Prepared in cooperation with the U.S. Fish and Wildlife Service

Eelgrass (*Zostera marina*) and Seaweed Abundance along the Coast of Togiak National Wildlife Refuge, Alaska, 2008–10

Open-File Report 2020–1114

U.S. Department of the Interior
U.S. Geological Survey

Cover: A photosomatic image showing channels in one of the embayments in this study: Chagvan Bay, Togiak NWR, Alaska.

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Contents

Figures

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
gram dry weight per square meter	0.000205	pound per square foot (lbs/ft^2)
	Flow rate	
meter per year (m/yr)	3.281	foot per year (ft/yr)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Datums

Vertical coordinate information is referenced to the1984 World Geodetic System (WGS84).

Horizontal coordinate information is referenced to the referenced to the 1927 North American Datum (NAD27).

Abbreviations

BB	Braun-Blanquet
GPS	global positioning system
TNWR	Togiak National Wildlife Refuge

Eelgrass (*Zostera marina*) and Seaweed Abundance along the Coast of Togiak National Wildlife Refuge, Alaska, 2008–10

By David H. Ward[1], Kyle R. Hogrefe[1], Michael A. Swaim[2], Tyrone F Donnelly[1], and Lucretia L. Fairchild[3]

Abstract

We conducted a point-sampling survey to determine eelgrass (*Zostera marina*) and seaweed abundance in coastal waters adjacent to Togiak National Wildlife Refuge, Alaska, in July 2008–10. Eelgrass was known to be abundant in protected embayments of the southeastern Bering Sea and near the Togiak National Wildlife Refuge, but prior to this study, no systematic ground surveys had been conducted in these areas. We determined mean aboveground biomass of eelgrass to be highly variable among years observed, ranging from 32–72 grams dry weight per square meter (g/m^2) during successive years in Nanvak Bay and among the studied embayments in 2010: 47±4 g/m^2 in Nanvak Bay, 69±7 g/m^2 in Chagvan Bay, and 74±15 g/m^2 in Goodnews Bay. Seaweed density, abundance, and frequency scores were also highly variable among years and among embayments and were lower for seaweeds than for eelgrass in Nanvak and Chagvan bays, but not in Goodnews Bay. For all bays, mussels (*Mytilus* spp.) and gastropods were the most common macro-invertebrates detected during surveys, whereas sea stars, crabs, and sponges were not observed in the embayments.

Introduction

Seagrasses support a rich diversity of marine and terrestrial fauna and play an essential role in the health of estuarine and coastal ecosystems because of their high productivity, stabilization and enrichment of sediments, and support of a complex trophic web (Hemminga and Duarte, 2000). A significant portion of the eastern Bering Sea economy depends on marine resources (Weiland and others, 2003). Alaska's coastal human population relies on the health and continued productivity of the estuarine ecosystem.

The status and trends in the abundance and distribution of the seagrass species eelgrass (*Zostera marina*) is largely unknown in the coastal waters of the eastern Bering Sea, yet this seagrass is likely the dominant marine plant in the region (Winfree, 2005). Regular assessments have been made for Izembek Lagoon (Ward and Amundson, 2019), but few assessments have been conducted elsewhere in southwestern Alaska. Therefore, we initiated a study to obtain baseline information about the distribution and abundance eelgrass habitat within tidal land areas

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adjacent to the Togiak National Wildlife Refuge (TNWR) in southwestern Alaska. Ward and others (2022) presented the results of a mapping assessment to determine the spatial extent of eelgrass in 13 embayments along the coast of TNWR. In this report, we assess the abundance of eelgrass and presence of associated seaweeds and macro-invertebrates in Nanvak, Chagvan, and Goodnews bays (fig. 1). These three protective embayments contain about half of the total spatial extent of eelgrass in this region (Ward and others, 2022) and are important staging areas for waterbirds, particularly waterfowl in spring and fall. Nanvak and Chagvan bays are part of the Cape Newenham State Game Refuge administered by the Alaska Department of Fish and Game.

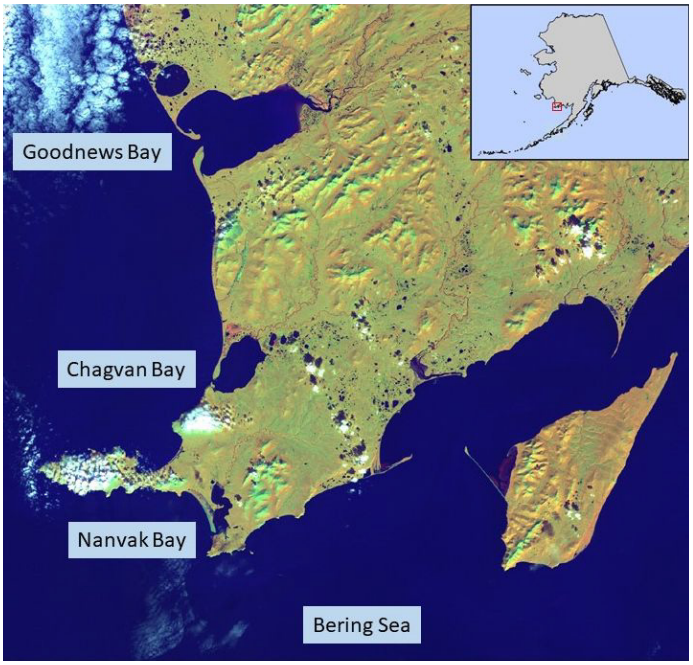

Figure 1. Location of Nanvak, Chagvan and Goodnews bays in Alaska.

