescent by late summer so that fall storms induce drastic shedding of fronds. The surface canopy is essentially absent during the remainder of the year. The major kelp species in the lower canopy are perennials. At least two species (Laminaria groenlandica and Agarum cribrosum) exhibit maximum growth during late winter and early spring. The lower canopy is consequently best developed during that period. Major shedding, is generally synchronized with shedding in the surface canopy, and apparently induced by the same causes.

Seasonal changes in the epifauna are also conspicuous and species composition of this assemblage may vary considerably on a long-term basis. However, several major epifaunal species are distinctly annual and exhibit substantial seasonal variation in cover and abundance. During 1975-76, the bryozoan Microporina borealis, several hydroids (Campanularia verticillata, Abietinaria turgida and A. variabilis) and several species of tunicates were important epifaunal forms that exhibited clear seasonal changes in abundance in several locations on the north Gulf of Alaska. Generally, these groups were most abundant in spring and summer.

The small mytilid Musculus vernicosus also displayed strong seasonal variation. This small mussel frequently encrusts large portions of the blades of seaweeds in the lower canopy. It, therefore, is strongly affected by changes in the condition of the canopy. Because of predation pressures, adult specimens of Musculus are rarely successful on the bottom and so adult abundance declines sharply after fall shedding. Possibly synchronized with shedding, however, extraordinary numbers of juvenile Musculus appear. As juveniles Musculus generally are brooded by the adults, it is possible that they are released when the shed kelp blades and attached adults are on the bottom. The juveniles form dense encrustations on many short-statured seaweeds and invertebrates. However, their growth during the winter is very slow; rapid growth probably commences concurrently with spring plankton blooms.

Brief surveys were made at the east end and near the west end of E. Chugach Island. The areas examined were rock and supported epibenthic assemblages similar to those described for Chugach Bay. The surface canopy of bull kelp was well-developed all along the north side of the island. The species forming the lower" canopy were quite similar. In fact, comparison of the species list compiled for these surveys (Appendices D-1 and D-2) reveals that most of the species observed at E. Chugach Island were also found in Chugach Bay. It is probably fairly safe to assume that the systems operate similarly and that most of the remarks made for Chugach Bay are also pertinent for E. Chugach Island.

In summary, the nearshore environments at Chugach Bay and E. Chugach Island are robust, pristine and appear highly productive. The plant materials that they contribute to offshore areas undoubtedly play a role in sustaining several important shellfish resources through winter, when other food supplies are low. The areas also are nursery areas for such commercially important species as herring and king crab. Finally, they have intangible value as true wilderness environments.

soft Substrates

Although the physical characteristics in Koyuktolik Lagoon and the West Arm of Port Dick differ somewhat, especially in respect to velocities of tidal currents, the composition of the intertidal and shallow subtidal assemblages was rather similar, and appeared fairly representative of estuarine conditions in southern Alaska. The substrate is predominantly sandy gravel, gravel and cobble. The upper intertidal zone was characterized by Fucus distichus and Littorina sitkana. Fucus was also abundant in the mid-intertidal zone, where blue mussels (Mytilus edulis) became abundant. Mussels dominated heavily in the lower intertidal. In many areas, Fucus was also abundant along the lower edge of the mussel beds (Appendices D-3 and D-4) . Species diversity in these intertidal areas is low, but the species that live there are very successful. Littorines are the major herbivore and the major predators are probably sea birds such as gulls, northwestern crows, surf scoters and harlequin ducks.

The substrate in the shallow subtidal zones of both locations are predominantly sandy silt or silty sand. These areas were characterized mainly by eelgrass (Zostera marina) and various densities of several species of marine algae such as Laminaria saccharin, Alaria sp., ? Ulva sp. and Ahnfeltia plicata. Species diversity was higher than in the intertidal zone, except in dense eelgrass meadows. Eelgrass was generally the dominant form, occupying considerable area and contributing great quantities of plant material to nearshore and offshore areas.

A fairly constant assemblage of animals was associated with these major plant species. The larger, more conspicuous forms were crustaceans, pelecypods and starfish. Principal among these are barnacles (Balanus ? glandula and B. rostratus alaskensis), crabs (Telmessus cheiragonus, Cancer magister and Oregonia gracilis), clams (Saxidomus giganteus, Tresus capax, Astarte spp., Hiatella arctica, Macoma balthica, Macoma spp., Mya arenaria and M. truncata) and sea stars (Evasterias troschelii and Pycnopodia helianthoides). The ice cream cone worm (Cistenides brevicomis) is often common in gravelly sand. Approximately 150 species were identified in both locations (Table 26; Appendices D-3 and D-4).

The fauna was dominated by suspension feeders, but scavengers and predators were common. Herbivores appeared unimportant. The major resident forms are Margaritas helicinus and Lacuna spp., small snails that mainly graze on epiphytes growing on the eelgrass leaves. Seasonally, several species of ducks and geese are known to stop in these areas to browse on the eelgrass (personal communication, Dave Erickson, ADF&G).

Size data collected for two major predators, the starfish Evasterias troschelii and Pycnopodia helianthoides, indicate that most of the animals are fairly young. Specimens of both species are relatively small. In view of the fairly rich supply of mussels and several species of clam, it appears that the mortality rate of the starfish must be fairly high. Fresh water is probably an important factor in this.

On their way to and from the spawning streams, large numbers of salmon pass through Port Dick, Koyuktolik Lagoon and several other estuarine areas on the outer Kenai. The major species entering Port Dick Creek is pink salmon. The ADF&G estimate of the adult pink salmon stocks in this area during the summer season range from 1,000 to 150,000 fish; variation is substantial between years (personal communication, Loren Flagg, ADF&G). Other species that are abundant in Port Dick are chum salmon, with a range from about 10,000 to 100,000 fish, and a few silvers. Residence time in the estuary for adults is approximately 8 weeks; juvenile salmon move into the estuarine areas around the end of March and remain until late August. The major species in Koyuktolik Lagoon is the chum salmon. The ADF&G estimate of the adult salmon stocks in this area during the summer 1971 season was *over 100,000* chum, and approximately 10,000 pinks. A surprising comparison is that the Koyuktolik streams have only about one-third the spawning area of those at Port Dick. It is very possible that the large and productive Koyuktolik Lagoon plays an important part in increasing fry survival, thus allowing a disproportionately larger return of adults.

BIOLOGY OF THE EELGRASS BEDS

Development of the eelgrass beds is strongly seasonal. This was observed mainly in the size of the turions, but also was reflected in the condition of the beds; turion density may show some seasonal variation in some locations. Data comparing density, turion height and estimated wet weight for all collections are presented in Table 27.

The density of the bed in Koyuktolik Lagoon is considerably higher than the bed at Port Dick. Additionally, the Koyuktolik bed is considerably larger (approximately $1.14 \times 10^6 m^2$ vs. $0.3 \times 10^6 m^2$). According to McRoy's data (1972), this would make Koyuktolik Lagoon about the fifth largest eel-grass bed in Alaska. However, the largest, Izembek Lagoon on the Alaska Peninsula, is more than 100 times larger ($170 \times 106 m^2$).

Because size structure of the Port Dick and Koyuktolik Lagoon beds were not examined throughout the growing season, and the probability that population growth is synchronized at these sites, it would be improper to compare size distributions between them. However, size comparisons within each area are valid.

Table 27. Comparison of population parameters fOr eelgrass samples from the southern Kenai Peninsula, 1976.

Location	Date	Density (#/m²)	Turion Height (cm) $\bar{x}$	s	Estimated Wet Weight per m2 (gin)	Estimated Dry Weight per m2 (gm)
Koyuktolik Lagoon						
Inner Lagoon	5/6	∿ 0	--	--	∿ 0	--
	7/9	∿50	73.0	33.2	<246	∿25
Transition Zone	7/9	456	95.5	30.6	2894	289
	8/30	440*	130.5	53.2	2133	213
Outer Lagoon	7/9	486	107.9	24.1	2770	277
	8/30	612*	160.0	46.3	4061	406
Port Dick-Head of West Arm						
Subtidal Bed	5/4	95	40.9	19.8	228	23
Inner Edge of Bed	8/31	109	164.1	58.3	1514	151
Outer Edge of Bed	8/31	108	126.4	63.9	936	94

*Difference between densities in the transitional zone and outer bed of 8/30 are significant ($p < 0.02$).

In Koyuktolik Lagoon, size data were collected from three general areas; lowest densities and smallest plants were observed in the inner lagoon (Table 27). Here plants were virtually absent in May, but small patches were present in July. In the transition zone between the inner and outer lagoon, density of turions (leaf bundles) within the bed was much higher, and the turions were significantly larger (Kolmogorov-Smirnov two sample test, $p < 0.05$). However, the bed did not completely cover the bottom, but rather co-dominated with the red alga Ahnfeltia plicata, which formed a low mat reminiscent of plastic scouring pads. Coverage by Zostera probably ranged between 50 and 75%. In the middle of the outer lagoon, toward the outer edge of the eelgrass bed, the density of the turions within the bed may be slightly higher. The bed is certainly more solidly distributed, occupying over 90% of the bottom. Turions here were significantly larger than in the transition zone ($p < 0.01$ both in July and August; Table 27).

The difference in density between the transition zone and outer lagoon in August, although statistically significant (Mann-Whitney U Test, $p < 0.05$), was probably due more to a difference in sampling locations in the outer lagoon than to real increases in the number of plants. This is supported by the size data. A large increase in density would be accompanied by the addition of numerous small plants to the population, which would, in turn, be reflected in the size structure and by a reduction of the mean size. Such changes were not apparent in the size structure of the population in August and the mean height was significantly larger than in July ($p \ll 0.001$)

Biomass patterns basically reflect density and size patterns. Wet biomass in the inner lagoon in July was less than 10% of that found in the outer areas. Unfortunately, the data Presented are only useful in indicating general standing stocks. Even preliminary estimates of primary production based on increases in biomass are invalid because the plants had started shedding before the sampling period in August. This is exemplified by data from the transition zone. Despite a rather substantial increase in mean turion height between July and August, estimates of biomass decreased considerably and to a much greater extent than justified by the slight (statistically insignificant) reduction in density (Table 27). Physical examination of the turions indicated a loss of leaves on the turions and a generally poor condition (Figure 7). These factors acted to reduce the ratio of wet weight to turion height, which in turn, resulted in a lower biomass.

On the shelf at the head of West Arm, Port Dick, size data for eelgrass were collected at three locations. The first sample (May 1976) was collected at an unspecified location within the bed, but the August samples were collected near the inner and outer edges of the bed. Densities for all samples were similar, averaging around 100 turions/m^2. Turion height was significantly greater in August ($p \ll 0.001$) and the size of the plants at the inner edge of the bed was significantly larger than at the outer edge ($p \ll 0.001$). The plants had grown approximately 100 cm in four months (Table 27). The bed appeared in peak condition in late August. Leaves were robust, turgid and generally unblemished; reproductive turions were scattered throughout the bed and had flowered. Wet biomass increased considerably during the summer and, because of the sampling times and apparent synchrony with peak summer condition, may provide a very preliminary, conservative estimate of primary productivity by eelgrass. Using the May estimate as the minimum biomass for the year, and the August estimate as the maximum, the difference of about 1,000 gm/m^2 wet weight is a conservative estimate of plant production by eelgrass during the summer of 1976. The confidence level of this estimate is low. This amounts to an increase of about 500%. Obviously, the number of samples and the coverage of the bed is low. The estimate does not take into account loss from grazing or leaf shedding. Additionally, it is based on the assumption that the biomass estimates available are the lowest and highest for the year; any changes in these values would only act to increase the estimated production of the bed. The overall estimate of primary production for this area is definitely too low, because the contribution of the algae has not been included. Several species, most notably sea lettuce (? Monostroma sp.), elephant ear kelp (Laminaria saccharin), rockweed (Fucus distichus) and several small epiphytes on Zostera contribute a substantial quantity of plant material to the overall production of the intertidal and subtidal areas in Port Dick.

It appears that the majority of the plant material produced in the eelgrass beds is exported to nearshore and offshore areas for utilization by benthic assemblages. Herbivores were generally uncommon within the eelgrass beds. The most important grazing probably occurs in the spring and fall, when geese visit these sites during their migrations. After a great deal of physical reworking, some of the eelgrass becomes available to local detritivores in the form of plant debris.

BIOLOGY OF THE MUSSEL BEDS

The physical environments at Koyuktolik Lagoon and Port Dick strongly influence the development at these two sites. Foremost among the important factors is tidal current, which is responsible for the great differences in density between the mussel beds in the two areas. Mussel densities in the entrance channel beds at Koyuktolik exceeded maximum densities at Port Dick by about 300%. Ice scouring appears to be an important factor at Koyuktolik; ice blocks gouge broad furrows through the beds, clearing considerable portions of substrate and causing substantial mortality. This phenomenon acts to open up large tracts of substrate for dense recruitment by juvenile mussels. At Port Dick, the major causes of mortality are unclear. A major kill involving both mussels and the starfish Evasterias troschelii appears to have occurred between August 1975 and May 1976. The cause is unknown. The major area of influence was in the low intertidal and shallow subtidal areas. Possible causes include red tide (summer 1975), low temperatures (winter 1976) and fresh water run-off (spring and summer 1976). In August 1975, however, Evasterias appeared to exert a strong predatory influence in those beds.

The average size of the mussels within a bed varies significantly with tidal elevation (Table 28), but since elevations were not determined accurately it would be improper to attempt size comparisons between Port Dick and Koyuktolik beds. Overall, however, the largest mussels were collected at Port Dick (Table 28).

Generally, the average size of the mussels was smaller at higher elevations at both Koyuktolik and Port Dick (Table 28; Figure 11). In nearly all cases, the differences in mean sizes between elevations in the same sampling period were highly significant when tested with the Kolmogorov-Smirnov two-sample test ($p < 0.01$). The main factors responsible for these

Table 28. Comparison of population parameters for blue mussel samples from the southern Kenai Peninsula.. 1975-76.

Location	Date	Density (#/m2)	Shell Length (mm) $\bar{x}$	s	Estimated Wet Weight per m2 (gin)
Koyuktolik Lagoon Entrance Channel					
Outer Mussel Bed					
10 m from upper edge	9/9/75	12,384	19.3	11.1	5,026*
	5/7/76	19,006	13.0	8.1	3,424
20 m from upper edge	9/9/75	24,680	17.9	10.4	7,400*
	5/7/76	29,167	14.6	9.3	7,228
80 m from upper edge	7/10/76	.9,130	23.8	7.4	5,455
150 m from upper edge, 10 m from lower	9/9/75	6,968	27.6	8.6	5, 504*
	5/7/76	12,865	24.3	8.7	5,976
	7.10/76	12,830	25.5	8.8	9,303
60 m from seaward edge, 10 m from lower	5/7/76	12,061	22.0	8.1	4,435
Inner Mussel Bed					
5 m from south end of bed	5/8/76	34,649	13.7	7.1	6,519
	7/10/76	17,826	16.7	8.1	6,973
10 m from south end of bed	7/10/76	21,957	19.7	9.6	11,461
30 m from south end of bed	7/10/76	12,717	19.6	9.6	6,555
75 m from south end of bed	5/8/76	4,751	30.0	13.8	5,483
	7/10/76	7,174	26.2	11.6	6,711
Port Dick					
Middle Shoal	5/3/76	507	21.1	9.4	223*
Subtidal Bed	5/3/76	--	23.1	11.2	
Dick's Head					
0 m	7/1/76	4,104	16.0	8.0	1,475
3 m	7/1/76	2,080	30.5	7.6	2,012
9 m	7/1/76	3,696	37.3	9.4	6,231
12 m	7/1/76	8,680	27.7	10.1	7,809

* Estimate based on whole wet weight: wet tissue weight ratio of 1:0.35.

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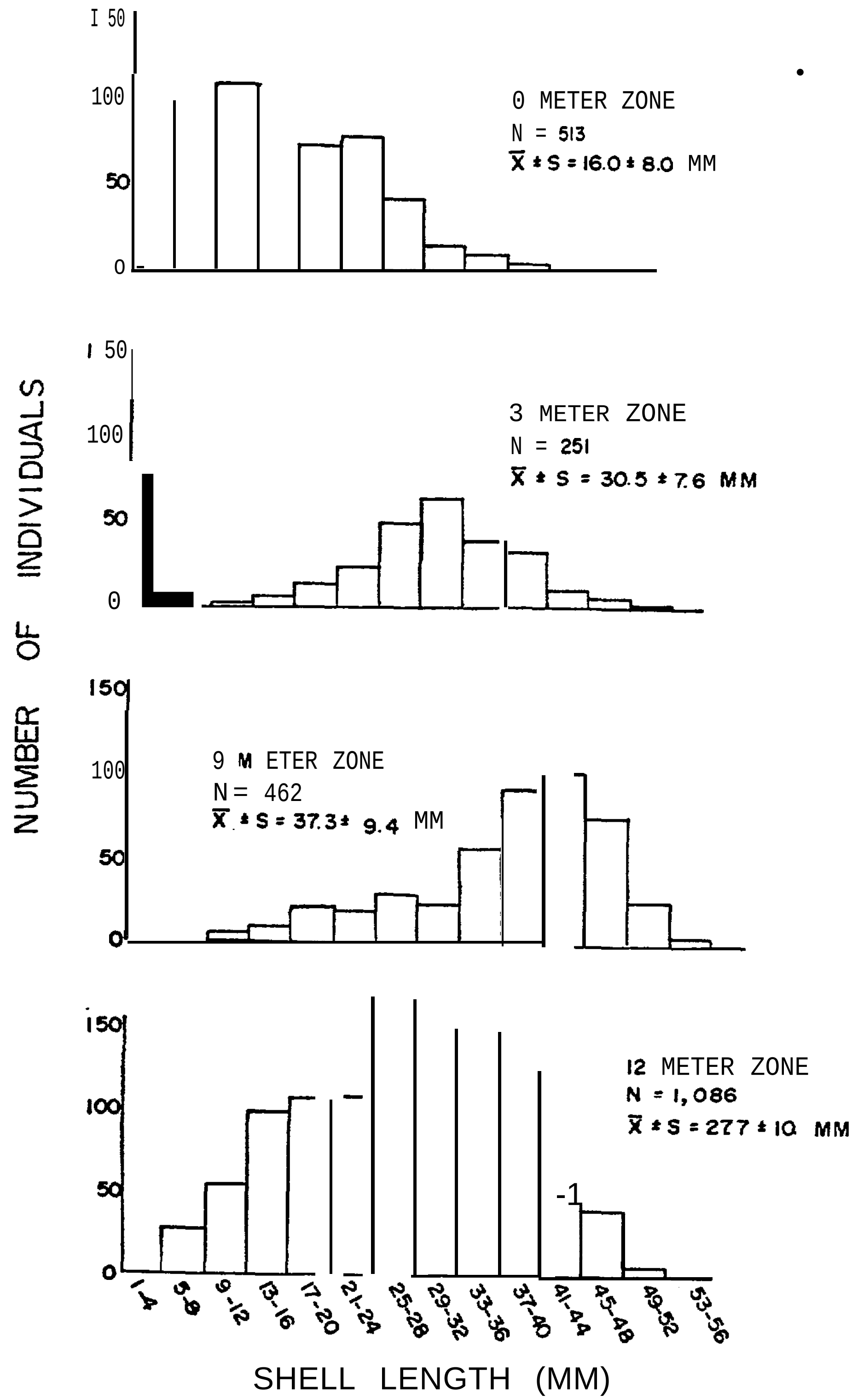

COMPARISON OF SIZE DISTRIBUTIONS FROM INTERTIDAL SITES ON DICK'S HEAD, AT THE HEAD OF WEST ARM, PORT DICK

DAMES & MOORE

FIGURE 11

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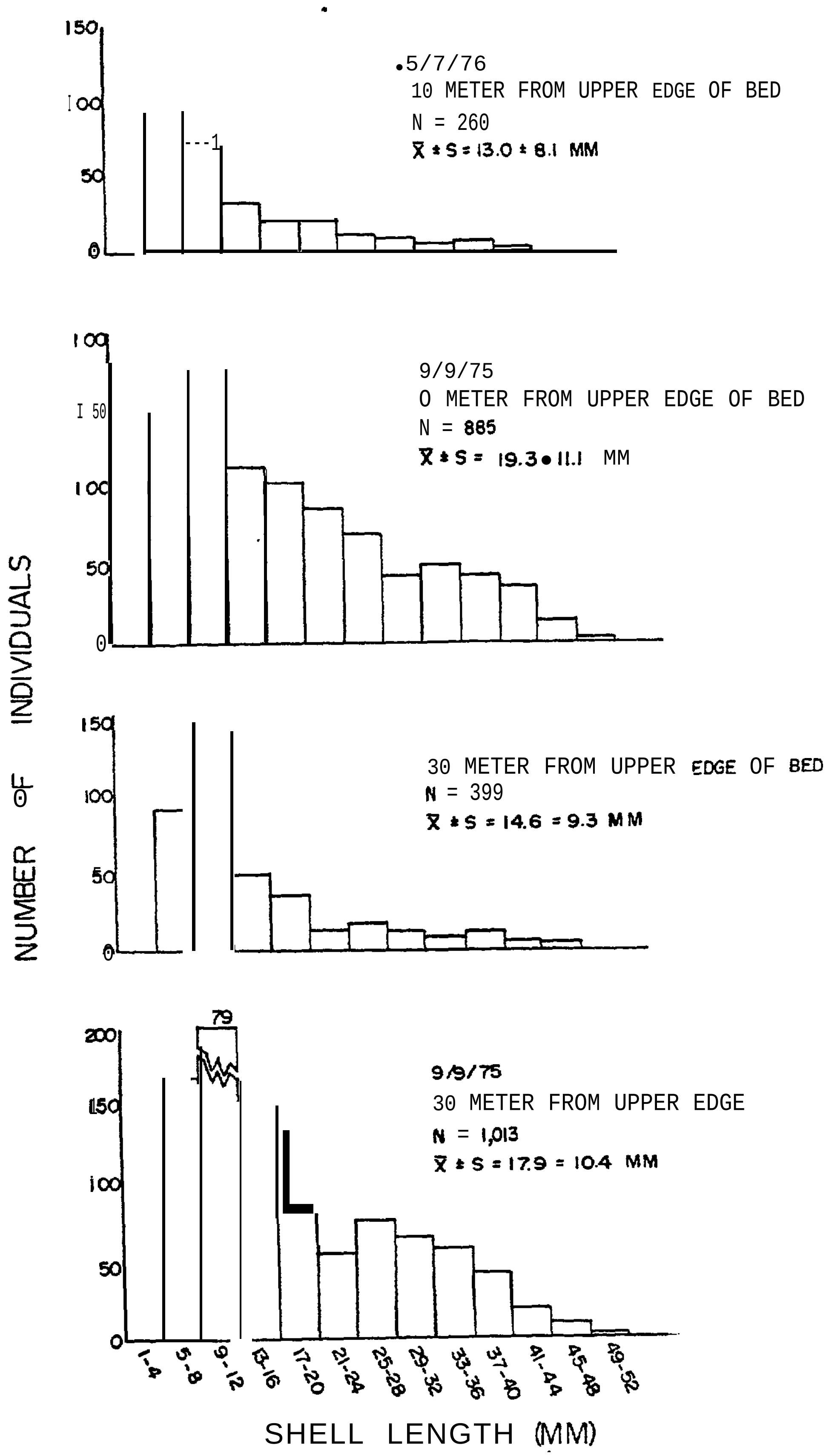
differences probably relate to the ratio of immersion and emersion periods. This controls duration of feeding periods and exposure to extremes in temperature, factors that are very important to growth and mortality rates.

