Coastal Habitat Mapping Program

ShoreZone

Yukon-Kuskokwim Delta
Data Summary Report
October 2015

Prepared for
NOAA National Marine
Fisheries Service
Alaska Region

NOAA

Coastal & Ocean
Resources

On the Cover:

Bangookbit Dunes, Nunivak Island
Scammon Bay
Cape Mohican, Nunivak Island

Coastal and Ocean Resources

MCORI Project: 14-38 **October 2015**

ShoreZone Coastal Habitat Mapping Data Summary

Yukon-Kuskokwim Delta

Prepared for:
NOAA National Marine Fisheries Service
Alaska Region

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ShoreZone is a coastal habitat mapping system in which georeferenced aerial imagery is collected specifically for the classification of geomorphological and biological features of the intertidal zone and nearshore environment. The mapping methods are described in a series of protocol documents, the most recent being Harper and Morris (2014).

This report summarizes the data collected on geomorphological and biological features from the 2014 coastal imaging survey of the Yukon-Kuskokwim (YK) Delta. The survey covered 4,440 km of shoreline which was broken into 4,112 along-shore units based on geomorphological attributes, with units averaging 1,080 m in length.

Several changes to the physical and biological mapping protocols were implemented on January 1st, 2015. The changes to the physical protocols include: the addition if the Coastal Vulnerability Module (CVM) which indicates areas vulnerable to erosion and flooding, and the revised Environmental Sensitivity Index (ESI) mapping protocol that follows the most recent NOAA guidelines. The biological mapping protocols were updated with new metrics for the biobands including length, width and percent cover for each band. New definitions and codes were also introduced to clarify and expand the current suite of biobands classified with ShoreZone. These revised protocols were applied over the portion of the YK Delta survey area mapped to date. These revisions will be added to the official protocol document in 2016.

Yukon-Kuskokwim Delta Survey Quick Facts

4,440 km of shoreline mapped:

4,112 shoreline units created:

Units averaged **1,080 m** in length.

18 biobands were classified.

The survey was part of the **YKDE bioarea**, which was newly created for this unique region.

ESI mapping following Peterson (2002) was applied to all units.

The Coastal Vulnerability Module was applied to all units.

Bioband classification followed new quantitative protocols.

Organic shore types, usually dominated by fine sediment and marshes were the most common, comprising 47% of the shoreline. *Rock* shore types were extremely uncommon, making up less than 1% of the survey area. Anthropogenic modifications, also not very common in the Yukon-Kuskokwim Delta area, were only mapped in 0.1% of shoreline units (54 units total). The most common types of shore modification observed were landfill and boat ramps (26 and 13 units, respectively) with most anthropogenic features concentrated around the communities of Mekoryuk on Nunivak Island and Hooper Bay on the mainland.

The dominance of lower wave exposures and sand-gravel sediment textures resulted in high Oil Residence Indices for approximately two thirds of the shore segments in the survey area, including the protected areas up the Kuskokwim River and at the mouth of the Yukon River.

The portion of the YK Delta survey area mapped for this summary report is part of a newly created *bioarea* called YKDE. This bioarea is characterized by the massive input of freshwater from both the Yukon and Kuskokwim Rivers. Repeatable assemblages of biota that can be recognized from the aerial imagery are termed *biobands*; 18 biobands were observed in the YK Delta survey area. The most widely distributed biobands were Wetland Vegetation (in 52% of units) and Dune Grass (22% of units). Rockweed was the most common intertidal bioband (18% of units), with most of it being mapped on the rocky shore of Nunivak Island. Eelgrass was uncommon being found in only 5% of the units.

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1.1 Overview of the ShoreZone Coastal Habitat Mapping Program

ShoreZone is an imaging and habitat classification system for the coastal nearshore margin including the shallow subtidal, intertidal shoreline and supratidal fringe. One objective of ShoreZone is to produce an integrated searchable inventory of the physical and biological attributes of coastal habitats. ShoreZone imagery and habitat attributes can provide a useful baseline from which to study change over time, while the attributes mapped (such as shoreline sediments, wetland distribution and biotic communities) provide an important resource for scientists and managers.

The ShoreZone system was developed in the 1980s and 1990s to map coastal habitats in British Columbia and Washington State (Howes 2001; Berry *et al.* 2004). In 2001 ShoreZone was implemented in Alaska, beginning with Cook Inlet, Outer Kenai, Katmai, and portions of the Kodiak Archipelago (Harper and Morris 2004).

The ShoreZone program has since expanded to a nearly continuous database of over 70,000 km of coastal Alaska and 45,000 km of British Columbia, Washington and Oregon (see Figure 1). Figure 2 shows the extent of the shoreline mapped in the Yukon-Kuksokwim (YK) Delta survey area in 2014. These sections of shoreline had the ESI mapping protocols following Peterson (2002) (section 2.2), Coastal Vulnerability Module (section 2.5), and new bioband protocols (section 3.2) applied to them.

The ShoreZone mapping system provides a spatial framework for coastal habitat assessment on local and regional scales. Applications of ShoreZone data and imagery for resource management and research include:

- natural resource and conservation planning
- environmental hazard response
- oil spill contingency planning
- linking habitat use and life-history strategy of nearshore fish and other intertidal organisms
- habitat suitability modeling (for example, to predict the spread of invasive species or the distribution of beaches appropriate for spawning fish)
- mariculture site evaluation
- ground-truthing of aerial data on smaller spatial scales
- public use for recreation, education, outreach, and conservation

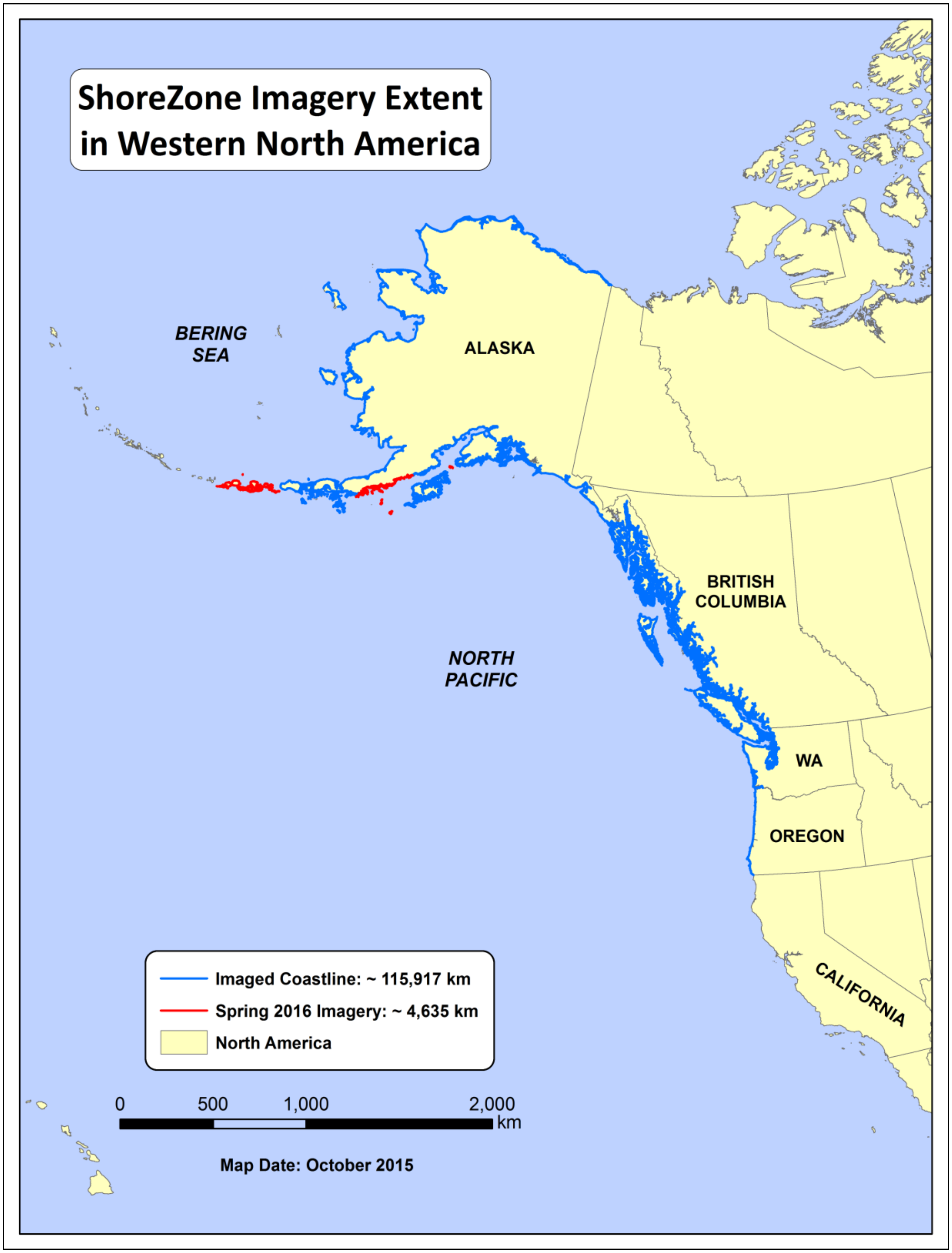

Figure 1. Extent of ShoreZone imagery in Alaska, British Columbia, Washington State and Oregon as of October 2015 (115,917 km).

Figure 2. Map of the areal extent of the YK Delta imaging survey from 2014 represented by this report. Please note there was more imagery taken south of Bethel to Cape Newenham during that survey that has not yet been mapped.

1.2 ShoreZone Mapping of Yukon-Kuskokwim Delta

The field survey conducted around the Yukon-Kuskokwim Delta in 2014 acquired aerial video and digital still images of the coast during minus tides (zero-meter tide levels and lower). The imagery and associated audio commentary were used to map the physical and biological attributes of the shoreline according to the most recent ShoreZone Coastal Habitat Mapping Protocol (Harper and Morris 2014) as well as recent protocol updates that will be included in the 2016 protocol document (these are described in the sections to which they apply). The purpose of this report is to provide a summary of the physical (geomorphological) and biological data imaged and classified in the survey area (Figure 2).

The length of shoreline mapped in the database is **4,440 kilometers** in **4,112 along-shore segments (units)**, **averaging 1,080 m in length**. The digital shoreline used for the ShoreZone mapping was compiled from multiple sources to create the best available representation of the current shoreline. The primary source was the Alaska_63,360 shapefile; the secondary source was the Continuously Updated Shoreline Product (CUSP) shapefile available in May 2015 from NOAA, and the tertiary was the National Hydrography Dataset (NHD).

2 PHYSICAL SHOREZONE DATA SUMMARY

2.1 Shore Types

The principal characteristics of each along-shore unit are used to assign an overall unit classification or “shore type” that represents the unit as a whole. ShoreZone mapping employs three along-shore **unit classification** systems: coastal geomorphology (Shore Types), the Environmental Sensitivity Index (ESI) and coastal habitat (Habitat Class) which is defined in Section 3.4.

The Shore Type classification is used to define along-shore coastal units based on the geomorphic features and attributes such as substrate size, substrate texture, across-shore width and slope (after Howes *et al.* (1994); Appendix A, Table A-2 & Table A-3) as well as unique features such as marshes and estuaries, anthropogenic alterations, current dominated channels, lagoons and low vegetated peat. There are currently 39 distinct Shore Types. Photographic examples of the Shore Types found in the YK Delta survey area can be found in Appendix A, Table A-18.

Bedrock shorelines (Shore Types 1-5) were found along 0.4% of the coast while **Rock and Sediment shorelines** (Shore Types 6-20) were found along 4.7%. **Sediment-dominated shorelines** (Shore Types 21-30) were found in 43.9% of the study area with *wide mud flats* (Shore Type 29) being the most common (20.1%). **Organic/Estuarine dominated shorelines** were the most commonly mapped at 47.3% of the shoreline length while **Lagoons** only comprised 0.4% of the survey area. The Shore Type 39, **Low Vegetated Peat**, was observed along 3.2% of the shoreline. This particular shore type is typically found in periglacial areas where permafrost is a dominant structuring force, but for the purpose of this study area was mapped in areas where permafrost most likely dominated in the past, with the tundra biome and peat sediment being an artifact of that landscape. The diversity and distribution of Shore Types in the study area are summarized in Table 1 and Figure 3. The distribution of groups of Shore Types over the survey area is shown in Figure 4 with more detail for the sediment dominated Shore Types being shown in Figure 5.

Table 1. Summary of Shore Types for the YK Delta survey area.

Substrate Type	Shore Type		Sum of Unit Length (km)	# of Units	% Occurrence (by length)	Cumulative Occurrence (%, km)
	No.	Description				
Rock	1	Rock Ramp, wide	<1	3	<1	<1% 19 km
	2	Rock Platform, wide	3	14	<1	
	3	Rock Cliff	11	36	<1	
	4	Rock Ramp, narrow	3	20	<1	
	5	Rock Platform, narrow	<1	3	<1	
Rock & Sediment	6	Ramp w gravel beach, narrow	14	41	<1	5% 210 km
	7	Platform w gravel beach, wide	22	63	<1	
	8	Cliff with gravel beach	44	126	1	
	9	Ramp with gravel beach	72	200	2	
	10	Platform with gravel beach	5	14	<1	
	11	Ramp w gravel & sand beach, wide	4	23	<1	
	12	Platform with G&S beach, wide	27	72	1	
	13	Cliff with gravel/sand beach	3	14	<1	
	14	Ramp with gravel/sand beach	18	54	<1	
	15	Platform with gravel/sand beach	1	6	<1	
Sediment	21	Gravel flat, wide	1	6	<1	44% 1,950 km
	22	Gravel beach, narrow	121	195	3	
	23	Gravel flat or fan	1	4	<1	
	24	Sand & gravel flat or fan	96	189	2	
	25	Sand & gravel beach, narrow	132	271	3	
	26	Sand & gravel flat or fan	12	37	<1	
	27	Sand beach	2	5	<1	
	28	Sand flat	477	308	11	
	29	Mudflat	893	360	20	
	30	Sand beach	215	275	5	
Organics	31	Organics/Estuarine	2100	1517	47	47% 2,100 km
Man-made	32	Man-made, permeable	1	5	<1	<1% 1 km
	33	Man-made, impermeable	<1	1	<1	
Current	34	Channel	<1	1	<1	<1% / 0.2km
Lagoon	36	Lagoon	19	27	<1	<1% 19 km
Periglacial	39	Low vegetated peat	143	222	3	3% / 143 km
Totals:			*4,440*	*4,112*	*100*	*100%*

Note: This table only includes Shore Types observed in the YK Delta survey area.

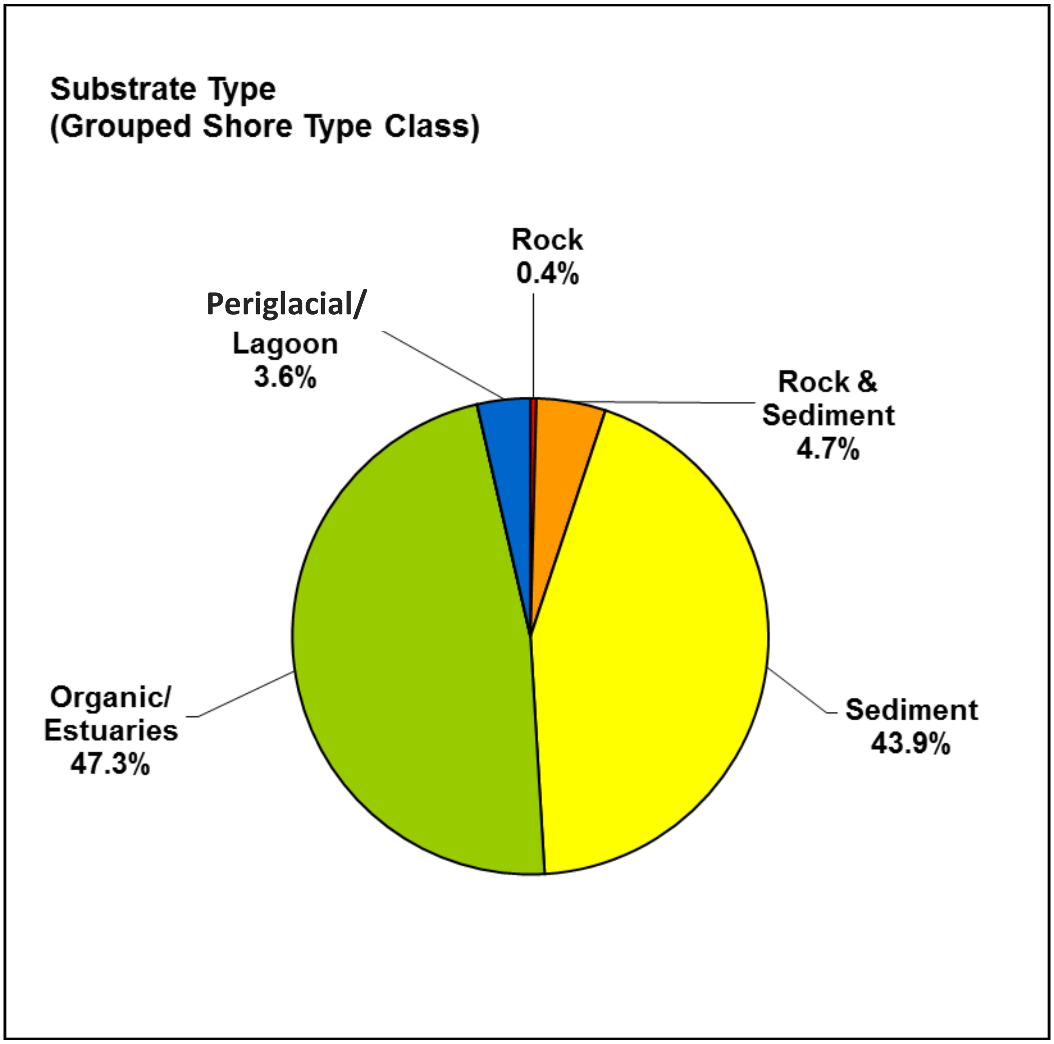

Figure 3. Relative distribution of principal substrate types in the YK Delta survey area (please note that the Periglacial Shore Type does not necessarily indicate the presence of permafrost. See the explanation in the text of Page 5).

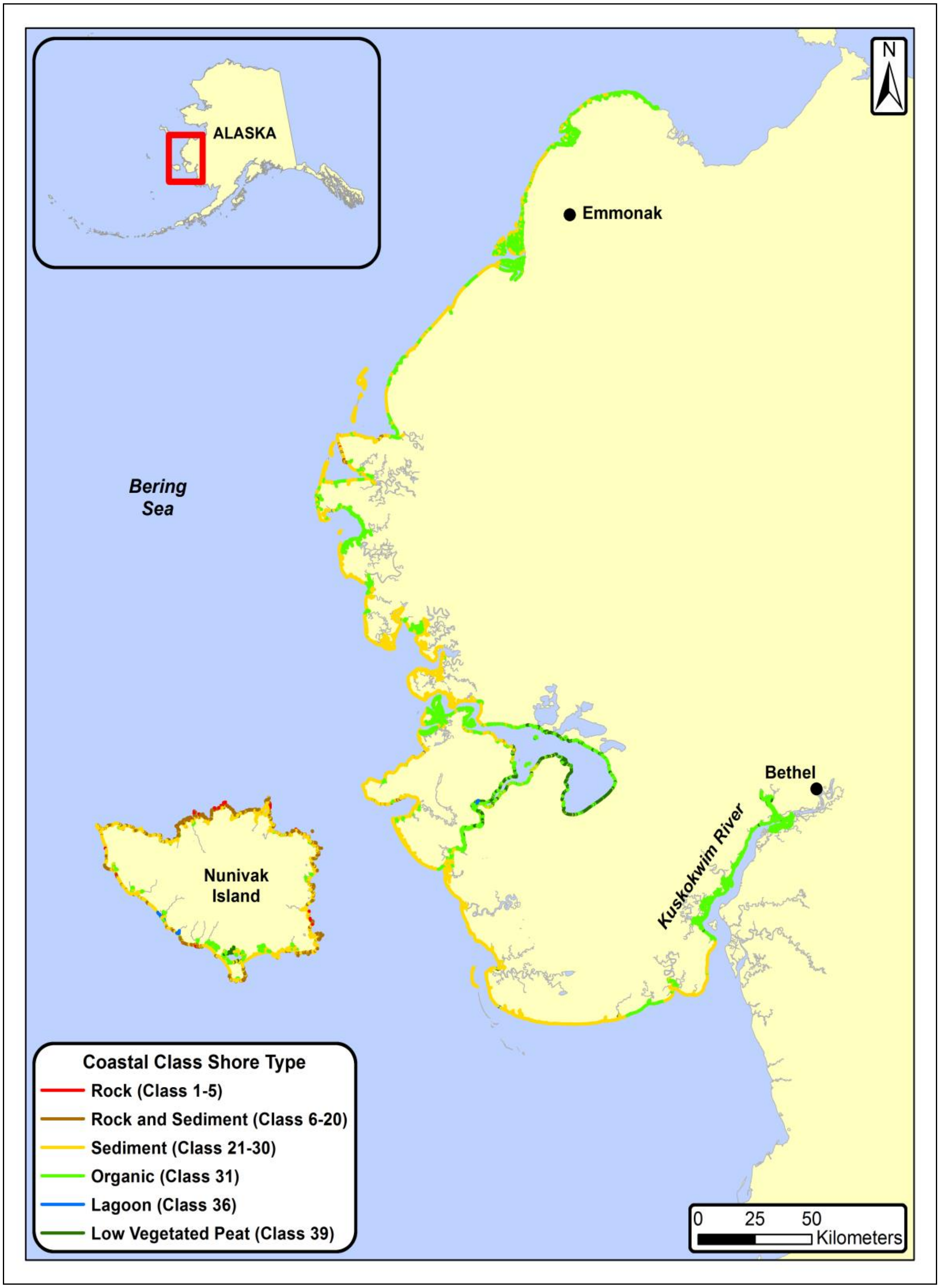

Figure 4. Map of the distribution of principal substrate types (on the basis of grouped Shore Types) in the YK Delta survey area.

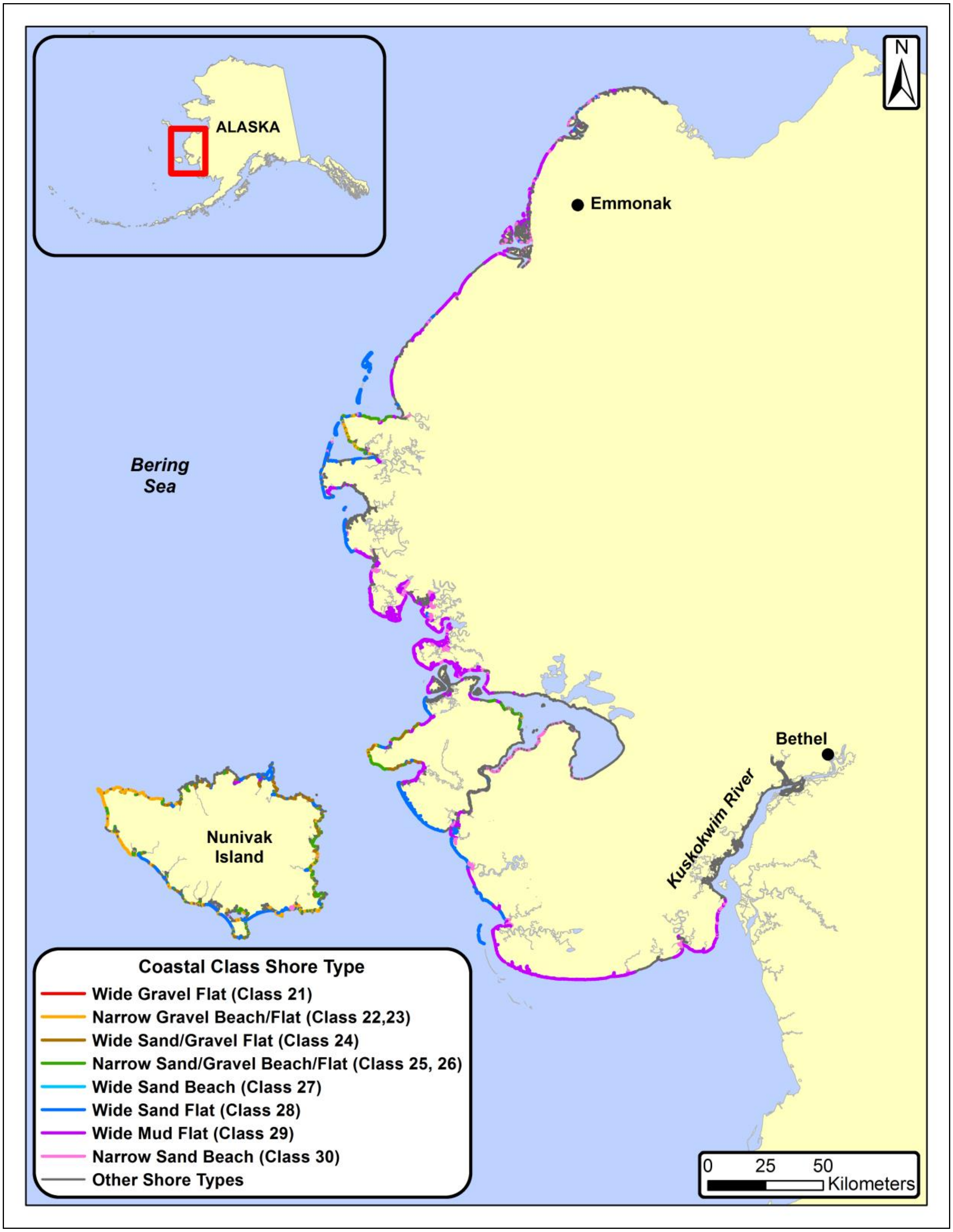

Figure 5. Map of the distribution of sediment dominated shorelines (Shore Types 21-30, grouped by geomorphology) in the YK Delta survey area.