Methods

Eelgrass Surveys

Abundance of eelgrass was assessed adjacent to TNWR in Nanvak Bay in 2008–10 and at Chagvan and Goodnews bays in 2010. The assessments were made during the seasonal peak of eelgrass biomass in July of each year using a point sampling approach where points were evenly distributed across the spatial extent of eelgrass in each of the bays. Points were located by boat using a Global Positioning System (GPS) unit and sampled while snorkeling in dry suits during high tide. At each point, we measured water temperature, salinity, and water depth, identified substrate type (for example, mud, sand or cobble), estimated substrate depth and percent cover of eelgrass and seaweeds, and determined the presence or absence of invertebrates: mussels (*Mytilus* spp), sponges, sea stars *(Pisaster* and *Evasterias* spp,), gastropods, and *Telmessus* crabs within four, 0.25 square meter (m^2) quadrats. The quadrats were positioned 1–4 meters (m) from the GPS point in the four cardinal directions, thereby defining a sampling area of 4–64 m^2 centered on the point. Cover was defined as the portion of the quadrat area obscured by eelgrass and seaweeds while viewed from above. Eelgrass was assessed to an approximate depth of 2.5 m below mean lower low water, the approximate maximum depth of eelgrass in these lagoons. If eelgrass was present in a quadrat, 10 representative shoots were collected and measured for shoot length and width. If seaweeds were present, we estimated the percent cover for all species combined and for the dominant seaweed genus within each of the four quadrats. Seaweeds were identified in the field or samples were collected and later identified by Dr. Sandra Lindstrom of the University of British Columbia (Ward, 2021; Ward and others, 2022).

Analyses

To minimize observer differences in estimates of eelgrass and seaweed cover, we assigned a cover score between 0 and 5 based on the Braun-Blanquet (BB) visual estimation technique (Braun-Blanquet, 1972) where cover scores are assigned as follows: 0 percent =0, 1–5 percent =1, 6–25 percent =2, 26–50 percent =3, 51–75 percent =4, and 76–100 percent =5. From these cover estimates we computed three BB scores for eelgrass and seaweed (all seaweeds combined) density, abundance and frequency of occurrence following Fourqurean and others, (2001). For eelgrass, we also calculated an abundance index by multiplying the BB score by shoot length (in centimeters) of eelgrass. Estimates were based on the average of the four quadrats sampled at a point.

We created maps of eelgrass density (percent cover) and abundance (aboveground biomass) for Nanvak and Chagvan bays using the inverse distance weighted interpolation (Valley and others, 2005). Maps were not made for Goodnews Bay because of an incomplete survey of the entire bay, but estimates of eelgrass density and abundance were calculated based on point sampling in the southwest portion of this bay. To determine annual aboveground biomass of eelgrass each year we collected shoots from calibration quadrats (Nanvak 2008–10, n=23–25; Chagvan 2010, n=23; Goodnews 2010, n=6) that were placed across a range of water depths in an eelgrass bed located near the entrance of each of the bays. Within each quadrat, we estimated percent cover of eelgrass and seaweeds, assigned a BB score, and collected five to ten of the aboveground portions of representative eelgrass shoots that were later measured for shoot length from meristem to tip of longest leaf in centimeters (cm), and shoot width in millimeters (mm). These shoots were dried to constant mass at approximately 50 degrees Celsius (°C) and weighed in grams (g). We calculated an abundance index for each quadrat, used linear regression to determine the relationship between the abundance index and aboveground biomass of eelgrass in the quadrat, and scaled results to grams dry weight per meter squared (g/m^2). We then back calculated aboveground biomass of eelgrass at each sampled point using the estimated abundance index and the regression formula. Averages and standard errors are provided unless otherwise indicated. All data generated in this study can be found in Ward (2021) and Ward and Hogrefe (2022).

Results and Discussion

Nanvak Bay

Eelgrass meadows compose approximately 46 percent of the total area of Nanvak Bay (Ward and others, 2022; fig. 1). This bay was characterized by low water temperature, low salinity, and a soft bottom substrate (table 1). The average surface temperature for all years was

11.3±0.7 (°C; range =7–14 °C) in Nanvak Bay, with coldest temperatures found near the mouth of the Slug River and at the entrance of the bay. The average surface salinity was 22±0.2 parts per thousand (ppt; range =1–31 ppt) with the lowest levels near the mouth of the Slug River in the back portion of the bay and the highest levels in the front portion of the bay (see fig. 2). Water clarity was lower in the back of the bay due to re-suspension of fine sediments and stratification of fresh and salt water. The average composition of the substrate was 75 percent fine (mud) sediments, 15 percent sand, and 10 percent cobble.

Table 1. Annual samples size (n) and mean and standard error (SE) of measurements of physical parameters and abundance of eelgrass (*Zostera marina*) and seaweeds in Nanvak Bay, Alaska, July 10–19 2008, July 23–27, 2009, and July 14–17, 2010.

[No data was collected on shoot width in 2010; °C, degree Celsius; ppt, part per thousand; cm, centimeter; g/m^2, gram dry weight per square meter; mm, millimeter; ND, no data]

Property	2008		2009		2010	
	n	Mean (SE)	n	Mean (SE)	n	Mean (SE)
Physical parameters						
Water temperature (°C)	116	10.10 (0.11)	99	12.19 (0.04)	62	11.10 (0.13)
Salinity (ppt)	109	19.23 (0.58)	99	20.97 (0.74)	62	25.80 (0.71)
Water depth (cm)	115	68.50 (3.51)	99	89.68 (3.31)	61	88.20 (5.13)
Substrate depth (cm)	75	12.73 (1.18)	99	14.37 (1.05)	55	13.50 (7.83)
Seagrass (*Zostera marina*)						
Aboveground biomass (g/m^2)	118	32.19 (3.50)	96	71.55 (6.77)	58	46.59 (4.46)
Seagrass vegetative shoots (BB score[1])						
Density (0-5)	118	2.56 (0.21)	99	3.18 (0.22)	59	3.80 (0.22)
Abundance (1-5)	75	4.03 (0.16)	74	4.3 (0.15)	55	4.20 (0.16)
Frequency (0-1)	118	0.63 (0.04)	99	0.73 (0.04)	59	0.88 (0.04)
Shoot length (cm)	75	32.60 (2.18)	71	41.83 (2.69)	54	35.30 (2.48)
Shoot width (mm)	74	2.92 (0.08)	71	3.28 (0.09)	ND	ND
Seaweeds (all species combined) vegetative shoots (BB score[1])						
Density (0-5)	117	0.98 (0.12)	95	0.72 (0.10)	58	1.91 (0.21)
Abundance (1-5)	62	1.98 (0.13)	58	1.58 (0.11)	52	2.45 (0.18)
Frequency (0-1)	117	0.44 (0.04)	98	0.41 (0.04)	58	0.71 (0.05)

