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ASSESSMENT OF INTERTIDAL AQUATIC PLANT ABUNDANCE IN THE TOGIAK AREA OF BRISTOL BAY, ALASKA, 1978 THROUGH 1980 WITH EMPHASIS ON *FUCUS* SP.

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April 1982

ALASKA DEPARTMENT OF FISH AND GAME
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Ronald O. Skoog
Commissioner

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ASSESSMENT OF INTERTIDAL AQUATIC PLANT ABUNDANCE IN THE TOGIAK AREA OF BRISTOL BAY, ALASKA, 1978 THROUGH 1980 WITH EMPHASIS ON *FUCUS* SP.

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ABSTRACT

The density and distribution of intertidal aquatic plants, particularly *Fucus* sp., in the Togiak area of Bristol Bay was examined during the spring and summer of 1978, 1979, and 1980. The study was initiated to develop management objectives for the rapidly expanding Bristol Bay herring spawn-on-kelp commercial fishery.

Intertidal beach from Kulukak Bay to Togiak Bay was divided into 10 areas. Each area was measured for length, width, and relative zonation above mean low water. Sample plots were randomly selected throughout the area to determine ground cover and density of aquatic plants. Biomass estimates were calculated based on beach area and plant density. This sampling procedure was repeated in selected areas over successive years.

Approximately 90% of the beach was composed of exposed inorganic material. *Fucus* sp. was the predominant organic ground cover and ranged in density from 19 g/m^2 to 1,244 g/m^2. Biomass estimates for *Fucus* sp. were calculated for each area and ranged from 2,487 kg (area 1, 1980) to 258,254 kg (area 9, 1979). Confidence intervals around these point estimates were very large because of the large variance associated with density estimates within individual strata. In all areas where measurements were repeated in successive years, the biomass point estimate decreased although no statistically valid differences could be found between years.

INTRODUCTION

Pacific herring *(Clupea harengus pallasi)* spawn in the Togiak area of Bristol Bay annually between late April and early June (Figure 1). Their adhesive eggs are deposited on benthic flora along the intertidal and shallow subtidal zones. A commercial fishery to harvest certain of these seaweeds laden with herring spawn (spawn-on-kelp) for Japanese markets has existed since 1968 and has varied between 10.1 and 414.7 thousand pounds (Table 1). While the monetary value of the spawn-on-kelp harvest (Table 2) represents only a small portion of the total Bristol Bay herring fishery (last 4 years $\leq$ 6%), intensive management and research of this fishery has become necessary to protect both herring spawn deposition and the intertidal community. It is conceivable that disturbance and overharvest of spawning substrate with attached eggs could reach a level that would decrease the availability of spawn substrate and drastically decrease the biomass of adult herring for the economically more important sac roe fishery.

The Commercial Fisheries Division of the Alaska Department of Fish and Game (ADF&G) initiated field studies in 1978 to determine the effect of the spawn-on-kelp harvest upon the aquatic plant resource. The objectives of the study were to quantify the intertidal distribution, density, and biomass of harvestable aquatic plants, with particular interest in rockweed *(Fucus* sp.*)*. Clark and Buklis (1978) initiated research on these resources and developed methodology for assessing the standing crop of intertidal aquatic plants. They estimated the biomass of intertidal *Fucus* in Metervik Bay (Figure 1) during the spring of 1978. These studies were expanded in 1979 to include the entire coastline from Kulukak Bay to the eastern edge of Togiak Bay. Results from these investigations were used to develop objectives for management of the Bristol Bay spawn-on-kelp harvest (McBride and Clark 1979). The Alaska Board of Fisheries adopted these objectives at the December 1979 meeting and directed ADF&G to regulate the spawn-on-kelp harvest accordingly. The intertidal aquatic plant biomass was estimated for the eastern portion of Togiak Bay in 1980 and, additionally, selected areas studied in 1978 and 1979 were reassessed.

The objective of this report is to present data concerning density and distribution of intertidal aquatic plants in the Togiak area during the spring and summer of 1978, 1979, and 1980. Estimates of the standing crop of the intertidal rockweed *Fucus* sp. are presented for each of these years. The format is intended to provide an initial data base for discussion of density, distribution, abundance, and species composition of intertidal aquatic plants in the Togiak area which can be expanded as additional data is acquired in future years.