Density patterns varied considerably between beds. In the outer bed at Koyuktolik Bay, density was highest near its upper edge and was uniformly lower along the main channel. In the inner bed, density declined with higher elevation and varied considerably along the main channel (Table 28); there was no distinct upper edge here. On Dick's Head, in Port Dick, density generally was lower at the higher elevations and greatest at the lowest level sampled (Table 28).

Examination of size structures for different sites provides insight into prevailing conditions. Populations near the upper edge of the outer bed at Koyuktolik are strongly dominated by small individuals (Figure 12). The strongly skewed distributions indicate a high mortality rate and heavy recruitment. A similar size structure was observed near the lower edge of the inner bed, 5 meters from its southern end (Figure 13). This area is at the confluence of the main channel and a major drainage channel from the lagoon. Evidence of ice scour is obvious and widespread. It appears that both areas are characterized by highly stressful conditions.

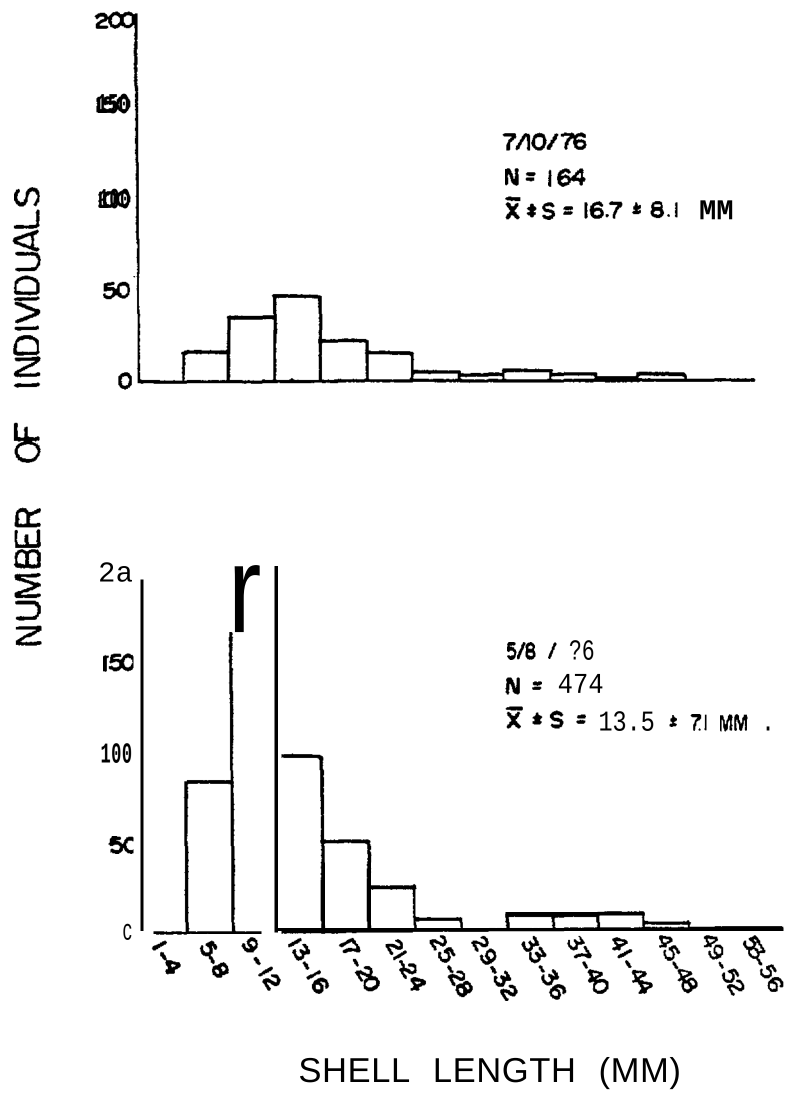
More favorable conditions are indicated by the size distributions from populations near the lower edge of the outer bed at Koyuktolik Bay and near the lower edge of the bed on Dick's Head, at Port Dick (Figures 11 and 14). These populations are strongly dominated by larger mature animals. It appears that recruitment and mortality rates are lower than in the areas previously discussed. Recruitment by larvae is probably strongly inhibited by the filtering influence of the adults (Thorson, 1950).



COMPARISON OF SIZE DISTRIBUTION FOR BLUE MUSSELS FROM NEAR
THE UPPER EDGE OF THE OUTER MUSSEL BED, KOYUKTOLIK BAY

DAMES & MOORE

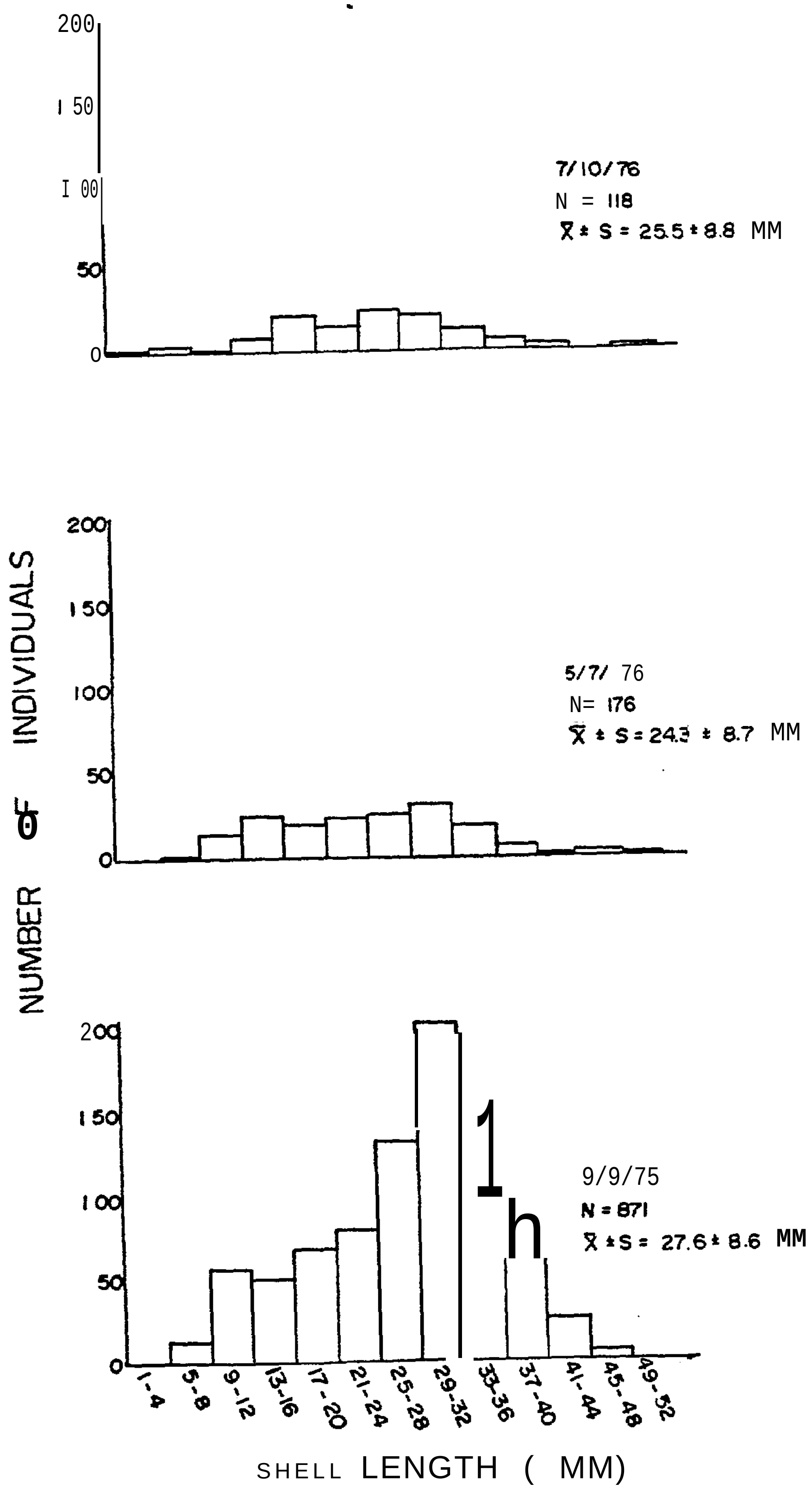
FIGURE 12



COMPARISON OF SIZE DISTRIBUTIONS FOR BLUE MUSSELS 5 m FROM THE SOUTH END OF THE INNERMUSSEL BED, KOYUKTOLIK BAY

DAMES & M

FIGURE



COMPARISON OF SIZE DISTRIBUTIONS FOR BLUE MUSSELS FROM NEAR THE LOWER EDGE OF THE OUTER MUSSEL BED, KOYUKTOLIK BAY

Using a technique described by Ebert (1973), attempts were made to estimate growth and mortality rates for mussels for specific sites at Koyuktolik. The results were not completely satisfactory, but nevertheless, are of interest. The data that are used to compute these curves are 1) mean sizes for a population at two times of the year (Table 28), 2) the time of year the population was sampled in relation to the suspected time of recruitment (October) , 3) the asymptotic size for a population (50 mm), 4) size at the time of recruitment to the sample (i.e., the smallest size that will be sampled by the collection technique utilized (4 mm); and finally, 5) the known size of individuals (XN) at a known age (DN).

Best estimates were obtained for the population at the lower edge of the outer bed. Samples were collected from this location three times during the year. Using two combinations of these data (May:July and May: September) and two sets of knowns (XN = 1 mm, DN = 0 years, and XN = 20 mm and DN = 1 year), four sets of survivorship and growth curves were" generated (Figure 15).

All combinations generated rather similar curves. Survivorship becomes negligible after about 5 years; 50% of the recruits are dead about 1 year after settlement, and 75% after about 2 years. Some specimens may live over 20 years, but only about 1% survive past 8 years. Rate of growth is fairly rapid in the first 4 years, after which it declines quickly. Size becomes asymptotic (50 mm) after about 14 years. The animals attain mean size about 2 years after settlement.

For several reasons, the accuracy or reliability of these curves must be evaluated. All of the basic assumptions of the model may not be

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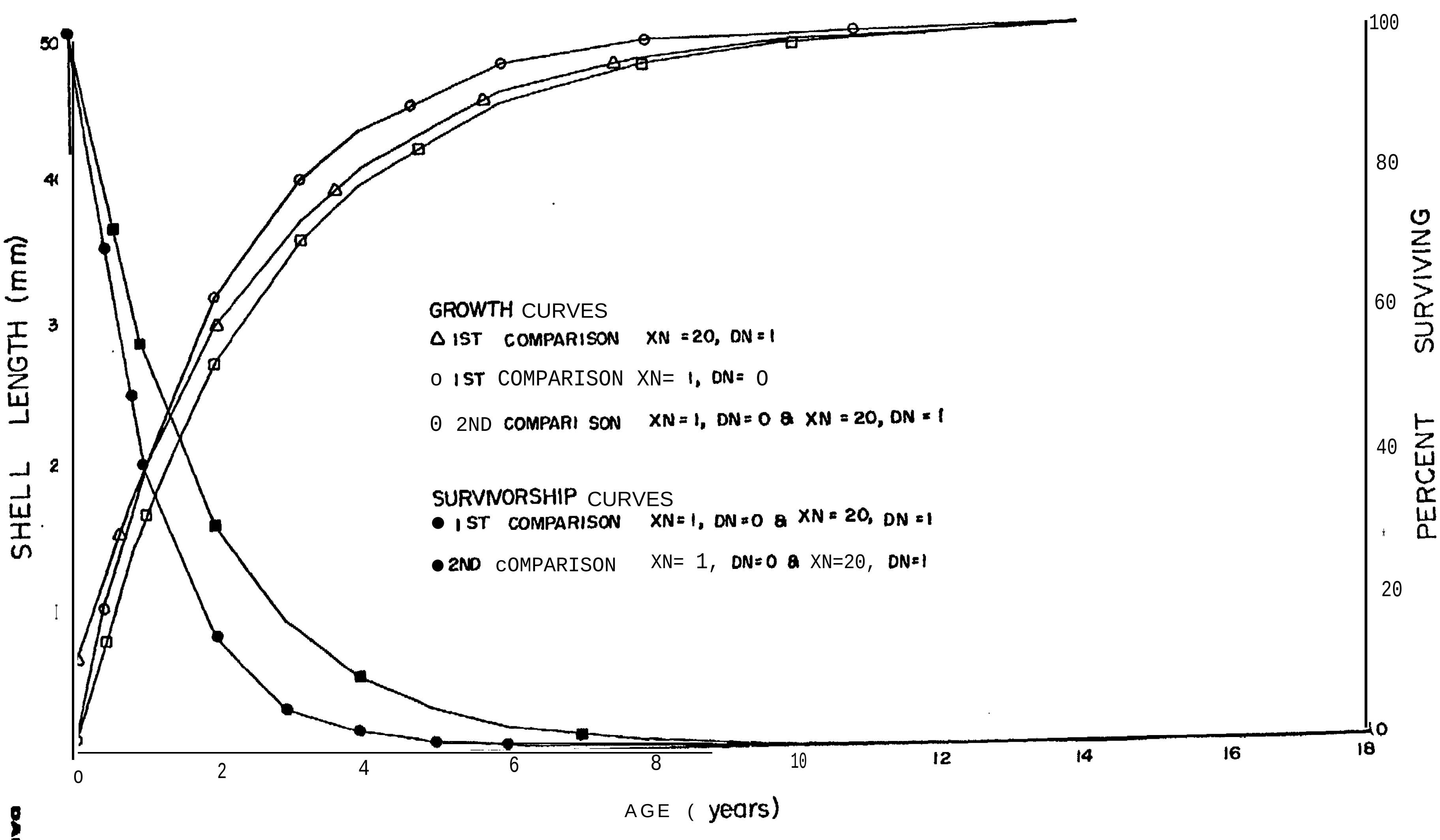

ESTIMATED GROWTH AND SURVIVORSHIP CURVES FOR THE BLUE MUSSEL POPULATION FROM THE LOWER EDGE OF THE OUTER MUSSEL BED AT KOYUKTOLIK LAGOON satisfied by the population being sampled. Of particular concern, are the assumptions of constant growth and mortality rates during the year and the requirement that most recruitment occur during a single month. It is possible that growth nearly ceases during the winter, and fairly probable that the mortality rate increases dramatically during winter and early spring, especially during spring breakup. Finally, the estimated time of maximum recruitment is a guess based on several pieces of indirect evidence, but no direct observations; the duration of this period is unknown. However, Ebert states that the method is sufficiently robust "to withstand some violations of assumptions and still produce reasonable estimates". Also, the standard errors for the samples utilized are within the range utilized by Ebert in his published examples. Basically, the tunes do not suggest conclusions that deviate strongly from those suggested by field observations. We have therefore concluded that the curves generated are reasonable estimates for growth and survivorship for the mussels near the lower edge of the outer mussel bed at Koyuktolik.

It is not safe to conclude that these curves are representative for other parts of that bed, or other beds. In fact, the computer program "blew up" on all other runs attempted. A suspected reason for this problem is the spatial heterogeneity of size structures resulting from the temporal instability of the populations in most of the other areas sampled. Replicate samples from such populations provide a mixture of size and age distributions which violates a major assumption of a stable population with a stationary age distribution.

Biomass for mussels in the two beds examined at Koyuktolik was fairly equal. Wet tissue weight in the dense areas averaged approximately 6.5 kg/m^2 (Table 28). Using an estimate of 7.5 acres of mussels, an overall coverage of 70% and the average biomass of 6.5 kg wet tissue/m^2, the estimated tissue weight for the two beds exceeds 135 metric tons. Over 50% of the tissue weight is contributed by individuals with shell lengths less than 2 years old (Figure 15). The survivorship curves indicate that 99% of a year class have died by year 7, so that a previous estimate of a turnover period of 10 years (Dames & Moore, 1976) was not unreasonable. Assuming a 10% annual turnover rate, mussel production would have to equal about 445 gm wet mussel tissue/m^2 if the population is stable.

Biomass in the mussel beds at Port Dick is generally somewhat lower than at Koyuktolik. Wet weights were lowest on the intertidal mudflats near the mouth of Port Dick (Table 28). Dick's Head supported greater stocks, approaching an average wet tissue weight of 4.5 kg/m^2. However, the size of this bed was quite small in comparison with the beds at Koyuktolik. Biomass clearly became greater moving downward across the intertidal zone. The major factors causing the differences observed between the intertidal flats and the several levels on Dick's Head are probably the intensity of the tidal currents and availability of suitable substrate. The influence of fresh water at both sites may have a slight effect.

During the study we have developed an impression of the natural history of the mussel beds. The major recruitment period is probaly in the fall, based on size distributions and other observations. Growth rates are probably fairly slow during the winter because of temperature induced reductions in feeding rates and reduction in food concentrations in the water. Major mortality is probably due mainly to low temperatures and, at Koyuktolik, ice scouring. An additional source of winter mortality is predation by sea otters, gulls, crows and overwintering sea ducks, all of which are major predators all year. During spring and summer, feeding rates, food supply and predation rates increase considerably. Additional predators in the mussel bed areas included the slender star *Evasterias troschelii*, which moves up from deeper water. The adult mussels themselves are probably quite efficient consumers of mussel larvae. Thorson (1949) estimated that a medium-sized mussel could ingest about 100,000 pelecypod larvae per day.

RECOMMENDATIONS FOR MONITORING STUDIES

The predictability of the changes that would occur following catastrophes at some future date is extremely restricted because of the limited nature of the existing data base. The small amount of information presently available for lower Cook Inlet and the north Gulf of Alaska indicates that substantial changes in the composition of the epibenthic assemblages are routine, long-term occurrences. However, no information regarding the range of variation exists, and so inferences concerning what is "normal" following a major disturbance would necessarily be weak. The information necessary to improve interpretation could be produced by a long-term monitoring program.

The experience of this study is useful in designing such a program. Generally, the nature of the studies should remain unchanged, but greater emphasis should be placed on obtaining useful estimates of plant and animal production. Furthermore, the objectives should be clearly and specifically stated in a manner conducive to standardized, quantitative examination.

A major problem encountered was the difficulty of sampling at Port Dick and Chugach Bay because of their inaccessibility, especially during fall and winter. Because of these difficulties, future studies would be more effective if monitoring sites were established at more accessible locations. A major necessity is accessibility by boat or plane during the fall and winter. Sites that may be suitable for intensive study are Port Graham, Koyuktolik Bay and Perl Island. Surveys should be conducted once during winter, fall and spring and three times during summer.

POTENTIAL PROBELMS OF OIL DEVELOPMENT

The impetus for funding this study was the proposal by Dept. of Interior to lease offshore areas in the Gulf of Alaska for development of suspected petroleum resources. Recent history provides abundant evidence that such development can be accompanied by several types of activities disruptive to natural systems (Anonymous, 1975; Smith, 1968; Nelson-Smith, 1973) . This knowledge created concerns over ignorance concerning the composition and distribution of the assemblages that might be affected by potential development and the processes crucial to the well-being of these assemblages.

In the marine environment, the most conspicuous consequences of oil development occur in intertidal and shallow subtidal assemblages. Effects in these areas are most noticeable for several reasons. First, man's maritime activities are concentrated in that area. Second, the proportion of observations and familiarity with these assemblages is greater, so that sudden changes are more obvious. Third, petroleum products are lighter than water and therefore often remain near the sea surface, at least initially. Wind can then drive conspicuous quantities of oil onshore. Finally, turbidity, often a consequence of petroleum related development can have strong detrimental effects on the visually dominant macrophyte assemblages, which are restricted to intertidal and shallow subtidal areas.

Basically, the kinds of problems encountered fall into three major categories. These include: 1) catastrophic spills resulting from blowouts of offshore wells, shipping accidents or severe damage to storage facilities or pipelines, 2) chronic, low-level contamination resulting from routine shipping operations and release of co-product brines, and 3) increased turbidity in the water column from disposal of dredge spoils produced by installation of port facilities, pipelines, wells, etc.