[1]Braun-Blanquet (BB) visual estimation technique (Braun-Blanquet 1972): 0 percent =0; 1–5 percent =1; 6–25 percent =2; 26–50 percent =3; 51–75 percent =4; 76–100 percent =5

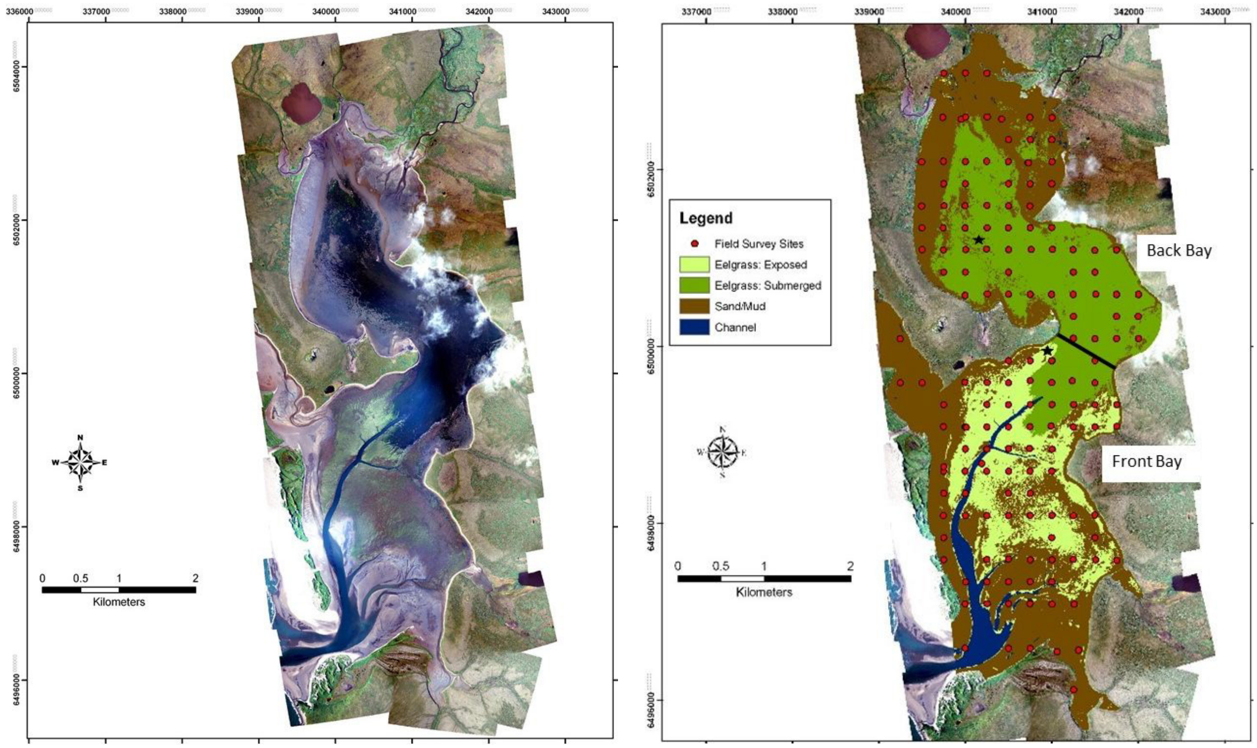

Figure 2. Depictions of 2007 photomosaic image (left) and classification of mud and sand, channels and eelgrass (*Zostera marina*), subdivided into exposed (intertidal) and submerged (subtidal) classes (right) in Nanvak Bay, Alaska. Stars show where light measurements were taken.

Eelgrass was present in 79 percent of points across the entire bay (fig. 2). Where eelgrass was present, it was also abundant (BB score =4.2±0.2; 80 percent cover; table 1). The aboveground biomass varied annually across years, ranging from 32–72 g/m^2 (table 1; fig. 3) and it was positively correlated with percent cover (r=0.72) and shoot length (r=0.63). Although there were only 3 years of annual estimates, abundance of eelgrass was also positively correlated with water temperature (r=0.99). The eelgrass percent cover was high throughout the bay, but the aboveground biomass was greatest in front of the bay (fig. 4). The average length and width of the eelgrass shoots were 36.6±2.2 centimeters (cm; range =11–98 cm) and 3.0±0.09 millimeters (mm; range =1.0–5.0 mm), respectively.

