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SURVEY OF MACROPHYTE RESOURCES IN THE COASTAL WATER OF ALASKA

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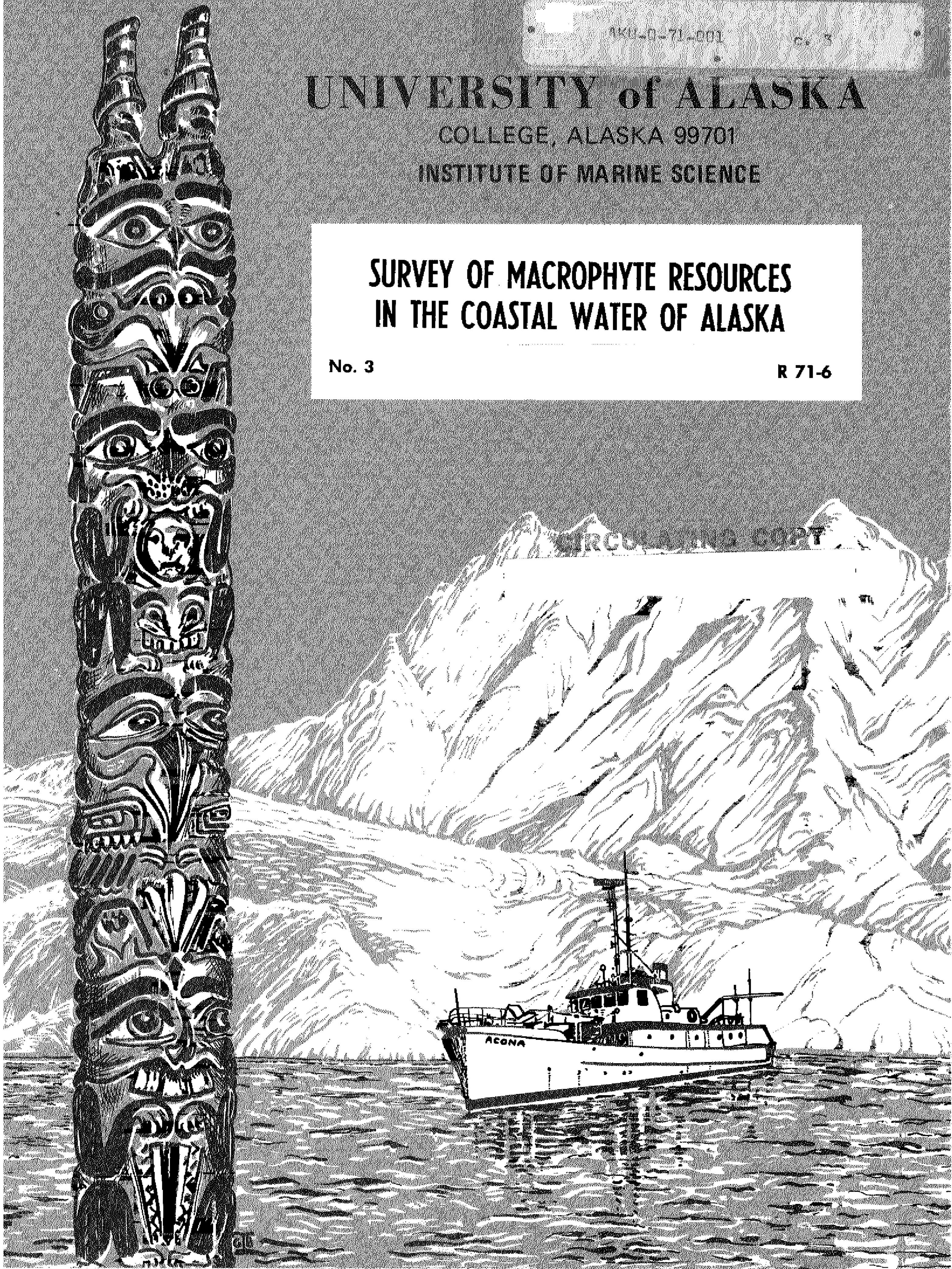

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SURVEY OF MACROPHYTE RESOURCES IN THE COASTAL WATERS OF ALASKA

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Report of Progress During First Year

to the

Sea Grant Program

Report No. R71-6
May 1971

D. W. Hood
Director

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INTRODUCTION

The objectives of this project include the quantitative assessment of natural stocks of marine macrophytes (seaweeds and seagrasses) in the coastal waters of Alaska, the determination of the commercial value of macrophyte species from data on abundance and chemical composition, the collection and preparation of a reference herbarium of marine macrophytes, and the compilation of data from the literature on the chemical composition of Alaska marine macrophytes. During the first year of this project we have made progress towards completion of all of the above objectives with our primary effort being directed towards the development of quantitative survey techniques. This project began in May, 1970 by a research grant from the Alaska Sea Grant Program to the Institute of Marine Science of the University of Alaska.

We anticipate that the significance of this research will be that it provides the background for the development of a new industry in Alaska. We have received letters from several firms indicating an interest in our project. One firm has plans to open an office in Juneau and to work cooperatively with natives.

As a result of an early survey Alaska is known to have sufficient stocks of brown seaweeds to support industry, the red seaweed stocks remain unknown (Chapman 1970).

DEVELOPMENT OF QUANTITATIVE SURVEY TECHNIQUES

A variety of techniques for the quantitative assessment of seaweed standing stocks has been presented in the literature. While the intertidal presents no special problem, the subtidal plants on hard bottoms are extremely difficult to sample. Our problem apart from the actual sampling is further compounded by the thousands of miles of coast of Alaska. Most workers in subtidal surveys have used SCUBA divers (Neushul, 1965; Wood and Hargraves, 1969; MacFarlane, 1966), in some cases diver operated sleds, cameras, or tape recorders are also used. Our struggle with methods during the first year has yielded a technique using SCUBA divers and submarine television.

Basically a diver makes parallel transects at right angles to shore on a sled towed by a surface vessel or winch. On the sled is also mounted the TV camera that makes a permanent record of the transect. A depth profile is also made with a recording depth sounder mounted on a Boston Whaler. In addition this can be used to identify certain types of kelp beds. This type of transect is rapid and gives a good record of the vertical distribution of the major species. From our preliminary efforts we know this can be used successfully in Southeast Alaska and we hope it can be extended to other regions. Following the visual survey divers then take replicate samples of all plants within a quadrat.

The problem of which areas to sample we have attacked by dividing the coast into a grid system that can be sampled with two stage sampling after the method of Grenager and Baardseth (1966). This method will hopefully permit us to make some generalizations about larger areas of the coast than our very limited sampling time will permit (relative to the size of the coast).

In addition to the above methods for macrophyte surveying, during the second year of this project we anticipate having photographic coverage of the Alaska coast from the ERTS satelite. This project, supported by NASA, will provide black and white as well as color photographs in both the visible and infrared spectra on at least a monthly basis. When cloud cover permits these photographs should make possible the mapping of the larger stands of macrophytes that reach the water surface such as kelp beds, and possibly those that are intertidal or just subtidal.

FIELD SURVEYS

Macrophyte surveys were made in Cold Bay on the Alaska Peninsula and in Berners Bay in Southeast Alaska in September 1970 and in the northern portion of Southeast Alaska in October 1970 (Table 1, Figure 1). The first field study utilized the availability of the R/V ACONA for a cruise in the waters of Cold Bay and the surrounding area of the Alaska Peninsula. On this cruise seaweeds were surveyed and collected by SCUBA divers in conjunction with an underwater television system (leased by the project); in addition shore parties collected plants during low tide. Two scientists from the Fisheries Research Institute of the University of Washington accompanied the cruise to collect marine algae and invertebrates as an extension of their studies of Amchitka Island in the Aleutians; they brought to our cruise considerable knowledge of the organisms as well as SCUBA diving experience in the harsh environment.

On this cruise 29 species were collected from the intertidal and subtidal of Cold Bay and 26 species from the intertidal of Izembek Lagoon (Table 2). In neither case are these collections an exhaustive representation of the total species compliment of the area. In addition to the Cold Bay cruise in September, M. Mueller was able to accompany a cooperative cruise sponsored by the National Marine Fisheries Service, Western Washington State University and the University of Alaska to study the littoral of Berners Bay in Southeast Alaska. Efforts in Berners Bay were principally limited to intertidal collecting but sufficient time was available to permit a fairly complete collection of this flora which included a total of 53 species of marine algae (Table 2).

Our third cruise was a rapid survey of eight locations in Southeast Alaska (Table 1, Figure 1) where we applied SCUBA and television techniques to a variety of habitats with only one day spent at each location. In addition, various methods of quantitative sampling were tried. The collections by shore parties and divers included from 11 to 24 species of macrophytes for the eight locations (Table 2). As with other surveys these species represent only the more abundant and obvious macrophytes present at each location. In addition to the species lists it was possible to construct diagramatic sketches of macrophyte zonation at several of the stations (Figures 2 to 6). A striking feature of the coast of Southeast is that the macrophytes extend only to about 12 to 15 meters below the low tide range and in several instances only to about 10 meters. On the Alaska Peninsula we observed reasonably high standing stocks of macrophytes down to 20 or 25 meters.

No quantitative samples of algae have yet been taken. However, McRoy (1967, 1970) has recently completed a survey of the distribution and abundance of eelgrass (*Zostera marina*) the major non-algal macrophyte on the Alaska coast. Our impressions for the areas visited suggest that seaweed species in the following genera attain high enough standing stocks in Alaska to sustain exploitation: *Alaria*, *Nereocystis*, *Laminaria*, *Thalassiophyllum*, *Fucus*, *Schizymenia*, *Rhodomela*, and *Rhodomenia*. Undoubtedly other species will be revealed by further surveys and quantitative measurements.

TAXONOMY AND HERBARIUM COLLECTION

Several hundred specimens representing some 100 species were collected during our surveys and these form the nucleus of a marine plant collection in the University of Alaska Herbarium and Marine Collection Center. Most of the species identifications in this report are the work of M. Mueller; much of the Cold Bay and Izembek material was identified by P. Lebednik.

Along with the taxonomic identifications of the species, a list of all known marine macrophyte species in Alaska has been compiled from literature sources and our own collections (Scagel, 1957; Johanson, 1965; Lebednik, 1970). This list (Appendix I) consists of over 300 species that we have systematically numbered following a current on-going survey of British seaweeds (Norton, personal communication).

INDUSTRY COOPERATION

This project has attracted the attention of several companies that harvest and process seaweeds for commerical products. One corporation hopes to open an office in Alaska and to enter into a cooperative seaweed harvest with Alaska natives. We expect to have at least one industry observer on our cruises during the 1971 field season.

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Table 1. Locations on the coast of Alaska sampled for marine macrophytes (also see Figure 1).

Location	Grid Reference	Station No.	Latitude	Longitude	Type of Collecting
Berners Bay	09010-09310	1	58°44'N	135°W	Shore
Marmion Island	08510	2	58°12.0'N	134°15.5'W	Diving
Morris Reef	07610	3	57°28.5'N	134°51.0'W	Diving
Bear Bay	07610	4	57°25.9'N	135°34.0'W	Diving
Neva Island	07110	5	57°03.5'N	135°24.2'W	Diving & shore
Baird Island	07710	6	57°32.5'N	136°02.1'W	Diving & shore
Smooth Channel	07810	7	57°36.0'N	136°06.5'W	Diving
Sholin Island	07910	8	57°44'N	136°15'W	Shore
Winifred Island	08010	9	57°48.3'N	136°22.5'W	Diving
Cold Bay	04630-05030	10	55°10'N	162°30'W	Diving & shore
Izembek Lagoon	04930-05230	11	55°20'N	163°W	Shore

Table 2. Macrophyte species collected according to location (station numbers refer to locations given in Table 1).