2.2 ESI Classification

The NOAA Environmental Sensitivity Index (ESI) is a shoreline classification system developed to categorize coastal regions on the basis of their sensitivity to a potential oil spill. The ESI system uses wave exposure and principal substrate type to assign alongshore units a rank from 1-10 with 1 being the least sensitive and 10 being the most sensitive (Petersen *et al.* 2002; Appendix A, Table A-4). The ESI system is used as an integral component of oil spill contingency planning. Substrate permeability is a factor used for estimating the residence time of oil on the shoreline, thus sediment texture is a key element in determining the ESI class. The distribution of the most sensitive ESI shore types in the study area are listed in Table 2 and Figure 6 shows the units classified as most sensitive with a rank of 10.

Up to three ESI codes are now linked to each ShoreZone unit, including the highest ranking ESI code for each unit (most sensitive). The ESI ranks mapped in the YK Delta survey area can be queried as spatial data in the geodatabase delivered with this report. The new ESI data is available for all shoreline mapped and delivered in 2015 and will be standard for all future ShoreZone mapping.

ESI mapping for this survey area used the National Wetlands Inventory (NWI) online mapping atlas (http://www.fws.gov/wetlands/data/mapper.HTML) to determine which areas were marine/estuarine or riverine and lacustrine. The NWI classification system was adopted by the Federal Geographic Data Committee as the standard in the United States for wetland classification in 1996.

Table 2. Summary of Shore Types by ESI Class for the YK Delta survey area.

Environmental Sensitivity Index (ESI)		Sum of Unit Length (km)	# of Units	% of Total Shoreline Length
No.	**Description**			
1A	Exposed rocky shores; Exposed rocky banks	6	15	<1
1C	Exposed rocky cliffs with boulder talus base	32	82	1
2A	Exposed wave-cut platforms in bedrock, mud, or clay	11	46	<1
3A	Fine- to medium-grained sand beaches	130	165	3
3C	Tundra Cliffs	28	36	1
4	Coarse-grained sand beaches	11	16	<1
5	Mixed sand and gravel beaches	161	375	4
6A	Gravel beaches (granules and pebbles)	25	63	1
6B	Gravel beaches (cobbles and boulders)	267	616	6
7	Exposed tidal flats	576	318	13
8A	Sheltered scarps in bedrock, mud, or clay; sheltered rocky shores (impermeable)	5	22	<1
8B	Sheltered, solid, man-made structures; sheltered rocky shores (permeable)	9	36	<1
8C	Sheltered rip rap	<1	1	<1
8D	Sheltered rocky rubble shores	1	2	<1
8E	Peat Shorelines	289	334	7
9A	Sheltered tidal flats	605	334	14
9B	Vegetated low banks	238	330	5
10A	Salt- and brackish-water marshes	1,607	686	37
10B	Freshwater marshes	402	579	9
10D	Scrub-shrub wetlands; Mangroves	35	56	1
	Totals:	***4,440***	***4,112***	***100***

Note: ESI Classes not observed in this survey were not included in the table.

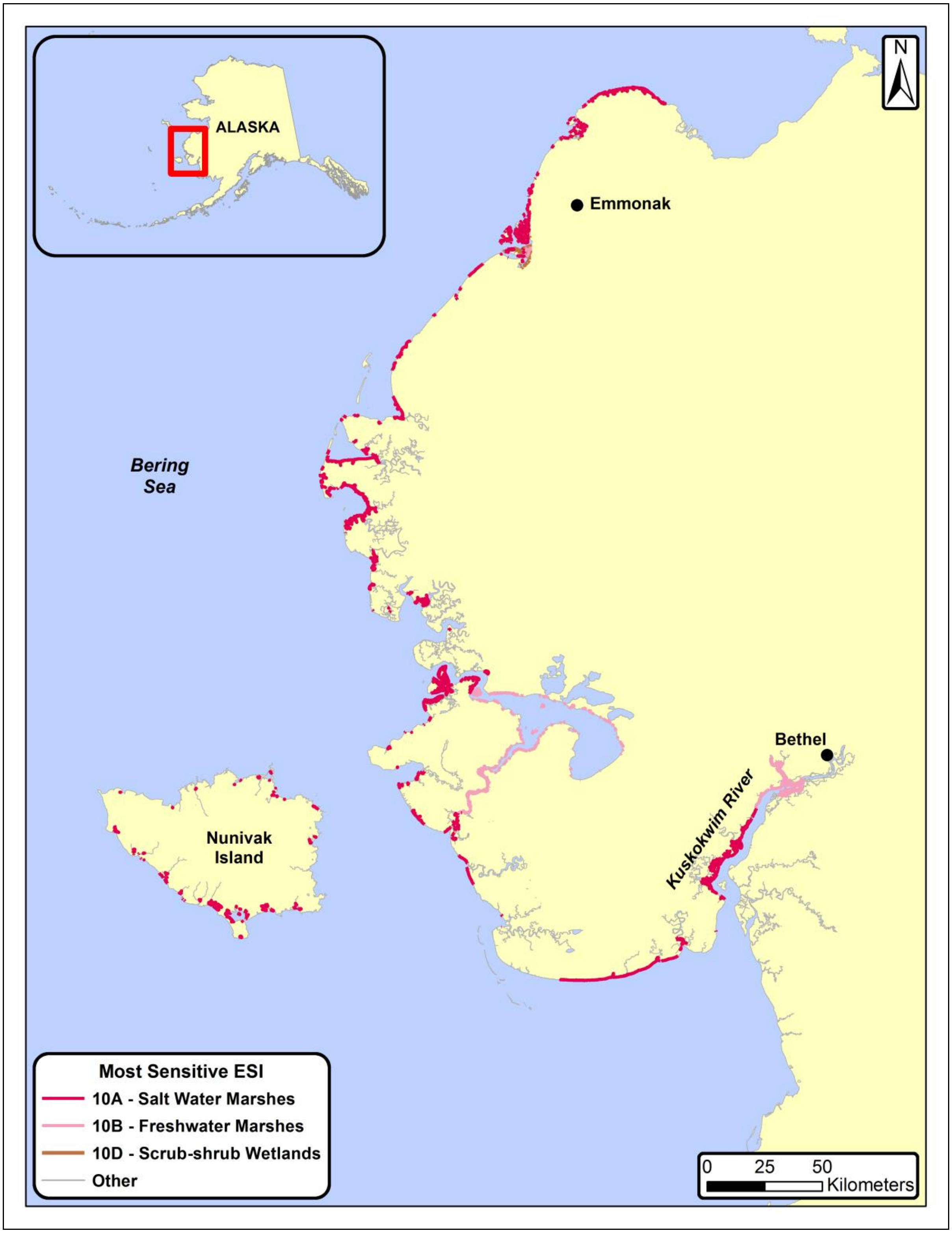

Figure 6. Map of the distribution of the most sensitive ESI rank (10) in the most sensitive ESI field category in the YK Delta survey area. The colour scheme follows the official ESI map colour scheme.

2.3 Anthropogenic Shore Modifications

Anthropogenic features such as seawalls, rip rap breakwaters, docks, dikes and wharves are included in the ShoreZone classification. Very little (0.1%) of the shoreline in this survey area has been modified in this fashion. The distribution of the types of shore modification features (boat ramps, bulkheads, rip rap etc.) in the survey area are summarized in Table 3 and Figure 7 while the distribution of these features are shown in Figure 8.

Table 3. Summary of Shore Modifications in the YK Delta survey area.

Shore Modification	# of Units	Shoreline Length (km)	% of Shoreline Length
Landfill	26	4	0.1
Riprap	5	1	<0.1
Boat ramp	13	1	<0.1
Wooden bulkhead	7	<1	<0.1
Concrete bulkhead	1	<1	<0.1
Sheet Pile	2	<1	<0.1
Totals:	***54***	***6.1***	***0.1%***

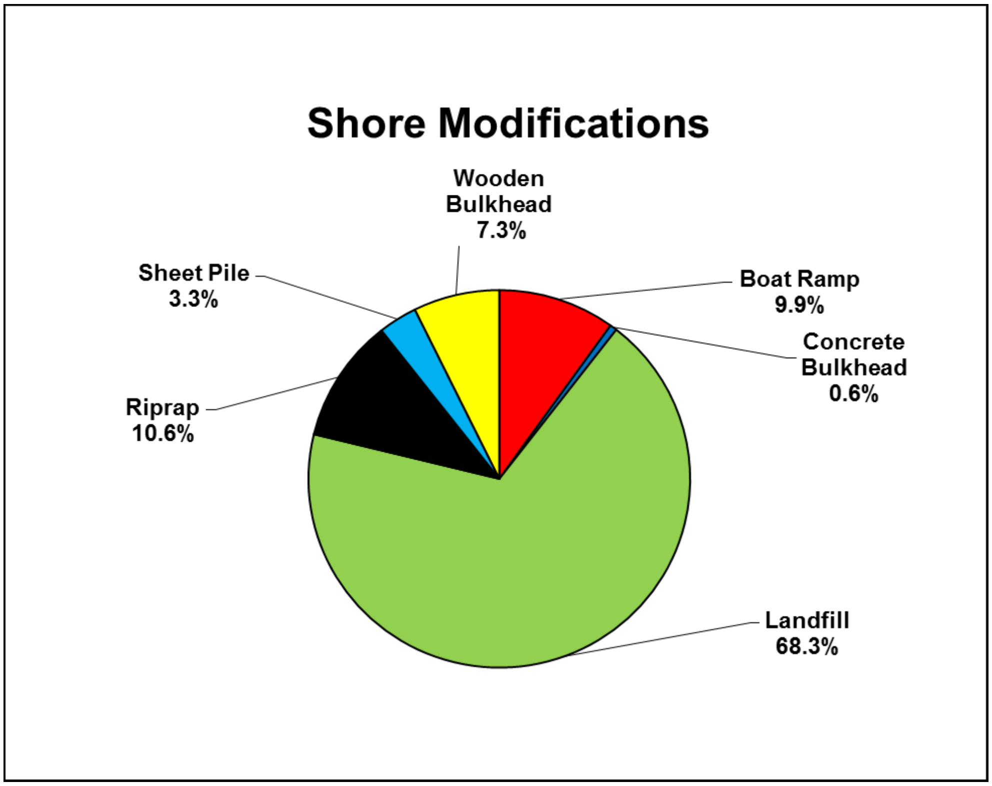

Figure 7. Distribution of Shore Modification types over the 6.1 km of shoreline classified as anthropogenically modified in the YK Delta survey area.

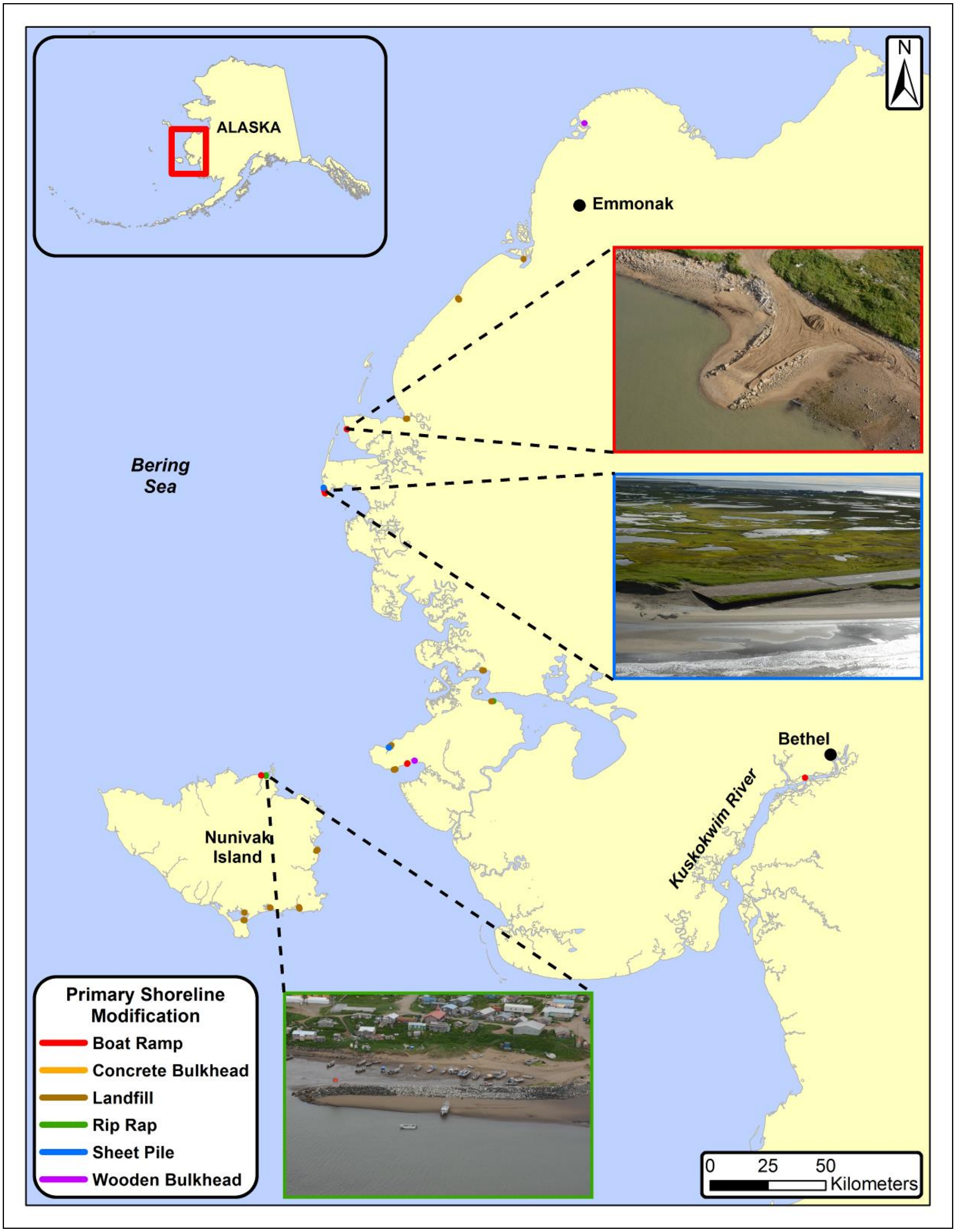

Figure 8. Map of the distribution of units in which shore modification features were observed in the YK Delta survey area.

2.4 Oil Residence Index (ORI)

The Oil Residence Index (ORI) is a rating between 1 and 5 that reflects the estimated persistence of spilled oil on a shoreline: a value of 1 reflects relatively short oil residence (days to weeks) while a value of 5 reflects potentially long oil residence times (months to years). An ORI value is applied to each across-shore component on the basis of sediment texture and wave exposure as well as to each along-shore unit on the basis of shore type and wave exposure (Appendix A, Table A-6).

The dominance of lower wave exposures and sand-gravel sediment textures results in high Oil Residence Indices for approximately two thirds of the shore segments in the Yukon-Kuskokwim survey area: 66% have an ORI of 4 or 5, indicating oil residence times are on the order of months to years (Table 4; Figure 9). All of the organic shorelines, which are particularly common along the Yukon-Kuskokwim Delta survey area, would have lengthy persistence should heavy oil reach those shorelines.

Table 4. Summary of Oil Residence Index values for the YK Delta survey area.

Relative Persistence	Oil Residence Index (ORI)	Estimated temporal persistence	Shoreline Length (km)	Shoreline Length (%)
Short	1	Days to weeks	16	<1
	2	**Weeks** to months	95	2
Moderate	3	Weeks to **months**	1394	31
	4	**Months** to years	454	10
Long	5	Months to **years**	2481	56
		Totals:	***4,440***	***100%***

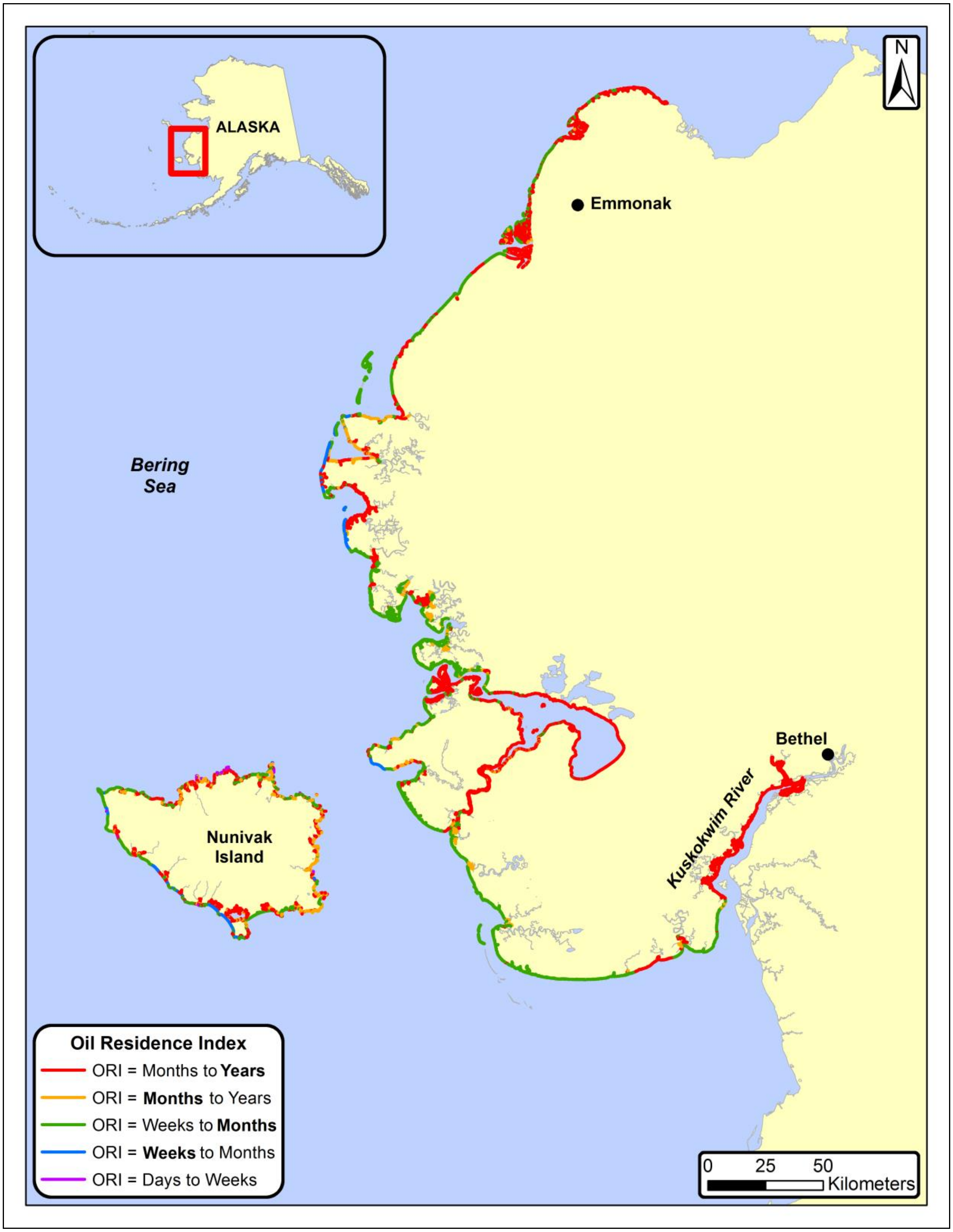

Figure 9. Oil Residence Index (ORI) for shorelines in the YK Delta survey area.

2.5 ShoreZone Coastal Vulnerability Module

The Coastal Vulnerability Module (CVM) for ShoreZone is intended to provide users with a spatial picture of where and how shorelines are likely to be sensitive to effects of climate change, specifically sea level rise. For example, shorelines with very low gradients have a higher risk of being flooded by storm surges which will become more extreme as the sea level rises.

The CVM provides a measure of coastal sensitivity to climate change for three indices:

> ***Coastal Stability Index*** that provides a measure of erosion (retreating or prograding) for both clastic/sediment shorelines or for wetland shorelines (see Appendix B, Table B-1).
>
> ***Flooding Sensitivity Index*** that provides an estimate of the degree of observed flooding of immediate backshore areas (see Appendix B, Table B-2).
>
> ***Thaw Sensitivity Index*** that provides an estimate of thaw lake or water coverage in the backshore that is an indirect indicator of thaw settlement potential (not applied to the YK Delta survey area due to the lack of current permafrost in the area, although permafrost did occur in the geologic past) (see Appendix B, Table B-3).

These indices are based on observed coastal geomorphology of the shoreline and are complemented by an inventory of descriptive coastal features of mass-wasting/wetland morphology (Appendix B, Table B-4) that are potentially of interest to coastal planners and managers. The CVM is only applied to soft sediment, low gradient shorelines which are likely to become inundated due to sea level rise.

The CVM was applied to 3,758 km of sediment shoreline mapped in the survey area. Data for the Coastal Stability and Flooding Sensitivity Indices are shown in Tables 5 and 6 and the observations of coastal features are shown in Table 7. Figure 10 provides an overview of the distribution of stability classes for the Yukon-Kuskokwim Delta. Figure 11 shows observations of units with wetland morphologies and Figure 12 shows the distribution of the units shoreline likely to experience storm surge inundation greater than 50m horizontally.

Table 5. Summary of the Coastal Stability Index for the YK Delta survey area.

Category	Code	Stability Class	Sum of Unit Lengths (km)	% of Shoreline Length	% of Shoreline Length for Category
Clastic	CE4	Erosional	25	1	16
	CE3		97	3	
	CE2		35	1	
	CE1		48	1	
	CS	Stable	184	5	
	CA1	Accretional	149	4	
	CA2		25	1	
	CA3		14	<1	
Wetland	WE2	Erosional	75	2	83
	WE1		907	24	
	WS	Stable	1469	39	
	WA1	Accretional	699	19	
Bedrock	R	Not applicable	32	1	1
Anthropogenic	A	Seawall	<1	<1	<1
Other	X	Provisional	0	0	0
		Total:	***3,758***	***100***	***100***

Table 6. Summary of the Flooding Sensitivity Index for the YK Delta survey area.

Category	Potential Inundation (m)	Flooding Class	Sum of Unit Lengths (km)	% of Shoreline Length
F4	>100	Major	1366	37
F3	50-100	↑	834	22
F2	10-50	↑	914	24
F1	<10	Minor	532	14
X	Not Applicable		112	3

Table 7. Summary of Coastal Mass-Wasting and Wetland Features for the YK Delta survey area.