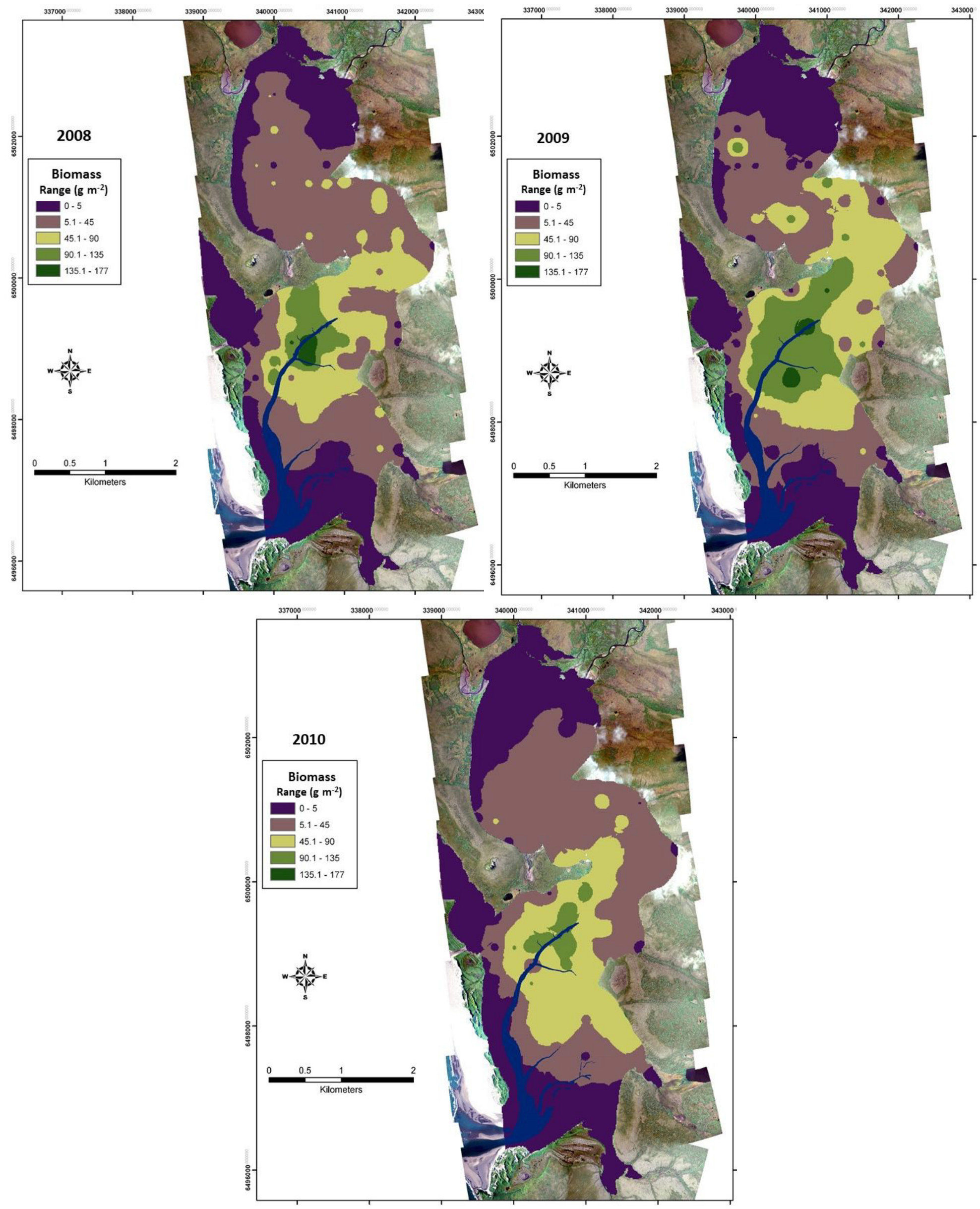

Figure 3. Inter-annual variation in aboveground eelgrass (*Zostera marina*) abundance (grams dry weight per meter squared, g/m^2 [g m^{-2}]) in Nanvak Bay, Alaska, 2008–10.

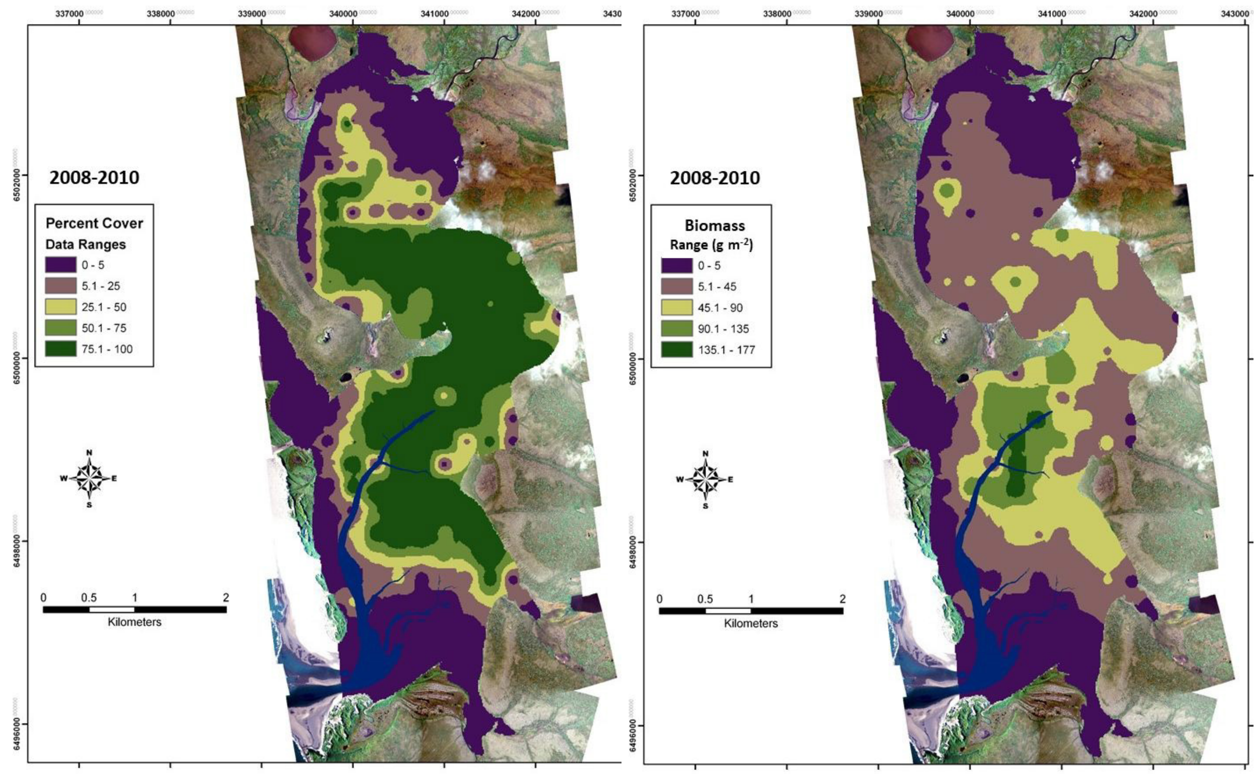

Figure 4. Mean variation in percent cover (left) and aboveground biomass (right; grams dry weight per meter squared, g/m^2 [g m^{-2}]) of eelgrass (*Zostera marina*) in Nanvak Bay, Alaska, 2008–10.

