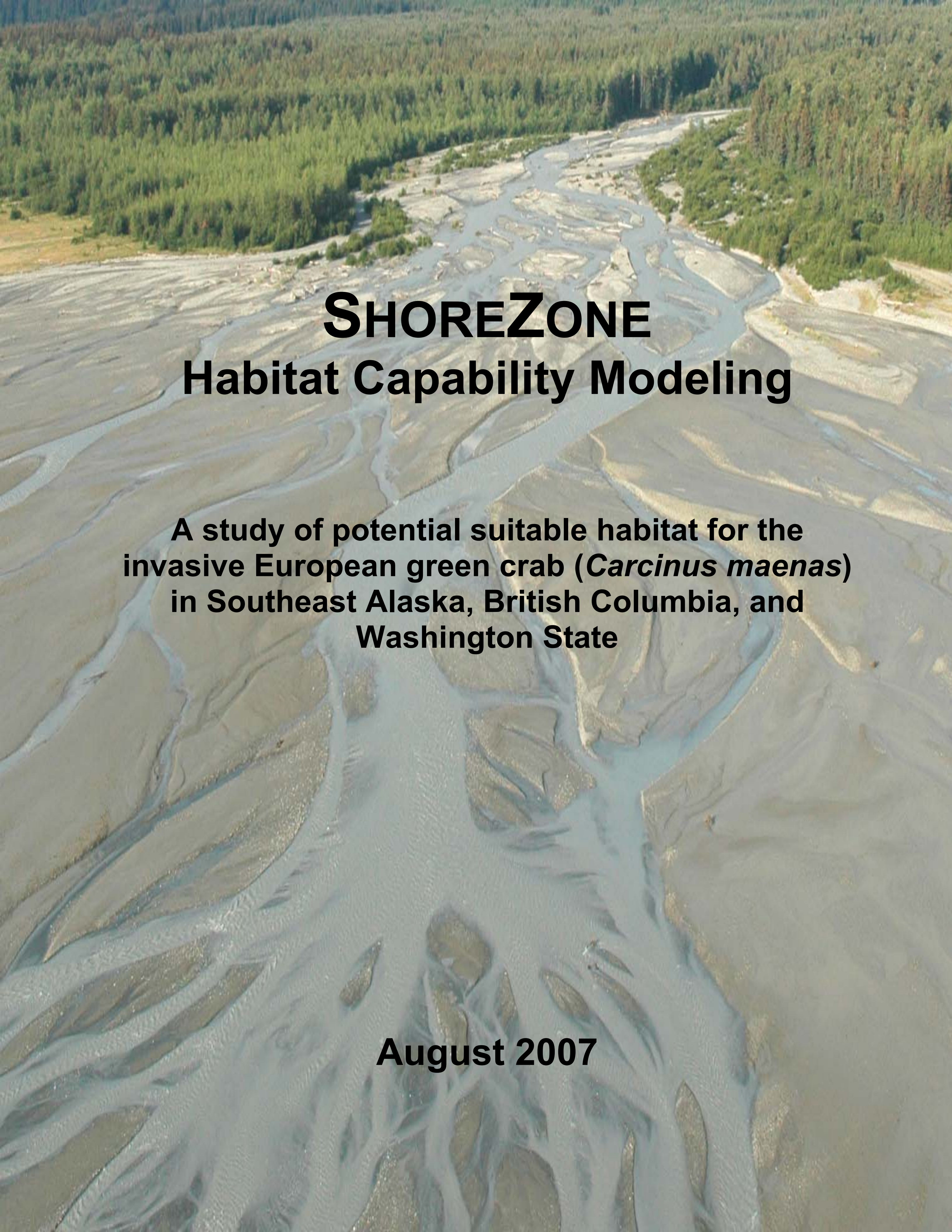

ShoreZone
Habitat Capability Modeling

A study of potential suitable habitat for the invasive European green crab (*Carcinus maenas*) in Southeast Alaska, British Columbia, and Washington State

August 2007

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Modeling habitat capability for the non-native European green crab (*Carcinus maenas*) using the ShoreZone mapping system in Southeast Alaska, British Columbia, and Washington State

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1 INTRODUCTION

1.1 ShoreZone Coastal Habitat Mapping

The ShoreZone Coastal Mapping Program is a partnership of scientists, GIS specialists, internet specialists, non-profit organizations, and governmental agencies. Field programs, data management and processing, and product deliveries are coordinated and executed primarily by coastal geologists John Harper and Jodi Harney of Coastal and Ocean Resources Inc. (Sidney BC, Canada) and biologist Mary Morris of Archipelago Marine Research Ltd. (Victoria BC). The processing, mapping, integration, and analysis of physical and biological data takes place in both organizations by mapping specialists who possess advanced academic and technical degrees. More information on techniques, methodology, and applications is included in the ShoreZone Protocol for the Gulf of Alaska available on the Coastal and Ocean Resources website (www.coastalandoceans.com).

ShoreZone is a coastal habitat mapping and classification system in which georeferenced aerial imagery is collected specifically for the interpretation and integration of geological and biological features of the intertidal zone and nearshore environment. Oblique low-altitude aerial video and digital still imagery of the coastal zone is collected during summer low tides (zero tide level or lower), usually from a helicopter flying at <100 m altitude. The flight trackline is recorded at 1-second intervals using Fugawi electronic navigation software and is continuously monitored in-flight to ensure all shorelines have been imaged. Video and still images are georeferenced and time-synchronized. Video imagery is accompanied by continuous, simultaneous commentary by a geologist and a biologist aboard the aircraft.

The mapping system provides a spatial framework for coastal habitat assessment on local and regional scales. Imagery exists for more than 28,000 km of coastline in the Gulf of Alaska and Southeast, and the summer 2007 field season is expected to add 12,000 km of imagery to the Alaska program (Figure 1.1). In the Pacific Northwest, the ShoreZone Coastal Mapping Program also includes more than 45,000 km of coastline in British Columbia and Washington state (from the Columbia River to the Alaska/BC border).

Research and practical applications of ShoreZone coastal mapping data and imagery include:

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

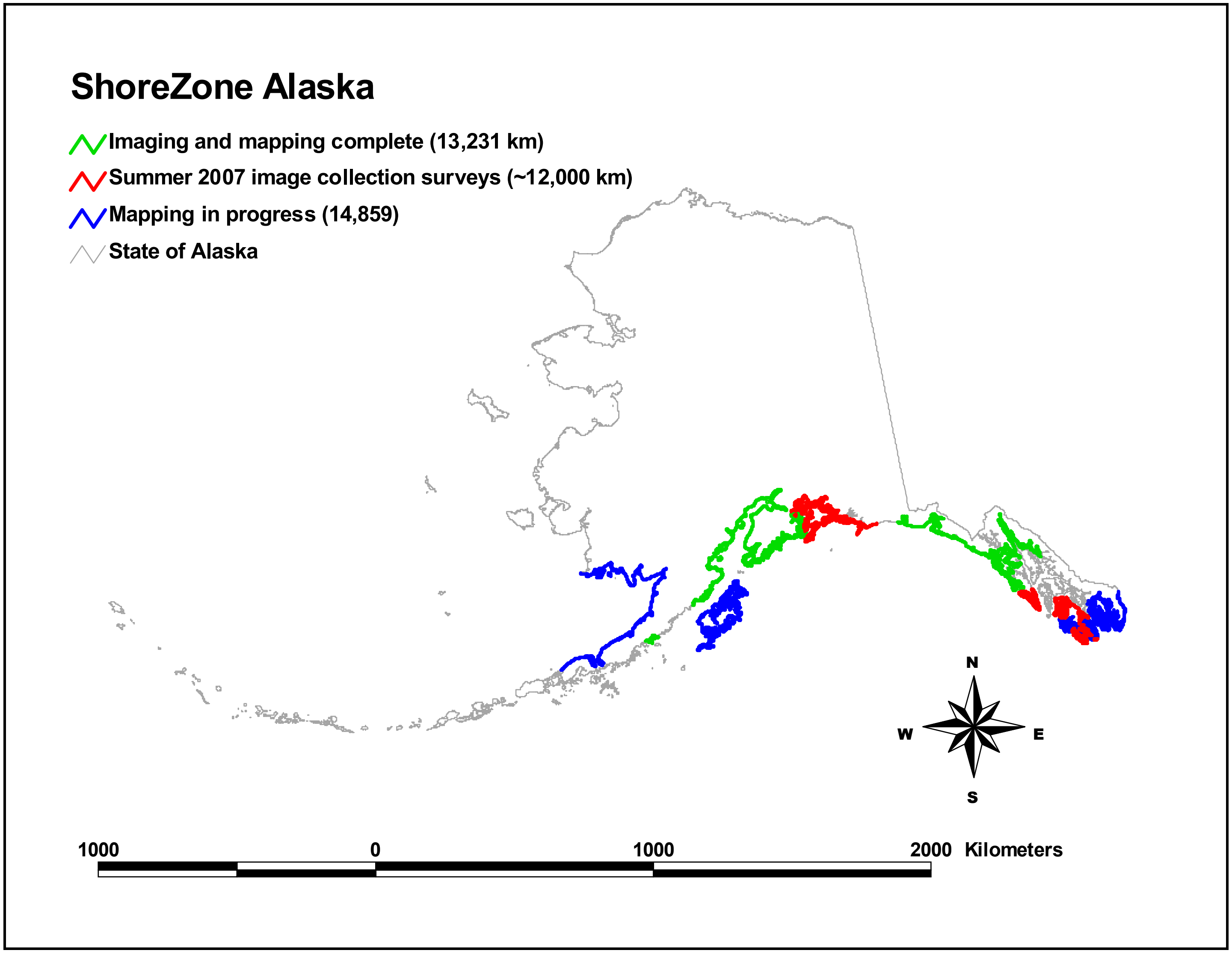

Figure 1.1. Extent of ShoreZone imagery and coastal habitat mapping in the State of Alaska.

The imagery and commentary are used in the definition of discrete along-shore coastal habitat **units** and the “mapping” of observed physical, geomorphic, sedimentary, and biological across-shore **components** within those units (Figure 1.2). Units are digitized as shoreline segments in ArcView or ArcGIS, then integrated with the along-shore and across-shore geological and biological data housed in a Microsoft Access database. Mapped habitat features include degree of wave exposure, substrate type, sediment texture, intertidal flora and fauna, subtidal algae, and some subtidal fauna. Data and imagery are posted on regional websites (such as www.coastalaska.net and www.fakr.noaa.gov/maps/szintro.htm for SE Alaska and www.shim.bc.ca/gulfislands/atlas.htm for the Gulf Islands in British Columbia, Canada).

Mapping data (in GIS and Access database formats) is in the form of **line** segments and **point** features. Line segments are the principal spatial features, representing along-shore units, each with a unique physical identifier (PHY_IDENT) that links the data to the digital shoreline in GIS. Point features (also called “variants”) are small features such as streams that are better represented as a point rather than a line. Such point features are also mapped as “forms” within the unit that contains them.

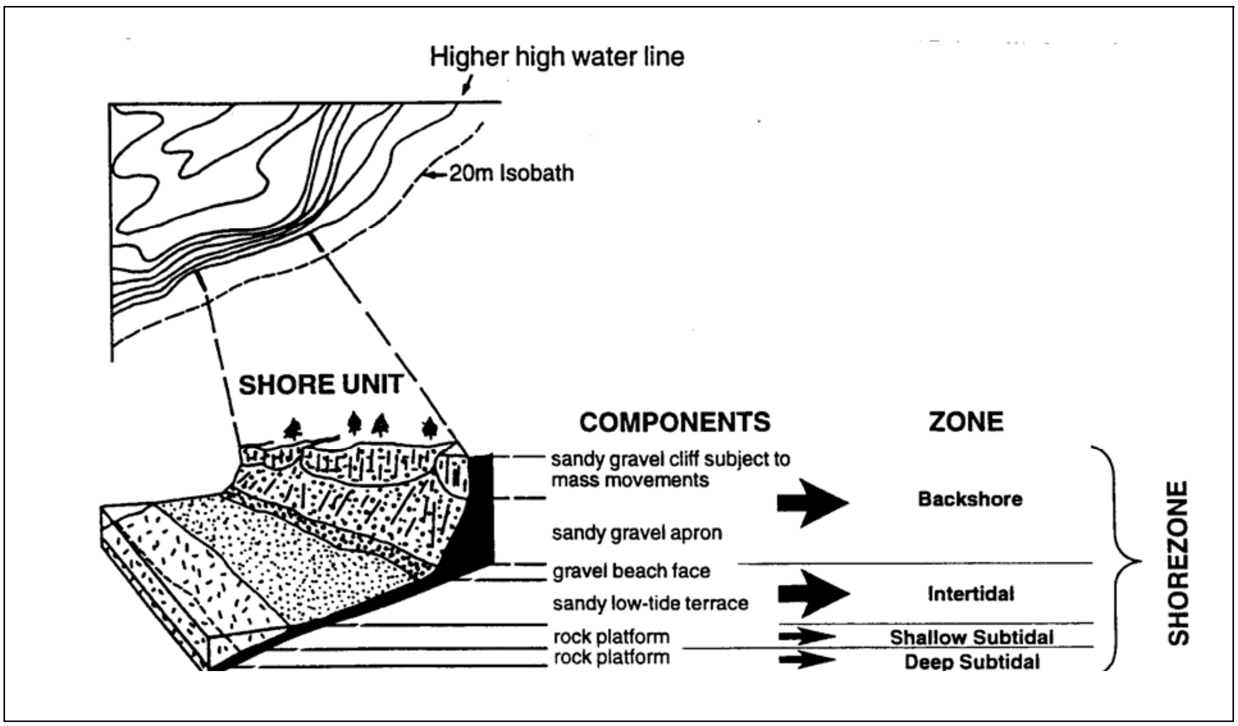

Figure 1.2. Schematic to illustrate how digital shorelines are segmented into alongshore units and across-shore components in the ShoreZone mapping system.

1.2 ShoreZone Mapping in Southeast Alaska (2004-2005)

Field surveys in Southeast Alaska in 2004 and 2005 collected more than 6,400 km of aerial video and digital still photographs of the coastal and nearshore zone at zero-tide and lower. The imagery was used to map the geological and biological resources of the region from Sitka Sound to Icy Bay (Figure 1.2). The purpose of this report is to provide a summary of the data for mapped shorelines in the region. Mapping data (in GIS and Access database formats) is in the form of line segments and point features. Line segments are the principal spatial features, representing along-shore units. Point features (also called "variants") are those that are too small to be represented as a line segment, such as streams and are digitized as points, as well as mapped into the unit that contains it.

1.3 Biogeographic Areas of Southeast Alaska

The regions of mapping interest in Southeast Alaska are divided into four biogeographic areas on the basis of differences in bioband occurrence, species composition within the biobands, and geographic boundaries. (Biobands are discussed in detail in Section 3.) These "BioAreas" are defined in Table 1.1 and shown in Figure 1.3. Briefly, the Yakutat BioArea (SEYA) is characterized by sparse biota, high wave exposure and few canopy kelps. The Icy Strait BioArea (SEIC) is the only area with significant amounts of the Dragon Kelp bioband (*Alaria fistulosa)*. The Fjords BioArea (SEFJ) shows milky glacial-fed inlets, with many units with coralline reds in the Red Algae bioband (), especially in sections with Semi-protected exposures. The Sitka BioArea (SESI) has fully marine waters, with a full range of wave exposures, and has a lush mixture of canopy kelps, particularly the giant kelp bioband (*Macrocystis integrifolia)* .

Table 1.1. Biogeographic areas ("BioAreas") defined in mapped regions of SE Alaska.

BioArea Code	**BioArea Name**	**BioBand Suffix**	**Description**
SEYA	SE Alaska Yakutat	12	Icy Point north to Icy Cape
SEIC	SE Alaska Icy Strait	12	North coast of Icy Strait from Icy Point at Boussole Bay east to Couverden Island; south coast of Icy Strait from Point Lucan east to the north end of Chatham Strait
SEFJ	SE Alaska Fjords	12	Lynn Canal north of Couverden Island and southeast to Stevens Passage
SESI	SE Alaska Sitka / Outer Coast	12	Point Lucan in Cross Sound south to Sitka and the inlets, including Tenakee Inlet on the west side of Chatham Strait

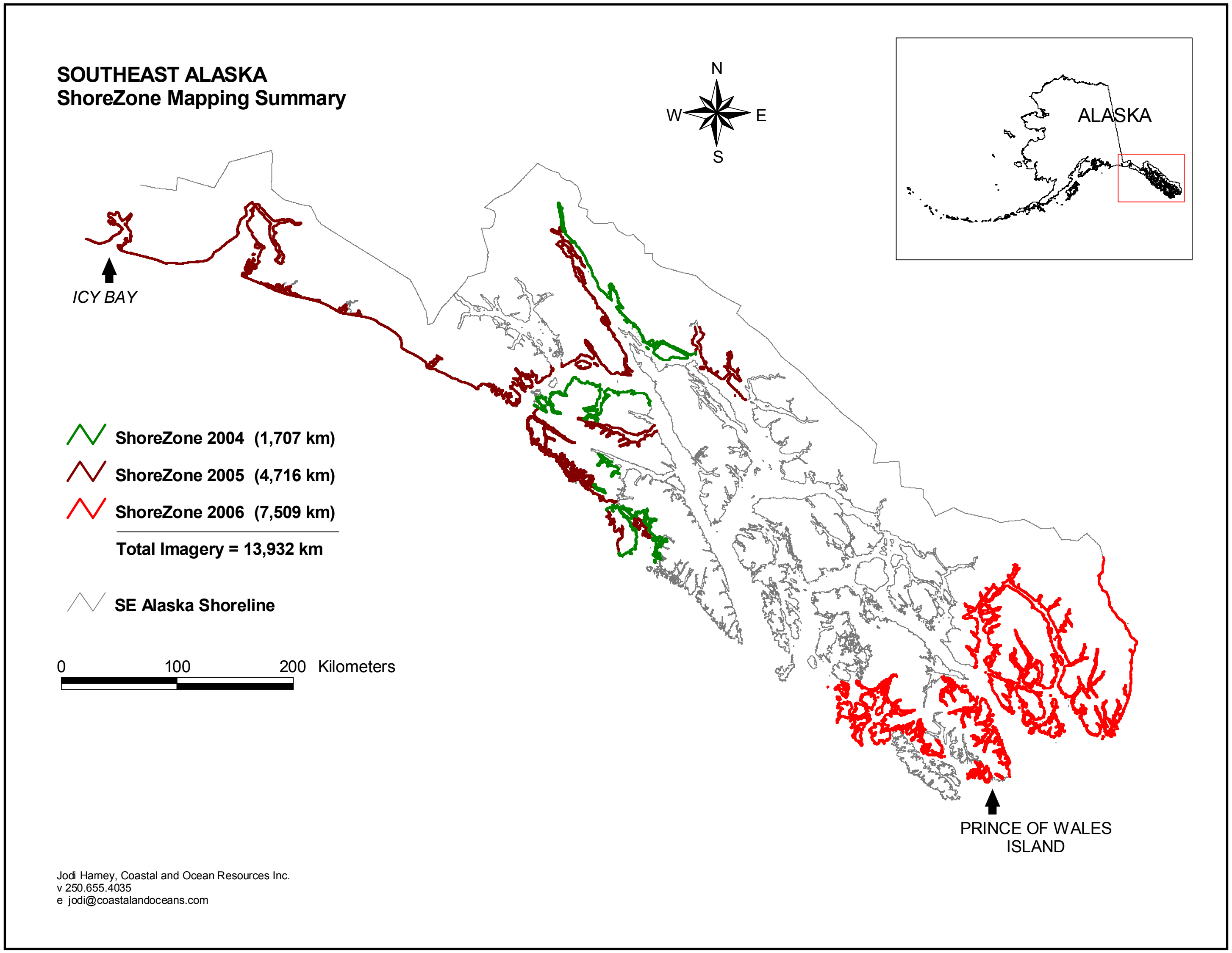

Figure 1.3. Shoreline of Southeast Alaska mapped in 2004 and 2005 using the ShoreZone technique. Shorelines flown in 2006 are shown in red (mapping in progress).