METHODS AND MATERIALS

Beach Surveys

During the spring and summer of 1978, 1979, and 1980, the intertidal beach from Kulukak Bay to Togiak Bay was surveyed and locations of major rockweed beds were mapped. Individual beach areas (K-areas in Figure 1) were paced

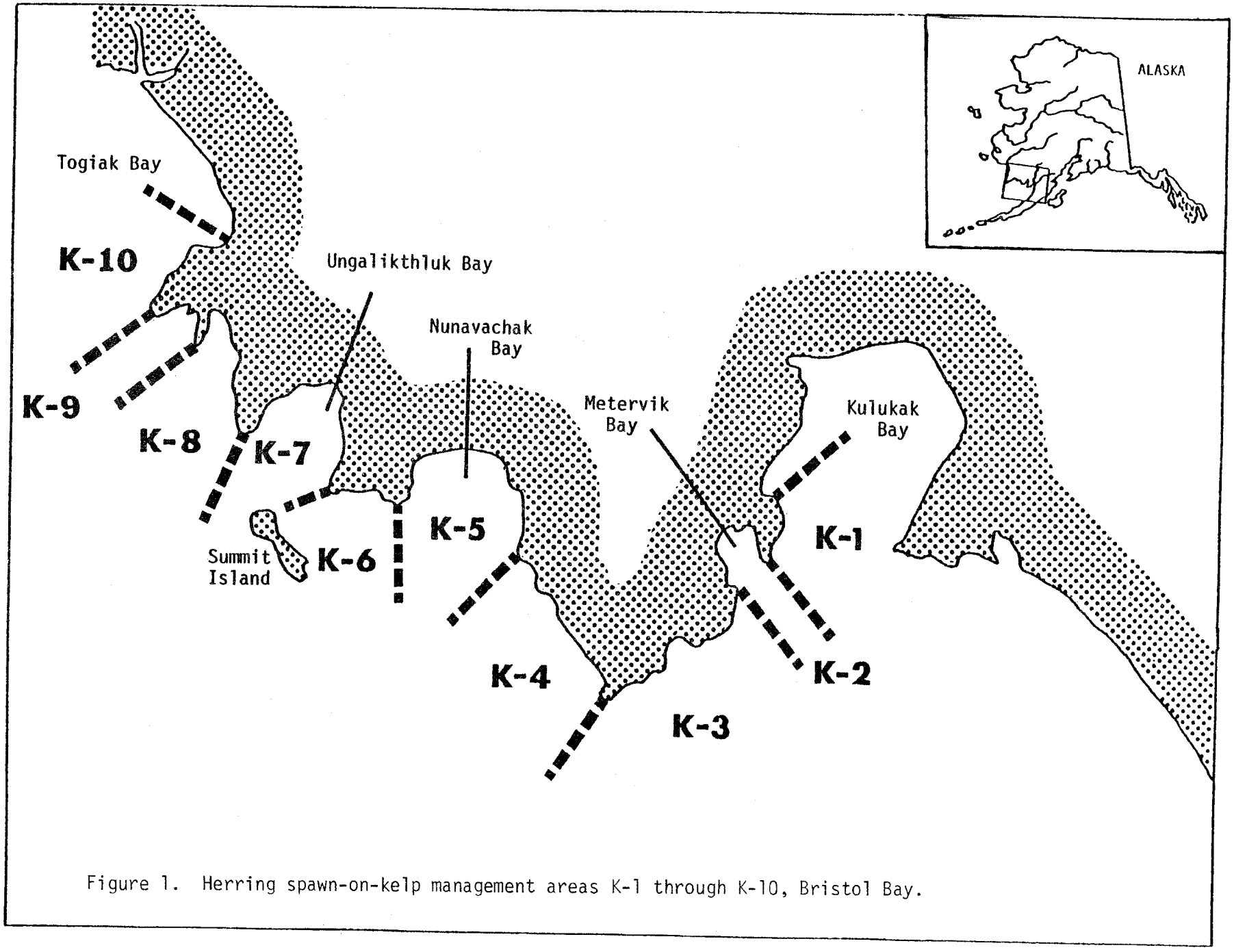

Figure 1. Herring spawn-on-kelp management areas K-1 through K-10, Bristol Bay.