Macrophyte Species	Habitat	Stations 1	2	3	4	5	6	7	8	9	10	11
CHLOROPHYTA												
Chaetomorpha cannabina	Intertidal	X										
" *melagonium*	"											X
Cladophora glaucescens	"										X	X
" *stimpsonii*	"					X						
" *sp.*	"	X										
Codium fragile	"					X						
Codium ritteri	Subtidal			X	X				X			
Enteromorpha clathrata	Intertidal	X										X
" *intestinalis*	"						X					
" *intestinalis f. clavata*	"	X										
" *linza*	Subtidal	X			X							X
" *micrococca*	Intertidal	X										
" *sp.*	"					X						
" *crinita*	"	X										
Lola lubrica	"	X										
Monostroma fuscum	Intertidal, Subtidal	X		X								
" *sp.* or *Ulva sp.*	Intertidal, Subtidal		X	X	X	X	X	X	X	X	X	X
Ulva fenestrata	Intertidal	X										X
Urospora mirabilis (?)	"	X										
PHAEOPHYTA												
Agarum cibrosum	Subtidal	X		X			X	X			X	
Alaria marginata	"					X				X		
" *nana*	"	X	X									
" *sp.*	"	X			X				X		X	X
Chorda filum	"											X
Chordaria flagelliformis	Intertidal	X							X		X	X
Colpomenia sinuosa	"	X					X					X
Costaria costata	Subtidal									X		
Cymathere triplicata	"	X		X		X		X				
Cystoseria geminata	Intertidal										X	X
Desmarestia intermedia	Intertidal, Subtidal	X		X			X	X		X	X	X
Ectocarpus sp. or *Pilayella sp.*	Intertidal	X					X	X				X
Elachistea fucicola f. lubrica	"	X										
Eudesme virescens	"										X	X

Table 2 (continued)

Macrophyte Species	Habitat	Stations 1	2	3	4	5	6	7	8	9	10	11
Fucus distichus	Intertidal	X	X	X	X	X	X	X	X	X	X	X
" *inflatus*	"											X
Laminaria dentigera	"	X										
" *groenlandica*	Intertidal, Subtidal	X		X		X	X					
" *saccharina*	"	X		X			X	X				
" *setchellii*	"					X						
" *sp.*	"	X		X					X		X	X
Macrocystis integrifolia	Drift						X	X				
Myelophycus intestinale	Intertidal											X
Nereocystis luetkeana	Subtidal		X	X	X	X	X	X	X	X	X	
Petalonia debilis	Intertidal	X							X			
Pilayella littoralis	"	X									X	X
Ralfsia fungiformis	"						X					
Scytosiphon lomentaria	"	X							X		X	X
Soranthera ulvoidea	"	X					X		X		X	
Thalassiophyllum clathrus	"										X	
RHODOPHYTA												
Antithamion nigricans	Intertidal										X	
" *subulatum*	"	X										
" *uncinatum*	"					X						
" *sp.*	"										X	
Bangia fuscopurpurea	"				X							
Botryoglossum farlowianum v. farlowianum	Subtidal							X				
Callithamnion biseriatum	"		X									
" *sp.*	"				X							
Callophyllis flabellulata	Intertidal, Subtidal	X		X	X							
" *edentata*	Subtidal					X						
Ceramium pacificum	Intertidal										X	
Constantinea rosa-marina	Intertidal, Subtidal	X	X									
" *sp.*	"	X			X						X	
Corallina sp.	Intertidal					X						
Cryptosiphonia woodii	"					X						
Delesseria decipiens	Subtidal						X					
Dilsea californica	"		X									
Endocladia muricata	Intertidal, Subtidal	X			X				X	X		
Fauchea laciniata (?)	Subtidal						X					
Gigartina cristata	Intertidal, Subtidal	X										
" *pacifica*	Intertidal					X					X	
" *sp.*	Intertidal, Subtidal	X			X		X		X			

Table 2 (continued)

Macrophyte Species	Habitat	Stations 1	2	3	4	5	6	7	8	9	10	11
Gracilaria verrucosa	Subtidal						X					
Halosaccion glandiforme	Intertidal, Subtidal	X		X	X	X	X		X		X	X
Iridaea heterocarpa	Subtidal					X						
" *whideyana* (?)	Intertidal	X										
" *sp.*	Subtidal				X							
Lithothamnion sp.	Intertidal	X										
Membranoptera weeksiae	"	X										
Nitophyllum mirabile	Subtidal		X									
Odoathalia floccosa	Intertidal, Subtidal	X	X	X		X	X	X	X	X	X	X
" *kamtschatscia*	"										X	
Opuntiella californica	Subtidal					X						
Phycodrys riggii	"	X										
Polysiphonia collinsii v. deliquescens	Intertidal					X					X	
" *pacifica*	"										X	
" *synderae*	"										X	
" *sp.*	Intertidal, Subtidal	X	X						X	X	X	
Porphyra occidentalis	Intertidal					X						
" *perforata f. perforata*	"	X										
" *sp.*	Intertidal, Subtidal	X		X								X
Prionitis lanceolata	Intertidal					X						
Pterosiphonia sp. (?)	"	X										
Ptilota densa	Intertidal, Subtidal	X				X						
" *filicina*	"	X	X								X	
" *sp.*	"		X									X
Pugetia fragilissma	Subtidal							X				
Rhodomela larix	Intertidal										X	
Rhodomenia palmata	Intertidal, Subtidal	X		X			X			X		
" *pertusa*	Subtidal						X					
" *sp.*	Intertidal	X										X
Schizymenia borealis	"	X										
" *sp.*	Subtidal	X	X	X	X		X	X				
Tokidadendron bullata	Intertidal, Subtidal	X								X		
Turnerella mertensiana	Subtidal				X							
SPERMATOPHYTES												
Phyllospadix scouleri	Subtidal					X						
Zostera marina	Subtidal						X	X			X	X
Total Species From Each Station		53	13	17	16	24	23	14	15	11	30	26

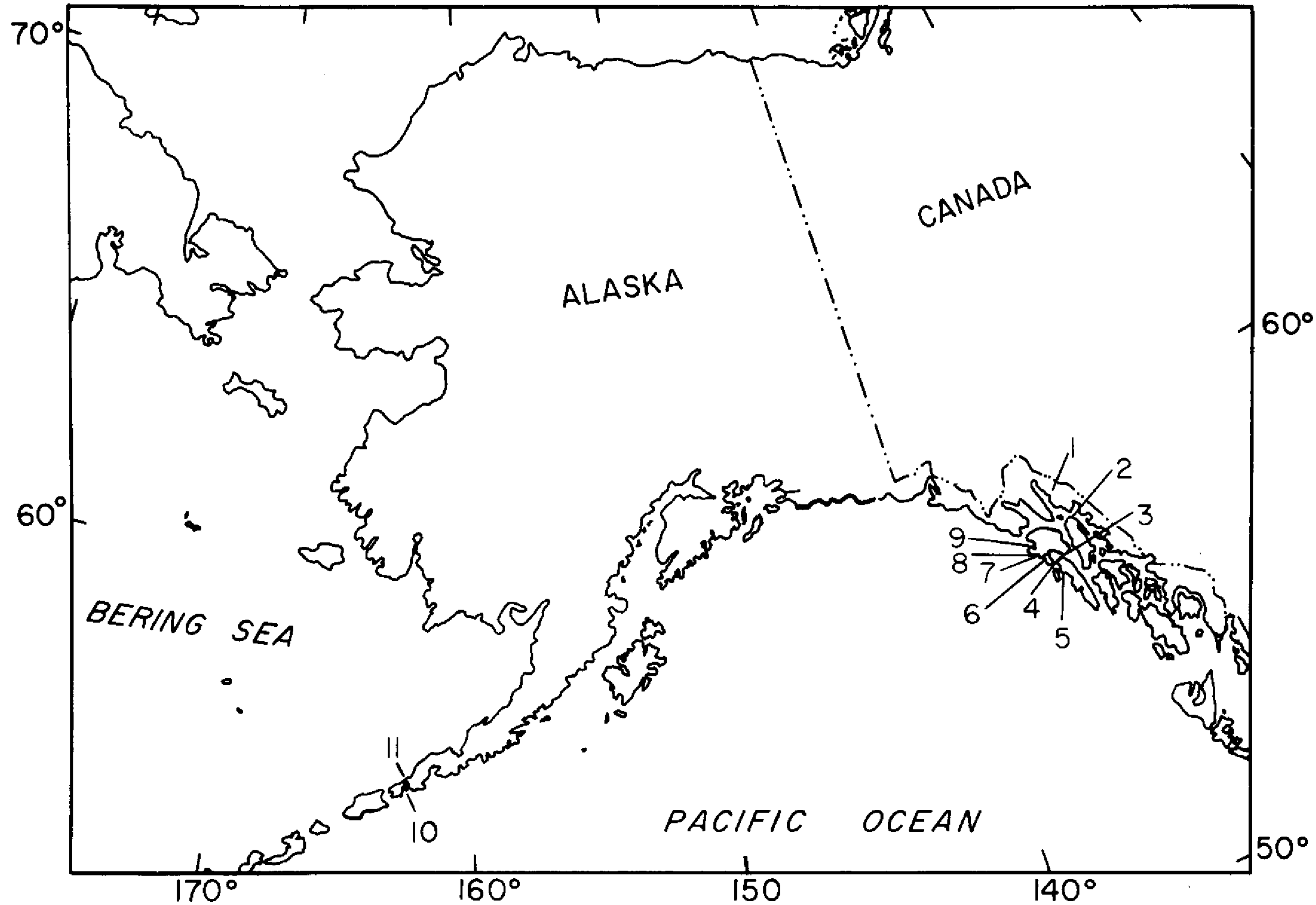

Figure 1. Chart showing locations of areas sampled for marine macrophytes (station descriptions given in Table 1).