In view of the development scenarios generated by the Bureau of Land Management for the Kodiak Shelf and lower Cook Inlet, the most probable type of pollution to be experienced by the area from Gore Point to Koyuktolik Bay is a catastrophic spill. The probability of damage from chronic, low-level pollutants or turbidity is low because of circulation patterns and the remoteness of the area from potential platform sites and onshore facilities. As a consequence, the prospects for continued high plant production are good. However, prospects are also fairly high that the faunal assemblages could be appreciably perturbed. Two major features characterizing the ecology of intertidal and nearshore assemblages of the outer Kenai Peninsula , and apparently many other northern areas, lead to this conclusion. First, two of the most important groups of predators on the benthos of nearshore and intertidal areas are sea otters and several species of marine birds. A major spill in nearshore areas would certainly have a severe effect on local sea otter populations, regardless of the time of year, because they are non-migratory. Spills in nearshore areas in spring and summer would additionally kill large numbers of marine birds and could severely disrupt their populations. The long-term effects of a reduction in the predation pressures from these two groups cannot be predicted clearly, but both groups consume large numbers of herbivores (Ebert, 1968; Cottam, 1939). Uncontrolled herbivore populations frequently cause depletion of algal resources (Paine and Vadas, 1969; Kitching and Ebling, 1967).

The next feature, indicated by the patchy distribution and age structure of many invertebrate populations, is their apparently slow rate of recruitment to established populations or establishment of new populations. In particular, mature subtidal epifaunal assemblages such as Modiolus beds could perhaps require decades to recover from catastrophic damage.

An additional, but lesser, concern is that disruption of the possible pattern of food supply could affect offshore productivity. Seagrasses are quite sensitive to oil contamination (Straughan, 1971) and heavy contamination could severely reduce their, production for many years. Kelps and other seaweeds are generally not as sensitive to oil contamination as seagrasses, but are definitely affected by refined products (Clendenning and North, 1960). If a major spill hit the intertidal and nearshore areas at a time when it disrupted reproduction or germination of such important "annuals" as Nereocystis, the subsequent reduction in plant production could have a substantial impact on the condition of offshore organisms.

Of major importance in determining the magnitude and nature of the damage caused by a catastrophic oil spill are the volume and type of petroleum. The recent grounding of the tanker Sealift Pacific clearly demonstrated that both crude and refined petroleum products are potential sources of contamination in lower Cook Inlet. The physical and chemical properties of refined products differ considerably from those of crudes and their effects on living organisms are considerably more severe. However, the probability of a major spill of refined petroleum products on the outer Kenai Peninsula is fairly low.

Many of the larger and more highly publicized spills have involved crude oil. The major physical effects of crude oil contamination include smothering and dislocation of organisms and alteration of substrate. Smothering is particularly pertinent to sedentary invertebrate forms such as barnacles, mussels and limpets. It generally only occurs in the intertidal zone as a consequence of very heavy oiling and is most damaging to small specimens. Dislocation can occur in several ways and affect both seaweeds and animals. Smaller seaweeds such as rockweed become heavily fouled and may be torn from the substrate as a consequence. Sessile intertidal forms such as limpets and littorine snails retract into their shells and release their hold on the" substrate. Wave action subsequently washes them into subtidal areas where they die. Motile forms such as crabs and fish can sometimes move from contaminated areas, but often those in embayments and estuaries cannot, and are subsequently killed (Blumer, 1972). Oiling can also render substrates unsuitable for recruitment by the forms normally encountered. This is particularly important in areas where heavy oiling leaves an asphaltic coating not suitable for recruitment by most intertidal forms. Major spills where these types of effects have been observed include the Torrey Canyon spill on the Cornish coast (Smith, 1968) , the Santa Barbara blow-out (Straughan, 1971), and the Metula accident, in the Straits of Magellan (personal communication, Dr. Miles O. Hayes, University of South Carolina).

Direct poisoning by crude oil has been poorly documented and studied but appears relatively uncommon (Boesch, Hershner and Milgram, 1971). It may be important to fish, however, by disturbing membrane permeability in the gills (Morrow, 1974). Ingestion of crude oil apparently has little immediate harmful effects on invertebrates but may damage marine birds. Food chain effects, particularly sublethal forms such as decreased reproductive potential or reduced fitness resulting from altered behavioral patterns, have been insufficiently investigated (Blumer, 1972).

Clean-up methods, particularly use of chemical emulsifiers and dispersants, have actually caused more damage than the spilled oil (Smith, 1968) . However, this is probably not a serious concern on the outer Kenai Peninsula. It is probably fairly safe to predict that because of its remoteness and physical inhospitality clean-up efforts would not be attempted.

It is difficult to predict the overall effects of a large spill of crude oil on the outer Kenai Peninsula. Numerous variables are very important in influencing the magnitude of damage. Among these are time of year, sea state and position in the monthly tide cycle. These factors determine composition and development of the intertidal and shallow subtidal assemblages, rates of evaporation, emulsification and decomposition of the oil, and the amount of sea floor contacted by it.

The predominance of evidence from recent spills indicates that major damage to the rocky shore would be to barnacles, limpets and chitons. Damage to seaweeds would be only temporary. Later, because of the absence of the major grazers, seaweeds would probably develop luxuriant, diverse assemblages. The period of time necessary for complete recovery is not predictable, but in the case of the _Tampico Maru_, which spilled diesel oil in Baja California, recovery was not complete seven years later (North, Neushul and Clendenning, 1964). The length of the recovery period would be considerably lengthened? however, if a spill caused high mortality among major predators such as sea otters and marine birds.

The potential consequences of a spill entering the lagoons or estuaries of the outer Kenai are much more serious. Dominant species such as eelgrass and marsh grasses, are more sensitive to oil contamination than the algal species (Straughan, 1971). Furthermore, the probability of contact is higher because of the flatness and greater extent of the intertidal zone in estuaries. The high concentrations of silt and organic debris would act to increase the quantity of oil retained in the system and the time necessary for flushing to occur. However, because of the well-developed microbial flora, degradation may occur more rapidly. Greatest damage would be to eelgrass, the dominant primary producer, but unfortunate timing could also cause severe damage to salmon stocks if adults or juveniles were trapped and killed, or if migrations into spawning streams were inhibited (Dept. of Interior, 19761.

Juvenile pink salmon are quite sensitive to low level exposures of crude oil (Rice, 1973). Highest sensitivity of fry was in salt water, where about 50% were killed by a 96 hour exposure to crude oil concentrations of 0.04 ml/1. . Significant mortalities occurred in young coho salmon when concentrations of crude oil poured on the surface of the water reached 500 ppm (Morrow, 1974). Further discussion of the problems and evidence supporting these projections are available in the environmental impact statement for lower Cook Inlet (Dept. of Interior, 1976).

The systems examined during this study are robust, pristine and quite productive. They appear to contribute significant quantities of food material to the offshore systems and may be particularly important in satisfying winter food requirements. This point of interaction appears to be a crucial consideration in planning for oil development because the loss or contamination of a large proportion of that food source could cause significant losses in valuable offshore fisheries resources. The estuarine systems are also very important to salmonid stocks, which are highly susceptible to contamination. Heavy oiling of a lagoon such as Koyuktolik could seriously reduce natural salmon runs (Dept. of Interior, 1976). However, evidence from other areas indicates that exposed intertidal and shallow subtidal systems are generally resilient and recover fairly well following major spills. Furthermore, it appears that the local systems occasionally sustain widespread damage from natural catastrophes (earthquakes, red tides), but most recover quickly. Disturbances of salmon stocks are not quickly resolved, however (National Research Council, 1971). In contrast, the effects of an oil spill on sea otters and marine birds are not analogous to those of natural catastrophes. Damage to populations could be severe and recovery would be slow. This is justifiable cause for great concern over the well-being of these important animals.

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Appendix A-1. Species observed on sand bottom on north side of Koyuktolik Bay, 7/9/76. Corrected depth - 32'.

Invertebrates

Echinarachnius parma - common
Elassochirus gilli
Maldanidae, unid. - ~ 50/m²
Olivella baetica - abundant
Pagurus ochotensis - common
Pycnopodia helianthoides - sparse
Tellina nuculoides - common

Fishes

Leptocottus armatus
Pleuronectiformes, unid. - juveniles, abundant

Substrate: Clean gray medium sand with little shell derbis, moderate organic debris, large ripple marks (5 x 45 cm); shell piles (egesta) common.

Appendix A-2. Species observed along south side of Koyuktolik Bay, 8/30/76. Water depth 18.9 m.

Macrophytes

Constantinea simplex
Cymathere triplicate
Fucus distichus
Laminaria saccharina-dominant; about 75% cover

Invertebrates

Elassochirus tenuimanus-uncommon
? Hermissenda crassicornis-uncommon
Hydractinia sp.-uncommon
Metridium senile-uncommon
Pagurus ochotensis-common
Pycnopodia helianthoides-common
Tonicella lineata-common

Fishes

Hexagrammos stelleri-common
Stichaeidae, unid.-common

Substrate: silty cobble/sand bottom, no ripple marks, with a considerable quantity of vegetative debris of marine and terrestrial origin. Laminaria, Cymathere and Fucus appeared to have been imported. Terrestrial debris included alder leaves and conifer leaves and branches.

Appendix A-3. Species observed in the mussel beds along the entrance channel to the lagoon, Koyuktolik Bay, 7/10/76.

Macrophytes

Chlorophyta	Rhodophyta	Phaeophyta
Cladophora sp.	Callophyllis sp.	Alaria fistulosa
? Monostroma sp.	Halosaccion glandiforme	Alaria spp.
Spongomorpha sp.	Iridaea lineare	Cymathere triplicate
	Odonthalia floccosa	Fucus distichus
	Porphyra sp.	

Invertebrates

Balanus cariosus
B. glandula
Collisella pelts
Cucumaria sp.
Gnorimosphaeroma oregonensis
Leptasterias ? hexactis
Littorina sitkana
Mytilus edulis
Nucella lima

Birds

Corvus caurinus (northwestern crow)
Larus spp. (seagulls)

Appendix A-4. Organisms observed in vicinity of rock pinnacle, entrance channel to Koyuktolik Lagoon, 7/10/76.

Side of Pinnacle Invertebrates

Abietinaria turgida-reprod.

Acmaea mitra
Anthopleura sp., small
Balanus ? glandula

Chthamalus dalli
Diaulula sandiegensis

? Diadumene sp.
Diestothyrus frontalis
Diodora aspera

Elassochirus gilli
E. tenuimanus
Eudistylia ? vancouveri
Evasterias troschelii
Flustrella corniculata-on alga
Halichondria panicea
Hippothoa hyalina
Hyas lyrata
Katharina tunicata
Metridium senile
Oregonia gracilis

Serpulidae, unid.
Tealia crassicornis
Tonicella insignis

Under Rocks Invertebrates

Alcyonidium polyoum
Cancer oregonensis

Cucumaria miniata

Elassochirus gilli-abundant

E. tenuimanus-abundant

Fusitriton oregonensis

Lebbeus sp.

Leptasterias hexactis-sparse

Paralithodes camtschatica

Strongylocentrotus ? drobachiensis

Tedania sp.

Bottom on Boulders Algae

Agarum cribrosum-on sides
Alaria sp.
Costaria costata
Desmarestia viridis
Laminaria groenlandica-much of area with 100% coverage

L. setchellii-much of area with 100% coverage

Under Seminarian Canopy Algae

Constantinea simplex
Corallina vancouveriensis
Delesseria decipiens
Encrusting coralline alga
Iridaea lineare

Opuntiella californica

Ptilota filicina
Rhodymenia palmata

Invertebrates

Abietinaria turgida
Acmaea mitra
Alcyonidium pedunculatum
Cucumaria miniata
Diaulula sandiegensis
Elassochirus spp.
Evasterias troschelii
Halichondria panicea

Modiolus modiolus-uncommon
Ophiopholus aculeata
Oregonia gracilis
Pagurus sp.
Porifera, syconid
Porifera, yellow, encrusting
Pugettia gracilis
Pycnopodia helianthoides-very common
Serpulidae, unid.
Tealia crassicornis
Tonicella lineata
Volutharpa ampullacea

Appendix A-5 Abundance of major macroinvertebrates in 1/16 m^2 quadrats from mid-intertidal zone on rock pinnacle in entrance to Koy:ıktolik Lagoon, 7/10/76.

	Katharina tunicata	*Tonicella insignis*	*Evasterias troschelii*
	3	0	0
	1	0	0
	2	0	0
	5	0	0
	2	0	0
	1	0	5
	2	0	0
	2	0	0
	0	1	0
	1	0	0
	4	0	0
	2	1	0
	4	0	1
	6	0	0
	1	0	0
	2	0	0
	5	1	0
	4	0	0
	7	2	0
	1	0	0
	6	1	0
	0	0	0
$\bar{x}$	2.8	0.3	0.3
s	2.0	0.6	1.1
Estimated No. /m^2	44.4	4.6	4.4

Appendix A-6. Species observed in outer lagoon, Koyuktolik Bay, 7/9/76.

Macrophytes

Chlorophyta

? Monostroma sp.

Rhodophyta

Ahnfeltia plicata
Halosaccion glandiforme

Phaeophyta

Alaria sp.
Costaria costata
Cymathere triplicate
Laminaria ? saccharin

Angiospermae

Zostera marina

Invertebrates

Astarte sp.
Clinocardium nuttalli
Evasterias troschelii
Haliclystis sp.-common
Lucuna sp.
Macoma sp.
Margaritas helicinus
Mopalia sp.
Musculus ? vernicosus
Mya ? arenaria
Mya truncata
Natica sp.
Oregonia gracilis
Protothaca staminea
Pycnopodia helianthoides
Saxidomus gigantea
Syconidae, unid.
Telmessus cheiragonus
Tresus capax

Fishes

Ammodytes hexapterus (Pacific sand lance)
Hexagrammos stelleri (White spotted greenling)
Salvelinus malma (Dolly Varden trout)

Marine Mammals

Euhydra lutris (Sea otter)

Subtrate: mud and sand/gravel patches with heavy shell debris.

Appendix A-7. Species observed in the inner lagoon, Koyuktolik Bay, 7/9/76.

Macrophytes

Zostera marina - about 10/m^2, in sparse patches.
? Monstroma sp. - sparse

Invertebrates

Abarenicola ? pacifica - common.

Substrate: Silt with some shell debris.

Appendix A-8. Relative cover and abundance data for Zostera marina and Ahnfeltia plicata in 1/16 m^2 quadrats in eelgrass bed in the lagoon at Koyuktolik Bay, 7/9/76.

Transition, Zone of Inner and Outer Lagoon

Zostera

No. of turions	0	0	0	0	0	0	0	0	0	41	27	37	36
Percent cover	0	0	0	0	0	0	0	0	0	90	100	90	100
Ahnfeltia-Percent cover	100	100	100	100	100	100	100	100	100	0	0	0	0

Zostera												$\bar{x} \pm s$	No. per m^2
No. of turions	21	34	0	0	6	26	0	0	0	0	0	11.4 ± 15.9	182
Percent cover	90	100	0	0	40	60	10	90	95	35	50	39.6 ± 43.2%	
Ahnfeltia - Percent cover	0	0	100	100	60	40	90	0	0	0	0	53.8 ± 48.4%	

Middle of Outer Lagoon

Zostera

No. Of turions	31	42	24	33	64	23	35	21	0	45	36	43
Percent cover	100	100	75	100	100	100	100	80	5	100	100	95

Zostera			$\bar{x} \pm s$	No. per m^2
No. of turions	5	23	30.4 ± 16.4	485.7
Percent cover	20	60	8.11 ± 31.7%	

Appendix A-9. Turion height data, zostera marina from middle of outer lagoon, Koyuktolik Bay, 7/9/76.

Maxim-m Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
61.0	127.0	121.0	122.0	81.0
95.0	100.0	50.0	75.0	104.0
104.0	134.0	99.0	100.0	123.0
63.0	136.0	120.5	43.0	138.0
128.0	46.0	38.0	126.0	89.0
93.0	129.0	128.0	141.0	103.0
110.0	127.0	137.0	122.0	130.0
124.0	112.0	121.0	123.0	89.0
129.0	139.0	131.0	54.0	97.0
118.0	92.0	129.0	58.0	90.0
139.5	111.0	73.5	128.0	125.5
118.5	114.0	103.0	91.0	103.0
122.0	107.0	134.0	106.0	80.0
130.0	123.0	97.0	129.5	113.0
103.0	107.5	103.0	120.0	123.5
130.0	130.0	118.0	121.5	142.0
120.0	86.0	88.0	120.0	133.0
113.0	81.5	112.0	70.0	84.0
116.0	97.0	113.0	82.5	119.0
121.0	114.0	111.0	98.0	85.0

n = 100

$\bar{x} \pm s =$ 107.9 ± 24.1 cm

Range = 38.0 - 142.0 cm

•Length of longest leaf from upper node.

Appendix A-10. Number of turions of *Zostera marina* in 1/16 m^2 quadrats in eelgrass beds of outer lagoon, Koyuktolik Bay, 8/30/76.

INNER EDGE

23	24	27	19	21
6	18	23	44	42
20	19	36	54	36

Average number per 1/16 m^2 quadrat: $\bar{x} \pm s =$ 27.5 ± 12.5

Estimated density = 440 plants/m^2

Note: area interspersed with broad channels of *Ahnfeltia plicata*

OUTER EDGE

22	59	35	44	39
42	34	39	30	49
37	29			

Average number per 1/16 m^2 quadrat: $\bar{x} \pm s =$ 38.3 ± 9.7

Estimated density = 61.2 plants/m^2

Appendix A-n. Turion height data; zostera marina from middle of outer lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
231.5	236.0	75.0	178.0	194.0
90.5	144.0	121.0	115.0	160.5
33.0	162.0	164.0	149.0	194.5
171.5	185.0	154.0	212.5	121.5
226.0	194.0	96.0	197.0	89.0
214.0	137.5	162.5	120.0	91.0
222.5	178.0	184.5	117.5	31.5
120.5	206.0	161.0	171.5	146.5
111.0	155.0	168.0	203.0	121.0
187.0	189.5	201.5	186.0	191.0
140.5	179.5	123.5	151.5	182.0
131.0	73.0	169.5	109.0	209.5
173.0	207.0	100.5	96.5	195.5
230.0	61.0	215.5	157.5	117.5
181.0	166.5	214.0	248.0	196.5
153.0	149.5	208.0	231.0	177.0
148.5	167.0	218.0	219.0	116.5
183.0	194.0	196.5	149.5	100.0
202.0	152.5	109.0	116.0	
120.0	188.5	139.0	113.0	

n = 99
$\bar{x} \pm s$ = 160.0 ± 46.3 cm
Range: 31.5 - 248.0 cm

* Length of longest leaf from upper node.

Appendix A-12. Turion height and wet weight data for *Zostera marina* from the transition zone between the inner and outer lagoons, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight -@!Q-	Maximum Leaf Length (cm)	Wet Weight (gm)
98.5	6.73	109.5	5.15	79.0	3.89	117.0	10.62
130.0	17.21	116.0	5.80	103.5	7.73	115.0	11.00
137.0	14.02	120.5	5.85	80.0	4.20	49.0	2.10
83.0	3.65	108.0	6.81	110.0	17.75	106.0	10.82
90.0	4.53	125.5	8.45	109.0	3.79	108.0	10.51
149.0	16.02	120.5	9.47	67.0	4.35	111.0	9.48
111.0	3.75	48.0	1.12	43.0	1.30	146.0	17.23
64.0	2.08	62.0	1.44	97.0	5.06	59.0	3.48
130.0	6.18	99.0	3.24	73.0	3.13	109.0	16.10
92.0	4.33	143.0	6.00	60.0	1.97	42.0	1.80
99.0	5.13	83.0	2.52	92.0	14.62	94.0	6.85
139.5	9.43	59.0	1.80	84.0	4.08	102.0	7.07
101.0	4.87	100.0	10.16	63.0	4.21	46.5	1.13
173.0	26.01	88.0	4.21	28.0	1.07	97.0	5.90
109.0	8.75	80.0	4.32	46.0	1.44	125.0	13.86

$n = 60$

Mean Plant Height: $\bar{x} \pm s = 95.5 \pm 30.6$ cm

Mean Plant Weight: $\bar{x} \pm s = 6.9 \pm 5.2$ gm

Turion Height range: 28.0 - 173.0 cm

Appendix A-13. Turion height data; Zostera marina from inner edge of outer lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
75.5	107.0	94.0
137.0	28.5	186.5
97.0	108.5	104.0
165.5	92.5	54.0
181.5	188.5	217.0
150.5	79.0	152.5
179.5	184.5	132.0
170.0	177.0	88.0
199.0	137.0	125.5
77.0	152.0	169.0
200.0	187.0	37.0
157.5	148.0	52.0
208.0	116.5	151.5
132.5	135.5	152.0
106.0	175.0	184.0
172.5	87.0	37.0
61.0	190.0	111.0
200.0	83.5	86.0
163.5	103.5	47.0
76.0	42.5	213.0
77.5	78.0	189.5
212.0	203.0	
87.0	67.5	

n = 67
$\bar{x} \pm s =$ 130.5 ± 53.2 cm
Range: 28.5 - 217.0 cm

* Length of longest leaf from upper node

Appendix A-14. Turion height and wet weight data for Zostera marina from inner lagoon, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)	Maximum Leaf Length (cm)	Wet Weight (gm)
90.0	4.12	103.0	6.36	44.0	6.35	80.0	5.16
118.5	6.47	67.0	2.97	42.0	6.18	107.0	8.88
87.0	10.42	30.0	3.28	35.0	0.98	106.0	5.48
99.5	5.42	84.0	3.51	33.0	2.49	32.0	2.28
134.0	18.02	67.0	5.91	45.0	3.46	30.0	3.48
122.0	9.07	100.0	8.83	36.0	1.52	36.0	2.86
87.0	4.60	44.0	1.56	41.0	1.86	27.5	1.59
128.0	10.21	68.0	2.95	34.0	1.57	42.0	4.50
68.0	4.49	58.0	4.54	33.0	0.92	92.0	4.40
106.0	21.66	47.0	1.19	36.0	1.30	89.0	4.49
136.0	10.28	75.0	2.67	44.0	2.33	132.0	9.52
91.0	8.45	70.0	2.06	116.0	8.99		
79.0	4.61	72.0	3.60	105.0	10.36		

n = 50

Mean Plant Height: $\bar{x} \pm s = 73.0 \pm 33.2$ cm

Mean Plant Wet-weight: $\bar{x} \pm s = 5.4 \pm 4.1$ gm

Range: 27.5 - 13.60 an

Appendix A-15. Turion height, wet weight and dry weight data for <u>Zostera marina</u> from middle of outer lagoon, Koyuktolik Bay, 7/9/76.