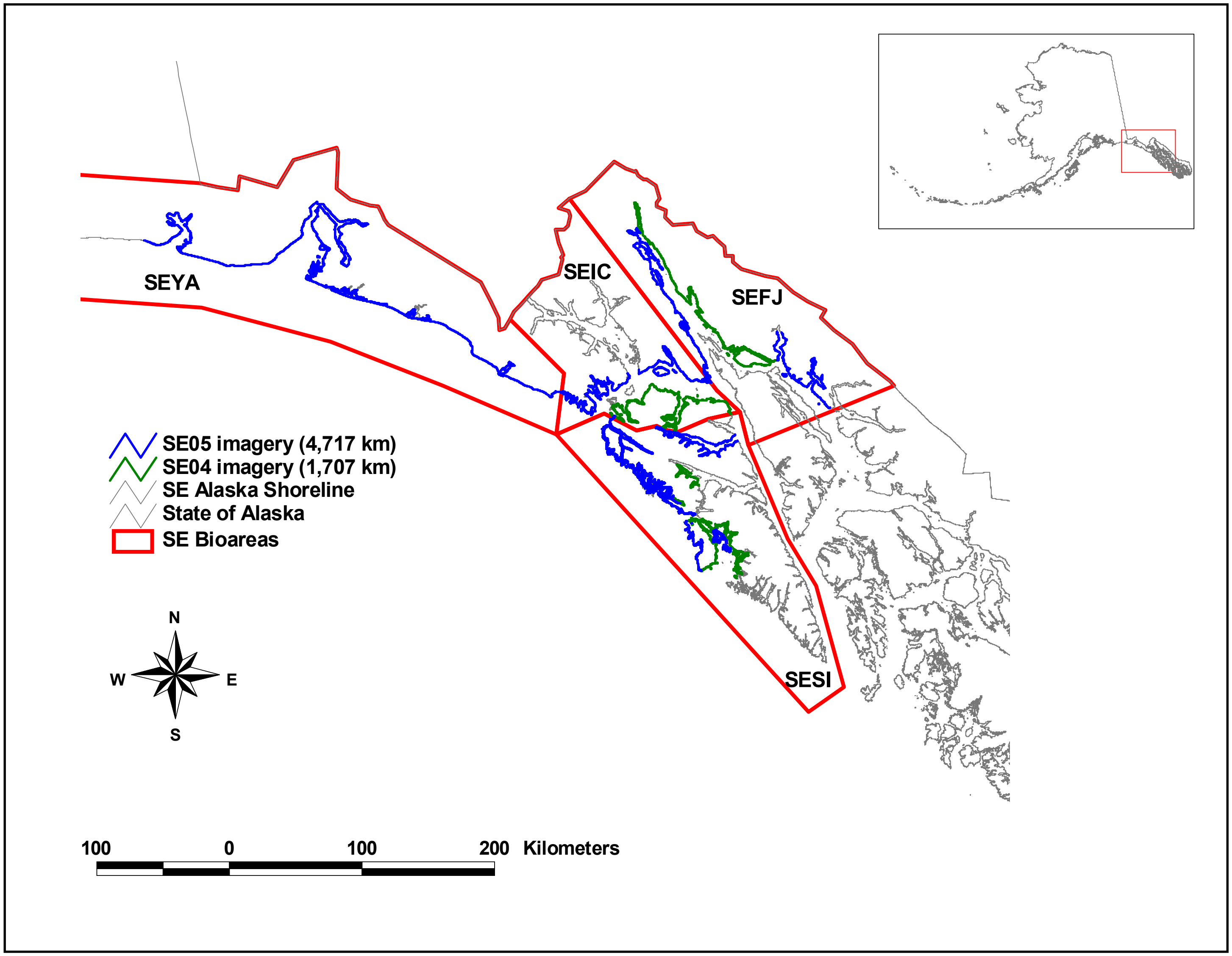

Figure 1.4. Map showing the distribution of biogeographic areas ("BioAreas") in Southeast Alaska as defined in the ShoreZone mapping program (SEYA, SEIC, SEFJ, and SESI). See Table 1.1 for descriptions.

2 HABITAT CAPABILITY MODELING

2.1 Approach and Methods

The ShoreZone coastal mapping system (housed in ArcGIS and Access databases) provides a spatial framework for coastal and nearshore habitat assessment on local and regional scales, characterizing physical and biological components of discrete intertidal **habitat units** both along-shore and across-shore from digital, georeferenced aerial imagery (including degree of wave exposure, type of substrate, sediment texture, intertidal flora and fauna, subtidal algae, and some subtidal fauna).

The coastal database also enables users to make reasonable interpretations of organism occurrence in coastal and nearshore ecosystems. When applied to the problem of the dispersal and spread of **invasive species**, it is possible to identify potential habitats likely to support the invasion of non-native or deleterious species. Predicting potential green crab habitat "hot spots" could provide a spatial basis for the planning and implementation of monitoring stations for species detection and early intervention efforts.

The principal objective of this study is to develop a **habitat capability model** that appraises the sensitivity of coastal environments to colonization by the non-native European green crab *Carcinus maenas*. In our usage, **habitat** is a spatial entity that possesses physical and biological attributes that support particular organisms or communities (e.g. Demarchi et al. 1999).

This approach is based on the rationale that successful colonization of the green crab in the coastal zone is related to **habitat attributes** (such as geomorphology, wave exposure, sediment grain size, and tidal elevation) that can be distinguished, rated in terms of their importance in the crab's life-history strategy, and enumerated in the ShoreZone coastal mapping data.

Critical green crab habitat attributes are identified and ranked on the basis of scientific literature review and a "delphi" approach to collecting the knowledge of experts through interviews. Queries of the ShoreZone database are performed using these attributes to identify shorelines that meet the criteria for supporting green crab colonization.

It is important to note that an analysis of oceanographic and biotic factors (such as water temperature, salinity, and currents) affecting the dispersal and colonization of the green crab is beyond the scope of this study. This work assumes that regional environmental variables are within the tolerable range of the organism. This assumption is generally validated by the documented occurrence of *Carcinus maenas* in the Pacific Northwest and British Columbia (Behrens Yamada 2005, Gillespie et al. 2007). Recent laboratory experiments and oceanographic models also suggest that ocean surface temperature and salinity are within the habitable range of the green crab, permitting its northward dispersal (Hines et al. 2004; de Rivera et al. 2006).

The **study area** used for development of the model includes shorelines in Southeast Alaska that have been mapped using the ShoreZone technique (6,416 km of shoreline). Following review of the SE Alaska model (Harney et al. 2007a,b), the approach is applied to

ShoreZone databases that exist for British Columbia (37,605 km of shoreline) and Washington State (4,936 km of shoreline).

This approach to habitat capability modeling integrates physical and biological attributes mapped in the ShoreZone database with an understanding of green crab habitat requirements. Model construction and reporting of results consists of:

1. A summary of green crab habitat requirements determined during literature review and expert interviews.
2. Analysis of the ShoreZone Geodatabases for Southeast Alaska, British Columbia, and Washington State on the basis of green crab habitat requirements.
3. Tabulation of model results as MS Access database output tables and/or shapefiles, both of which can be integrated with ArcView or ArcGIS software.

2.2 Species Account: European Green Crab (*Carcinus maenas*)

The European green crab, *Carcinus maenas*, is considered an invasive species in coastal environments of North America and other parts of the world, including South Africa, Australia, and Japan. Introduction of this species to the east coast of the United States occurred in the early 1800s. Its occurrence on the U.S. Pacific coast was first documented in 1989 in San Francisco, CA. Green crabs were subsequently observed in Oregon in 1997, in Washington in 1998, and in British Columbia in 1999. In Washington, more than 1,100 adult specimens have since been captured in Willapa Bay and Grays Harbor, leading to the declaration of *C. maenas* as a deleterious species (Behrens Yamada 2001).

The green crab's tolerance of a range of environmental conditions has enabled its colonization in coastal habitats well outside its native extent. Adult green crabs tolerate a wide range of temperatures (0-33°C) and salinities (4-54 ppt), as do their larvae (11-25°C and 26-39 ppt), allowing prolonged survival during dispersal and settling. Larvae are planktotrophic, spending up to two months in the water column, thus northward dispersal may occur into British Columbia and Southeast Alaska by transport in the Davidson current. Juveniles and adults occupy estuarine and intertidal marine environments, preferring soft substrates and semi-protected settings.

In the Pacific Northwest, green crabs have been found associated with tidal marshes and oyster beds, favoring muddy substrates and protected, intertidal settings. Green crab habitat attributes include: (1) low-energy mudflats and marshes comprised of soft sediment, (2) refuge from predators, (3) low salinity and high temperature, (4) shellfish growing areas, (5) nurseries for fishes and Dungeness, and (6) shorebird foraging habitat (Behrens Yamada et al. 2005).

Green crabs feed on clams, oysters, mussels, polychaetes, and other crustaceans (including Dungeness crabs, *Cancer magister*), as well as compete with native species for both habitat and food. The impact on local fisheries and coastal ecosystems related to the introduction of the green crab to northern BC and Southeast Alaska is unknown. Elsewhere, green crab introductions have been linked to declines in shellfish abundance and increased mortality in crustacean populations.

2.3 Identification of Critical Green Crab Habitat Attributes

A review of the scientific literature was conducted, and a online survey was submitted to experts in the field of invasive species (particularly those studying the green crab). The purpose of the survey was to identify which habitat attributes (or combinations of attributes were *most* important in affecting the colonization of juvenile green crabs in a new environment, assuming the larvae could be transported to the potential site. The survey can be viewed at http://www.questionpro.com/akira/TakeSurvey?id=604320.

Responses from six experts were tabulated and ranked on the basis of the scores each habitat attribute received. Regional differences in expert opinions were noted. For example, the width of the intertidal zone was an important factor in green crab mortality in Washington owing to habitat separation between green crabs and red rock crabs. Some habitat attributes presented to experts for ranking did not result in scientific consensus. For example, the relative importance of fresh water sources in green crab habitat was expressed by some experts, while others suggested this factor was of low importance.

The resultant green crab habitat capability model defines the geologic, physical, and biologic features of the intertidal zone deemed *most* advantageous to colonization by this invasive species. Thus, shorelines that possess the greatest potential to support green crab colonization can be distinguished within an extensive regional database.

Coastal attributes considered "critical" to support green crabs and that are mapped and searchable in the ShoreZone database be include:

- Semi-protected and protected wave exposures
- Sediment-dominated shorelines
- Mudflats and tidal flats
- Organic shorelines (marshes, estuaries)
- Fine sediment in the lowest intertidal
- Eelgrass in the subtidal
- Salt marsh vegetation in the supratidal

On the basis of these characteristics, the mapped ShoreZone attributes of **Wave Exposure**, **Coastal Class**, and **Bioband** occurrence are particularly important in predicting the distribution of suitable habitats for green crabs. A general description of these attributes and maps of their distribution in the Southeast Alaska study area follow in Section 2.4. Nested attribute queries using cross-shore bioband data are discussed in Section 2.5.

2.4 Habitat Attributes in ShoreZone: Wave Exposure and Coastal Class

Wave Exposure is an important attribute of coastal habitats, strongly influencing physical processes as well as the biotic character of the intertidal and nearshore zones. Each alongshore unit in the ShoreZone database is assigned one of six codes to describe the degree of exposure to wave energy. A summary of the length of each exposure category is listed in Table 2.1, and the mapped distribution is shown in Figure 2.1.

Protected (P) and Semi-Protected (SP) shorelines are most favorable to green crab colonization. Of the mapped areas in the Southeast Alaska (2004-2005) ShoreZone database, 74% are classified in these categories. Query results are summarized here and presented in digital data as shapefiles and output tables.

Table 2.1. Summary of **wave exposure** categories in the Southeast Alaska study area.

Code	Degree of Exposure	Sum of unit lengths (km)	% of mapped area
VE	Very Exposed	0	0
E	Exposed	590.3	9%
SE	Semi-exposed	699.9	11%
SP	**Semi protected**	**2550.3**	**41%**
P	**Protected**	**2066.3**	**33%**
VP	Very Protected	354.0	6%

Coastal Class is defined on the basis of the principal geomorphic features, substrate type, sediment texture, across-shore width, and slope of that section of coastline (Table A-2; Howes et al. 1994). Query results are summarized here and presented in digital data as shapefiles and output tables.

The occurrence of coastal classes in the Southeast Alaska study area is summarized in Table 2.2. Coastal classes are grouped with respect to dominant substrate type (rock, rock and sediment, or sediment-dominated). The distribution of principal substrate types in the study area is illustrated in Figure 2.2.

Sediment-dominated shorelines such as mudflats and tidal flats are among the shore types most likely to support green crab colonization. Combined, these shorelines (classes 21-30) comprise 35% of the mapped area in Southeast Alaska (2,180 km). Maps and images from the Southeast Alaska study area are illustrated in Figures 2.3-2.6.

Table 2.2. Summary of **coastal class** distribution in the Southeast Alaska study area. Classes are grouped according to the presence of rock and/or sediment See Table A-3 for classes definitions. Distribution of grouped classes is shown in Figure 2.1.

Coastal Class	Sum of Unit Length (m)	Average Unit Length (m)	# of Units	Sum of Unit Length (km)	% Occur-rence	Sum of % Occur-rence	General Substrate Type
1	41,368	376	110	41	0.7%		
2	62,200	319	196	62	1.0%		
3	441,405	234	1,928	441	7.0%		
4	217,216	229	951	217	3.5%		
5	20,255	199	102	20	0.3%	12%	Rock
6	93,388	223	430	93	1.5%		
7	161,967	253	651	162	2.6%		
8	292,829	183	1,620	293	4.7%		
9	523,296	185	2,852	523	8.4%		
10	51,885	193	273	52	0.8%		
11	109,691	186	627	110	1.8%		
12	240,555	259	995	241	3.8%		
13	139,537	211	707	140	2.2%		
14	259,518	155	1,732	260	4.1%		
15	45,929	206	236	46	0.7%		
16	4,008	154	27	4.0	0.1%		
17	7,041	243	35	7.0	0.1%		
18	25,272	308	88	25	0.4%		
19	6,084	196	32	6	0.1%		
20	466	155	3	0	0.0%	31%	Rock+Sediment
21	109,345	280	422	109	1.7%		
22	149,737	195	796	150	2.4%		
23	4,089	215	20	4	0.1%		
24	845,366	309	3,431	845	13.5%		
25	529,777	233	2,640	530	8.5%		
26	50,778	219	274	51	0.8%		
27	22,287	378	72	22	0.4%		
28	395,479	739	647	395	6.3%		
29	57,930	369	201	58	0.9%		
30	15,785	376	47	16	0.3%	35%	**Sediment**
31	1,194,181	691	3,254	1,194	19.1%	19%	**Organics / Marsh**
32	57,105	213	278	57	0.9%		
33	3,885	134	31	4	0.1%	1%	Man-made
34	60,600	415	158	61	1.0%	1%	Channel
35	21,262	2658	8	21	0.3%	0.3%	Glacier
Total	**6,261,516**	**242**	**25,874**	**6,262**	**100%**	**100%**	

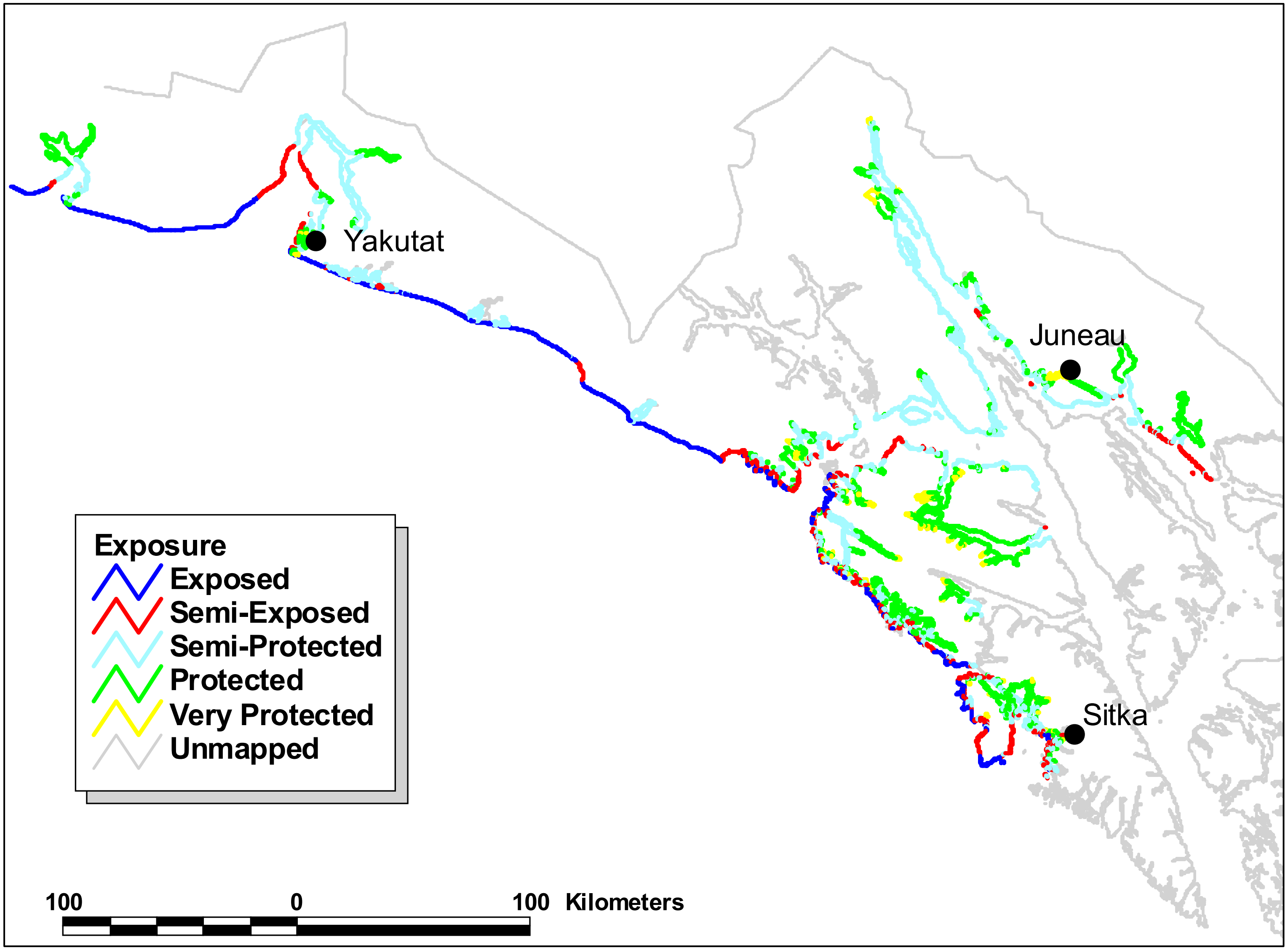

Figure 2.1. Distribution of **wave exposure** categories in the Southeast Alaska study area. Data are provided in Table 2.1.

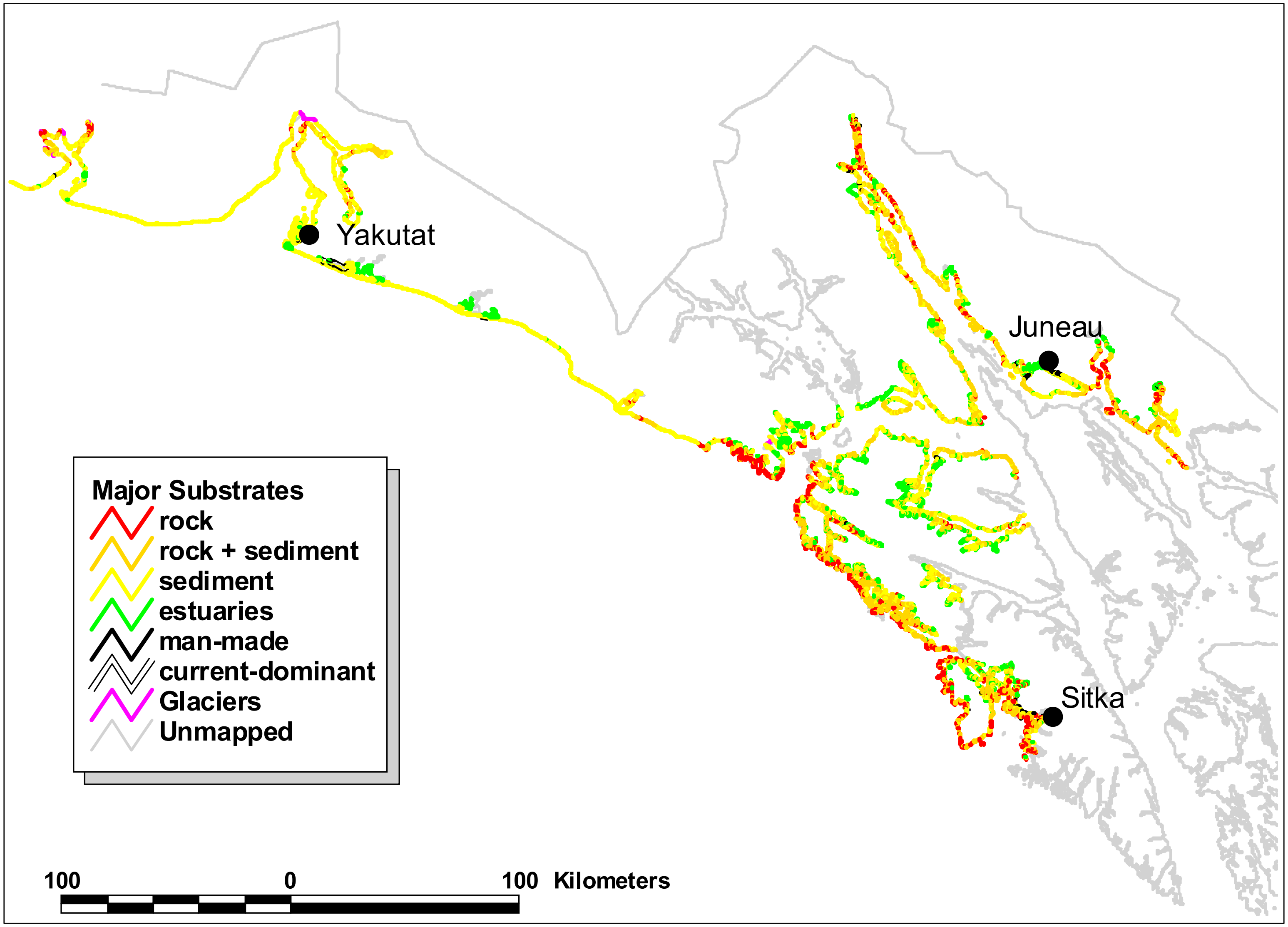

Figure 2.2. Distribution of general **substrate types** (based on grouped Coastal Class) in the Southeast Alaska study area. Data are provided in Table 2.2.