Category	Feature	Sum of Unit Lengths (km)	% of Shoreline Length
Mass Wasting	Ground ice slumps	0	0
	Block slumps	39	1
	Debris flows/solifluction	20	1
	Ice Wedges	0	0
Wetlands	Lagoonal complex	134	4
	Deltaic complex	69	2
	Marsh clones	151	4
	Associated mudflats	842	22
	Submerged morphology	752	20
	Relict river morphology	142	4
	Relict shoreline morphology	30	1
Other	All other features of potential interest to coastal planners and managers that might be at risk due to sea level rise such as archaeological sites	86	2
None	No relevant features	1480	39
Not Applicable	Coastal hazards not applicable	14	<1

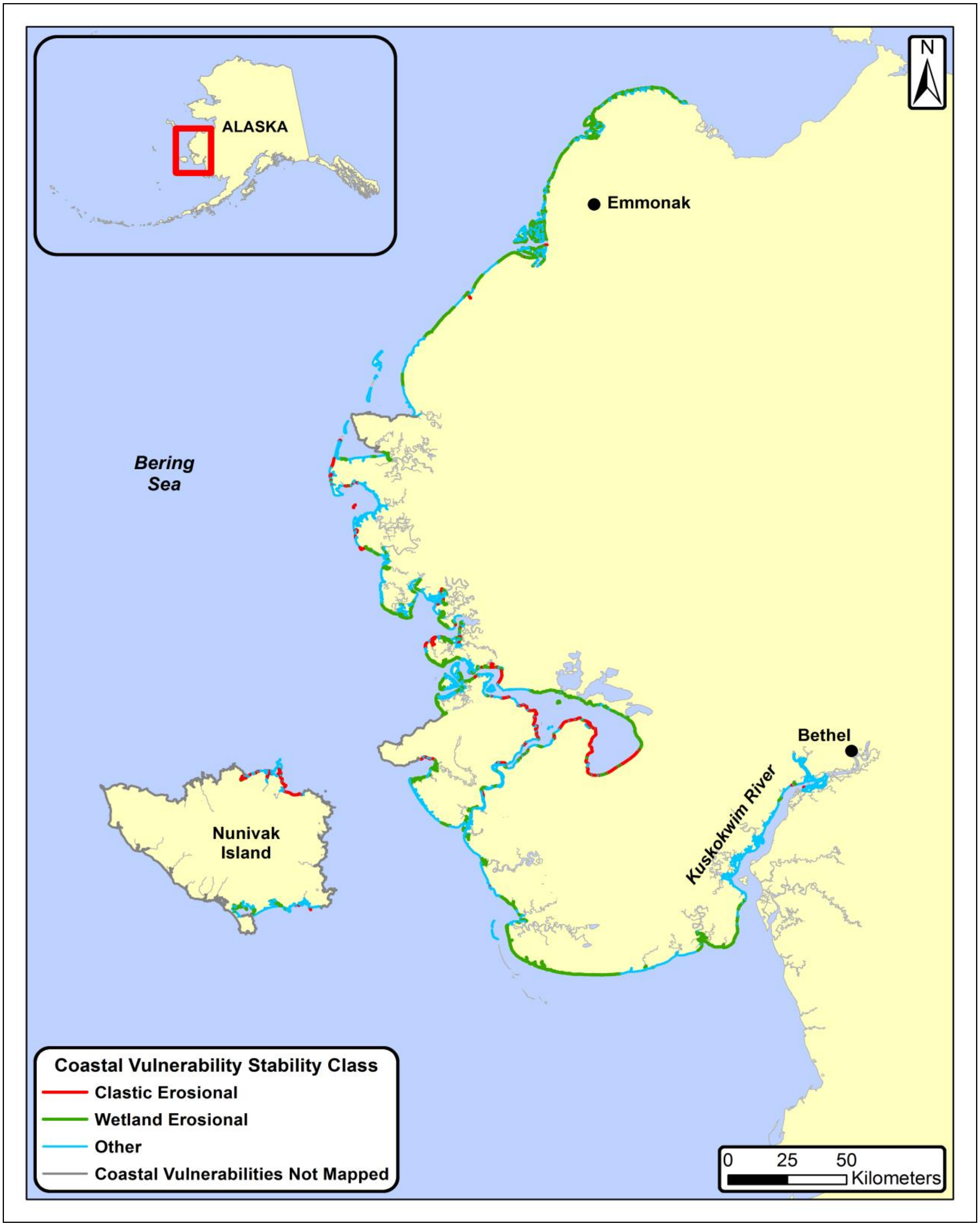

Figure 10. Distribution of the Coastal Vulnerability Module stability class in the YK Delta survey area.

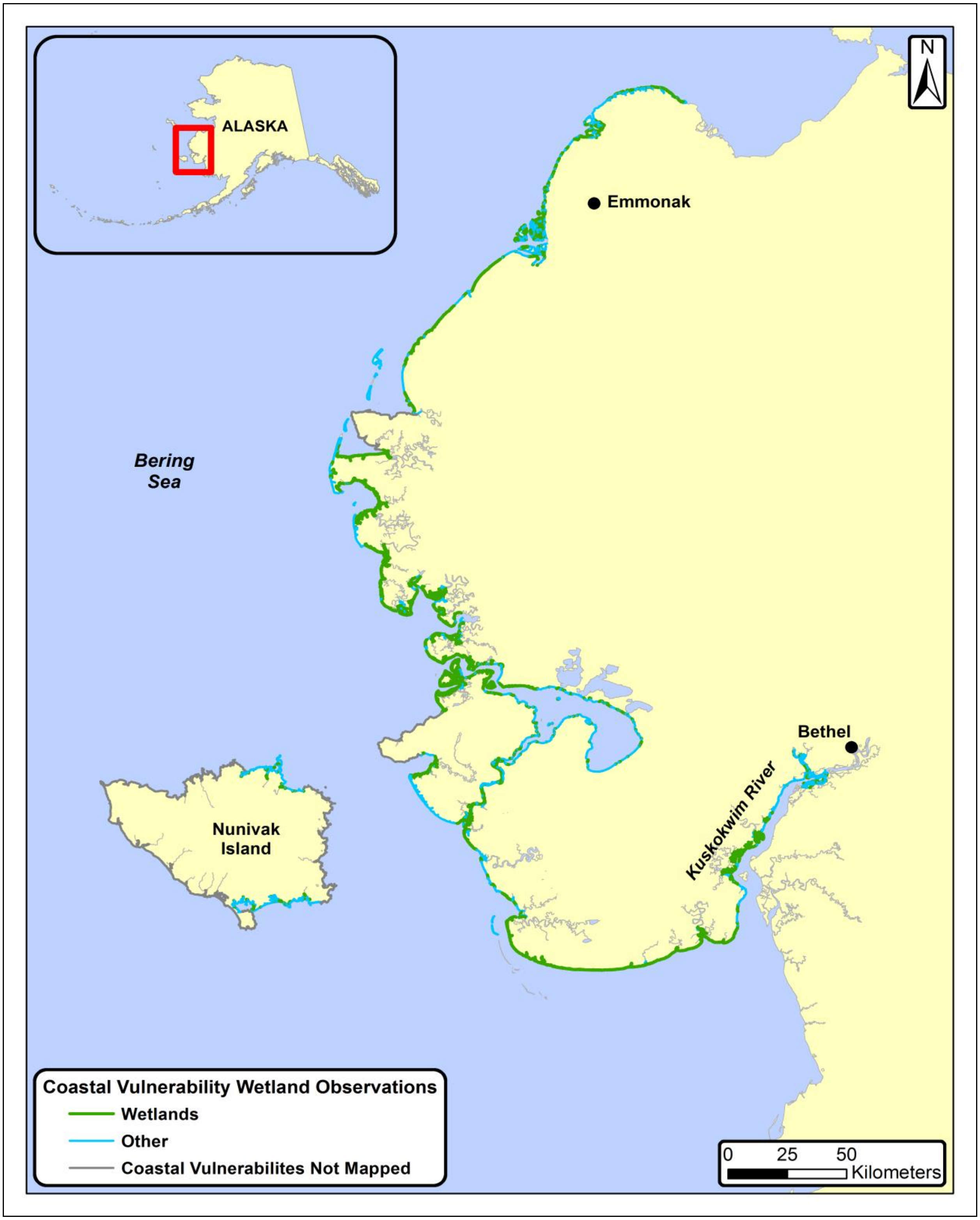

Figure 11. Distribution of wetland observations in the YK Delta survey area.

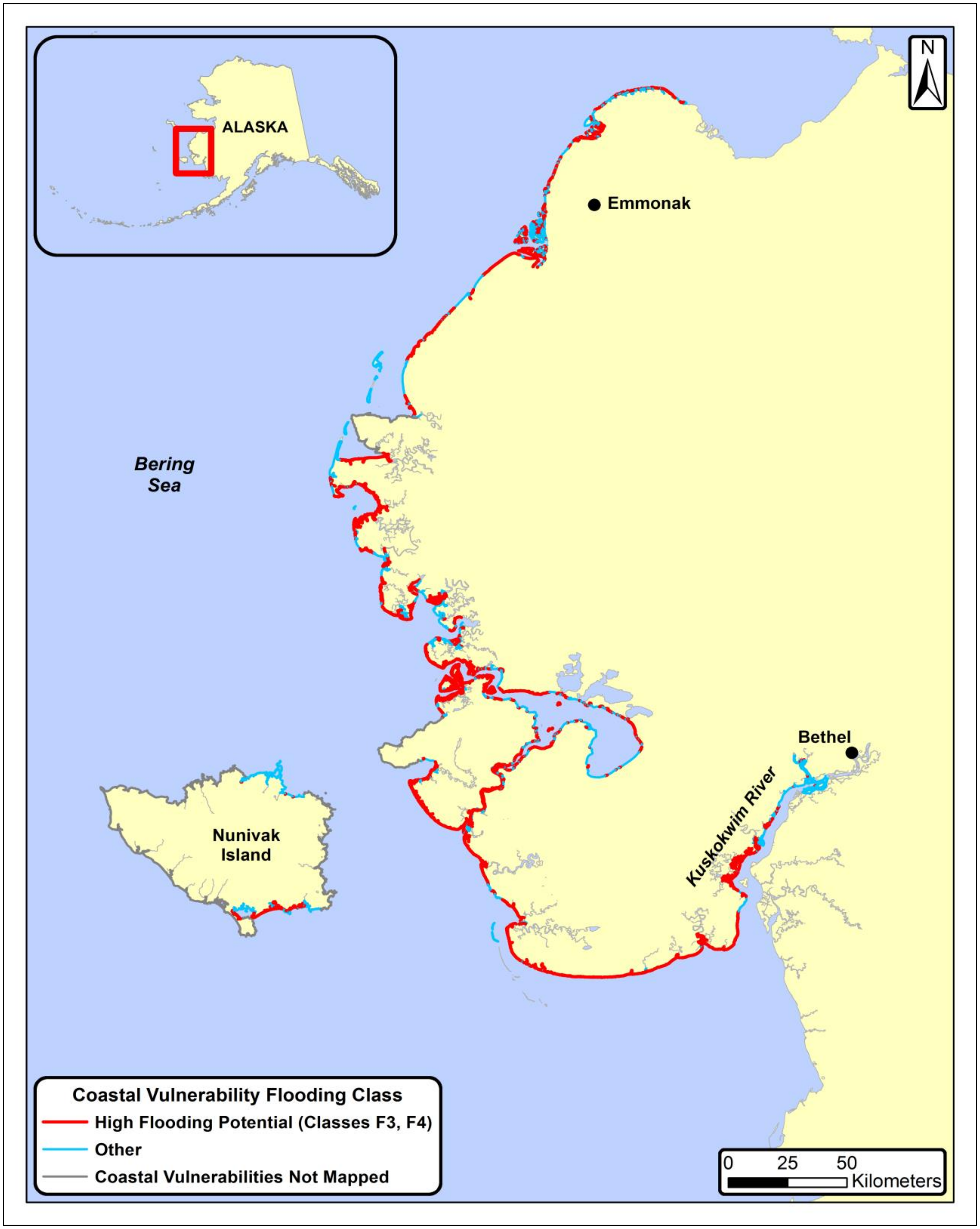

Figure 12. Distribution of potential high inundation areas (>50m inundation) for the YK Delta survey area.

3 BIOLOGICAL SHOREZONE DATA SUMMARY

Biological ShoreZone mapping is based primarily on image interpretation corroborated by direct observation of intertidally stratified horizontal bands of biota (e.g., barnacles, mussels, algae, etc.) referred to in the ShoreZone protocol as **biobands**. The presence, absence and relative distribution of specific biobands are recorded for each alongshore unit. Based on aerial image interpretation of intertidal biota, a **wave exposure** classification and a **habitat class** category are assigned (see sections 3.3 and 3.4 respectively). Geographical trends observed in the distribution of biobands and how they are associated with wave exposure and habitat class are summarized as **bioareas** that are analogous to biogeographic regions.

3.1 Bioarea

Bioareas describe broad regional differences between distribution and composition of biobands and are delineated on the basis of qualitative observations regarding the distribution of biobands, biological exposure and coastal habitat class and are often related to differences in coastal morphology, characteristics of bodies of water and other physical changes from one region to another. Please refer to Appendix A, Table A-9 for more detailed descriptions of the bioareas and their geographic boundaries.

The survey area detailed in this report is quite distinct from other areas surveyed by the ShoreZone program, mostly due to the huge input of fresh water from the two major rivers (the Yukon River and the Kuskokwim River) that have their outlets in the region. The YK Delta is the world's largest river delta and is comparable in size to the state of Oregon. This freshwater influence means the YK Delta bioarea (YKDE) has few marine biobands in the areas near the river mouths, with only Nunivak Island showing more typical Bering Sea biobands, similar to what was seen on Saint Lawrence Island (in the KOTZ bioarea). Other rocky areas were quite bare of intertidal and subtidal biobands due not only to the lower salinity but also the high level of suspended sediments in the water. This sediment, outflowing from the rivers, means the outer, more exposed beaches are composed of mobile sand and fines and often stretch for over a kilometer offshore. The whole shoreline appeared to be quite changeable with the freshwater marshes that dominate the supratidal eroding and growing constantly. See Figure 13 for the extent of this bioarea at present. The areas directly to the north and south have not yet been classified using the ShoreZone system so the boundaries of this bioarea have not yet been fully defined.

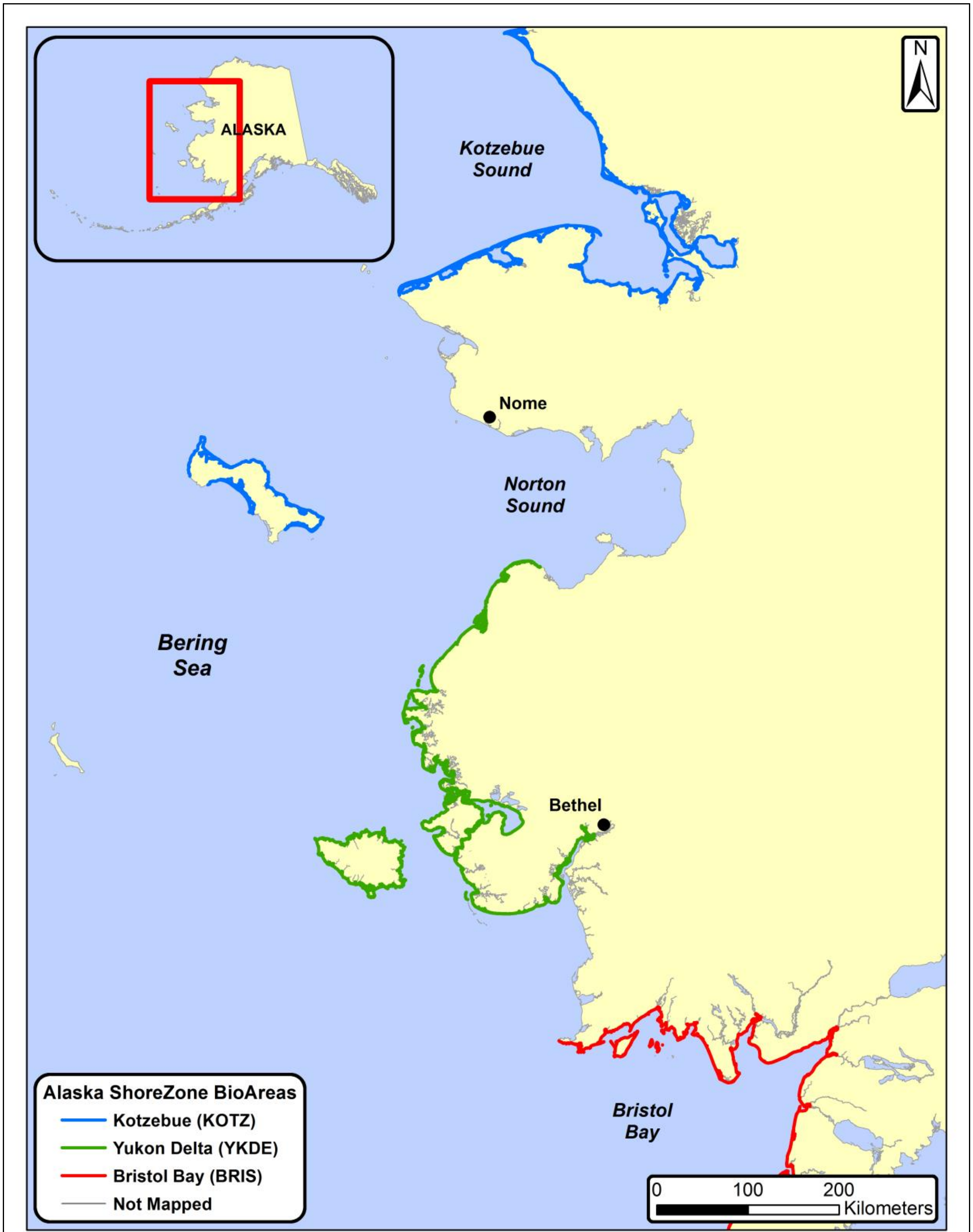

Figure 13. Bioareas identified in the YK Delta survey area and adjacent areas.

3.2 Biobands

Biobands represent assemblages of coastal biota found on the shoreline at characteristic wave exposures, substrate conditions and typical across-shore elevations. Biobands are spatially distinct, with alongshore and across-shore patterns of color and texture that are visible in aerial imagery (see Figures 14 through17 for examples from YK Delta). The biobands mapped in YK Delta are listed in Tables 8 and 9. The full descriptions of all biobands, including indicator and associated species, can be found in Appendix A, Table A-16. It is important to note that a new nested bioband classification has been developed and applied to all ShoreZone mapping completed after January 1st, 2015, including the area covered in this report. Changes to the bioband definitions include the application of a consistent naming convention and new four digit codes for each bioband. A number of new biobands were added, and some were split to better describe the banding that has been observed as ShoreZone continues to move into new and unique areas.

The specific elevation or zone of the intertidal determines how the bioband attributes are described. For example, biobands found in the A (supratidal) and B (intertidal) zones are described by percent of alongshore length of unit, percent of across-shore width of zone, and percent cover of the zone. Each attribute is assigned one of six categories: **<5%, 5-25%, 26-50%, 51-75%, 76-95%, >95%** and **Not Assessed (NA)**. Splash zone biobands (see Table 8) are recorded as an estimate of the across-shore width. The categories for the splash zone biobands are: **Narrow (<1m), Medium (1-5m)** or **Wide (>5m)**. The C zone biobands only have an estimate of % alongshore length (using the same categories listed above) because width and percent cover are impossible to estimate from the imagery; however, the extent of some C zone biobands can be estimated (such as canopy kelps which float on the surface of the water) and for those a measure of width is estimated using the categories: **Narrow (>10m), Medium (10-30m), Wide (>30m)** or **Not Assessed (NA)**.

These new bioband mapping protocols were implemented for all ShoreZone mapping on January 1st, 2015 and were applied across the whole YK Delta mapping project. All changes to the bioband mapping protocols will be detailed in the next version of the protocol document for Alaska ShoreZone in 2016.

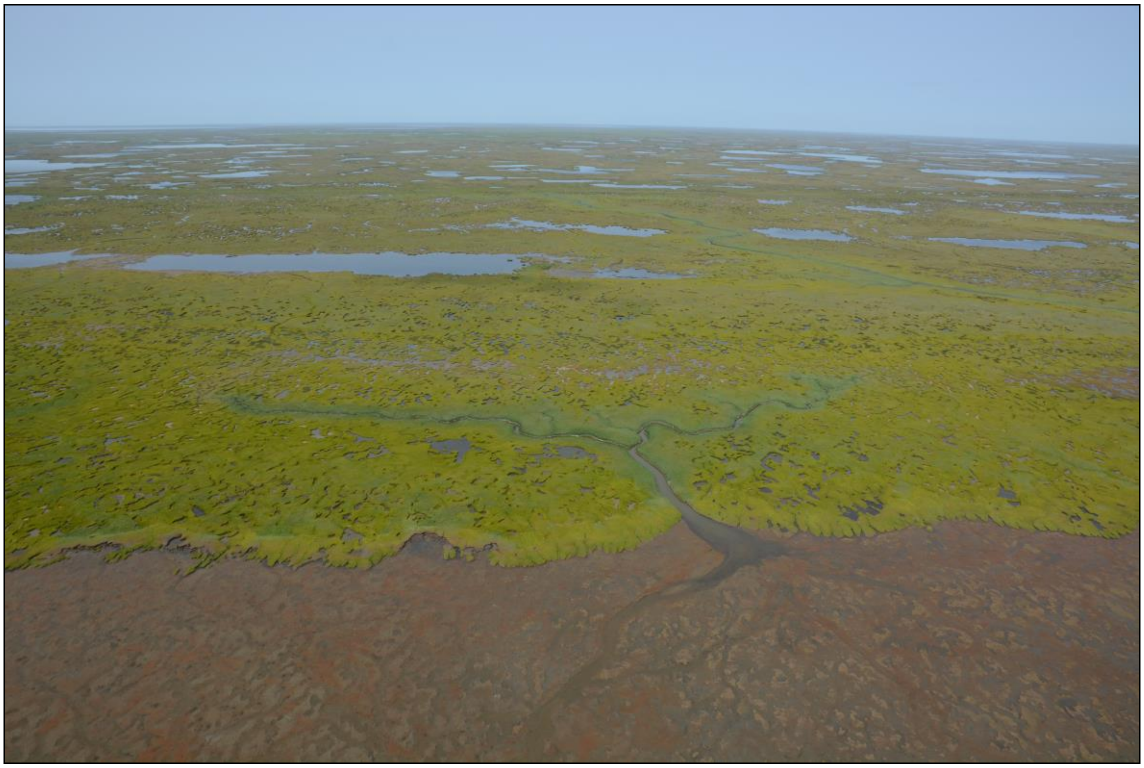

Figure 14. Wetland Vegetation bioband (WEVE) near Kwingillingok (photo bs14_bt_07738.jpg).

Figure 15. Supratidal Dune Grass (DUGR) band with Rockweed (ROCK) in the intertidal and Eelgrass (EELG) in the nearshore. This is a protected beach in Wide Bay, Nunivak Island (bs14_bt_03429.jpg).

Figure 16. Salt Marsh bioband (SAMA) transitioning to Wetland Vegetation (WEVE) at the outlet of the Kolvinarak River (photo bs14_bt_06007.jpg).

Figure 17. Tundra bioband (TUND) on an eroding bank in the protected portion of Baird Inlet (photo bs14_bt_04962.jpg).

Biobands mapped in the YK Delta survey area are summarized in Tables 8 and 9. The most commonly occurring bioband was Wetland Vegetation (WEVE), found in 52% of the units (distribution shown in Figure 18). Dune Grass (DUGR) was the next most commonly occurring bioband, in 22% of the units (see Figure 19 for distribution). The Salt Marsh (SAMA) bioband was only found in 11% of the units mapped (see Figure 20 for distribution), with the majority of those occurrences on Nunivak Island rather than the mainland. This is considerably less than may be expected for an area that consists almost entirely of a large estuary, which is the typical habitat for coastal salt marshes; however, this area is structured by the presence of large amounts of freshwater dominating the backshore. This can be seen in the maps of the area created by the National Wetlands Inventory (http://www.fws.gov/wetlands/data/mapper.HTML) which shows the coastal vegetation falling mostly under the Freshwater Emergent Wetland category as opposed to the relatively small amount of Estuarine and Marine Wetland that intersects with the coastal vegetation. The Salt Marsh bioband was therefore only mapped where there was a distinct colour change noted in the vegetation closest to the water and where the water was likely to be more saline or where the fringing Salt Marsh vegetation in the splash zone co-occurred with Dune Grass on sandy beaches. The NWI maps were used as a guide to where more saline water might influence the coastal vegetation types.

Supratidal vegetation dominated this survey area with 84% of units having at least one supratidal vegetation bioband (not including splash zone bands, see Table 8 for biobands included) classified within the unit, while only 24% of units had intertidal vegetation (see Table 8 for biobands included) and 9% of units had subtidal biobands (see Table 9 for biobands included). This is due to several factors: 1) the freshwater influence in the area causing low nearshore salinity, 2) high suspended sediments in the nearshore waters limiting the growth of intertidal and subtidal vegetation, 3) the prevalence of mobile sand and mud beaches on the mainland portion of the survey area and 4) the presence of ice on the beaches and in the nearshore for much of the year, scouring the upper surfaces of the bedrock and gravel on the rockier coastlines and limiting the growth of nearshore vegetation. The most commonly mapped bioband was Rockweed (ROCK) in 18% of units, most of those on Nunivak Island, with all other intertidal biobands combined mapped in fewer than 9% of units. The Eelgrass bioband (EELG) (see Figure 21 for distribution) was only found in the more protected bays of Nunivak Island and was in 5% of units overall. The high turbidity of the nearshore waters of the mainland would account for this distribution.

The Tundra bioband (TUND) was mapped in 18% of units and Trees and Shrubs (TRSH) were mapped in 15% of units, which is unusual as both are generally considered to be terrestrial biomes; however, these biobands were mostly mapped in Baird Inlet and up the Kuskokwim River near Bethel or near another major river outlet and were generally associated with undercuts and eroding bank where terrestrial vegetation was falling into the water (see Figure 17 for an example of the Tundra bioband on an erosional bank in Baird Inlet). These areas were unlike any other surveyed by ShoreZone in Alaska, being more riverine or palustrine in nature than marine.