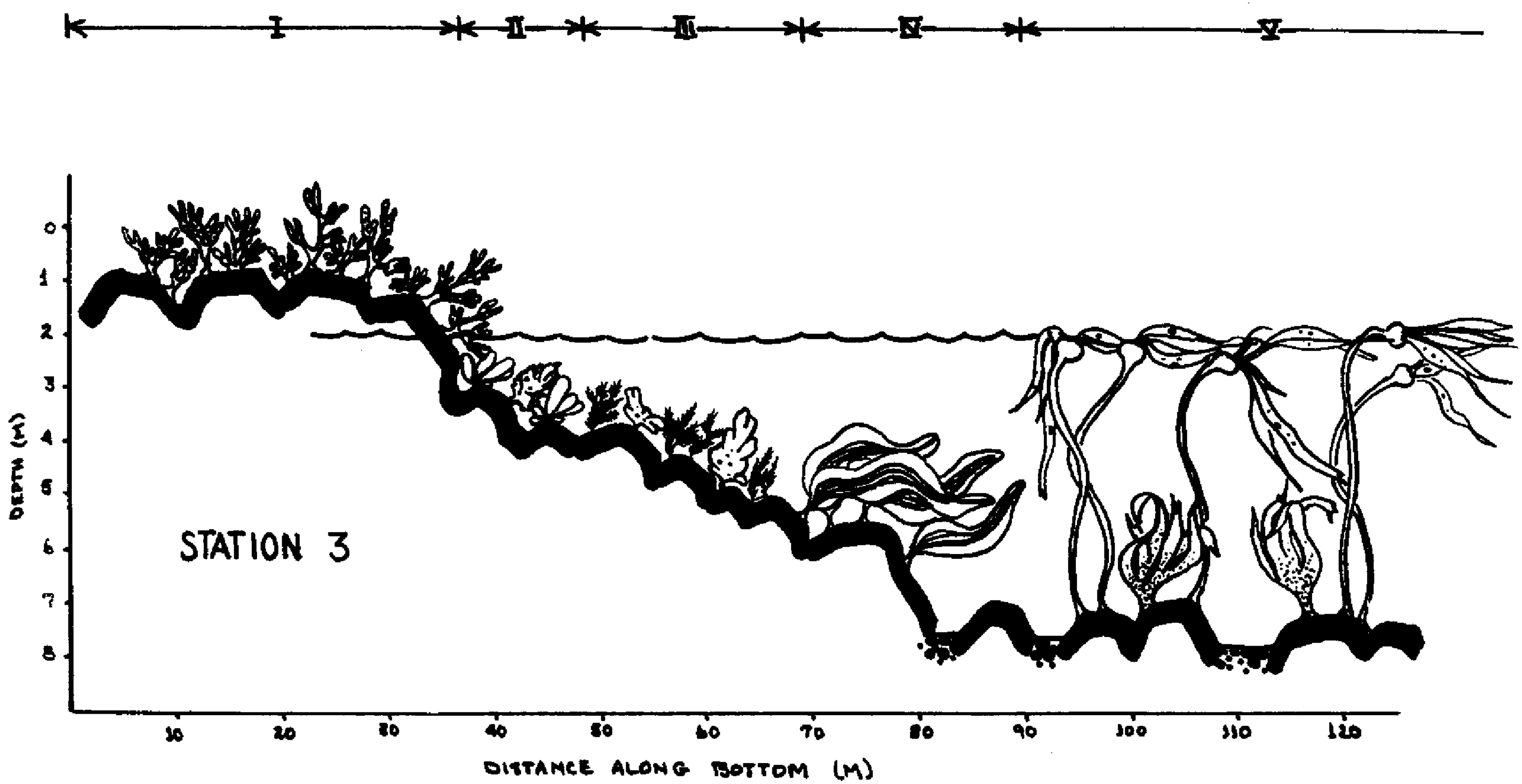

Figure 2. Diagramatic representation of macrophyte zonation at Morris Reef in Southeast Alaska (Station 3).

Zone I: *Fucus*
Zone II: *Halosaccion*, *Ulva*, mixed reds and browns
Zone III: *Ulva*, mixed reds, *Rhodomela*
Zone IV: *Cymathere*
Zone V: *Nereocystis*, *Laminaria*

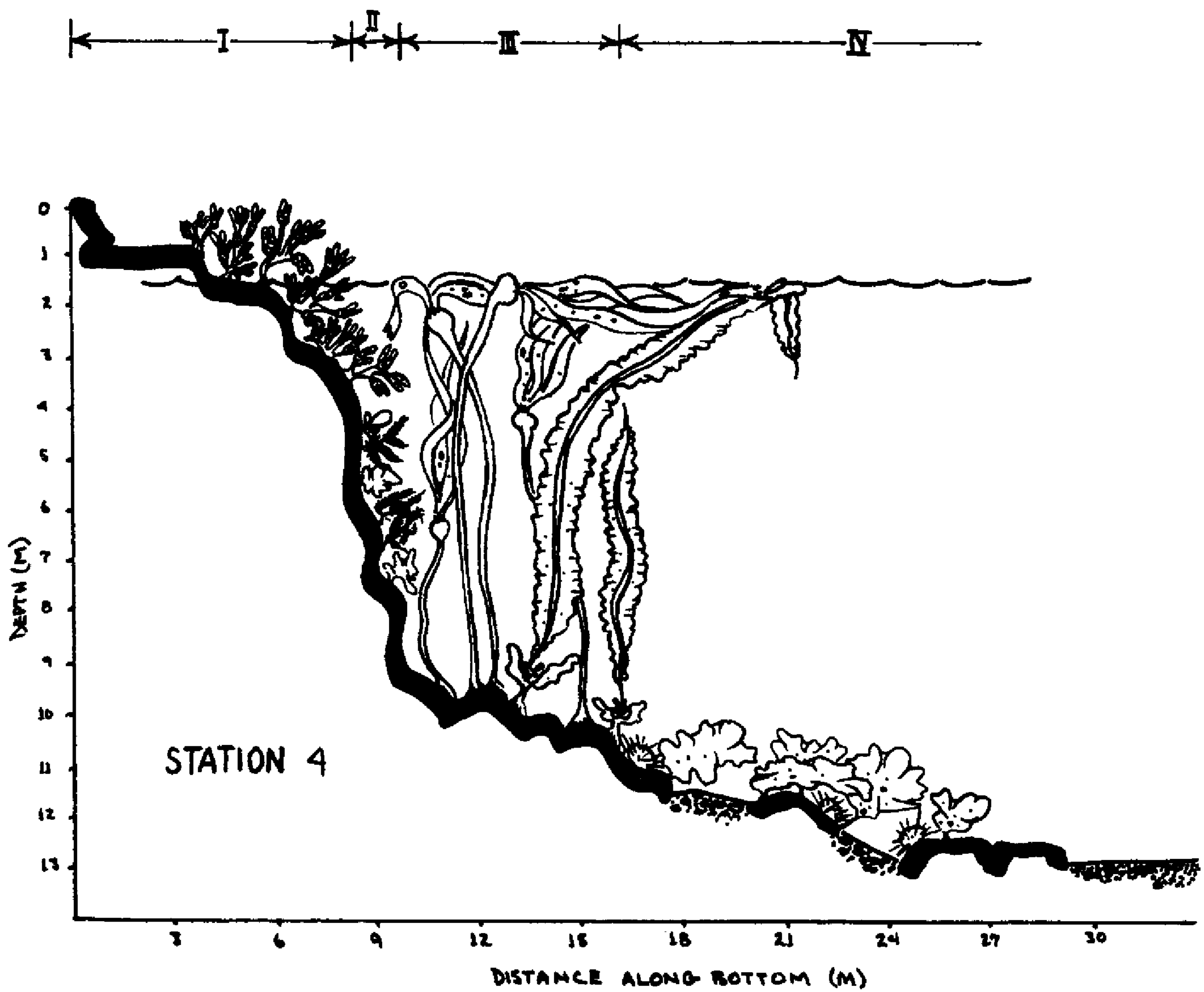

Figure 3. Diagramatic representation of macrophyte zonation at Baby Bear Bay, Peril Strait, in Southeast Alaska (Station 4).

Zone I:	*Fucus*
Zone II:	*Ulva*, many branched reds
Zone III:	*Nereocystis, alaria*
Zone IV:	*Schizymenia*, branched reds, sea urchins

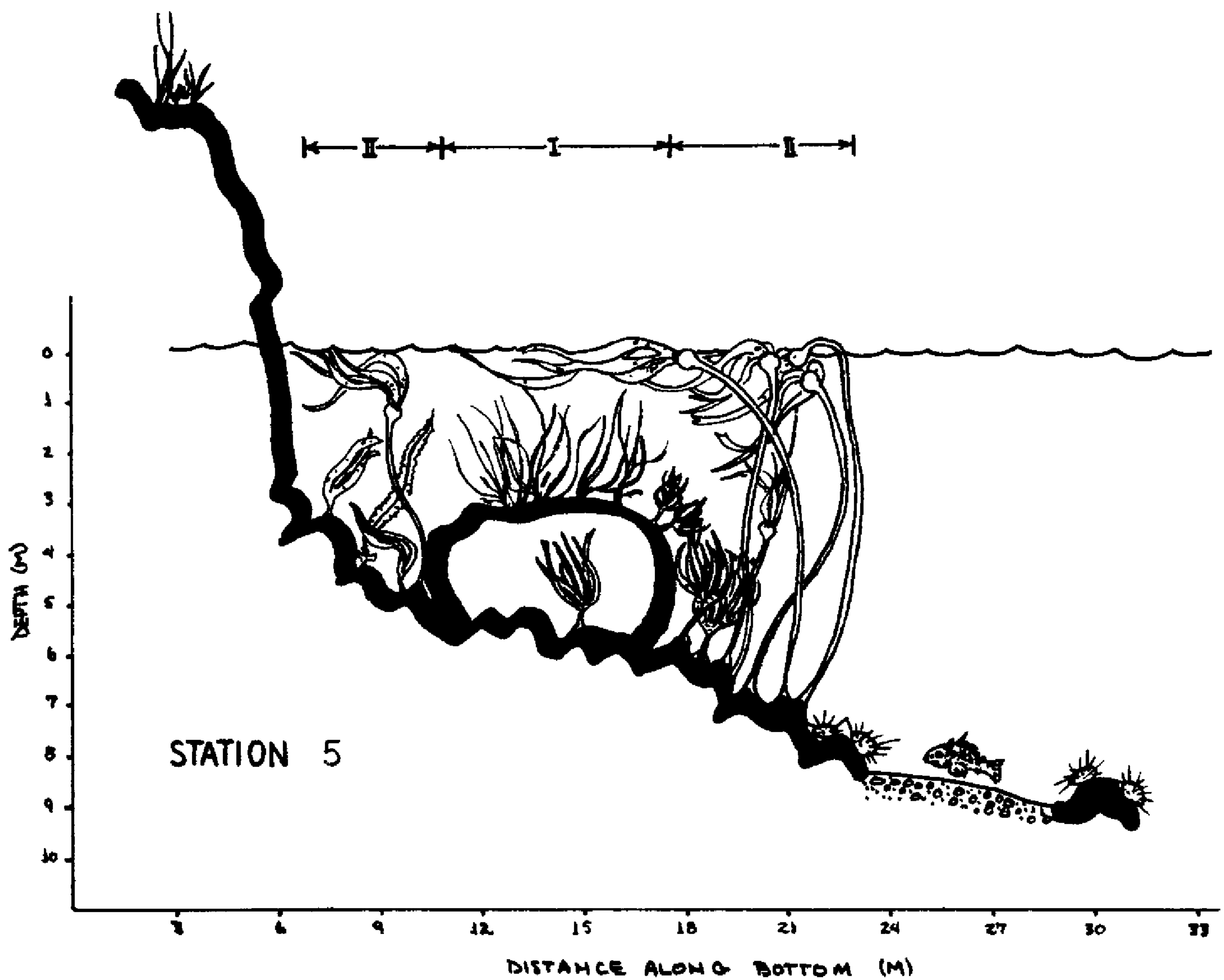

Figure 4. Diagramatic representation of macrophyte zonation at Neva Island, Sitka Sound, in Southeast Alaska (Station 5).