Table 1. Harvest and effort for the Bristol Bay herring spawn-on-kelp fishery between 1968 and 1981.

Year	Harvest (pounds)[1]	Number of fishermen	Harvest per fisherman
1968	54,600	1	54,600
1969	10,100	3	3,400
1970	38,900	5	7,800
1971	51,800	12	4,300
1972	64,200	12	5,300
1973	11,600	10	1,200
1974	125,600	26	4,800
1975	111,100	44	2,500
1976	295,800	49	6,000
1977	275,800	75	3,700
1978	329,900	160	2,100
1979	414,700	100	4,100
1980	189,700	78	2,400
1981	378,200[1]	108	3,500
TOTAL	2,352,000	683	3,440

[1] Preliminary data.

Table 2. Comparison of the relative ex-vessel value of the Bristol Bay herring spawn-on-kelp and sac roe fisheries between 1977 and 1981.

	Value:		Percent of total value:	
Year	Spawn-on-kelp	Sac Roe[1]	Spawn-on-kelp	Sac Roe
1977	$116,000	$ 446,000	21	79
1978	$120,000	$2,635,000	4	96
1979	$269,000	$7,322,000	4	96
1980	$ 95,000	$3,205,000	3	97
1981	$250,000[2]	$3,989,000[2]	6	94

[1] Includes a minor amount of food and bait herring in 1980 and 1981.

[2] Preliminary data.

to roughly estimate beach length and all transects were measured to provide estimates of beach width. The area of each beach was estimated by multiplying beach length by the average beach width. A randomized sampling design was employed to select transects for study within each of the 10 beach areas containing rockweed. Locations for the transects were selected with the use of a random number table on the basis of distance from the eastern boundary of each K-area. Two transects were also selected perpendicular to each other on an intertidal island in Metervik Bay.

At each transect location, a surveyor's measuring tape was used to measure the perpendicular distance from the high water mark to the water's edge. Each transect was roughly stratified by eye according to tidal height. The strata or beach zones identified were 4.9 to 3.7 m (16 to 12 ft), 3.7 to 2.4 m (12 to 8 ft), 2.4 to 1.2 m (8 to 4 ft), and 1.2 to 0 m (4 to 0 ft) above mean low water. The total area of each of these four beach zones within each K-area was calculated based upon beach length and estimates of zone width in a manner similar to that described above. Individual sample plots were selected along each transect with the aid of a random number table. The sample unit (plot) was a 0.372 m^2 section of the substrate in 1978, whereas each sample unit was 0.250 m^2 section in area in 1979 and 1980. Percent ground cover by inorganic (e.g., rock, mud, sand) and organic (e.g., the macrophytes, *Fucus* sp., *Laminaria* sp.) substrate type was visually estimated. All plants were removed, separated by species, washed clean of attached eggs, and weighed to the nearest 0.1 gram.

Tidal Height Adjustment

Transects were sampled within a time frame from 1 hour before to 1 hour after book low tide listed for Black Rock, Walrus Islands, Alaska. Because not all transects were sampled at actual book low water, a model of tidal height fluctuations through time was necessary to adjust biomass estimates for transects sampled at times other than low tide and to better determine which tidal zone strata a particular plot was actually located. Deviations of tidal height from book time was measured for the Togiak area in 1978 and 1979. Approximately 1 hour before book low tide, a measuring stick was set into the substrate in approximately 0.5 m of water. Water height was measured every 5 minutes thereafter for a period of 2 hours. These data were used to calculate water surface height at the completion of each transect based upon Alaska Daylight Savings Time.

Density and Biomass Calculations

Density estimates were calculated for *Fucus* sp., *Zostra* sp., *Laminaria* sp., and other algae found in the intertidal zone as follows:

The probability of sampling a plot within stratum i, with no organic material (i.e., a 'zero plot') is estimated by

$$\hat{P}_i = Z_i/N_i ,$$

where N_i is the total number of sampled plots within A_i,

Z_i is the number of zero plots within A_i,

and the variance of $\hat{P}_i$ is estimated by

$$S^2_{\hat{P}_i} = \frac{\hat{P}_i\ (1 - \hat{P}_i)}{N_i}$$

Therefore, the estimated proportion of zero plots on the entire beach is

$$\hat{P} = \sum_{i=1}^{4} W_i\ \hat{P}_i\ ,$$

with an estimated variance of $S^2_{\hat{P}} = \sum_{i=1}^{4} W_i^2 S^2_{\hat{P}}$.