Maximum Leaf Length (cm	Wet Weight (gm)	Dry Weight (gm)	Dry Weight Wet Weight Ratio	Maximum Leaf Length (Cm)	Wet Weight (gm)	Dry Weight (gm)	Dry Weight Wet Weight Ratio
139.5	8.82	0.90	0.102	107.0	4.15	0.38	0.092
118.5	6.19	0.66	0.106	123.0	4.69	0.38	0.081
122.0	10.21	0.92	0.090	107.5	5.13	0.47	0.092
130.0	8.32	0.78	0.094	130.0	4.78	0.41	0.086
103.0	7.03	0.66	0.094	86.0	3.43	0.31	0.090
130.0	8.38	0.79	0.094	81.5	3.06	0.29	0.095
120.0	8.29	0.79	0.095	97.0	5.59	0.40	0.072
113.0	9.97	0.96	0.096	114.0	5.35	0.47	0.088
116.0	6.49	0.59	0.091	73.5	2.36	0.18	0.076
121.0	9.57	0.93	0.097	103.0	4.82	0.42	0.087
111.0	6.06	0.63	0.104	134.0	8.21	0.69	0.084
114.0	5.63	0.51	0.091	97.0	2.53	0.17	0.067

Average Dry Weight/'Wet Weight Ratio: $\bar{x} \pm s = 0.09 \pm 0.01$

Appendix A-16. Data on relationship between turion height and dry weight for *Zostera marina* from inner edge of outer lagoon, Koyuktolik Bay, 8/30/76.

Maximum Leaf Length (cm)	Dry Weight (gin)
208.0	1.23
132.5	0.37
106.0	0.44
163.5	0.52
76.0	0.14
77.5	0.24
212.0	0.98
28.5	0.11
92.5	0.40
188.5	0.95
152.0	0.51
148.0	0.62
83.5	0.22
42.5	0.11
203.0	0.98
186.5	0.95
54.0	0.09
217.0	0.91
151.5	0.62
86.0	0.32
213.0	0.99

Appendix A-17. Relative cover data for Mytilus edulis and Fucus distichus in outer mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover*		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
At east end of bed		Moving toward northwest corner bed		0	85	0	100
				0	90	0	100
0	20	30	50	0	90	0	100
5	70	5	40	0	95	0	100
0	80	0	70	At northwest corner, moving south		0	100
0	75	0	5	0	95	0	100
0	75	0	40	0	85	0	99
0	50	0	55	0	95	0	95
0	90	0	95	0	100	0	90
0	100	0	95	0	99	0	100
0	95	0	15	0	100	0	100
0	90	0	90	0	100	0	100
0	25	0	90	0	100	0	100
0	60	0	90	0	40	0	100
0	65	0	10	0	25	0	95
0	90	0	15	0	50	0	99
1	85	0	95	0	99	0	100
0	30	0	60	0	60	0	0
0	95	0	80	0	85	0	0

% Cover		% Cover		% cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
At east corner moving to southwest corner		25	90	0	98	0	100
0	85	0	100	0	75	0	100
0	50	0	100	0	100	0	95
0	75	25	85	0	75	0	95
0	80	0	75	0	80	0	100
0	40	0	90	0	85	0	100
40	95	0	97	0	85	0	100
60	75	At southwest corner moving north and through center		0	95	0	45
50	70	0	50	0	100	0	90
0	90	0	75	0	85	0	100
0	100	5	75	0	98	0	70
0	95	2	97			0	90

Appendix A-17 (cont.). Relative cover data to *Mytilus edulis* and *Fucus distichus* in outer mussel bed, entrance channel to lagoon, Koyuktoli Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
10	100	0	85	0	85	0	90
10	80	0	100	0	90	0	65
0	95	0	98	0	100	0	85
0	100	0	98	0	90	0	90
0	90	0	98	0	60	0	80
0	90	0	95	0	90	0	97
0	90	0	95	0	95	0	100
0	50	0	100	0	75	0	65
80	100	0	100	0	70	0	95
0	70	0	100	0	98	0	95
25	70	0	98	0	75	0	95
5	70	0	80	0	15	0	60
0	65	0	40	0	40	0	70
0	75	0	95	0	25	0	75
0	100	0	95	0	65	0	35
0	90	0	98	0	35	0	10
0	80	0	100	0	40	0	30
0	100	0	95	0	25	0	45
0	100	0	98	0	45	0	50
0	100	0	100	0	50	0	30
0	100	0	98	0	40	0	85
0	100	0	90	0	70	0	100
0	80	0	75	0	70	0	100
0	80	0	80	0	40	0	0

Relative cover by *Fucus*: $\bar{x} \pm s = 1.8 \pm 8.9\%$
Relative cover by *Mytilus*: $\bar{x} \pm s = 79.6 \pm 23.9\%$

* Visual estimates based on haphazard casts with 1/16 m^2 quadrat

Appendix A-18. size data, *Mytilus edulis* from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

80 m from upper edge

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	Percent
5	0	1	1	1.2
6	0	0	0	0.0
7	0	0	0	0.0
8	0	0	0	0.0
9	0	0	0	0.0
10	2	0	2	2.4
11	0	0	0	0.0
12	0	2	2	2.4
13	2	0	2	2.4
14	4	2	6	7.1
15	1	1	2	2.4
16	1	0	1	1.2
17	2	1	3	3.6
18	4	3	7	8.3
19	1	0	1	1.2
20	0	1	1	1.2
21	0	0	0	0.0
22	2	1	3	3.6
23	3	3	6	7.1
24	2	3	5	6.0
25	2	1	3	3.6
26	0	2	2	2.4
27	3	2	5	6.0
28	4	4	8	9.5
29	1	2	3	3.6
30	3	6	9	10.7
31	2	0	2	2.4
32	2	0	2	2.4
33	1	0	1	1.2
34	0	0	0	0.0
35	1	2	3	3.6
36	1	0	1	1.2
37	1	1	2	2.4
38	0	0	0	0.0
39	0	0	0	0.0
40	0	1'	1	1.2
$\bar{x} \pm s$ (mm)	23.3 ± 7.4	24.5 ± 7.5	23.8 ± 7.4	
n	45	39	84	

Appendix A-18 (Cont.). Size data, *Mytilus edulis* from outer bed on entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

150 m from upper edge, 10 m from lower edge

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	Percent
4	0	1	1	0.8
5	1	1	2	1.7
6	0	0	0	0.0
7	0	0	0	0.0
8	1	1	2	1.7
9	0	1	1	0.8
10	0	0	0	0.0
11	0	0	0	0.0
12	0	1	1	0.8
13	0	2	2	1.7
14	1	1	2	1.7
15	1	3	4	3.4
16	0	1	1	0.8
17	1	5	6	5.1
18	4	4	8	6.7
19	0	2	2	1.7
20	3	1	4	3.4
21	1	0	1	0.8
22	0	5	5	4.2
23	4	3	7	5.9
24	0	2	2	1.7
25	4	2	6	5.1
26	1	3	4	3.4
27	4	2	6	5.1
28	4	3	7	5.9
29	0	1	1	0.8
30	3	3	6	5.1
31	4	2	5	5.1
32	5	2	7	5.9
33	3	1	4	3.4
34	2	1	3	2.5
35	1	3	4	3.4
36	0	1	1	0.8
37	0	2	2	1.7
38	2	2	4	3.4
39	0	0	0	0.0
40	1	0	1	0.8
41	0	0	0	0.0
42	3	0	3	2.5
43	0	1	1	0.8
44	0	0	0	0.0
45	0	0	0	0.0
46	0	0	0	0.0
47	0	0	0	0.0
48	0	0	0	0.0
49	0	0	0	0.0
50	0	1	1	0.8
$\bar{x} \pm s$ (mm)	27.2 ± 8.0	24.1 ± 9.3	25.5 ± 8.8	
n	54	64	118	

Appendix A-19. Relative cover data for Mytilus edulis and Fucus distichus in inner mussel bed, entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
75 m north of		0	0	0	25	100	80
southern tip,		At upper edge of		0	5	0	80
moving ENE		bed, moving due		0	5	80	70
across bed		south		0	10	0	85
100	100	0	40	Moving SSW		0	85
100	100	0	0			0	90
10	90	0	0	0	20	0	95
20	60	0	90	0	90	0	0
0	20	0	0	0	75	0	40
0	95	0	70	2	95	0	100
0	50	0	10	0	100	0	100
0	75	0	0			Moving west	
0	50	40	60	Moving west			
0	75	0	95	0	100	0	85
0	30	60	60	5	50	0	0
0	70	0	25	0	65	0	90
0	75	0	70	0	70	2	95
1	95	0	25	0	90	0	0
0	60	0	5	0	90	0	25
0	10	0	85	20	90	0	100
0	10	At SE corner of bed		40	85	10	65
0	5	Moving WSW		0	50	Ended at SW corner of bed	
0	1	0	75	Back at 75 m location, moving south			
0	0	0	20				

% Cover		% Cover		% Cover		% Cover	
Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus	Fucus	Mytilus
5	75	15	50	2	55	0	65
5	100	5	40	2	65	0	80
70	100	0	80	15	75	0	75
65	75	60	60	5	70	0	50
75	70	2	55	2	50	0	0
15	60	10	60	0	40	0	35
0	70	0	15	0	50	0	70

Appendix A-19 (Cont.). Relative cover data for *Mytilus edulis* and *Fucus distichu* in imer mussel bed, entrance channel to lagoon, Koyuktol Bay, 7/10/76.

% Cover		% Cover		% Cover		% Cover	
Fucus	*Mytilus*	*Fucus*	*Mytilus*	*Fucus*	*Mytilus*	*Fucus*	*Mytilus*
0	40	0	85	10	65	80	75
0	75	15	60	2	65	2	55
0	60	2	90	60	75	2	60
0	40	20	40	0	45	60	60
0	80	0	60	0	45	20	80
0	75	100	80	0	55	0	95
0	60	60	60	0	75	0	75
0	75	10	55	0	85	25	70
0	65	15	50	0	75	20	95
0	50	2	45	15	70	2	70
0	80	50	70	0	60	75	80
0	80	35	55	0	50	0	65
0	65	30	45	0	55	0	100
0	60	50	80	0	70	0	, 95
2	45	20	60	0	55	0	0
0	0	80	65	0	80	65	65
0	80	40	60	0	45	0	0
0	90	75	85	2	55	0	0

Relative cover by *Fucus*: $\bar{x} \pm s = 11.2 \pm 24.1\%$
Relative cover by *Mytilus*: $\bar{x} \pm s = 58.9 \pm 29.2\%$

* Visual estimates based on haphazard casts with 1/16 m^2 quadrat.

Appendix A-20a. Size data, *Mytilus edulis*, 5 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Station No. 1 Frequency	Station No. 2 Frequency	Total	%
5	0	1	1	0.6
6	0	2	2	1.2
7	0	5	5	3.1
8	4	6	10	6.1
9	2	4	6	3.7
10	1	7	8	4.9
11	2	4	6	3.7
12	4	14	18	11.0
13	5	9	14	8.5
14	8	5	13	7.9
15	6	5	11	6.7
16	6	2	8	4.9
17	5	3	8	4.9
18	5	0	5	3.1
19	2	1	3	1.8
20	4	3	7	4.3
21	3	3	6	3.7
22	5	2	7	4.3
23	2	0	2	1.2
24	1	1	2	1.2
25	0	2	2	1.2
26	0	3	3	1.8
27	0	1	1	0.6
28	0	0	0	0.0
29	0	0	0	0.0
30	0	1	1	0.6
31	0	1	1	0.6
32	1	1	2	1.2
33	1	2	3	1.8
34	0	1	1	0.6
35	1	0	1	0.6
36	1	0	1	0.6
37	0	2	2	1.2
38	1	0	1	0.6
39	0	0	0	0.0
40	0	0	0	0.0
41	1	0	1	0.6
42	0	0	0	0.0
43	0	0	0	0.0
44	0	0	0	0.0
45	1	0	1	0.6
46	0	0	0	0.0
47	1	0	1	0.6
n	73	91	164	
$\bar{x} \pm s$ (mm)	18.3 ± 8.3	15.3 ± 7.7	16.7 ± 8.1	

Approx. No./m^2 = 17,826

Appendix A-20b. Size data, Mytilus edulis, 10 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Sample No. 1	Sample No. 2	Total	Shell Length (mm)	Sample No. 1	Sample No. 2	Total
7	0	1	1	29	0	1	1
8	1	4	5	30	3	2	5
9	1	2	3	31	0	0	0
10	0	7	7	32	2	1	3
11	0	5	5	33	0	0	0
12	4	13	17	34	1	2	3
13	6	18	24	35	1	1	2
14	2	15	17	36	0	2	2
15	1	7	8	37	2	0	2
16	5	4	9	38	3	2	5
17	4	14	18	39	1	0	1
18	3	9	12	40	1	0	1
19	2	4	6	41	0	0	0
20	3	5	8	42	0	1	1
21	2	2	4	43	1	2	3
22	1	1	2	44	0	0	0
23	2	3	5	45	1	0	1
24	2	4	6	46	0	0	0
25	1	4	5	47	0	1	1
26	0	1	1	48	0	2	2
27	0	2	2	49	0	0	0
28	0	2	2	50	2	0	2

	Sample No. 1	Sample No. 2	Total
n	58	144	202
$\bar{x}$	23.2	18.3	
s	10.9	8.7	9.6

Appendix A-20c. Size data, *Mytilus edulis* 30 m from south end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

Shell Length (mm)	Sample No. 1 Frequency	Sample No. 2 Frequency	Total	%
7	1	1	2	1.7
8	2	1	3	2.6
9	4	3	7	6.0
10	3	4	7	6.0
11	3	1	4	3.4
12	1	5	6	5.1
13	3	6	9	7.7
14	1	2	3	2.6
15	2	7	9	7.7
16	6	4	10	8.6
17	1	1	2	1.7
18	4	3	7	6.0
19	2	1	3	2.6
20	3	1	4	3.4
21	5	1	6	5.1
22	1	2	3	2.6
23	0	2	2	1.7
24	0	1	1	0.9
25	0	1	1	0.9
26	1	1	2	1.7
27	1	1	2	1.7
28	1	0	1	0.9
29	0	0	0	0.0
30	2	1	3	2.6
31	0	0	0	0.0
32	0	4	4	3.4
33	1	1	2	1.7
34	1	1	2	1.7
35	0	1	1	0.9
36	0	1	1	0.9
37	0	1	1	0.9
38	4	0	4	3.4
39	0	0	0	0.0
40	0	0	0	0.0
41	0	0	0	0.0
42	0	2	2	1.7
43	0	1	1	0.9
44	0	1	1	0.9
45	0	0	0	0.0
46	0	0	0	0.0
47	0	0	0	0.0
n	53	64	117	
$\bar{x} \pm s$ (mm)	18.6 ± 8.6	20.3 ± 10.4	19.6 ± 9.6	

Approx. No./m* = 12,717

Appendix A-20d. Size data, *Mytilus edulis* 75 m from South end of the inner bed in entrance channel to lagoon, Koyuktolik Bay, 7/10/76.

shell Length (mm)	Station No. 1 Frequency	Station No. 2 Frequency	Total	%
9	3	1	4	6.1
10	2	0	2	3.0
11	0	0	0	0.0
12	3	1	4	6.1
13	0	2	2	3.0
14	0	2	2	3.0
15	0	0	0	0.0
16	1	2	3	4.6
17	1	1	2	3.0
18	1	0	1	1.5
19	1	0	1	1.5
20	1	1	2	3.0
21	0	1	1	1.5
22	1	3	4	6.1
23	2	0	2	3.0
24	0	0	0	0.0
25	1	0	1	1.5
26	0	1	1	1.5
27	2	3	5	7.6
28	0	4	4	6.1
29	0	0	0	0.0
30	2	2	4	6.1
31	1	1	2	3.0
32	1	0	1	1.5
33	0	0	0	0.0
34	1	0	1	1.5
35	1	0	1	1.5
36	0	0	0	0.0
37	0	2	2	3.0
38	0	0	0	0.0
39	0	1	1	1.5
40	1	3	4	6.1
41	0	0	0	0.0
42	2	2	4	6.1
43	0	0	0	0.0
44	0	0	0	0.0
45	1	0	1	1.5
46	0	0	0	0.0
47	0	1	1	1.5
48	2	0	2	3.0
49	0	0	0	0.0
50	0	1	1	1.5
n	31	35	66	
$\bar{x} \pm s$ (mm)	25.1 ± 12.4	27.3 ± 10.9	26.2 ± 11.6	

Approximate No./m^2 7,174

Appendix A-21. Observations of predation at Koyuktolik Bay, 7/9 and 7/10/76.

Predator	Prey	Depth (m)	Number	Type of Evidence
BAY				
Pycnopodia helianthoides	Echinarachinus parma	12	1	Direct
Melanitta sp.	Small clams	12	Numerous	Indirect
ENTRANCE CHANNEL				
Salvelinus malma (Dolly Varden)	Gammarid amphipods	2	Numerous	Direct
Corvus caurinus (Northwestern crow)	Mytilus edulis	Intertidal	Numerous	Indirect
Larus spp. (Gulls)	Mytilus edulis	Intertidal	Numerous	Indirect
Evasterias troschelii	Mytilus edulis	2	4	Direct
LAGOON				
Enhydra lutris (Sea otter)	Saxidomus gigantea	2	Numerous	Indirect
	Mya truncata	2	Numerous	Indirect

Appendix B-1. Abundance of macrophytes and echinoids in 1/4 m^2 quadrats in Raft Cove, Chugach Bay, 7/6/76.

	Quadrat									
	1	2	3	4	5	6	7	8	$\bar{x} \pm s$	No. per m^2
Alaria sp.	0	0	0	3	4	0	0	0	0.9 ± 1.6	3.5
Cymathere triplicate	0	0	0	4	2	0	5	0	1.4 ± 2.1	5.5
Desmarestia spp.	2	0	0	6	0	0	4	0	1.5 ± 2.3	6.0
Laminaria ? *groenlandica*	5	15	11	4	6	0	4	0	5.6 ± 5.2	22.5
Nereocystis luetkeana	1	0	0	11	0	0	10	1	2.9 ± 4.7	11.5
Phaeophyta, unid. (juveniles)	6	0	0	25	0	15	21	19	10.8 ±10.4	43.0
Strongylocentrotus drobachiensis	0	0	2	0	0	0	2	0	0.5 ± 0.9	2.0
Depth (m)	10.7	10.7	10.7	10.7	10.7	9.1	9.1	9.1		

Appendix B-2. Abundance of macrophytes and echinoids in 5 x 1 m quadrats off Raft Cove, Chugach Bay, 7/6/76.

Species	Quadrats 1	2	Total	No. per m^2
Agarum cribrosum	104	42	146	14.6
Laminaria groenlandica	123	46	169	16.9
Pleurophycus gardneri.	3	5	8	0.8
Strongylocentrotus drobachiensis	1	0	1	0.1

Habitat Notes:		
Depth (m)	15.8	16.1
Substrate	Rock	Sand w/rock patches

Appendix B-3. Abundance and relative cover of macrophytes and echinoderms in 1/4 m^2 quadrats off Baft Cove, Chugach Bay in 7.5-13.5 m depths, 7/16/76.

	Quadrats 1	2	3	4	5	6	7	8	9	10	11	12	13	$\bar{X} \pm s$	No. Per m^2
Agarum cribrosum (N)	2	3	0	0	0	0	0	3	0	3	0	0	0	0.8 ± 1.3	3.2
Agarum cribrosum (C)	0	0	0	0	0	0	0	40%	O	40%	0	0	0	6.2 ± 15.0%	0.0
Laminaria groenlandica (N)	0	0	0	O	2	0	0	2	0	2	4	5	7	1.7 ± 2.3	6.8
Laminaria groenlandica (C)	70%	0	50%	50%	20%	70%	70%	10%	75%	10%	50%	20%	65%	43.1 ± 27.3%	0.0
L. yezoensis (N)	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1	0.4
Pleurophycus gardneri (N)	0	2	1	2	4	0	4	0	0	0	3	7	2	1.9 ± 2.1	7.6
Pleurophycus gardneri (C)	0	40%	40%	30%	60%	0	30%	O	0	0	40%	60%	15%	24.2 ± 23.1%	0.0
Crossaster papposus (N)	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1	0.4
Henricia sp. (N)	0	0	1	0	0	0	0	3	0	0	0	0	0	0.3 ± 0.9	1.2
Strongylocentrotus droebach-	0	0	0	0	0	1	0	3	1	0	2	0	0	0.5 ± 1.0	2.0
S. franciscanus	0	0	0	0	0	0	0	2	0	0	0	0	0	0.2	0.8
Tosiaster arctics	0	0	0'	0	1	0	0	0	0	0	0	1	0	0.2	0.8
Depth (m)	13.5	13.0	12.0	11.0	11.5	10.5	10.5	10.5	10.5	10.5	9.0	9.0	7.5		

Appendix B-4. Abundance and relative cover of organisms in 1/4 m^2 quadrats at 30 feet off Raft Cove, Chugach Bay, 7/8/76.