Zone I: Boulder covered by *Phyllospadix* and mixed reds including foliose corralines, *Laminaria*

Zone II: *Nereocystis*, *Laminaria*, *Alaria* also sea urchins and rock fish

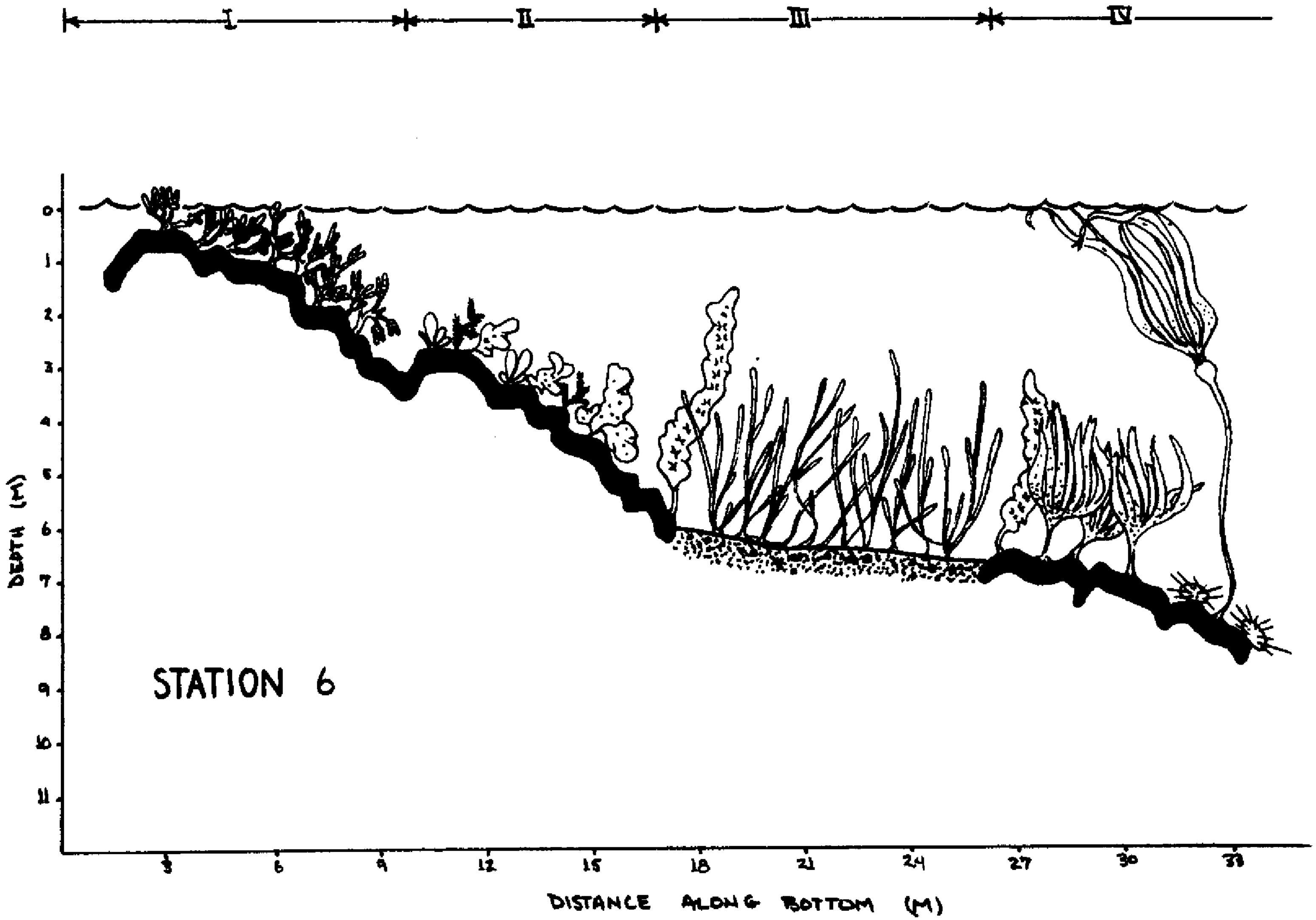

Figure 5. Diagramatic representation of macrophyte zonation at Baird Island, near Chicagof Island, in Southeast Alaska (Station 6).

Zone I: *Fucus*
Zone II: *Halosaccion* mixed reds, *Ulva*
Zone III: *Zostera*, *Laminaria*
Zone IV: *Laminaria*, *Nereocystis*, sea urchins

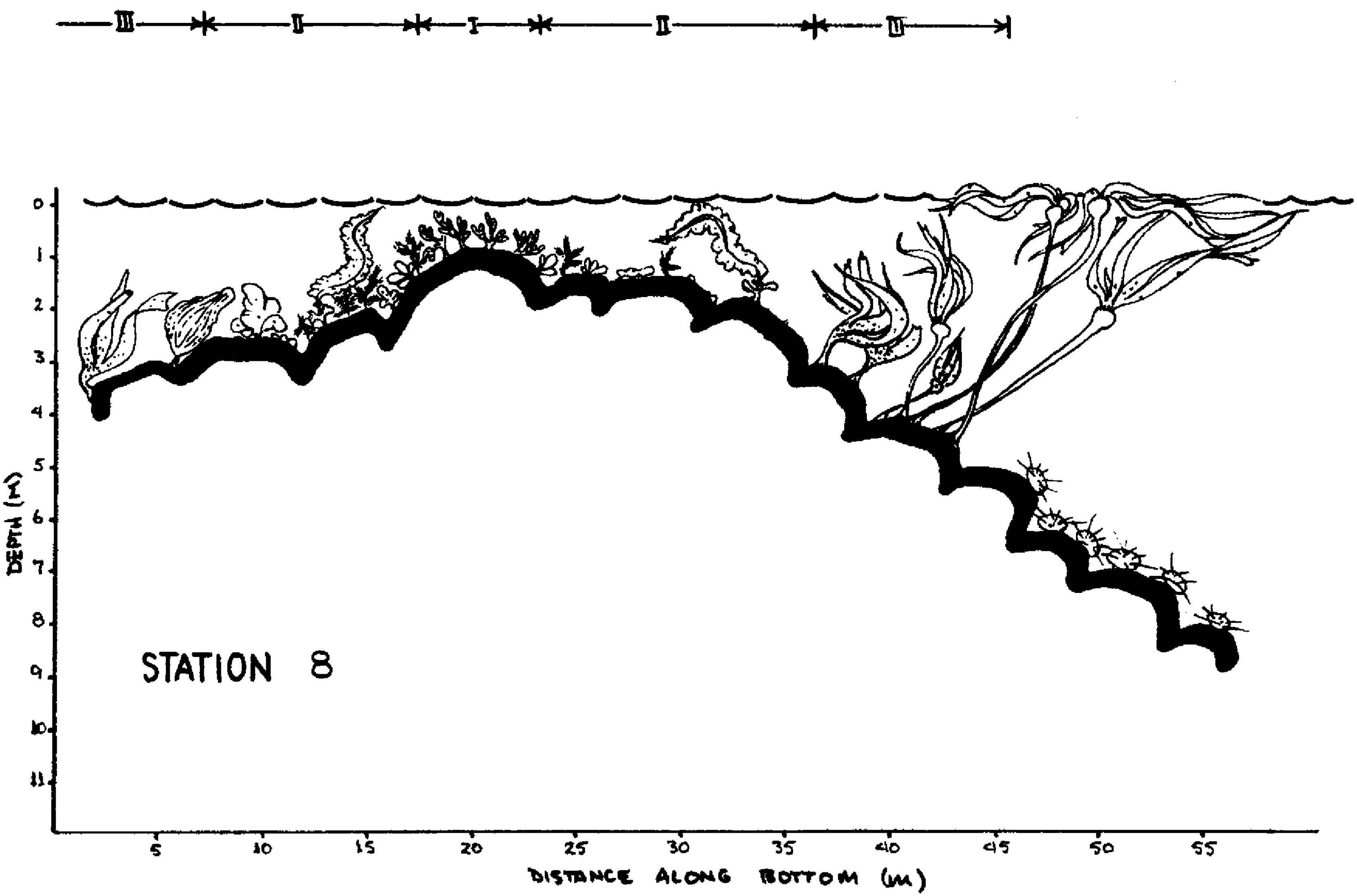

Figure 6. Diagramatic representation of macrophyte zonation at reef off Winifred Island, near Chicagof Island, in Southeast Alaska (Station 8).

Zone I: *Fucus, Ulva, Halosaccion* mixed reds
Zone II: *Alaria, Laminaria, Codium, Odonthalia*
Zone III: *Nereocystis, Laminaria*, some reds, sea urchins

PUBLICATIONS

Articles describing this survey of marine macrophyte resources appeared in Alaska Industry and in the Northern Engineer. In addition a quantitative survey of some eelgrass (*Zostera marina* L.) populations was completed and published. The eelgrass work began before the funding of the present project and was funded largely by other sources (Arctic Institute of North America, Water Quality Office and National Science Foundation). Reprints are attached to this report.

Standing Stocks and Other Features of Eelgrass (*Zostera marina*) Populations on the Coast of Alaska[1]

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MCROY, C. P. 1970. Standing stocks and other features of eelgrass (*Zostera marina*) populations on the coast of Alaska. J. Fish. Res. Bd. Canada 27: 1811–1821.

Of eelgrass populations sampled from southeast Alaska to Bering Strait, those in Kinzarof and Izembek lagoons on the Alaska Peninsula had the highest standing stocks (mean, 1510 g dry wt/m^2) and that in Calder Bay in southeast Alaska had the lowest (65 g dry wt/m^2). Caloric content of eelgrass averaged 4211 cal/g in the leaves and 3571 cal/g in the roots and rhizomes. The concentration of chlorophyll *a* in eelgrass had a mean of 0.513 mg/g fresh wt, with one exception. Population densities were high in Kinzarof and Izembek lagoons (mean, 4576 turions/m^2) and low in all other sample areas (599 turions/m^2). Flowering plants were 3–4% of the total population. Mean leaf length varied from 13 to 48 cm and width from 2.4 to 5.1 mm. The differences in the eelgrass populations appeared to be related to local conditions rather than a large geographical gradient.

Received March 16, 1970

INTRODUCTION

THIS STUDY is a comparison of standing stocks of eelgrass (*Zostera marina* L.) populations from 10 locations on the coast of Alaska. This species is widespread and abundant and forms the major sea grass community on the coast of Alaska. In this region, the plant ranges from the protected bays and inlets of southeast Alaska to the lagoons of the Bering and Chukchi seas (McRoy, 1968). This distribution represents a gradient of environmental conditions varying from temperate to arctic with a variety of local differences in any single location.

Though the biology of eelgrass has received a considerable amount of attention (Phillips, 1964; McRoy and Phillips, 1968), few studies have dealt with the basic quantitative measurements necessary to understanding the role of eelgrass in an ecosystem. The observations in this study include measurements of standing stock, caloric content, chlorophyll *a* concentration, turion density, and leaf size. (A turion consists of a stem and group of leaves growing from a prostrate rhizome; a plant may consist of many turions.)

This is not the first study of eelgrass standing stocks, although it is the first report of chlorophyll *a* concentrations and caloric contents of eelgrass. The earliest studies (Peterson and Boysen-Jensen, 1911; Boysen-Jensen, 1914) were concerned with eelgrass in Danish coastal waters. Other reports

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of standing stocks are from widely scattered areas of the Northern Hemisphere: Denmark, Great Britain, Soviet Union, Japan, and the United States (Grøntved, 1957, 1958; Zenkevitch, 1963; Vozzhinskaya, 1964; Kireeva, 1965; Burton, 1961, 1962; Kita and Harada, 1962; Conover, 1958; Moeller, 1964; Burkholder and Dohney, 1968).

