Alaska SHOREZONE

Coastal Habitat Mapping Protocol

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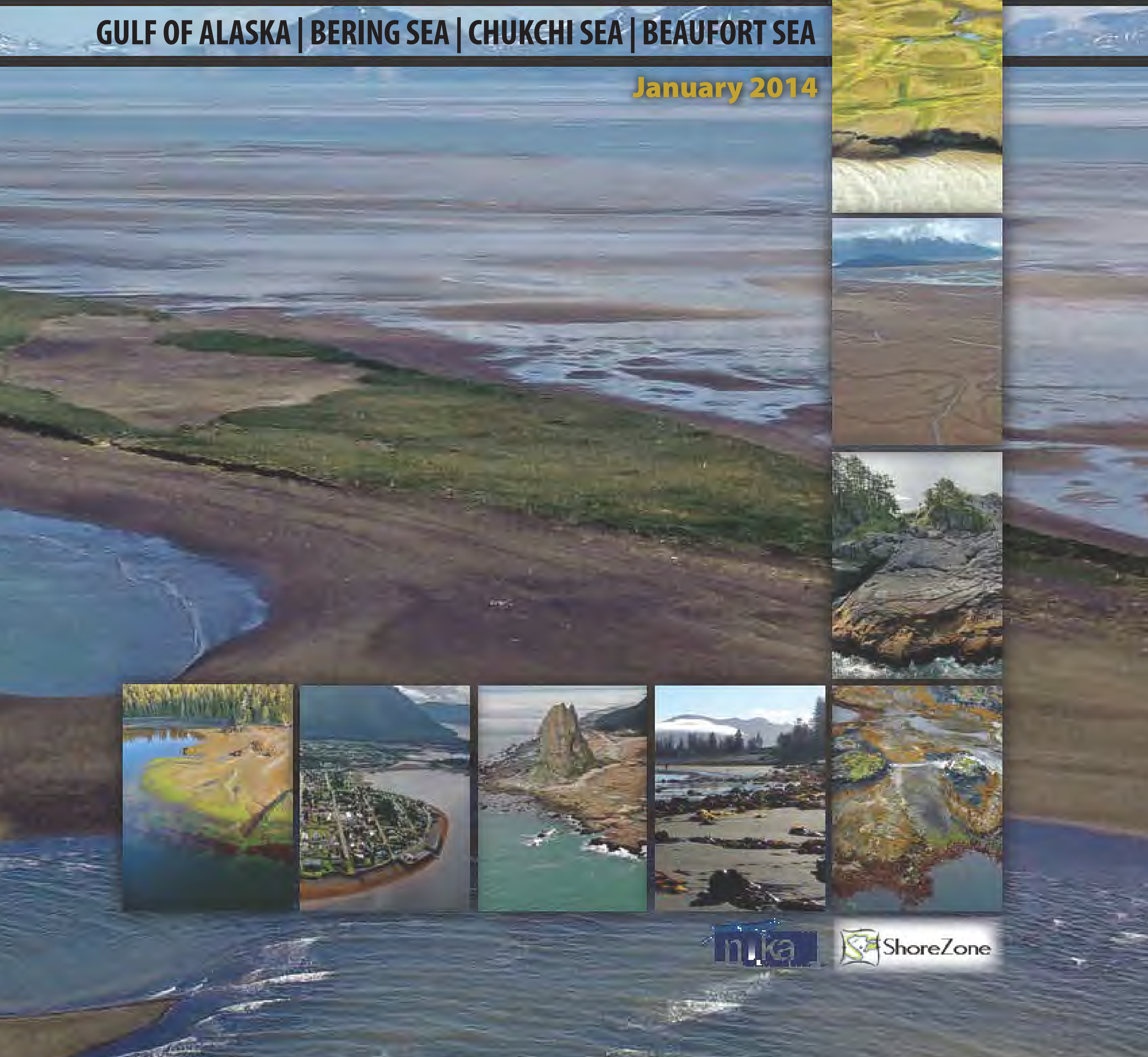
January 2014



nuka

ShoreZone

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Coastal Habitat Mapping Protocol

January 2014

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SUMMARY

ShoreZone is a coastal habitat mapping system, originally developed in British Columbia (Howes 2001), and now applied to the entire coasts of Oregon, Washington and British Columbia, and two-thirds of the Alaska coast. The mapping system catalogs coastal geomorphology and biology into searchable databases. All of the Alaska data are web accessible and the dataset has been used for coastal planning, identification of vulnerable resources, strategic oil spill response, habitat capability modeling, recreational planning, and scientific research.

ShoreZone mapping protocols were previously released in 2004 and 2008, to include procedures for the Gulf of Alaska shoreline from Southeast Alaska to the Aniakchak coast. This update adds ShoreZone attribute definitions for Alaskan Arctic coasts, where permafrost is one of the dominant factors influencing the biology, landscape morphology, and coastal processes.

The primary purpose of this manual is to:

> *specify standards of mapping and classification to ensure a consistent dataset that covers a wide geographic extent (~75,000 km of shoreline) and that has been collected over several decades (2001 to present).*

This manual is for ***mappers***, who may be interpreting imagery and classifying it into the ShoreZone dataset and for ***users***, who wish to apply the data to a variety of resource management issues. The manual provides users with insight into the classification rules and assumptions so that they can apply the data appropriately.

The ShoreZone system primarily utilizes spatially referenced, oblique aerial video and digital still imagery of the coastal zone collected during the summer or spring daylight low tides. Image interpretation and mapping is accomplished by a team of physical and biological scientists. The mapping system (housed in an ArcGIS geodatabase) catalogs both geomorphic and biological coastal resources at effective mapping scales of better than 1:10,000 and provides a spatial framework for coastal habitat assessment on local and regional scales.

Specific ShoreZone data products include:

- technical flightline reports
- imagery (videotapes, DVDs, still photos on external drives)
- linked geomorphic and biological attribute data (GIS data products)
- ground station data collected in support of the aerial mapping program
- data summary reports
- research applications

Data and reports are accessible through the www.ShoreZone.org website.

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OVERVIEW OF THE SHOREZONE MAPPING SYSTEM 1.0

1.1 Background

Alaska has the longest coastline of any US state and comprises approximately half the coastline length of the United States. The extent and complexity of this coast results in a wide range of coastal habitats that present special management and mapping challenges.

ShoreZone is a coastal habitat mapping tool that documents both physical habitat as well as the associated biota along the coast. Data created by Alaskan ShoreZone surveys and mapping are easily accessible (imagery and key mapped attributes are posted online) and are searchable by specific features that can assist resource managers. The ShoreZone coastal mapping data and imagery are used for coastal planning, oil spill response, habitat management, development evaluation, and other uses.

The ShoreZone system was developed and applied in the 1980s and 1990s to map coastal features in British Columbia and Washington (Howes 2001; Berry *et al*. 2004). ShoreZone mapping was initiated in Alaska in 2001 and now extends from the Alaska-British Columbia border to the Beaufort Sea (Fig. 1). ShoreZone was extended to Oregon in 2011 and is now a nearly contiguous mapping dataset of >100,000 km (Fig. 2). This version of the ShoreZone protocol builds on previous protocols by Harper and Morris (2004) and Harney *et al*. (2008). This protocol revision was necessary to integrate periglacial coastal landforms that occur along the North Slope of Alaska, however; the protocol remains applicable to all data that had already been compiled in Alaska ShoreZone program.

Although the early ShoreZone datasets in British Columbia and Washington have some attributes that are specific to those geographic areas and are not observed in Alaska, the overall methodology of collecting low-tide imagery, completing the shoreline classification with the descriptive biophysical attributes housed in a spatial database follows the same standard protocols. This consistency is at the heart of the ShoreZone program and enables spatial data queries over large geographic regions.

Figure 1. Extent of ShoreZone imagery in Alaska.