Species	Quadrats 1	2	3	$\bar{x} \pm s$
Constantinea simplex (C)	0	0	1%	0.3% ± 0.6
Corallina vancouveriensis (C)	5%	2%	0	2.3% ± 2.5
encrusting coralline alga (C)	50%	70%	55%	58.3% ± 10.4
Delesseria decipiens (C)	0	0	1%	0.3% ± 0.6
Laminaria ? setchellii (adult)(C)	75%	25%	60%	53.3% ± 25.7
Laminaria ? setchellii (adult)(N)	0	0	4	1.3 ± 2.3
Laminaria ? setchellii (juvenile)(N)	0	8	8	5.3 ± 4.6
Opuntiella californica (C)	0	2%	0	0.7% ± 1.2
Phaeophyta, unid. (juvenile)(N)	0	3	0	1.0 ± 1.7
Pleurophycus gardneri (C)	50%	75%	20%	48.3% ± 27.5
Pleurophycus gardneri (adult) (N)	0	4	4	2.7 ± 2.3
Pleurophycus gardneri (juvenile) (N)	0	1	1	0.7 ± 0.6
Abietinaria sp. (C)	1%	10%	15%	8.7 ± 7.1
? Aplidium solidum (C)	0	6%	1%	2.3% ± 3.2
Asteriidae, unid. (small)(N)	0	1	1	0.7 ± 0.6
Dendrobeania murrayana (C)	0	1%	1%	0.7% ± 0.6
Heteropora sp. (C)	0	1%	0	0.3% ± 0.6
Margaritas pupillus (N)	0	0	2	0.7 ± 1.2
Microciona sp. (C)	2%	1%	2%	1.7 ± 0.6
Microporina borealis (C)	0	15%	5%	6.7% ± 7.6
Notoacmaea instabilis (N)	0	1	0	0.3 ± 0.6
Ophiopholis aculeata (N)	0	0	P	
Paguridae, unid. (N)	3	2	6	3.7 ± 2.1
? Rhabdodermella sp. (C)	0	0	2%	0.7 ± 1.2
Bryozoa (unid. brown encruster)(C)	3%	3%	0	2.0% ± 1.7
Crucigera SF. (N)	1	0	0	0.3 ± 0.6
Synoicum sp. (C)	0	1	0	0.3 ± 0.6
Tonicella insignia	2	0	0	0.6 ± 1.2
Trichotropis cancellata (N)	0	0	1	0.3 ± 0.6
Trophon multicostatus (N)	0	1	0	0.3 ± 0.6
Tunicate, encrusting orange, social (C)	0	0	2	0.6 ± 1.2

Extralimital species: Musculus vernicosus sparse on kelps.

Habitat Notes: Bottom of boulders from 2' to 8' in diameter, up to 10' relief, extending to intertidal nearby.

Bottom dominated by Laminaria ? setchellii and Pleurophycus gardneri.

Appendix B-5. Abundance and relative cover Of organisms in 1/4 m^2 quadrats Off Raft Cove, Chugach Bay, 7/6/76.

	1	2	3	4	5	6	7	8	x̄ ± s	No. per m^2
Agarum cribrosum (C)	20%	0	15%	0	20%	30%	0	600	18.1 ± 20.3%	
Agarum cribrosum (N)	0	0	0	0	4	1	0	2	0.9 ± 1.5	3.5
Callophyllis sp. (C)	0	0	0	0	10%	2%	0	5%	2.1 ± 3.6$	
Constantine sp. (C)	0	0	0	0	0	5%	0	2%	0.9 ± 1.8%	
encrusting coral line alga(C)	0	0	0	0	80%	70%	80%	85%	39.4 ± 42.3%	
Hildenbrandia sp. (C)	0	0	0	0	0	5%	10%	0	1.9 ± 3.7%	
Lami nar ia groenlandica (C)	40%	25%	15%	0	0	40%	0	40%	20.0 ± 18.7%	
Laminaria groenlandica (N)	0	0	2	0	0	2	0	2	0.8 ± 1.0	3.0
Laminaria sp. (C)	0	0	0	0	0	5%	5$	2%	1.5 ± 2.3%	
Laminaria sp. (N)	0	0	0	0	0	2	3	6	1.4 ± 2.2	5.5
Odonthalia kamschatica (C)	0	0	0	0	0	0	0	2%	0.3%	
Opuntiella californica (C)	0	0	0	0	0	5%	20	0	0.9 ± 1.8%	
Pleurophycus gardneri (C)	0	0	0	15%	40%	60%	75%	0	23.8 ± 30.6%	
Pleurophycus gardneri (N)	0	0	0	1	4	1	4	0	1.3 ± 1.8	5.0
Ptilota sp. (C)	0	0	10%	0	0	2%	0	0	2.5 ± 4.6%	
Rhodophyta, unid. (filamentous) (C)	0	0	0	0	0	6%	0	0	0.8 ± 2.1%	
Rhodymenia pertusae (C)	0	0	10%	0	0	10%	10%	0	3.8 ± 5.2%	
Acmaea mitra (N)	0	0	0	0	1	0	0	0	0.1	0.5
Amphissa columbiana (N)	0	0	0	0	0	1	0	0	0.1	0.5
Calliostoma ligature(N)	0	0	0	0	P	3	7	0	1.4 ± 2.5	5.5
Campanularia verticillata (C)	0	0	0	0	15%	0	0	0	1.9%	
Cliona celata (C)	0	0	0	0	0	0	0	2%	0.3%	
Dendrobeania ? murrayana (C)	0	0	0	0	5%	0	2%	2%	1.1 ± 1.8%	
Didemnum sp. (C)	0	0	0	0	0	0	0	2%	0.3%	
Distaplia sp. (C)	0	0	0	0	20%	25%	5%	0	6.3 ± 10.3%	
Distaplia sp. (N)	0	0	0	0	0	0	0	2	0.3	1.0
Flustrella gigantea (C),	0	0	0	0	5%	5%	10%	0	2.5 ± 3.8%	
Fusitriton oregonensis (N)	0	0	0	0	0	1	0	1	0.3 * 0.5	1.0
Henricia sp. (N)	0	0	0	0	0	1	0	0	0.1	0.5
Heteropora sp. (C)	0	0	0	0	8%	0	5%	2$	1.9 ± 3.0%	
Margaritas pupillus (N)	0	0	0	0	0	0	2	2	0.5 ± 0.9	2.0
Microcladia sp. (C)	0	0	0	0	0	20%	25%	15%	7.5 ± 10.7%	
Microporina borealis(C)	0	0	0	0	0	25%	50%	20%	11.9 ± 18.5%	
Musculus vernicosus (N)	0	0	0	0	P	0	0	0	P	
Pagurus sp. (N)	0	0	0	0	3	L	0	1	0.6 ± 1.1	2.5
Placiphorella sp. (N)	0	0	0	0	0	0	0	1	0.1	0.5
Polyplacophora, unid. (N)	0	0	0	0	0	0	0	1	0.1	0.5
Porifera, unid. (orange)(C)	0	0	0	0	0	0	0	58	0.6%	
Puncturella multistriata(N)	0	0	0	0	0	0	1	0	0.1	0.5
Searlesia dira(N)	0	0	0	0	0	1	0	1	0.3 ± 0.5	1.0
Serpulidae, unid. (C)	0	0	0	0	0	2%	2%	2%	0.8 ± lo%	
Sertulariidae, five spp. (C)	0	0	0	0	10%	2%	10%	2%	3.0 ± 4.4	
Strongylocentrotus droebachiensis (N)	0	0	1	0	0	2	0	2	0.6 ± 0.9	2.5
Strongylocentrotus franciscanus (N)	0	0	0	0	0	0	1	0	0.1	0.5
Tonicella sp. (N)	0	0	0	0	3	3	3	3	1.5 ± 1.6	6.0
Tosiaster arctics	0	0	0	0	0	0	1	0	0.1	0.5
Tricellaria sp. (C)	0	0	0	0	0	2%	0	0	0.3%	
Trichotropis cancellata	0	0	0	0	P	P	P	0	P	

Habitat Notes

	1	2	3	4	5	6	7	8
Substrate Type:	Rock/Gravel/Shell	Gravel/Shell	Gravel/Shell	Grave 3/Shell	Rock	Rock	Rock	Rock
Depth (m)	16.5	16.5	16.5	16.5	15.5	12.0	12.0	12.0

Extralimital species: Abietinaria filicina (reproductive), Abietinaria turgida, Alaria crisps, Bonneviella grandis [reproductive) , Calliostoma annulatum, Campanularia verticillata (mature) , Odonthalia Iyallii, Halecium labrosum (immature), Ptilosarcus gurneyi, Sertularella polyzonias (immature), Clupea harengus (juv. , var 1-2" long), schooling 10'-15' above algal canopy, Sertularella polyzonias var. gigantea (immature) , Sertularella tricuspidata (reproductive], Sertularella sp., Nassarius ? mendicus, Nucella lima

Appendix B-6. Abundance and relative cover of macrophytes in 1/4 m^2 quadrats at northeast point of Raft Cove, Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	8	9	10	x̄ ± s
Agarum cribrosum (N)	1	0	0	0	2	1	4	0	1	3	1.2 * 1.4
Agarum cribrosum (C)	30%	0	0	20%	60%	60%	15%	2%	25%	10%	22.2 ±22.4%
Laminaria groenlandica (N)	0	0	0	1	0	0	2	12	5	6	2.6 ± 4.0
Laminaria groenlandica (C)	0	0	0	60%	10%	10%	60%	80%	50%	80%	3.5 *34.1%
Laminaria saccharin	0	80%	0	0	0	0	0	0	0	0	8.0%
Pleurophycus gardneri (N)	0	0	0	0	0	0	0	0	0	1	0.1
Pleurophycus gardneri (C)	0	0	0	0	0	0	0	0	0	10%	1.0%
Depth (m)	10.5	10.5	-	9.0	9.5	9.0	9.0	8.5	8.5	8.0	9.2m

Appendix B-7. Abundance and relative cover of rock subs.trate in 0.25 m^2 quadrats at northeast point of Raf t Cove, Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	8	9	10	x̄ ± s
Agarum cribrosum (N) 1/			1				3		2	1	0.7 ± 1.1
Agarum cribrosum (C) 2/		20%	10%		15%		70%		30%	20%	16.5 ± 21.6%
Boss iella sp. (C)			4%				5%	2%			1.1 ± 1.9%
Callophyllis sp. (C)										2%	0.2%
Constantinea sp. (C)			2%		2%	15%	15%	5%	2%	15%	5.6 ± 6.7%
Delesseria decipiens (C)							2%				0.2%
Desmarestia munda (N)			1								0.1
Desmarestia munda (C)			5%								0.5%
Encrusting coralline alga (C)			25%			70%	60%	300		30%	21.5 ± 26.5%
Hildenbrandia sp. (C)						20%	30%	20%			7.0 ± 11.6%
Laminaria groenlandica (N)			1			2		5	2	4	1.4 ± 1.8
Laminaria groenlandica (C)			25%			15%		40%	30%	40%	15.0 ± 17.3%
L. saccharin	25%			30%							5.5 ± 11.7%
L. yezoensis (N)							2				0.2
L. yezoensis (C)							20%				2.0%
Laminaria sp. (N)							2	3			0.5 * 1.1
Laminaria sp. (C)							2%	2%			0.4 ± 0.8%
Microcladia sp. (c)										2%	0.2%
Ralfsia pacific							5%				0.5%
Rhodymenia pertusae (C)			2%	10%	10%	10%			2%		3.4 ± 4.6%
Acmaea mitra (N)							2		1	1	0.4 * 0.7
Calliostoma ligatum (N)										1	0.1
Dendrobeania ? murrayana (C)								2%		2%	0.4 ± 0.8%
Diodora aspera (N)										1	0.1
Distaplia sp. (C)						5%	5%				1.0 ± 2.1%
Evasterias troschelii (N]										1	0.1
Flustrella gigantea (C)							2%				0.2%
Fusitriton oregoneneis (N)										1	0.1
Heteropora sp. (C)						2%					0.2%
Microporina borealis (C)							2%			2%	0.4 ± 0.8%
Mopalia sp. (N)							1				0.1
Myriozoum ? tenue (C)										5%	0.5%
Musculus discors (N)									1		0.1
M. vernicosus						P					
Olivella baetica (N)		8									0.S
Paguridae, unid. (N)		1				2					0.3 ± 0.7
Placiphorella sp. (N)								1			0.1
Searlesia dira (N)							2				0.2
Strongylocentrotus droebachiensis (N)						1					0.1
Ton sp. (N)			3				4	3	1		1.1 ± 1.6
Trichotropis cancellata (N)							P	P			

1/ N · Number
2/ C = Relative cover

Habitat Notes:

	1	2	3	4	5	6	7	8	9	10	
Substrate	S & S	S & H	S & R	S	S, R & SH	R& Sh	R	R & S	R & S	R & S	
Depth (m)	11.5	11.5	11.5	11.5	11.5	10.5	10.5	10.5	10.5	10.5	11.0 ± 0.5

S = Sand
R = Rock
Sh= Shell

Appendix B-8. Density and relative cover of macrophytes in 1/4 m2 quadrats inside south point at Chugach Bay, 7/5/76.

Species	Quadrats 1	2	3	4	5	6	7	x̄ ± s	No. per m^2
Agarum cribrosum (N)	3	0	0	1	0	0	0	0.6 ± 1.1	2.3
Agarum cribrosum (C)	35%	10%	0	25%	O	0	45%	16.4 ± 18.6%	
Constantinea sp. (C)	20%	20%	0	20%	3%	10%	10%	11.9 ± 8.4%	
Encrusting coralline alga (c)	0	0	0	20%	10%	5%	15%	7.1 ± 8.1%	
Laminaria groenlandica (N)	2	1	0	2	"3	0	0	1.1 ± 1.2	4.6
Laminaria groenlandica (C)	55%	20%	0	10%	75%	10%	0	24.3 ± 29.2%	
Laminaria saccharin	0	0	15%	0	0	0	0	2.1%	
Laminaria yezoensis (N)	0	0	1	0	0	1	0	0.3 ± 0.5	1.1
Laminaria yezoensis (C)	0	0	75%	0	0	25%	0	14.3 ± 28.3 %	
Pleurophycus gardneri (N)	0	0	0	0	1	0	0	0.1	0.6
Pleurophycus gardneri (C)	0	0	0	0	25%	0	0	3.6%	
Rhodymenia pertusae (C)	0	0	0	10%	o	0	0	1.4%	
Rhodymenia pertusae (N)	0	0	0	0	0	0	0		
Rhodymenia sp. (C)	5%	0	0	0	0	0	0	0.7%	

Habitat Notes:	1	2	3	4	5	6	7
Depth (m):	12.5	12.5	12.0	12.0	12.0	12.0	12.0
Substrate:	Sand, scattered, rock	Sand, stattered, rock	Sand	Rock	Rock	Sand, rock	Sand, rock

Extralimital invertebrate species: Evasterias troschelii, Dermasterias imbricata, Fusitriton oregonensis (spawning), Paguridae, unid.

Appendix B-9. Abundance, relative cover and composition of organisms on rocks in 1/4 m^2 quadrats on western finger off southern headland, Chugach Bay, 7/8/76.

Depth: 21 m

Species	Quadrats 1	2	$\bar{x}$
Agarum cribrosum (N)	0	2	1.0
Agarum cribrosum (C)	0	30%	15.0%
Encrusting coralline alga (C)	30%	35%	32.5%
Hildenbrandia sp. (C)	2%	10%	6.0%
Membranoptera sp. (C)	0	5%	2.5%
Ptilota sp. (C)	2%	5%	3.5%
Abietinaria sp. (C)	15%	10%	12.5%
Alcyonidium ? pedunculatum (C)	0	1%	0.5%
Campanularia verticillata (C)	2%	0	1.0%
Cryptochiton stelleri (N)	1	0	0.5
Dendrobeania murrayana (C)	5%	2%	3.5%
Entoprocta, unid. (C)	"1%	0	0.5%
Flustrella gigantea (C)	0'"	5%	2.5%
Henricia leviuscula (N)	1	0	0.5
Heteropora sp. (C)	2%	0.	1.0%
Leptasterias leptalea	1	1	1.0
Margaritas pupillus (N)	1	0	0.5
Microporina borealis (C)	20%	15%	17.5%
Obelia ? loveni (C)	0	10%	5.0%
Pagurus spp. (2 species) (N)	4	3	3.5
Placiphorella sp. (N)	1	0	0.5
Sertularia cupressoides (C)	0	5%	2.5%
Sertulariidae, (5 species) (C)	5%	0	2.5%
Strongylocentrotus droebachiensis (N)	1	0	0.5 (juvenile)
Trichotropis cancellata (N)	3	2	2.5
Tubularia sp. (N)	4	5	4.5 (reproductive
TUniCate, orange enc. (C)	10%	5%	7.5%

Extralimital Species

Algae

Cryptonemia sp.
Rhodymenia palmata
R. pertusae

Invertebrates

Abietinaria turgida-reproductive
A. ? variabilis
Amphissa columbiana
Bougainvilliidae, unid.
Bryozoans, encrusting brown and encrusting orange
Hippothoa hyalina
Humilaria kennerlyi (Shell only)
Lafoea fruticosa
Leucosolenia sp.
Mopalia sp.
Musculus discors
Myriozoella plana
Myriozoum ? tenue
Orthasterias koehleri
Orthopyxis caliculata-reproductive
Oweniidae, unid.
Pagurus ? caurinus-juvenile
P. ? confragosus-juvenile
Pugettia gracilis

Appendix B-9 (Cont.). Abundance, relative cover and composition of organisms on rocks in 1/4 m^2 quadrats on western finger off southern headland, Chugach Bay, 7/8/76.

Calycella syringa
Campanularia speciosa-reproductive
C. volubilis-reproductive
Cancer oregonensis
Costazia ventricosa
Crossaster papposus
Dendrobeania ? murrayana
Dermasterias imbricata
Eudendrium vaginatum-reproductive
Garveia annulata-reproductive
Halecium ? labrosum-imm

Sabellidae, unid.
Serpulidae, unid.
Sertularella albida-reproductive
S. polyzonias var. gigantea-reproductive
Strongylocentrotus ? pallidus
Tonicella lineata
Trophon multicostatus

Vertebrates

Cottidae, unid.
Hexagrammos decagrammus

Habitat Notes: Bottom of low undulating rock fingers with boulders shale, shell sand and debris interspersed Agarum, Rhodymenia ? palmata, an encrusting orange colonial tunicate and hydroids dominated by cover. Fauna very complex.

Appendix B-10. Summary of density and relative cover data for the principal macrophyte species in the vicinity of Raft Cove, Chugach Bay, July 1976.

Location / Species — Depth (m)	N. of Raft Cove 7.5-9	N.E. Pt. of Raft Cove 8-8.5	N. of Raft Cove 9	N.E. Pt. of Raft Cove 9-9.5	Raft Cove 9.1	N.E. Pt. of Raft Cove 10.5	N.E. Pt. of Raft Cove 10.5-11.5	N. of Raft Cove 10.5-11.5	Raft Cove 10.7	N. of Raft Cove 12	S. of Point 12-12.5	N. of Raft Cove 12-13.5	N. of Raft Cove 15-16.5	N. of Raft Cove 16	E. of Point 21
Agarum cribrosum (N)•	0	5.2	0	7.0	0	2.0	0.3	3.4	0	4.0	2.3	6.7	3.2	14.6	4.0
Agarum cribrosum (C)	0	12.3%	0	38.8%		15%	16.5%	14.3%		30%	16.4%	0	11%		15%
Alaria sp. (N)	0	0	0	0	0	0	0	0	5.6	0	0	0	0	0	0
Constantine sp. (C)			0.3%				5.6%			2.3%	11.9%		0		0
Cymathere triplicate (N)	0	0	0	0	6.7	0	0	0	4.8	0	0	0	0	0	0
Encrusting coralline alga (C)			58.3%				21.5%			78.3%	7.1%		16%		32.5%
Hildenbrandia sp. (C)							7%			0	0		0		6%
Laminaria ? groenlandica (N)	21.2	30.7	5.2	3.0	5.3	0	5.6	3.4	32.8	5.3	4.6	0	1.6	16.9	0
Laminaria ? groenlandica (C)	45%	70%	53.3%	35%		0	15%	43.6%		26.7%	24.3%	40%	16%		0
L. saccharin (C)	0	0	0	0		40%	5.5%	0		0	2.1%	0	0		0
L. yezoensis (N)	0	0	0	0	0	0	0.8	0.6	0	0	1.1	0	0	0	0
L. yezoensis (C)	0	0	0	0		0	2%	0		0	14.3%	0	0		0
Nereocystis luetkeana (N)	0	0	0	0	14.7	0	0	0	2.6	0	0	0	0	0	0
Opuntiella californica (C)			0.7%				0		·	9.-I	0		0		0
Pleurophycus gardneri (N)	20.0	1.3	10.8	0	0	0	0	5.7	0	6.7	0.6	4.0	4.0	0.8	0
Pleurophycus gardneri (C)	38.3%	3.3%	48.3%	0		0	0	17.1%		45%	3.6%	26.7%	11%		0
Rhodymenia pertusae (C)			0				3.4%			6.7%	1.4%		2%		0

•N = number of individuals
C = relative cover

Appendix B-n. Size data for echinoderms off Raft Cove, Chugach Bay in 7.5-16.8 depths, 7/6/76.

Strongylocentrotus droebachiensis - test diameter' (mm): 30, 28, 18, 25, 21, 35, 23, 19, 29, 25, 17, 25, 30, 26, 18, 25, 25, 20, 30, 17, 20, 22, 20, 30, 25, 25, 20, 30, 30, 28, 25, 25, 25, 25, 25, 30, 12, 8, 8, 7, 7, 12, 30, 18, 12, 18, 18, 15, 16, 18, 40, 15, 23, 32, 20, 20, 30, 15, 35, 20, 22, $\bar{x} \pm s$ = 21.9 ± 7.7 mm.

S. franciscanus - test diameter (mm): 20, 33, 22, 28, 22, 18, 9, 7, $\bar{x} \pm S$ = 19.9 ± 8.7 nun.

Asteriidae, unid. - maximum radius (mm): 16, 27, 12, 13, 17, $\bar{x} \pm S$ = 17.0 ± 6.0 mm.

Henricia sp. - maximum radius (mm) : 18, 18, 24, 26, 16, 72, 20, 35, 18, 19, 20, 22, 39, 68, $\bar{x} \pm S$ = 29.6 ± 18.3.