There have been three studies of Pacific coast eelgrass populations. In Humboldt Bay, California, Keller (MS, 1963) and Keller and Harris (1966) examined the depth distribution of eelgrass biomass, and Waddell (MS, 1964) studied the effects of dredging for oysters on eelgrass standing stocks. In Alaska, McRoy (MS, 1966) studied the standing stock and ecology of eelgrass in Izembek Lagoon, an area that may well contain the largest single stand of eelgrass in the Northern Hemisphere.

One additional measurement made in this study was the amount of benthic algae present in the eelgrass beds. Few measurements of this type have been included in studies of eelgrass beds. Grøntved (1958) in his studies of the vegetation of Danish coastal waters included measurements of algae along with the sea grasses. Also Conover (1958) and Moeller (1964) included all species of marine macrophytes in their studies. Finally, several Soviet studies of benthic marine plants have included biomass estimates of all macrophytes present, algae and seagrasses (Shchapova and Vozzhinskaya, 1960).

METHODS

A sampler modified slightly from Grøntved (1957) was used to collect bottom samples having an area of 0.042 m^2. Samples were washed to remove sediments and sorted into leaves, roots and rhizomes, and algae. Eelgrass turions were then counted and each group was weighed separately for fresh weight (biomass). After drying for 24 hr at 90 C the samples were cooled in a desiccator and weighed again to determine dry weight. The dried samples were stored in plastic bags for further analyses. On additional samples, measurements were made of caloric content and chlorophyll *a* concentration.

Caloric contents were determined with a Parr oxygen bomb calorimeter. Samples were prepared by being ground to a fine powder, dried overnight at 60 C, and cooled in a desiccator; a subsample was then weighed and combusted. Ash weight of the sample was taken to be the residual weight after combustion. Data are expressed as calories per ash-free gram.

Chlorophyll *a* was measured in fresh leaves as outlined by Odum et al. (1958). Concentrations were calculated with the Richards and Thompson (1952) equations.

Turion density was calculated by counting vegetative and reproductive (flowering) turions in the bottom samples as previously noted.

Leaf sizes were measurements of length and width of all fresh leaves from several turions in each bottom sample. Leaf length was the distance from the leaf base to tip; width was measured midway between base and tip.

Bottom samples were collected from 10 bays and lagoons on the coast of Alaska. The areas were Klawak, Craig, and Calder Bay in southeast Alaska (April 1967); Redhead Lagoon, Sawmill Bay, and Stockdale Harbor in Prince William Sound (June 1967); Kinzarof and Izembek lagoons on the Alaska Peninsula (July 1967); and Safety Lagoon and Port Clarence on the Seward Peninsula (September 1967) (Fig. 1). Not all determinations were made in each area. Standing stock and caloric content were measured in all areas; chlorophyll *a* in Prince William Sound, the Seward Peninsula, and Izembek Lagoon; turion density in all areas outside of southeast Alaska; leaf length in all areas except Sawmill Bay, Kinzarof Lagoon, and the Seward Peninsula; and leaf width in all areas except Sawmill Bay and Kinzarof Lagoon.

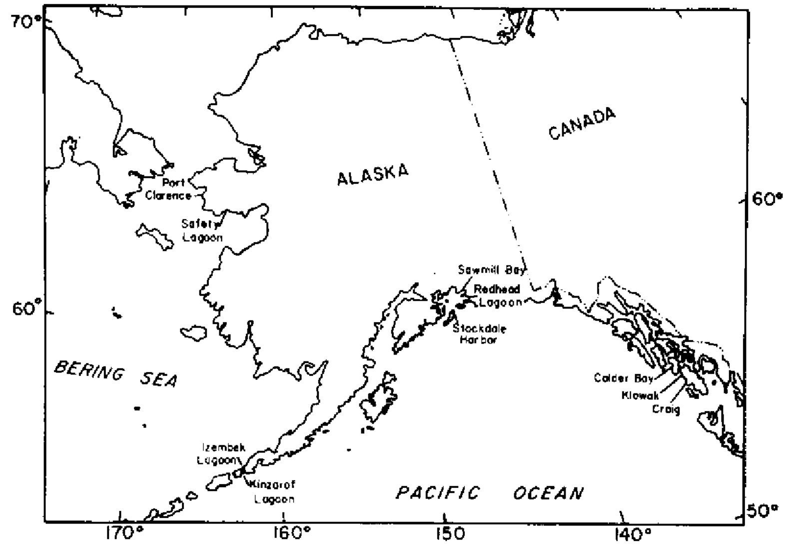


FIG. 1. Locations of the 10 eelgrass populations studied.

Observations were examined by analysis of variance techniques (Snedecor, 1956). Where the standard deviation was proportional to the mean a logarithmic transformation of the data was used after adding one to each datum.

RESULTS AND DISCUSSION

EELGRASS STANDING STOCK

In the 10 locations studied on the coast of Alaska the mean standing stock of eelgrass ranged from 62 to 1840 g dry wt/m^2, a 30-fold variation (Fig. 2). Standing stocks were highest in the two lagoons on the Alaska Peninsula and decreased in both directions away from the Peninsula. The values fell into three groups: those for Kinzarof and Izembek lagoons, averaging 1510 g wt/m^2; those for Safety Lagoon and Sawmill Bay, averaging 415; and those for the other areas, averaging 113.

Standing stocks of leaves and of roots and rhizomes resembled those for the total standing stock except that those for roots and rhizomes showed less geographical variation (Fig. 2). For all areas the roots and rhizomes averaged 35% of the total eelgrass standing stock. The standing stock of leaves fell into three groups: those for Kinazarof and Izembek lagoons, averaging 1047 g dry wt/m^2; those for Safety Lagoon and Sawmill Bay, averaging 296; and those for the others, averaging 57. The standing stocks of roots and rhizomes also fell into three groups: those for Kinzarof and Izembek lagoons, averaging 382; that for Craig, averaging 11; and those for all other areas, averaging 65.

The variation in standing stock in the 10 areas studied does not indicate a relation to the increasingly arctic environment that exists from southeast Alaska to the Seward Peninsula. It suggests that the standing stock depends

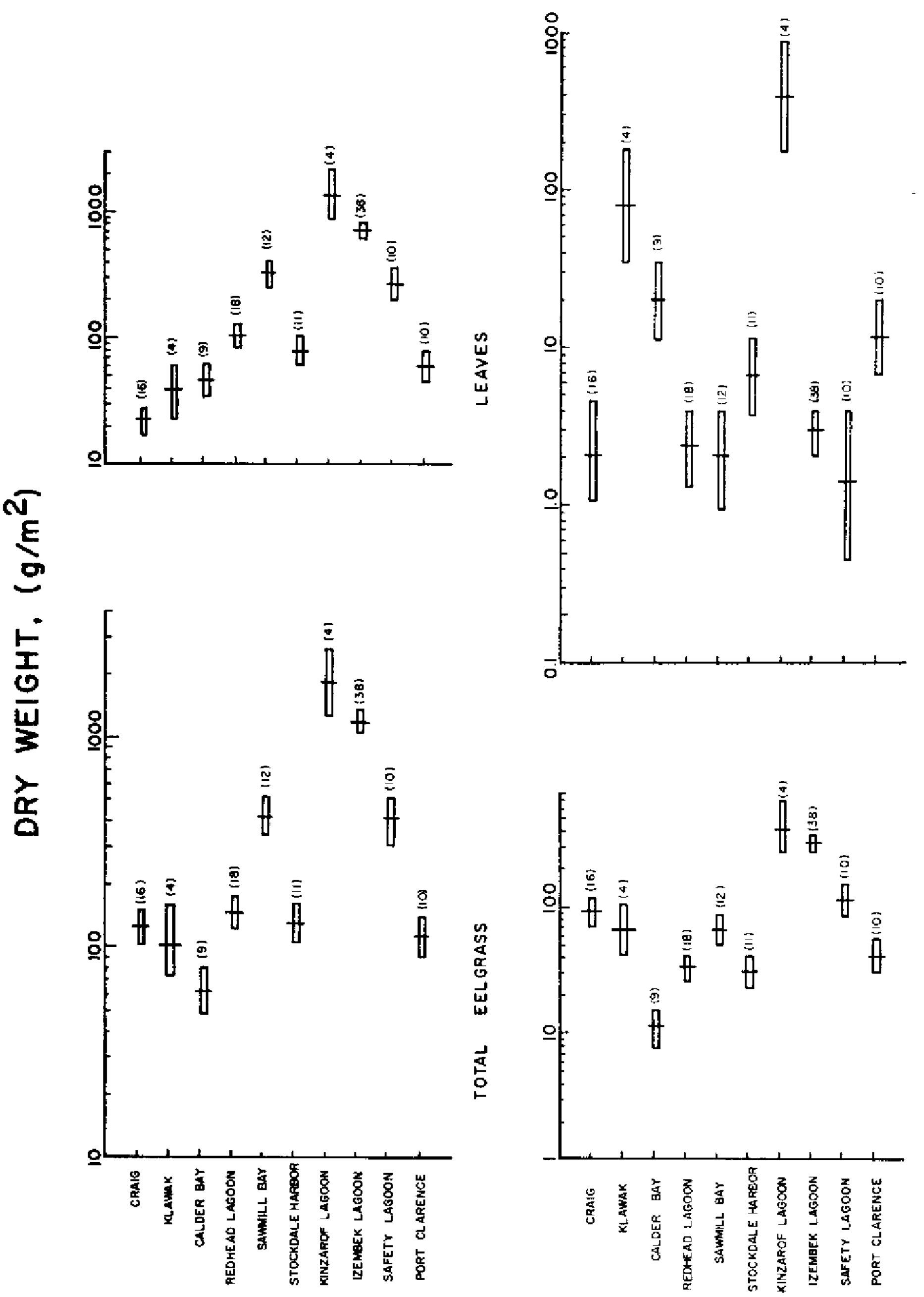


FIG. 2. Standing stocks of macrophytes for the 10 study areas; *upper left*, total eelgrass standing stock; *upper right*, eelgrass leaves standing stock; *lower left*, eelgrass roots and rhizomes standing stock; *lower right*, algae standing stock. A rectangle represents one standard error on each side of the mean; number of observations is given in parentheses.

on the conditions of the local environment. In addition, part of the variation can be attributed to different sampling times, although this effect was offset to some extent by the differences in latitude. The low values from southeast Alaska probably resulted from the early spring sampling.

On the basis of the mean standing stocks (Fig. 2) and the areas of eelgrass beds, as estimated from charts and aerial photographs, the total crops in the 10 areas were

Area	Craig	Klawak	Calder Bay	Redhead Lagoon	Sawmill Bay	Stockdale Harbor	Kinzarof Lagoon	Izembek Lagoon	Safety Lagoon	Port Clarence
Eelgrass area (*$m^2 \times 10^4$*)	26	4.3	51	45	97	45	871	17,000	910	420
Total crop (*metric tons $\times 10^3$*)	0.30	0.04	0.32	0.89	5.7	0.57	153	2,300	47	5

These estimates are based on fresh weights, which were found in the samples to have a 9 to 1 ratio to the dry weight.