Here, W_i is the proportion of beach area in stratum i:

$$W_i = A_i/(A_1+A_2+A_3+A_4)\ ,$$

where A_i is the area (m^2) of stratum i.

The estimated long-density of organic material for all non-zero plots in stratum i is

$$\overline{X}_i = 1/K_i \sum_{j=1}^{K_i} X_{ij}\ ,$$

where X_{ij} is the natural logarithm of the biomass density b_{ij} in plot j of stratum i (g/m^2), and K_i is the number of non-zero plots in stratum i:

$$X_{ij} = ln\ (b_{ij})\ ,$$

and

$$K_i = N_i - Z_i\ .$$

The variance of $\overline{X}_i$ is estimated by:

$$S^2_{\overline{X}_i} = \frac{1}{K_i\ (K_i - 1)} \sum_{j=1}^{K_i} (X_{ij} - \overline{X}_i)^2$$

Therefore, the estimated log-density of organic material for all non-zero plots on the entire beach is

$$\overline{X} = \sum_{i=1}^{4} W_i \overline{X}_i \quad \text{and}$$

$$S^2_{\overline{X}} = \sum_{i=1}^{4} W_i^2\ S^2_{\overline{X}_i}$$

The estimated average density (kg/m^2) of organic material for stratum i is

$$B_i = (1-\hat{P}_i)exp\left\{\bar{X}_i + \tfrac{1}{2}S^2_{\bar{X}_i}\right\}$$

and the estimated average density (kg/m^2) of organic material for the entire beach is

$$B = (1 - \hat{P})exp\left\{\bar{X} + \tfrac{1}{2}S^2_{\bar{X}}\right\}$$

Biomass estimates were ultimately calculated by multiplying the appropriate plant density per square meter by the estimate of beach area.

RESULTS AND DISCUSSION

Physical Measurements and Sample Sites

About 75 km of beach east of the village of Togiak, Alaska was measured to determine length, width, and relative zonation above mean low water. The majority of the beach was characteristically only exposed for a short time during low tide. The 2.4 to 1.2 m and the 1.2 to 0 m tidal zones contained the largest area, and average overall beach width varied from about 50 to 300 m (Table 3). The 75 km of beach represented about 600 hectares of area within which 353 transects were laid out over the 3 years of the study allowing 2,390 plots to be located in a random fashion (Table 4).

Tidal Measurements

The tidal deviation measurements of 30 May 1978 indicated that low tide at Metervik Bay was 16 minutes earlier than the predicted tide book time listed while the measurements of 1 June 1978 indicated a deviation of 13 minutes earlier than predicted time (Table 5). The final estimate of tidal deviation used for analysis of data collected in 1978 was 15 minutes before predicted low tide.

Eight separate tidal deviation measurements were made in 1979. The results ranged from deviations of 12 minutes before to 15 minutes after predicted low tide with an average deviation of 1.5 minutes after predicted low tide. As no trends were observed in the data to explain the large variation in the results, it was concluded that deviations in tidal fluctuations in the Togiak area from book times were largely the result of weather. Weather patterns were not monitored and no attempt was made to model tidal deviations against other variables. Therefore, book times were used for an estimate of time of low tide in 1979 and 1980.

Tidal height of the high water beach line was estimated at 4.9 m (16 ft) based on book high water listed for Black Rock, located on the Walrus Islands, Bristol Bay, Alaska. Water height at the lower end of each transect was calculated based on: (1) time and water depth at the lower end of each transect as it was completed, (2) suggested book time and tidal height, and (3) tidal deviation data collected at Metervik Bay (1978 data only).

Table 3. Estimated length and average width of beach for areas K-1 to K-10, 1978 through 1980.