Crossaster papposus - maximum radius (mm): 28, 27, 37, 65, $\bar{x} \pm S$ = 39.3 ± 17.7 mm.

Pteraster tesselatus - maximum radius (mm): 30

Tosiaster arcticus - maximum radius (mm): 19, 20, 27, 27, $\bar{x} \pm S$ = 23.3 ± 4.3 mm.

Orthasterias koehleri - maximum radius (mm): 115, 119, 65, 143, 122, 126, 75, 92, 115, 120, 70, 100, $\bar{x} \pm S$ = 105.2 ± 24.7 mm.

Dermasterias imbricata - maximum radius (mm): 80, 120, 115, 85, 109, $\bar{x} \pm S$ = 101.8 ± 18.1 mm.

Pycnopodia helianthoides - maximum radius (mm): 22, 105, $\bar{x}$ = 63.5 mm

Evasterias troschelii - maximum radius (mm): 92.

Appendix B-12. Abundance of echinoderms in 1/4 m^2 quadrats off Raft Cove, Chugach Bay, 7/6/76.

Quadrat	Depth (ft)	*Ophiopholis*[1] *aculeata*	Aster iidae unid. (small]	*Strongylocentrotus*[1] *droebachiensis*	*S.*[1] *franciscanus*	*Henricia* sp.	*Crossaster papposus*	*Pteras tessel*
1	55	5	1					
2	55	3						
3	50	5		4				
4	50							
5	50							
6	50	16		7	2			
7	48					2		
8	48			1				
9	45							
10	45							
11	45							
12	45			2				
13	45							
14	45							
15	45				1			
16	45			5				
17	43	2						
18	43							
19	42							1
20	42				$\bar{x}\pm s$ = 0.1±0.4			
21	40			16	No. per m^2=0.3			
22	60		1					
23	60							*Eupent*
24	60			4				*? quir*
25	58	2		4				1
26	55					1		
27	55							
28	55			2				
29	55			1	*Dermasterias imbricata*			
30	52			2	1			
31	52							*Orthas koehle*
32	50							1
33	50				1			1
34	52			2				1
35	55							
36	55						1	
$\bar{x} \pm s$		0.9 ± 2.9	0.1 ± 0.2	1.4 ± 3.1	0.1 ± 0.2	0.1 * 0.4	0.1 ± 0.4	0.1 ±
No. per m^2		3.7	0.2	5.6	0.2	0.3	0.4	0.3

Appendix B-13. Species observed on vertical face of 8 foot high pinnacle off Raft Cove, Chugach Bay, 7/8/76.

ALGAE-Rhodophyta

Encrusting coralline alga-sparse
Rhodymenia pertusae

PORIFERA

Leucosolenia sp.
? Scypha sp.-common
White saccate sponge-common
Gray globose sponge-common

CNIDARIA-Hydrozoa

Abietinaria spp.-abundant
Campanularia verticillata-common
C. integra
Garveia annulata-common
Tubularia sp.-common

CNIDARIA-Anthozoan

Tealia crassicornis

ANNELIDA-Polychaeta

Crucigera sp.

MOLLUSCA

Cadlina luteomarginata-sparse
Calliostoma ligature-common
Crepidula nummaria
Cryptochiton stelleri-sparse
Fusitriton oregonensis-sparse
Lepidozona mertensii
Margaritas sp.-common
Musculus discors
Placiphorella sp.-common
Tonicella insignis
T. lineata

ARTHROPODA-Crustacea

Balanus nubilis-common, large
Elassochirus gilli-common
E. tenuimanus-common
Oregonia gracilis
Pagurus beringanus
P. kennerlyi
Pugettia gracilis

ECHINODERMATA

Dermasterias imbricata
Henricia leviuscula-common
Ophiopholis aculeata
Orthasterias koehleri-sparse

BRYOZOA

Crisis sp.
Costazia ventricosa
Heteropora sp.
Microporina borealis-75% cover
Myriozoella plana
Encrusting brown bryozoan

CHORDATA-Tunicata

Boltenia ? villosa-common
Didemnum sp.-common
Metandrocarpa taylori
Orange social colonial tunicate

CHORDATA-Pis ces

Hexagrammos decagrammus

Appendix C-1. Relative cover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer sdge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

Species	Low Intertidal												Quadrats												
	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
Alaria sp.	30	0	0	0	5	5	0	0	0	0	0	0	80	0	0	0	0	35	25	0	0	0	5	0	0
Costaria costata	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptosiphonia woodii	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Enteromorpha sp.	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Fucus distichus	20	75	80	05	30	50	50	75	100	100	75	25	0	25	75	100	100	95	25	100	100	75	80	30	15
Gigartina papillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	5
Halosaccion glandiforme	5	0	0	0	5	0	10	0	0	0	0	0	2	3	0	0	0	2	0	0	0	0	2	2	0
Rhodophyta, unid. (filamentous)	60	25	10	5	0	30	0	15	0	0	0	0	0	0	15	0	0	0	0	0	2	5	0	0	5
Rhodymenia palmata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Spongomorpha sp.	0	0	0	0	5	10	5	0	0	5	0	2	2	35	20	0	0	10	15	0	0	5	0	0	5
? Ulva sp.	10	2	20	75	25	20	35	75	40	40	50	5	25	15	10	15	10	0	15	20	25	15	20	30	20
Balanus ? glandula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2
Callophyllis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloiopeltis furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Littorina sitkana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C-1 (Cont.). Relative cover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer edge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrats 26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	40	50
Alaria sp.	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Costaria costata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptosiphonia woodii	0	10	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enteromorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fucus distichus	25	30	10	75	75	60	50	60	50	75	40	20	3	6	25	0	50	3	4	25	2	100	60	95	80
Gigartina papillata	5	10	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halosaccion glandiforme	30	10	25	2	0	0	20	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodophyta, unid. (filamentous)	0	5	3	15	0	0	0	30	0	0	0	0	0	0	0	7	5	0	0	0	0	0	0	25	0
Rhodymenia palmata	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spongomorpha sp.	50	0	30	25	5	30	30	25	10	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
? Ulva sp.	35	35	10	25	20	3	0	15	30	5	0	0	0	0	0	0	0	0	2	0	0	2	0	5	0
Balanus ? glandula	0	0	2	2	0	0	5	2	2	2	5	2	2	2	15	0	10	5	5	2	3	3	3	0	5
Callophyllis sp.	0	0	0	00	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloiopeltis furcata	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	20	0	0	2	0	0	0	3	0	0
Mytilus edulis	0	0	0		0	0	0	0	0	0	0	10	0	0	0	0	0	75	60	95	90	0	0	0	0
Littorina sitkana	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	2	0	0

Appendix C-1 (Cont.). Relative oover for epibiotic organisms in 1/16 m^2 quadrats on Dick's Head, near the outer edge of the shelf, at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrats										High Intertidal						
	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	$\bar{x} \pm s$
Alaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8 * 12.8%
Costaria costata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2 ± 1.2%
Cryptosiphonia woodii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3 ± 1.4%
Enteromorpha sp.	0	0	0	0	0	0	0	5	5	0	25	2	0	0	0	0	0.8 ± 3.3%
Fucus distichus	75	100	100	100	100	80	70	30	30	25	35	70	100	30	75	100	57.8 ± 32.1%
Gigartina papillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0 ± 3.2%
Halosaccion glandiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0 ± 5.6%
Rhodophyta, unid. (f ilamentous)	0	0	0	0	0	2	15	0	0	0	0	0	0	0	0	0	4.2 ± 10.1%
Rhodymenia palmata	0	0	0	0	0	o	3	0	0	0	0	0	0	0	0	0	3.7 * 4.8%
Scytosiphon lomentaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 * 0.3%
Spongomorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3 ± 10.5%
? *Ulva* sp.	0	0	0	15	7	15	0	5	0	2	0	0	0	0	0	0	12.8 ± 16.9%
Balanus ? *glandula*	20	5	5	2	10	50	40	5	10	2	5	2	7	0	5	45	4.6 ± 9.7%
Callophyllis sp.	0	0	0	0	0	o	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.4%
Gloiopeltis furcata	0	0	0	o	0	0	0	0	0	0	0	0	0	0	0	0	0.4 ± 2.5%
Mytilus edulis "	0	5	15	2	10	10	2	5	0	95	2	2	5	0	0	0	8.4 ± 23.8%
Littorina sitkana	5	0	5	3	3	0	2	0	0	0	2	2	2	2	2	5	0.6 ± 1.3%

Appendix C-2. Species observed intertidally on Dick's Head at the head of West Arm, Port Dick, 6/30/76.

MACROPHYTES

CHLOROPHYTA

Cladophora sp.
Enteromorpha intestinalis
Spongomorpha sp.
? Ulva sp.
Urospora ? penicilliformis

RHODOPHYTA

Agardhiella tenera
Cryptosiphonia woodii
Gigartina papillata
Gloiopeltis furcata
Halosaccion glandiforme
Odonthalia floccosa
Polysiphonia ? pacifica
Porphyra sp.
Rhodymenia palmata

PHAEOPHYTA

Alaria ? crisps
Costaria costata
Desmarestia aculeata
D. viridis
Fucus distichus
Laminaria saccharin
Scytosiphon lomentaria
Soranthera ulvoidea

INVERTEBRATES

Balanus ? glandula
Collisella pelts
Gnorimosphaeroma oregonensis
Halichondria panicea
Lacuna ? variegata
Littorina scutulata
L. sitkana
Modiolus modiolus
Mytilus edulis
Nereis sp.
Notoacmaea scutum
Protothaca staminea
Telmessus cheiragonus

FISHES

High cockscomb (Anoplarchus purpurescens)
Crescent gunnel (Pholis laeta)
Ribbon prickleback (Phytichtys chirus)

SEA BIRDS

Double-crested cormorant (Phalacrocorax auritus
Black-legged kittiwake (Rissa tridactyla)
White winged scoter (Melanitta deglandi)

MARINE MAMMALS

Sea otter (Enhydra lutris)
Harbor seal (Phoca vitulina)

Appendix C-3. Wet weights of marcophytes in 1/16 m^2 quadrats from a transect around Dick's Head, at the head of West Arm, Port Dick, 6/30/76 **and 7/1/76**.

	Low *Fucus* zone										High ***Fucus*** Zone	
	0 m		3 m		6 m[1]	9 m		12 m		12 m		
	a	b	a	b		a	b	a[1]	b	a	b	$\bar{x} \pm s$ (gin)
Chlorophyta, unid. (filamentous)	46.6	10.3[1]	0	14.1	79.9	0	0	0	0	5.4	0	14.2 ± 25.8
Fucus distichus	257.7	11.4	201.3	134.0[2]	83.43	36.0	340.7	1099.0	1217.0	33.7	32.1	313.4 ± 431.3
? *Ulva* sp.	17.0	31.7	30.8	26.1	0	0	0	0	0	2.8	0	9.8 ± 13.6
Rhodophyta, unid. (foliose)	∿ 1.0	3.2	5.3	8.0	0	0	0	0	0	0	0	1.6 ± 2.7
Rhodophyta, unid. (filamentous)	0	trace	1.0	0	trace	0	0	0	0	0	0	trace
Phaeophyta, unid. (ribbob-like)	0	trace	0	0	0	0	0	0	0	0	0	trace
Paheophyta, unid. (filamentous)	0	0	29.1	18.8	0	0	0	0	0	0	0	4.4 ± 10.0
Total Wet Weight (gin)	322.3	56.6	267.5	202.0	163.3	36.0	340.7	1099.0	1217.0	41.9	32.1	343.5 ± 419.2
Mean Wet Weight per Quadrat (gin)	189.4		234.8			188.4		1158.0		37.0		
Mean Wet Weight Quadrat (gin)	3,030		3,757		2,613	3,014		18,528		592		

[1] With numerous small ***Mytilus***, perwinkles or limpets included.

[2] Small plants, heavy algae growth.

[3] Small plants, covered with heavy **filamentous** algal **growth**.

Appendix c-4. Abundance of limpets (Acmaeidae) in 1/4 m^2 quadrats in *Fucus* zone, Dick's Head, West Arm, Port Dick, 7/1/76.

	Low *Fucus* Zone	Mid *Fucus* Zone	High *Fucus* Zone
	4	21	5
	4	7	9
	6	8	4
	3	24	3
$\bar{x} \pm s$:	4.3 ± 1.3	15.0 ± 8.8	5.3 ± 2.6
No. per m^2:	17	60	21

Appendix C-5a. Size data for *Mytilus edulis* from Dick's Head, West Ann, Port Dick, July 1976.

Shell Length (mm)	O m Zone (High Intertidal) No. 1	No. 2	Total	%
2	1	0	1	0.2
3	1	0	1	0.2
4	2	2	4	0.8
5	9	4	13	2.5
6	17	6	23	4.5
7	28	8	36	7.0
8	21	8	29	5.7
9	17	16	33	6.4
10	15	13	28	5.5
11	16	5	21	4.1
12	19	10	29	5.7
13	7	10	17	3.3
14	7	10	17	3.3
15	6	14	20	3.9
16	3	6	9	1.8
.17	12	7	19	3.7
18	9	6	15	2.9
19	10	8	18	3.5
20	15	8	23	4.5
21	9	9	18	3.5
22	9	12	21	4.0
23	8	12	20	3.9
24	11	11	22	4.3
25	11	10	21	4.1
26	4	7	11	2.1
27	2	2	4	0.8
28	3	4	7	1.4
29	2	0	2	0.4
30	2	4	6	1.2
31	0	7	7	1.4
32	0	0	0	0.0
33	0	1	1	0.2
34	2	1	3	0.6
35	1	1	2	0.4
36	0	4	4	0.8
37	0	3	3	0.6
38	1	1	2	0.4
39	0	2	2	0.4
40	0	0	0	0.0
41	0	1	1	0.2
n	280	233	513	
$\bar{x} \pm s$ (mm)	14.4 ± 7.3	18.0 ± 8.4	16.0 ± 8.0	
Relative cover	50%	35%		
No./m^2			4,104	

Appendix C-5b (Cont.) Size data for <u>Mytilus edulis</u> from Dick's Head, West Arm, Port Dick, July 1976.

Shell Length (mm)	3 m Zone (High Intertidal) No. 1	No. 2	Total	%
3	1	0	1	0.4
4	0	0	0	0.0
5	0	0	0	0.0
6	0	0	0	0.0
7	0	0	0	0.0
8	0	0	0	0.0
9	0	0	0	0.0
10	0	0	0	0.0
11	1	0	1	0.4
12	1	0	1	0.4
13	1	0	1	0.4
14	2	0	2	0.8
15	1	2	3	1.2
16	1	0	1	0.4
17	3	0	3	1.2
18	3	3	6	2.3
19	1	1	2	0.8
20		2	2	0.8
21	2	2	4	1.6
22	2	5	7	2.7
23	1	4	5	1.9
24	5	2	7	2.7
25	6	9	15	5.8
26	3	4	7	2.7
27	6	12	18	6.9
28	11	7	18	6.9
29	3	2	5	1.9
30	5	17	22	8.5
31	13	3	16	6.2
32	8	14	22	8.5
33	1	4	5	1.9
34	6	3	9	3.5
35	6	8	14	5.4
36	7	4	11	4.2
37	6	7	13	5.0
38	3	4	7	2.7
39	1	3	4	1.6
40	0	9	9	3.4
41	1	0	1	0.4
42	2	3	5	1.9
43	2	2	4	1.6
44	0	0	Q	0.0
45	O	5'	5	2.0
46	0	0	0	0.0
47	1	1	2	0.8
48	0	O	0	0.0
49	O'	0	0	0.0
50	1	0	1	0.4
51	0	0	0	0.0
52	0	1	1	0.4
n	117	143	260	
$\bar{x} \pm s$ (mm)	29.3 ± 7.8	31.3 * 7.0	30.4 ± 7.4	
Relative cover	45%	50%		
No./m^2			2,080	

Appendix C-5c (Cont.). Size data for *Mytilus edulis* from Dick's Head, West Arm, Port, Dick, July 1976.

Shell Length (mm)	3 m Zone (High Intertidal) No. 1	No. 2	Total	%
8	1	0	1	0.2
9	0	1	1	0.2
10	1	1	2	0.4
11	1	1	2	0.4
12	1	1	2	0.4
13	1	0	1	0.2
14	2	1	3	0.6
15	1	2	3	0.6
16	2	0	2	0.4
17	3	3	6	1.3
18	3	0	3	0.6
19	1	1	2	0.4
20	4	5	9	2.0
21	2	1	3	0.6
22	5	4	9	2.0
23	1	2	3	0.6
24	2	2	4	0.9
25	5	4	9	2.0
26	3	4	7	1.5
27	5	4	9	2.0
28	2	2	4	0.9
29	2	3	5	1.1
30	2	3	5	1..
31	1	3	4	0.9
32	6	3	9	2.0
33	5	12	17	3.7
34	1	5	6	1.3
35	10	8	18	3.9
36	7	10	17	3.7
37	12	12	24	5.2
38	7	14	21	4.5
39	3	6	9	2.0
40	12	27	39	8.4
41	5	13	18	3.9
42	19	13	32	6.9
43	22	10	32	6.9
44	6	13	19	4.1
45	15	17	32	6.9
46	6	6	12	2.6
47	12	7	19	4.1
48	5	6	11	2.4
49	2	3	5	1.1
50	5	4	9	2.0
51	0	4	4	0.9
52	2	4	6	1.3
53	1	2	3	0.6
54	1	0	1	0.2
n	215	247	462	
$\bar{x} \pm s$ (mm)	36.9 ± 10.0	36.7 ± 8.9	37.3 ± 9.4	
Relative cover	80%	90%		
No./m^2			2,696	

Appendix C-5d (Cont.) Size data for *Mytilus edulis* from Dick's Head, West Arm, Port, Dick, July 1976.

Shell Length (mm)	12 m Zone (High Intertidal) No. 1	No. 2	Total	%
5	3	1	4	0.4
6	2	2	4	0.4
7	2	3	5	0.5
8	7	8	15	1.4
9	10	7	17	1.6
10	4	12	16	1.5
11	1	5	6	0.6
12	6	11	17	1.6
13	8	12	20	1.8
14	4	14	18	1.7
15	6	21	27	2.5
16	6	26	32	3.0
17	20	15	35	3.2
18	3	21	24	2.2
19	2	10	12	1.1
20	10	26	36	3.3
21	4	18	22	2.0
22	12	20	32	3.0
23	13	17	30	2.8
24	6	19	25	2.3
25	17	29	46	4.2
26	17	25	42	3.9
27	21	14	35	3.2
28	25	20	45	4.1
29	9	5	14	1.3
30	33	25	58	5.3
31	14	8	22	2.0
32	33	13	46	4.2
33	26	12	38	3.5
34	13	14	27	2.5
35	40	17	57	5.2
36	12	14	26	2.4
37	31	15	46	4.2
38	22	9	31	2.9
39	3	11	14	1.3
40	14	23	37	3.4
41	1	14	15	1.4
42	11	13	24	2.2
43	3	7	10	0.9
44	3	6	9	0.8
45	4	13	17	1.6
46	4	8	12	1.1
47	1	5	6	0.6
48	3	2	5	0.5
49	0	2	2	0.2
50	1	1	2	0.2
51	0	2	2	0.2
52	0	0	0	0.0
53	0	0	0	0.0
54	0	0	0	0.0
55	0	1	1	0.1

n	490	596	1,086
$\bar{x} \pm s$ (mm)	28.8 ± 9.3	26.7 ± 10.6	27.7 ± 10.1
Relative cover	95%	95%	
No./m^2			8,688

Appendix C-6. Data for relationship between shell length, whole wet weight, and wet and dry tissue weights for *Mytilus edulis* from Dick's Head, West Arm, Port Dick, 7/1/76.

shell Le _th (mm)	Whole Wet Weight (gm)	Wet Tissue Weight (gm)	Dry Tissue Weight (gm)	Wet Weight: Whole Weight Ratio	Dry Weight: Wet Weight Ratio	Shell Length (mm)	Whole Wet Weight A!!Q-	Wet Tissue Weight _@!Q-	Dry Tissue Weight (gm)	Wet Weight: Whole Weight Ratio	Dry Weight: Wet Weight Ratio
44.0	3.58	1.59	0.34	0.44	0.21	"52.0	9.63	3.71	0.65	0.39	0.18
51.0	5.69	2.65	0.53	0.47	0.20	44.0	4.82	2.32	0.38	0.48	
46.0	7.49	3.09	0.49	,0.41	0.16	45.0	7.38	2.73	0.37	0.37	0.14
40.0	3.31	1.65	0.34	0.50	0.21	50.0	7.55	2.87	0.43	0.38	0.15
32.0	2.18	0.93	0.26	0.43	0.20	41.0	4.17	2.00	0.40	0.48	0.20
41.0	4.45	2.21	0.39	0.50	0.18	40.0	3.89	1.95	0.37	0.50	0.19
49.0	6.91	3.29	0.59	0.48	0.18	45.0	6.65	2.56	0.52	0.39	0.20
41.0	3.26	1.27	0.29	0.39	0.22	40.0	4.85	2.12	0.38	0.44	0.18
52.0	6.26	2.95	0.55	0.47	0.19	44.0	6.34	2.90	0.40	0.46	0.14
40.0	4.91	1.66	0.24	0.34	0.15	49.0	10.24	3.69	0.57	0.36	0.15
50.0	6.87	2.60	0.51	0.38	0.20	41.0	4.12	2.11	0.38	0.51	0.18
34.0	3.27	1.31	0.25	0.40	0.19	44.0	4.76	2.64	0.41	0.56	0.16
39.0	4.36	1.62	0.29	0.37	0.18	43.0	5.90	2.48	0.42	0.42	0.17
37.0	3.62	1.39	0.28	0.38	0.20	39.0	3.22	1.54	0.30	0.48	0.19
48.0	6.36	3.21	0.53	0.51	0.17	39.5	4.09	1.99	0.37	0.49	0.19
41.0	4.42	2.22	0.43	0.50	0.19	32.0	2.05	1.01	0.21	0.49	0.20
47.0	4.80	2.38	0.37	0.50	0.16	37.0	4.42	1.99	0.33	0.45	0.17
40.0	3.79	1.56	0.30	0.41	0.19	35.0	3.53	1.39	0.24	0.39	0.17
38.0	3.10	1.40	0.22	0.45	0.16	36.0	3.53	1.79	0.29	0.57	0.16
45.0	7.38	2.45	0.35	0.33	0.14	27.0	1.51	0.72	0.13	0.48	0.18
39.0	4.16	1.50	0.23	0.36	0.15	38.0	3.20	1.66	0.31	0.52	0.19
46.0	4.82	2.64	0.44	0.55	0.17	22.5	0.91	0.47	0.10	0.52	0.21
38.0	2.80	0.73	0.22	0.26	0.30	27.0	1.63	0.80	0.14	0.49	0.18
40.0	5.50	2.01	0.37	0.36	0.18	16.0	0.37	0.18	0.06	0.49	0.33
35.0	2.59	1.26	0.28	0.49	0.22	19.0	0.72	0.28	0.06	0.39	0.25
									$\bar{x}$	0.44	0.19
									s	0.06	0.04

Appendix C-7. Species observed subtidally around Dick's Head at the head of West Arm, Port Dick, 7/3/76.