The maximum standing stocks were all found in shallow lagoons. The low depth profile of these lagoons results in a great expansion of the eelgrass zone, and it is in these areas that the eelgrass community forms a meadow. Examples are Izembek, Kinzarof, and Safety lagoons and Sawmill Bay. In these areas the eelgrass beds are large, shallow tide pools that are exposed to optimum conditions of light and temperature during low tide (McRoy, MS, 1966). In bays with a steeper depth profile the eelgrass is limited to a narrow belt and has a less significant contribution to the littoral biomass. Examples are Craig, Klawak, and Port Clarence.

The range of standing stocks was similar to that in other areas (Table 1). Reported extremes of eelgrass standing stock are from 5 g dry wt/m^2 in Great Pond, Massachusetts to 2445 in Long Island Sound, New York; most reports are in the range of 100 to 1000 g dry wt/m^2. The (geometric) mean of the maximum values from all reports is 460 g dry wt/m^2. This average, approximately 0.5 kg/m^2, is probably good for eelgrass beds on a worldwide basis and could be used to characterize unknown areas. The value is about 2 to 5 times higher than the average biomass of benthic fauna on the continental shelf

TABLE 1. Eelgrass standing stock measurements (ranges) in the Northern Hemisphere.

Location	Standing stock (*dry weight, g/m^2*)	Source
New York	2445–133	Burkholder and Dohney (1968)
Alaska	1840–62	This study
Denmark	960–272	Petersen (1914)
Sakhalin Island (Bering Sea, USSR)	895–31	Vozzhinskaya (1964)
White Sea	550	Kireeva (1965)
Black Sea	550–166	Zenkevitch (1963)
Denmark	487–210	Grøntved (1957)
New Jersey	426–110	Moeller (1964)
California	421–32	Keller and Harris (1966)
Japan	235–70	Kita and Harada (1962)
England	120	Burton (1961)
Massachusetts	29–5	Conover (1958)

of the North Pacific Ocean (Zenkevitch, 1963); it is very similar to the standing stock of a *Macrocystis* kelp bed (McFarland and Prescott, 1959).

The variation in standing stock in Alaska and throughout the distribution of the species indicates that in most regions environmental conditions, including grazing, prevent accumulation of the maximum attainable standing stock. The very high value of nearly 2.5 kg/m^2 reported by Burkholder and Doheny (1968) must be close to the maximum possible for the species. At this standing stock eelgrass beds must be so dense that self shading becomes a major limitation to growth.

Algal Standing Stock

Algae composed 0.3–72% and averaged 14% of the total macrophyte standing stock in the eelgrass beds studied. As with eelgrass the standing stocks of algae fell into three groups (Fig. 2): that in Kinzarof Lagoon, averaging 393 g dry wt/m^2; those in Klawak, Calder Bay, Stockdale Harbor, and Port Clarence, averaging 28.5; and those in all other areas, averaging 2.4. In the areas with the lowest standing stocks the filamentous green alga *Chaetomorpha* sp. contributed practically all the biomass. In the other areas several larger species (*Fucus* sp., *Ulva* sp., and others) contributed the bulk of the algal biomass.

The amount of algae in the eelgrass beds varied with the bottom type, which also influenced the species of algae present. In all locations *Chaetomorpha* sp. occurred entangled in the eelgrass. Where the sediments were not well sorted, larger seaweeds were found attached to stones and the number of stones for places of attachment in an area dictated biomass. In well-sorted sediments only *Chaetomorpha* sp. was present.

By comparison, Moeller (1964) found that algae composed an average of 32% of the total macrophyte biomass in eelgrass beds in Barnegat Bay, New Jersey. In the only other possible comparison, Shchapova and Vozzhinskaya (1960) reported that algae were about 11% of the total macrophyte biomass in a region of Sakhalin Island in the Bering Sea.

Caloric Content

The mean caloric contents of eelgrass leaves (Fig. 3) ranged from 3950 to 4382 cal/ash-free g, and did not differ statistically ($P = 0.05$) between areas (Fig. 3). The mean for all areas was 4211. The mean caloric contents of the roots and rhizomes ranged from 3368 to 4047 cal/ash-free g, and did not differ statistically between areas. The mean for all areas was 3571. The average ash content of the 55 samples used in the caloric determinations was 20% of the dry weight. The caloric content of eelgrass indicates that the plant accumulates essentially carbohydrates (Thomas et al., 1960).

Chlorophyll *a* Concentration

With one exception the chlorophyll *a* concentrations in eelgrass leaves from all areas were similar (Fig. 4). The average concentrations are 1.20

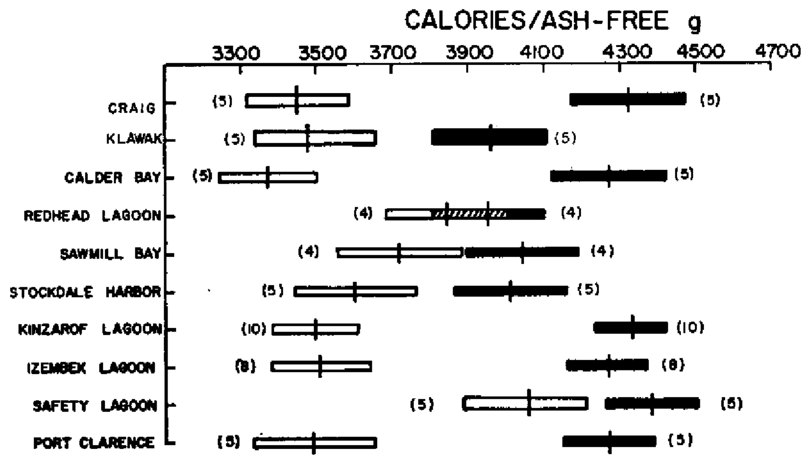


FIG. 3. Caloric contents of eelgrass leaves (solid) and roots and rhizomes (open) for the 10 locations. Data presented as in Fig. 2.

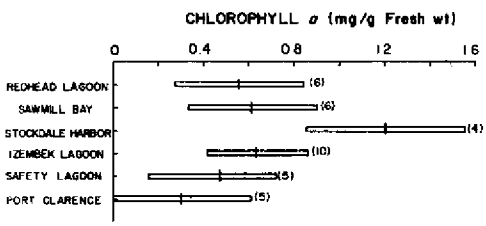


FIG. 4 Chlorophyll *a* concentrations in eelgrass leaves for six locations. Data presented as in Fig. 2.

mg/g fresh wt from Stockdale Harbor and 0.513 from all other areas. The high value from Stockdale Harbor is statistically different from all other areas but it appears to be anomalous. A high value could occur if epiphytes were not cleaned from the leaf.

The similarity of concentrations from the different latitudes indicates that eelgrass does not adapt to varying light conditions by changing the concentration of chlorophyll *a* in the leaf. That is, there do not appear to be sun-adapted and shade-adapted eelgrass plants in Alaska. Adaptation could occur, however, through a varying leaf size. The concentration in eelgrass is also similar to that reported for another sea grass, turtle grass (*Thalassia testudinum*), from Bermuda (Pomeroy, 1960) suggesting a general lack of light adaptation in sea grasses.

Combining the mean chlorophyll *a* concentration with the mean leaf biomass (Fig. 2) gives the amount of chlorophyll on a unit area basis. For the Alaska populations studied (eelgrass only) the range is 0.3–1.7 g chlorophyll a/m^2. This amount is close to the average (1.04) found by Gifford and Odum (1961) for seaweeds in the littoral zone at Woods Hole, Massachusetts. In addition McFarland and Prescott (1959) calculated that *Macrocyctis* in southern California contained 0.57–0.78 g chlorophyll a/m^2 and that the total kelp bed community had 0.69–0.92.

Turion Density

Two groups of total (vegetative + reproductive) turion density were found (Fig. 5): those from Prince William Sound and the Seward Peninsula averaged 599 turions/m^2, and those from the Alaska Peninsula averaged 4576. The reproductive (flowering) turions varied from 3.3 to 4.5% of the total. The two groups were those in Prince William Sound, averaging 20 reproductive turions/m^2, and those on the Alaska and Seward peninsulas, averaging 192.

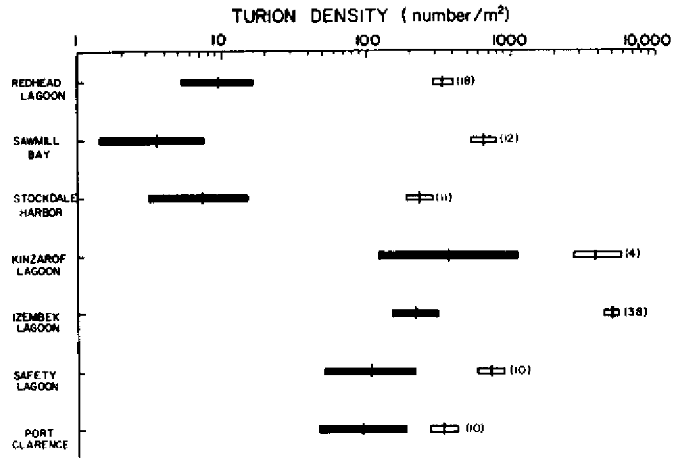


Fig. 5. Total turion densities (open) and flowering turion densities (solid) for seven locations. Data presented as in Fig. 2.

Turion density was directly related to standing stock (r = 0.82) and a regression equation can be used to predict standing stock from density (Fig. 6). The relation indicates that a high turion density also results in a high standing stock.

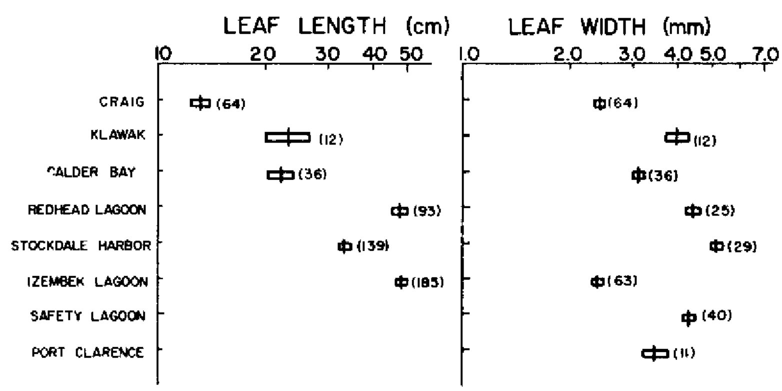


Fig. 6. Length and width of eelgrass leaves for eight locations. Data presented as in Fig. 2.

LEAF SIZE

The leaves of eelgrass can be placed into three groups on the basis of width (Fig. 7): those from Craig and Izembek Lagoon, averaging 2.38 mm; those from Klawak, Calder Bay, Redhead Lagoon, Safety Lagoon, and Port Clarence, averaging 3.80; and those from Stockdale Harbor, averaging 5.11.

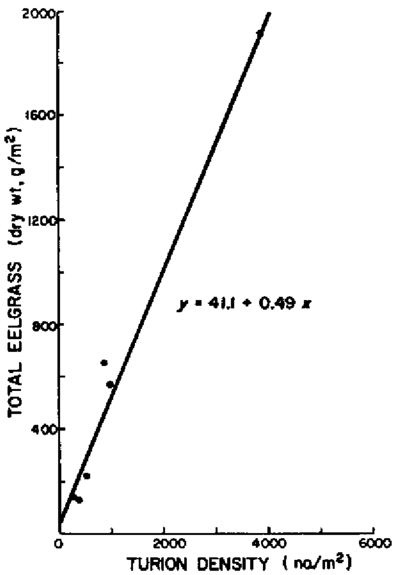
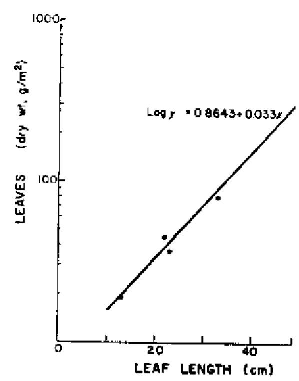


FIG. 7. Linear regression of means of total eelgrass standing stock to total turion density for seven eelgrass populations.