K-Area	Year sampled	Average width of beach in meters					Length of beach (m)
		4.9 to 3.7	3.7 to 2.4	2.4 to 1.2	1.2 to 0	Total	
1	1979	9	14	16	9	49	2,653
1	1980	6	9	18	16	49	3,046
2	1978	5	6	8	247	266	8,230
Intertidal island[1]	1978			110	187	297	
3	1979	8	10	34	15	67	10,603
3[2]	1979	9	10	33	14	66	5,603
3[2]	1980	8	8	14	19	49	5,201
4	1979	8	8	16	19	50	12,500
5	1979	7	10	14	27	58	9,107
6	1979	10	11	15	12	49	5,428
7	1979	10	17	19	17	62	5,016
8	1979	7	6	12	34	59	10,197
9	1979	5	4	15	59	84	5,600
10	1980	5	5	10	28	48	5,335

[1] Size of intertidal island not calculated during 1979 and 1980.

[2] Western edge of Metervik Bay to eastern edge of Eagle Bay.

Table 4. Number of transects and sample plots examined by beach zone for areas K-1 to K-10, 1978 through 1980.

K-Area	Year sampled	Number of transects	Number of sample plots within each beach zone				
			4.9 to 3.7 m	3.7 to 2.4 m	2.4 to 1.2 m	1.2 to 0 m	Total
1	1979	12	13	20	17	4	54
1	1980	20	8	23	36	34	101
2	1978	24	17	30	34	355	413
Intertidal Is.	1978	2			35	50	85
Intertidal Is.[1]	1979	2					28
Intertidal Is.[1]	1980	2					33
3	1979	42	49	58	134	41	282
3[2]	1979	22	24	33	66	16	139
3[2]	1980	29	27	20	42	55	144
4	1979	50	49	51	76	86	262
5	1979	29	25	33	49	69	176
6	1979	23	31	36	22	15	104
7	1979	24	24	21	41	21	107
8	1979	39	45	29	55	93	222
9	1979	15	9	13	24	89	135
10	1980	18	4	7	22	49	82
Total		353	325	374	651	977	2,390

[1] Beach regions not determined in 1979 and 1980.

[2] Western edge of Metervik Bay to eastern edge of Eagle Bay.

Table 5. Deviations in time of observed low tide versus predicted low tide in the Togiak area of Bristol Bay, 1978 and 1979.

Date	Location	Heighth tide (ft)	Predicted time of low tide	Observed time of low tide		Difference in minutes
			1978			
May 30	Metervik Bay	- 0.4	16:12	15:56		- 16
June 1	Metervik Bay	- 1.0	16:54	17:41		- 13
					Average	- 14.5
			1979			
May 5	Metervik Bay	3.8	16:46	16:58		+ 12
May 6	Metervik Bay	3.4	17:30	17:45		+ 15
May 7	Metervik Bay	3.0	18:12	18:15		+ 3
May 8	Metervik Bay	2.5	18:55	18:43		- 12
May 9	Metervik Bay	2.0	19:34	19:25		- 9
May 10	Metervik Bay	1.5	20:16	18:19		+ 3
May 13	Metervik Bay	6.3	10:40	10:40		0
June 6	Ungalikthuk Bay	1.3	18:13	18:13		0
					Average	+ 1.5

Density Estimates

Approximately 90% of the intertidal beach was composed of exposed inorganic matter (Table 6). *Fucus* sp. was the predominant organic groundcover. *Laminaria* sp. (ribbon kelp) and *Zostera* sp. (eelgrass) were easily identified, but were present only in small amounts. The remaining "organic" groundcover was combined in an "other" category and includes *Rhodomela* sp. (red algae), *Halososcion, Ulva, Cladophoa, Sytosiphon,* as well as several other genera of red, green, and brown algae.

Aquatic plant density within each beach zone of each K-area was estimated (Table 7). Average weight of *Fucus* sp. ranged from 19.0 g/m^2 in K-area 1 to 1,244.1 g/m^2 on the intertidal island. The largest density value by K-area for *Laminaria* sp., *Zostera* sp., and "other" aquatic plants was 423.8, 30.5, and 148.9 g/m^2, respectively.

Biomass Estimates

Biomass estimates for *Fucus* sp., with corresponding confidence intervals, were calculated by combining the average density and total area by K-area (Table 8). The large variance in density estimates within individual strata resulted in very large confidence intervals. In all areas where measurements were repeated in successive years, the point biomass estimate decreased; however, no statistically significant differences could be found between years. Some of the variation observed in the biomass estimates may be due to insufficient sampling and/or seasonal changes in the plants.