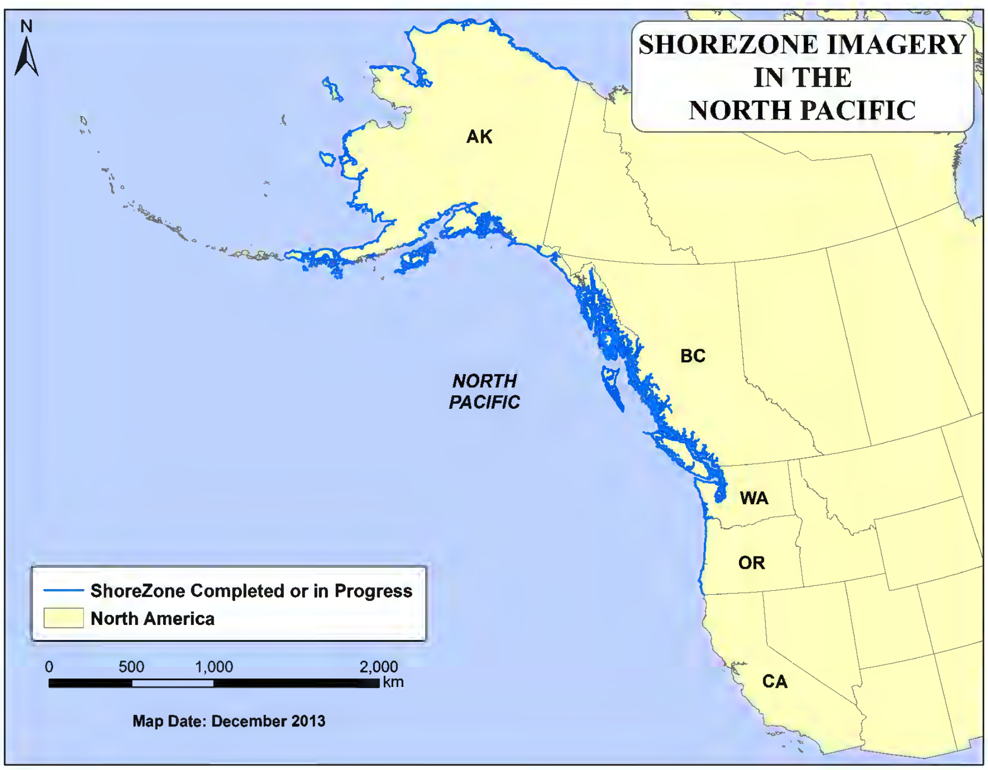


Figure 2. Extent of ShoreZone imagery in Alaska, British Columbia, Washington and Oregon.

1.2 Overview of Alaska Coastline – the Big Picture

The Alaska coast stretches from the Arctic to temperate North America, touching on two oceans and encompassing tidewater glaciers and active volcanoes. The tectonically active coastal margins undergo both uplift and subsidence and are subject to tsunamis. The tides of Cook Inlet are the highest in western North America at over 9 m. The Aleutian low pressure zone is noted to be one of the stormiest locations on the planet and generates huge seas that frequently impinge on adjacent coastlines. The Yukon River is the third largest in North America and its delta extends for hundreds of kilometers along the Bering Sea coast. Much of the Arctic coasts of Alaska are changing quickly as permafrost thaws.

Coastal habitats and associated biota are strongly controlled by the composition and character of coastal substrate and Figure 3 shows a generalization of Alaska's dominant types of substrate. The bedrock coasts typically have high coastal relief, are resistant to erosion and have diverse biological communities (e.g., kelp beds) attached to the stable rock. In Alaska, these rocky shores are most commonly associated with the Gulf of Alaska and the Aleutian Islands.

Much of the remainder of Alaska's shoreline is dominated by "soft" sediments (Fig. 3), which are typically dynamic as a result of transport by waves, currents and tides. These sediment-dominated shorelines may change significantly in a single storm and are usually more sensitive to erosion than rocky coasts. Mobile beaches often have no attached intertidal flora and fauna and the beaches are largely bare. The dominant biota are likely to be infauna (e.g., clams and other invertebrates).

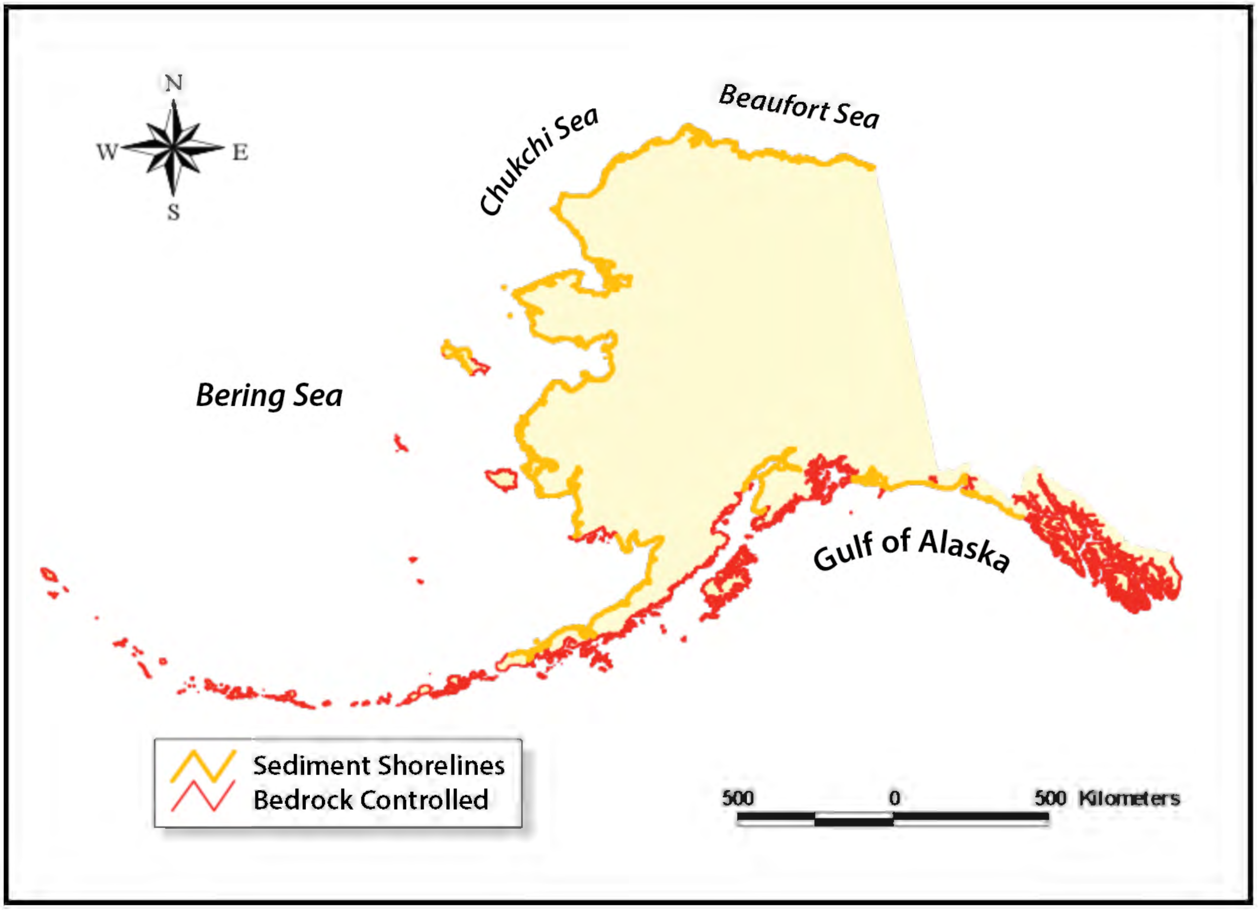


Figure 3. Distribution of major substrate types on the Alaska coast.

An additional geomorphic influence in Alaska is the presence of periglacial landforms/ processes, including tapped/untapped thermokarst lakes; patterned ground; ice-wedge polygons; thaw slumps; niche formation; and permafrost degradation on the coast (Fig. 4). The presence of permanently frozen ground ice (i.e., *permafrost*) strongly influences coastal landform morphology, shoreline stability, and shoreline ecology. The permafrost zones are also consistent with the locations of landfast sea ice formation, which limits wave exposure for up to nine months of the year.

Many permafrost areas have very high erosion rates, as a result of mechanisms such as ground ice slumps and thaw subsidence. The effects of predicted climate change, such as warming, longer ice-free seasons, larger areas of open-water; greater storm intensity and sea-level rise are likely to make these shorelines more vulnerable to erosion and inundation. This protocol revision incorporates relevant observations of periglacial landforms and processes so that these features can be inventoried and can be addressed within future coastal planning initiatives.