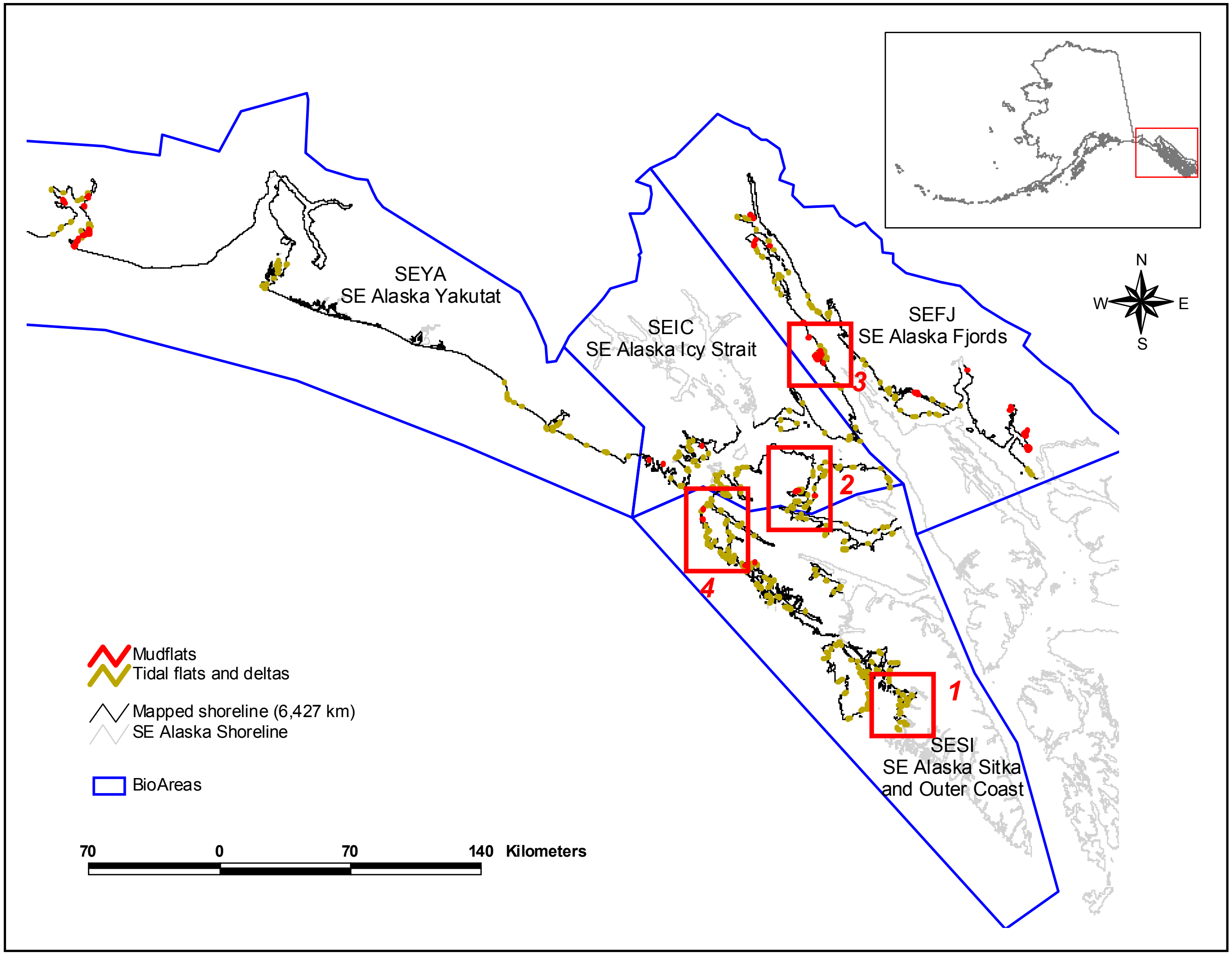

Figure 2.3. Distribution of **sediment-dominated shorelines** in the Southeast Alaska study area. Boxes 1-4 mark the locations of detail maps on the following pages.

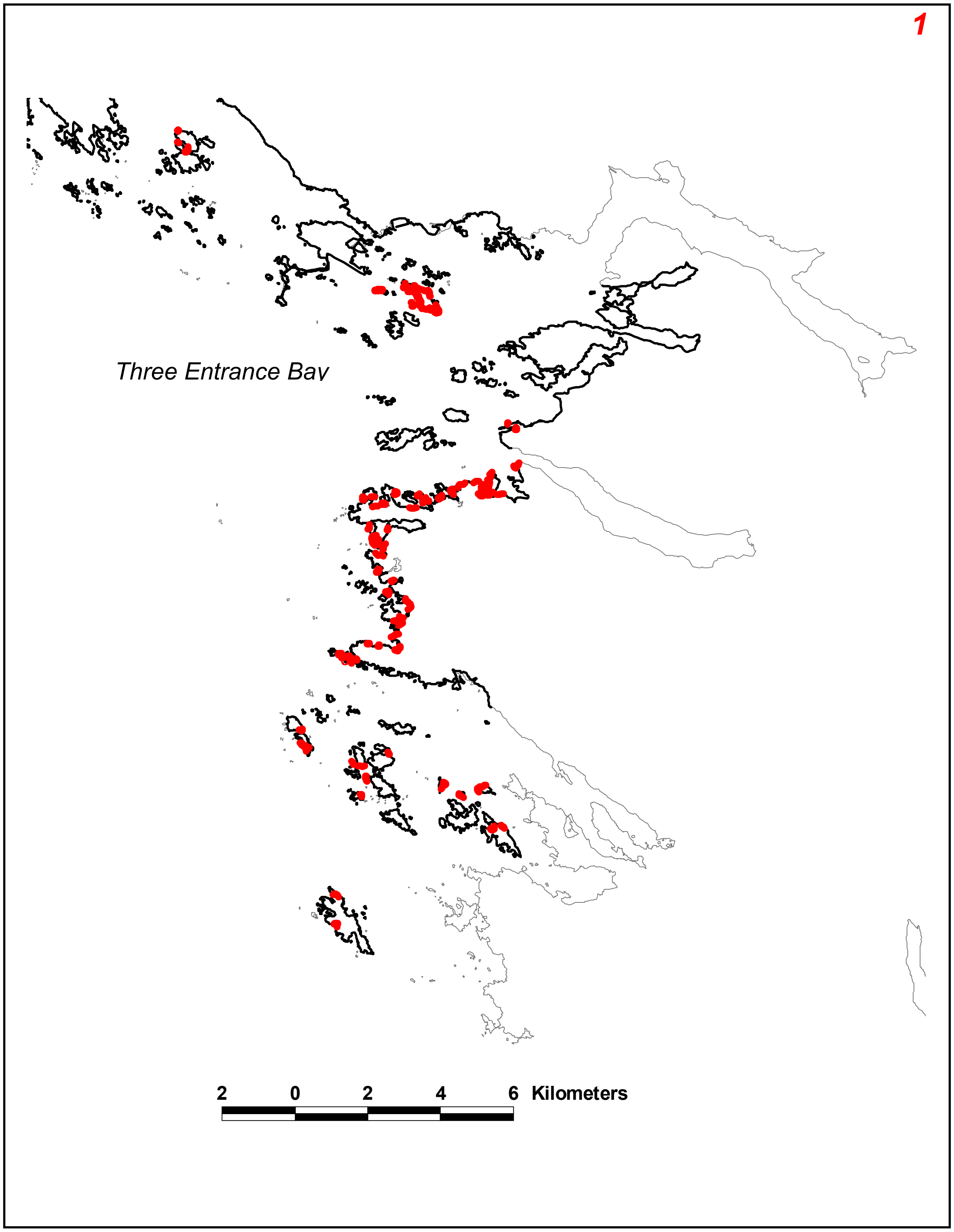

Figure 2.4. Mudflats in Sitka Sound. Analysis of along-shore attributes in the ShoreZone database reveals that mudflats are relatively uncommon features in Southeast Alaska, comprising only 1% (68 km) of mapped shorelines. In contrast, nearly 20% of mapped shorelines are classified as wetlands (1,194 km). Location is shown by box 1 in Fig. 2.3.

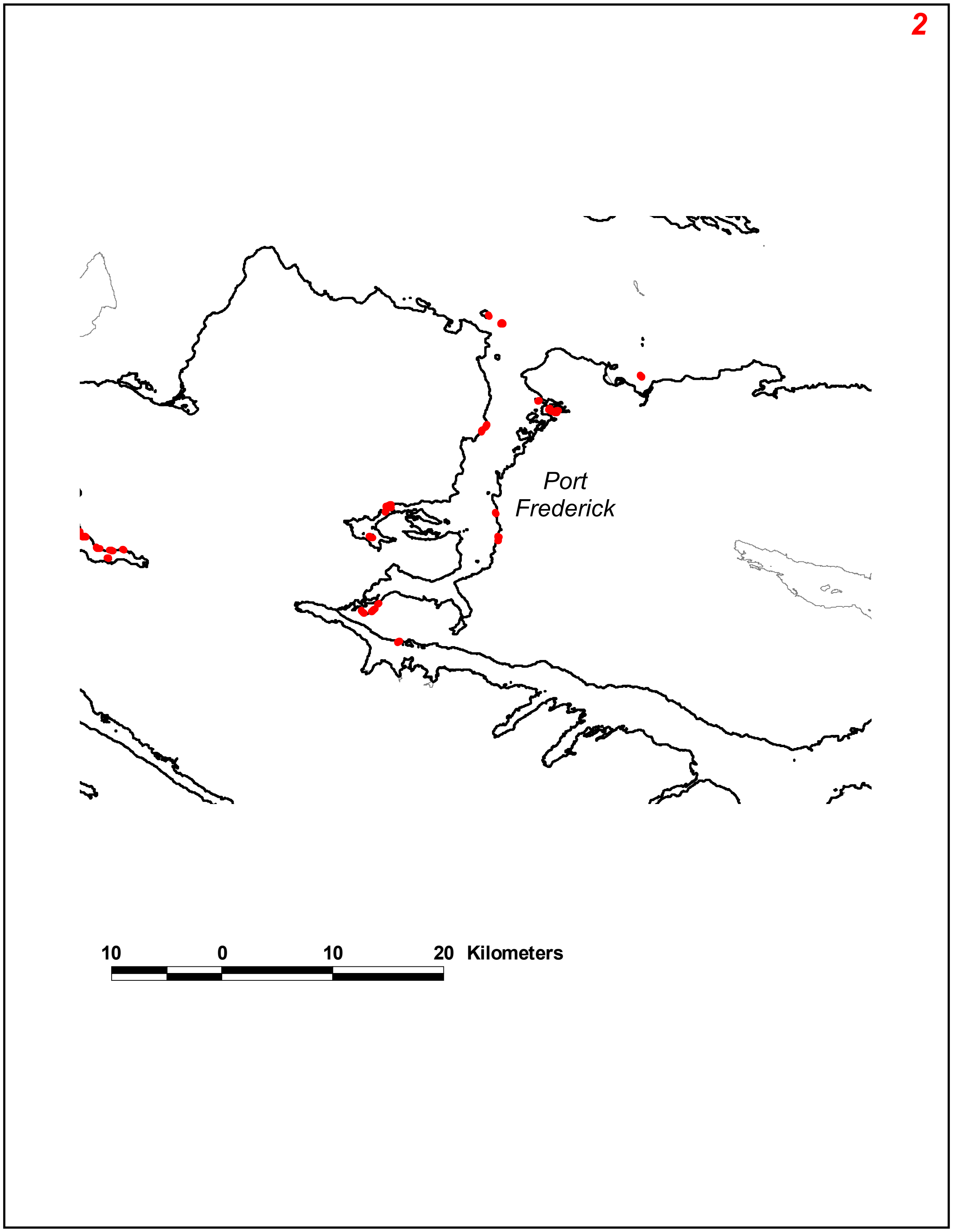

Figure 2.5. Mudflats in Port Frederick. The Icy Strait bioarea has 16 km of mudflats (24% of those mapped in Southeast Alaska). Location is shown by box 2 in Fig. 2.3.

Three Entrance Bay, Sitka Sound
The Sitka bioarea has 38 km of mudflats (56% of those mapped in SE Alaska).
Unit 10/01/1120, Photo SEAK04_J7_D4_00216

Port Frederick
Unit 10/02/0116, Photo SEAK04_J3_D1_00054

Figure 2.6. Wide mudflats and tidal flats revealed as potential green crab habitat in SE Alaska. Sediment-dominated shorelines comprise 35% of the study area.

Mud flat west of Sullivan Island, Lynn Canal
Unit 10/04/2529, Photo SE05_ML_0447.JPG

Kochu Island, Chilkat Inlet
Unit 10/04/2781, Photo SEAK04_J7_D4_00183.JPG

Figure 2.7. Examples of wide mudflats and tidal flats revealed as potential green crab habitat in Lynn Canal, Southeast Alaska (location not shown on map). Sediment-dominated shorelines comprise 35% of the study area.

2.5 Habitat Attributes in ShoreZone: Biobands

A **Bioband** is an observed assemblage of coastal biota with a characteristic color and cross-shore elevation, from the high supratidal to the shallow subtidal. Biobands are named for the dominant species or group that best represents the entire band. They are spatially distinct, with alongshore and cross-shore patterns of color and texture that are visible in aerial imagery (Table 2.3 and Figure 2.8). Some biobands are characterized by a single indicator species (such as the “Blue Mussel” band, code “BMU”), while others represent an assemblage of co-occurring species (such as the “Red Algae” band, code “RED”).

Biological ShoreZone mapping is based on the principle that the occurrence and extent of biobands is directly related to both the degree of wave exposure and the substrate type in the coastal zone. The presence, absence, and relative abundance of biobands are recorded in across-shore data from the supratidal to the shallow subtidal. Relative abundance of each band in each across-shore zone is mapped as continuous (“C”) or patchy (“P”), indicating a coverage in the unit of >50% or <50%, respectively.

Some biobands are observed in all wave exposure categories and are considered weak as indicators (such as the ubiquitous Barnacle bioband). Other biobands are indicators of a particular wave exposure category (e.g. Dark Brown Kelps are associated with higher wave exposures). Upper intertidal biota tend to be similar between different wave exposure categories and between geographic areas, while lower intertidal biobands are often diagnostic of particular wave exposures. For example, the “Surfgrass” bioband (code “SUR”) is indicative of semi-exposed settings, while the “Eelgrass” bioband (code “ZOS”) is indicative of semi-protected and protected environments.

Biobands that represent potential green crab habitat include lower intertidal eelgrass (ZOS band) and supratidal sedges (SED) and grasses (GRA). Example images of these bands are shown in Figure 2.8. The occurrence and distribution of biobands in the Southeast Alaska study area is summarized in Table 2.4 and Figure 2.9.

Nested queries using biobands to identify potential green crab habitat are discussed in Section 2.6.

Eelgrass (ZOS) in the lower intertidal zone, Krestof Island
Unit 10/01/8588, Photo SE05_MM_6227

Supratidal sedges (SED) and dune grass (GRA), Dundas Bay, Icy Strait.
Unit , Photo SE05_ML_1346

Figure 2.8. Intertidal “biobands” or assemblages of species that occur at particular tidal elevations (locations not shown on map).

Table 2.3. Description of **biobands** of Southeast Alaska.

Zone	Bioband Name	Database Label	Colour	Diagnostic Indicator Species	Exposure*
Supratidal	Splash Zone	**VER**	Black or bare rock	Encrusting black lichens	Width varies with exposure.
	Dune Grass	**GRA**	Pale blue-green	*Leymus mollis*	P to E
	Sedges	**SED**	Bright green to yellow-green	*Carex sp.*	VP to SP
	Marsh grasses, herbs and sedges	**PUC**	Light or bright green	*Puccinellia sp.* Other salt-tolerant herbs and grasses	VP to SE
Upper to Mid-Intertidal	Barnacle	**BAR**	Grey-white to pale yellow	*Balanus sp.* *Semibalanus sp.*	P to E
	Rockweed	**FUC**	Golden-brown	*Fucus sp.*	P to SE
	Green Algae	**ULV**	Green	*Ulva sp.* Other small green algae	P to E
	Blue Mussels	**BMU**	Black or blue-black	*Mytilus trossulus*	P to E
	Bleached Red Algae	**HAL**	Olive, golden or yellow-brown	Bleached foliose or filamentous red algae	P to SE
	Red Algae	**RED**	dark to bright red (non-corallines) or pink (corallines)	*Odonthalia sp.* *Neorhodomela sp.* *Palmaria sp.* other red algae, and other coralline algae	P to E
Lower Intertidal and Nearshore Subtidal	Surfgrass	**SUR**	Bright green	*Phyllospadix sp.*	SP to SE
	Alaria	**ALA**	Dark brown	*Alaria sp.*	SP to E
	Soft brown Kelps	**SBR**	Yellow-brown, olive brown or brown.	*Laminaria saccharina* morph	VP to SP
	Dark brown Kelps	**CHB**	Dark chocolate brown	Stalked *Laminaria sp.* *Lessoniopsis littoralis* other bladed kelps	SE to E
	Eelgrass	**ZOS**	Bright to dark green	*Zostera marina*	VP to SP
Sub-tidal	Dragon Kelp	**ALF**	Golden-brown	*Alaria fistulosa*	SP to E
	Macrocystis	**MAC**	Golden-brown	*Macrocystis integrifolia*	P to SE
	Bull Kelp	**NER**	Dark brown	*Nereocystis luetkeana*	SP to E

**Wave Exposure Codes: VP = Very Protected, P = Protected, SP = Semi-Protected, SE = Semi-Exposed, E = Exposed

Table 2.4. Bioband occurrence in the Southeast Alaska study area.

Bioband Names	Code	Continuous (km)	Continuous %	Patchy (km)	Patchy %	Total (km)	% of Mapped
Dune Grass	GRA	2,365	38%	984	16%	3,349	54%
Sedges	SED	754	12%	482	8%	1,235	20%
Marsh grasses & herbs	PUC	1,114	18%	933	15%	2,047	33%
Barnacle	BAR	2,802	45%	1,109	18%	3,911	62%
Rockweed	FUC	1,619	26%	1,496	24%	3,115	50%
Green Algae	ULV	1,066	17%	1,504	24%	2,570	41%
Blue Mussels	BMU	914	15%	886	14%	1,800	29%
Bleached Red Algae	HAL	149	2%	199	3%	348	6%
Red Algae	RED	1,448	23%	630	10%	2,078	33%
Surfgrass	SUR	74	1%	117	2%	192	3%
Alaria	ALA	1,000	16%	453	7%	1,453	23%
Soft Brown Kelps	SBR	1,033	17%	779	12%	1,812	29%
Dark Brown Kelps	CHB	402	6%	148	2%	551	9%
Eelgrass	ZOS	767	12%	506	8%	1,274	20%
Dragon Kelp	ALF	190	3%	123	2%	313	5%
Macrocystis	MAC	420	7%	164	3%	584	9%
Bull Kelp	NER	359	6%	271	4%	629	10%

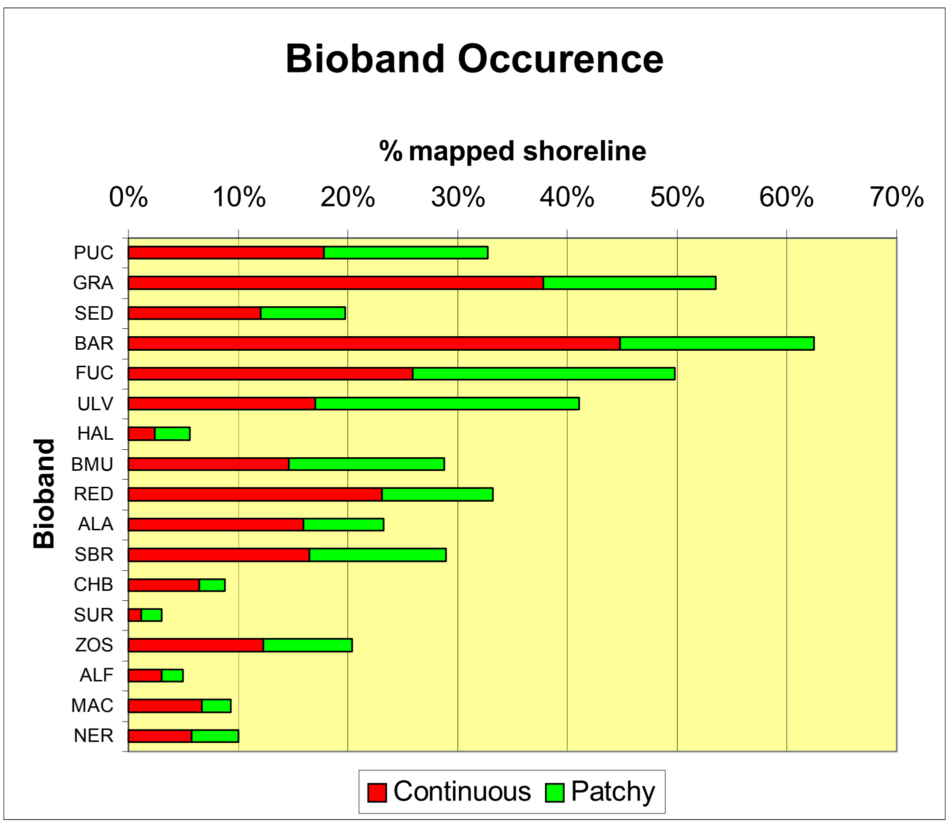

Figure 2.9. Bioband occurrence as a percentage of mapped shoreline length in Southeast Alaska.

2.6 Nested Queries to Identify Potential Green Crab Habitat

Nested queries of combinations of along-shore and across-shore habitat attributes mapped in the ShoreZone database identify shorelines in Southeast Alaska with more than one feature considered favorable to green crab colonization. These nested queries can be run for the entire Southeast Alaska study area, as well as examined on smaller scales of specific shoreline locations. Query results are summarized here and presented in digital data as shapefiles and output tables.

Supratidal Salt Marsh Vegetation and Lower Intertidal Fine Sediment

The map and images in Figures 2.10-2.11 provide an example of semi-protected and protected units with salt marsh vegetation mapped in the supratidal zone (such as *Puccinella* and sedges, shown in green) overlain by units with fine sediment mapped in the lowest intertidal (shown in red). This combination of habitat attributes could be particularly capable of supporting colonization by the green crab. The scale of this map illustrates how regional queries can be useful in providing local information with respect to particular shorelines or sensitive areas. Shapefiles of these query results are provided and can be viewed at any scale for the study area in Southeast Alaska.

Eelgrass and Lower Intertidal Fine Sediment

The map and images in Figures 2.12-2.13 provide an example of semi-protected and protected units with eelgrass in the nearshore subtidal (shown in green) overlain by units with fine sediment mapped in the lowest intertidal (shown in red). This combination of habitat attributes could be particularly capable of supporting colonization by the green crab. The scale of this map illustrates how regional queries can be useful in providing local information with respect to particular shorelines or sensitive areas. Shapefiles of these query results are provided and can be viewed at any scale for the study area in Southeast Alaska. A summary of model results and digital files is provided in Table 3.1.