Mean leaf length ranged from 13 cm in Craig to 48 cm in Izembek Lagoon (Fig. 7). Similarities occurred between leaves from Izembek and Redhead lagoons and between Klawak and Calder Bay.

A rapid estimate of the standing stock of eelgrass in a new area is possible from the relation between the length and dry weight of leaves (Fig. 8). These features are highly correlated ($r = 0.88$), but the regression equation needs further substantiation, especially for seasonal differences, to evaluate its general application.

FIG. 8. Linear regression of leaf width to leaf length for six eelgrass populations.



PRODUCTIVITY

Individual standing stock measurements of eelgrass do not provide an estimate of productivity or production capacity (Westlake, 1965). In a previous study (McRoy, MS, 1966), I measured the productivity of eelgrass in Izembek Lagoon using changes in dissolved oxygen in light and dark bottles. These measurements when applied to the standing stock in Izembek Lagoon yield rates of net productivity of 1.46 g O_2/m^2 per hr or 0.55 g C/m^2 per hr. In a 15-hr day the net production would be 8 g C/m^2 or 27 g dry wt/m^2. Turnover based on this rate would be about 2% per day. This estimate is consistent with that of Petersen (1914) who doubled the maximum standing stock to approximate the annual production of eelgrass in Danish coastal waters.

ACKNOWLEDGMENTS

The assistance of Dr J. Goering and Mrs R. Nauman, University of Alaska, Dr T. S. English, University of Washington, and Mr R. D. Jones, Jr., U.S. Fish and Wildlife Service, is most gratefully appreciated. This study was supported by the Arctic Institute of North America under contractual agreements with the Office of Naval Research, the Federal Water Quality Administration, the National Science Foundation Grant GB7800, and the Institute of Marine Science, University of Alaska.

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MARINE PLANT RESOURCES OF ALASKA

C. PETER McROY

Thousands of miles of rocky coast of Alaska support an abundance of seaweeds that are the potential for a new northern industry offering a technological challenge to engineers. Seaweeds are currently harvested in California, along the Atlantic coast of Canada and the United States, in Japan and numerous other countries. A new seaweed processing plant is under development in British Columbia. One use of marine plants exists in Alaska. In Southeast Alaska, the giant kelp, **Macrocystis**, when covered with herring spawn is collected and sold to the Japanese as a food delicacy. The potential for other types of seaweed utilization appears large.

Seaweeds are algae, they lack roots and the vascular system of terrestrial plants but their holdfast permits them to exploit hard rock surfaces and even withstand a battering surf. The chemistry of these plants also differs greatly from that of the land plants. Many species produce, through metabolism, gelatinous compounds and herein lies much of their commercial value. Although in some countries seaweeds are eaten directly, in the United States they are valued for their chemical extracts. Two major groups of seaweeds, the browns and the reds, are important to industry. Conveniently color coded, color in this instance indicates a biological relationship among the species within each group.

The brown seaweeds (**Phaeophyceae**) are a group of intertidal and subtidal algae that epitomize the common notion of seaweeds. This group includes the kelps of which **Macrocystis, Nereocystis, Alaria**, and **Laminaria** are abundant and important species in Alaska. Kelp beds are features of the temperate and higher latitudes of the world ocean, exclusive of the tropics. Some species, such as **Alaria**, common in Cook Inlet, grow to 70 feet long. Also among the brown seaweeds is the ubiquitous rockweed of northern coasts, **Fucus**. The brown algae attain very high standing crops, up to 20 kg/m^2 in Alaska. An early 1912-14 survey of kelp by the U.S. Department of Agriculture estimated more than 10 million tons grew on the Pacific coast of Alaska (Table 1). I would guess that this quantity exists today since most of the coast remains unpolluted.

Kelp was once harvested for its potash and iodine, but today the most valuable products are algins. Algins are a group of compounds that have a remarkable water absorbing quality. They are used as thickening, stabilizing, emulsifying, gel-forming, or film-forming colloids in numerous industries—foods, pharmaceuticals, drugs and antibiotics, paint, cosmetics, printing and several others. Every bowl of ice cream, all powdered milk products and all beer contain a little seaweed.

The red seaweeds, **Rhodophyceae**, are smaller, less obvious inhabitants of the lower intertidal to deep subtidal. Some of the important Alaska species include the intertidal **Gigartina, Iridaea, Porphyra**, and **Prionitis** and the subtidal **Schizymenia, Rhodomenia, Callophyllis**, and **Dasyopsis**. All these plants have leaflike bodies that are red, brownish-red, or purple, and occur in dense coverings on rocks, reaching standing crops of 5 kg/m^2. No measure of total crops in Alaskan waters is available; a fair estimate might be 2 million tons.

Red algae are valued for their agar, which is a group of gelatinous compounds used widely in the medical, food, textile, paper, film, tanning, and other industries. Japan is currently the major world supplier of this material. The slicing quality of cheese is improved by agar additive.

With the exception of the herring eggs on Macrocystis, no current utilization of seaweeds exists in Alaska. As background for the industry that is sure to come, the Institute of Marine Science of the University of Alaska through the National Sea Grant Program began a study in the summer of 1970 of the distribution and abundance of seaweeds in Alaska. This research will provide the basic information on the regions and species available for harvest.

Although distribution and abundance seem like rather simple information to acquire, in practice they require some of the latest developments of ocean technology, especially when the entire Alaska coast is the goal. In current work scuba divers coupled with underwater television are the basic data acquisition system. More traditional trawls and grabs have only limited application. In the future we also hope to use satellite imagery with infrared photos to map intertidal and surface floating species over large areas of the coast. There appears to be considerable technological opportunity in developing

Region	Tons
Western Alaska	2,437,000
Southeast Alaska	7,833,000
Puget Sound	397,500
Puget Sound to Pt. Conception	4,377,400
Pt. Conception to San Diego	9,000,000
San Diego to Cedros Island	8,500,000

Table 1 Standing Stocks of Kelp on the American Pacific Coast (USDA, 1915)

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equipment for the rapid survey of shallow water areas, especially for tools that can be used in quantitative work. In general, available undersea cameras and related devices are for use from vessels and cannot be used in continuous surveys from the beach to deeper water. Scuba divers help but are limited to very small areas and need large amounts of time. The growing need for seaweeds in the world will before long make it economically reasonable to apply considerable technological effort toward seaweed survey equipment.

The development of a seaweed industry in Alaska awaits the solution of one other problem, the development of harvesting equipment suitable for the Alaska coast. The range of tides and depths of valuable algae species are, to considerable extent, features of a local geographical area. Techniques used on the Atlantic Coast and in California are not generally applicable to Alaska. While industry may not follow right on the heels of the University's research, the growing demand coupled with a diminishing supply (largely due to pollution) cannot keep it out of Alaska; the technological challenge to engineers to develop the equipment for the seaweed industry appears unlimited.

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Seaweed—Undeveloped Marine Resource

By C. PETER McROY

Seaweeds are one more undeveloped marine resource of the rich, extensive Alaska coast. Seaweed industries currently exist in California, the Atlantic coast of Canada and the United States, Japan, and numerous other countries. In addition a new seaweed processing plant is currently being developed in British Columbia. Only one use of seaweeds currently exists in Alaska; in a restricted area of Southeast, the giant kelp, *Macrocystis*, covered with herring spawn, is collected and sold to the Japanese as a food delicacy. A great potential exists for other types of seaweed utilization in Alaska.

Seaweeds are algae, a distinction that makes them very different from the common terrestrial plants. Their lack of roots but development of a holdfast permits them to exploit rock surfaces, a feat impossible for a rooted plant. Even in the face of a battering surf seaweeds tenaciously cling to smooth rock surfaces. The internal structure and chemistry are also quite different from the land plants. They are without a vascular system, a character typical of all land plants, that transports fluids and materials internally. In addition their metabolic products include a variety of gelatinous materials and herein lies much of their commercial value. Although in some countries seaweeds are eaten directly, in the United States they are valued for their chemical extracts.

There are two major groups of seaweeds that are valuable to industry. These are called the "browns" and the "reds" because of their color but in this case the color is indicative of a biological relationship among the species within each group.

The brown seaweeds (Phaeophyceae) are a group of intertidal and sublittoral plants that epitomize the common

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PERSONNEL of the Institute of Marine Science surveying seaweeds in Prince William Sound. The rocks in the foreground have a dense covering of the common rockweed or *Fucus*.

notion of the term seaweed. This group includes the kelps of which *Macrocystis*, *Alaria*, and *Laminaria* are the abundant and important species in Alaska. Some of these, such as *Alaria* common in Cook Inlet, grow to be 70 feet long. Also included in the brown seaweeds is the ubiquitous rockweed of the Alaska coast, *Fucus*. These algae attain very high standing crops, probably up to 40 lbs per square yard in Alaska. An early 1912-14 survey of kelp in Alaska by the U. S. Department of Agriculture estimated that more than 10 million tons grew on the Pacific coast of Alaska. I would guess that this quantity exists today since much of the coast is still unpolluted.

The kelps were once harvested for their content of potash and iodine, but today the most important products are algins. Algins are a group of compounds that have a remarkable water absorbing quality. They are used as thickening, stabilizing, emulsifying, gel-forming, or film-forming colloids in numerous industries — foods, pharmaceuticals, drugs and antibiotics, paint, cosmetics, printing and several others. Every bowl of ice cream contains a little seaweed.

The red seaweeds (Rhodophyceae) are smaller, less obvious inhabitants of the lower intertidal to deep sublittoral. Some of the most important species in Alaska are the intertidal *Gigartina*, *Iridaea*, *Porphyra*, and *Prionitis* and the sublittoral *Rhodymenia*, *Callophyllis*, and *Dasyopsis*. All these plants have a leaf-like body that is red, brownish-red, or purple. They can occur in dense coverings of rocks and reach a standing crop of 10 lbs. per square yard. No measure of the total crops in Alaskan waters is available; a fair estimate might be 2 million tons.

The principle product extracted from the red algae is agar. This is a group of gelatinous compounds that are widely used in the medical, food, textile, paper, film, tanning, and a variety of other industries. Japan is currently the major supplier of this material. The slicing quality of cheese is improved by an agar additive.

With the exception of the herring eggs on kelp there is no utilization of seaweeds in Alaska. Yet we know from cursory surveys by the Institute of Marine Science of the University of Alaska that seaweeds exist in great abundance in many areas of the Alaska coast. I estimate the approximate worth of this seaweed crop in Alaska to be about $200 million. Industry has already indicated an interest in Alaska but the development of this as a raw material awaits the solution of numerous problems.

Before any development can begin a basic study of the distribution, abundance, and content of extractives of seaweeds in Alaska must be made. Rising to this need, the Institute of Marine Science under the sponsorship of the National Sea Grant Program will initiate in summer 1970 a study of the seaweeds of Alaska and their potential for industry. While industry may not follow right on the heels of the University's research, the needs of a growing demand coupled with a diminishing supply (largely due to pollution) cannot keep them out of Alaska. I do not envision Alaskans ever sitting down to a steaming plate of strange looking, rubbery red and brown seaweeds but, since seaweed products are used in everything from shoe polish to beer, just try to avoid them.