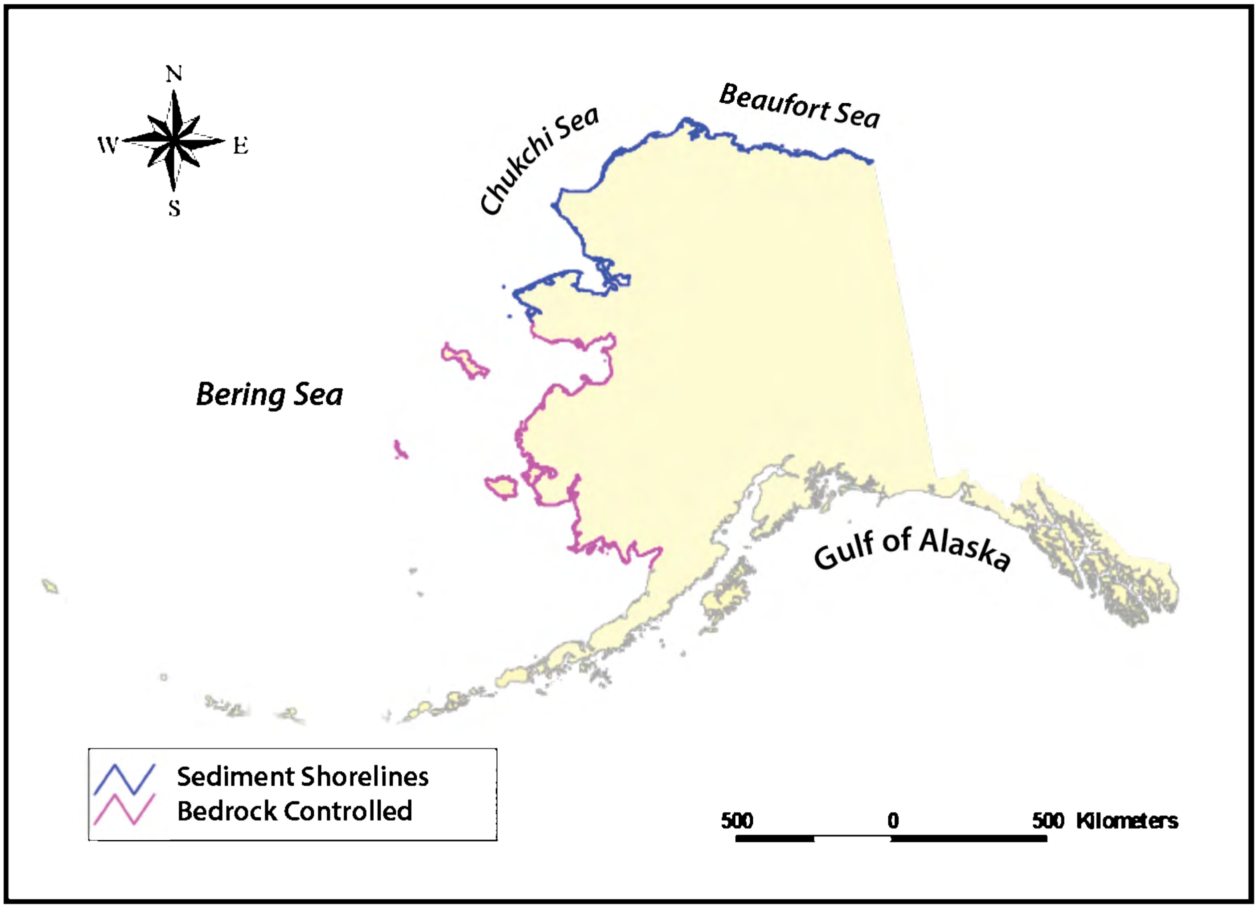


Figure 4. Distribution of permafrost along the Alaska coast.

1.3 ShoreZone in Alaska

Survey Description

Oblique low-altitude aerial video and digital still imagery of the coastal zone are collected for ShoreZone during the low tide windows (daylight tides lower than mean low water) from helicopter or fixed wing aircraft. Survey altitudes are typically 100 to 300 m (300 to 1000 ft). During image collection, the aircraft's GPS position is recorded at one-second intervals using electronic navigation software and is continuously monitored in-flight to ensure all shorelines have been imaged (Fig. 5). Video and still imagery are spatially-referenced and time-synchronized using a six-digit UTC time code (Fig. 6 and 7). The video imagery is accompanied by continuous, simultaneous commentary by a geologist and a biologist aboard the aircraft. (Further description of survey methods are provided in Section 2.0).

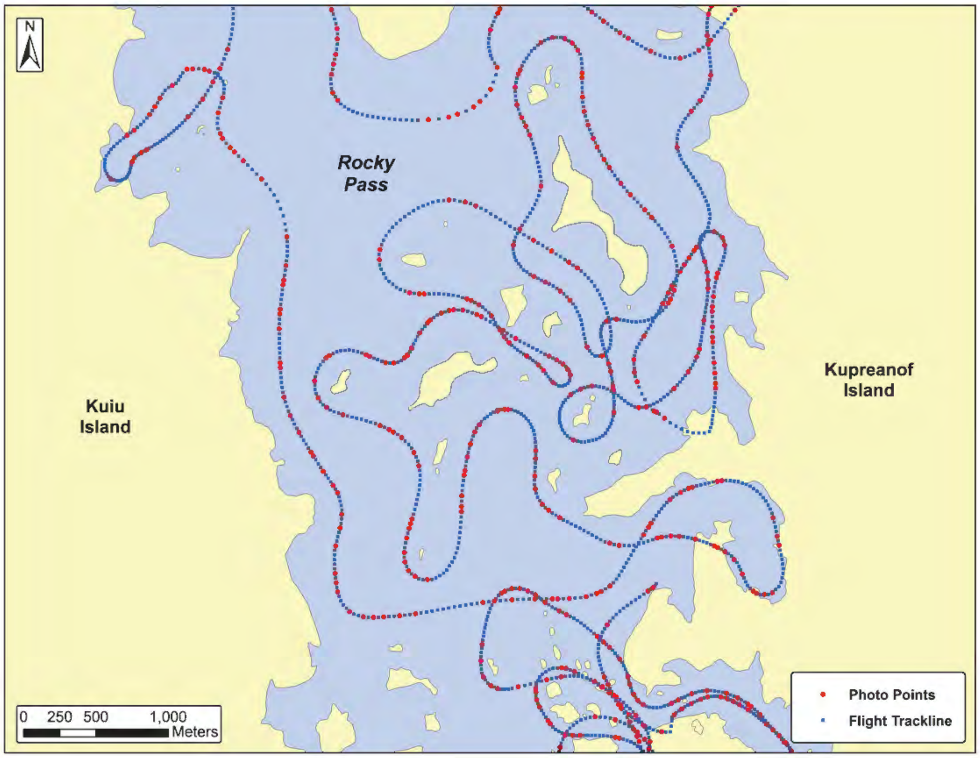


Figure 5. Example of recorded flight trackline, showing one-second GPS navigation fixes (in blue) and photo locations (in red) (Rocky Pass, Southeast Alaska, 2009).

In some geographic regions, (i.e., the North Slope shoreline), previously collected video and photographic imagery is used for ShoreZone mapping. This imagery is collected to standards comparable with those of ShoreZone in terms of georeferencing and image resolution.

The Mapping System

The ShoreZone mapping system is based on shoreline segments. Descriptive attributes are entered into a database for each shore segment to describe both the alongshore segment (the Unit) and the across-shore morphology within each Unit (Across-shore Components). Line segments representing the alongshore units are the principal spatial features, each with a unique identifier that links the data to the digital shoreline in GIS (see Section 3.0).

Point features (called variants) are also mapped, to represent small features such as stream mouths or anthropogenic features such as docks or boat ramps. Variants are always associated with a linear unit as a 'subunit'.

The coastal zone mapped within each line segment extends across three Zones in the across-shore components, from the uppermost marine limit at the top of the 'splash zone' at the edge of terrestrial vegetation, (the supratidal zone), the intertidal zone, and the nearshore subtidal zone.