Table 8. Percent cover of the zone for the supratidal and intertidal biobands in the YK Delta survey area.

Bioband		Zone	Number of Units						Total Number of Units*	% of Total Units Mapped
			Percent Cover of Zone							
Name	Code		<5	5-25	26-50	51-75	76-95	>95		
Splash Zone	SPZO	Supratidal (A) To High Intertidal (B)							416	10
Black Lichen	BLLI								398	10
White Lichen	WHLI								4	<1
Yellow Lichen	YELI								48	1
Dune Grass	DUGR		14	388	293	179	39	0	913	22
Tundra	TUND		3	400	171	82	65	0	721	18
Trees and Shrubs	TRSH		4	164	88	90	240	0	599	15
Salt Marsh	SAMA		50	181	98	50	57	0	436	11
Wetland Vegetation	WEVE		6	298	238	352	1204	59	2157	52
Barnacle	BARN	Upper to Mid-Intertidal (B)	0	6	1	0	0	0	7	<1
Rockweed	ROCK		77	378	182	107	12	0	756	18
Biofilm	BIOF		0	8	3	0	0	0	11	0
Green Algae	GRAL		31	54	4	0	0	0	89	2
Bleached Red Algae	BRAL		0	4	0	0	0	0	4	<1
Filamentous and Foliose Red Algae	FFRA		4	31	6	0	0	0	41	1
Brown Bladed Algae	BRBA	Lower Intertidal (B)	13	164	10	0	0	0	187	5
Eelgrass	EELG		0	1	10	10	9	0	30	<1
Rooted Vegetation	ROVE		0	2	1	1	0	0	4	<1

*Please note that Total Number of Units is used to describe the distribution of biobands rather than length (in kilometers) because biobands are usually not continuous along the entire length of a unit. A calculation could be performed to estimate length of a bioband over a region using the percent length metric in the dataset.

Table 9. Percent alongshore length and width of subtidal biobands in the YK Delta survey area.

Bioband		Zone	Percent Length of Unit						Width of Bioband (m)				Total Number of Units	% of Total units Mapped
Name	Code		<5	5-25	26-50	51-75	76-95	>95	<10	10-30	>30	Not Assessed		
Eelgrass	EELG	Subtidal (C)	0	3	31	73	87	0	6	42	145	0	194	5
Brown Bladed Algae	BRBA		0	8	62	100	27	0	N/A	N/A	N/A	N/A	197	5
Rooted Vegetation	ROVE		0	4	7	8	2	0	9	6	6	0	21	1

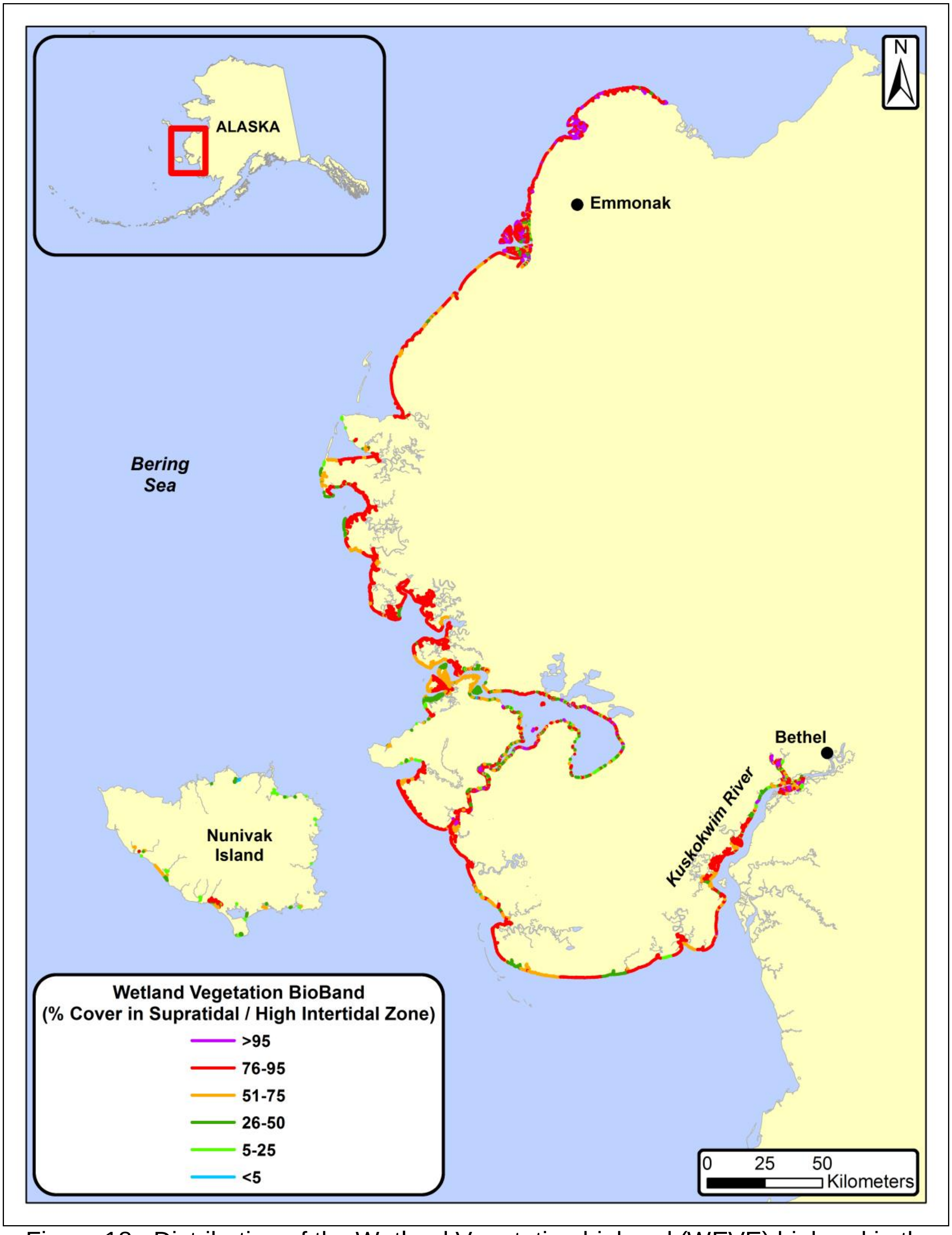

Figure 18. Distribution of the Wetland Vegetation bioband (WEVE) bioband in the supratidal (A zone) and high intertidal (B zone) of the YK Delta survey area.

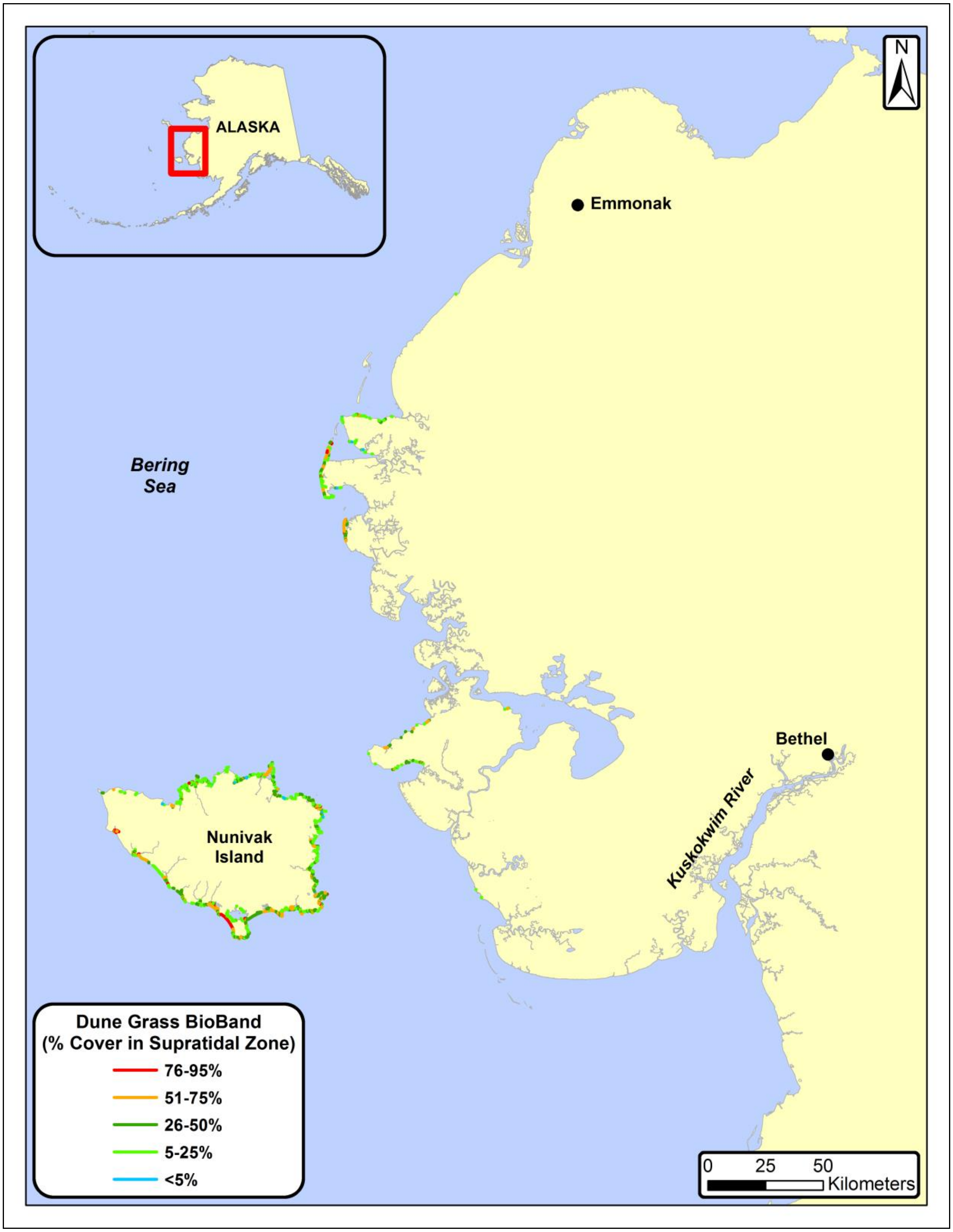

Figure 19. Distribution of the percent cover categories mapped for the Dune Grass (DUGR) bioband in the supratidal (A zone) of the YK Delta survey area.

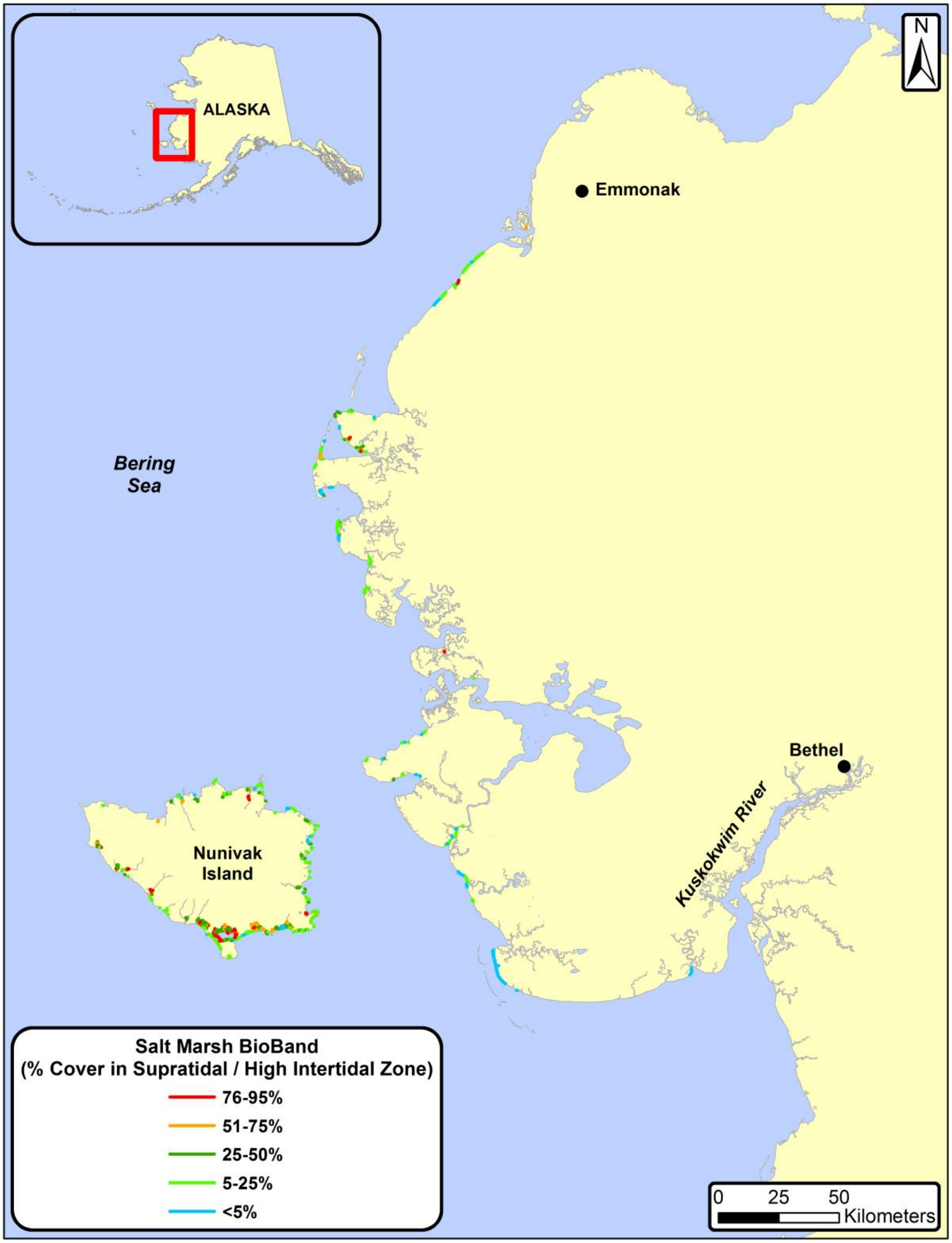

Figure 20. Distribution of the Salt Marsh (SAMA) bioband in the supratidal (A zone) and high intertidal (B zone) of the YK Delta survey area.

Figure 21. Distribution of the width categories mapped for the Eelgrass (EELG) bioband in the subtidal (C zone) of the YK delta survey area.

3.3 Biological Wave Exposure

Biological wave exposure categories range from Very Protected (VP) to Very Exposed (VE) and are usually defined in ShoreZone on the basis of a typical set of biobands. When present, the observation and relative abundance of biota in each alongshore unit is used to determine the classification for the biological wave exposure. The assemblages of biota observed are then used as a proxy for the wave exposure at that site. The six biological wave exposure categories are the same as those used in the physical mapping (Appendix A, Tables A-5 and A-10).

On mobile substrate beaches such as those on the mainland coast of YK Delta, biobands are usually absent. Without attached biota the physical mappers' estimate of wave exposure (EXP_OBSER) was used for the biological wave exposure. The physical wave exposure is interpreted from maximum wave fetch estimates and coastal geomorphology. In this case, the physical wave exposure was also then used in the look up matrix for determining the Oil Residence Index (ORI) (Table A-7).

Biobands used as indicators of wave exposure for ShoreZone are listed in Appendix A Table A-11. For more information about biobands, biological wave exposure, habitat class definitions and examples from other bioareas in Alaska, see previous data summary reports and the current ShoreZone protocols. These reports are available for download from the ShoreZone website at http://alaskafisheries.noaa.gov/shorezone/.

The distribution of the wave exposure categories mapped in the YK Delta survey area is summarized in Table 10 and Figure 22 respectively. A summary map of the biological wave exposure categories is shown in Figure 23. Most of the coastline was in the lower exposure categories of Protected or Semi-Protected (77%) with the rocky coast on the west side of Nunivak Island and the some of the large mudflats on the mainland being Exposed (6%). It should be noted that many of the beaches classed as Exposed do not receive high wave energy during the winter months when the nearshore ice pack has formed and are therefore only truly Exposed or Semi-Exposed during the ice-free months. They are therefore not exposed to the worst of the winter storms that play a role in structuring the biotic community in more southern areas. This is one factor that makes this a unique bioarea compared to adjacent Bioareas such as Bristol Bay (BRIS) and Southwest Alaska (SWAK) (see Figure 13 for a map of the Bioareas).

Table 10. Summary of Wave Exposure mapped in the YK Delta survey area.

Wave Exposure		Shoreline Length (km)	% of Shoreline
Name	**Code**		
Exposed	E	271	6
Semi-Exposed	SE	768	17
Semi-Protected	SP	767	17
Protected	P	2634	59
Totals		**4440**	**100**

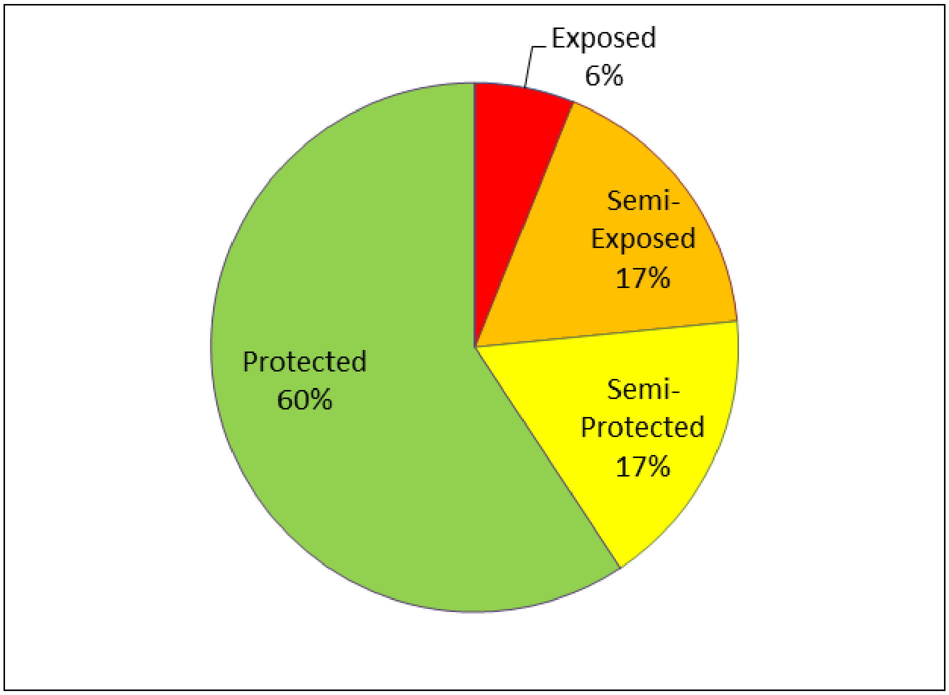

Figure 22. Distribution of biological wave exposures mapped in the YK Delta survey area.

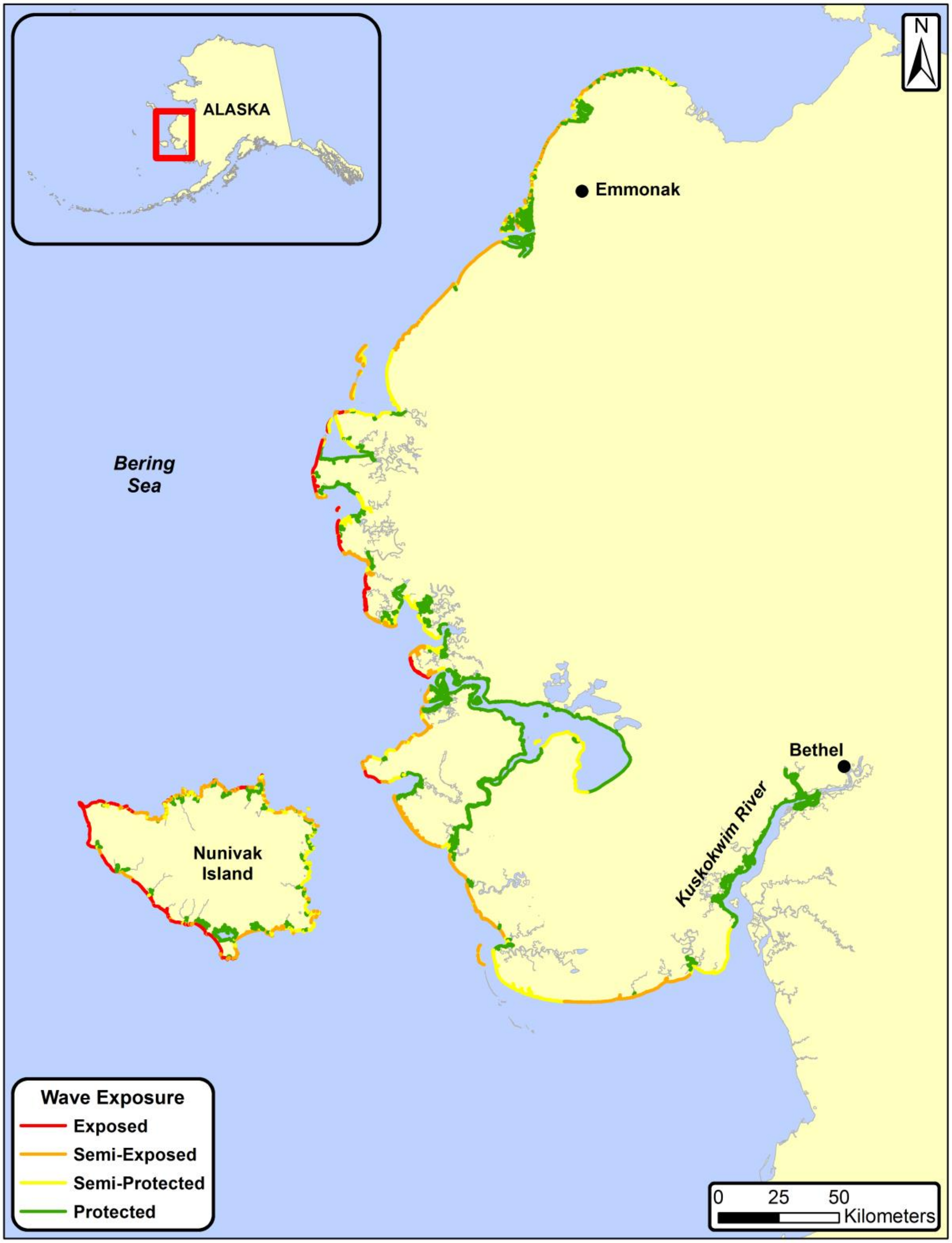

Figure 23. Distribution of the biological wave exposure over the YK Delta survey area.

3.4 Habitat Class

Habitat Class is a classification based on wave exposure and geomorphic characteristics observed on an alongshore unit. The habitat class is intended to provide a single attribute to characterize the biophysical features of each unit. This section includes a summary of all mapping done for YK Delta.

The habitat class is assigned by the biological mapper and weighted according to the dominant structuring process. Wave exposure is the most common structuring process, and less commonly observed habitats are those structured by current, estuarine/fluvial processes, and anthropogenic structures. For habitat classes structured by wave exposure, substrate mobility determines the presence of epibenthic biota. Where the substrate is highly mobile, biota is sparse or absent, and where the substrate is stable, biota can be abundant.

The three categories of habitat classes based on substrate mobility are as follows:

- **Immobile** or stable substrates, such as bedrock or large boulders, enabling a well-developed epibenthic bioband to form;
- **Partially Mobile** mixed substrates such as a rock platform with a beach or sediment veneer where the development of biobands are limited by the partial mobility of the sediments;
- **Mobile** substrates such as sandy beaches where wave exposure is sufficient to frequently move sediment, thereby limiting the development of biobands.

Habitat classes determined by dominant structuring processes other than wave exposure are:

- **Estuary** complexes, with freshwater stream or river flow, delta form at the stream mouth and fringing wetland and salt marsh biobands;
- **Current-Dominated** channels where high tidal currents support assemblages of biota typical of higher wave exposure sites (these units are usually associated with lower wave exposure conditions in adjacent shore units);
- **Anthropogenic** features where the shoreline has undergone human modification (e.g., areas of rip rap or fill, diked fields, marinas and landings);
- **Lagoons**, which have enclosed coastal ponds of brackish or salty water. This class is considered a 'secondary' habitat class and is assigned in addition to the main habitat class. It is only used for small backshore lagoons that are not truly part of the main shoreline but are still important features to note. Large lagoon features such as Izembek Lagoon are part of the main shoreline and would not have a secondary lagoon habitat class assigned to them. This secondary habitat class is not used in shoreline length calculations (because it would 'double count' those units) and is therefore not included in some of the figures below.

Further definition and explanation of Habitat Class codes are listed in Appendix A (Tables A-10 and A-11) and in the Alaska ShoreZone protocols (Harper and Morris 2014).