Although seaweed diversity was relatively low (*n*=10 genera and species; table 2), seaweeds were present in 63 percent of the sampled points and nearly always with eelgrass (>95 percent of quadrats). When present, seaweed abundance was relatively low compared to eelgrass (table 1). The most common seaweed species were *Eudesme virescens* in 2010 and *Neorhodomela aculeata* in 2008 and 2009, occurring on >50 percent of points when seaweeds were present. Macro-invertebrates were found on >40 percent of points and always in association with eelgrass. The most common macro-invertebrates were mussels (40–44 percent of points) and gastropods (12–44 percent of points) across the three years. No sponges, crabs, or sea stars were detected at any of the points in Nanvak Bay.

Table 2. Seaweed genera and species identified on sample points in Nanvak, Chagvan, and Goodnews bays, Alaska.

[Seaweed taxonomy is based on Guiry and Guiry (2020); X, present; —, not present]

Number	Genus	Species	Location		
			Nanvak	Chagvan	Goodnews
1	*Acrosiphonia*	sp.	—	X	—
2	*Ceramium*	*pacificum*	—	X	X
3	*Chaetomorpha*	sp.	X	X	—
4	*Chorda*	*filum*	X	X	X
5	*Chordaria*	*flagelliformis*	—	X	—
6	*Chordaria*	sp.	X	—	—
7	*Cladophora*	*sericea*	—	X	X
8	*Cladophora*	sp.	X	—	—
9	*Dictyosiphon*	*foeniculaceus*	X	—	—
10	*Dumontia*	*alaskana*	X	X	
11	*Ectocarpus*	*siliculosus*	—	X	X
12	*Eudesme*	*virescens*	X	X	X
13	*Kornmannia*	*zostericola*	—	X	—
14	*Mastocarpus*	sp.	X	—	—
15	*Monostroma*	*grevillea*	—	X	X
16	*Neorhodomela*	*aculeate*	X	X	X
17	*Palmaria*	*callophylloides*	—	X	—
18	*Polysiphonia*	*pacifica*	X	X	X
19	*Porphyra*	sp.	—	X	X
20	*Pterosiphonia*	*bipinnata*	—	X	—
21	*Rhizoclonium*	*tortuosum*	—	X	—
22	*Rhodomela*	*tenuissima*	—	X	—
23	*Saccharina*	sp.	—	—	X
24	*Scytosiphon*	sp.	—	X	—
25	*Stictyosiphon*	*tortilis*	—	X	—
26	*Ulva*	*intestinalis*	—	X	—
27	*Ulva*	*linza*	—	X	—
28	*Ulva*	*prolifera* or *radiata*	—	X	—
29	*Ulva*	sp.	X	—	X
Total			11	23	8

The distribution of eelgrass is influenced by substrate type, wave and tidal action, sediment transport, and nutrient availability (Hemminga and Duarte, 2000) and these factors may be driving eelgrass distribution in Nanvak Bay (figs. 3 and 4). The absence of eelgrass near the entrance of Nanvak Bay is likely due to transport of large grain sediments through wave and tidal action that prevent eelgrass from taking root. In the upper reaches of the bay, the influx of fine grain sediments from the Slug River likely increase turbidity, thereby reducing light and likely lowering eelgrass productivity (fig. 5). Much of the upper portion of the bay is permanently submerged (fig. 2), therefore eelgrass was most abundant at the front of the bay behind sand bars that protect against wave action and near channels that deliver essential nutrients (figs. 3 and 4).

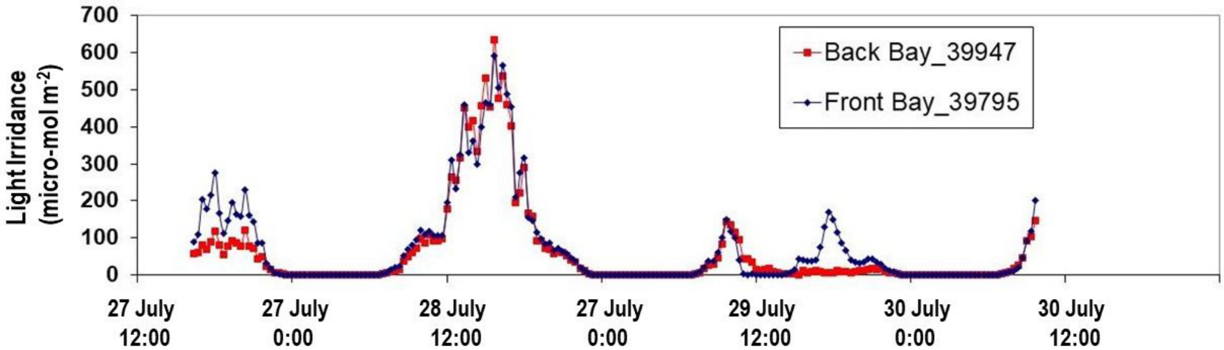

Figure 5. Variation in underwater photosynthetic active radiation between the front (blue dots) and back (red dots) portions of Nanvak Bay, Alaska (see location of light measurements in figure 2), July 27–30, 2009. Light irradiance levels (micro moles per meter squared, micro-mol m^{-2}) were monitored using an Odessey photosynthetic active radiation recorder that was placed in front and back portions of the bay (fig. 2) at a height equivalent to the top of eelgrass (*Zostera marina*) canopy.

Chagvan Bay

Eelgrass was the dominant cover type in Chagvan Bay, covering 58 percent of the total area of the bay (Ward and others, 2022; fig. 6). Unlike Nanvak Bay, eelgrass in Chagvan Bay occurred near the mouth of the bay (fig. 6), possibly because this bay contains a series of shallow bars seaward from the mouth that reduce damaging wave action, thereby allowing eelgrass shoots to establish beds close to their presumed primary source of nutrients, the Bering Sea. Eelgrass was present throughout much of Chagvan Bay except in the upper reaches where fine sediments and freshwater inputs from streams likely increased sediment inputs and decreased salinity and photosynthetic light.