An example of how an image of coastline is segmented into alongshore units is illustrated in Figure 8: units are delineated primarily by changes in substrate and across-shore width. Using the position of the aircraft from the digital trackline together with the oblique aerial imagery, the mappers mark shoreline segments on a digital shoreline map. Observations of physical, geomorphic, sedimentary, and biological features for each alongshore Unit are then systematically recorded in the Unit database. Mapped habitat features include general substrate type and morphology, general habitat type, and class of wave exposure.

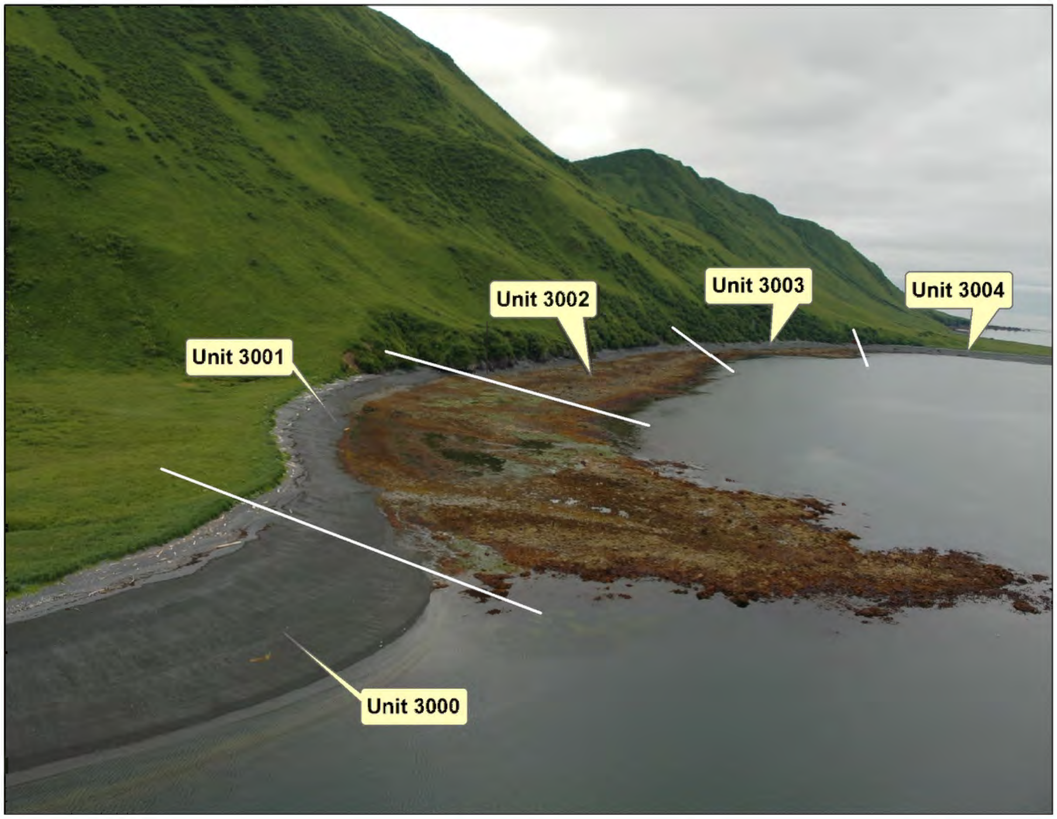
Describing the Across-shore Geomorphology, Substrate and Biota

ShoreZone database includes attributes for observations of morphology, substrate, and biotic variation in the across-shore direction, as if an observer is walking from the 'marine limit' on the land, across the shore towards the lower low water line (Fig. 9).

The across-shore within each unit is divided into three Z*ones* (A - supratidal, B - intertidal and C - subtidal). Each Zone is further broken down into at least one or more *Components*, numbered sequentially from upper to lower across-shore (e.g., A1, A2, B1, B2…) Biological observations (the *Biobands*) are also assigned to across-shore Component in the database (Fig. 9).

Figure 6. Example of frame capture from video imagery in Rocky Pass, Southeast Alaska (see Fig.5). Latitude, longitude, and six-digit UTC time stamp are burned onto each frame of video imagery.

Figure 7. Example of digital still imagery, showing biobands in Rocky Pass, Southeast Alaska. Digital photographs are linked to the recorded digital track lines by six-digit UTC time code.



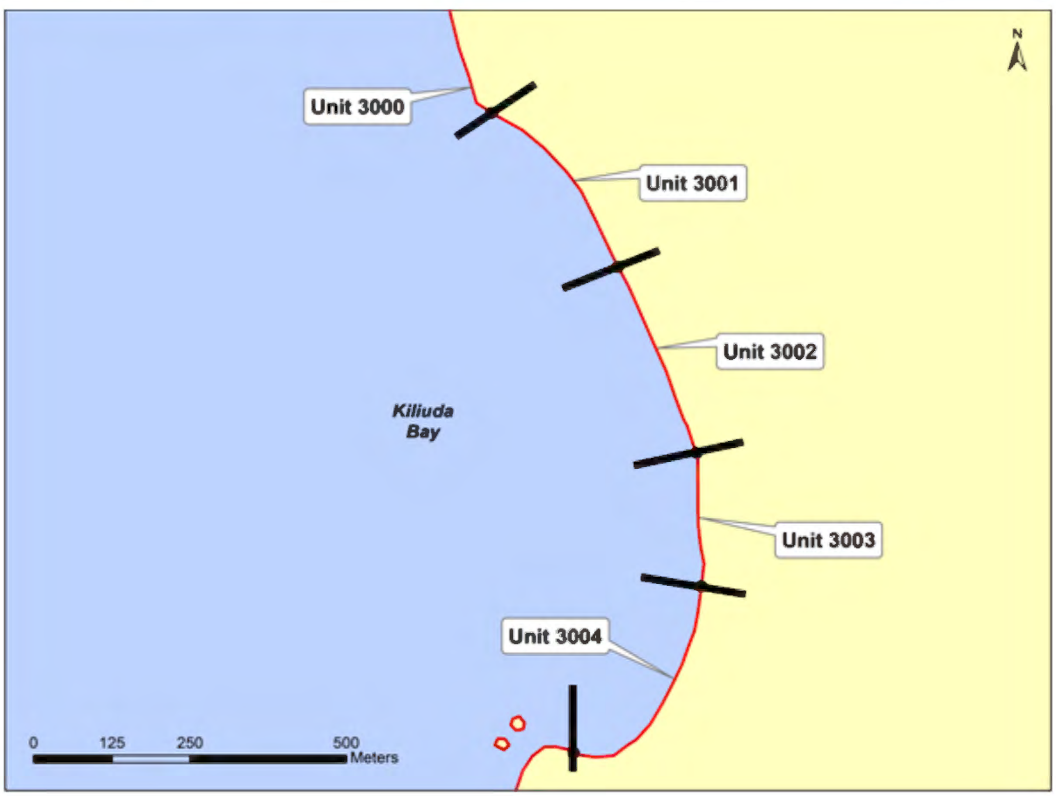


Figure 8. Example of how an oblique aerial photo (top) is used to segment the shoreline into alongshore units (bottom) (Kiliuda Bay, southwest Kodiak Island).