The distribution of habitat class categories mapped for the YK Delta is summarized in Figure 24 and in Table 11. Mobile substrate is the dominant shoreline type (58%). Estuaries are not very common in this area with only 3% of the shoreline in that classification. The estuary habitat class is associated with spawning and nursery habitats for fish as well as breeding and foraging grounds for birds and other wildlife. This is, however, a bit misleading for the YK Delta as the entire mainland survey area is a giant estuary for two major rivers (the Yukon and the Kuskokwim) as well as numerous smaller rivers and streams, and is very rich in all kinds of wildlife, especially shorebirds. The Permafrost habitat class occurred in 3% of units (see Figure 25 for distribution). This habitat class is only mapped when the Tundra bioband (TUND) is present in the intertidal zone, usually associated with eroding shoreline where terrestrial vegetation is eroding into the water. The TUND bioband does not always indicate permafrost is present as Tundra can form in the absence of ground-level permafrost. As can be seen in Figure 25, this habitat class was found almost exclusively in and near Baird Inlet or up the Kuskokwim River near Bethel and is therefore associated with the riverine and palustrine, rather than the marine, portions of this survey (according to the National Wetlands Inventory maps at http://www.fws.gov/wetlands/data/mapper.HTML). According to the permafrost maps of Alaska by Jorgenson et al. (2008) (http://permafrost.gi.alaska.edu/sites/default/files/AlaskaPermafrostMap_Front_Dec2008_Jorgenson_etal_2008.pdf) there is discontinuous permafrost present around the eastern portion of Baird Inlet and near Bethel, which is consistent with our distribution of the Permafrost habitat class.

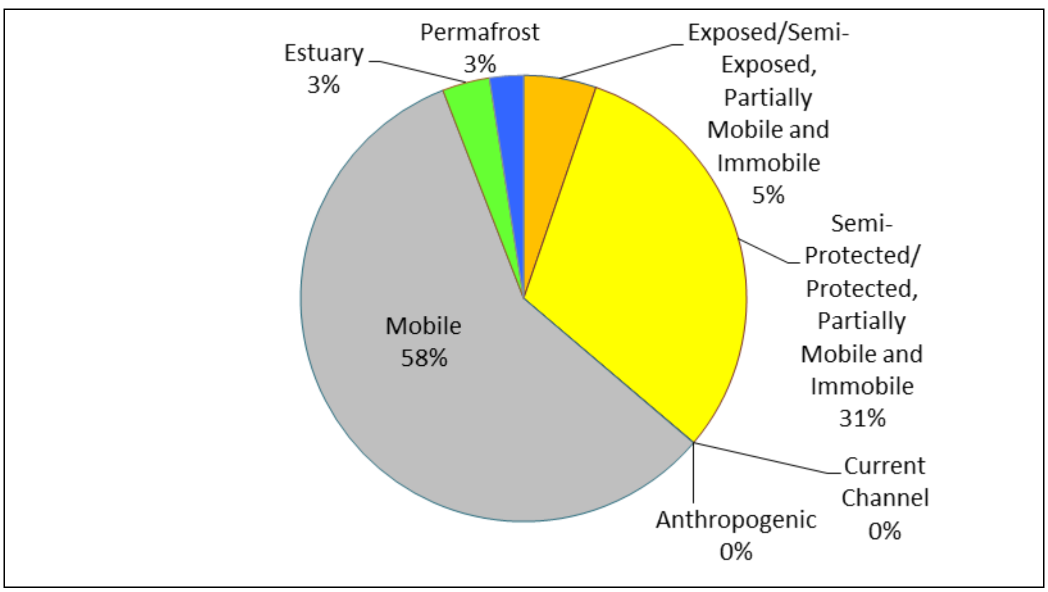

Figure 24. Summary of Habitat Class categories in the YK Delta survey area (please note that the Permafrost habitat class does not necessarily indicate the presence of permafrost in the unit – see text above for explanation).

Table 11. Summary of Habitat Class distribution in the YK Delta survey area.

Dominant Structuring Process	Habitat Class			
	Exposure Category	**Substrate Mobility**	**Length (km)**	**% of Mapping**
Wave Exposure	Exposed (E)	Immobile & Partially Mobile	86	2
	Semi-exposed (SE)	Immobile & Partially Mobile	148	3
	Semi-protected (SP)	Immobile & Partially Mobile	178	4
	Protected (P)	Immobile & Partially Mobile	1195	27
	E, SE, SP, P, VP	Mobile	2571	58
Fluvial/ Estuarine processes	Estuary/organics		153	3
Current energy	Current dominated		<1	<1
Man-modified	Anthropogenic		1	<1
Permafrost*	Permafrost/Tundra		109	3
Lagoon**	Lagoon		4	<1
TOTALS:			**4440**	**100**

* This habitat class is not necessarily associated with permafrost, but is associated with the Tundra bioband dominating the unit (in the intertidal zone). See text on Page 40 for full explanation.
**Lagoons are classified as *secondary habitat class* (Appendix A, Table A – 10 and A – 11) and are not included in the total shoreline length

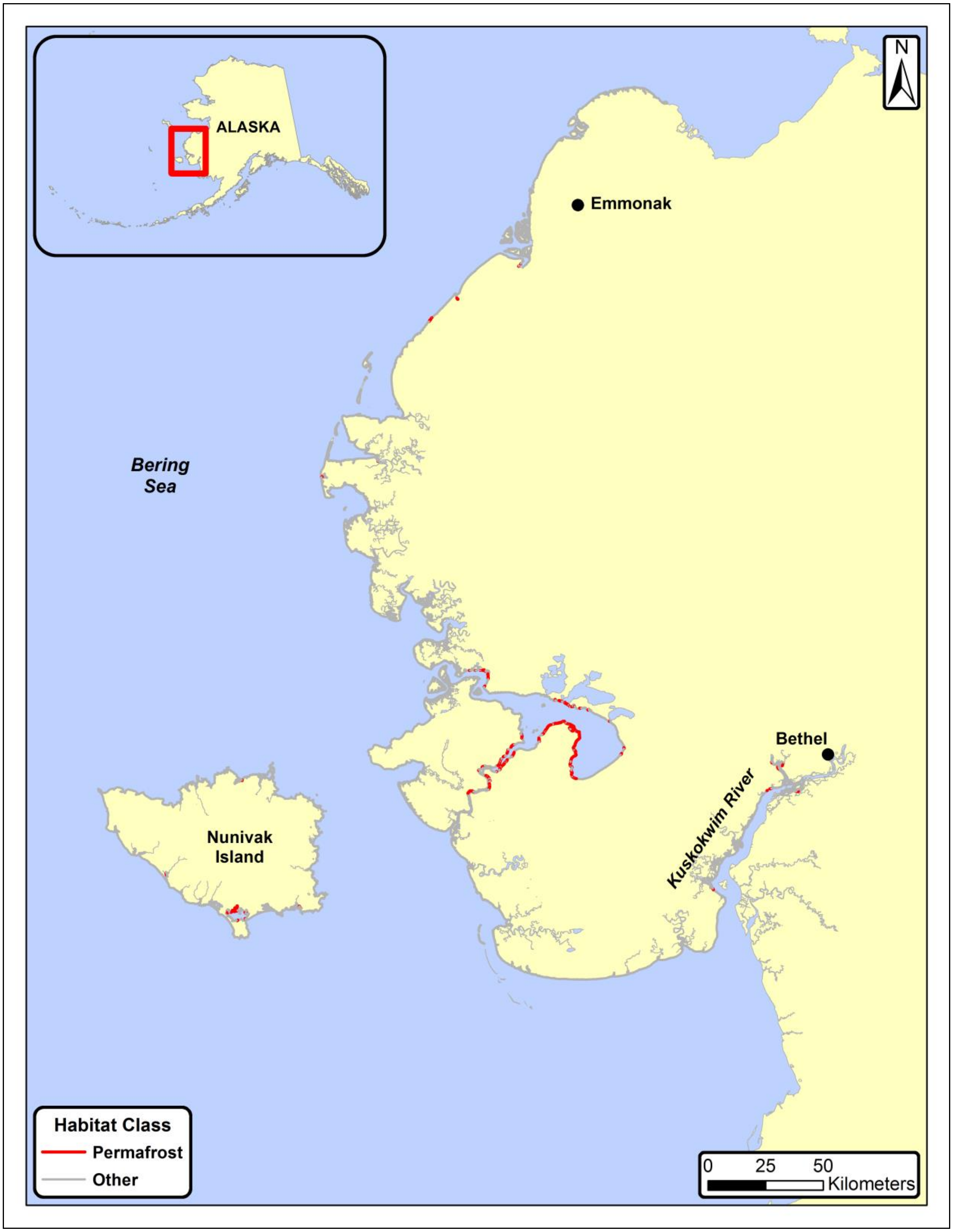

Figure 25. Distribution of the Permafrost habitat class in the YK Delta survey area (please note that this habitat class does not necessarily indicate the presence of permafrost in the unit – see text on Page 40 for explanation).

4 CONCLUSIONS & RECOMMENDATIONS

4.1 Conclusions

1. This ShoreZone project covers close to 4,440 km of the Yukon-Kuskokwim Delta. The system will allow for the searching of a wide variety of attributes that are captured in the ShoreZone dataset. Users can examine all the information for a small site or look at the distribution of a single attribute over a large region. This summary report and existing protocol documents will allow users to better understand the ShoreZone dataset in the YK Delta and how to appropriately use the data for further analysis.

2. The attributes in ShoreZone provide an important tool for habitat capability modelling. For example, ShoreZone has been used in British Columbia and Alaska for identifying high probability sites for colonization by invasive green crabs (Harney 2007). ShoreZone attributes of substrate, exposure and associations with marshes and eelgrass were used to identify and map these sites. Similar analyses could be done using the YK Delta dataset alone or in combination with other ShoreZone datasets over a wider area.

3. Georeferenced imagery, available on the website (www.shorezone.org) will allow users of ShoreZone to see the photos and video that were used in the classification summarized in this report. The imagery, combined with the ShoreZone classification and this summary report, provide a powerful tool for analysis as well as a crucial baseline record of conditions at a given point in time.

4.2 Recommendations

1. In general, ShoreZone does not provide sufficient resolution of attributes to be used in change detection for most areas of concern. However, it is an excellent tool for selecting sites that can be used for monitoring of change over time and provides a regional baseline that can put those monitoring efforts into context on a broader scale.

2. Another frequent question is: how often should ShoreZone be updated? As climate change affects the coastal zone, shorelines may move in position but generally, the physical attributes of that shoreline do not change.; however, the biotic communities are likely to be more changeable both due to effects of climate shifts and changes in shoreline position. How far this change goes before the ShoreZone imagery needs to be updated is a question better answered on a regional scale as different areas will be more changeable than others (the Arctic may change more rapidly for instance). Another reason to update ShoreZone is the rapid changing of technology since it was started. In 2003, ShoreZone was still using film and a few hundred photos per day were being collected. But in

2014, digital technology allowed thousands of georeferenced photos to be collected in a day. This new technology allows for more detailed classification and opened up new opportunities for analysis and would provide a sound reason to update areas previously captured with ShoreZone. The updating of the protocols to include the Coastal Vulnerability Module, new ESI protocols and new bioband metrics and definitions would also be a good reason to update older ShoreZone classifications, especially with the current priorities around creating resilient shorelines and communities in the face of sea-level rise due to climate change.

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Protocols for data access and distribution are established by the program partner agencies. Please see www.ShoreZone.org for a list of partner agencies and related web sites. Video imagery can be viewed and digital stills downloaded online at www.ShoreZone.org. Any hardcopies or published data sets utilizing ShoreZone products shall clearly indicate their source. For questions regarding the protocols or information in this report, please contact Sarah Cook, the ShoreZone Program Manager at Sarah@coastalandoceans.com (Tel: 250-658-4050). For data requests or analytical support contact Kalen Morrow at Kalen@coastalandoceans.com or Dr. G. Carl Schoch at Coastal and Ocean Resources: Carl@coastalandoceans.com.

APPENDIX A DATA DICTIONARY

Appendix Table	Description
A-1	Data dictionary for UNIT table
A-2	Classification of shore types employed in ShoreZone mapping
A-3	Environmental Sensitivity Index (ESI) Shore Type classification
A-4	Exposure matrix used for estimating observed physical exposure (EXP_OBSER) on the basis of fetch distance
A-5	Oil Residence Index (ORI) definitions
A-6	Oil Residence Index (ORI) look-up matrix based on exposure (columns) and substrate type (rows)
A-7	Data dictionary for BIOUNIT table
A-8	Definition of BIOAREAS
A-9	Exposure Codes used in *Biounit* Table
A-10	Habitat Class Codes
A-11	Habitat Class Definitions
A-12	Data dictionary for across-shore component table (XSHR)
A-13	‘Form’ Code Dictionary
A-14	‘Material’ Code Dictionary
A-15	Data dictionary for the BIOBAND Table
A-16	Bioband Definitions
A-17	Data dictionary for the PHOTO Table
A-18	Examples of the Shore Types in the YK Delta survey area
A-19	Examples of the Biobands in the YK Delta survey area

Table A-1. Data dictionary for UNIT table

Field Name	Description
UnitRecID	Automatically-generated number field; the database "primary key" for unit-level relationships
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0); this field is completed by the database manager using an update query
REGION	2-digit coastal region number (see reference maps and GIS materials)
AREAS	2-digit coastal area number (see reference maps and GIS materials)
PHY_UNIT	4-digit physical along-shore unit number; segmented during physical mapping and delineated on paper maps and in GIS
SUBUNIT	Set to 0 for line features (units) or non-zero for point features (also called variants); several subunits in a unit are numbered sequentially (1, 2, 3…) according to the order occurring within the unit (based on UTC time)
TYPE	Single-letter description of Unit type: a (L)ine [unit] or (P)oint feature [variant]
BC_CLASS	Coastal class or "shore type" of the unit based primarily on substrate type, across-shore width, and slope (Table A-2)
ESI	Environmental Sensitivity Index shore unit classification (Table A-3)
LENGTH_M	Along-shore length in meters; calculated after digitizing using ArcGIS and updated using database query
GEO_MAPPER	Last name of the physical mapper
GEO_EDITOR	Last name of the physical mapper who QA/QCs the work (10% of all units are reviewed by an editor)
GEO_MAP_DATE	the mapping date
VIDEOTAPE	Title of the videotape (DVD imagery) used for mapping; naming convention for Oregon is ORG11_OR_02, in which ORG11 is the region and year, OR is the team, 02 is tape
HR	Hour at which unit starts; based on the first two digits of the 6-digit UTC time on video when start of unit is at center of screen
MIN	Minute at which unit starts; based on third and fourth digits of 6-digit UTC time on video when start of unit is at center of screen
SEC	Seconds at which unit starts; based on the last two digits of the 6-digit UTC time on video when start of unit is at center of screen
EXP_OBSER	Estimate of wave exposure as observed by the physical mapper, as a function of the relative fetch (Table A-4), with a consideration of geomorphology.
ORI	Oil Residence Index indicates a possible residence time of heavy oils stranded on the shore. It is largely determined by wave exposure levels and shore substrate types (see Tables A-5 and A-6)
SED_SOURCE	Estimated sediment source for the unit: (A)longshore, (B)ackshore, (F)luvial, (O)ffshore, (X) not identifiable
SED_ABUND	Code indicating the relative sediment abundance within the shore-unit, (A)bundant, (M)oderate, (S)carce

Table A-1. Data dictionary for UNIT table (continued)

Field Name	Description
SED_DIR	One of the eight cardinal points of the compass indicating dominant sediment transport direction (N, NE, E, SE, S, SW, W, NW). (X) Indicates transport direction could not be discerned from imagery.
CHNG_TYPE	Code indicating the stability of the shore unit, reflecting the relative degree of "measurable change" during a 3-5 year time span: (A)ccretional, (E)rosional, (S)table
SHORENAME	Name of a prominent geographic feature near the unit (from nautical chart or gazetteer)
UNIT_COMMENTS	Text field used for miscellaneous comments and notes during physical mapping
SHORE_PROB	Comment on nature of difference between digital shoreline and observed shoreline
SM1_TYPE	2-letter code indicating the *primary* type of shore modification occurring within the unit: BR = boat ramp; CB = concrete bulkhead; DK = dyke; LF = landfill; SP= sheet pile; RR = rip rap and WB = wooden bulkhead
SM%	Estimated % occurrence of the primary shore modification type in tenths (i.e. "2" = 20% occurrence with the unit alongshore)
SM2_TYPE	2-letter code indicating the *secondary* type of shore modification occurring within the unit
SM2%	Estimated % occurrence of the *secondary* type of shore modification occurring within the unit
SM3_TYPE	2-letter code indicating the *tertiary* type of shore modification occurring within the unit
SM3%	Estimated % occurrence of the *tertiary* seawall type in tenths (i.e., "2" = 20% occurrence within the unit)
SMOD_TOTAL	Total % occurrence of shore modification in the unit in tenths
RAMPS	Number of boat ramps that occur within the unit; ramps must impact some portion of the shore-zone and generally be constructed of concrete, wood or aggregate
PIERS_DOCK	Number of piers or wharves that occur within the unit; piers or docks must extend at least 10 m into the intertidal zone; does not include anchored floats
REC_SLIPS	Estimated number of recreational slips at docks of the unit; based on small boat length ~<50'
DEEPSEA_SLIP	Estimated number of slips for ocean-going vessels in the unit; based on ship length ~>100'
ITZ	Sum of the across-shore width of all the intertidal components (B zones) within the unit
EntryDate ModifiedDate	Date and time the unit was physically mapped (or modified)

Table A-2. Classification of shore types employed in ShoreZone mapping
(after Howes *et al* [1994] "BC Class" system in British Columbia)

SUBSTRATE	SEDIMENT	WIDTH	SLOPE	COASTAL CLASS	NO.
ROCK	N/A	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Rock Ramp, wide	1
			FLAT (<5°)	Rock Platform, wide	2
		NARROW (<30 m)	STEEP (>20°)	Rock Cliff	3
			INCLINED (5-20°)	Rock Ramp, narrow	4
			FLAT(<5°)	Rock Platform, narrow	5
ROCK & SEDIMENT	GRAVEL	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp with gravel beach, wide	6
			FLAT (<5°)	Platform with gravel beach, wide	7
		NARROW (<30 m)	STEEP (>20°)	Cliff with gravel beach	8
			INCLINED (5-20°)	Ramp with gravel beach	9
			FLAT (<5°)	Platform with gravel beach	10
	SAND & GRAVEL	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp w gravel & sand beach, wide	11
			FLAT (<5°)	Platform with G&S beach, wide	12
		NARROW (<30 m)	STEEP (>20°)	Cliff with gravel/sand beach	13
			INCLINED (5-20°)	Ramp with gravel/sand beach	14
			FLAT (<5°)	Platform with gravel/sand beach	15
	SAND	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp with sand beach, wide	16
			FLAT (<5°)	Platform with sand beach, wide	17
		NARROW (<30 m)	STEEP (>20°)	Cliff with sand beach	18
			INCLINED (5-20°)	Ramp with sand beach, narrow	19
			FLAT (<5°)	Platform with sand beach, narrow	20
SEDIMENT	GRAVEL	WIDE (>30 m)	FLAT (<5°)	Gravel flat, wide	21
		NARROW (<30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Gravel beach, narrow	22
			FLAT (<5°)	Gravel flat or fan	23
	SAND & GRAVEL	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	n/a	
			FLAT (<5°)	Sand & gravel flat or fan	24
		NARROW (<30 m)	STEEP >20°)	n/a	
			INCLINED (5-20°)	Sand & gravel beach, narrow	25
			FLAT (<5°)	Sand & gravel flat or fan	26
	SAND / MUD	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	27
			FLAT (<5°)	Sand flat	28
			FLAT (<5°)	Mudflat	29
		NARROW (<30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	30
			FLAT (<5°)	n/a	n/a
	ORGANICS	n/a	n/a	Estuaries	31
ANTHRO-POGENIC	Man-made	n/a	n/a	Man-made, permeable	32
			n/a	Man-made, impermeable	33
CHANNEL	Current	n/a	n/a	Channel	34
GLACIER	Ice	n/a	n/a	Glacier	35

Table A-3. Environmental Sensitivity Index (ESI) Shore Type classification
(after Petersen *et al* 2002)

ESI No.	Description
1A	Exposed rocky shores; exposed rocky banks
1B	Exposed, solid man-made structures
1C	Exposed rocky cliffs with boulder talus base
2A	Exposed wave-cut platforms in bedrock, mud, or clay
2B	Exposed scarps and steep slopes in clay
3A	Fine- to medium-grained sand beaches
3B	Scarps and steep slopes in sand
3C	Tundra cliffs
4	Coarse-grained sand beaches
5	Mixed sand and gravel beaches
6A	Gravel beaches; Gravel Beaches (granules and pebbles
6B	Gravel Beaches (cobbles and boulders)
6C	Rip rap (man-made)
7	Exposed tidal flats
8A	Sheltered scarps in bedrock, mud, or clay; Sheltered rocky shores (impermeable)
8B	Sheltered, solid man-made structures; Sheltered rocky shores (permeable)
8C	Sheltered rip rap
8D	Sheltered rocky rubble shores
8E	Peat shorelines
9A	Sheltered tidal flats
9B	Vegetated low banks
9C	Hypersaline tidal flats
10A	Salt- and brackish-water marshes
10B	Freshwater marshes
10C	Swamps
10D	Scrub-shrub wetlands; mangroves
10E	Inundated low-lying tundra

Table A-4. Exposure matrix used for estimating observed physical exposure (EXP_OBSER) on the basis of fetch distance

Maximum Fetch (km)	Modified Effective Fetch (km)				
	<1	**1 - 10**	**10 - 50**	**50 - 500**	**>500**
<1	very protected	n/a	n/a	n/a	n/a
<10	protected	protected	n/a	n/a	n/a
10 – 50	n/a	semi-protected	semi-protected	n/a	n/a
50 – 500	n/a	semi-exposed	semi-exposed	semi-exposed	n/a
>500	n/a	n/a	semi-exposed	exposed	exposed & very exposed

Codes for exposures:		
	very protected	**VP**
	protected	**P**
	semi-protected	**SP**
	semi-exposed	**SE**
	exposed	**E**
	very exposed	**VE**

Table A-5. *Oil Residence Index* (ORI) Definitions

Persistence	Oil Residence Index	Estimated persistence
Short	1	Days to weeks
	2	**Weeks** to months
Moderate	3	Weeks to **months**
	4	**Months** to years
Long	5	Months to **years**

Table A-6. *Oil Residence Index* (ORI) Look-up Matrix

Substrate	VE	E	SE	SP	P	VP
rock	1	1	1	2	3	3
man-made, impermeable	1	1	1	2	2	2
boulder	2	3	5	4	4	4
cobble	2	3	5	4	4	4
pebble	2	3	5	4	4	4
sand w/ pebble, cobble, or boulder	1	2	3	4	5	5
sand w/o pebble, cobble, or boulder	2	2	3	3	4	4
mud	999	999	999	3	3	3
organics/vegetation	999	999	999	5	5	5
man-made, permeable	2	2	3	3	5	5

Table A-7. Data Dictionary for Biounit Table

Field Name Code	Description
UnitRecID	**Unit Record ID:** Automatically-generated number field; the database “primary key” required for relationships between tables
PHY_IDENT	**Physical_Ident** is a unique code to identify each unit, assigned by physical mapper; defined as an alphanumeric string determined by the codes for: Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0), where ‘12’ is Region 12, ‘03’ is Area 3, ‘0552’ is the Unit number, and ‘0’ is the Subunit number.
BIOAREA	**Bioarea:** Geographic division used to describe regional differences in observed biota and coastal habitats (Bioarea codes and descriptions listed in Table A-8)
EXP_BIO	**Biological Wave Exposure:** A classification of the wave exposure category within the Unit, assigned by the Biological mapper, based on observed indicator species and biobands (Table A-9)
HAB_CLASS	**Habitat Class**: Code for a classification of overall habitat category within the Unit, assigned by the biological mapper. Based on the Biological Exposure (EXP_BIO) and the geomorphic features of the shoreline (Table A-10 and A-11).
HAB_CLASS_LTRS	**Habitat Class** in alphabetic code: translation in the HAB CLASS lookup table (Table A-11)
HAB_OBS	**Habitat Observed**: Original Habitat code categories used to classify Habitat Type; not used in current protocol but kept for backward-compatibility with earlier projects; replaced by HAB_CLASS
BIO_SOURCE	**Biomapping Source:** The source data used to interpret coastal zone biota: (V)ideotape, (V2) - lower quality video imagery, (S)lide, (I)nferred
HAB_CLASS2	**Secondary Habitat Class**: Code for a classification of secondary Lagoon-type habitat within the Unit, assigned by the biological mapper. Based on the Biological Exposure (EXP_BIO) and lagoon habitat types (Table A-10 and A-11)
HC2_SOURCE	**Secondary Habitat Class Source:** Source used to interpret the Secondary Habitat Class (HAB_CLASS2) as: OBS(erved) as viewed from video, L(oo)KUP refering to ‘Form’ Code Lo or Lc in XSHR table
HC2_Note	**Secondary Habitat Class Comment:** comment field for Secondary Habitat Class (HAB_CLASS2)
RIPARIAN_PERCENT	**Riparian Percent Overhang:** Estimate of the percentage of alongshore length of the intertidal zone, in which the shoreline is shaded by overhanging riparian vegetation; all substrate types (Expanded definition in Table A-10)
RIPARIAN_M	**Riparian Overhang Meters:** Calculated portion of the unit length, in meters, of riparian overhang in the intertidal (B) zone, using LENGTH_M field of UNIT table, and RIPARIAN_PERCENT of BIOUNIT table; all substrate types.
BIO_UNIT_COMMENT	**Biological Comments**: regarding the along-shore unit as a whole. Included as deliverable data, as note format.
BIO_MAPPER	**Biological Mapper:** The initials of the biological mapper that provided the biological interpretation of the imagery
PHOTO	Still Photo in Unit: **Yes/No tick box** to indicate if high resolution photo is available for the Unit. (see BIOSLIDE table)
DateAdded DateModified	**Date/Time Mapped or Modified:** Date and time the unit was physically mapped (or modified)

Table A-8. Definitions of the BIOAREA attribute in BIOUNIT table.