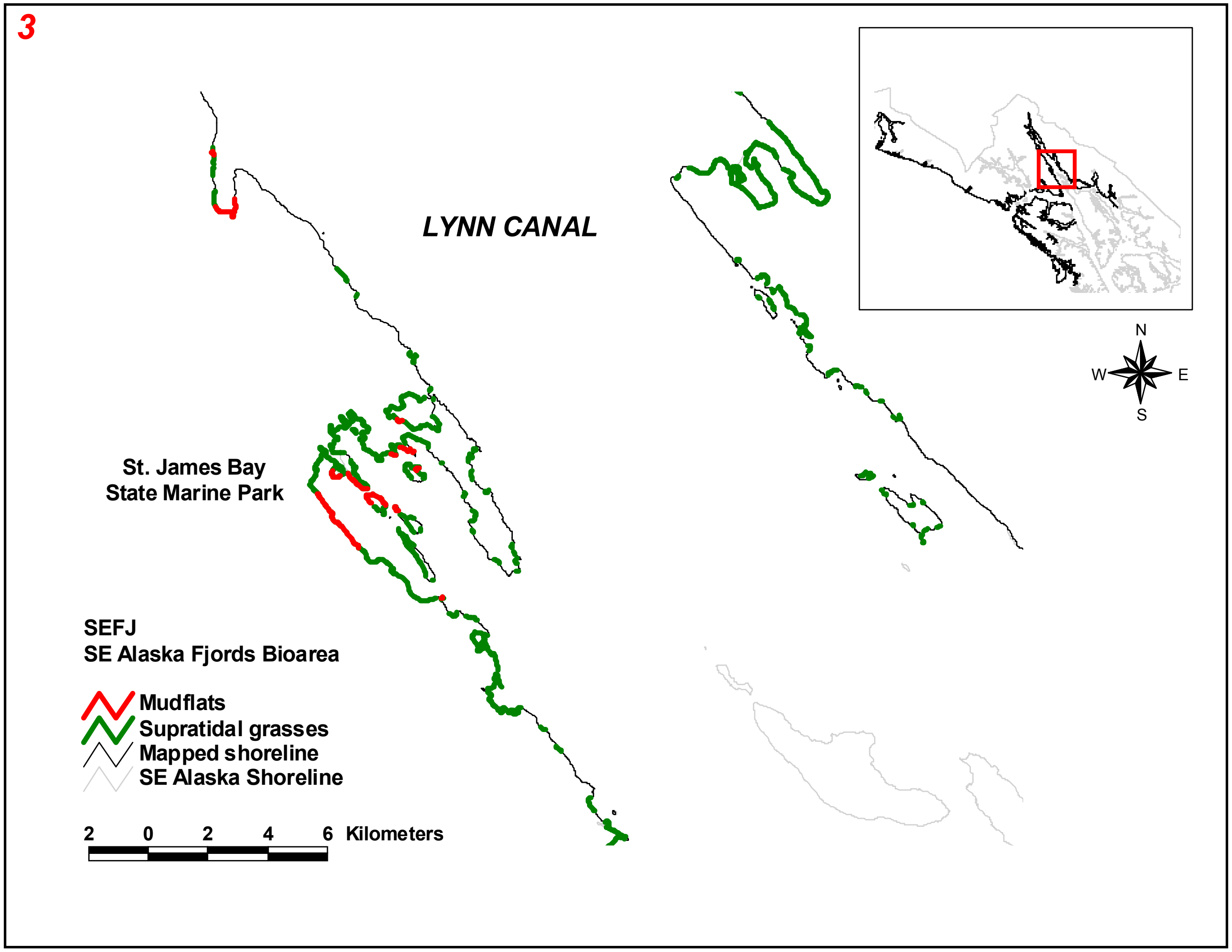

Figure 2.10. Local-level detail map of St. James Bay Marine Park in Lynn Canal, illustrating units with salt marsh vegetation (such as *Pucinella* and sedges, shown in green) overlain by units with fine sediment mapped in the lowest intertidal (shown in red). This combination of habitat attributes is considered particularly suitable for green crab colonization. Shapefiles of query results are provided and can be viewed at any scale for the study area in Southeast Alaska. Location is shown by box 3 in Fig. 2.3.

St. James Bay, Lynn Canal
Unit 10/04/2105, Photo SE05_ML_0117

St. James Bay, Lynn Canal
Unit 10/04/2124, Photo SE05_ML_0138

Figure 2.11. Units with salt marsh vegetation in the supratidal and fine sediment in the lowest intertidal, resulting from nested queries of along-shore and across-shore data to identify shoreline segments in which combinations of critical green crab habitat attributes occur.

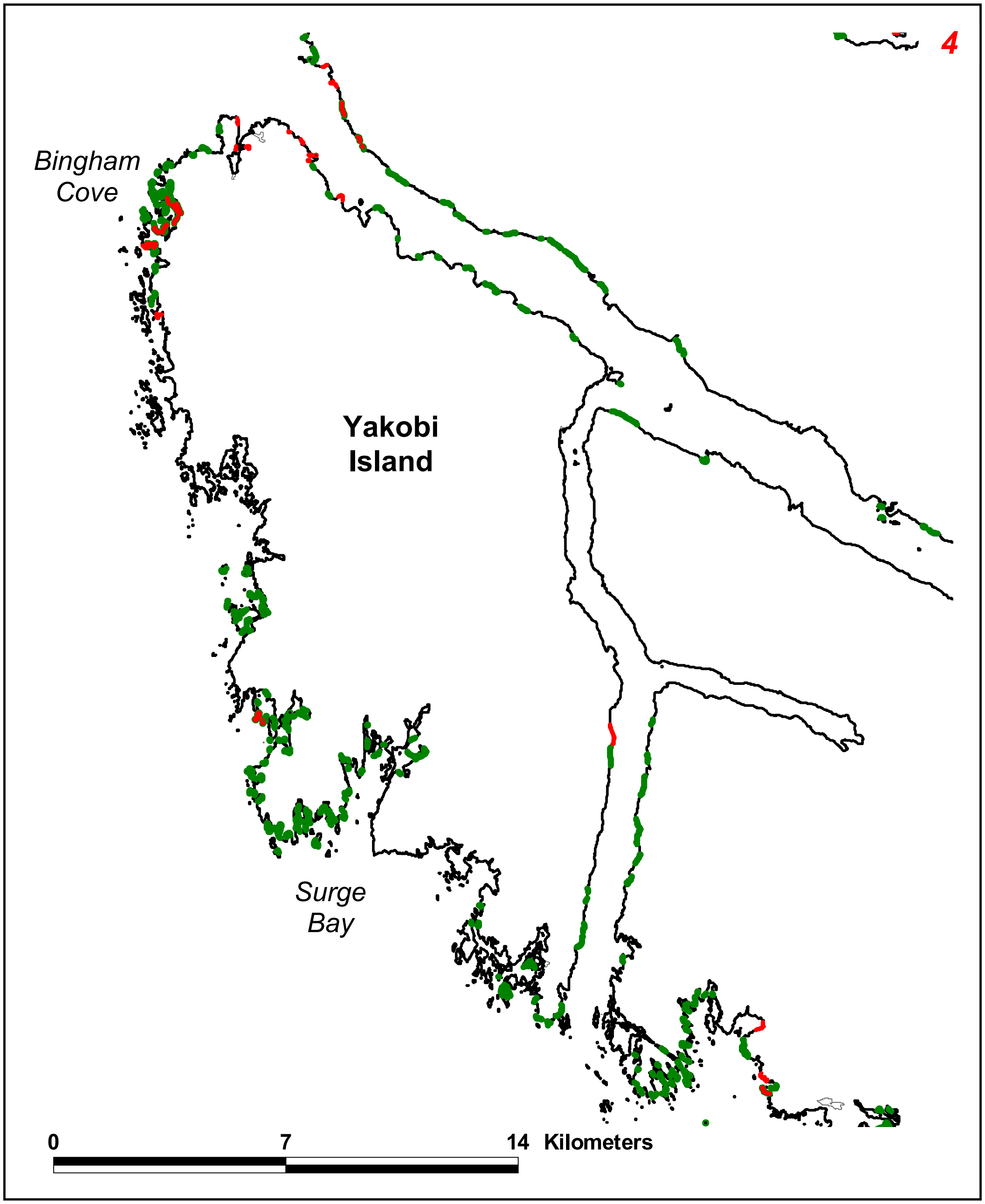

Figure 2.12. Map of Yakobi Island illustrating units with eelgrass (shown in green) overlain by units with fine sediment mapped in the lowest intertidal (shown in red). This combination of habitat attributes is considered particularly suitable for green crab colonization. Shapefiles of query results are provided and can be viewed at any scale for the study area in Southeast Alaska. Location is shown by box 4 in Fig. 2.3.

Bingam Cove, NW Yakobi Island
Unit 10/01/3383, Photo SE05_MM_0791

Bingam Cove, NW Yakobi Island
Unit 10/01/3393, Photo SE05_MM_0798

Figure 2.13. Units with eelgrass and fine sediment in the lowest intertidal, resulting from nested queries of along-shore and across-shore data to identify shoreline segments in which combinations of green crab habitat attributes occur.

3 MODEL APPLICATION IN BC AND WASHINGTON

3.1 British Columbia ShoreZone

ShoreZone data for British Columbia (BC) can be used to map the distribution of geologic and biologic features of the intertidal and shallow subtidal, in the alongshore and across-shore directions. "Unit" data is along-shore information (such as shore type, ESI class, ORI index, sediment mobility). This type of data exists for all of BC (37,605 km of coastline). "XShr" data is the process of breaking a unit into cross-shore components from the supratidal (A zone) and intertidal (B zone) to the subtidal (C zone) and mapping in the geomorphic "Forms" and "Materials" (after Howes et al. 1994).

The length of shoreline in BC was flown and mapped over the course of many years, and most of it was done prior to including across-shore geology. Thus, cross-shore data does not exist for most of BC. Because bioband data is valuable for mapping the distribution of marsh grasses, mussels, canopy kelps, eelgrass, and other biological attributes of the coastal zone, the following biological attributes were incorporated into the BC ShoreZone database by reviewing video imagery (Morris and Howes 2006):

- bioband observations
- biological exposure
- habitat type
- bioareas

The Strait of Georgia and other areas of southern BC and Vancouver Island fall into the "old data polygon" shown on the following maps. Data for this region is either incomplete or inaccessible, thus is not always included in query results.

Information specific to the biological communities in BC ShoreZone data is provided with this report, including a description of BioAreas and BioBands in BC (Appendix A).

The BC ShoreZone database is housed entirely in ArcView GIS tables rather than in MS Access 2000. Model results and query outputs are thus provided in the form of shapefiles compatible with ArcView and ArcGIS. Although the BC ShoreZone database structure differs from the Southeast Alaska ShoreZone database, the approach and principles used to identify potential green crab habitat are the same as outlined in the previous sections of this report.

Unlike in Alaska and Washington, most BC ShoreZone data are considered the property of the Integrated Land Management Branch of the Provincial government. For these and other reasons, a data summary report for British Columbia is lacking. Provincial web sites provide some supporting information and imagery, including photographs and metadata specific to the British Columbia shoreline. We suggest the following:

Gulf Islands Atlas	http://www.shim.bc.ca/gulfislands/
BC Coastal Data Index	http://srmapps.gov.bc.ca/apps/dss_coastal/

3.2 Green Crab Habitat Capability Model Results (British Columbia)

The habitat attributes of wave exposure, coastal class, and intertidal biota are examined within the BC ShoreZone ArcGIS project. ArcGIS shapefiles and output tables for each of the maps and queries (e.g. substrate type, wave exposure, eelgrass) are provided with this report to enable exploration of model output at any location within the study area. A summary of model results and related digital files is provided in Tables 3.2.

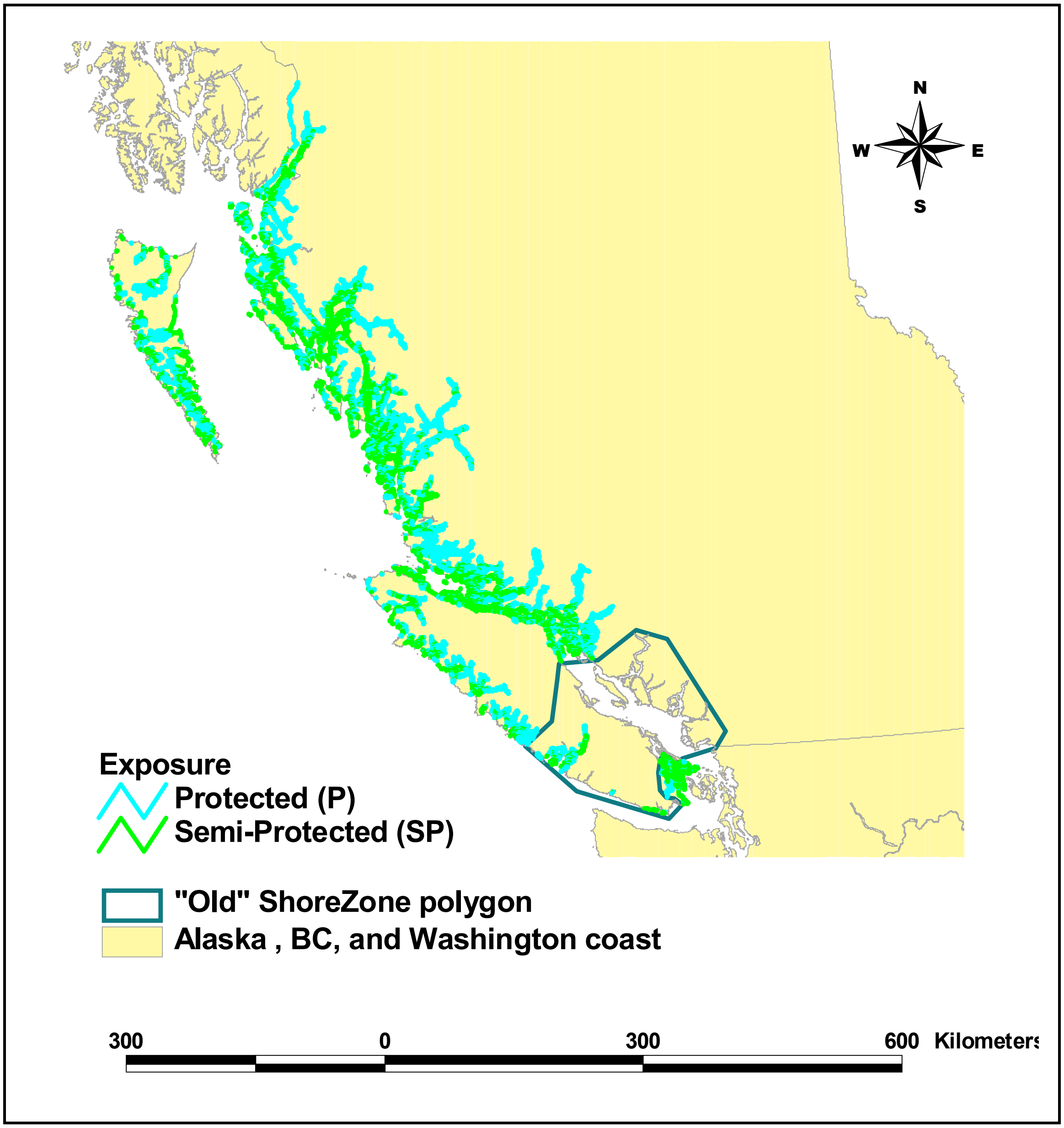

Figure 3.1. Distribution of protected and semi-protected **wave exposures** for coastal environments in BC, comprising 25,179 km of shoreline.

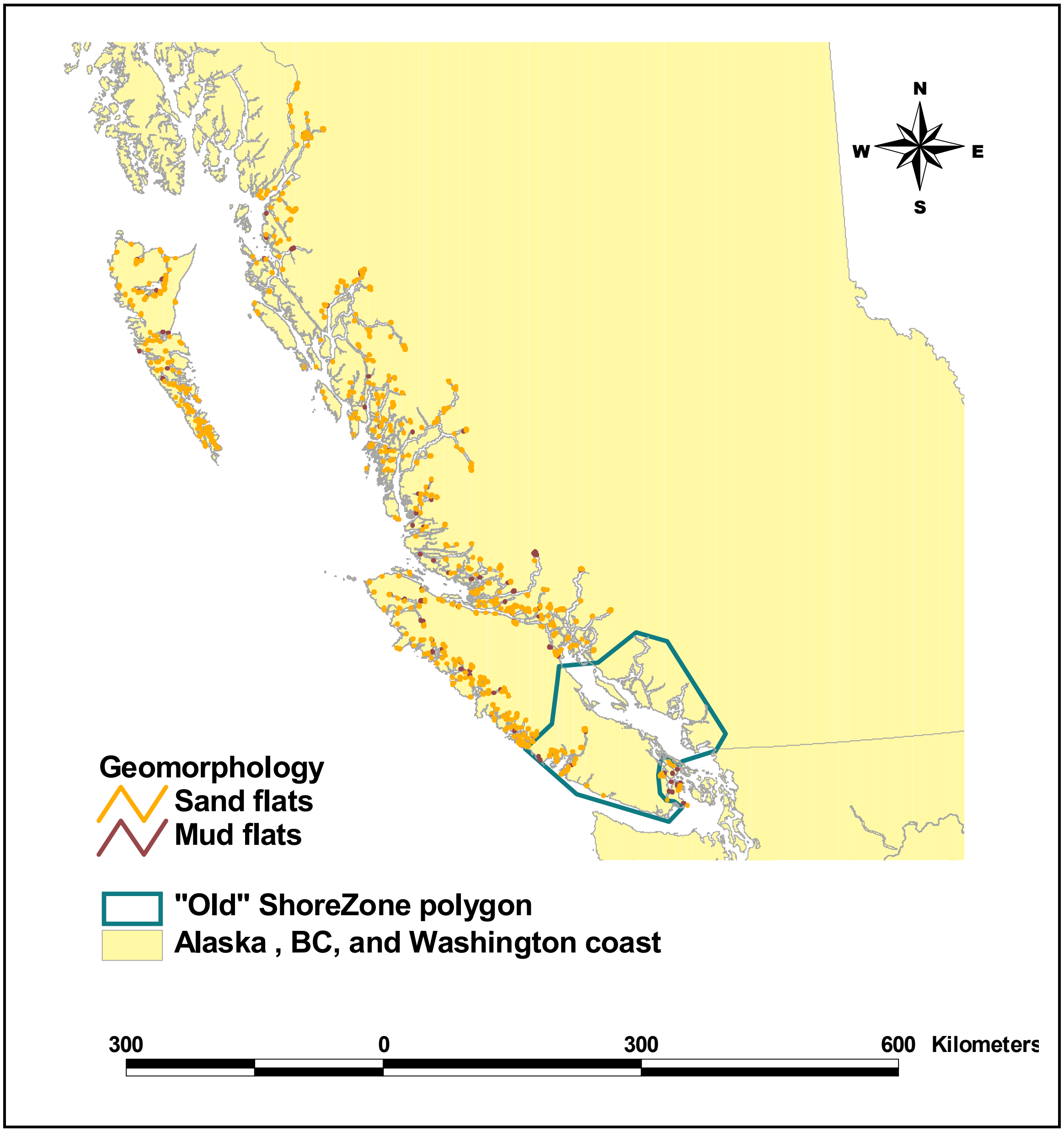

Figure 3.2. Distribution of **sand flats and mud flats** in BC, comprising 1,592 km and 188 km of shoreline, respectively.

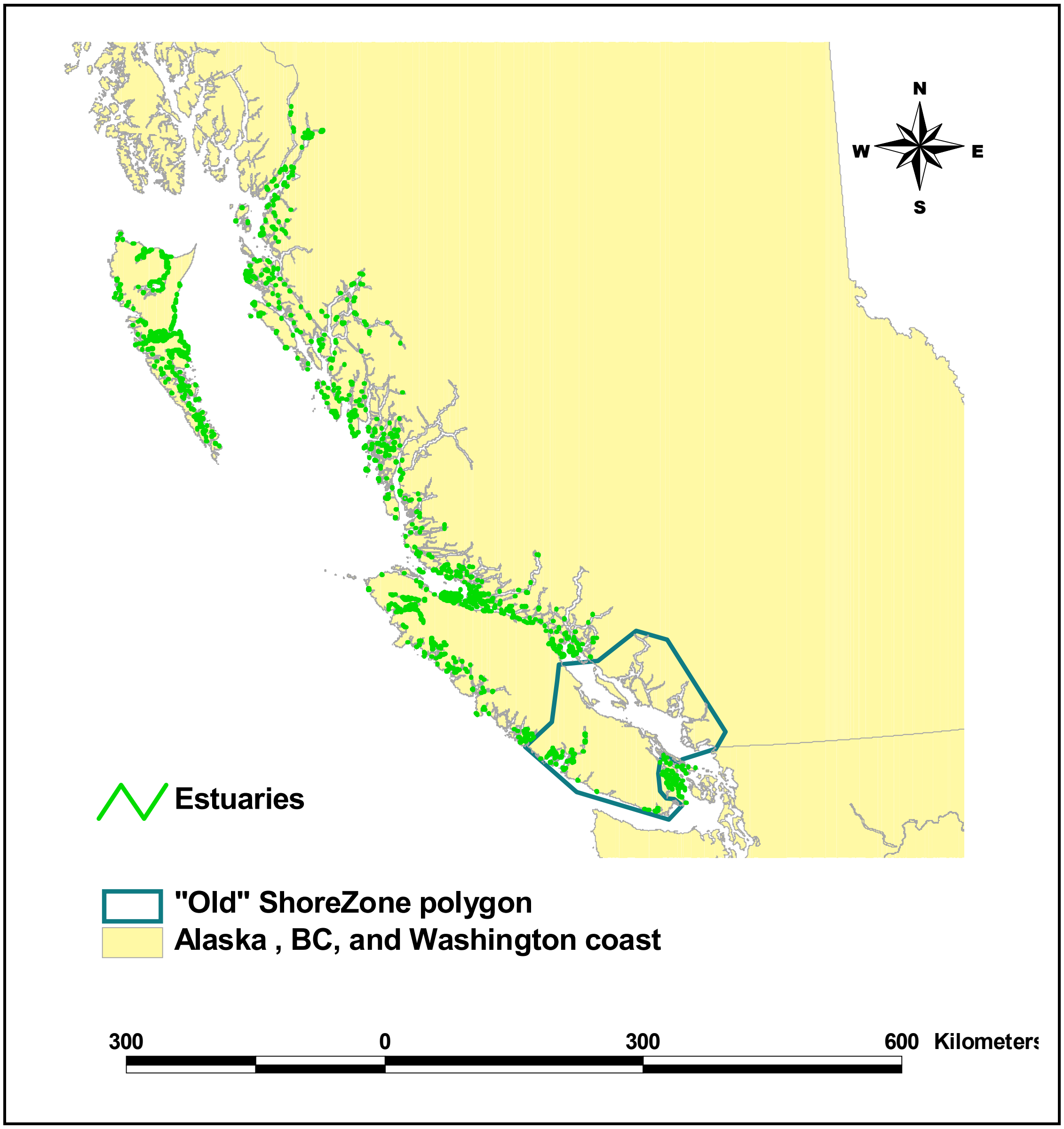

Figure 3.3. Distribution of **estuaries** in BC, comprising 1,769 km of shoreline.