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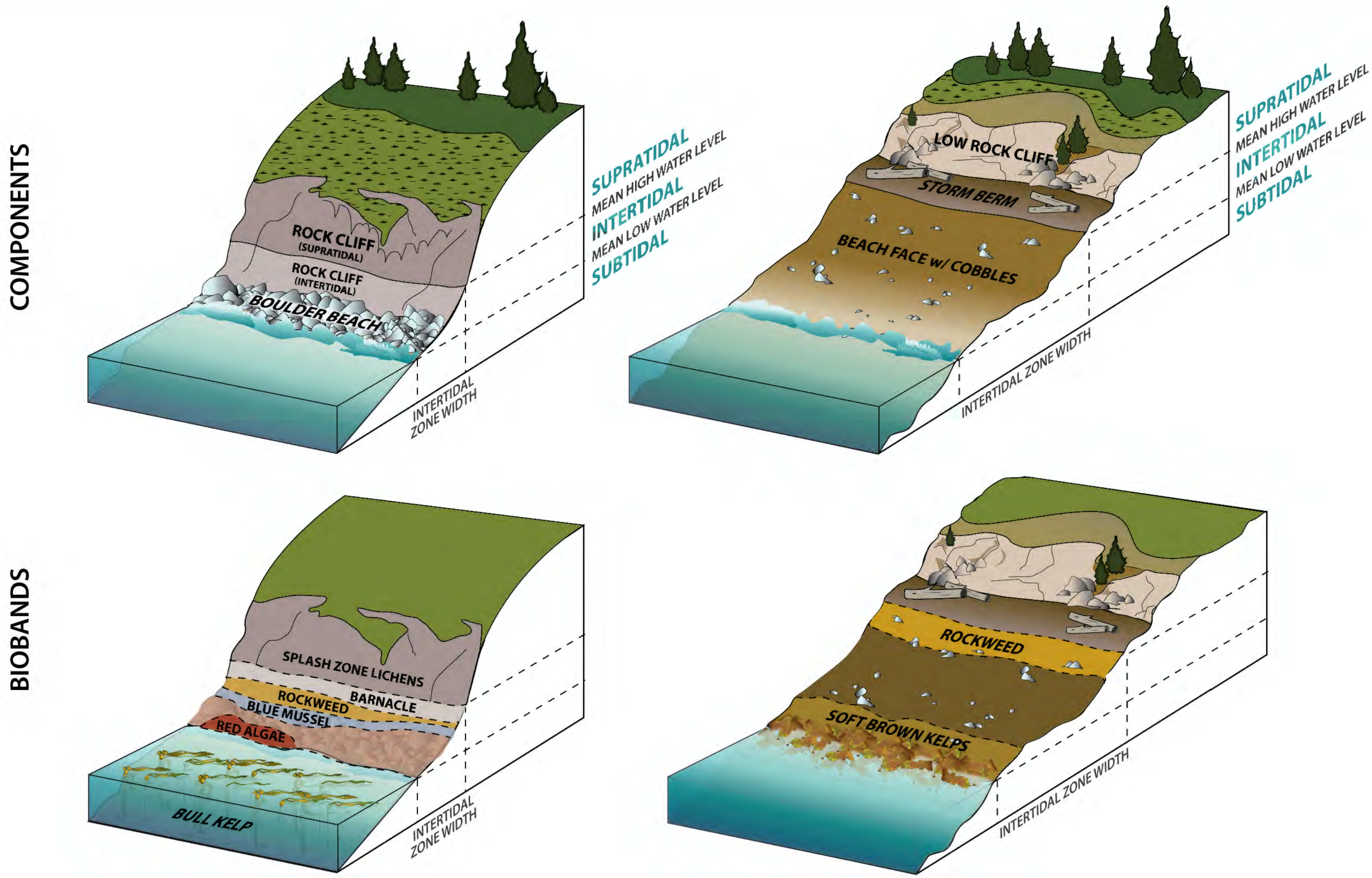


Figure 9a. Illustrated examples of a typical Gulf of Alaska rocky shore (left) and of a sediment shore (right) with the associated geomorphology/substrate features (top) and biotic features (bottom) as they are cataloged within the ShoreZone "across-shore" database.

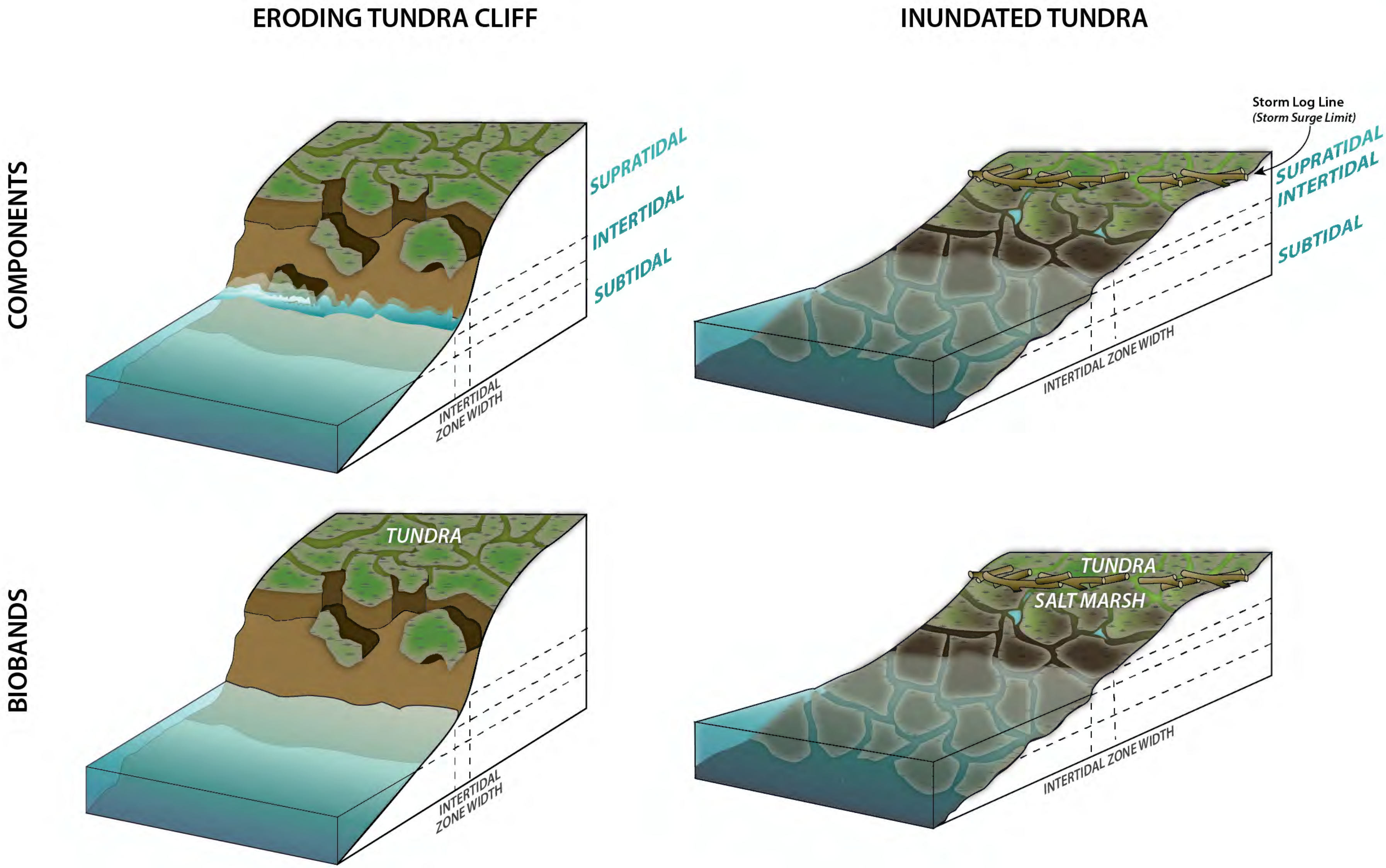


Figure 9b. Two examples of permafrost shoreline eroding tundra cliff (left) and inundated tundra (right) typical of those on Arctic coasts in Alaska. Note that the intertidal zone widths are often narrow, while storm surge extent may be very wide.

Generalization of Map Data

The systematically recorded data allows information to be summarized for thousands of kilometers of shoreline. For example, a single observation of eelgrass in a photo (Fig. 10a) contributes to the mapping of eelgrass within a bay (Fig. 10b) as well as to the total picture of eelgrass within Southeast Alaska (Fig. 11). This example shows how a single feature is mapped, unit by unit, and how that data can be scaled up to show occurrence of the attribute over thousands of kilometers of shoreline.

Figure 10a. An oblique aerial photo of an eelgrass bed on Prince of Wales Island. This continuous eelgrass bed was coded into the database for unit 11/05/5079/0.