ACKNOWLEDGMENTS

The authors are grateful to all field crews and ADF&G staff members who helped with data collection. Virtually all of the sampling was done from remote field camps under extremely adverse conditions. We also thank Ivan Frohne for providing biometric assistance in summarizing these data, Dan Bergstrom for helping to finalize the tables and figures, Marshal Kendziorek and Gary Finger for providing editorial comments, and Penny Fitzgerald, Sheri Bratton, and June Grant for clerical assistance.

Table 6. Average percent ground cover visually estimated along beach areas K-1 through K-10.

K-Area	Year sampled	Beach region (m)	Number of plots examined	Organic cover: *Fucus* sp.	*Laminaria* sp.	*Zostera* sp.	Other	Total	Inorganic cover: Mud	Sand	Gravel	Rock	Total
1	1979	4.9 to 3.7	13	tr			3	3			28	69	97
1		3.7 to 2.4	20	7			1	8		4	27	61	92
1		2.4 to 1.2	17	5	tr		2	7		4	16	73	93
1		1.2 to 0	4	38				38				62	62
1		4.9 to 0	54	11	tr		2	13		3	18	66	87
1	1980	4.9 to 3.7	8							27	48	25	100
1		3.7 to 2.4	23	2			tr	2		19	24	55	98
1		2.4 to 1.2	36	2	1		2	5		21	28	46	95
1		1.2 to 0	34	1			1	2	8	10	34	46	98
		4.9 to 0	101	1	tr		1	2	3	18	32	45	98
Intertidal Is.	1978	2.4 to 1.2	35	16	tr		2	18			28	54	82
		1.2 to 0	50	5	1	tr	4	10	38		41	11	90
		2.4 to 0	85	10	tr	tr	3	13	22		36	29	87
Intertidal Is.	1979	2.4 to 0	28	10	tr		1	11		7	42	40	89
Intertidal Is.	1980	2.4 to 0	33	7	tr		2	9		tr	62	29	91
2	1978	4.9 to 3.7	17							8	38	54	100
2		3.7 to 2.4	30	1			tr	1	12	11	29	48	99
2		2.4 to 1.2	34	9			1	10	9	1	30	50	90
2		1.2 to 0	355	2	tr	tr	tr	2	47	33	11	7	98
2		4.9 to 0	413	2	tr	tr	tr	2	43	31	13	11	98
3	1979	4.9 to 3.7	49							13	29	58	100
3		3.7 to 2.4	58	4		tr	tr	4		11	23	62	96
3		2.4 to 1.2	134	14	tr	tr	1	15	27	10	12	36	85
3		1.2 to 0	41	17	tr		1	18	10	9	7	56	82
3		4.9 to 0	282	11	tr	tr	1	12	16	10	15	47	88
3[1]	1979	4.9 to 3.7	24							10	31	59	100
3[1]		3.7 to 2.4	33	4		tr		4		14	16	66	96
3[1]		2.4 to 1.2	66	22	tr	tr	1	23	4	12	9	52	77
3[1]		1.2 to 0	16	22			1	23		2		75	77
3[1]		4.9 to 0	139	16	tr	tr	1	17	2	10	11	60	83
3[1]	1980	4.9 to 3.7	27							22	34	44	100
3[1]		3.7 to 2.4	20	tr				tr		20	62	18	100
3[1]		2.4 to 1.2	42	1	tr	tr	tr	1		9	50	40	99
3[1]		1.2 to 0	55	4	1	tr	1	6	11	2	31	50	94
3[1]		4.9 to 0	144	2	tr	tr	tr	2	4	10	42	42	98

-Continued-

Table 6. Average percent ground cover visually estimated along beach areas K-1 through K-10 (continued).