MACROPHYTES

RHODOPHYTA

Constantine simplex
C. subulifera
Corallina sp.
Gigartina spp.
? Lithotham ium sp.
Phycodrys sp.
? Prionitis sp.
Rhodoglossum affine
Rhodophyta, unid.
Rhodymenia sp.

PHAEOPHYTA

Agarum cribrosum
Alaria sp.
Fucus distichus
Laminaria groenlandica
L. yezoensis

ANGIOSPERMAE

Zostera marina

INTERTEBRATES

Clinocardium nuttalli
Coryphella sp.
Hydroida, unid.
Macoma spp.
Musculus vernicosus
Mya arenaria
M. truncata
Mytilus edulis
Protothaca staminea
Serpulidae, unid.
Saxidomus gigantea
Telmessus cheiragonus
Tresus capax

FISHES

Ammodytes hexapterus (Pacific sand lance)
Hexagrammos stelleri (white-spotted greenling)
Microgadus proximus (Pacific tomcod)
Pholididae, unid. (light brown)
Pholis laeta (crescent gunnel)
Pleuronectiformes, unid. (flatfish)
Stichaeidae, unid. (Prickleback)

Appendix C-8. Abundance of some dominant macroinvertebrates in subtidal quadrats on Dick's Head, Port Dick, 7/1/76.

Species	Number per Quadrat				Total	No. per m^2
Evasterias troschelii	46	20	17	29	112	1.12
Chiridota sp.	13	--*	--	7	20	0.50
Cancer magister	4	0	0	0	4	0.04
Strongylocentrotus drobachiensis	--	--	--	53	53	5.30
Quadrat area (m^2)	30	30	30	10	100	

*-- indicates the spaces was not counted.

Appendix C-9. Line contact data from shell at head of West Arm, port Dick, 7/1/76.

Transect No. and Length	*Zostera marina* Line Contact (m)	*Zostera marina* Distance (m)	? *Ulva* sp. Line Contact (m)	? *Ulva* sp. Distance (m)	*Mytilus edulis* Line Contact (m)	*Mytilus edulis* Distance (m)	Gravel Line Contact (m)	Gravel Distance (m)
1 - 30 m	1.4- 2.0	0.6	0.0- 1.4	1.4	None		None	
	7.2- 8.2	1.0	2.0- 7.2	5.2				
	16.0-17.0	1.0	8.2-16.0	7.8				
	19.0-19. s	0.8	17.0-19.0	2.0				
			19.8 -30.0	10.2				
	Total	3.4		26.6				
	% Cover	11.3		08.7				
2 - 30 m	2.0- 2.8	0.8	0.0- 2.0	2.0	None			
	7.3- 7.9	0.6	2.8- 7.3	4.5				
	10.5 -11.0	0.5	7.9-10.5	2.6				
	15.7-17.0	1.3	11.0-15.7	4.7				
	19.8 -19.9	0.1	17.0-19.8	2.8				
	28.5 -29.2	0.7	19.9-28.5	8.6				
			29.2-30.0	0.8				
	Total	4.0		26.0				
	% Cover	13.3		86.7				
3 - 30 m	7.0- %.0	1.0	0.0- 7.0	7.0	None		None	
	14.8-16,1	1.3	8.0-14.8	6.8				
	26.0-30.0	4.0	16.1 -26.0	9.9				
	Total	6.3		23.7				
	% Cover	21.0		79.0				
4 - 30 m	12.2-13.3	1.1	0.0- 9.0	9.0	None		9.0-10.00	1.0
	20.3-22.4	2.1	10.0-12.2	2.2				
			13.3-20.3	7.0				
			22.4-30.0	7.6				
	Total	3.2		25.8				1.0
	% cover	10.7		86.0				3.3
5 -30m	5.6- 6.5	0.9	3.5- 5.6	2.1	0.0- 3.5	3.5		
	8.9- 9.3	0.4	6.5- 8.9	2.4	17.0-20.8	3.8		
	23-5-24.8	1.3	9.3-17.0	7.7	27.2-30.0	2.8		
			20.8-23.5	2.7				
			24.8-27.2	2.4				
	Total	2.6		17.3		10.1		
	% Cover	8.7		57.7		33.7		
6 - 30 m	14.1-15.0	0.9	0.0-11.0	11.0	11.0-12.0	1.0		
	20.2-23.4	3.2	12.0-14.1	2.1	23.4-26.0	2.6		
			15.0-20.2	5.2				
			26.0-30.0	4.0				
	Total	4.1		22.3		3.6		
	% Cover	13.7		74.3		12.0		
7 - 30 m	14.6-15.9	1.3	5.3-10.0	4.7	0.0- 5.3	5.3	None	
			12.3-14.6	2.3	10.0-12.3	2.3		
			15.9-24.5	8.6	24.5-30.0	5.5		
	Total	1.3		15.6		13.1		
	% Cover	4.3		52.0		43.7		
8 - 30 m	3.8- 5.7	1.0	2.3- 3.8	1.5	0.0- 2.3	2.3	None	
	18.0-19.6	1.6	5.7- 7.3	1.6	7.3-17.0	9.7		
			17.0-18.0	1.0	22.1-29.8	7.7		
			19.6 -22.1	2.5				
			29.8 -30.0	0.2				
	Total	3.5		6.8		19.7		
	% Cover	11.7		22.7		65.7		

Appendix C-9 (Cont.) . Line contact data from shell at head of West Arm, Port Dick, 7/1/76.

Transect No. and Length	*Zostera marina* Line Contact (m)	*Zostera marina* Distance (m)	? *Ulva* sp. Line Contact (m)	? *Ulva* sp. Distance (m)	*Mytilus edulis* Line Contact (m)	*Mytilus edulis* Distance (m)	Gravel Line Contact (m)	Gravel Dis
9 - 30 m	15.4 -16.1	0.5	3.2- 6.2	3.0	0.0- 3.2	3.2		None
			7.5-11.0	3.5	6.2- 7.5	1.3		
			14.4-15.4	1.0	11.0-14.4	3.4		
			16.1-17.5	1.4	17.5-23.0	5.5		
			23.0 -26.0	3.0	26.0 -29.2	3.2		
			29.2 -30.0	0.8				
	Total	0.5		12.7		16.6		
	% Cover	1.7		42.3		55.3		
Overall Cover:		10.7%		65.5%		23.4%		

Appendix 10. Size data, Evasterias troschelii from outer edge of shelf at head of West Arm, Port Dick, 7/1/76.

Radius (mm)*	Radius (mm)	Radius (mm)	Radius (mm)	Radius (mm)
35	30	50	30	25
35	35	84	92	90
30	30	40	55	112
25	20	125	18	40
18	40	32	28	38
22	30	22	50	57
25	22	30	36	88
25	25	38	17	28
45	90	58	92	28
30	70	28	90	28
35	42	30	15	20
28	40	25	52	16
40	25	25	52	18
60	43	15	90	40
23	19	20	130	115
20	20	22	111	28
25	40	20	72	40
70	30	23	44	18
20	15	20	20	28
48	25	25	50	57
60	45	30	20	
30	17	18	118	
25	22	25	63	

n = 112

$\bar{x} \pm s = 41.2 \pm 27.0$ mm

*Mouth to tip of longest ray

Appendix C-11. Abundance and relative cover of major epibiotic organisms in 1/4 m^2 quadrats on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrat Numbers 1	2	3	4	5	6	7	8	9	10	11
Costaria costarum (C)	0	0	0	0	0	0	0	0	0	0	0
Desmarestia viridis (C)	0	0	0	0	15%	0	0	0	0	0	2%
Laminaria saccharin (N)	0	0	0	0	0	0	0	0	0	0	0
Laminaria saccharin (c)	25%	0	0	25%	20%	0	30%	0	0	0	60%
Rhodophyta, unid. (filamentous) (C)	0	0	10%	0	0	0	0	0	0	0	0
? *Ulva* sp. (C)	0	10%	0	0	10%	0	0	30%	0	0	0
Zostera marina (C)	90%	95%	90%	70%	40%	10%	15%	20%	10%	306	30%
Pycnopodia helianthoides (N)	0	0	0	0	0	0	1	0	0	0	0
Telmessus cheiragonus (N)	2	0	0	0	0	0	0	0	0	0	0
Algal debris (C)	0	0	0	5%	0	80%	60%	0	60%	25%	0
Substrate:	soft	soft light shell	soft	soft	soft	soft	soft	soft silt	Soft silt light shell de-ris	Silt, light shell	Silt
Depth (m):	12.5	12.5	12.5	12.5	12.5	12.5	12.5	13	13	13	9

Appendix c-n (Cont.). Abundance and relative cover of major epibiotic organisms in 1/4 m^2 quadrats on the outer edge of the shelf at the head of West Arm, Port Dick, 6/30/76.

Species	Quadrat Numbers 12	13	14	15	16	17	18	19	20	$\bar{x} \pm s$
Costaria costarum (C)	5%	0	0	0	0	40%	0	0	0	2.3 ± 8.0%
Desmarestia viridis (C)	75%	60%	0	60%	20%	0	0	20%	0	12.6 ± 23.7%
Laminaria saccharin (N)	0	0	0	1	1	0	0	0	0	0.1 * 0.3
Laminaria saccharine (C)	20%	25%	40%	25%	80%	0	20%	80%	25%	23.8 ± 25.1%
Rhodophyta, unid. (filamentous) (C)	0	0	0	0	0	0	0	0	0	0.5%
? Ulva sp. (c)	0	0	0	0	0	0	0	0	0	2.5 ± 7.2%
Zostera marina (C)	0	0	0	0	0	0	0	0	0	13.8 ± 12.1%
Pycnopodia helianthoides (N)	0	0	0	0	0	0	0	0	0	0.05; 0.2/m^2
Telmessus cheiragonus (N)	0	0	0	0	0	0	0	0	0	0.1; 0.4/m^2
Algal debris (C)	0	0	0	0	0	10%	10%	0	20%	13.5 ± 24.3 %
Substrate:	silt	Silt	Silt gravel shell	Silt	Silt	Silt/shell	Sand shell	Gravel/ sand	Grave 1	
Depth (m):	9	9	9	8	8	6	6	6	5	

Appendix C-12. Number of turions of Zostera marina in 1/16 m^2 quadrats in the eelgrass bed at the head of West Arm, Port Dick, 8/31/76.

Turions per Quadrat	Frequency at Inner Edge of Bed	Frequency at Outer Edge of Bed
0	8	5
1	5	1
2	2	5
3	7	2
4	12	14
5	11	7
6	9	11
7	12	12
8	4	12
9	4	3
10	3	4
11	1	4
12	2	1
13	5	1
14	1	1
15	1	0
16	1	0
17	0	1
18	1	0
19	1	0
20	0	1
21	2	1
22	1	0
23	0	0
24	1	0
25	0	1

Average No. per 1/16 m^2: $\bar{x} \pm s$	6.8 ± 5.2	6.7 ± 4.3
Estimated Density	109/m^2	108/m^2
No. of quadrats	94	87

Appendix C-13. **Turion height** data, *Zostera marina,* inner edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length * (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
142.0	216.5	152.5	234.5
111.0	121.5	200.5	224.5
51.5	165.0	194.5	197.0
44.5	217.5	200.0	207.0
101.0	182.5	81.0	198.0
97.0	191.0	209.0	227.0
198.0	193.5	151.5	92.0
158.5	145.5	211.5	201.0
235.5	182.5	99.0	125.0
169.0	214.5	81.5	145.0
206.5	189.0	85.0	186.0
201.0	35.5	187.5	188.0
59.0	144.0	77.5	186.5
220.0	144.0	202.0	70.5
214.0	143.0	103.0	145.5
225.0	127.5	170.5	87.0
214.5	274.0	38.5	230.0
233.5	250.5	198.0	236.0
97.0	198.0	44.0	218.0
210.5	227.5	134.0	167.5
153.5	233.5	97.0	144.0

n = 81
$\bar{x} \pm s =$ 164.1 ± 58.3 cm

* Length of longest leaf from upper node.

Appendix C-14. Turion height data, Zostera marina from outer edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length* (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)	Maximum Leaf Length (cm)
23.5	154.0	55*5	90.5	118.5
98.0	238.5	132.5	134.5	64.5
196.5	28.0	179.0	88.5	137.0
190.5	141.5	164.5	137.0	119.5
145.0	214.0	174.5	110.0	137.0
192.0	178.0	104.5	88.5	64.5
170.0	120.0	73.5	216.5	66.0
147.5	221.5	126.0	112.5	145.0
191.0	48.0	76.0	23.5	155.0
253.5	206.5	60.0	34.0	152.5
99.0	175.0	135.5	56.0	155.0
40.5	85.0	23.0	33.0	191.5
103.5	176.5	73.5	138.0	213.5
168.5	206.0	152.0	142.5	224.5
118.5	13.5	147.5	126.5	230.5
96.0	164.5	94.0	60.0	267.0
138.5	91.5	73.0	149.0	208.5
23.0	35.0	26.0	136.5	262.0
132.0	104.0	13.5	86.5	176.5
139.5	125.0	87.5	55.5	232.5
179.5	69.0	51.5	134.0	255.0
194.5	175.5	31.5	94.0	
167.0	36.5	19.5	186.0	
170.5	213.5	59.5	196.0	
49.0	135.5	76.5	91.0	

n = 121

$\bar{x} \pm s$ = 126.4 ± 63.9 cm

* Length of longest leaf from upper node.

Appendix C-15. Turion height and dry weight data for *Zostera marina* from outer edge of bed, West Arm, Port Dick, 8/31/76.

Maximum Leaf Length (cm)	Dry Weight (gin)	Maximum Leaf Length (cm)	Dry Weight (gin)
23.5	0.08	141.5	0.45
196.5	1.61	48.0	0.29
190.5	1.70	206.5	1.85
145.0	0.68	85.0	0.24
192.0	1.85	206.0	2.54
147.5	0.80	13.5	0.01
191.0	1.24	91.5	0.39
253.5	2.36	35.0	0.18
99.0	0.31	104.0	0.25
40.5	0.05	213.5	3.26
103.5	0.26	55.5	0.18
96.0	0.24	104.5	0.29
23.0	0.17	152.0	1.43
139.5	0.94	147.5	1.30
194.5	2.27	94.0	0.33
49.0	0.32	51.5	0.08
154.0	0.84	19.5	0.09
238.5	3.35	59.5	0.17
28.0	0.09	90.5	0.26
		262.0	2.89

Appendix C-16. Abundance of *Laminaria saccharin* and *Pycnopodia helianthoides* in quadrats on slope at outer edge of shelf, West Arm, Port Dick, 7/1/76.

Depth (m)	Quadrat Size (m*)	*Laminaria saccharin*	*Pycnopodia helianthoides*
12.2	10	4	2
10.7	10	3	1
7.6	10	13	0
6.1	5	3	0
4.6	5	19	2
3.7	5	57	2
7.6	10	--*	2
6.1	10	--	0
Total		99	9
No. per m^2		2.20	0.14

* No data

Appendix C-17. Size data for _Pycnopodia helianthoides_ from slope at edge of shelf at head of West Arm, Port Dick, 7/1/76.

Radius (mm)*	Radius (mm)	Radius (mm)
130	90	110
65	140	300
270	60	110

$\bar{x} \pm s = 141.7 \pm 85.8$ mm

* Mouth to tip of longest ray.

Appendix C-18. Extralimital species observed on the outer slope of the shelf at the head of West Arm, Port Dick, 6/30/76.

Invertebrates	Fishes
Cancer magister	Cottidae, unid.
Macoma sp.	Snake prickleback (Lumpenus sagitta)
Metridium senile	
Protothaca staminea	
Pycnopodia helianthoides	
Telmessus cheiragonus - mated pair	

Appendix D-1. Species observed at Chugach Bay.

Species	Dates Observed 9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
ALGAE-Chlorophyta					
? *Monostroma* sp.	x	x			
ALGAE-Phaeophy ta					
Agarum cribrosum (adults)	x	x	x	x '	x
Agarum cribrosum (juv.)		x			
Alaria crisps				x	
A. marginata	x	x			
Alaria sp.	x[1]	x[1]		x	
Costaria costata		x			
Cymathere triplicate	x	x		x	
Desmarestia munda			x		
D. viridis	x	x			
Desmarestia sp.				x	
Fucus distichus		x			
Laminaria groenlandica (adults)	x	x	x	x	
Laminaria groenlandica (juv.)		x			
L. saccharin			x		
L. setchelii					x
L. ? *sinclairii*		x			
L. yezoensis			x	x	
Laminaria sp.			x	x	
Nereocystis luetkeana	x	x		x	
Pleurophycus gardneri	x	x	x	x	x
Ralfsia pacifica			x		
Phaeophyta, unid. (juv.)				x	
ALGAE-Rhodophyta					
Bossiella sp.			x		
Callophyllis edentata		x			
Callophyllis sp.	x	x	x	x	
Constantinea simplex	x	x			x
C. subulifera	x	x			
Constantinea sp.			x	x	
Corallina ? *officinalis*	x	x			
C. vancouveriensis	x	x			x
Coralline spp., encrusting	x	x	x	x	x
Cryptonemia sp.	x	x			x
Delesseria decipiens		x	x		x
Halosaccion glandiforme		x			
Hildenbrandia sp.	x	x	x	x	x
Iridea lineare		x			

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed 9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
Membranoptera		X			X
Microcladia sp.	X	X	X	X	
Odonthalia floccosa	X	X			
O. kamchatica	X	X		X	
O. lyallii				X	
Opuntiella californica	X	X		X	X
Polysiphonia sp.		X			
Porphyra sp.	X	X[1]			
Ptilota filicina	X	X			
Ptilota sp.	X	X		X	X
Rhodophyta, unid. (filamentous)				X	
Rhodymenia palmata	X	X			X
R. pertusae	X	X	X	X	X
Rhodymenia sp.			X		
Schizymenia sp.	X	X			
PORIFERA					
Cliona celata	X			X	
Leucosolenia sp.					X
Microciona sp.					X
Porifera, unid.				X	
Rhabdodermella sp.					X
Porifera, gray globose					X
Porifera, white saccate					X
Porifera, yellow, osculate		X			
? Scypha sp.					X
CNIDARIA-Hydrozoa					
Abietinaria filicula				X	
A. turgida (adults)					X[2]
A. turgida (juveniles)				X	
A. variabilis					X[2]
Abietinaria sp.	X[3]	X			X
Bonneviella grandis				X[2]	
Bougainvilliidae, unid.		X			X
Calycella syringa (immature)					X
Campanularia integra					X[2]
C. speciosa					X[2]
C. verticillata		X		X	X
C. volubilis					X[2]
Eudendrium vaginatum					X[2]
Garveia annulata					X[2]
Halecium ? labrosum (immature)				X	X
Lafoea fruticosa					X

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed 9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
Obelia ? *loveni*					X
Orthopyxis caliculata					X[2]
Sertularella albida					X[2]
S. polyzonias (immature)				X	
S. polyzonias var. *gigantea* (adults)					X[2]
S. polyzonia var. *gigantea* (immature)				X	
S. tricuspidata				X[2]	X[2]
Sertularella sp. (immature)				X	
Sertularia cupressoides					X
Sertulariidae, unid.				X[4]	X[4]
Tubularia sp.					X[2]
CNIDARIA-Anthozoa					
? *Diadumene* sp.	X				
Metridium senile	X				
Ptilosarcus gurneyi				X	
Tealia crassicornis	X				X
ANNELIDA-Polychaeta					
Crucigera sp.					X
Oweniidae, unid.					X
Sabellidae, unid.					X
Serpulidae, unid.	X			X	X
ARTHROPODA-Crustacea					
Balanus nubilis	X				X
Cancer oregonensis					X
Caridea, unid. (immature)		X			
Elassochirus gilli	X	X			X
E. tenuimanus		X			X
Oregonia gracilis					X
Paguridae, unid.			X		X
Pagurus beringanus					X
P. ? *caurinus*					X
P. ? *confragosus*					X
P. kennerlyi					X
Pagurus sp.	X			X	X
Pandalidae, unid., orange	ʺX				
Paralithodes camtschatica (juvenile)	X				
Pugettia gracilis					X

Appendix D-1 (Cont.) . Species observed at Chugach Bay.