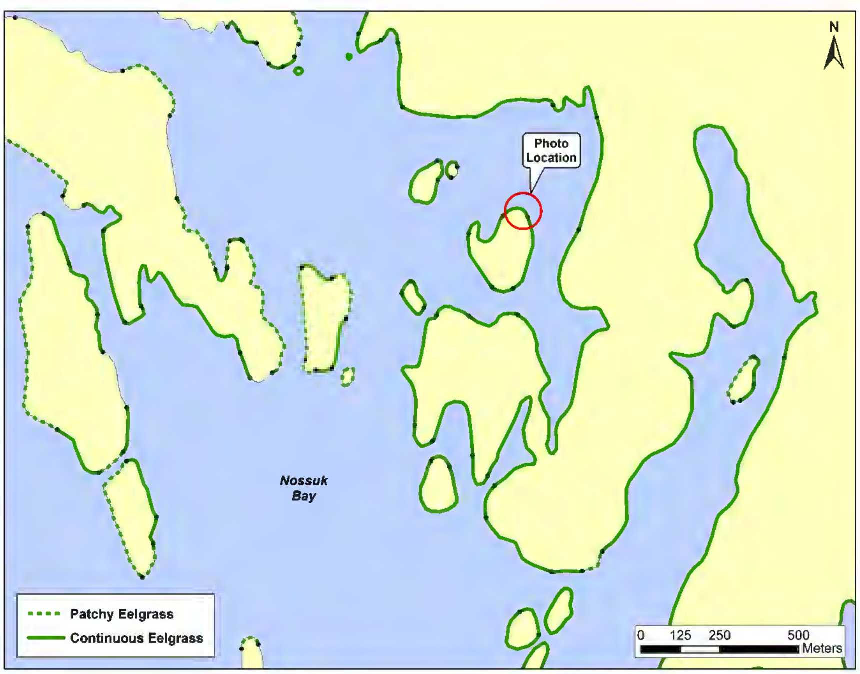


Figure 10b. Map of shoreline showing the location of the photograph, the unit to which the eelgrass bed was assigned and the distribution of eelgrass in adjacent units.

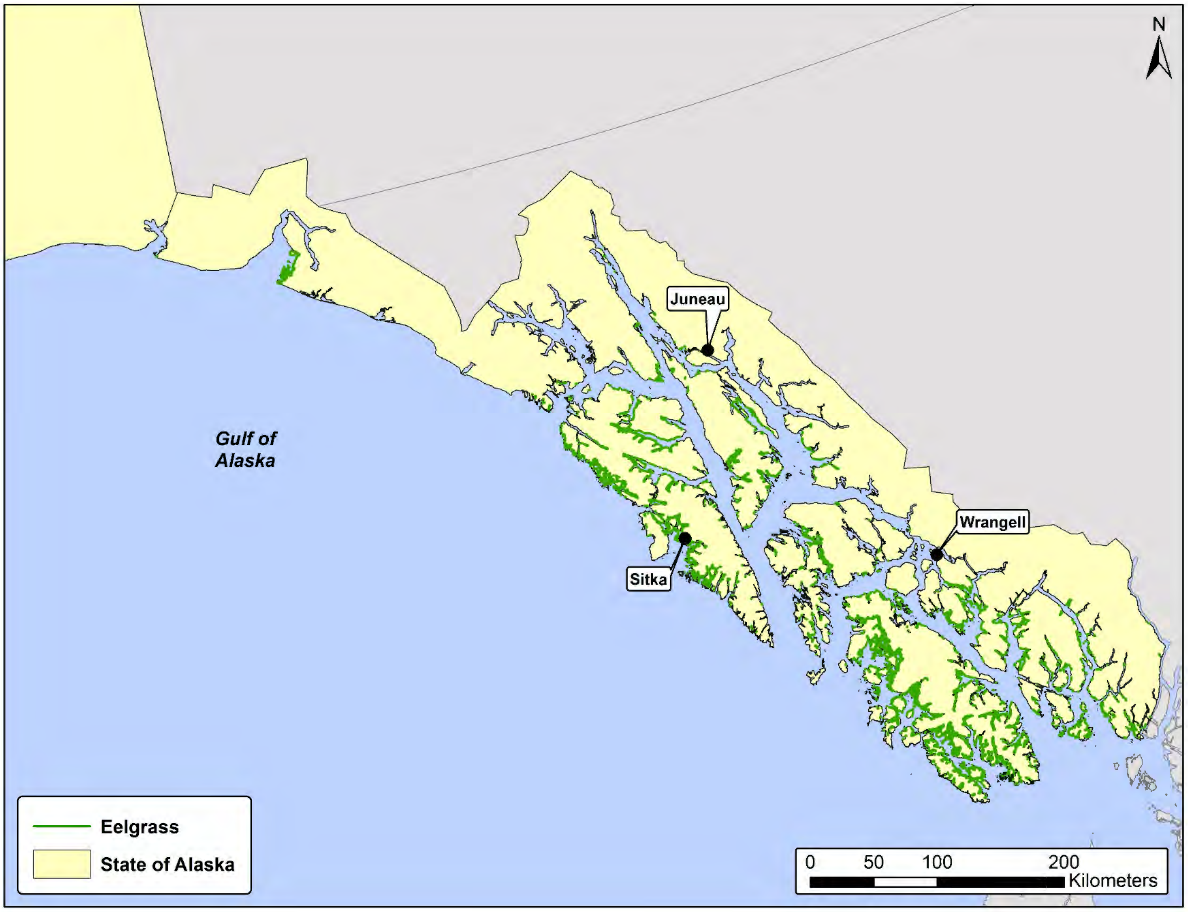


Figure 11. A regional distribution map of eelgrass in southeast Alaska, showing units where eelgrass was mapped as either 'patchy' or 'continuous'.

Eelgrass was mapped as either 'patchy' or 'continuous' along approximately 5,600 km of the 29,000 km of shoreline in southeast Alaska (approximately 20%) (Fig. 11). This estimate is based on observations from more than 88,000 coastal units.

SHOREZONE AERIAL VIDEO IMAGING (AVI) 2.0

2.1 AVI Survey Overview

Planning for an aerial survey program must begin well in advance (typically months) of the actual fieldwork to secure the appropriate survey personnel, videographic equipment, aircraft, and ground support.

The principal scheduling criteria for the aerial survey program is the selection of low-tide windows during which tidal elevations will be lower than mean low water for all the imagery acquisition. There are typically three to four suitable tidal windows per summer season, each five to six days in duration. Low tides that are suitable for image collection range between 2.5 to 4 hours per day in duration on the open coast (estuaries, inlets, and lagoons may have delayed tides). In some regions where astronomical tidal ranges are very low (e.g., Beaufort Sea) and wind-driven or atmospheric surges are the primary control on local water elevations, survey windows are less sensitive to tides.

For complex shorelines, using a maneuverable helicopter as the imaging aircraft is preferred, as this permits the crew to survey all coastal sections in a single flight pass. Helicopters are typically limited to 2.5 hours of flight time, so organizing for fuel stops is critical to optimizing imagery acquisition during the low-tide window. The minimum amount of time required for refueling is 20-30 minutes, or ~10% of the potential imaging window.

Imaging is conducted from the left side of the helicopter, thus the survey route is usually planned to achieve a contiguous, sequential imaging of the shoreline. However, weather conditions may require alteration of the plan so primary, secondary, and tertiary survey objectives are important aspects of each daily plan.

Detailed daily flight plans are constructed by the survey navigator (Table 1). Typical personnel functions are summarized in Table 2. Pre- and post-flight responsibilities tend to be shared among personnel, but in-flight activities are generally assigned to a particular crew member. Table 3 provides guidelines for the videographer/geologist and Table 4 provides guidelines for the photographer/biologist.

Imagery collected is identified by an abbreviation code for each survey region, as well as by team and year, and all imagery is labeled with the unique survey identifier code. For example, the 2011 Alaska Peninsula (SW) survey in May was conducted by team ‘Sand Point’ (SP) and videotapes were numbered sequentially. Thus, a video from this survey is labeled: SW11_SP_01, where “SW11” was the survey region and year, “SP” was the Sand Point team for the May survey and “01” was tape number 1. These unique videotape identifiers are part of the GIS dataset, and can be used to determine each tape’s survey date/time and geographic location.

Table 1. Example of Flight Planning Table that was used in Prince William Sound, Team 'Cordova', May, 2007.