Bioarea Name	Bioarea Code	Bioarea Suffix *	Geographic Extent	Characteristics
Outer Kenai	KENA	8	Kenai Coast, Alaska, including Kenai Fjords National Park, from Cape Elizabeth at the east entrance of Cook Inlet to Port Bainbridge at the west entrance of Prince William Sound.	Rugged coastline, dominated by extremely steep shores and Very Exposed wave exposure. Fjord heads with tidewater glaciers. Absence of Dragon Kelp and Giant Kelp biobands.
Cook Inlet	COOK	9	Cook Inlet, Alaska, from Cape Douglas on the southwest entrance Cook Inlet, north to Anchorage, including Turnagain Arm and Kachemak Bay, to Cape Elizabeth at the southeast entrance of Cook Inlet.	Sediment-dominated, wide, low-slope shorelines, moderate to lower wave exposures. Affected by silt-laden freshwater input, absence of Giant Kelp and Dragon Kelp. Very wide complexes of salt marshes and estuaries.
Kodiak Island	KODI	10	Kodiak archipelago, Gulf of Alaska side, from Tugidak Island and Akhiok at the southwest end of the archipelago, to Shuyak Island at the northeast end of the islands.	Diversity of habitats and wave exposures, from Very Protected estuaries to Exposed rock cliffs. Fully marine and open to Gulf of Alaska. Lush lower intertidal brown algae, red algae and canopy kelps, in particular at north end. Southwest coast has wide rock platforms with surfgrass beds and sediment dominated offshore islands.
Katmai / Shelikof Strait side of Kodiak Island	KATM	11	Katmai National Park and Preserve, Alaska Peninsula, Shelikof Strait, includes the northwest side of the Kodiak archipelago.	Moderate to high wave exposures, affected by outflow from Cook Inlet, and separated from open Gulf of Alaska by Kodiak archipelago. Limited diversity of lower intertidal browns and canopy kelps, with diversity of red algae characterizing higher exposure sites. Includes both coasts of Shelikof Strait.
Aniakchak	ANIA	11	Aniakchak National Monument and Preserve, Alaska Peninsula, Shelikof Strait, southwest of Katmai National Park.	High wave exposure, wide bedrock platforms and mobile sediment beaches. Included in KATM bioareas for species descriptions, pending further delineation of bioarea boundaries. Likely transitional to Aleutian bioareas.
Southeast Alaska -- Yakutat	SEYA	12	The Yakutat region, on the Gulf of Alaska coast. Extends from the outer edge of the Copper River delta, near Cordova, south through Yakutat Bay, to Icy Point, just north of Cross Sound.	Exposed west-facing coast, open to Gulf of Alaska. Mobile, highly exposed sediment beaches dominant. Limited canopy kelp distribution.
Southeast Alaska – Lynn Canal (fjord)	SEFJ	12	Lynn Canal from Point Howard at the southwest edge, at SEIC boundary, north to Skagway, and the east side of Lynn Canal south. Includes Juneau, Douglas Island, Taku Inlet and Port Snettisham with the southeast edge to the south tip of Glass Peninsula, Hugh Point on Admiralty Island.	Fjord landscape, bedrock dominated, moderate to low wave exposures, glacial silty waters. Low species diversity in intertidal, dense Blue Mussel bioband, absence of Dragon Kelp and Giant Kelp biobands.

* Suffix applied to bioband codes for four lower intertidal biobands (HAL, RED, SBR, CHB) to distinguish between regional differences in species composition of these bands in different bioareas.

[continued]

Table A-8. Definitions of the BIOAREA attribute in BIOUNIT table (continued).

Bioarea Name	Bioarea Code	Bioarea Suffix *	Geographic Extent	Characteristics
Prince William Sound	PRWS	13	All of Prince William Sound from Orca Inlet at Cordova on the east, to the south end of Montague Island, and across to Port Bainbridge on the west.	Diverse habitat, with high Semi-Exposed to Very Protected wave exposures. Differences between conditions in eastern and western Sound, with interaction of circulation complexities. Numerous tidewater glaciers and effects of Copper River. Absence of Giant Kelp and Dragon Kelp.
Southeast Alaska – Icy Strait	SEIC	12	The Icy Strait region, of northern SE Alaska. The north extend is at Icy Point, at SEYA boundary, south to Cape Spencer and the north shore Cross Sound, east to the southwest entrance of Lynn Canal at Point Howard. Includes entire south shore Icy Strait, from Point Lucan at west to False Bay, northeast Chichagof Island.	Glacial silty water, wide, sediment-dominated beaches common, fringing salt marsh common, moderate and lower wave exposures, wide estuary flats common. Dragon Kelp dominant canopy kelp.
Southeast Alaska – Sitka	SESI	12	The Sitka area includes the northwest sides of Chichagof and Baranof Islands. The northern boundary is at Point Lucan in Icy Strait, including Yakobi and Kruzof Islands with the southern boundary at the southern tip of Baranof Island at Cape Ommaney.	Fully marine, west coast, includes diversity of species, exposure and habitat categories, from Exposed to Very Protected. Giant Kelp abundant, Dragon Kelp limited distribution.
Southeast Alaska – Misty Fjords	SEMJ	12	Misty Fjords area includes all fjords in the southeast region of Southeast Alaska, including Behm Canal, George Inlet, Carroll Inlet, Thorne Arm, Boca de Quadra and the western side of Portland Inlet.	Fjord landscape, bedrock-dominated, low wave exposures. Low species diversity. Absence of Giant Kelp and Dragon Kelp.
Southeast Alaska – Craig	SECR	12	The Craig area includes islands in the southwest region of Southeast Alaska, including areas around Ketchikan as well as Prince of Wales Island, Dall Island and all surrounding archipelagos, from southern Coronation Island, south to Dixon Entrance.	Fully marine, west coast. High species diversity and habitat heterogeneity. Northern limit of California Mussel and Urchin Barrens biobands and certain species of other lower intertidal kelps. Southern limit of Dragon Kelp.
Southeast Alaska -- Stikine	SESK	12	The Stikine area encompasses central Southeast Alaska. Northern extent includes east Chichagof Island from False Bay, west Admiralty Island and south from Tracy and Endicott Arms. Includes east Baranof, Kuiu and Kupreanof Islands as well as the Stikine River and surrounding Islands, Etolin and Wrangell. Southern boundary crosses Coronation and Warren Islands and northwest Prince of Wales Island	Glacial silty water affected, diversity of shoreline habitats and substrate types, moderate and lower wave exposures. Dragon Kelp dominant canopy kelp.

* Suffix applied to bioband codes for four lower intertidal biobands (HAL, RED, SBR, CHB) to distinguish between regional differences in species composition of these bands in different bioareas.

Table A-8. Definitions of the BIOAREA attribute in BIOUNIT table (continued).

Bioarea Name	Bioarea Code	Bioarea Suffix *	Geographic Extent	Characteristics
Beaufort Sea coast	BEAU	15	Point Barrow to Canadian border	Tundra cliffs and flats, extensive offshore barrier sand islands, permafrost dominated shore
Chukchi Sea coast	CHUK	14	Chukchi Sea coast from Point Barrow, to Point Hope	Low tundra cliffs and flats, permafrost dominated shore; barrier beach lagoon systems
Kotzebue Sound and St. Lawrence Island	KOTZ	18	Point Hope on Chukchi Sea south including Cape Krusenstern, east including Hotham Inlet, Selawik Lake and Baldwin Peninsula, south Kotzebue Sound, west through Cape Espenberg and southwest to Cape Prince of Wales. Also includes all of St. Lawrence Island.	Wide highly exposed bare beaches - large tidal lagoon complexes, extensive salt marsh. Much of the coast is sediment dominated with some rock and gravel sections on St. Lawrence Island. Selawik Lake section includes large areas of near-freshwater marsh and shallow nearshore.
Bristol Bay	BRIS	16	False Pass, Bechevin Bay to Cape Newenham	Wide sand and mud flats, braided stream and river mouths, dominated by mobile beaches, with few areas of immobile substrate.
Southwest Alaska Peninsula	SWAK	17	Southwest Alaska Peninsula from Unimak Island, northeast to include all survey area from 2011 of Cold Bay and Sand Point teams. Northeast boundary to be determined, and may be extended to include Aniakchak (ANIA). Offshore Shumagin and Sanak Islands groups included in SWAK.	Wide highly exposed beaches and rock platforms on mainland peninsula and offshore islands. Some lower wave exposures lagoons with eelgrass. Nearshore kelps include Dragon Kelp.

* Suffix applied to four lower intertidal biobands (HAL, RED, SBR, CHB) to distinguish between regional differences in species composition of these bands in different bioareas.

Table A-9. *Biological Wave Exposure* Codes

Biological Wave Exposure	
Name	**Code**
Very Exposed	VE
Exposed	E
Semi-Exposed	SE
Semi-Protected	SP
Protected	P
Very Protected	VP

Table A-10. Expanded descriptions for HABITAT CLASS, SECONDARY HABITAT CLASS, and RIPARIAN fields of the BIOUNIT table.

Attribute	Description
HAB_CLASS	**Habitat Class** attribute is a classification of the biophysical characteristics of an entire unit, and provides a single attribute that describes the typical intertidal biota and the associated biological wave exposure together with the geomorphology. That is, a typical example of a Habitat Class includes a combination of biobands, and their associated indicator species (which determine the Biological Exposure category) and the geomorphological features of the Habitat Class. The biological mapper observes and records the biobands in the unit, if any, and determines the Biological Exposure Category (EXP_BIO). The Habitat Class is determined on the basis of presence/absence of biobands, exposure category, geomorphology, and spatial distribution of biota within the unit. Within the database, an alpha code provides a summary indicator of habitat. (Table A-11), in which the matrix includes all combinations of Dominant Structuring Process, with associated substrate mobility and general geomorphic type on the vertical axis, and Biological Exposure on the horizontal axis.
HAB_CLASS2	The '**Secondary Habitat Class**' was added as an attribute in the BioUnit Table during biological mapping of the Kodiak Archipelago in Alaska in order to specifically identify lagoon habitats. Many backshore lagoons were observed in the Kodiak region, and they represent an unusual coastal habitat that differs from other estuaries and marshes. Backshore lagoons are also a coastal feature in Oregon. Units classified as lagoons contain brackish or salt water contained in a basin with limited drainage. They are often associated with wetlands and may include wetland biobands in the upper intertidal. Single units classified as lagoons often have the lagoon form in the A zone; however, some lagoons are large and may encompass several units when the lagoon form is mapped as the C zone.
RIPARIAN_PERCENT	As an attribute in the BIOUNIT table, the **Riparian_Percent** value is intended to be an index for the potential habitat for upper beach spawning fishes. The value recorded in the **Riparian_Percent** field is an estimate of the percentage of the unit's total alongshore length in which riparian vegetation (trees and shrubs) shades the upper intertidal zone. Shading of the highest high water line is a good estimate of riparian shading; therefore, shading of wetland herbs and grasses is not included in the estimate, nor is any shading of the splash zone alone. Shading must be visible in the upper intertidal zone, and the shading vegetation must be woody trees or shrubs. Riparian overhanging vegetation is also an indicator of lower wave exposures, in which the splash zone is narrow. Shading may occur in on sediment-dominated or in rocky intertidal settings.

Table A-11. Codes for HABITAT CLASS and SECONDARY HABITAT CLASS attributes, in the BIOUNIT table.

Dominant Structuring Process	Substrate Mobility	Coastal Type	Description	Biological Exposure Category					
				Very Exposed (VE)	Exposed (E)	Semi-Exposed (SE)	Semi-Protected (SP)	Protected (P)	Very Protected (VP)
Wave exposure	Immobile	Rock or Rock & Sediment or Sediment	The epibiota in the immobile mobility categories is influenced by the wave exposure at the site. In high wave exposures, only solid bedrock shorelines will be classified as 'immobile'. At the lowest wave exposures, even pebble/cobble beaches may show lush epibiota, indicating an immobile Habitat Class.	VE_I	E_I	SE_I	SP_I	P_I	VP_I
	Partially Mobile	Rock & Sediment or Sediment	These units describe the combination of sediment mobility observed. That is, a sediment beach that is bare in the upper half of the intertidal with biobands occurring on the lower beach would be classed as 'partially mobile'. This pattern is seen at moderate wave exposures. Units with immobile bedrock outcrops intermingled with bare mobile sediment beaches, as can be seen at higher wave exposures, could also be classified as 'partially mobile'.	VE_P	E_P	SE_P	SP_P	P_P	VP_P
	Mobile	Sediment	These categories are intended to show the 'bare sediment beaches', where no epibenthic macrobiota are observed. Very fine sediment may be mobile even at the lowest wave exposures, while at the highest wave exposures; large-sized boulders will be mobile and bare of epibiota.	VE_M	E_M	SE_M	SP_M	P_M	VP_M
Fluvial/ Estuarine processes		Estuary	Units classified as the 'estuary' types always include salt marsh vegetation in the upper intertidal; are always associated with a freshwater stream or river and often show a delta form. Estuary units are usually in lower wave exposure categories.	VE_E	E_E	SE_E	SP_E	P_E	VP_E
Current energy		Current-Dominated	Species assemblages observed in salt-water channels are structured by current energy rather than by wave exposure. Current-dominated sites are limited in distribution and are rare habitats.	VE_C	E_C	SE_C	SP_C	P_C	VP_C
Glacial processes		Glacier	In a few places in coastal Alaska, saltwater glaciers form the intertidal habitat. These Habitat Classes are rare and include a small percentage of the shoreline length.	VE_G	E_G	SE_G	SP_G	P_G	VP_G
Anthropogenic		Anthropogenic – Impermeable	Impermeable modified Habitats are intended to specifically note units classified as Coastal Class 33. These Habitat Classes are mapped to specifically inventory modified shoreline.	VE_X	E_X	SE_X	SP_X	P_X	VP_X
		Anthropogenic – Permeable	Permeable modified Habitats are intended to specifically note shore units classified as Coastal Class 32. These Habitat Classes are mapped to specifically inventory modified shoreline.	VE_Y	E_Y	SE_Y	SP_Y	P_Y	VP_Y
Lagoon		Lagoon	Units classified as Lagoons in the Secondary Habitat Class contain brackish or salty water that is contained within a basin that has limited drainage. They are often associated with wetlands and may include wetland biobands in the upper intertidal.	VE_L	E_L	SE_L	SP_L	P_L	VP_L
Periglacial		Permafrost	Units consist of forms structured permafrost at the coast, such as inundated tundra, tundra sea cliffs or other periglacial features	19 VE_T	29 E_T	39 SE_T	49 SP_T	59 P_T	69 VP_T

Habitat Class codes in shaded boxes are very infrequent or do not occur.

Table A-12. Data dictionary for across-shore component table (XShr)
(after Howes *et al* 1994)

Field Name	Description
UnitRecID	Automatically-generated number field; the database "primary key" for unit-level relationships
XshrRecID	Automatically-generated number field; the database "primary key" for across-shore relationships
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0)
CROSS_LINK	Unique across-shore identifier; an alphanumeric string comprised of the PHY_IDENT followed by the Zone and Component separated by slashes (e.g. 12/03/0552/0/A/1)
ZONE	Code indicating the across-shore position (tidal elevation) of the component: (A) supratidal, (B) intertidal, (C) subtidal
COMPONENT	Subdivision of zones, numbered from highest to lowest elevation in across-shore profile (e.g. A1 is the highest supratidal component; B1 is the highest intertidal; B2 is lower intertidal)
Form1	Principal geomorphic feature within each across-shore component, described by a specific set of codes (Table A-11)
MatPrefix1	Veneer indicator field; blank = no veneer; "v" = veneer
Mat1	Material (substrate and/or sediment type) that best characterizes Form1, described by a specific set of codes (Table A-12)
FormMat1Txt	Automatically-generated field that is the translation of codes used in Form1 and Mat1 into text
Form2	Secondary geomorphic feature within each across-shore component, described by a specific set of codes (Table A-11)
MatPrefix2	Veneer indicator field; blank = no veneer; "v" = veneer
Mat2	Material (substrate and/or sediment type) that best characterizes Form2, described by a specific set of codes (Table A-12)
FormMat2Txt	Automatically-generated field that is the translation of codes used in Form2 and Mat3 into text
Form3	Tertiary geomorphic feature within each across-shore component, described by a specific set of codes (Table A-11)
MatPrefix3	Veneer indicator field; blank = no veneer; "v" = veneer
Mat3	Material (substrate and/or sediment type) that best characterizes Form3, described by a specific set of codes (Table A-12)
FormMat3Txt	Automatically-generated field that is the translation of codes used in Form3 and Mat3 into text
Form4	Fourth-order geomorphic feature within each across-shore component, described by a specific set of codes (Table A-11)
MatPrefix4	Veneer indicator field; blank = no veneer; "v" = veneer
Mat4	Material (substrate and/or sediment type) that best characterizes Form4, described by a specific set of codes (Table A-12)
FormMat4Txt	Automatically-generated field that is the translation of codes used in Form4 and Mat4 into text
WIDTH	Mean across-shore width of the component (e.g. A1) in meters
SLOPE	Estimated across-shore slope of the mapped geomorphic Form in degrees; must be consistent with Form codes (Table A-11)
PROCESS	Dominant coastal process affecting the morphology: (F)luvial, (M)ass wasting (landslides), (W)aves, (C)urrents, (E)olian (wind, as with dunes) (O)ther
COMPONENT_ORI	Oil Residence Index on the basis of substrate type; 1 is least persistent, 5 is most persistent (Tables A-5 and A-6)

Table A-13. 'Form' Code Dictionary (after Howes *et al* 1994)

A = Anthropogenic

a	pilings, dolphin
b	breakwater
c	log dump
d	derelict shipwreck
f	float
g	groin
h	shell midden
i	cable/ pipeline
j	jetty
k	dyke
l	breached dyke
m	marina
n	ferry terminal
o	log booms
p	port facility
q	aquaculture
r	boat ramp
s	seawall
t	landfill, tailings
u	tide gates
w	wharf
x	outfall or intake
y	intake
z	beach access

B = Beach

b	berm (intertidal or supratidal)
c	washover channel
f	face
i	inclined (no berm)
m	multiple bars / troughs
n	relic ridges, raised
p	plain
r	ridge (single bar; low to mid intertidal)
s	storm ridge (occas marine influence; supratidal)
t	low tide terrace
v	thin veneer over rock (also use as modifier)
w	washover fan

C = Cliff

stability/geomorph

a	active / eroding
p	passive (vegetated)
c	cave

slope

i	inclined (20°-35°)
s	steep (>35°)

Cliff cont.

height

l	low (<5m)
m	moderate (5-10m)
h	high (>10m)

modifiers (optional)

f	fan, apron, talus
g	surge channel
t	terraced
r	ramp

D = Delta

b	bars
f	fan
l	levee
m	multiple channels
p	plain (no delta, <5°)
s	single channel

E = Dune

b	blowouts
i	irregular
n	relic
o	ponds
r	ridge/swale
p	parabolic
v	veneer
w	vegetated

F = Reef

(no vegetation)

f	horizontal (<2°)
i	irregular
r	ramp
s	smooth

I = Ice

g	glacier

L = Lagoon

o	open
c	closed

M = Marsh

c	tidal creek
d	dead marsh by salt intrusion
e	levee
f	drowned forest
h	high
l	mid to low (discontinuous)
o	pond
s	brackish, supratidal
t	tidal swamp, shrub/scrub

O = Offshore Island

(not reefs)

b	barrier
c	chain of islets
t	table shaped
p	pillar/stack
w	whaleback

elevation

l	low (<5m)
m	moderate (5-10m)
h	high (>10m)

P = Platform

(slope <20°)

f	horizontal
g	surge channel
h	high tide platform
i	irregular
l	low tide platform
r	ramp (5-19°)
t	terraced
s	smooth
p	tidepool

R = River Channel

a	perennial
i	intermittent
m	multiple channels
s	single channel

T = Tidal Flat

b	bar, ridge
c	tidal channel
e	ebb tidal delta
f	flood tidal delta
l	levee
p	tidepool
s	multiple tidal channels
t	flats

Table A-14. ‘Material’ Code Dictionary (after Howes *et al* 1994)

A = Anthropogenic

a	metal (structural)
c	concrete (loose blocks)
d	debris (man-made)
f	fill, undifferentiated mixed
o	concrete (solid cement blocks)
r	rubble, rip rap
t	logs (cut trees)
w	wood (structural)

B = Biogenic

c	coarse shell
f	fine shell hash
g	grass on dunes
l	dead trees (fallen, not cut)
o	organic litter
p	peat
t	trees (living)

C = Clastic

a	angular blocks (>25cm diameter)
b	boulders (rounded, subrounded,>25cm)
c	cobbles
d	diamicton (a poorly-sorted sediment mixture containing a range of particle sizes in a mud matrix)
f	fines/mud (mix of silt/clay, <0.0.63 mm diameter)
g	gravel (unsorted mix pebble, cobble, boulder >2 mm)
k	clay (compact, finer than fines/mud, <4 µm diameter)
p	pebbles
r	rubble (boulders>1 m diameter)
s	sand (0.063 to 2 mm diameter)
$	silt (0.0039 to 0.063 mm)
x	angular fragments (mix of block/rubble)
v	sediment veneer (used as modifier)

R = Bedrock

rock type:

i	igneous
m	metamorphic
s	sedimentary
v	volcanic

rock structure:

1	bedding
2	jointing
3	massive

SEDIMENT TEXTURE
(Simplified from Wentworth grain size scale)

GRAVELS

boulder	> 25 cm diameter
cobble	6 to 25 cm diameter
pebble	0.5 cm to 6 cm diam

SAND

very fine to very coarse:
0.063 mm to 2 mm diameter

FINES (“MUD”)

includes silt and clay

silt	0.0039 to 0.063 mm
clay	<0.0039 mm

TEXTURE CLASS BREAKS

sand / silt	63 µm (0.063 mm)
pebble / granule	0.5 cm (5 mm)
cobble / pebble	6 cm
boulder / cobble	25 cm

SHORE MODIFICATIONS

BR	boat ramp
CB	concrete bulkhead
DK	dyke
LF	landfill
RR	riprap
SP	sheet pile
WB	wooden bulkhead

‘Percent of unit length’ for Shore Modification recorded to nearest ten percent, with default value for Shore Modification = 0

Note: The ‘material’ descriptor consists of one primary term code and associated modifiers (e.g. Cash). If only one modifier is used, indicated material comprises 75% of the volume of the layer (e.g. Cs). If more than one modifier is used, they are ranked in order of relative volume. A surface layer can be described by prefix *v* for veneer (e.g. vCs/R). Grayed items are not used in the Alaska ShoreZone program.