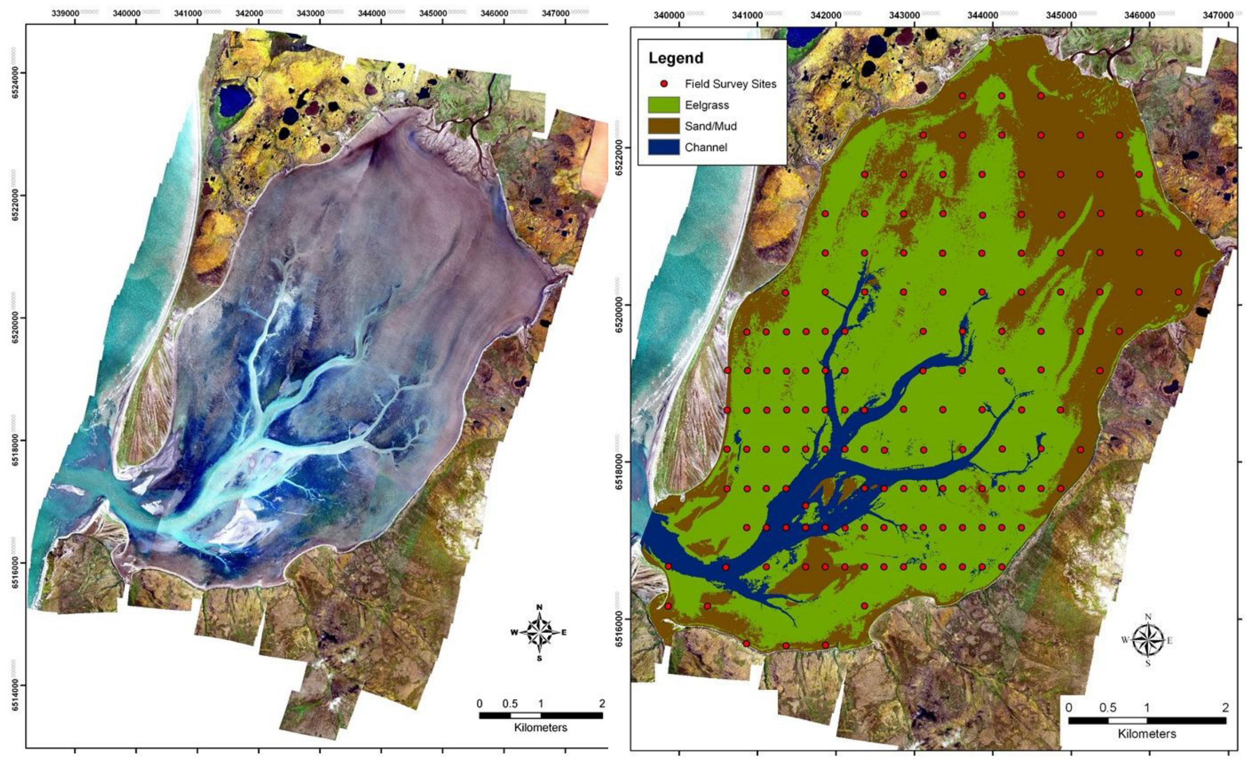

Figure 6. 2008 photomosaic image (left) and classification of mud and sand, channels, and eelgrass (right) in Chagvan Bay, Alaska. Red circles represent where eelgrass (*Zostera marina*) sampling occurred.

The initial survey of eelgrass and seaweed abundance in Chagvan Bay occurred from 6–13 July 2010. The mean surface water temperature was 12.6±0.1 °C (range =11–18 °C) and the salinity was 27.4±0.2 ppt (range =19–30 ppt). These averages were slightly greater than the averages in Nanvak and Goodnews bays in 2010 (table 3). Similarly to Nanvak Bay, water temperatures were colder and salinities were higher at the mouth of the bay than in other areas of the bay. Chagvan Bay contained more sand (35 percent) and cobble (15 percent), but less mud (60 percent) than Nanvak Bay. This difference in substrate composition was also reflected in substrate depth, which averaged shallower across all substrates in Chagvan Bay (6±0.5 cm) compared to Nanvak Bay (14±0.8 cm).

Eelgrass was the dominant macrophyte in Chagvan Bay, occurring at 83 percent of all points (n=63), and when present, eelgrass was abundant (average abundance BB score =4.0 or approximately 75 percent cover; table 3). Eelgrass was most abundant in the central third of Chagvan Bay near tidal channels (fig. 7). Overall, average aboveground biomass of eelgrass in Chagvan Bay was similar to estimates in Goodnews Bay, but slightly greater than estimates in Nanvak Bay in 2010 (table 3). This general pattern was also reflected in the length of eelgrass shoots with values in Chagvan Bay (range =17–83 cm), intermediate between Nanvak (range =11–98 cm) and Goodnews Bay (range =10–141 cm; table 3).

Table 3. Annual samples size (n) and mean and standard error (SE) of measurements of physical parameters and abundance of eelgrass (*Zostera marina*) and seaweeds in 2010 in Nanvak (14–17 July), Chagvan (7–12 July) and Goodnews (21 July) bays, Alaska.