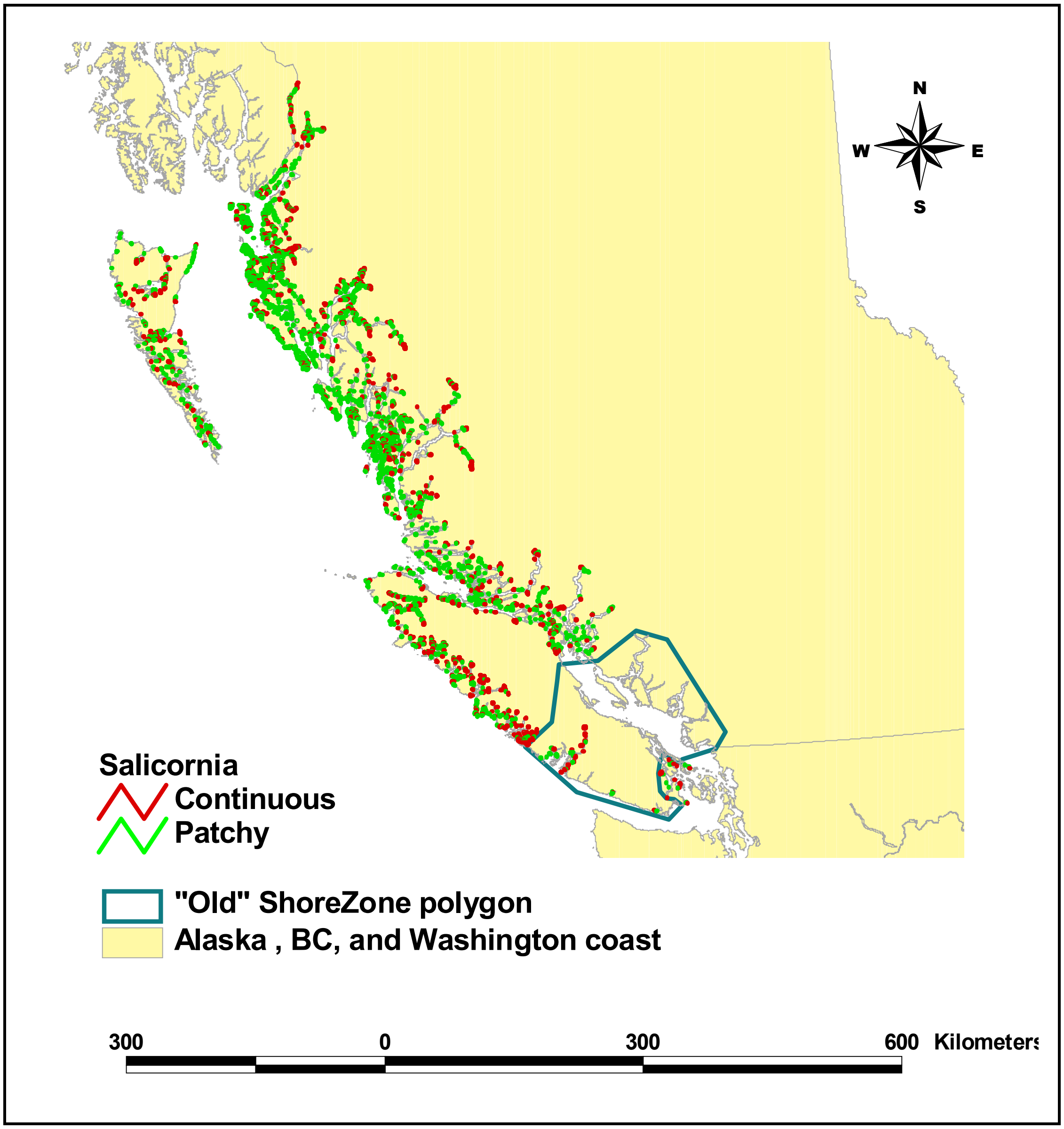

Figure 3.4. Distribution of **salt marsh** vegetation in BC (as indicated by the presence of the plant *Salicornia*), comprising 6,608 km of shoreline.

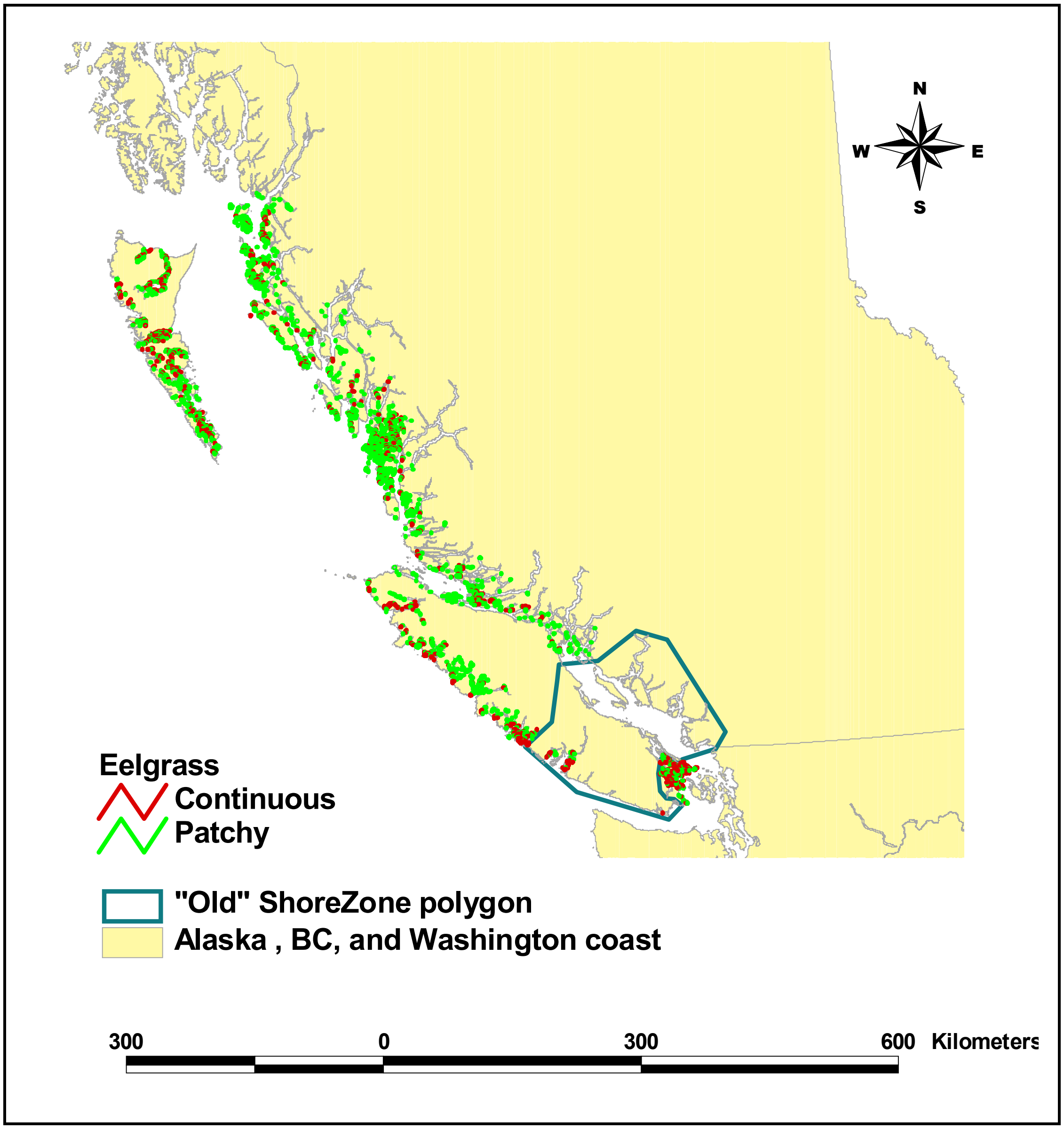

Figure 3.5. Distribution of **eelgrass** in BC, comprising 5,469 km of shoreline.

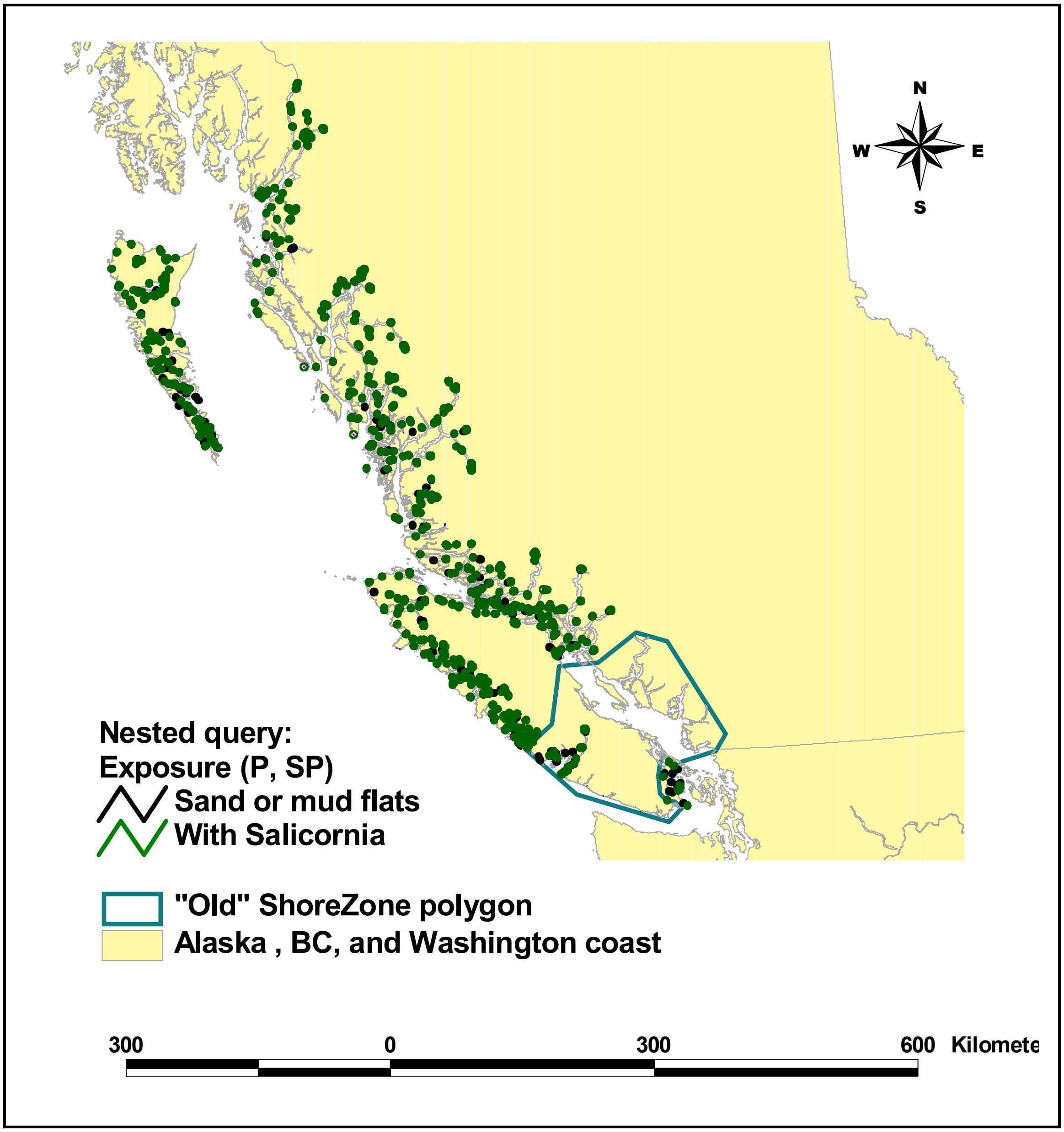

Figure 3.6. Units with protected and semi-protected wave exposures, sand or mud flats in the lower intertidal, and salt marsh vegetation in the supratidal, resulting from **nested** queries of along-shore and across-shore data to identify shoreline segments in which combinations of critical green crab habitat attributes occur. Shorelines meeting all three criteria are shown in green, representing 1,471 km of shoreline.

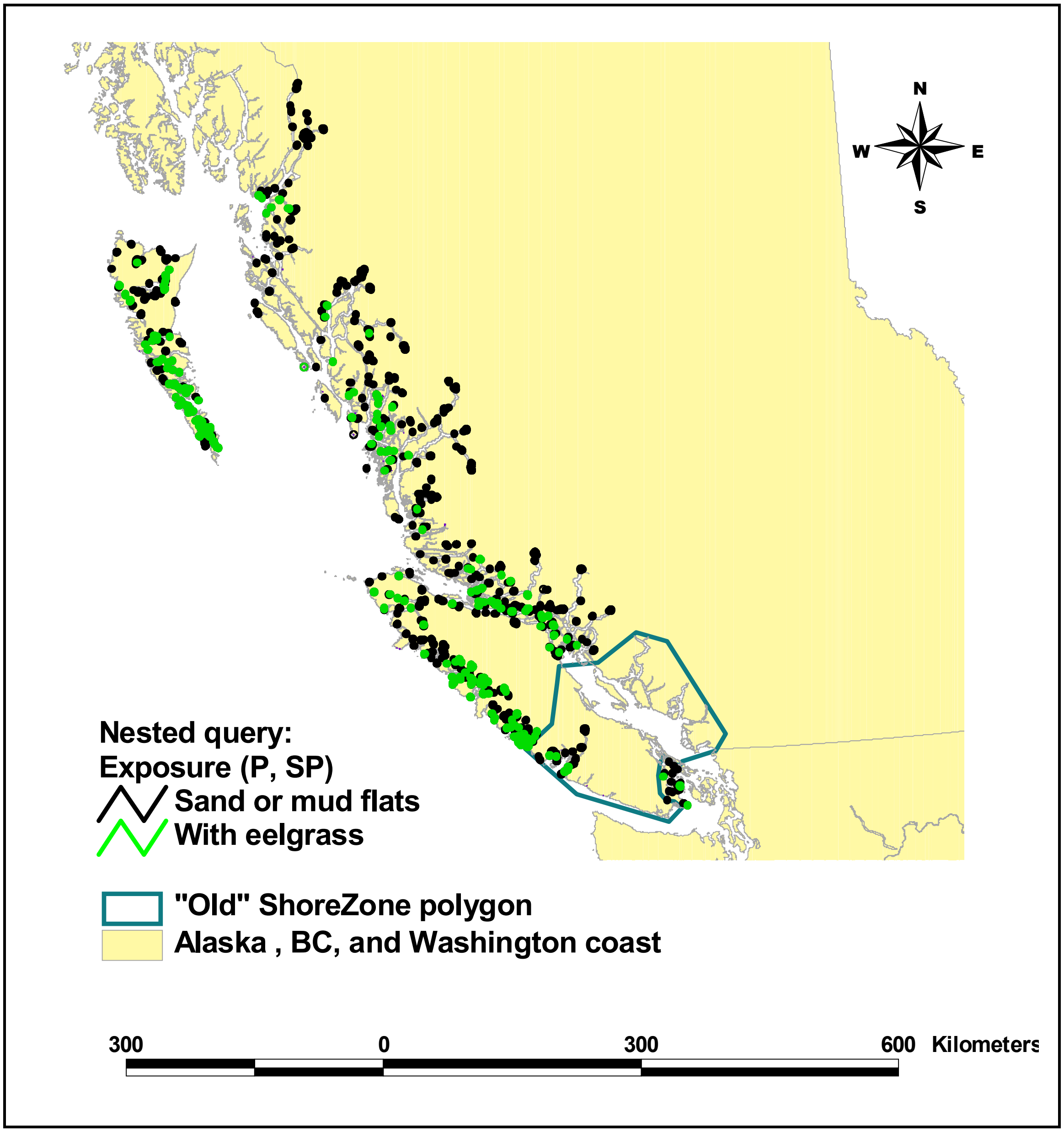

Figure 3.7. Units with protected and semi-protected wave exposures, sand or mud flats in the lower intertidal, and eelgrass in the shallow subtidal, resulting from **nested** queries of along-shore and across-shore data to identify shoreline segments in which combinations of critical green crab habitat attributes occur. Shorelines meeting all three criteria are shown in green, representing 5,469 km of shoreline.

3.3 Washington ShoreZone Program

The ShoreZone coastal mapping program was adopted as a state-wide coastal inventory system in Washington as part of a joint project between the Washington State Department of Natural Resources (DNR) Nearshore Habitat Program (part of the Puget Sound Ambient Monitoring Program) and the Washington State Department of Fish and Wildlife (DFW) between 1995 and 1999.

ShoreZone data for Washington (WA) can be used to map the distribution of geologic and biologic features of the intertidal and shallow subtidal, in the alongshore and across-shore directions. “Unit” data is along-shore information (such as shore type, ESI class, ORI index, sediment mobility). This type of data exists for all of Washington (4,946 km of shoreline). “XShr” data is the process of breaking a unit into cross-shore components from the supratidal (A zone) and intertidal (B zone) to the subtidal (C zone) and mapping in the geomorphic “Forms” and “Materials” (after Howes et al. 1994).

Documentation specific to Washington ShoreZone data is provided on CD in PDF format with this report, including a summary of key findings and a basic user manual.

3.4 Green Crab Habitat Capability Model Results (Washington State)

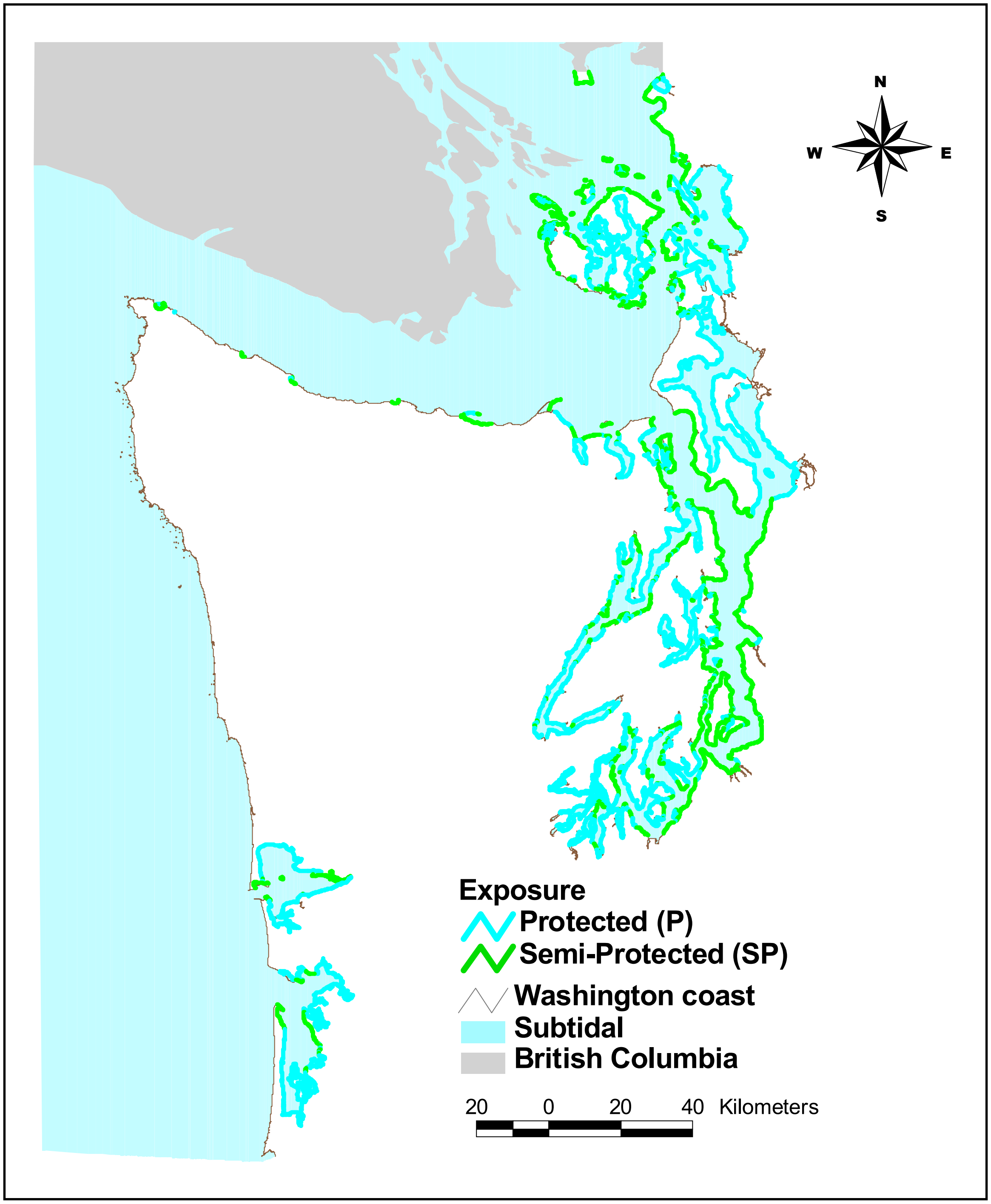

Figure 3.8. Distribution of protected and semi-protected **wave exposures** for coastal environments in Washington, comprising 3,363 km of shoreline.