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APPENDIX I

Check List of Subarctic Marine Macrophytes on the Coast of Alaska.

CHECK LIST OF SUBARCTIC MARINE MACROPHYTES ON THE COAST OF ALASKA

CHLOROPHYTA

101	*Blidingia minima*
102	*minima v. minima*
103	*minima v. ramifera*
104	*minima v. subsalsa*
201	*Chaetomorpha canabina*
202	*melagonium*
203	*sp.*
301	*Cladophora flexuosa*
302	*glaucescens*
303	*stimpsonii*
304	*sp.*
401	*Codiolum petrocelidis*
501	*Codium fragile*
502	*ritteri*
503	*setchellii*
601	*Derbesia marina*
602	*vaucheriaeformis*
701	*Enteromorpha clathrata*
702	*compressa*
703	*compressa v. compressa*
704	*groenlandica*
705	*intestinalis*
706	*intestinalis f. clavata*
707	*intestinalis f. cylindracea*
708	*intestinalis f. intestinalis*
709	*intestinalis f. maxima*
710	*linza*
711	*micrococca*
712	*prolifera*
713	*ramulosa*
714	*sp.*
801	*Halicystis ovalis*
802	*sp.*
901	*Lola lubrica*
1001	*Monostroma arcticum*
1002	*areolatum*
1003	*fuscum*
1004	*fuscum v. fuscum*
1005	*fuscum v. splendens*
1006	*grevillei*
1007	*grevillei v. gtevillei*
1008	*oxyspermum*
1009	*sp.*
1101	*Percursaria percursa*
1201	*Prasiola borealis*
1301	*Rhizoclonium implexum*
1302	*riparium*
1303	*tortuosum*

1304	*sp.*
1401	*Rosenvingiella sp.*
1501	*Spongomorpha arcta*
1502	*coalita*
1503	*mertensii*
1504	*saxatilis v. chamissonis*
1505	*saxatilis v. saxatilis*
1506	*spinescens*
1507	*sp.*
1601	*Ulothrix flacca*
1602	*implexa*
1603	*laetevirens*
1604	*pseudoflacca f. maxima*
1605	*sp.*
1701	*Ulva fenestrata*
1702	*lactuca*
1703	*latissima*
1704	*rigida*
1705	*sp.*
1801	*Uorspora grandis*
1802	*mirabilis*
1803	*penicilliformis*
1804	*sp.*

PHAEOPHYTA

2501	*Agarum cibrosum*
2601	*Alaria crispa*
2602	*dolichorhachis*
2603	*fistulosa*
2604	*marginata*
2605	*nana*
2606	*praelongia*
2607	*pylaii*
2608	*valida f. valida*
2609	*sp.*
2701	*Analipus filiformis*
2801	*Chorda filum*
2901	*Chordaria flagelliformis*
2902	*gracilis*
3001	*Coilodesme bulligera*
3002	*cystoseirae*
3003	*fucicola*
3101	*Colpomenia peregrina*
3102	*sinuosa f. sinuosa*
3103	*sinuosa f. tuberculata*
3201	*Compsonema sporangiiferum*
3301	*Costaria costata*
3302	*mertensii*
3401	*Cymathere triplicate*
3501	*Cystoseira geminata*
3601	*Delamarea attenuata*
3701	*Desmarestia herbacea*
3702	*intermedia*

3703 *media v. tenius*
3704 *viridis*
3705 *sp.*
3801 *Desmotrichum undlatum*
3901 *Dictyosiphon foeniculaceus*
4001 *Ectocarpus confervoides f. confervoides*
4002 *corticulatus*
4003 *pygmaeus*
4004 *terminalis*
4005 *tomentosus*
4006 *sp.*
4101 *Elachista fucicola*
4102 *fucicola f. lubrica*
4201 *Eudesme virescens*
4301 *Fucus distichus*
4302 *distichus spp. edentatus*
4303 *distichus spp. evanescens*
4304 *inflatus*
4401 *Giffordia sp.*
4501 *Haplogloia andersonii*
4502 *kuckuckii*
4601 *Hedophyllum sessile*
4701 *Heterochordaria abietina*
4801 *Laminaria cunefolia*
4802 *cunefolia f. amplissina*
4803 *cunefolia f. cunefolia*
4804 *dentigera*
4805 *groenlandica*
4806 *longipes*
4807 *platymeris*
4808 *saccharina*
4809 *saccharina f. linearis*
4810 *saccharina f. membranacea*
4811 *setchellii*
4812 *yezoensis*
4813 *sp.*
4901 *Leathesia difformis*
5001 *Lessoniopsis littoralis*
5101 *Macrocystis integrifolia*
5201 *Myelophycus intestinale*
5301 *Myrionema foecundum f. simplicissimum*
5302 *globosum f. affine*
5303 *primarium*
5304 *strangulans*
5401 *Nereocystis lutkeana*
5501 *Petalonia debilis*
5502 *fascia*
5601 *Pilayella littoralis*
5701 *Pleurophycus gardneri*
5801 *Punctaria lobata*
5802 *sp.*
5901 *Ralfsia fungiformis*
5902 *pacifica*
6001 *Saundersella simplex*
6101 *Scytosiphon bullosus*

6102	*lomentaria f. lomentaria*
6201	*Soranthera ulvoidea f. ulvoidea*
6202	*ulvoidea f. difformis*
6301	*Sphacelaria racemosa*
6302	*subfuca*
6401	*Stictyosiphon tortilis*
6501	*Streblonema pacificum*
6601	*Thalassiophylum clathrus*

RHODOPHYTA

8001	*Acrochaetium sp.*
8101	*Ahnfeltia plicata*
8201	*Amplisiphonia pacifica*
8301	*Antithamnion floccossum*
8302	*nigricans*
8303	*occidentale*
8304	*shimamuranum*
8305	*subulatum*
8306	*uncinatum*
8307	*sp.*
8401	*Asterocolax hypophyllophila*
8501	*Bangia fuscopurpurea*
8502	*sp.*
8601	*Bossiella frondescens*
8602	*sp.*
8701	*Botryoglossum farlowianum v. farlowianum*
8801	*Callithamnion californicum*
8802	*biseriatum*
8803	*pikeanum v. pikeanum*
8804	*sp.*
8901	*Callophyllis edentata*
8902	*flabellulata*
8903	*sp.*
9001	*Ceramium codicola*
9002	*pacificum*
9003	*rubum*
9004	*sp.*
9101	*Cirrulicarpus gmelini*
9201	*Clathromorphum circumscriptum*
9301	*Constantinea rosa-marina*
9302	*sp.*
9401	*Corallina officinalis*
9402	*officinalis v. chilensia*
9403	*officinalis v. vancouveriensis*
9404	*pilulifera*
9405	*sp.*
9501	*Cryptosiphonia woodii*
9601	*Delesseria decipiens*
9701	*Dilsea calfornica*
9801	*Dumontia filiformis*
9802	*simplex*
9901	*Endocladia muricata*
10001	*Erythrotrichia kylinii*

10101	*Euthora fruticulosa*
10201	*Farlowia mollis*
10301	*Fauchea laciniata*
10302	*laciniata f. pygamea*
10401	*Gigartina cristata*
10402	*pacifica*
10403	*papillata*
10404	*sitchensis*
10405	*unalaschcensis*
10406	*sp.*
10501	*Gloiopeltus furcata*
10601	*Gloisiphonia californica*
10602	*verticillaris*
10701	*Grateloupia pinnata*
10801	*Gracilaria verrucosa*
10901	*Halosaccion glandiforme*
10902	*ramentaceum*
10903	*tilesii*
11001	*Heterosiphonia sp.*
11101	*Heterochordaria abientina*
11201	*Heteroderma nicholsii*
11301	*Hildenbrandia occidentalis*
11302	*prototypus*
11401	*Hymenena ruthenica*
11501	*Hypophyllum dentatum*
11502	*ruprechtianum*
11601	*Iridaea cornucopiae*
11602	*heterocarpa*
11603	*whideyana*
11604	*sp.*
11701	*Kallymenia oblongifructa*
11801	*Laingia aleutica*
11901	*Laurencia spectibilis*
12001	*Lithothamion sp.*
12101	*Membranoptera dimorpha*
12102	*serrata*
12103	*setchellii*
12104	*spinulosa*
12105	*weeksiae*
12106	*sp.*
12001	*Microcladia borealis*
12301	*Myriogramme kjellmanianum*
12401	*Nemalion helminthoides*
12501	*Neoptilota asplenioides*
12601	*Nienburgia prolifera*
12701	*Nitophyllum mirabile*
12801	*Odonthalia dentata*
12802	*floccosa*
12803	*kamtschatica*
12804	*lyallii*
12805	*sp.*
12901	*Opuntiella californica*
13001	*Pachyarthron cretaceum*
13101	*Pantoneura jurgensii*
13201	*Petrocelis franciscana*

13202 *middendorffii*
13301 *Phycodrys riggii*
13302 *amchitkensis*
13401 *Platythamnion villosum*
13402 *sp.*
13501 *Plocamium tenue*
13601 *Polyporolithon reclinatum*
13701 *Polysiphonia collinsii*
13702 *collinsii v. deliquescens*
13703 *mollis*
13704 *pacifica*
13705 *pacifica v. delicatala*
13706 *pacifica v. determinata*
13707 *pacifica v. pacifica*
13708 *synderae*
13709 *urceolata*
13710 *urceolata f. urceolata*
13711 *sp.*
13801 *Porphyra amplissima*
13802 *gardneri*
13803 *laciniata*
13804 *laciniata v. umbilicalis*
13805 *minata*
13806 *minata f. cuneformis*
13807 *nereocystis*
13808 *perforata*
13809 *perforata f. perforata*
13810 *perforata f. segregata*
13811 *pseudolinearis*
13812 *tasa*
13813 *tenuissima*
13814 *unbilicalis*
13815 *sp.*
13901 *Prionitis lanceolata*
14001 *Pterosiphonia arctica*
14002 *bipinnata*
14003 *bipinnata v. bipinnata*
14004 *gardneri*
14005 *sp.*
14101 *Ptilota asplenioides*
14102 *densa*
14103 *filicina*
14104 *hypnoides*
14105 *pectinata*
14106 *tenuis*
14107 *sp.*
14201 *Pugetia fragilissima*
14301 *Rhodochorton penicilliforme*
14302 *purpureum*
14401 *Rhodoglossum pulchra*
14402 *sp.*
14501 *Rhodomela larix*
14502 *lycopodioides*
14601 *Rhodymenia palmata*
14602 *palmata f. mollis*

14603	*palmata f. palmata*
14604	*pertusa*
14605	*sp.*
14701	*Schizymenia borealis*
14702	*pacifica*
14703	*sp.*
14801	*Sphacelaria racemosa*
14802	*subfusca*
14901	*Tenarea dispar*
15001	*Tokidadendron bullata*
15101	*Turnerella mertensiana*
15201	*Yendonia crassifolia*
15301	*Zinovaea acanthocarpa*

SPERMATOPHYTA

17501	*Phyllospadix scouleri*
17502	*serrulatus*
17503	*torreyi*
17601	*Zostera marina*