Table A-15. Data Dictionary for the *Bioband* Table

Field	Description
UnitRecID	Automatically-generated number field; the database “primary key” required for relationships between tables
XshrRecID	Automatically-generated number field; the database “primary key” required for relationships between tables
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0)
CROSS_LINK	Unique alphanumeric identifier of component made up of: REGION, AREA, PHYS_UNIT, SUBUNIT, ZONE and COMPONENT fields
VER	Bioband for Splash Zone (black lichen **VER***ucaria*) in supratidal (Table A-16)
MSH	Bioband code for Shrub Meadow, upper salt marsh shrub fringe (Table A-16)
MAG	Bioband code for High Grass Meadow, upper salt marsh grass meadow (Table A-16)
GRA	Bioband code for Dune **GRA**ss in supratidal (Table A-16)
AMM	Bioband code for European Beach Grass (**AMM**ophilia spp) (Table A-16)
SED	Bioband for **SED**ges in supratidal (Table A-16)
TRI	Bioband for Salt Marsh grasses, including ***TRI****glochin* and other salt tolerant grasses, herbs and sedges, in supratidal. Same bioband included in Washington ShoreZone. (Table A-16)
BAR	Bioband for **BAR**nacle (*Balanus/Semibalanus*) in upper intertidal (Table A-16)
FUC	Bioband for Rockweed, the **FUC***us*/barnacle in upper intertidal (Table A-16)
ULV	Bioband for Green Algae, including mixed filamentous and foliose greens (**ULV***a* sp*., Cladophora, Acrosiphonia*) in mid-intertidal (Table A-16)
BMU	Bioband for **B**lue **MU**ssel (*Mytilus trossulus*) in mid-intertidal (Table A-16)
MUS	Bioband for California **MUS**sel/gooseneck barnacle assemblage (*Mytilus californianus/Pollicipes polymerus*) in mid-intertidal (Table A-16)
HAL	Bioband for Bleached Red Algae, including mixed filamentous and foliose reds in mid-intertidal (Table A-16)
OYS	Bioband code for **OYS**ter, primarily cultured on mud flats, mid-intertidal (Table A-16)
RED	Bioband for **RED** Algae, including mixed filamentous and foliose reds (*Odonthalia, Neorhodomela, Mazzaella,* coralline algae) in lower intertidal (Table A-16)
ALA	Bioband for ribbon kelp, **ALA***ria* spp. (Table A-16)
SBR	Bioband for **S**oft **BR**own Kelps, including unstalked large-bladed laminarians, in lower intertidal and nearshore subtidal (Table A-16)
CAL	Bioband for infaunal mud flat shrimp (***CAL****lianassa*), in sand/mud flats in larger estuaries. Same bioband included in Washington ShoreZone. (Table A-16)
CHB	Bioband for Dark Brown Kelps, including stalked bladed dark **CH**ocolate-**B**rown kelps in lower intertidal and nearshore subtidal (Table A-16)
SUR	Bioband for **SUR**fgrass (*Phyllospadix*) in lower intertidal and nearshore subtidal (Table A-16)
ZOS	Bioband for **ZOS***tera* (Eelgrass) in lower intertidal and subtidal (Table A-16)
ZOS2	*Zostera* occurrence data taken from EPS mapping data of some of the Oregon estuaries
MAC	Bioband for Giant Kelp (**MAC***rocystis spp*) in nearshore subtidal (Table A-16)
NER	Bioband for Bull Kelp (**NER***eocystis luetkeana*) in nearshore subtidal (Table A-16)
NER2	Nereocystis occurrence data taken from ODFW mapping data.

Table A-16. (a) Supratidal Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Common Associates
Primary Level	Secondary Level	Tertiary Level								
Terrestrial Vegetation				TEVE	A	N/A	N/A	Non-specific vegetation existing in the supratidal zone that does not fit into any other more specific supratidal bioband or cannot be clearly identified.	All	N/A
	Tundra**		TUN	TUND	A	Green to Grey-green	*Salix* spp. *Vaccinium* spp. *Dupontia fisheri*	Low turf of dwarf shrubs, herbs, grasses, sedges with lichens and mosses, in uppermost supratidal and splash zone. May be inundated in storm surge.	All	*Eriophorum* sp. *Dryas integrifolia* *Artemisia* spp. Lichens
	Trees & Shrubs			TRSH	A	Greens and browns	N/A	Non-specific trees and shrubs in the supratidal zone that do not fit into any other more specific tree/shrub bioband or cannot be clearly identified.	All	N/A
		Deciduous Trees		DETR	A	Greens and browns, possibly white-grey	*Alnus* spp. *Betula* spp.	This bioband consists mostly of stands of alder and birch trees mixed with understory shrubs in the supratidal zone. Mostly confined to river banks.	All	Understory shrubs and herbs
		Coniferous Trees		COTR	A	Greens and browns	*Picea* spp. *Pinus* spp.	This bioband consists mostly of stands of pine and spruce trees mixed with understory shrubs in the supratidal zone. Mostly confined to river banks.	All	Understory shrubs and herbs
		Shrub Meadow	MSH	SHME	A	Pale green	*Deschampsia caespitosa* *Picea sitchensis*	A narrow strip at the uppermost marsh edge, next to the tree line; usually a transition to spruce forest, including small spruce, shrubs and mixed grasses, sedges and herbs. Created for Oregon SZ.	VP to P	*Heracleum lanatum* *Achillea millefolium* *Rumex maritimus* *Grindelia integrifolia* *Hordeum brachyantherum*
	Grasses			GRAS	A	Green to blue-green to beige	N/A	Non-specific grass in the supratidal zone that does not fit into any more specific grass bioband.	All	N/A
		High Grass Meadow	MAG	HIGM	A	Pale grassy green or beige	*Deschampsia caespitosa* *Trifolium wormskjoldii*	Mixed grassy meadow, on uppermost salt marsh, interfingers with Salt Marsh (TRI) or Sedge (SED) at lower elevation transition. Specific to Oregon SZ	VP to P	*Distichlis spicata* *Juncus gerardii* *Juncus leuceurii* *Agrostis alba*
		European Beach Grass	AMM	EUBG	A	Beige-green	*Ammophila* spp.	Outer coastal sand dunes, forming clumps and stabilizing active dunes. Non-native species which is displacing native dune grass species. Specific to Oregon SZ.	SE to E	*Hypochaeris radicata* *Lupinus littoralis* *Fragaria chiloensis* *Aira praecox* *Aira caryophyllea*
		Dune Grass**	GRA	DUGR	A	Pale blue-green	*Leymus mollis*	Found in the upper intertidal zone, tall grasses observed as clumps continuous on dunes, in logline or on berms.	VP to E	

Table A-16 (continued) (a) Supratidal Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Common Associates
Primary Level	Secondary Level	Tertiary Level								
Splash Zone			VER[†]	SPZO	A	Black, white or bare rock	N/A	Non-specific band marking the upper limit of the intertidal zone that does not fit into any more specific splash zone bioband. All bands in the splash zone are recorded by width: Narrow (<1m), Medium (1m-5m) or Wide (>5m)	All	N/A
	Lichen			LICH	A	Black, white to yellow/green white	N/A	Non-specific lichen band in the supratidal zone that does not fit into any more specific splash zone bioband.	All	N/A
		Black Lichen		BLLI	A	Black to grey-black	*Verrucaria* sp. Encrusting black lichens	Visible as a dark stripe on bare rock marking the upper limit of the intertidal zone.	All	*Littorina* sp.
		White Lichen		WHLI	A	Creamy white to pinkish-grey	*Coccotrema maritimum* Encrusting white lichens	Visible as a bright white stripe on bare rock marking the upper limit of the intertidal zone. When present, this band usually occurs above the Black Lichen band.	All	*Littorina* sp
		Yellow Lichen		YELI	A	Bright to dark yellow or orange	*Caloplaca* spp. *Xanthoria* spp.	Visible as bright yellow to dark orange blotches, sometimes forming a stripe, on bare rock. Usually co-occurs with the Black Lichen bioband.	SE to VE	*Littorina* sp.

**Note Arctic coast assemblages described by Taylor (1981) found in Tbale A-21 of the 2014 ShoreZone protocol document.
[†]The old Splash Zone (VER) bioband has been split into several new biobands (LICH, BLLI, WHLI, YELI) so it will not directly translate to the new Splash Zone (SPZO) band.

Table A-16 (b) Invertebrate Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Associate Species
Primary Level	Secondary Level	Tertiary Level								
Invertebrate				INVE	B & C	N/A	N/A	Non-specific band of invertebrates that does not fit into any more specific invertebrate bioband.	All	N/A
	Crustaceans			CRUS	B	N/A	N/A	Non-specific band of crustaceans that does not fit into any more specific bioband or cannot be clearly identified.	All	N/A
		Barnacle	BAR‡	BARN	B	Grey-white to pale yellow	*Balanus glandula* *Semibalanus cariosus*	Visible on bedrock or large boulders. Can form an extensive band in higher exposures where algae have been grazed away.	P to VE	*Endocladia muricata* *Gloiopeltis furcata* *Porphyra* sp. *Fucus distichus*
		Mud Flat Shrimp	CAL	MUFS	B	Mottling on sand flats, burrows	*Neotrypaea californiensis* *Upogebia pugettensis*	On sand/mud flats in larger estuaries, where textured surface indicates presence of infauna. Specific to Oregon and Washington State SZ.	VP to P	Bivalves and worms
	Molluscs			MOLL	B	N/A	N/A	Non-specific band of molluscs that does not fit into any more specific bioband or cannot be clearly identified.	All	N/A
		Blue Mussels	BMU	BLMU	B	Black or blue-black	*Mytilus trossulus*	Visible on bedrock and on boulder, cobble or gravel beaches. Appears in dense clusters that form distinct black patches or bands, either above or below the barnacle band.	P to VE	*Fucus distichus* *Balanus glandula* *Semibalanus cariosus* Filamentous red algae
		California Mussels	MUS	CAMU	B	Grey-blue	*Mytilus californianus*	Dominated by a complex of California mussels (*Mytilus californianus*) and thatched barnacles (*Semibalanus cariosus*) with gooseneck barnacles (*Pollicipes polymerus*) seen at higher exposures.	SE to VE	*Semibalanus cariosus* *Pollicipes polymerus*
		Oyster	OYS	OYST	B	Dark beige to brown	*Crassotrea gigas*	Generally inconspicuous and of limited Extent in BC. Includes areas of oyster aquaculture on mudflats in Oregon and Washingon State, in particular in Coos Bay and Yaquina Bay. Specific to Oregon, BC and Washington State SZ.	VP to P	Filamentous brown algae Filamentous green algae *Balanus glandula*
	Sponges			SPON	B & C	Most commonly yellow, purple or red	N/A	Encrusting sponges usually occur as brightly colored patches at the waterline or in the shallow subtidal. Usually associated with high wave energy or current-dominated habitats.	SP to E	Bladed brown kelps Surfgrass

Table A-16 (continued) (b) Invertebrate Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Associate Species
Primary Level	Secondary Level	Tertiary Level								
	Cnidarians			CNID	B & C	N/A	N/A	Non-specific band of cnidarians that does not fit into any more specific bioband or cannot be clearly identified from the imagery.	All	N/A
		Anemones		ANEM	B & C	Usually white to yellow and red	N/A	Anemones usually appear as small circular dots of colour in the low intertidal and shallow subtidal. It is usually associated with high wave energy or current-dominated habitats. Could include *Metridium* spp. and *Urticina* spp.	SP to E	Bladed brown kelps Encrusting invertebrates
	Echinoderms			ECHI	B & C	N/A	N/A	Non-specific band of echinoderms that does not fit into any more specific bioband or cannot be clearly identified from the imagery.	All	N/A
		Urchin Barrens	URC	URBA	C	Coralline pink/white	*Strongylocentrotus franciscanus*	Shows rocky substrate clear of macroalgae. Often has a pink-white color of encrusting coralline red algae. May or may not see urchins.	SP to E	Encrusting invertebrates *Strongylocentrotus droebachiensis*
		Sand Dollars	DEN	SAND	Lower B & Upper C	Black spots within beige sand matrix	*Dendraster excentricus*	Beds of sand dollars, usually on sand beaches. Specific to Washington State SZ.		N/A

‡ The old Barnacle (BAR) bioband has been split into BARN and WILA (now under Red Non-Coralline Algae) so these would have to be combined to be equal to the old BAR band.

Table A-16 (c) Intertidal/Subtidal Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Common Associates
Primary Level	**Secondary Level**	**Tertiary Level**								
Intertidal/ Subtidal Vegetation				INSV	B & C	N/A	N/A	Non-specific intertidal or subtidal vegetation that does not fit into a more specific algal bioband.	All	N/A
	Wetland Vegetation			WEVE	A & upper B	Greens and browns	N/A	Non-specific wetland vegetation in the supratidal zone that does not fit into any more specific wetland bioband.	VP to E	N/A
		Sedges**	SED	SEDG	A & upper B	Bright green to yellow-green	*Carex lyngbyei*	Appears in wetlands around lagoons and estuaries. Usually associated with freshwater. This band can exist as a wide flat pure stand or be intermingled with dune grass.	VP to SE	*Carex* spp.
		Spartina	SPA	SPAR	Upper & mid B	Bright emerald green	*Spartina* spp.	*Spartina*-invaded and dominated salt marshes and mudflats. Specific to Washington State.	P to SP	N/A
		Salt Marsh**	PUC	SAMA	A & upper B	Light, bright or dark green with red-brown	*Puccinellia* spp. *Plantago maritima* *Glaux maritime* *Deschampsia* spp.	Appears around estuaries, marshes, and lagoons and is usually associated with freshwater. In some areas, PUC can be sparse vegetation on coarse sediment or a wetter, peaty meadow with associated herbs and sedges.	VP to SE	*Carex* spp. *Potentilla anserine* *Honckenya peploides* *Salicornia depressa* *Triglochin maritima* *Spergularia* spp. *Achillea* spp.
		Salt Marsh (Oregon & Washington State)	TRI	SAMO	A & upper B	Light, bright or dark green with red-brown	*Triglochin maritima* *Distichlis spicata* *Deschampsia caespitosa.* *Plantago maritima* *Scirpus americanus* *Salicornia virginica*	Appears around estuaries, marshes, and lagoons, associated with freshwater. Separated as 'high marsh' and 'low marsh' as gradation of assemblages according to elevation/salt water inundation in Oregon, but describes only a 'high marsh' in Washington State. Can be sparse grasses and herbs on coarse sediment or a wetter, peaty meadow with an assemblage of herbs, grasses and sedges. Specific to Oregon and Washington State SZ.	VP to SE	*Carex* spp. *Potentilla pacifica* *Spergularia marina* *Juncus* spp *Eleocharis* sp *Atriplex patula*
		Salt Marsh (BC & Washington State)	SAL	SAMB	A & upper B	Light, bright, or dusty green	*Salicornia virginica*	Salt-tolerant herbs and. This band is often associated with estuaries, marshes, and lagoons although it is not uncommon as a fringing meadow in the supratidal. Used to describe a 'low marsh' in Washington State and generally lacking associated grass species in that classification. Specific to BC and Washington State SZ.	SE to VP	*Carex* spp. *Deschampsia* sp. *Distichlis/ Puccinellia* sp *Leymus mollis* *Plantago maritima* *Triglochin maritimum*

Table A-16 (continued) (c) Intertidal/Subtidal Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Associate Species
Primary Level	Secondary Level	Tertiary Level								
	Biofilm		BFM	BIOF	B	Rusty orange-beige or dark green-black	Bacterial or diatom mat, blue-green algal mat	Low turf or stain on sediment. Includes moss-like turf of blue-green algal mat. Usually seen in pools of washover bars and river deltas.	P to SE	N/A
		Diatom	DIA	DIAT	B	Beige or bleached white	Diatoms	This band describes bare-looking lower intertidal areas in the coastal fjords of BC where a low turf of encrusting filamentous diatoms may be present. Specific to BC.	P to SP	*Balanus glandula* Filamentous green *Fucus* sp. *Ulva* spp.
	Green Algae		ULV	GRAL	B	Various shades of green	*Ulva* sp. *Monostroma* sp. *Cladophora* sp. *Acrosiphonia* sp.	Found on a variety of substrates. This band can consist of filamentous and/or foliose green algae. Filamentous species often form a low turf of dark green.	VP to E	Filamentous red algae
	Red Coralline Algae		RED†	RECA	B	Pink to whitish-pink	*Corallina* sp. *Lithothamnion* sp.	A combination of foliose and encrusting coralline algae occurring in the low intertidal.. Lush coralline red algae indicate highest wave exposures.	SE to VE	Brown bladed kelps
	Red Non-Coralline Algae*		RED†	RENA	B	Dark to bright red and red-brown	*Odonthalia* sp. *Neorhodomela* sp. *Palmaria* sp. *Neoptilota sp*. *Mazzaella* sp.	Diversity of foliose red algae indicates medium to high exposures, with filamentous species, often mixed with green algae, occurring at medium and lower exposures.	P to E	*Ulva* spp. Brown bladed kelps
		Winter Laver	BAR‡	WILA	Upper B	Pale green to greenish-gold	*Porphyra pseudolanceolata* *Porphyra hiberna*	These species of *Porphyra* grow in the high intertidal section of more exposed coasts in the winter season (sometimes surviving into spring or summer in colder climes). *P. hiberna* replaces *P. psuedolanceolata* south of Sitka Sound. It is associated with the Barnacle band.	SE to E	*Balanus* sp. *Endocladia muricata* *Gloiopeltis furcata* *Fucus distichus*
		Bleached Red Algae*	HAL	BRAL	B	Olive, golden or yellow-brown	Bleached foliose/ filamentous red algae	Common on bedrock platforms, and cobble or gravel beaches. Distinguished from the FFRA band by color, although may be similar species. The bleached color usually indicates lower wave exposure than where the FFRA band is observed.	P to SP	*Halosaccion glandiforme* *Mazzaella* sp. *Porphyra* sp. Filamentous green algae
		Graceful Red Weed	GCA	GRRW	B	Dark reddish brown	*Gracilaria* spp.	Usually present as patches in the mid-intertidal on sandy and muddy tidal flats. Specific to Washington State SZ.	P to SP	N/A

Table A-16 (continued) (c) Intertidal/Subtidal Bioband Definitions

<table>
<tr><th colspan="3">Bioband Name</th><th rowspan="2">Old Three-Digit Code</th><th rowspan="2">Four Digit Code</th><th rowspan="2">Zone</th><th rowspan="2">Typical Color</th><th rowspan="2">Indicator Species</th><th rowspan="2">Description</th><th rowspan="2">Biological Wave Exposure</th><th rowspan="2">Associate Species</th></tr>
<tr><th>Primary Level</th><th>Secondary Level</th><th>Tertiary Level</th></tr>
<tr><td rowspan="7"></td><td rowspan="3">Rooted Vegetation</td><td></td><td></td><td>ROVE</td><td>B & C</td><td>Green to green-grey</td><td>N/A</td><td>Non-specific rooted vegetation in the lower intertidal and/or shallow subtidal that do not fit in any more specific subtidal bioband or cannot be clearly identified from the imagery.</td><td>VP to SE</td><td>N/A</td></tr>
<tr><td>Surfgrass</td><td>SUR</td><td>SURF</td><td>B & C</td><td>Bright to dark green</td><td>Phyllospadix sp.</td><td>Appears in tide pools on rock platforms, often forming extensive beds. This species has a clearly defined upper exposure limit of Semi-Exposed and its presence in units of Exposed wave energy indicates a wide across-shore profile, where wave energy is dissipated by wave run-up across the broad intertidal zone.</td><td>SP to SE</td><td>Foliose and coralline red algae</td></tr>
<tr><td>Eelgrass</td><td>ZOS</td><td>EELG</td><td>B & C</td><td>Bright to dark green</td><td>Zostera marina</td><td>Commonly visible in estuaries, lagoons or channels, generally in areas with fine sediments. Eelgrass can occur in sparse patches or thick dense meadows.</td><td>VP to SP</td><td>Pilayella sp.</td></tr>
<tr><td rowspan="4">Brown Bladed Algae</td><td></td><td></td><td>BRBA</td><td>B & C</td><td>Various shades of brown</td><td>N/A</td><td>Non-specific bladed brown algae in the lower intertidal and/or shallow subtidal that do not fit in any more specific kelp bioband or cannot be clearly identified from the imagery.</td><td>All</td><td>N/A</td></tr>
<tr><td>Alaria</td><td>ALA</td><td>ALAR</td><td>B & C</td><td>Dark brown to red-brown</td><td>Alaria marginata</td><td>Common on bedrock cliffs and platforms, and on boulder/cobble beaches. This band has a distinct ribbon-like texture, and may appear iridescent in some imagery.</td><td>SP to E</td><td>Foliose red algae
Saccharina sp.
Laminaria sp.</td></tr>
<tr><td>Soft Brown Kelps*</td><td>SBR</td><td>SOBK</td><td>B & C</td><td>Brown to yellow-brown to olive</td><td>Saccharina latissima
Cystoseira sp.
Sargassum muticum</td><td>This band is defined by non-floating large browns and can form lush bands in semi-protected areas. The kelp fronds have a ruffled appearance and can be encrusted giving the blades a 'dusty' appearance.</td><td>VP to SE</td><td>Alaria sp.
Cymathere sp.
Saccharina groenlandica
Saccharina sessilis</td></tr>
<tr><td>Dark Brown Kelps*</td><td>CHB</td><td>DABK</td><td>B & C</td><td>Dark brown</td><td>Laminaria setchelli
Lessoniopsis littoralis
Laminaria longipes
Laminaria yezoensis</td><td>Found at higher wave exposures, these stalked kelps grow in the lower intertidal. Blades are leathery, shiny, and smooth. A mixture of species occurs at the moderate wave exposures, while single-species stands of Lessoniopsis occur at high exposures.</td><td>SE to VE</td><td>Alaria sp.
Cymathere sp.
Saccharina groenlandica
Saccharina sessilis
Costaria sp.
Filamentous and foliose red algae</td></tr>
</table>

Table A-16 (continued) (c) Intertidal/Subtidal Bioband Definitions

Bioband Name			Old Three-Digit Code	Four Digit Code	Zone	Typical Color	Indicator Species	Description	Biological Wave Exposure	Associate Species
Primary Level	Secondary Level	Tertiary Level								
	Brown Non-Bladed Algae			BRNA	B & C	Various shades of brown	N/A	Non-specific non-bladed brown algae that does not fit into a more specific algal bioband or cannot be clearly identified from the imagery.	All	N/A
		Rockweed	FUC	ROCK	B	Golden-brown to brown	*Fucus distichus*	Appears on bedrock cliffs and boulder, cobble or gravel beaches. Commonly occurs at the same elevation as the barnacle band.	VP to E	*Balanus glandula* *Semibalanus cariosus* *Ulva* sp. *Pilayella* sp.
		Sargassum	SAR	SARG	Lower B & C	Golden-brown to brown	*Saragssum muticum*	This bioband descrbes continuous satnds of Sargassum in the lower intertidal and nearshore subtidal. It is often 'fuzzy' looking and golden-brown in colour. Specific to Washington State SZ.	P to SP	Bladed brown algaes
	Brown Canopy-Forming Algae			BRCA	C	Dark brown	N/A	Non-specific canopy kelp that does not fit into any more specific canopy kelp bioband or cannot be clearly identified from the imagery.	P to VE	N/A
		Dragon Kelp	ALF	DRKE	C	Dark brown to golden-brown	*Eularia fistulosa*	Canopy-forming kelp, with winged blades on gas-filled center midrib. Usually associated with silty, cold waters near glacial outflow rivers. Range: southern Southeast AK to Aleutian Islands, AK.	SP to SE	*Nereocystis luetkeana*
		Giant Kelp	MAC	GIKE	C	Dark brown to golden-brown	*Macrocystis pyrifera*	Canopy-forming giant kelp, long stipes with multiple floats and fronds. If associated with NER, it occurs inshore of the bull kelp. Range: Baja California, Mexico to Kodiak Islands, AK.	P to SE	*Nereocystis luetkeana* *Eularia fistulosa*
		Bull Kelp	NER	BUKE	C	Dark brown	*Nereocystis luetkeana*	Distinctive canopy-forming kelp with many long strap-like blades growing from a single floating bulb atop a long stipe. Can form an extensive canopy in nearshore habitats, usually further offshore than *Eularia fistulosa* and *Macrocystis pyrifera*. Often indicates higher current areas if observed at lower wave exposures. Range: Point Conception, CA to Unimak Island, AK.	SP to VE	*Eularia fistulosa* *Macrocystis pyrifera*

*Note that four biobands (Foliose/Filamentous Red Algae, Bleached Red Algae, Soft Brown Kelps and Dark Brown Kelps) have slightly different species compositions in the Gulf of Alaska bioareas. See Table A-20 in the 2014 ShoreZone protocol document for species lists for those bands.

**Note Arctic coast assemblages described by Taylor (1981) found in Tbale A-21 of the 2014 ShoreZone protocol document.
†The old Red Algae (RED) bioband has been split into RECA and RENA. These would need to be combined to be equal to the old RED band (NOT including WILA, GRRW or BRAL in the roll-up).
‡ WILA used to be an associate species for the old Barnacle (BAR) band and was not mapped as a separate band as the surveys were often completed in the summer months when WILA is not present.

Please note: An additional bioband, called the Bare (BRE) band was mapped in BC but because it was defined by the lack of any biota it could not be incorporated into this table.

Table A-17. Data Dictionary for the Photos Table

Field Name	Description
PhotoID	A unique numeric ID assigned to each slide or photo
UnitRecID	Automatically-generated number field; the database “primary key” required for relationships between tables
PhotoName	A unique alphanumeric name assigned to each slide or photo
ImageName	Full image name with .jpg extension (required to enable “PhotoLink”)
TapeTime	Exact UTC time during aerial video imaging (AVI) survey when digital image was collected; used to link photo to digital trackline and position
PhotoDescription	Text field for biological comments regarding the digital photo
ImageType	Media type of original image: “Digital” or “Slide"
FolderName	Name of the folder in which digital images are stored (required to enable “PhotoLink”)
PhotoLink	Enables linkage to photos placed in directories near the database
PHY Good Example?	When set to “Y,” photo is geomorphological representative of a particular feature or classification type
PhotoComment	Text field for geomorphological comments regarding the digital photo

Table A-18. Examples of the Shore Types in the YK Delta survey area.