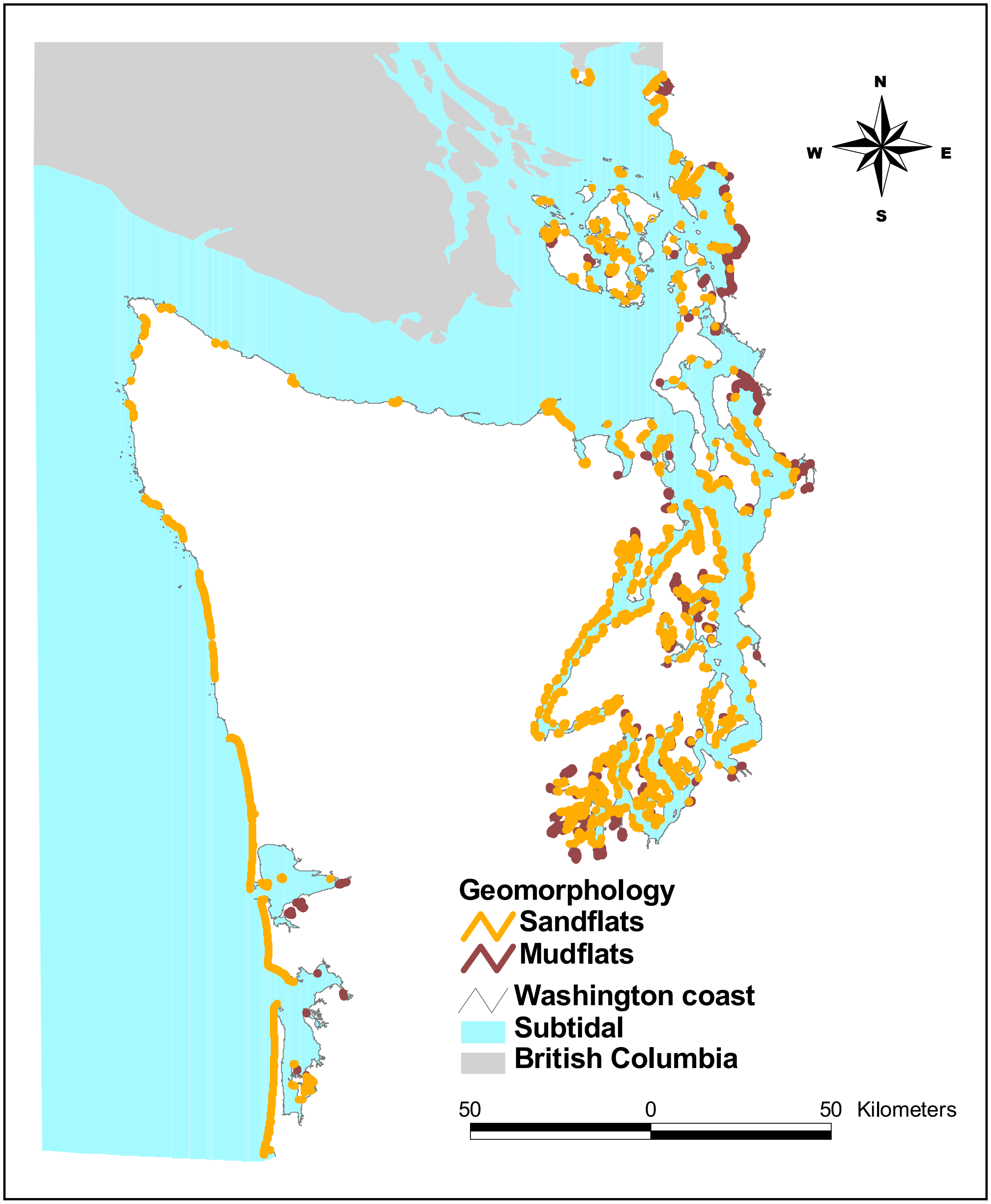

Figure 3.9. Distribution of **sand flats and mud flats** in Washington, comprising 756 km and 301 km of shoreline, respectively.

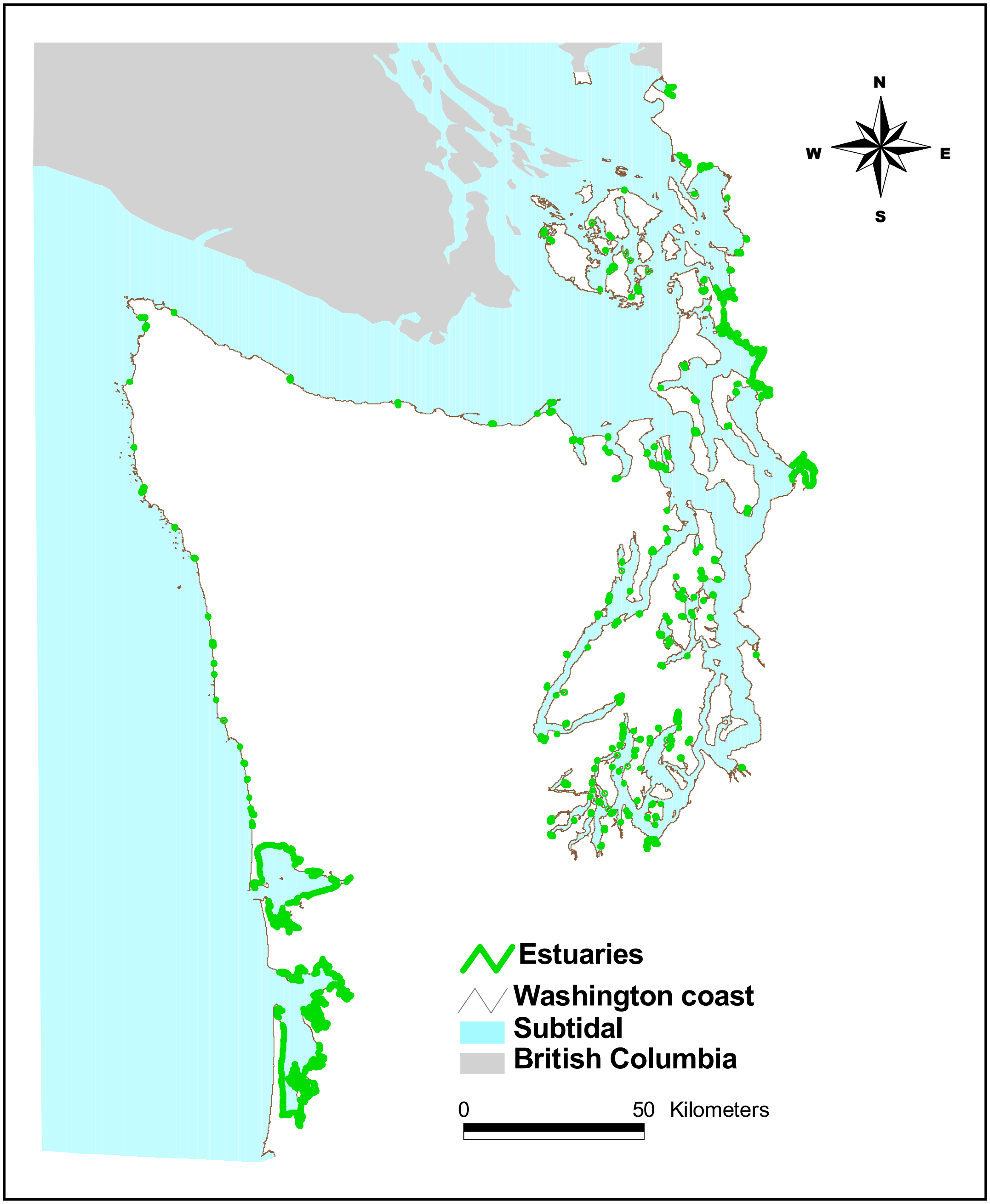

Figure 3.10. Distribution of **estuaries** in Washington, comprising 870 km of shoreline.

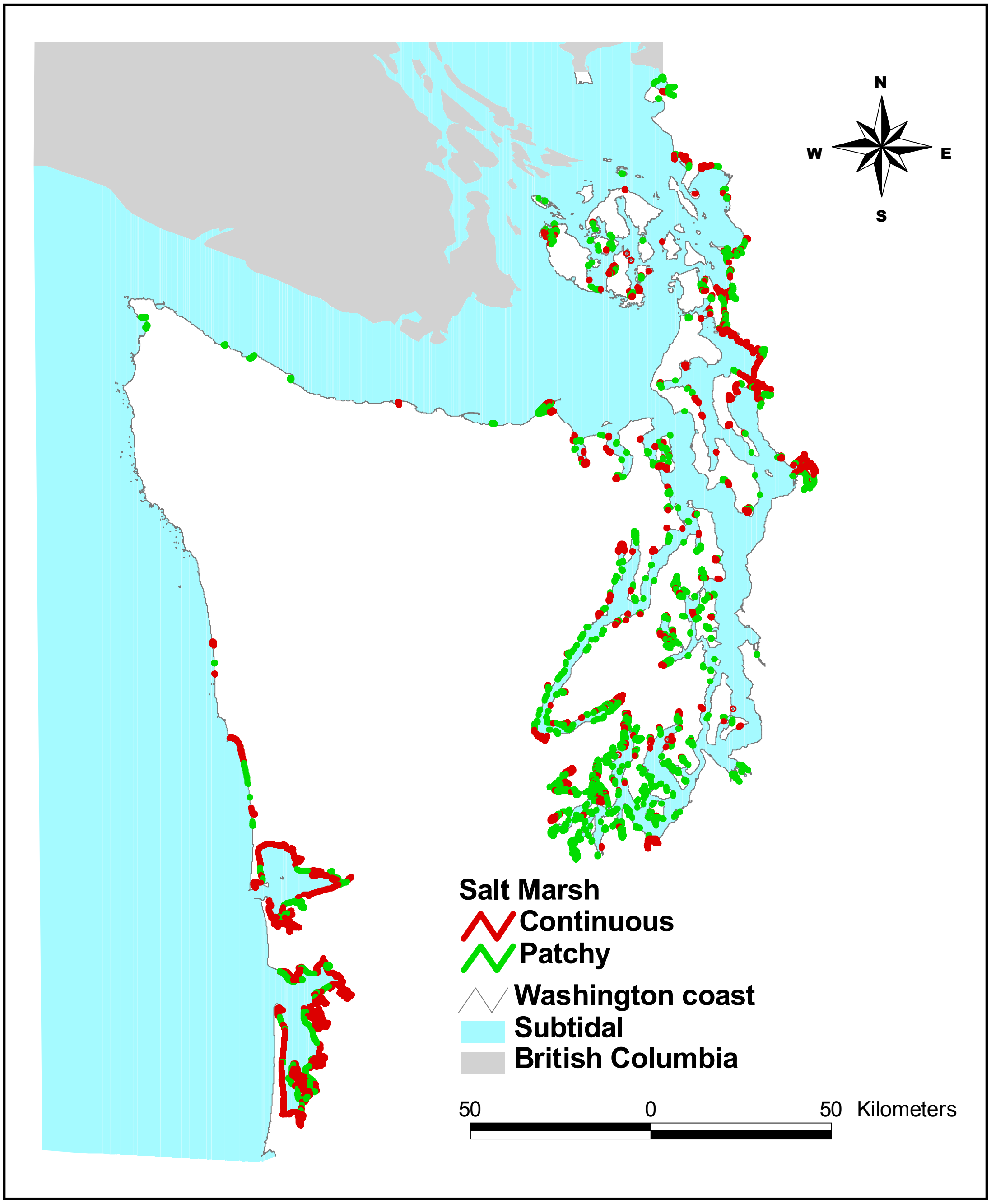

Figure 3.11. Distribution of **salt marsh** vegetation in Washington (as indicated by the presence of salt-tolerant sedges, *Salicornia*, *Triglochin*, *Carex*, or *Spartina*) comprising 1,536 km of shoreline.

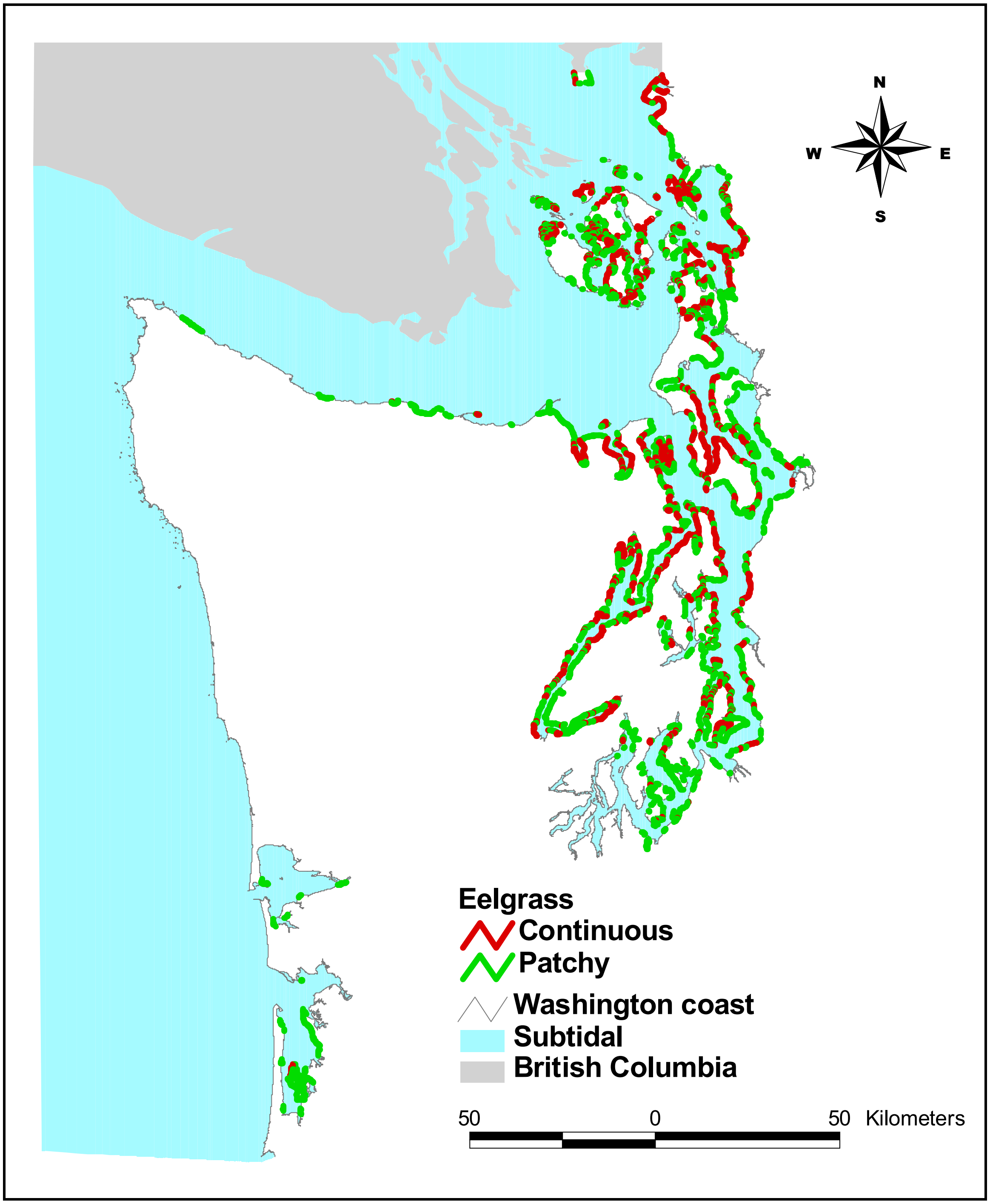

Figure 3.12. Distribution of **eelgrass** in Washington, comprising 1,813 km of shoreline.

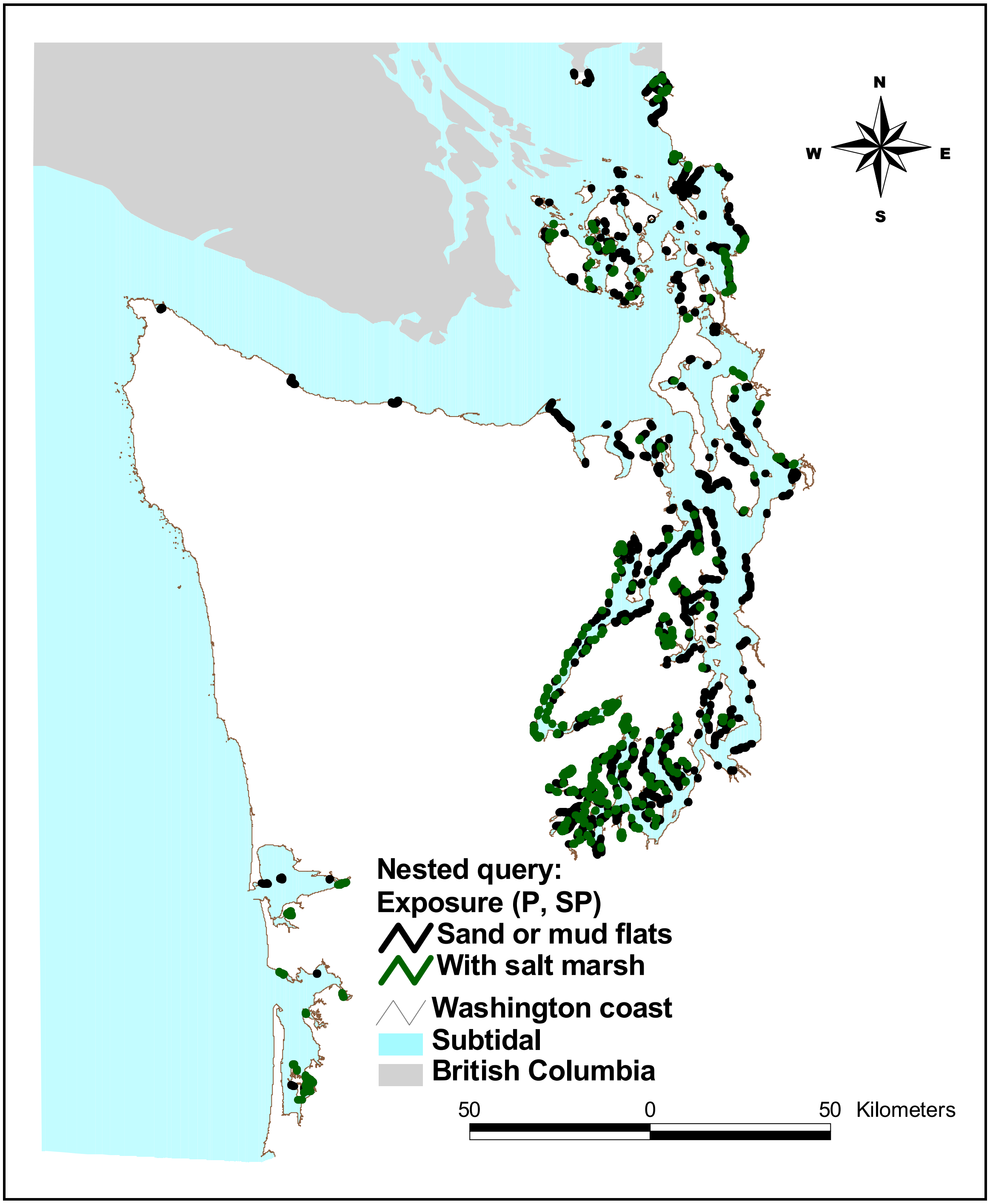

Figure 3.13. Units with protected and semi-protected wave exposures, sand or mud flats in the lower intertidal, and salt marsh vegetation in the supratidal, resulting from **nested** queries of along-shore and across-shore data to identify shoreline segments in which combinations of critical green crab habitat attributes occur. Shorelines meeting all three criteria are shown in green, representing 210 km of shoreline.