Species	Dates Observed				
	9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
MOLLUSCA-Polyplacophera					
Cryptochiton stelleri					X
Katharina tunicata		X			
Lepidozona mertensii					X
Mopalia sp.			X		X
Placiphorella sp.			X	X	X
Polyplacophora, unid.				X	
Tonicella insignis					X
T. lineata				X	X
Tonicella sp.	X	X	X		
MOLLUSCA-Pelecypoda					
Astarte sp.	X	X[5]			
? Chlamys Sp.		X			
Clinocardium californiense		X[5]			
Entodesma saxicola		X			
Humilaria kennerlyi	X	X			X
Musculus discors	X	X	X		X
M. vernicosus	X[6]	X[6]	X	X	X
Mya truncata	X[7]				
Mytilus edulis		X			
Protothaca staminea	X				
Saxidomus gigantea	X[7]				
MOLLUSCA-Gastropoda					
Acmaea mitra	X	X	X	X	
Amphissa columbiana	X	X		X	X
Cadlina luteomarginata		X			X
Calliostoma annulatum				X	
C. ligatum	X	X	"X . . . "	X	X
Crepidula nummaria					X
Crepipatella lingulata	X				
Diodora aspera	X		X		
Fusitriton oregonensis	X	X	X[9]	X	X
Margarites pupillus				X	X
Margaritas sp.					X
Nassarius ? mendicus				X	
Notoacmaea instabilis	X[8]	X			X
Nucella lamellosa	X	X			
N. lima				X	
Olivella baetica			X		
Puncturella multistriata		X		X	
Searlesia dira	X	X	X	X	
Trichotropis cance llata	X	X	X	X	X
Trophon multicostatus	X				X
Volutharpa ampullacea	X				

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	Dates Observed 9/11/75 1/	9/12/75	7/5/76	7/6/76	7/8/76
ECTOPROCTA					
Alcyonidium pedunculatum					x
Costazia ventricosa					x
Crisis sp.					x
Dendrobeania ? murrayana			x	x	x
Flustrella gigantea			x	x	x
Heteropora sp.	x	x	x	x	x
Hippothoa hyalina					x
Lichenopora sp.	x	x			
? Membranipora sp.		x			
Microporina borealis	x	x	x	x	x
Myriozoella plana					x
Myriozoum ? tenue			x		x
Tricellaria sp.				x	
Bryozoa, unid., brown, encrusting					x
Bryozoa, orange, encrusting					x
Bryozoa, unid, encrusting	x				
ENTOPROCTA, unid.					x
BRACHIPODA					
Terebratalia transverses	x				
ECHINODERMATA					
Crossaster papposus	x	x		x	x
Dermasterias imbricata	x	x	x		x
Eupentacta quinquesemita	x	x			
Evasterias troschelii	x	x	x		
Henricia leviuscula	x	x			x
H. sanguinoleuta				x	
Leptasterias? hexactis		x			
L. ? leptalea (= Asterias, am)		x			x
Ophiopholis aculeata	x	x			x
Orthasterias koehleri	x	x			x
Parastichopus californicus (juvenile)		x			
Pisaster ochraceus		x			
Pteraster tesselatus	x	x			
Pycnopodia helianthoides	x	x			
Solaster dawsoni	x				
S. stimpsoni		x			
Strongylocentrotus drobachiensis	x	x 10/	x	x	x

Appendix D-1 (Cont.). Species observed at Chugach Bay.

Species	9/11/75[1]	9/12/75	7/5/76	7/6/76	7/8/76
			Dates Observed		
S. franciscanus	X	X		X	
S. ? *pallidus*					X
Strongylocentrotus sp.		X			
Ceramaster (= *Tosiaster*) *arcticus*				X	
CHORDATA-Tunicata					
? *Aplidlium solidum*					X
Ascidians, unid., small orange, social		X			
Boltenia villosa	X	X			
B. ? *villosa*					X
Didemnum sp.	X			X	X
Distaplia sp.			X	X	
Halocynthia aurantia	X	X			
H. igaboja	X	X			
Metandrocarpa taylori	X	X			X
Styela montereyensis	X	X			
Synoicum sp.					X
Tunicata, unid., orange, encrusting					X
CHORDATA-Pis ces					
Ammodytes hexapterus	X	X			
Clupea harengus (adults)				X[11]	
Clupea harengus (juv.)	X[12]	X[12]			
Cottidae, unid.	X	X			X
Hemilepidotus sp.	X	X			
Hexagrammos decagrammus	X				X
H. stelleri	X				
H. supercilious	X				
Microgadus proximus	X	X			
Ronquilus jordani	X	X			
Sebastes melanops	X	X			
CHORDATA-Mamma lia					
Enhydra lutris	X	X			

Appendix D-1 (Cont.). Species observed at Chugach Bay.

1/ Locations examined on specified dates:

9/11/75
Off Sea otter Pt - 10-23 m
West of Sea Otter Pt -10-13 m
Off West Pt, 2nd cove - 14 m

9/12/75
NE of Sea Otter Pt - 13-23 m
Outer point of Raft Cove - 6.5-10 m
2nd Cove - 5.0-0.0 m

7/5/76
NE point of Raft Cove - 10.5-11.5 m
South Point - 12.0-12.5 m

7/6/76
In Raft Cove - 9.1-10.7 m
Off Raft Cove - 7.5-16.8 m

7/8/76
West finger off south headland - 70 ft
Off Raft Cove - 30 ft
8′ pinnacle off Raft Cove - 30 ft

2/ On Nereocystis
3/ Reproductive
4/ 3 species
5/ 5 species
6/ In shell debris
7/ On seminarians
8/ Shell only
9/ On stipes of Laminaria and Pleurophycus
B/Spawning
11/On shell debris and rock
32/Schooling above algal canopy
13/Schooling

Appendix D-2. Species observed at East Chugach Island, 8/1/75.

SPECIES

ALGAE-Phaeophyta
- Agarum cribrosum
- Alaria fistulosa
- A. ? praelonga
- Cymathere triplicate
- Desmarestia ligulata
- D. viridis
- Laminaria groenlandica
- Nereocystis luetkeana
- Pleurophycus gardneri

ALGAE-Rhodophyta
- Bossiella sp.
- Constantinea sp.
- Corallina sp.
- Coralline spp., encrusting
- Cryptonemiales, unid.
- Delesseria decipiens
- Membranoptera sp.
- Microcladia sp.
- Odonthalia kamschatica
- Opuntiella californica
- Polyneura latissima
- Polysiphonia sp.
- Porphyra sp.
- Ptilota sp.
- Rhodymenia palmata
- R. pertusae
- Schizymenia sp.

PORIFERA
- Porifera, unid.

CNIDARIA-Hydro zoa
- Abietinaria filicula
- A. turgida - reprod.
- A. ? variabilis - reprod.
- Abietinaria sF.
- Campanularia speciosa - reprod.
- C. volubilis - reprod.
- Eudendrium vaginatum - reprod.
- Garveia annulata - reprod.
- Halecium beani - imm
- Hydractinia ? armata - on Nereocystis
- Orthopyxis caliculata
- Sertularella Pinnata -imm
- S. tricuspidata - reprod.
- S. turgida - reprod.
- Sertulariidae, unid.

CNIDARIA-Anthozoa
- Gersemia rubriformis
- Tealia crassicornis

SIPUNCULA
- Phascolosoma agassizii

ARTHROPODA-Crustacea
- Balanus nubilis
- Elassochirus gilli
- E. tenuimanus
- Metacaprella kennerlyi
- Oregonia gracilis
- Pagurus beringanus
- P. ? caurinus
- Paguridae, unid.
- Pugettia gracilis

MOLLUSCA-Polyp lacophora
- Lepidozona mertensii
- Mopalia sp.
- Tonicella insignis
- Tonicella Sp.

MOLLUSCA-Pelecypoda
- Humilaria kennerlyi - juv.
- Modiolus modiolus - juv.
- Musculus vernicosus - on Laminarians
- Mytilus californianus
- Pododesmus macroschisma

MOLLUSCA-Gas tropoda
- Acmaea mitra
- Calliostoma ligature
- Crepidula nummaria
- Fusitriton oregonensis
- Lepeta sp.
- Margaritas helicinus
- Notoacmaea scutum

Appendix D-2 (cont.). Species observed at East Chugach Island, 8/1/75.

SPECIES

Nucella canaliculata
Trophon multicostatus
Trophonopsis sp.
Velutina sp.

ECHINODERMATA
Crossaster papposus
Dermasterias imbricata
Evasterias troschelii
Henricia leviusculus
? Lethasterias nanimensis
Ophiopholis aculeata
Orthasterias koehleri
Pycnopodia helianthoides
Strongylocentrotus drobachiensis
Ceramaster (= Tosiaster) arcticus

ECTOPROCTA
Caulibugula sp.
Filicrisia sp.
Flustrella corniculata
Hippothoa hyalina
Membranipora sp.
Microporella sp. (nr. californica)
Microporina borealis
Tricellaria sp.

CHORDATA-Tunicata
Ascidians, unid. (compound, social)
? Didemnum sp.
Halocynthia aurantia
Styela montereyensis
Synoicum sp.

CHORDATA-Pisces
Hemilepidotus hemilepidotus
Hexagrammos decagrammus
Microgadus proximus - juv.
Pleuronectiformes, unid.

CHORDATA-Mammalia
Eumetopias jubatus
Enhydra lutris

Appendix D-3. Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dic He
ALGAE-Chlorophyta						
Chlorophyta, unid. (filamentous)						X
Cladophora sp.			X	X		X
Enteromorpha sp.						X
? Monostroma sp.			X	X[1]		X
Spongomorpha sp.						X
? ulva sp.					X	X
Urospora ? penicilliformis						X
ALGAE-Phaeophyta						
Agarum cribrosum						X
Alaria ? crisps						X
A. marginata		X[1/]	X	X		
Alaria sp.			X[1/]			X
Costaria costata					X[1/]	X
Cymathere triplicate			X	X		
Desmarestia aculeata				X		X
D. ? viridis			X	X	X	X
? Ectocarpus sp.			X	X		
Fucus distichus	X	X	X		X[1/]	X
Laminaria groenlandica						X
L. saccharine			X	X	X	X
L. yezoensis						X
Phaeophyta, unid. (ribbon-like)						
Phaeophyta, unid. (filamentous)						
Nereocystis luetkeana		X[1/]				
Scytosiphon lomentaria						X
Soranthera ulvoidea						X
ALGAE-Rhodophyta						
Agardhiella tenera						X
Callophyllis sp.						X
Constantinea simplex				X		X
C. subulifera						X
Corallina sp.						X
Cryptosiphonia woodii						X
Gigartina papillata						X
Gigartina spp.						X
Gloiopeltis furcata						X
Gloiosiphonia verticillaris				X		
Halosaccion glandiforme			X	X		X
Iridaea lineare			X	X		
? Lithothamnium sp.						X
Odonthalia floccosa						X

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Phycodrys sp.						X
Polysiphonia ? pacifica						X
Porphyra sp.		X1/	X	X		X
? Prionitis sp.						X
Rhodoglossum affine						X
Rhodomela larix				X		
Rhodophyta, unid. (filamentous)			X	X	X	X
Rhodophyta, unid. (foliose)						X
Rhodophyta, unid. (saccate)	X					
Rhodymenia palmata			X	X		X
Rhodymenia sp.						X
ANGIOSPERMAE						
Zostera marina		X1/	X	X	X	X
PROTOZOA						
Gromia oviformis				X		
PORIFERA						
Halichondria panicea						X
CNIDARIA-Hydrozoa						
Hydroida, unid.						X
CNIDARIA-Anthozoa						
Anthopleura ? artemisia	.					
Metridium senile					X	
ANNELIDA-Polychaeta						
Cirratulidae, unid.					X	
Cistenides brevicomis				X		
Crucigera sp.				X		
Nereis sp.						X
Serpulidae, unid.						X
Terebellidae, unid.			X	X		
ARTHROPODA-Crustacea						
Balanus cariosus			X2/			
B. ? glandula		X	X			X
B. hesperius laevidomus			X	X		
B. rostratus alaskensis				X		
Balanus spp.		X				
Cancer magister				X	X	X

Appendix D-3 (Cont.) . species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dicl Hea
Caridae, unid.				X		
Chthamalus dalli	X					
Cirripedia-Rhizocephala				X[3]		
Elassochirus tenuimanus (juvenile)				X		
Eualus townsendi[5]						
Gnorimosphaeroma oregonensis				X		X
Paguridae, unid.			X	X		
Pagurus hirsutiusculus			X	X		
Pandalidae, unid.					X	
Pandalus hypsinotus[5]						
Pentidotea wosnesenskii				X		
Telmessus cheiragonus				X	X	X
MOLLUSCA-Pelecypoda						
Clinocardium nuttalli			X	X		X
Hiatella arctica				X		
Macoma balthica			X	X		
M.? inconspiqua					X	
M. ? inquinata			X			
M. nasuta					X[4]	
Macoma spp.						X
Modiolus modiolus						X
Musculus vernicosus						X
Mya arenaria			X	X		X
M. truncata					X	X
Mya sp.			X			
Mytilus edulis	X		X			X
Pododesmus ? macroschisma					X	
Protothaca staminea				X	X	X
Saxidomus gigantea			X	X	X	X
Tresus capax						X
MOLLUSCA-Gas tropoda						
Acmaea asmi			X	X		
A. pelta			X	X		
A. ? triangularis			X	X		
Acmaea spp.	X					
Acmaeidae, unid.						X
Aeolidida, unid.				X		
Collisella pelta						X
Coryphella sp.						
? Cryptobranchia concentric				X		

Appendix D-3 (Cont.). species observed at port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed; mud flat	Zostera Bed, mud flat	Shelly Slope	Dick's Head
Hermissenda crassicornis				X		X
Lacuna ? variegata						X
L. vincta				X		
Lacuna sp.				X		
Littorina scutulata			X			X
L. sitkana	X	X	X	X		X
Margaritas helicinus				X		
M. pupillus				X		
Margaritas sp.				X		
Mitrella gouldi[5]						
Natica clausa					X	
Notoacmaea scutum						X
Nucella ? canaliculata						
ECTOPROCTA						
Membranipora sp.					X	
ECHINODERMATA						
Chiridota sp.						X
Dermasterias imbricata					X	
Evasterias troschelii				X	X	X
Pycnopodia helianthoides				X	X	
Strongylocentrotus drobachiensis						X
CHORDATA-Pisces						
Ammodytes hexapterus				X		X
Anoplarchus purpurescens						X
Bathymaster sp.					X	
Blepsias cirrhosus				X		
Cottidae, unid.	X				X	
Hexagrammos decagrammus					X	
Hexagrammos stelleri						X
Hippoglossus stenolepis					X	
? Lamna ditropis					X	
Limanda aspera[5]					X	
Lumpenus sagitta					X	
Microgadus proximus						X"
Myoxocephalus ? polyacanthocephalus				X		
Oncorhynchus gorbuscha	X					
Oncorhynchus sp. (fry)	X					
Pholididae, unid., light brown						
Pholis laeta						

Appendix D-3 (Cont.). Species observed at Port Dick.

	Creek Mouth	Fucus Zone	Mussel Bed, mud flat	Zostera Bed, mud flat	Shelly Slope	Dic He
Phytichtys chirus						X
Platichthys stellatus					X	
Pleuronectiformes, unid. (adults)						X
Pleuronectiformes, unid. (juveniles)					X	
Ronquilus jordani				X		
Stichaeidae, unid.						X
CHORDATA-Aves						
Anas platyrhynchos			X			
Larus spp.			X			
Melanitta deglandi						X
Phalacrocorax auritus						X
Rissa tridactyla						X
CHORDATA-Mammalia						
Enhydra lutris						X
Phoca vitulina				X		X

1/ Drift
2/ Brooding
3/ Parasitic
4/ Shell only
5/ Caught in shrimp trap at 60 fathoms 7/31/75

Appendix D 4. Species observed in Koyuktolik Bay and Lagoon.

	Bay	outer Lagoon	Inner' Lagoon	Subtidal Entrance Channel	Pinnacle	Intertid. Mussel Beds
ALGAE-Chlorophyta						
Cladophora sp.						X
Enteromorpha sp.		X				
? Monostroma sp.		X	X	X	X	X
Rhizoclonium ? tortuosam						X
Spongomorpha sp.		X		X		X
Ulothrix sp.						X
? Urospora sp.					X	
ALGAE-Phaeophyta						
Agarum cribrosum					X	
Alaria fistulosa						X
A. ? marginata		X			X	
A. tenuifolia				X		X
Alaria sp.		X	X		X	X
Costaria costata		X			X	
Cymathere triplicate	X	X		X		X
Desmarestia ? viridis				X	X	X
Fucus disti.thus	X	X	X	X	X	X
Laminaria groenlandica		X		X	X	X
L. saccharin	X				X	
L. setchellii					X	
Laminaria sp.					X	
Nereocystis luetkeana		X		X		X
Phaeophyta, unid. (saccate)					X	
Scytosiphon lomentaria					X	
ALGAE-Rhodophyta						
Ahnfeltia plicata		X	X			
Callophyllis sp.						X
Constantinea simplex	X				X	
Corallina vancouveriensis					X	
Delesseria decipiens					X	
Encrusting coralline algae					X	
Halosaccion glandiforme		X		X	X	X
Iridaea lineare		X			X	X
Microcladia sp.					X	
Odonthalia floccosa						X
O. kamschatica					X	
Opuntiella californica					X	
Porphyra sp.		X	X	X		X
Ptilota filicina					X	
Ptilota sp.					X	
Rhodymenia palmata					X	
R. pertusae					X	
Schizymenia sp.		X		X	X	X

Appendix D-4 (Cont.) . Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Inter Mus Be
ANGIOSPERMAE						
Zostera marina		X	X[1]	X		X
PORIFERA						
Halichondria panicea (encrusting)					X	
Porifera, unid., syconid					X	
Tedania sp.		X			X	
CNIDARIA-Hydrozoa						
Abietinaria turgida					X	
Hydractinia sp.	X					
Sertulariidae, unid.					X	
CNIDARIA-Scyphozoa						
Haliclystus sp.		X[3]				
CNIDARIA-Antho zoa						
Anthopleura ? artemesia					X	
Anthopleura sp.					X	
? Diadumene sp.					X	
Metridium senile	X				X	
Tealia crassicornis					X	
ANNELIDA-Polychaeta						
Abarenicola sp.			X			
Eudistylia ? vancouveri					X	
Myxicola infundibulum					X	
Polychaeta, unid. (tubicolous)	X					
? Serpula vermicularis					X	
Serpulidae, unid.					X	
Terebellidae, unid.					X	
ARTHROPODA-Crustacea						
Balanus cariosus					X	X
B. ? glandula		X			X	X
Brachyura, unid.		X			X	
Cancer oregonensis					X	
Chthamalus dalli					X	
Elassochirus gilli	X				X	
E. tenuimanus	X				X	
Gammaridea, unid.					X	
Gnorimosphaeroma oregonensis						X
Hyas lyrata					X	

Appendix D-4 (Cont.) . Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Interti Musse Beds
Lebbeus sp.					X	
Oregonia gracilis					X	
Pagurus ochotensis	X					
Pagurus sp.					X	
Paralithodes camtschatica					X	
Pugettia gracilis					X	
Telmessus cheiragonus		X		X	X	
MOLLUSCA-Polyplacophora						
Katharina tunicata					X	
Mopalia sp.					X	
Polyplacophora, unid.		X				
Tonicella insignis					X	
T. lineata					X	
MOLLUSCA-Pelecypoda						
Astarte sp.		X			X[4/]	
Clinocardium nuttalli		X				
Humilaria kennerlyi		X[4/]			X[4/]	
Macoma sp.		X				
Modiolus modiolus					X	
Musculus vernicosus		X				
Mya arenaria		X				
Mya truncata		X[4/]				
Mytilus edulis		X		X	X	
Protothaca staminea		X				
Saxidomus gigantea		X				
Tellina nuculoides	X					
Tresus capax		X			X[4/]	
MOLLUSCA-Gastropoda						
Acmaea mitra					X	X
Acmaea sp.				X	X	X
Acmaeidae, unid.					X	X
Collisella pelta						X
Diaulula sandiegensis					X	
Diodora aspera					X	
Fusitriton oregonensis					X	
Hermissenda crassicornis						
Lacuna sp.		X			X	
Littorina sitkana		X		X	X	X
Margaritas helicinus		X[4/]				
Margarites sp.					X	
Natica clausa		X			X	
Natica sp.					X	
Notoacmaea persona						X

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Int M
N. scutum					X	
Nucella lima						
Olivella baetica	X					
Volutharpa ampullacea					X	
ECTOPROCTA						
Alcyonidium pedunculatum					X	
A. po lyoum					X	
Ectoprocta, unid.					X	
Flustrella corniculata					X	
Hippothoa hyalina					X	
BRACHIPODA						
Diestothyrus frontalis					X	
ECHINODERMATA						
Cucumaria miniata					X	
Cucumaria sp.					X	
Echinarachnius parma	X					
Eupentacta quinquesemita						
Evasterias troschelii		X			X	
Henricia leviusculus					X	
Leptasterias ? hexactis		X			X	
Ophiopholis aculeata					X	
Pycnopodia helianthoides (adults)	X	X			X	
Pycnopodia helianthoides (juveniles)				X		
Strongylocentrotus drobachiensis					X	
CHORDATA-Tunicata						
Ascidians, social, colonial	X					
CHORDATA-Pisces						
Ammodytes hexapterus		X				
Cottidae, unid.		X				
Hexagrammos decagrammus	X					
H. stelleri						
Hexagrammos sp.		X				
Leptocottus armatus	X					
Microgadus prodimus		X				
Pleuronectiformes, unid. (adults)					X	
Pleuronectiformes, unid. (juveniles)	X					

Appendix D-4 (Cont.). Species observed in Koyuktolik Bay and Koyuktolik Bay Lagoon.

	Bay	Outer Lagoon	Inner Lagoon	Subtidal Entrance Channel	Pinnacle	Intertic Mussel Beds
Salvelinus malma				X		
Stichaeidae, unid.	X					
CHORDATA-Aves						
Corvus caurinus						X
Larus glaucescens						X
Larus Sp.						X
Melanitta perspicillata						X
CIiORDATA-Mamma lia						
Phoca vitulina		X	X			
Enhydra lutris			X	X		X

1/Drift
2/Orange-vellow, in Ahnfeltia
3/On eelgrass
4/Shell only
5/Black and white species