[°C, degree Celsius; ppt, part per thousand; cm, centimeter; g/m^2, gram dry weight per square meter; mm, millimeter; ND, no data]

	Nanvak Bay		Chagvan Bay		Goodnews Bay	
	n	**Mean (SE)**	**n**	**Mean (SE)**	**n**	**Mean (SE)**
Physical parameters						
Water temperature (°C)	62	11.10 (0.13)	144	12.60 (0.14)	27	11.00 (0.04)
Salinity (ppt)	62	25.80 (0.71)	143	27.40 (0.20)	27	24.70 (0.06)
Water depth (cm)	61	88.20 (5.13)	142	96.70 (3.70)	27	114.70 (8.70)
Substrate depth (cm)	55	13.50 (0.78)	139	5.90 (0.47)	27	5.10 (0.10)
Seagrass (*Zostera marina*)						
Aboveground biomass (g/m^2)	58	46.59 (4.46)	63	69.14 (7.01)	25	73.80 (14.70)
Seagrass vegetative shoots (BB score[1])						
Density (0-5)	59	3.80 (0.22)	81	3.11 (0.22)	25	2.32 (0.33)
Abundance (1-5)	55	4.20 (0.16)	65	3.95 (0.16)	19	3.27 (0.23)
Frequency (0-1)	59	0.88 (0.04)	81	0.77 (0.04)	25	0.69 (0.08)
Shoot length (cm)	54	35.30 (2.48)	47	44.90 (2.42)	19	74.10 (7.10)
Shoot width (mm)	-	-	-	-	-	-
Seaweeds (all species combined) vegetative shoots (BB score[1])						
Density (0-5)	58	1.91 (0.21)	81	1.76 (0.16)	25	2.63 (0.28)
Abundance (1-5)	52	2.45 (0.18)	71	2.34 (0.14)	24	3.26 (0.19)
Frequency (0-1)	58	0.71 (0.05)	81	0.69 (0.04)	25	0.76 (0.06)

[1]Braun-Blanquet (BB) visual estimation technique (Braun-Blanquet 1972): 0 percent =0; 1–5 percent =1; 6–25 percent =2; 26–50 percent =3; 51–75 percent =4; 76–100 percent =5.

Seaweeds were also a dominant macrophyte in Chagvan Bay, occurring at 76 percent of points (*n*=81), and were typically associated with eelgrass shoots (88 percent of points). However, density and abundance of seaweeds were relatively low compared to the other two bays (table 3). Of the 23 different species of seaweeds we detected, green seaweeds were the most dominant: green blades at 18 percent of seaweed points (examples, *Ulva* spp., *Monostroma grevillei* and *Kornmannia zostericola*) and fine filamentous greens at 59 percent of seaweed points (examples, *Ulva*, *Cladophora sericea* spp., *Rhizoclonium tortuosum*, and *Chaetomorpha* sp.; table 3). Macro-invertebrates occurred at 59 percent of points and always in association with eelgrass. Like Nanvak Bay, the most common macro-invertebrates were gastropods (51 percent of points) and mussels (41 percent of points). No sea stars, crabs or sponges were observed in Chagvan Bay.

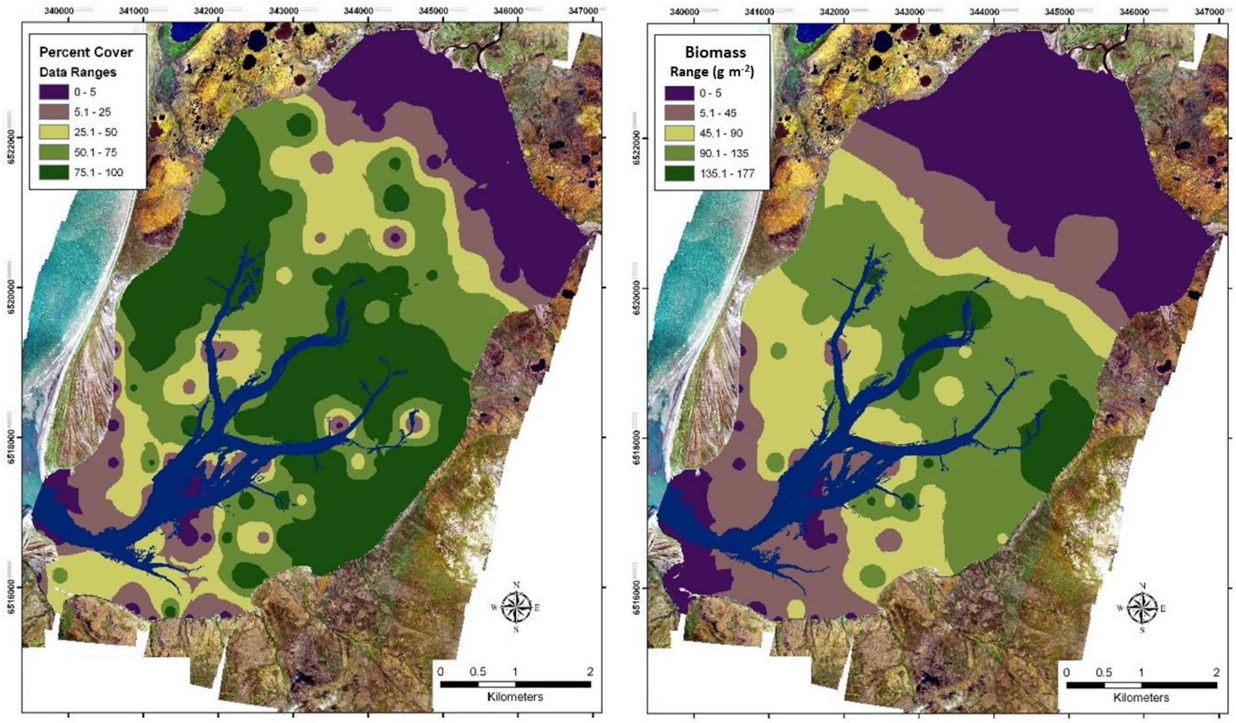

Figure 7. Mean variation in percent cover (left) and aboveground biomass (right; grams dry weight per meter squared, g/m^2 [g m^{-2}]) of eelgrass (*Zostera marina*) in Chagvan Bay, Alaska, 2010.

Goodnews Bay

The assessment of eelgrass in Goodnews Bay occurred from 20–23 July 2010 in the southwest portion of the bay (fig. 8). The assessment was conducted in the largest known bed of eelgrass in Goodnews Bay (Ward and others, 2022; fig. 8). The surface water temperature averaged 11.0±0.04 ˚C (range =10–11 °C) and salinity 24.7±0.1 ppt (range =23–26 ppt) and were the lowest of the three bays, which is likely due to the proximity of the eelgrass beds to the mouth of the bay and the Bering Sea. Goodnews Bay is a considerably larger bay than the other two bays with significantly deeper water and larger entrance to the bay.