Team Cordova (DV)								*Homer-Cordova 300 km @ 160km/h = 2 hr = 60 gal
				Flight	Shoreline	Total	Transit	
Day	Date	Gal*	Time	Time (hr)	(km)	(km)	(km)	Location
1	15-May-07	60	*05:05*				20	sunrise 5:09; lift off, transit to outside Boswell Bay, NE tip Hinchinbrook
			05:13		100			**tide opens**; survey N HINCHINBROOK to Shelter Bay (no refuel)
			06:15		100			SW Hinch, Port Etches, Cape Hinch
			07:15		70			Hook Pt to Boswell Bay (finish Hinchinbrook)
	tide=		08:00		10			Mummy Island
	03:23		08:10		#			begin South Hawkins if time/fuel permit
			08:20				10	set down Cordova; refuel after tide
		100	**08:36**	*03:15*		280		**tide closes**
2	16-May-07		*04:50*				120	lift off; transit to Squaw Bay, head of Eaglek (arr 5:40)
			05:46		150			**tide opens**; Eaglek Bay and islands
			07:10		75			Schoppe Bay, Kniklik, Olsen Island
		90	*07:45*	*02:55*			5	setdown and refuel Cannery Creek
			08:15		75		5	liftoff; lower Unakwik to Mueller Bay
	tide=		09:00		100			Mueller Cove, Siwash Bay, Jonah Bay
	03:50		**09:36**					**tide closes** (later in upper Unakwik)
			10:00				130	return to Cordova
		90	*10:50*	*03:05*		400		set down and refuel, Cordova
3	17-May-07		*05:30*				130	lift off; transit to Unakwik (arr 6:20)
			06:28		130			**tide opens**; Jonah to upper Unakwik, Wells Bay
			07:50		80			Cedar Bay, Granite Bay
		100	*08:40*	*03:10*			20	setdown and refuel Cannery Creek
			09:10		40		20	liftoff; Fairmount, Eickelberry Bay
	tide=		09:35		100			Glacier Island
	03:59		**10:27**					**tide closes**
			10:35				100	return to Cordova
		60	*11:15*	*02:05*		350		set down and refuel, Cordova
4	18-May-07		*06:30*				100	lift off; transit to Long Bay (arr 7:10)
			07:16		70			**tide opens**; Long Bay
			07:50		110			Columbia Bay (not all of Heather Isl or Bay); end at 9
		90	*09:15*	*02:45*			35	transit and refuel Tatitlek (set down at time shown)
			09:45				35	liftoff after fuel; return to Heather Is (Columbia Bay)
	tide=		10:00		100			finish Columbia; Valdez Arm up to near Sawmill Bay
	03:55		11:00		50			Port Valdez (won't finish)
			11:11				130	**tide closes**; push tide til 11:30; return to Cordova
		60	*12:10*	*02:10*		330		set down and refuel, Cordova
5	19-May-07		*06:50*				130	lift off; transit to Port Valdez (arr 7:40 to do Valdez early)
			08:11		100			**tide opens**; finish Port Valdez, Jack Bay (by 8:40)
			08:40		130		5	Galena Bay, Tatitlek, Boulder Bay (~30 km past Tatitlek fuel)
		90	*10:00*	*03:10*				setdown and refuel Tatitlek
	tide=		*10:30*		75			liftoff after refuel; Bligh, Busby (Tatlk Narrows tide ends @ 11:20)
	03:38		11:15		75			Copper Mtn Pen, Landlocked Bay, Fish Bay, Port Fidalgo to pass
			11:49				80	**tide closes**; push tide in Fidalgo tli 12:00 (ok to fly Fid-Grav pass)
		60	*12:30*	*02:00*		380		set down and refuel, Cordova
6	20-May-07		*08:35*				80	lift off; transit to head of Port Fildalgo (arrive 9:05)
			09:16		100			**tide opens**; finish Port Fidalgo to Knowles Head
			10:05		100			Port Gravina
			11:05		100			Beartrap Bay to Gravina Pt., Sheep Bay; begin Simpson if fuel permits
	tide=	*105*	*12:05*	*03:30*			30	set down and refuel, Cordova (after tide)
	03:05		**12:21**			300		**tide closes**
				28:05:00	heli time	**2,040**	**km**	
				04:40	avg daily he	**340**	**km/day**	

Notes

- only leave gaps near Cordova; not far field sites!
- 100 km/h survey rate, 150 km/h transit rate
- transits can be faster if clear
- blue refuels are drums Jet-A in the field; others are at base
- push tides (5 min on each side of the window), esp in fjords
- note flight time in italics (between fuels and total each day)
- Tatitlek tides are up to 30 minutes earlier (consult tides sheet; plan as written considers this)

Fuel Placement

- lift off and set down shown in italics; flight time is difference between the two
- gallons of fuel based on flight time in italics

Table 2. Responsibilities of ShoreZone Aerial Video Imaging (AVI) Survey Personnel.

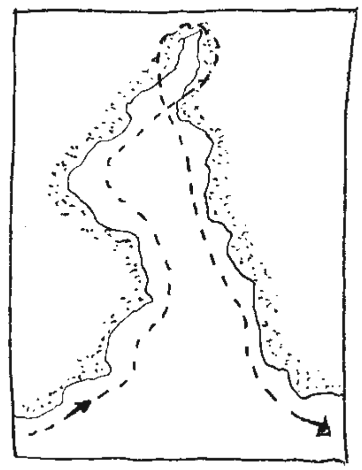
PERSONNEL	PRE FLIGHT ACTIVITIES	IN FLIGHT ACTIVITIES
Videographer Geologist	• responsible for setting up camera • test entire system prior to lift off • synchronize video camera clock to GPS clock • synchronize tape deck clock to GPS clock • label and pack videotapes (with 1-min headers)	• video-imaging and continuous geological description • check image framing color • manually adjust exposure if necessary • advise pilot about flying corrections • check camera switches at regular intervals • check audio meters for sound level • check display counter on recorder
Photographer Biologist	• set-up digital cameras • test designated audio-sound track	• provide continuous biological commentary • shoot digital still photos • organize and store digital media • assist in navigation using paper charts • assist pilot in identification of sensitive biota
Navigator	• assist in design of flight track • prepare flight line maps • document tide window • synchronize computer clock to GPS clock • organize backup navigation and paper charts	• check monitor for framing and exposure • monitor electronic mapping and logging system • coordinate tape changes • direct pilot in general strategy (use clock face for directional instructions) • provide geographic reference points to the geologist for recording on audio track • provide feedback on quality of commentary to biologist and geologist

Table 3. Guidelines for Videographer (Geologist).

1. Speed and Altitude: Typical flight speed is 60 knots and altitude is ~300 feet (100 km/h survey rate, 150 km/h transit rate). Be sure to monitor the speed and maintain communication with the pilot as they may unintentionally speed up or slow down over the course of the flight. On intricate shorelines, speed will have to be lower and on long straight sections it can be a bit faster. Altitude should vary as width of the shore zone. Wide shore zones require higher altitudes (500-600' is typical for estuaries). Generally the pilot becomes familiar with the survey requirements and can independently adjust the flight path to climb as she or he approaches an estuary.

2. Shooting Angles: Keep the horizon level (using a treeline can help), shooting about 45 degrees off the trackline with the door jamb just out of the right side of the image. The camera should be pointed around 45 degrees down so the shoreline is appearing in the right upper corner, passing through the center of the screen and out of the left lower corner (sketch at right). It does help the mappers to shoot ahead occasionally so they get a single view showing the overall complexity (or similarity) of the coast. Also you can follow a particular feature with a slight zoom in, holding the framing stationary on the feature as the helicopter passes over.

3. Cornering: Counter-clockwise turns (see preferred trackline at right) will put the left side of the helicopter in a down-looking configuration which allows for better filming, although the camera person will have to lift the camera during the turn. Be sure to state a turn direction preference to avoid clockwise, "hover" turns at the end of long narrow inlets in which the helicopter has to slow down more, becomes less stable and will cause struts and skids to enter the image.