K-Area	Year sampled	Beach region (m)	Number of plots examined	Organic cover: *Fucus* sp.	*Laminaria* sp.	*Zostera* sp.	Other	Total	Inorganic cover: Mud	Sand	Gravel	Rock	Total
4	1979	4.9 to 3.7	49	tr				tr		21	30	49	100
4		3.7 to 2.4	51	9	tr		1	10		16	32	42	90
4		2.4 to 1.2	76	10		3	3	15	17	13	26	29	85
4		1.2 to 0	86	15	tr		4	19	16	13	8	44	81
4		4.9 to 0	262	10	tr	1	2	13	12	14	21	40	87
5	1979	4.9 to 3.7	25							20	27	53	100
5		3.7 to 2.4	33	tr				tr		18	21	61	100
5		2.4 to 1.2	49	14			1	15	1	10	19	55	84
5		1.2 to 0	69	14	5	1	2	22	28	14	9	27	78
5		4.9 to 0	176	10	2	1	1	14	14	14	15	43	86
6	1979	4.9 to 3.7	31								39	61	100
6		3.7 to 2.4	36	12			tr	12		2	26	60	88
6		2.4 to 1.2	22	30			2	32			18	50	68
6		1.2 to 0	15	21			2	23		30	25	22	77
6		4.9 to 0	104	18			1	19		8	26	47	81
7	1979	4.9 to 3.7	24	4				4		4	10	82	96
7		3.7 to 2.4	21	16		14	1	31		5	7	57	69
7		2.4 to 1.2	41	23	tr		tr	23	39	1	8	29	77
7		1.2 to 0	21	13				13	29	36		22	87
7		4.9 to 0	107	15	tr	4	tr	19	20	13	6	42	81
8	1979	4.9 to 3.7	45	1				1		2	14	83	99
8		3.7 to 2.4	29	4				4	3	16	27	50	96
8		2.4 to 1.2	55	4		5	tr	9	33	5	16	37	91
8		1.2 to 0	93	23		1	3	27	25	8	9	31	73
8		4.9 to 0	222	14		2	2	18	21	8	13	40	82
9	1979	4.9 to 3.7	9							10	46	44	100
9		3.7 to 2.4	13							15	54	31	100
9		2.4 to 1.2	24	8				8	2	42	16	32	92
9		1.2 to 0	89	18		tr	1	19	31	23	3	24	81
9		4.9 to 0	135	14		tr	tr	14	23	25	11	27	86
10	1980	4.9 to 3.7	4	tr				tr				100	100
10		3.7 to 2.4	7	16				16		7	14	63	84
10		2.4 to 1.2	22	12			1	13	4	9	13	61	87
10		1.2 to 0	49	11		1	1	13	25	9	4	49	87
10		4.9 to 0	82	11		tr	1	12	16	8	7	57	88

[1] Western boundary of Metervik Bay to eastern boundary of Eagle Bay.

Table 7. Estimated density of intertidal plants found in beach areas K-1 through K-10.

K-Area	Year sampled	Beach region (m)	Mean density in grams per m²			
			Fucus sp.	*Laminaria* sp.	*Zostera* sp.	Other
1	1979	4.9 to 3.7				60.0
1		3.7 to 2.4	148.1[1]			36.2
1		2.4 to 1.2	109.0	2.1		65.1
1		1.2 to 0	638.2			
1		Total	124.3	2.1	0	26.7
1	1980	4.9 to 3.7				
1		3.7 to 2.4	54.3			
1		2.4 to 1.2	29.0			21.6[2]
1		1.2 to 0	21.5			18.8
1		Total	19.0	0	0	16.2
Intertidal Island	1978	2.4 to 0	1,244.1	23.9	1.0	37.2
Intertidal Island	1979	2.4 to 0	303.1	5.9	0	6.1
Intertidal Island	1980	2.4 to 0	166.5	6.7	0	56.0
2	1978	4.9 to 3.7				
2		3.7 to 2.4	16.1			
2		2.4 to 1.2	36.3			3.2[2]
2		1.2 to 0	158.1	47.0	1.4	10.3
2		Total	117.0	47.0	1.4	8.8
3	1979	4.9 to 3.7				
3		3.7 to 2.4	151.0			17.5
3		2.4 to 1.2	387.6		0.1	12.9
3		1.2 to 0	514.4	77.6[4]		15.4
3		Total	252.1	77.6	0.1	7.2
3[3]	1979	4.9 to 3.7				
3[3]		3.7 to 2.4	102.4			293.0
3[3]		2.4 to 1.2	544.9	0.2	0.2	17.8
3[3]		1.2 to 0	795.4			3.2
3[3]		Total	312.3	0.2	0.2	7.1
3[3]	1980	4.9 to 3.7				
3[3]		3.7 to 2.4	51.2			
3[3]		2.4 to 1.2	26.4			5.1
3[3]		1.2 to 0	145.3	7.4[4]		15.3
3[3]		Total	37.2	7.4	0	7.0
4	1979	4.9 to 3.7	27.5			
4		3.7 to 2.4	632.2			7.1[6]
4		2.4 to 1.2	571.9		10.5	139.5
4		1.2 to 0	1,048.3	2.3		262.9
4		Total	247.3	2.3	10.5	61.9