Eelgrass occurred at 76 percent of points in Goodnews Bay; however, BB scores for density, abundance, and frequency of occurrence were consistently lower in this bay than in the other two bays (table 3). Nevertheless, the eelgrass aboveground biomass along the south spit of this bay (74±15 g/m^2) was comparable to Chagvan Bay (69±7 g/m^2) and greater than in Nanvak Bay (47±4 g/m^2). We were unable to complete the field survey of the other beds of eelgrass in Goodnews Bay because of weather and time constraints, so comparisons among the bays in this report should be considered cautiously because the sample sizes were lower ($n \leq 27$) in this bay than in the other two bays ($n \geq 52$; table 3).

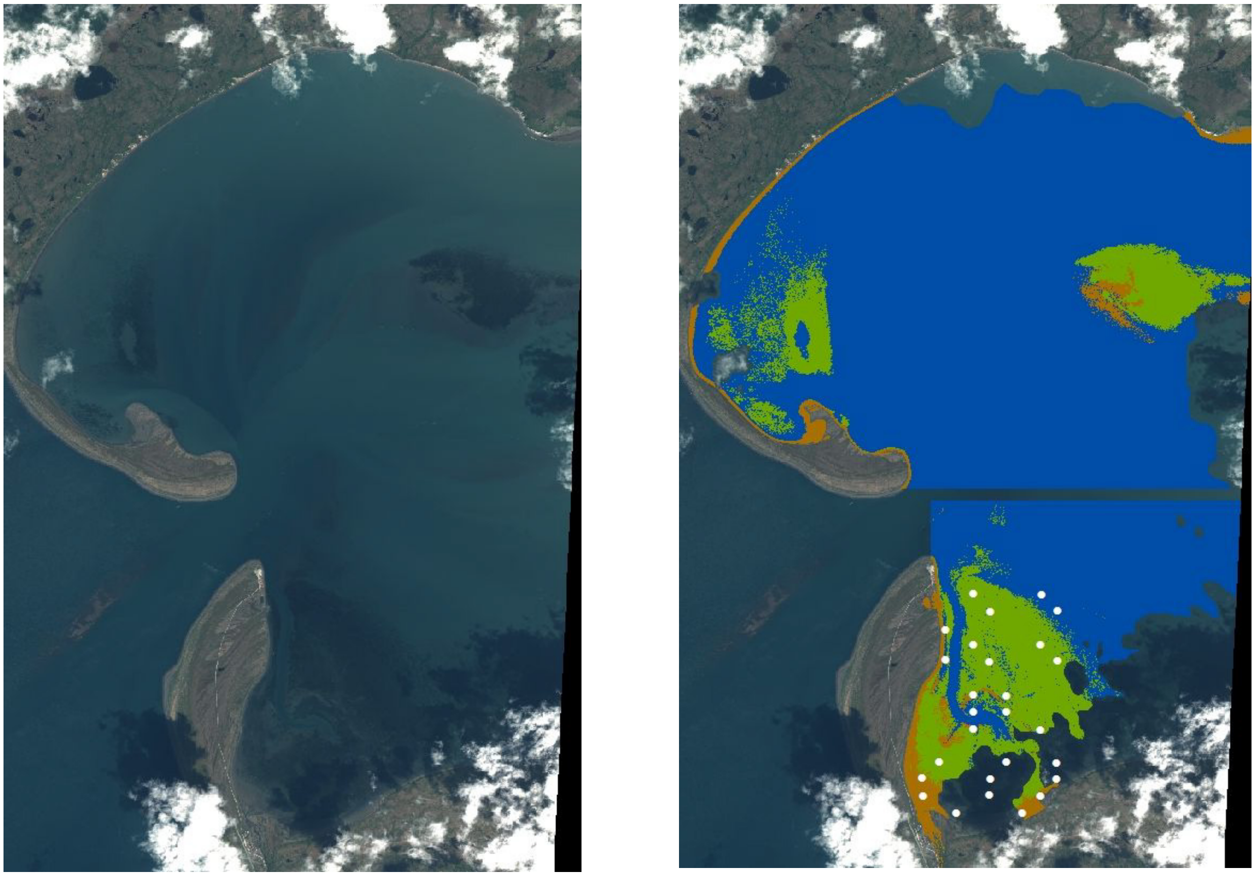

Figure 8. Quickbird2 satellite image (left) and classification of mud and sand (orange), water (blue), and eelgrass (*Zostera marina*) (green; right) in Goodnews Bay, Alaska. Also shown are clouds (white) and cloud shadows (black) where classification was undetermined. White circles represent where eelgrass point sampling occurred in 2010.

In contrast to Nanvak and Chagvan bays, seaweeds were the most common macrophyte in Goodnews Bay at 96 percent of all points. Fine filamentous brown/red seaweeds at 76 percent of seaweed points, such as *Eudesme virescens*, *Ectocarpus siliculosus*, *Ceramium pacificum*, and *Polysiphonia pacifica*, were the most dominant (*n*=25 points sampled). Although seaweeds were frequently associated with eelgrass (at 76 percent of points), seaweeds often occurred in areas void of eelgrass (20 percent of points). Seaweeds were abundant in Goodnews Bay with an average abundance BB score of 3.3 (approximately 60 percent cover) when present, an abundance score that was greater than those estimated in the other two bays (table 3). The greater presence of seaweeds in Goodnews Bay is likely related to the increased percentage of cobble substrate in this bay (32 percent cover) compared to Nanvak (10 percent cover) and Chagvan (11 percent cover) bays (table 3). A rocky bottom substrate is an ideal surface for attachment of seaweed holdfasts. Macro-invertebrates occurred on 65 percent of points and always in association with eelgrass. Like Nanvak and Chagvan bays, mussels (56 percent of points) and gastropods (48 percent of points) were the most common macro-invertebrates and no sea stars, crabs, or sponges were detected at sampling points.

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