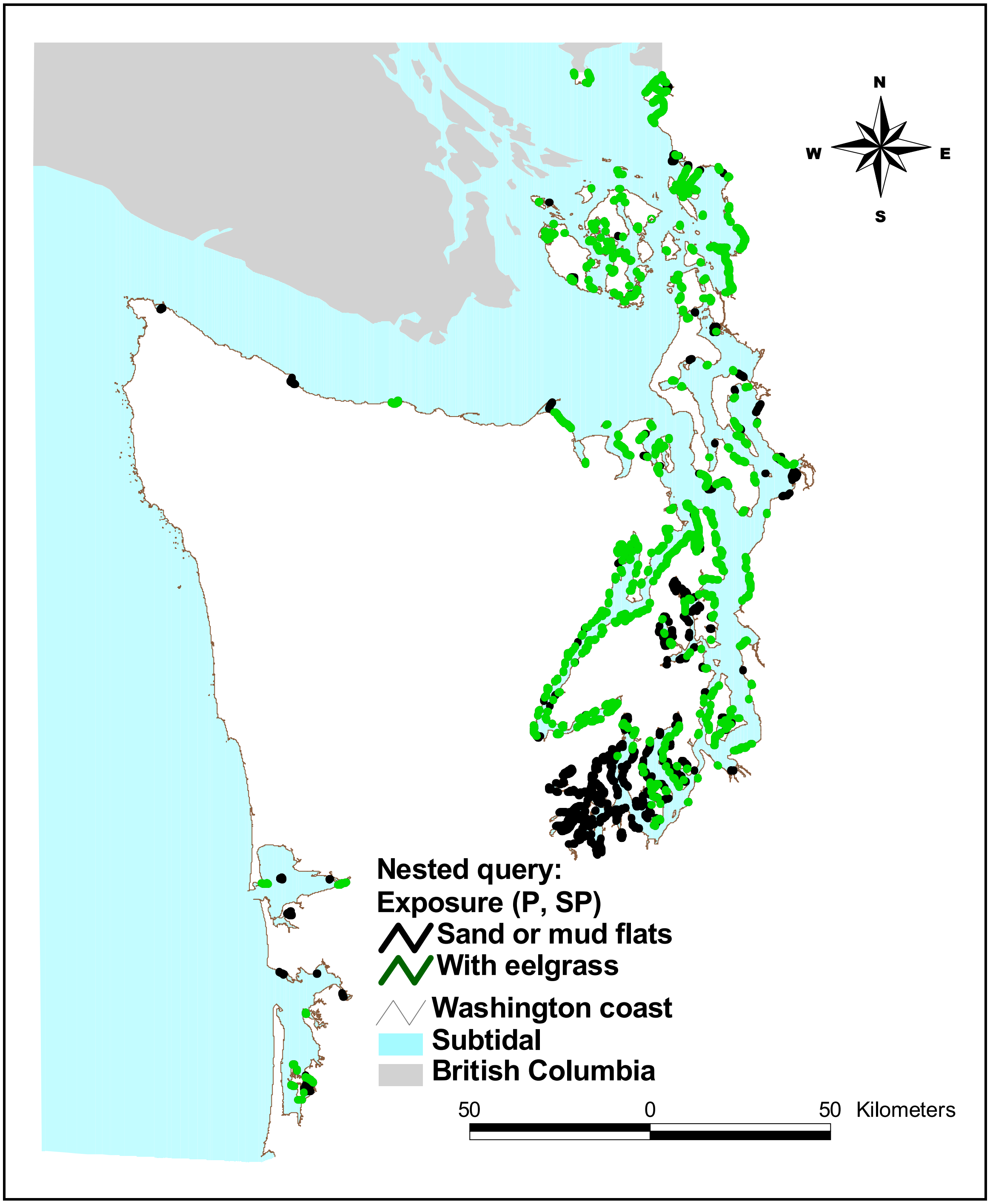

Figure 3.14. Units with protected and semi-protected wave exposures, sand or mud flats in the lower intertidal, and eelgrass in the shallow subtidal, resulting from **nested** queries of along-shore and across-shore data to identify shoreline segments in which combinations of critical green crab habitat attributes occur. Shorelines meeting all three criteria are shown in green, representing 397 km of shoreline.

3.5 References and Acknowledgments

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Zuboy, J.R. 1981. A new tool for fishery managers: the Delphi technique. North Am. J. Fish. Mgmt. 1:55-59.

Model development and application was dependent on the contributions and expertise of many individuals, including: Sylvia Yamada, Linda Shaw, P. Sean McDonald, Graham Gillespie, Tom Therriault, Mattias Herborg, Catherine de Rivera, Greg Ruiz, Ted Grosholz, Kevin See, Blake Feist, Erik Hansen, John Darling, John Harper, Mary Morris, Mandy Lindeberg, Joe Banta, Roger Green, Helen Berry, and Jim Brennan.

4 GREEN CRAB HABITAT MODEL: DIGITAL DATA

4.0 Summary of Query Results and Digital Files

ArcGIS shapefiles and output tables for each of the maps and queries (e.g. substrate type, wave exposure, eelgrass) are provided with this report to enable exploration of model output at any location within the study areas of Southeast Alaska, British Columbia (BC), and Washington State (WA).

Table 4.1. Southeast Alaska ShoreZone database files (housed in Microsoft Access) and GIS files (compatible with ArcView3.2 and ArcGIS9.x) included with this report. Information tabulated for each unit includes alongshore unit identifier (PHY_IDENT), across-shore identifier (CROSSLINK), shoreline name, alongshore unit length, and relevant data compiled from different tables. Database relationships are shown in query design windows. Nested queries are run in sequential order to compile data from Unit, XShr, and BioBand tables.

SEAK ShoreZone 2004-2005	**km**	**Description**	**File Name**
SE05 ShoreZone (database)	--	Access database that houses SE04-05 ShoreZone data	SE05_GreenCrabDB_01Aug07.mdb
SE05 ShoreZone (project)	--	ArcGIS project that houses all shapefiles, data, maps	Se05_gc_habitat_model.apr
SE05 ShoreZone (shapefile)	6,416	Mapped units, SE Alaska ShoreZone (2004-2005)	Se05_units_anad83.shp
Tongass NF shoreline (shapefile) AK shoreline (shapefile) AK polygon (shapefile)	--	No data; shoreline basemaps for display only	Se_tnf_anad83.shp Ak_coast63line_anad83.shp Ak_coast63poly_anad83.shp

SEAK Model Results				***Data tables (*.dbf)***
Data Type	**Habitat attribute**	**Query**	**Description**	**GIS shapefiles (*.shp)**
Unit	Protected and semi-protected exposures	qryExpBio=PorSP	Tabulates wave exposure on the basis of bbiological data (EXPBIO); units must be Protected or Semi-Protected.	*EXPBIOPSP.DBF* Exposure_P_SP.shp
Unit	Sand flats	qryBC=28	Tabulates alongshore data for units classified as sandflats.	*BC28_SAND.DBF* BC28_Sandflats.shp
Unit	Mud flats	qryBC=29	Tabulates alongshore data for units classified as mudflats.	*BC29_MUD.DBF* BC29_Mudflats.shp
Unit	Tidal flats	qryESI=9A	Tabulates alongshore data for units classified as tidal flats. Note these may also be included in BC Class queries for mud or sand flats.	ESI9A_TIDEFLAT.DBF ESI9A_Tidalflats.shp
Unit	Estuaries, brackish marshes, organic shorelines	qryBC=31 qryESIclass10A	Tabulates alongshore data for units classified as organic shorelines (estuaries and brackish marshes).	*BC31_ORGANIC.DBF* BC31_Organic.shp *ESI10A_MARSH.DBF* ESI10A_Marsh.shp

[Continued]

SEAK Model Results [continued]				***Data tables (*.dbf)***
Data Type	**Habitat attribute**	**Query**	**Description**	**GIS shapefiles (*.shp)**
BioBand	Salt marsh vegetation in supratidal	qryBioMarshGrass	*Salicornia, Puccinella*, and other salt marsh vegetation mapped as continuous in the A zone (>50% cover); PUC, GRA, or SED bioband = "C"	*SALTMARSH_VEG.DBF* SaltMarshVeg.shp
BioBand	Eelgrass	qryBioEelgrass	*Zostera* bioband mapped as patchy or continuous; ZOS="P" or "C"	*EELGRASS.DBF* Eelgrass.shp
Unit + XShr + BioBand	Lowest intertidal zone geo+bio	qryLowestB_nest1 qryLowestB_nest2	Selects the highest B zone mapped in each unit, indicating the lowest intertidal component (at the zero-tide level waterline), and summarizes Unit, XShr, and Bioband data.	*LOWB_DATA.DBF* Lowest_Bzone.shp
XShr	Fine sediment in lowest intertidal	qryLowestB_nest3_ Mud_Mat1	Sediment texture: primary material ("Mat1") in lowest intertidal (B) zone is fine sediment.	*LOWB_MUD.DBF* LowB_Mud.shp
XShr	Tidal flats and deltas in lowest	qryLowestB_nest3_ TidalFlat_Form1	Geomorphology: primary form ("Form1") in lowest intertidal zone is tide flat, delta or beach flat.	*LOWB_FLAT.DBF* LowB_Flat.shp

Table 4.2. British Columbia ShoreZone ArcGIS queries and shapefiles included with this report. Each shapefile contains all related along-shore (unit) data (and across-shore bioband data where available).

BC ShoreZone	**km**	**Query Type**	**Description**	**File Name**
BC ShoreZone (database)	--		Access database that houses BC ShoreZone data	
BC ShoreZone (GIS project)	--	--	ArcGIS project that houses all shapefiles, data, and maps	bc_gc_habitat_model.apr
BC ShoreZone (GIS shapefile)	37,604.8	--	All mapped shorelines	bc_gi_shorezone_final_a.shp
BC, AK, WA shoreline polygon (GIS shapefile)	--	--	No data; for display only	ak_bc_wash_bcalbers.shp
BC "old data" polygon (GIS shapefile)	--	--	For display only; areas in BC lacking complete across-shore and bioband data	old_poly_ver1.shp
BC Model Results	**km**	**Query Type**	**Description**	**File Name**
Exposure (P, SP)	25,179.0	unit	Bio Exp Ob = Protected or Semi-Protected	bc_exposure_p_sp.shp
Mud Flats	187.7	unit	Coast Type = Mud Flat	bc_mudflats.shp
Sand Flats	1,592.3	unit	Coast Type = Sand Flat	bc_sandflats.shp
Mud or Sand Flats	1,780.0	unit	Coast Type = Mud Flat or Sand Flat	bc_mudflats_sandflats.shp
Estuaries	1,768.5	unit	Coast Type = Estuary	bc_estuaries.shp
Salicornia (SAL)	6,608.2	bioband	Salicornia (patchy or continuous)	bc_salicornia.shp
Eelgrass (ZOS)	5,469.0	bioband	Eelgrass (patchy or continuous)	bc_eelgrass.shp
ExpPSP, Mud or Sand Flat	1,699.0	nested	Protected or Semi-Protected Exposure, Mud or Sand Flat	bc_nest1_flat_sp_p.shp
ExpPSP, Mud or Sand Flat, Salicornia	1,471.0	nested	Protected or Semi-Protected Exposure, Mud or Sand Flat, Salicornia	bc_nest2_flat_sp_p_sal.shp
ExpPSP, Mud or Sand Flat, Eelgrass	497.8	nested	Protected or Semi-Protected Exposure, Mud or Sand Flat, Eelgrass	bc_nest3_flat_sp_p_zos.shp

Table 4.3. Washington ShoreZone ArcGIS queries and shapefiles included with this report. Each shapefile contains all related along-shore (unit) and across-shore (bioband) data.

WA ShoreZone	km	Query Type	Description	File Name
WA ShoreZone (project)	--	--	ArcGIS project that houses all shapefiles, data, and maps	wa_gc_habitat_model.apr
WA ShoreZone (shapefile)	4,935.7	--	All mapped shorelines	wa_shorezone_final_a.shp
Marine areas polygon		--	No data; for display only	wabcwtr.shp
BC land area polygon		--	No data; for display only	bc_land.shp
WA Model Results	**km**	**Query Type**	**Description**	**GIS Shapefile**
Exposure (P, SP)	3,362.8	unit	Exp Class = Protected or Semi-Protected	wa_exposure_p_sp.shp
Sand Flats	756.2	unit	Coastal Class = 28	wa_sandflats.shp
Mud Flats	301.2	unit	Coastal Class = 29	wa_mudflats.shp
Sand or Mud Flats	1,057.4	unit	Coastal Class = 28 or 29	wa_mudflats_sandflats.shp
Estuaries	869.6	unit	Coastal Class = 31	wa_estuaries.shp
Salt Marsh	1,536.5	bioband	Sedges, Triglochlin, Salicornia, or Spartina (patchy or continuous)	wa_saltmarsh.shp
Eelgrass (ZOS)	1,812.9	bioband	Eelgrass (patchy or continuous)	wa_eelgrass.shp
ExpPSP, Mud or Sand Flat	651.4	nest1	Protected or Semi-Protected Exposure, Mud or Sand Flat	wa_nest1_flat_sp_p.shp
ExpPSP, Mud or Sand Flat, Salt Marsh	210.4	nest2	Protected or Semi-Protected Exposure, Mud or Sand Flat, Salt Marsh	wa_nest2_flat_sp_p_saltmarsh.shp
ExpPSP, Mud or Sand Flat, Eelgrass	397.0	Nest3	Protected or Semi-Protected Exposure, Mud or Sand Flat, Eelgrass	wa_nest3_flat_sp_p_zos.shp

APPENDIX A DATA DICTIONARY

Table A-1. Data dictionary for UNIT table

Field Names	Type	Description
UnitRecID	N	unique numerical number for each record
PHY_IDENT	T	unique alphanumeric identifier made up of the REGION, AREA, PHY_UNIT and SUBUNIT numbers (RR/AA/UUUU/SS)
REGION	T	coastal region number
AREAS	T	coastal area number
PHY_UNIT	T	physical shore unit number; the unit is the primary alongshore subdivision during the mapping
SUBUNIT	T	subunit number: "0" for main Unit and "1,2,3…" for variants or point features
TYPE	T	a description of Unit type: a (**L**)line-type unit, or a (**P)**oint variant
BC_CLASS	N	a number indicating the BC "coastal class" or "shoreline type" (see Table A-2)
ESI	T	a number code for the ESI coastal classification system (see Table A-3)
LENGTH_M	N	the unit alongshore length in M, calculated using GIS software
GEO_MAPPER	T	last name of geology mapper
GEO_EDITOR	T	last name of individual responsible for reviewing and editing
GEO_MAP_DATE	D/T	date of original geological mapping
GEO_SOURCE	T	data sources for geological interpretation: (V)ideotape, (P)hoto-aerial, (T)opo maps, (C)harts, (O)ther
SCALE	T	scale of base maps used to delineate units
VIDEOTAPE	T	the videotape identifier number
HR	T	the "burned-in" tape time from the GPS that appears on the video image; "X" indicates no screen time was available
MIN	T	the "burned-in" tape time from the GPS that appears on the video image; "X" indicates no screen time was available
SEC	T	the "burned-in" tape time from the GPS that appears on the video image; "X" indicates no screen time was available
MAP_NO	I	page number from the DeLorme Alaska Atlas where the Unit is plotted
CHART	T	NOAA chart number(s) for the Unit
EXP_OBSER	T	an estimate of the wave exposure as observed by geomorphologist during mapping based on Table A-4
EXP_CLASS	T	a numeric code for best exposure estimate where EXP_BIO is better than ESP_OBS (see Table A-4)
ORI	I	a code indicating the potential oil residence index, see Tables A-5 and A-6
SED_SOURCE	T	a code indicating the estimated sediment source for the unit, (B)ackshore, (A)longshore, (F)luvial, (O)ffshore
SED_ABUND	T	a code indicating the relative sediment abundance within the shore-unit, (A)bundant, (M)oderate, (S)carce
SED_DIR	T	one of the eight cardinal points of the compass indicating dominant sediment transport direction
CHNG_TYPE	T	a code indicating the stability of the shore unit, (A)ccretional, (E)rosional, (S)table
CHNG_RATE	N	the rate of change of the shoreline within the unit in m/yr

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

SHORENAME	T	the name of a prominent geographic feature near the unit; used to facilitate searches
UNIT_COMMENTS	T	a text field used for miscellaneous comments and notes during the mapping
SHORE_PROB	T	comment on nature of the shore problem, usually the difference between electronic shoreline and observed shoreline
SM1_TYPE	T	the *primary* type of seawall occurring within the unit where: BR = boat ramp; CB = concrete bulkhead; LF = landfill; SP= sheet pile; RR = rip rap and WB = wooden bulkhead
SM%	N	the estimated % occurrence of the *primary* seawall type in tenths (i.e., “2” = 20% occurrence within the unit)
SM1_M	N	the calculated length in meters of the *primary* seawall type
SM2_TYPE	T	the *secondary* type of seawall occurring within the unit where: BR = boat ramp; CB = concrete bulkhead; LF = landfill; SP = sheet pile; RR = rip rap and WB = wooden bulkhead
SM2%	N	the estimated % occurrence of the *secondary* seawall type in tenths (i.e., “2” = 20% occurrence within the unit)
SM2_ M	N	the calculated length in meters of the *secondary* seawall type
SM3_TYPE	T	the *tertiary* type of seawall occurring within the unit where: BR = boat ramp; CB = concrete bulkhead; LF = landfill; RR = rip rap and WB = wooden bulkhead
SM3%	N	the estimated % occurrence of the *tertiary* seawall type in tenths (i.e., “2” = 20% occurrence within the unit)
SM3_ M	N	the calculated length in meters of the *tertiary* seawall type
SMOD_TOTAL	N	the total % occurrence of seawall in the unit, in tenths
RAMPS	N	the number of boat ramps that occur within the shore zone of the unit or subunit. Ramps must impact some portion of the shore-zone and generally be constructed of concrete, wood or aggregate. Public boat ramps are shown as variants
PIERS_DOCK	N	the number of piers or wharves that occur within the unit. Piers or docks must extend at least 10m into the shore zone. Category does not include anchored floats
REC_SLIPS	N	the estimated number of recreational (or small) slips associated with the piers/docks of the unit based on small boat length (~<50’)
DEEPSEA_SLIP	N	the estimated number of slips for ocean-going vessels (~>100’)
ITZ	N	the sum of the across-shore width of all the intertidal components (B-Zone) within the unit

Table A-2. Shore Type classification employed in the ShoreZone mapping methodology in Alaska (after Howes et al. 1994 for British Columbia "BC Class")

SUBSTRATE	SEDIMENT	WIDTH	SLOPE	Shore Type Code & Description
ROCK	n/a	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(1) Rock Ramp, wide
			FLAT(<5°)	(2) Rock Platform, wide
		NARROW (<30m)	STEEP(>20°)	(3) Rock Cliff
			INCLINED(5-20°)	(4) Rock Ramp, narrow
			FLAT(<5°)	(5) Rock Platform, narrow
ROCK + SEDIMENT	GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(6) Ramp w gravel beach, wide
			FLAT(<5°)	(7) Platform w gravel beach, wide
		NARROW (<30m)	STEEP(>20°)	(8) Cliff w gravel beach
			INCLINED(5-20°)	(9) Ramp w gravel beach
			FLAT(<5°)	(10) Platform with gravel beach
	SAND & GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(11) Ramp w gravel & sand beach, wide
			FLAT(<5°)	(12) Platform w G&S beach, wide
		NARROW (<30m)	STEEP(>20°)	(13) Cliff w gravel/sand beach
			INCLINED(5-20°)	(14) Ramp w gravel/sand beach
			FLAT(<5°)	(15) Platform with gravel/sand beach
	SAND	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(16) Ramp w sand beach, wide
			FLAT(<5°)	(17) Platform w sand beach, wide
		NARROW (<30m)	STEEP(>20°)	(18) Cliff w sand beach
			INCLINED(5-20°)	(19) Ramp w sand beach, narrow
			FLAT(<5°)	(20) Platform w sand beach, narrow
SEDIMENT	GRAVEL	WIDE (>30m)	FLAT(<5°)	(21) Gravel flat, wide
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(22) Gravel beach, narrow
			FLAT(<5°)	(23) Gravel flat or fan
	SAND & GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	n/a
			FLAT(<5°)	(24) Sand & gravel flat or fan
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(25) Sand & gravel beach, narrow
			FLAT(<5°)	(26) Sand & gravel flat or fan
	SAND/MUD	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(27) Sand beach
			FLAT(<5°)	(28) Sand flat
				(29) Mudflat
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	(30) Sand beach
			n/a	
	ORGANICS/FINES	n/a	n/a	(31) Organics/Fines
ANTHRO-POGENIC	MAN-MADE	n/a	n/a	(32) Man-made, permeable
				(33) Man-made, impermeable
CURRENT-DOMINATED				(34) Channel
ICE				(35) Glacial ice shoreline

Table A-3 ESI Shore Type classification (after Peterson 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	Rip rap; Gravel Beaches (cobbles and boulders)
6C	Rip rap
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_OBS)

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

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 definition and component look-up matrix

ORI Definition

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**

ORI Look-up matrix for cross-shore components

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-6. Look-up table of calculated ORI defined by shore type and exposure

Shore Type	Calculated Exposure					
CLASS	VE	E	SE	SP	P	VP
1	1	1	1	2	3	3
2	1	1	1	2	3	3
3	1	1	1	2	3	3
4	1	1	1	2	3	3
5	1	1	1	2	3	3
6	2	3	5	4	4	4
7	2	3	5	4	4	4
8	2	3	5	4	4	4
9	2	3	5	4	4	4
10	2	3	5	4	4	4
11	1	2	3	4	5	5
12	1	2	3	4	5	5
13	1	2	3	4	5	5
14	1	2	3	4	5	5
15	1	2	3	4	5	5
16	1	2	3	3	4	4
17	1	2	3	3	4	4
18	1	2	3	3	4	4
19	1	2	3	3	4	4
20	1	2	3	3	4	4
21	2	3	5	4	4	4
22	2	3	5	4	4	4
23	2	3	5	4	4	4
24	1	2	3	4	5	5
25	1	2	3	4	5	5
26	1	2	3	4	5	5
27	2	2	3	3	4	4
28	2	2	3	3	4	4
29	--	--	--	3	3	3
30	2	2	3	3	4	4
31	5	5	5	5	5	5
32	2	2	3	3	5	5
33	1	1	1	2	2	2
34	--	--	--	4	4	4

Table A-7. Data dictionary for BIOUNIT table

Field Names	Type	Description
UnitRecID	N	unique numerical number for each record
PHY_IDENT	T	unique alphanumeric identifier made up of the REGION, AREA, PHY_UNIT and SUBUNIT numbers (RR/AA/UUUU/SS)
BioArea*	T	a geographic region used to describe regional differences in biota observed in the lower intertidal biobands.
EXP_BIO	T	estimate of the exposure based on observed indicator species (see Section 3.2 for details).
HAB_CLASS	T	Habitat Classification determined by the BIO mapper that combines the EXP_BIO and the Physical features of the shoreline (see Table A-8).
HAB_OBS	N	the observed biotic assemblage from the imagery (not used in current project, kept for backward compatible with earlier AK projects)
BIO_SOURCE	T	the source that was used to interpret shore-zone biota, (V)ideotape, (S)lide, (I)nferred
HAB_CLASS2**	N	Secondary Habitat Classification determined by the BIO mapper used to denote lagoon habitat types
HC2_SOURCE	T	the source that was used to interpret the secondary lagoon habitat class, OBS(erved) as viewed from video, L(oo)KUP refering to 'Form' Code (Table A-11) Lo or Lc in Across-Shore Component Table (XSHR)
HC2_Note	T	comment field
RIPARIAN% ***	N	estimate of the percentage of alongshore length of the intertidal zone, where the shoreline is shaded by overhanging riparian vegetation, all substrate types (see additional note below)
RIPARIAN_M	N	length, in meters, of the unit shaded by overhanging riparian vegetation, all substrate types
BIO_UNIT_COMMENT	T	comment field
BIO_MAPPER	T	the last name of the biologist that provided the biological interpretation of the imagery
BIO_MAP_DATE	D/T	date of biological mapping
Photo	Y/N	marks if there is a photo (digital or slide) or a ground station associated with the unit

* Further Description of the **BIOAREA** attribute:

BIOAREA NAMES in Alaska ShoreZone Mapping To Date	BIOAREA Codes in Alaska SZ Mapping	SUFFIX Used in Database to Identify Bioarea
Southeast Alaska -- Lynn Canal	SEFJ	12
Southeast Alaska --Sitka	SESI	12
Southeast Alaska --Icy Strait	SEIC	12
Southeast Alaska --Yakutat	SEYA	12
Southeast Alaska --Misty Fjords	SEMJ	12
Southeast Alaska --Craig	SECR	12
Prince William Sound	PRWS	13
Outer Kenai	KENA	8
Cook Inlet	COOK	9
Kodiak Island	KODI	10
Katmai	KATM	11
Aniakchak	ANIA	11

Table A-7. Data dictionary for BIOUNIT table (continued)

**** Further description of the HabClass2 attribute:**

As an attribute in the BioUnit table, this category is intended to denote lagoon habitat types.