-Continued-

Table 7. Estimated density of intertidal plants found in beach areas K-1 through K-10 (continued).

K-Area	Year sampled	Beach region (m)	Mean density in grams per m^2			
			Fucus sp.	*Laminaria* sp.	*Zostera* sp.	Other
5	1979	4.9 to 3.7				
5		3.7 to 2.4				
5		2.4 to 1.2	658.1			23.0
5		1.2 to 0	1,061.2	423.8	2.7	97.5
5		Total	507.5	423.8	2.7	55.5
6	1979	4.9 to 3.7				
6		3.7 to 2.4	535.4			
6		2.4 to 1.2	1,756.1			
6		1.2 to 0	1,585.8			148.9[7]
6		Total	878.1	0	0	148.9
7	1979	4.9 to 3.7	209.2			
7		3.7 to 2.4	1,230.0			
7		2.4 to 1.2	1,678.0	5.4		16.9[2]
7		1.2 to 0	849.8			
		Total	597.1	5.4	0	16.9
8	1979	4.9 to 3.7				
8		3.7 to 2.4	76.6[1]			
8		2.4 to 1.2	198.6			67.1
8		1.2 to 0	1,006.1		30.5[4]	166.9
8		Total	330.3	0	30.5	102.3
9	1979	4.9 to 3.7				
9		3.7 to 2.4				
9		2.4 to 1.2	627.5			
9		1.2 to 0	1,003.4		2.5	16.2
9		Total	623.2	0	2.5	16.2
10	1980	4.9 to 3.7				
10		3.7 to 2.4	5,593.6[1]			
10		2.4 to 1.2	1,527.8			10.4
10		1.2 to 0	550.6		3.2	13.0
10		Total	322.1	0	3.2	10.4

1 Beach region combined, 4.9 to 2.4 m.
2 Beach region combined, 3.7 to 1.2 m.
3 Western boundary of Metervik Bay to eastern boundary of Eagle Bay.
4 Beach region combined, 2.4 to 0 m.
5 Beach region combined, 3.7 to 2.4 and 1.2 to 0 m.
6 Beach region combined, 4.9 to 2.4 m.
7 Beach region combined, 3.7 to 0 m.

Table 8. Estimated biomass of *Fucus* sp. along the intertidal beach of areas K-1 through K-10.

K-Area	Year sampled	Beach area in m^2	Biomass in kilograms		
			Estimate	80% confidence interval	
K-1	1979	127,300	15,823	4,634 to	52,091
K-1	1980	130,900	2,487	812 to	7,317
Intertidal Is.	1978	68,900	85,718	3,183 to	2,296,520
Intertidal Is.	1979	68,900	20,884	2,983 to	139,791
Intertidal Is.	1980	68,900	11,472	923 to	135,850
K-2	1978	2,148,000	251,316	14,392 to	4,097,954
K-3	1979	625,500	157,689	51,166 to	481,135
K-3[1]	1979	319,300	99,717	29,727 to	330,124
K-3[1]	1980	213,200	7,931	1,876 to	32,449
K-4	1979	637,500	158,291	55,016 to	446,824
K-5	1979	464,500	235,734	51,792 to	1,053,022
K-6	1979	206,200	181,064	63,159 to	505,952
K-7	1979	316,100	188,743	72,481 to	479,871
K-8	1979	601,700	182,496	56,078 to	694,482
K-9	1979	414,400	258,254	41,274 to	1,566,349
K-10	1980	256,200	82,522	18,318 to	364,778

[1] Western boundary of Metervik Bay to eastern boundary of Eagle Bay.

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