Photo bs14_bt_03220: Example of Shore Type 1; Rock Ramp, wide.
North Nunivak Island.

Photo bs14_bt_02736: Example of Shore Type 2; Rock Platform, wide.
North Nunivak Island.

Photo bs14_bt_03939: Example of Shore Type 3; Rock Cliff
Cape Mohican, Nunivak Island.

Photo bs14_bt_02974: Example of Shore Type 4; Rock Ramp, narrow.
North Nunivak Island.

Photo bs14_bt_02877: Example of Shore Type 5; Rock Platform, narrow.
North Nunivak Island.

Photo bs14_bt_01033: Example of Shore Type 6; Ramp with gravel beach, wide.
North Nunivak Island.

Photo bs14_bt_01773: Example of Shore Type 7; Platform with gravel beach, wide.
Cape Manning, Nunivak Island.

Photo bs14_bt_03363: Example of Shore Type 8; Cliff with gravel beach.
Kikoojit Rocks, Nunivak Island.

Photo bs14_bt_01733: Example of Shore Type 9; Ramp with gravel beach.
Cape Manning, Nunivak Island.

Photo bs14_bt_02824: Example of Shore Type 10; Platform, with gravel beach.
North Nunivak Island.

Photo bs14_bt_02741: Example of Shore Type 11; Ramp with gravel and sand beach, wide.
Lookswarat Bay.

Photo bs14_bs_02663: Example of Shore Type 12; Platform with gravel and sand beach, wide.
North Nunivak Island.

Photo bs14_bt_09340: Example of Shore Type 13; Cliff with gravel and sand beach.
Cape Vancouver, Nelson Island.

Photo bs14_bt_01581: Example of Shore Type 14; Ramp with gravel and sand beach.
East Nunivak Island.

Photo bs14_bt_06589: Example of Shore Type 15; Platform with gravel and sand beach.
Kangirlvar Bay.

Photo bs14_bt_09324: Example of Shore Type 21; Gravel flat, wide.
Cape Vancouver, Nelson Island.

Photo bs14_bt_00093: Example of Shore Type 22; Gravel beach, narrow.
South Nunivak Island.

Photo bs14_bt_00040: Example of Shore Type 23; Gravel flat or fan.
South Nunivak Island.

Photo bs14_yk_04482: Example of Shore Type 24; Sand and gravel flat or fan.
Scammon Bay.

Photo bs14_yk_04471: Example of Shore Type 25; Sand and gravel beach, narrow.
Scammon Bay.

Photo bs14_bt_03431: Example of Shore Type 26; Sand and gravel flat or fan.
West of Nariksmiut River.

Photo bs14_yk_05433: Example of Shore Type 27; Sand beach.
South of Kokechik Bay.

Photo bs14_yk_04541: Example of Shore Type 28; Sand flat.
Scammon Bay.

Photo bs14_bt_08473: Example of Shore Type 29; Mud flat.
Ninglick River.

Photo bs14_yk_04430: Example of Shore Type 30; Sand beach.
Scammon Bay.

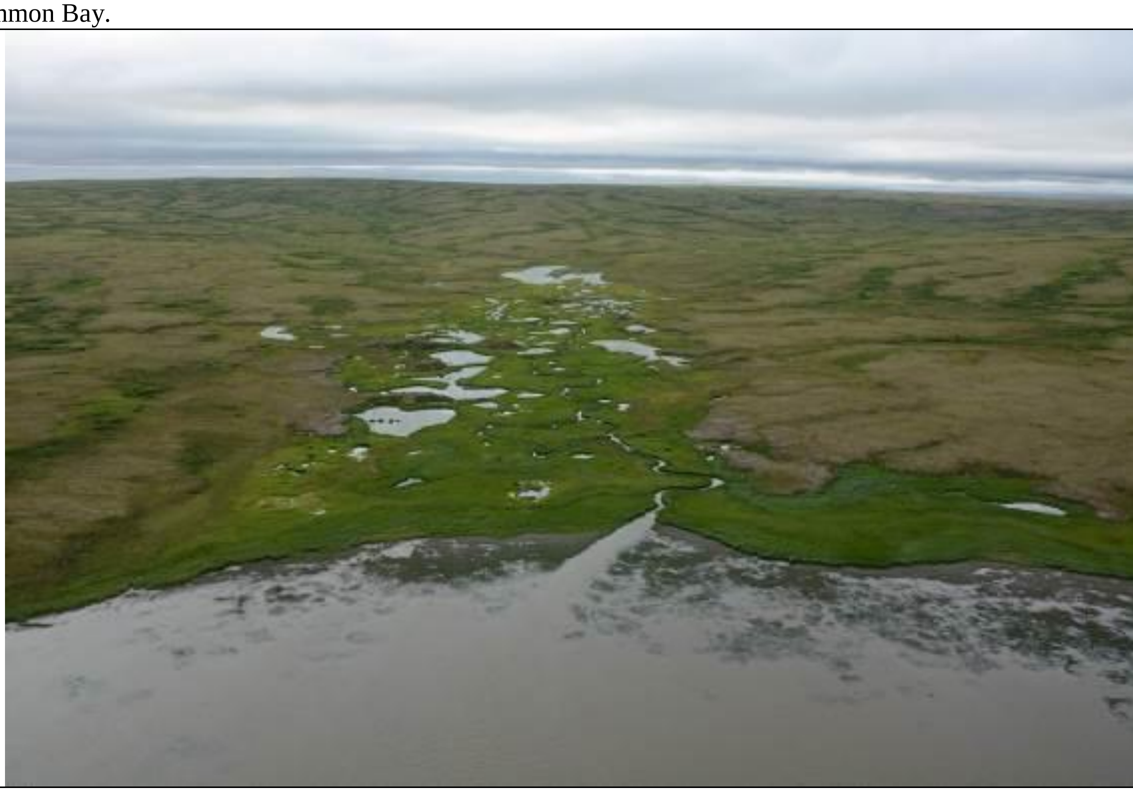

Photo bs14_bt_08287: Example of Shore Type 31; Organics/Fines.
Baird Inlet.

Photo bs14_yk_04888: Example of Shore Type 32; Man-made, permeable.
Kokechik Bay.

Photo bs14_bt_09285: Example of Shore Type 33; Man-made, impermeable.
Tununak Bay.

Photo bs14_bt_04076: Example of Shore Type 34; Channel.
Dooksook Lagoon.

Photo bs14_bt_03805: Example of Shore Type 36; Lagoon.
West of Nash Harbor.

Photo bs14_bt_04841: Example of Shore Type 39; Low vegetated peat.
Baird Inlet.

Table A-19. Examples of the Biobands in the YK Delta survey area.

Splash Zone (SPZO)

Photo bs14_bt_03655: Good example of the Splash Zone (SPZO) bioband which is defined by the lack of any lichens or other vegetation in the supratidal (A) zone. This bioband often occurs where there are eroding cliffs in the A zone as seen in this example from northeast Nunivak Island.

Black Lichen (BLLI)

Photo bs14_bt_02153: Good example of the Black Lichen (BLLI) bioband which is defined as a black band in the supratidal splash zone, usually cause by the lichen *Verrucaria* sp. This beach has a Narrow BLLI band (<1 in width). This photo was taken on northeastern Nunivak Island.

White Lichen (WHLI)

Photo bs14_bt_00993: Good example of a Medium (1-5 m) White Lichen (WHLI) bioband. This semi-protected beach on the southeastern side of Nunivak Island shows the White Lichen bioband above the Black Lichen band but below the Yellow Lichen.

Yellow Lichen (YELI)

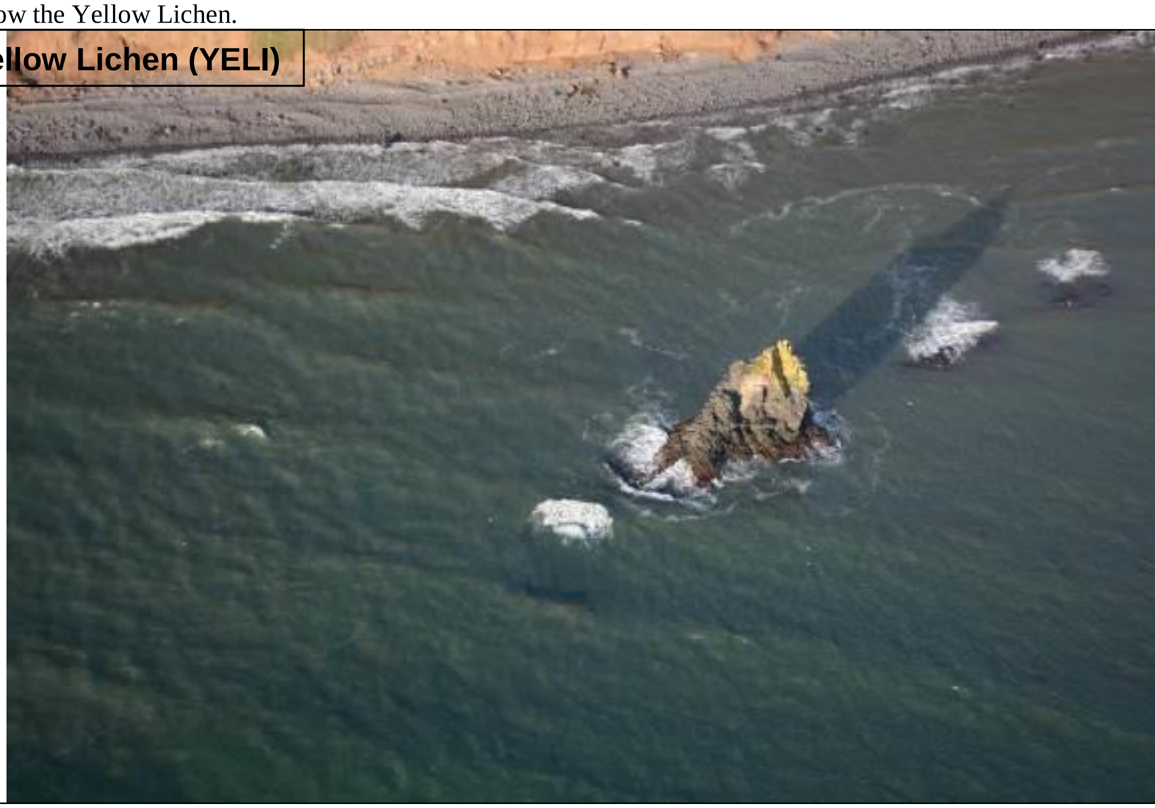

Photo bs14_bt_04008: Good example of a Wide (>5m) Yellow Lichen (YELI) bioband above the Black Lichen band on a seastack off the coast of the west side of Nunivak Island.

Dune Grass (DUGR)

Photo bs14_bt_03586: Good example of the Dune Grass (DUGR) bioband on the dunes of Nunivak Island. It appeared bright green in many places on Nunivak Island rather than the usual blue-green.

Tundra (TUND)

Photo bs14_bt_04949: Good example of the Tundra (TUND) bioband in the protected portion of Baird Inlet. This bioband is defined by its grey-green colour and is dominated by lichens, grasses and shrubs.

Trees and Shrubs (TRSH)

Photo bs14_yk_01253: Example of the Trees and Shrubs (TRSH) bioband with Wetland Vegetation in front on the Kuskokwim River. This would typically be considered a terrestrial bioband however in the riverine and palustrine areas of the survey area, it was often inundated and therefore in the A or B zone as defined in ShoreZone.

Salt Marsh (SAMA)

Photo bs14_bt_06077: Good example of a Salt Marsh (SAMA) bioband transitioning into Wetland Vegetation . The distinct colur change between the two types of vegetation indicate the bright green vegetation is more influenced by saline water. The maps from the National Wetlands Inventory also show this are near the mouth of the Kolavinarak River also shows this small section of marsh as Estuarine and Marine Wetland.

Wetland Vegetation (WEVE)

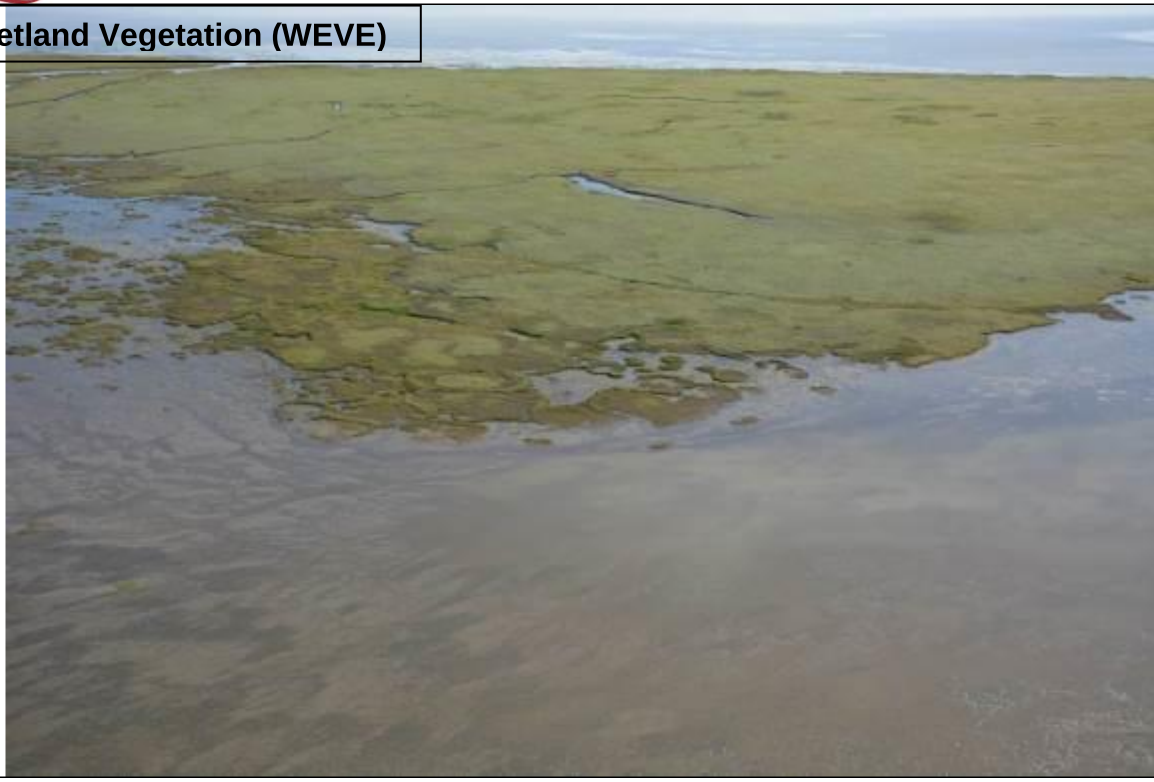

Photo bs14_yk_08201: Example of the Wetland Vegetation (WEVE) bioband which in the YK Delta survey area is freshwater dominated vegetation in the supratidal and high intertidal zone. This photo, taken on Flat Island near Emmonak, shows some of the variation in the colour and texture of this bioband.

Wetland Vegetation (WEVE)

Photo bs14_bt_07738: Good example of the Wetland Vegetation (WEVE) bioband near Kwingillingok. This photo show more of the variety in colour and texture of this bioband in the YK Delta survey area.

Barnacle (BARN)

Photo bs14_bt_04100: Good example of the beige Barnacle (BARN) bioband, which appears as a whitish band at the waters edge. This is a protected lagoon on the west side of Nunivak island. This bioband was rare in the YK Delta survey area.

Rockweed (ROCK)

Photo bs14_bt_03429: Good example of the golden-brown Rockweed (ROCK) bioband on the shore of Wide Bay on Nunivak Island. The Eelgrass bioband is in the nearshore.

Green Algae (GRAL)

Photo bs14_bt_03935: Good example of a Green Algae (GRAL) bioband in the intertidal (B) zone. This the Exposed Cape Mohican on Nunivak Island. Filamentous and Foliose Red Algae bioband appears at the waterline.

Biofilm (BIOF)

Photo bs14_bt_09680: Good example of the dark green Biofilm (BIOF) bioband on a protected mudflat in Baird Inlet. Although this band can be confused with the Green Algae bioband, on close inspection it is flat and mat-like and can sometimes be cracked in appearance. It is generally found on mudflats. This bioband was only observed in Baird Inlet and up the Yukon River. It is possibly a blue-green algae mat.

Bleached Red Algae (BRAL)

Photo bs14_bt_03402: An example of the golden-reddish coloured Bleached Red Algae (BRAL) bioband in the intertidal (B) zone. This bioband was difficult to distinguish from the Rockweed bioband (they were likely mixed together much of the time). Here the reddish tinge at the waterline suggests it is BRAL rather than ROCK.

Filamentous and Foliose Red Algae (FFRA)

Photo bs14_bt_03935: Good example of the dark red Filamenouts and Foliose Red Algae (FFRA) bioband in the lower intertidal (B) zone. This exposed shore is Cape Mohican on Nunivak Island.

Eelgrass (EELG)

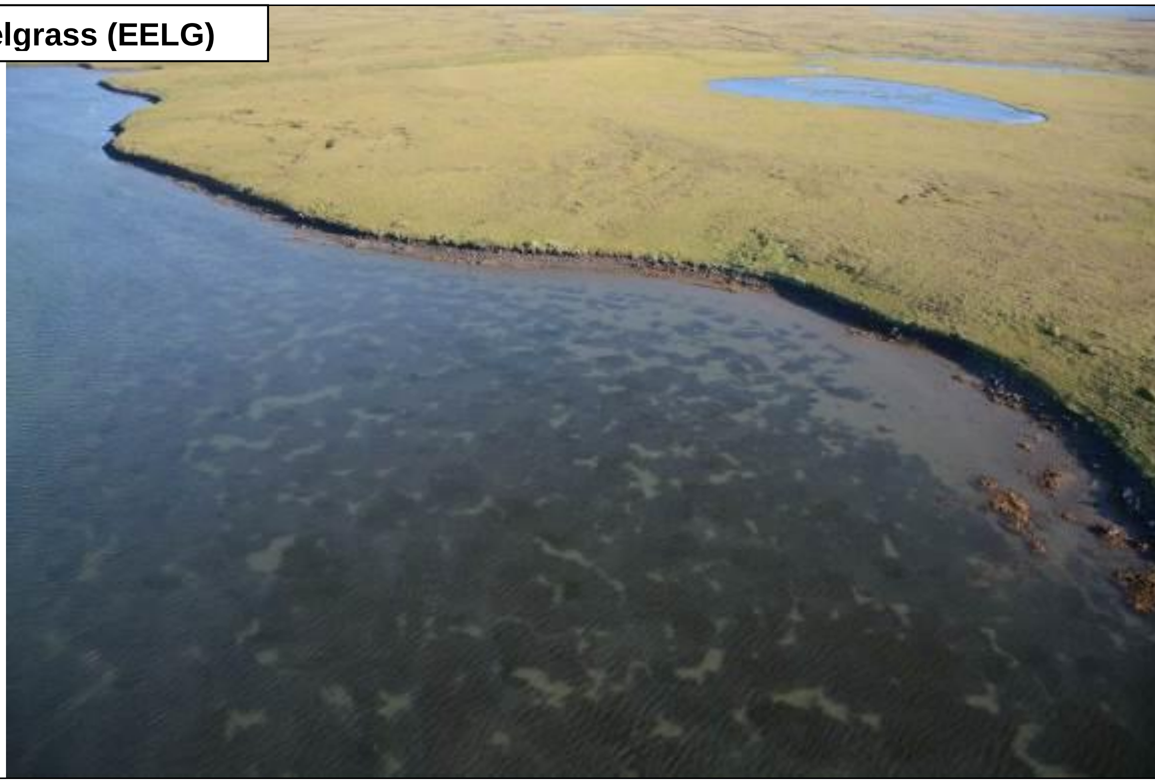

Photo bs14_bt_03426: Good example of the dark green Eelgrass (EELG) bioband in the subtidal (C) zone. This is the protected Wide Bay on Nunivak Island.

Eelgrass (EELG)

Photo bs14_bt_02794: Good example of the Eelgrass (EELG) bioband on a sand beach with rock platforms. The Eelgrass does not extend into the nearshore. This protected shore is on northeastern Nunivak Island.

Rooted Vegetation (ROVE)

Photo bs14_yk_08155: Good example of a Wide (>30m) patchy Rooted Vegetation (ROVE) bioband in the subtidal (C) zone. This bioband is defined as non-lagal vegetation in the nearshore that cannot be identified to a more specific bioband. This photo is from Flat Island near Emmonak. This is a more riverine area.

Bladed Brown Algae (BRBA)

Photo bs14_bt_04541: Good example of the Bladed Brown Algae (BRBA) bioband at the waterline on this otherwise bare beach. This Exposed shore is on the southwestern side of Nunivak Island.

APPENDIX B

Coastal Vulnerability Module
Code and Category Descriptions

The Coastal Vulnerability Module (CVM) for ShoreZone is intended to provide users with a spatial picture of where and how shorelines are likely to be sensitive to climate change, specifically sea level rise. For example, shorelines with very low gradients will become increasingly flooded by storm surges.

Coastal Vulnerability Module provides a measure of coastal sensitivity to climate change in terms of three indices that are based on observed coastal geomorphology of the shoreline. The three indices are:

> ***Coastal Stability Index*** (Table B-1) that provides a measure of stability (retreating or prograding) for both clastic/sediment shorelines or for wetland shorelines.
>
> ***Flooding Sensitivity Index*** (Table B-2) that provides an estimate of the degree of observed flooding of immediate backshore areas.
>
> ***Thaw Sensitivity Index*** (Table B-3) that provides an estimate of thaw lake or water coverage in the backshore that is an indirect indicator of thaw settlement potential.

These indices are complemented by an inventory of descriptive coastal features of mass-wasting/wetland morphology (Table B-4) that are potentially of interest to coastal planners and managers.

Table B-1 Coastal Stability Index

		Stability Class	Description
CLASTIC	CE4	Erosional	Actively eroding, bare-faced cliff (<10% vegetation cover)
	CE3		Actively eroding, partially vegetated cliff (10 - 90% vegetation cover) cliff
	CE2		Actively eroding, complete vegetated cliff (>90% cover) but veg "disturbed"
	CE1		Retreating barrier island, spit; possibly with outcropping peat
	CS	Stable	Stable slope with tundra vegetation
	CA1	Accretional	Prograding beach with a single storm berm or dune
	CA2		Prograding beach with multiple storm berms or dunes
	CA3		Prograding beach with wide beach ridge plain in backshore
WETLAND	WE2	Erosional	Peat layers in sub-tidal, often with polygon form still evident
	WE1		Eroding peat scarp
	WS	Stable	Stable – no obvious features indicating erosion or accretion
	WA1	Accretional	Prograding wetland – immature wetland Prograding across flats (most common in deltaic wetland complexes)
Bedrock	R	Not applicable	Assumed stable, Coastal Vulnerability Module not applicable
Anthropogenic	A	Seawall	Assumed stable, Coastal Vulnerability Module not applicable
Other	X	Provisional	use for initial testing phase, if unit cannot be assigned to any of above

Table B-2 Flooding Sensitivity Index

	Flooding Class	Description
F4	Major	Flooding >100 m inland from HWL as indicated by the highest logline
F3	↑	Flooding 50-100m inland from HWL as indicated by the highest logline
F2	↑	Flooding 10-50 m inland from HWL as indicated by the highest logline
F1	Minor	Flooding <10 m inland from HWL as indicated by the highest logline
X		Coastal Hazards not applicable (rock, anthropogenic)

Table B-3 Thaw Sensitivity Index

	Thaw Sensitivity Class	Description
T4	High	Extensive thaw lakes, standing water, >50% standing water in flooding zone
T3	↑	Moderate thaw lake density, 25-50% standing water in flooding zone
T2		Minor thaw lake density or standing water, 10-25% standing water in flooding zone
T1	Low	Negligible standing water, <10% standing water in flooding zone
X		Coastal Hazards not applicable (rock, anthropogenic)

Table B-4 Coastal Mass-Wasting and Wetland Features

Category	Feature
Mass Wasting	Ground ice slumps
	Block slumps
	Debris flows/solifluction
	Ice Wedges
Wetlands	Lagoonal complex
	Deltaic complex
	Marsh clones
	Associated mudflats
	Submerged morphology
	Relict river morphology
	Relict shoreline morphology
Other	Add description of relevant feature
None	Unit assessed, no relevant features (none of the above)
Not Applicable	Unit assessed, Coastal Hazards not applicable (rock, etc.)