Units classified as Lagoons 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. 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.

It should be noted lagoons represent unique habitat types that differ from estuaries and other areas designated as marshland. It is an unusual coastal habitat and a prominent feature observed in the Kodiak region. It is for these reasons that it is important to employ the secondary hab class designation to highlight these areas as distinct from any other.

***** Further description of the Riparian% attribute:**

As an attribute in the BioUnit table, this category is intended to be an index for the potential habitat for upper beach spawning fishes.

The value recorded in the 'Riparian%' field is an estimate of the percentage of the unit's total alongshore length where riparian vegetation of trees and shrubs is shading the upper intertidal zone. Shading of the last higher 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 splashzone 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, where the splashzone is narrow. Shading may be on sediment-dominated or on rocky intertidal.

Table A-8. Habitat Class Codes

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 together with the geomorphology. That is, a 'typical' example of a Habitat Class would include a combination of biobands, and their associated indicator species (which determine the Biological Exposure category) and the geomorphological features of the Habitat Class.

The biomapper observes and records the biobands in the unit, if any, and determines the Biological Exposure Category. From the presence/absence of the biobands, the Exposure Category, the geomorphology and the spatial distribution of the biota within the unit, the Habitat Class is determined.

Within the database, both a numeric code and an alpha code are used. Both codes are listed in Table A-8, where the matrix includes all combinations of 'Dominant Structuring Process' on the vertical axis, and 'Biological Wave Category' on the horizontal axis.

Biological Exposure Categories

VE – Very Exposed
E – Exposed
SE – Semi-exposed
SP – Semi-protected
P – Protected
VP – Very protected

Dominant Structuring Process Categories

Wave – Immobile, Bedrock or Sediment & Bedrock, or Sediment (can have lush epibenthic biota)
– Partially mobile, Sediment or Rock and Sediment
– Mobile, Sediment (bare beach)
Other – Estuary (wetland vegetation associated with freshwater stream, often with delta form)
– Current-dominated Saltwater Channel
– Glacier Ice
– Man-made – Impermeable Substrate
– Man-made – Permeable Substrate

Table A-9. Habitat Class Definitions (shaded boxes in the Habitat Class matrix are 'Not Applicable' in most regions)

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 Energy	***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.	10 VE_I	20 E_I	30 SE_I	40 SP_I	50 P_I	60 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'.	11 VE_P	21 E_P	31 SE_P	41 SP_P	51 P_P	61 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.	12 VE_M	22 E_M	32 SE_M	42 SP_M	52 P_M	62 VP_M
Fluvial/Estuarine Processes		***Estuary/Wetland***	Units classified as the 'estuary' types always include wetland biobands 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.	13 VE_E	23 E_E	33 SE_E	43 SP_E	53 P_E	63 VP_E
Current energy		***Current-dominated channel***	Species assemblages observed in salt-water channels are structured by current energy rather than by wave energy. Current-dominated sites are limited in distribution and are rare habitats.	14 VE_C	24 E_C	34 SE_C	44 SP_C	54 P_C	64 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.	15 VE_G	25 E_G	35 SE_G	45 SP_G	55 P_G	65 VP_G
Man-modified		***Anthropogenic – Impermeable***	Impermeable man-made Habitats are intended to specifically note units classified as Coastal Class 33.	16 VE_X	26 E_X	36 SE_X	46 SP_X	56 P_X	66 VP_X
		Anthropogenic – Permeable	Permeable man-made Habitats are intended to specifically note shore units classified as Coastal Class 32.	17 VE_Y	27 E_Y	37 SE_Y	47 SP_Y	57 P_Y	67 VP_Y

Table A-10. Data dictionary for across-shore component table (XSHR) (after Howes et al. 1994)

Field Names	Type	Description
UnitRecID	N	unique record number that relates across-shore records to a unit record
XshrRecID	N	unique record number for each across-shore record
PHY_IDENT	T20	unique alphanumeric identifier made up of the REGION, AREA, PHY_UNIT and SUBUNIT numbers (RR/AA/UUUU/SS)
CROSS_LINK	T20	unique alphanumeric identifier of component made up of: REGION, AREA, PHYS_UNIT, SUBUNIT, ZONE and COMPONENT fields
ZONE	T1	a text code indicating the across-shore position of the component: (A) supratidal, (B) intertidal or (C) subtidal zone
COMPONENT	Is	further subdivision of Zones, numbered from highest elevation in across-shore profile within Zone to lowest.
Form1	T20	describes primary physical Form within each across-shore component (see Table A-11 for codes)
MatPrefix1	T1	veneer indicator field; blank = no veneer; "v" = veneer
Mat1	T20	describes substrate associated with primary form (see Table A-12 for codes)
FormMat1Txt	T50	translation of Form and Material codes into a sentence descriptor
Form2	T20	describes secondary physical Form within each across-shore component (see Table A-11 for codes)
MatPrefix2	T1	veneer indicator field; blank = no veneer; "v" = veneer
Mat2	T20	describes substrate associated with secondary form (see Table A-12 for codes)
FormMat2Txt	T50	translation of Form and Material codes into a sentence descriptor
Form3	T20	describes tertiary physical Form within each across-shore component (see Table A-11 for codes)
MatPrefix3	T1	veneer indicator field; blank = no veneer; "v" = veneer
Mat3	T20	describes substrate associated with tertiary form (see Table A-12 for codes)
FormMat3Txt	T50	translation of Form and Material codes into a sentence descriptor
Form4	T20	describes forth most common physical Form within each across-shore component (see Table A-11 for codes)
MatPrefix4	T1	veneer indicator field; blank = no veneer; "v" = veneer
Mat4	T20	describes substrate associated with forth-order form (see Table A-12 for codes)
FormMat4Txt	T50	translation of Form and Material codes into a sentence descriptor
WIDTH	N	the mean across-shore width of the component in meters
SLOPE	N	the estimated across-shore slope of the component in degrees; not coded in Carr Inlet
PROCESS	T4	the dominant coastal process affecting the morphology of the component (F)luvial, (M)asswasting, (W)aves, (C)urrents, (O)ther, (E)olean
COMPONENT_ORI	N	a numeric index between 1 and 5 that indicates the potential oil residency based on Table A-13

Table A-11. 'Form' Code Dictionary (after Howes et al. 1994)

A = Anthropogenic

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

B = Beach

b	berm
c	washover channel
f	face
i	inclined (no berm)
m	multiple bars&troughs
n	relic ridges, raised
p	plain
r	ridge (single intertidal bar)
s	storm ridge
t	low tide terrace
w	washover fan
v	veneer (modifier)

C = Cliff

a	eroding
p	passive
slope	
i	inclined (20to35°)
s	steep (>35°)

Cliff cont.

height	
l	low (<5m)
m	moderate (5-10m)
h	high (>10m)
modifiers	
f	fan, apron
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

f	horizontal
i	irregular
r	ramp
s	smooth

I = Ice

g	glacier

L = Lagoon

o	open
c	closed

M = Marsh

f	drowned forest
h	high
l	mid to low (discontinuous)
c	tidal creek
e	levee
o	pond
s	brackish – supratidal

O = Offshore Island

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

f	horizontal
g	surge channel
h	high tide platform
i	irregular
l	low tide platform
r	ramp
t	terraced
s	smooth
p	tidepool

R = River Channel

a	perennial
t	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
s	multiple tidal channels
t	flats
p	tidepool
w	plunge pool

Table A-12. '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	trees, fallen not cut, dead
o	organic litter
p	peat
t	trees (alive)

C = Clastic

a	blocks (angular,>25cm)
b	boulders (round, subround,>25cm)
c	cobbles
d	diamicton (poorly sorted sediment containing a range of particles in a mud matrix)
f	fines or mud (mix of silt, clay)
g	gravel (mix pebble, cobble, boulder >2mm)
k	clay
p	pebbles
r	rubble (boulders>1m)
s	sand
$	silt
x	angular fragments (mix block & rubble)

v	**sediment veneer**

R = Bedrock

rock type:

I	igneous
m	metamorphic
s	sedimentary
v	volcanic

rock structure:

1	bedding
2	jointing
3	massive

U = Undefined

DESCRIPTION OF SUBSTRATE
Simplified from Wentworth scale

GRAVELS

boulder	> 25cm
cobble	6 to 25 cm
pebble	0.5 to 6 cm
granule	0.2 to 0.5 cm

SAND

from very coarse to very fine:
all between .5mm to 2 mm

FINES (MUD)

from silt to clay:
smaller than .5mm

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, they are ranked in order of volume. A surface layer can be described by prefix 'v' for veneer (e.g. vCs/R).

Table A-13. Data dictionary for the BIOBAND table

	Type	Description
UnitRecID	N	unique record number that relates across-shore records to a unit record
XshrRecID	N	unique record number for each across-shore record
PHY_IDENT	T20	unique alphanumeric identifier made up of the REGION, AREA, PHY_UNIT and SUBUNIT numbers (RR/AA/UUUU/SS)
CROSS_LINK	T20	unique alphanumeric identifier of component made up of: REGION, AREA, PHYS_UNIT, SUBUNIT, ZONE and COMPONENT fields
Note: all Biobands are coded **P**atchy (<50% cover) or **C**ontinuous (>50% cover) except the VER band, coded by width **N**arrow (<1m), **M**edium (1-5m) or **W**ide (>5m). See Table B-1 for details.		
VER	T1	bioband for 'VERrucaria' black lichen in supratidal splash zone
PUC	T1	bioband for PUCcinellia and other salt tolerant grasses and herbs
GRA	T1	bioband code for dune GRAsses of supratidal
SED	T1	bioband for mixed sedge of supratidal
BAR	T1	bioband for continuous *Balanus/Semibalanus* BARnacle in upper intertidal
FUC	T1	bioband for FUCus-/barnacle of upper intertidal
ULV	T1	bioband for mixed filamentous and foliose green algae band, mid intertidal
HAL	T1	bioband for bleached mixed filamentous and foliose red algae
BMU	T1	bioband for blue mussels (*Mytilus trossulus)* of mid-intertidal, protected areas
RED	T1	bioband for mixed filamentous and foliose RED algae of lower intertidal
ALA	T1	bioband for stand of large or small morph of *Alaria spp*.
SBR	T1	bioband for unstalked large-bladed laminarins; in the lower intertidal and nearshore subtidal
CHB	T1	bioband for stalked bladed dark chocolate-brown kelps of lower intertidal/nearshore subtidal
SUR	T1	bioband for green SURfgrass of lower intertidal
ZOS	T1	bioband for *ZOStera* (eelgrass) of sheltered areas, lower intertidal and subtidal
ALF	T1	nearshore dragon kelp bioband
MAC	T1	Nearshore canopy kelp *Macrocystis* bioband
NER	T1	bioband for nearshore subtidal *NEReocystis* bull kelp

Table A-14. Data dictionary for the BIOSLIDE table

Field Names	Type	Description
SlideID	N	A unique numeric ID given to each slide
UnitRecID	N	unique record number that relates across-shore records to a unit record
SlideName	T50	A unique alphanumeric name assigned to each slide or photo
ImageName	T75	Full image acronym and .jpg for photolink
TapeTime	D/T	Exact time during flight when jpg collected. Used to link photo to digital trackline and position.
SlideDescription	T255	a text field used for comments made by the biomapper to describe each slide
Good Example?	Y/N	Marks good example photos of shorezone features
ImageType	T10	Media type of original image “Digital” or “Slide"
FolderName	T50	name of the folder where the images are stored - required for hyperlink to digital image
PhotoLink	Hyper-link	clicking this link will open the photos related to each unit

Table A-15. Data dictionary for the GroundStationNumber table

Field Names	Type	Description
StationID	N	A unique numeric ID given to each ground station
UnitRecID	N	The unique ID from Unit Table to link data tables
Station	T50	Unique alphanumeric name assigned to each ground station
StationDescription	T255	a text field used for comments made by the biomapper to describe each ground station
Location	T50	General location of each ground station

Table A-16. Description of biobands in the British Columbia ShoreZone coastal habitat mapping program (after Morris and Howes 2006).

Zone *	Order **	Bioband Name	Bioband Code	Bioband Colour	Description
A	1	Splashzone 'Verrucaria'	VER	black or bare rock	splash zone lichens, black *Verruaria* and others: marked by black encrusting lichen & blue-green algae.
A	2	Dune Grass	GRA	dusty green	dominated by dune grass (*Leymus mollis*.) Used only in Burrard Inlet and Gwaii Haanas mapping. Other Bioareas include Dune grass in the SAL bioband.
A	5	'Salicornia'	SAL	light/bright green	named for pickleweed, (*Salicornia*), but represents an assemblage of marsh grasses, *Salicornia,* dune grasses, sedges and other salt-tolerant herbaceous plants
B upper	6	Barnacle	BAR	grey-white	continuous band of acorn barnacle and/or thatched barnacle (*B. glandula* &/or *S. cariosus*) in upper intertidal, may also include bare rock.
B upper	7	Rockweed	FUC	golden brown	dominated by rockweed (*Fucus spp*), includes acorn barnacle (*Balanus glandula)*.
B mid	8	Green Algae	ULV	bright green	named for the assemblage of foliose and filamentous green algae (sea lettuce *Ulva/Monostroma spp* and filamentous *Enteromorpha*-type species)
B mid	9	Blue Mussel	BMU	blue-black	dense beds of blue mussel (*Mytilus trossulus*) Strongly associated with areas of freshwater influence (especially in the Fraser River plume in the Strait of Georgia) as well as in mid and north coast fjord shorelines
B mid	10	California Mussel	MUS	grey-blue	dominated by a complex of California mussels (*Mytilus californianus*) and thatched barnacles *(Semibalanus cariosus*) with gooseneck barnacles (*Pollicipes polymerus*) seen at higher exposures.
B mid	11	Oyster	OYS	Beige-white	Japanese oyster (*Crassostrea gigas*). Used in the Strait of Georgia and Campbell River bioareas.
B mid	12	Bare	BRE	brown sand	bare sand/mudflats, used only in the Strait of Georgia bioarea
B lower	13	Diatoms	DIA	'beige'	occurs in mid and north coast fjords, as a low turf or bare-looking substrate on lower intertidal. May appear stringy and mixed with filamentous green algae.

B lower	14	Bleached Red Algae	HAL HAL2 HAL3 HAL4 HAL5 HAL6 HAL7	golden yellow	**Definition specific to Bioarea**. Bleached red algal complex of lower intertidal. Depending on bioarea may include: *Gastroclonium, Gelidium, Odonthalia, Halosaccion, Mazzaella* or other bleached foliose and filamentous red algae.
B lower	15	Red Algae	RED RED2 RED3 RED4 RED5 RED6 RED7	dark red-brown	**Definition specific to Bioarea**. algal-rich band of lower intertidal, complex of filamentous and foliose blade red algae. Depending on bioarea may include: *Microcladia, Odonthalia, Polysiphonia., Mazzaella, Neorhodomela,* or other foliose and filamentous red algae.
B lower	17	Soft Brown Kelps	SBR SBR2 SBR3 SBR4 SBR5 SBR6 SBR7	brown	**Definition specific to Bioarea**. large brown algae, usually a mixture of species. Depending on bioarea, includes combinations of: *Laminaria saccharina, L. bongardiana, Agarum, Alaria, Sargassum* and other large brown algae. May include a bullate, cabbage-type morph of *Hedophyllum.*
B lower	18	Dark Brown Kelps	CHB CHB2 CHB3 CHB4 CHB5 CHB6 CHB7	dark brown	**Definition specific to Bioarea**. Large brown stalked algae, usually a mixture of species. Kelps are dark brown and shiny, showing the high-energy morph of species that may also occur in SBR exposures. Depending on bioarea, may include combinations of: *Laminaria setchellii, L. bongardiana, Hedophyllum, Lessoniopsis, Egregia, Alaria* and other large brown algae.
B lower	19	Surfgrass	SUR	emerald green	surfgrass (*Phyllospadix spp.),* attaches to coarse sediment or bedrock substrates
C upper	20	Eelgrass	ZOS	dark green	eelgrass (*Zostera marina*), occurs on fine sediment, may extend slightly upslope into lower intertidal.
C upper	21	Urchin Barrens	URC	underwater, coralline white	shows rocky substrate clear of macroalgae. Often has pink-white colour of encrusting coralline red algae. May or may not see urchins (*Strongylocentrotus spp.*).
C upper	23	Giant Kelp	MAC	brown	giant kelp (*Macrocystis integrifolia*) leafy, soft kelp beds, usually indicator of fully-marine waters.
C upper	24	Bull Kelp	NER	dark brown, shiny	bull kelp beds (*Nereocystis luetkeana*), floating blades and fronds in nearshore

* Zone: Across-shore elevation as: A – supratidal, splashzone, B – intertidal, C – nearshore subtidal.
** Order skips a numbers to accommodate other biobands that occur in Alaska ShoreZone mapping.

Table A-17. Definitions of bioareas in the British Columbia ShoreZone coastal habitat mapping program (after Morris and Howes 2006). Bioareas are distinguished on the basis of regional biotic differences observed in four lower intertidal biobands: Bleached Red Algae (HAL), Red Algae (RED), Soft Brown Kelps (SBR) and Dark Brown Kelps (CHB) biobands.

BioArea	Bioband Code Suffix	Description of Area	Across-Shore Mapping?	Notable Aspects of Biota/Habitats in this Bioarea
West Coast Vancouver Island (WCVI)	1	Includes the whole west coast of Vancouver Island, from Juan de Fuca Strait to Cape Scott. This area was mapped during several separate projects, from the late 1980s to late 1990s and data is compilation of these projects from different original data sources. Includes WCVI North (Cape Sutil to Esperanza - 1998), WCVI Hesquiat to Nootka and Esperanza (1995), WCVI Barclay Sound to Claoquot Sound (1993), and the Pacific Rim National Park (1990), and SCVI Strait of Juan de Fuca to Barclay Sound.	yes, mapped across-shore components	- *Postelsia* as indicator, other large browns in CHB include *Eisenia*. Unique to CHB for this bioarea - Open fully-marine west coast environment, E to VP exposures
Strait of Georgia (SOG)	2	Within the Strait of Georgia, from Sooke and Victoria north to include Campbell River. Includes re-map of Burrard Inlet in 1999 (BI area - Point Atkinson to Point Gray), and the earlier northern Strait of Georgia (NSOG) and southern Strait of Georgia (SSOG).	yes, but biomapping not included in original survey	- no higher wave exposures - not fully-marine, missing marine indicators (*Macrocystis, Egregia,* surfgrass, and many others). - Fraser R influence strong - warm summer temperatures, includes OYS band -HAL2 unique small reds, includes *Gelidium* as indicator

Campbell River (CR)	3	Campbell River to Sayward, southernmost part of MidCoast project	no, unit level only	- no highest wave exposure. - not fully-marine, missing marine indicators (*Macrocystis, Egregia,* surfgrass and many others). - warm summer temperatures, includes OYS band - many current-affected areas
Johnstone Strait (JS)	4	Johnstone Strait and Queen Charlotte Strait, Sayward to Port Hardy, middle portion of the MidCoast project	no, unit level only	- no highest wave exposures - many current-affected areas
Central Coast (CC)	5	Central Coast from Port Hardy, Cape Caution to Bella Bella and Princess Royal Island, northern (and largest) portion of the MidCoast project	no, unit level only	- diverse area, with exposures from E to VP however highest exposure somewhat moderated by Queen Charlote/Hecate Strait nearshore topography - out-of-range of southern indicator species *Postelsia, Eisenia*
Haida Gwaii (GH and QCIN)	6	Northern QCI, Graham Island and northern Moresby Island, all north of Gwaii Haanas as QCIN (1997) and southern islands, in the Gwaii Haanas shoreline (1991-92) as GH area.	yes, mapped across-shore components for Gwaii Haanas, but unit level only for all north of GH	- has areas of VE on southwest Moresby Island, extreme wave exposure unique in BC - long areas of higher energy bare sand beaches on northeast Graham Island - complex and diversity of coastal habitats thru archipelagos - only bioarea with all wave exposures represented, from VE to VP
North Coast (NC)	7	North coast: Princess Royal Island to Stewart and Alaska border, including Prince Rupert, all offshore islands (Banks Is., Pitt Is., Dundas Group etc.)	yes, mapped across-shore components	- northern ranges of species - limited high wave exposures (E) - complex and diversity of coastal areas in archipelagos