4. Framing: Use the monitor to frequently check framing. You should also check that the recording indicator (red dot) is visible in the image and that the tape-remaining counter is running. At the same time, make sure that the camera is recording. Minimize the percentage of sky in the image to avoid silhouetting the coastal zone due to auto contrast; too much sky will cause the shore zone to be almost black. This can be difficult to avoid in bright surf areas.

5. Narration: Generally the morphology does not need to be described because mappers can see this in the videography. Concentrate on the sediment texture, which is not so clear in the imagery; be as precise as possible ("a veneer of pebbles and cobbles over sand"; "medium sand beach face and a pebble sand berm"; "pebbles and sand with scattered boulders"). Provide the descriptions from supra-tidal down to lower intertidal. Continually describing precise widths, (i.e., "the beach face is 20 m wide") and widths on all across-shore components is helpful, but even if you can only provide a few, it is still useful to the mappers. Allow your enthusiasm to be part of the narration as mappers will need to listen to the entirety of these recordings in the office. Geographic names provided by the navigator must be repeated as the navigator's comments are not recorded.

6. Camera settings: Autofocus with filter adjustments off. Toggle the "display" button to prevent red "REC" and other information appearing in recorder frame. Follow manufacturer recommended settings for auto adjustment settings. Tape all connections securely. Use head cleaner and lens cleaner to maintain recording and image quality. Ensure familiarity with all camera settings and troubleshooting procedures for in flight efficiency. Complete test recording of audio and video prior to each day's flight.

7. Time: Synchronize watch, digital camera, and laptop at GPS time, to the nearest second, at the start of each day.

8. Mapping Terminology tips: Use "ramp" for 5-15 degrees slope, "platform" for <5 degrees, and note whether a cliff is MORE or LESS than 35 degrees. Note if widths are more or less than the 30 m. Ensure familiarity with mapping attribute definitions to use precise terminology in audio description of features.

9. Video camera and filming reminders: Reset white balance according to manufacturer instructions. Use only a skylight filter, not a polarizing filter. Check small watch batteries that enable memory functions. Look over pilot's shoulder to see 60 knots speed. Ask navigator to monitor GPS for air speed ~ 100 km/h. Maintain an appropriate filming distance from shore. Try to shoot 45 degrees out the door and 45 degrees down to the ground.

Table 4. Guidelines for Photographer (Biologist).

1. **Streaming Commentary:** Keep up a streaming commentary mentioning ALL biobands present even if the biota is not changing and you feel as though you are repeating yourself. More is always better.
2. **Use Bioband Names:** Use bioband names when describing individual species which are not easily identified.
3. **Biological exposure:** Make note of changes in biological wave exposure and always mention the exposure at the beginning of the day and when starting a new section of shoreline or after a tape change.
4. **Lower Intertidal Biobands:** Pay particular attention to what is at the waterline and in the subtidal as this is the area that is most difficult to see when reviewing the video. Also make note of offshore kelp beds that may not be captured in the video.

2.2 Post-Flight Data Processing

The navigation trackline data are processed daily by the survey navigator and updated to a MS Access Master Trackline Database file (Fig. 12). Trackline position, video imagery, and digital photo times are linked to a GPS location using the six-digit UTC time code.

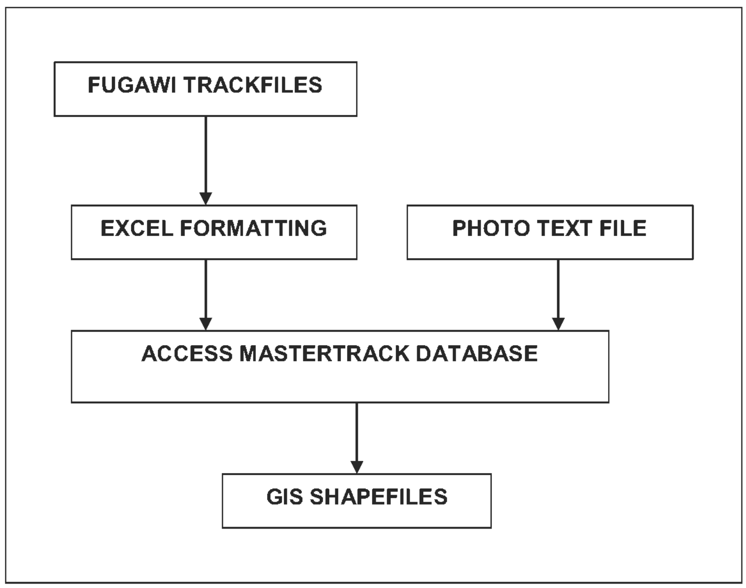


Figure 12. Schematic illustrating the processing of navigation software output (Fugawi) and linking digital photos and video imagery to GIS shapefiles.

Following the manual editing of the flight track to show only the “useable” imagery, a trackline log is compiled. An example of the flight track map (Fig. 13) and the associated tape log (Fig.14) provide a tape by tape summary of the survey. This flightline manual is compiled immediately following completion of the survey and usually accompanies the DVD video and digital still photograph copies as part of the deliverables. The report is useful for locating imagery in particular prior to web-posting. This product generally precedes any ShoreZone classification or mapping, and is intended as a data report to accompany the imagery collected.

Figure 13. Example of trackline log for a single video tape from Cold Bay-based survey, May 2011. Times noted on the map are UTC, synched to the GPS time on all imagery.

2011 Southwest Alaska Aerial Video Imaging Survey
Team Cold Bay (CB)

Tape: SW11_CB_07 **Date 17 May 2011**

General Location: False Pass, Ikatan Bay, Ikatan Peninsula

Time Start (UTC): 17:20:00 **Geo:** Schoch
Fuel Break: 17:28:26 to 17:52:36 **Bio:** Lindeberg
Time End (UTC): 18:52:30 **Nav:** Morrow
Tape Length: 56 min 53 sec **Pilot:** Egli

Weather: Cloudy, high overcast, light winds

Time (UTC)	Location	Photo
17:20:00	Ikatan Bay, Ikatan Peninsula	sw11_cb_03832
17:28:23	City of False Pass	sw11_cb_03989
	Fuel Break: 17:28:26 to 17:52:36	
17:52:39	Nichols Point, False Pass	sw11_cb_03995
18:14:44	Kenmore Head, Morzhovoi Bay	sw11_cb_04400
	Transit to Ikatan Peninsula – 18:14:46 to 18:26:09	
18:26:31	Otter Cove, Ikatan Peninsula	sw11_cb_04401
18:31:02	Bird Island, Ikatan Peninsula	sw11_cb_04470
18:52:30	Cape Pankof, Ikatan Peninsula	sw11_cb_04836

Figure 14. Example of tape log compiled for Tape SW11_CB_07, Cold Bay-based survey, May 2011 (accompanies map in Figure 13).

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SHOREZONE DATABASE 3.0

3.1 Overview of Database Structure

Data are stored in more than two dozen linked tables, in a SQL relational database, including data tables, lookup tables, and data entry forms (Fig. 15). Spatial data are housed in ArcGIS software, linked to units in the ShoreZone database by a unique physical identifier (PHY_IDENT field), an alphanumeric string composed of the identifier for the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0 is Region 12/ Area 03/ Unit 0552/ and Subunit 0) (See also Section 1.3).

What is the PHY_IDENT?

The PHY_IDENT field is the key index connecting the mapped line segment mapped in GIS (the along-shore *Unit*) to the attributes describing the features in each Unit in the SQL database.

Definitions of field names within each table are provided in the data dictionaries (Appendix A). General "rules of thumb" applied during physical mapping and image interpretation are included in the physical mapping guidelines in Section 4.0. Biological mapping guidelines are provided in Section 5.0.

3.2 Unit Tables

The Unit table (Fig. 15) includes attributes that describe the entire unit, including geomorphic attributes such as overall coastal morphology type, coastal stability, sediment sources, wave exposure level, and potential oil residence. Administrative metadata, such as the names of the mappers, editors, videotape number, and date of mapping, are also included within the Unit table.

The Biounit table (Fig. 15) is the biological complement to the Unit table. It houses biological information related to the entire unit, including biological wave exposure and habitat class. These attributes are discussed further in Sections 5.0 and 6.0. Administrative metadata is also included in the Biounit table, including the names of biomappers and editor, digital photos of the unit, ground station number, and the sources of information used in the biological interpretations.

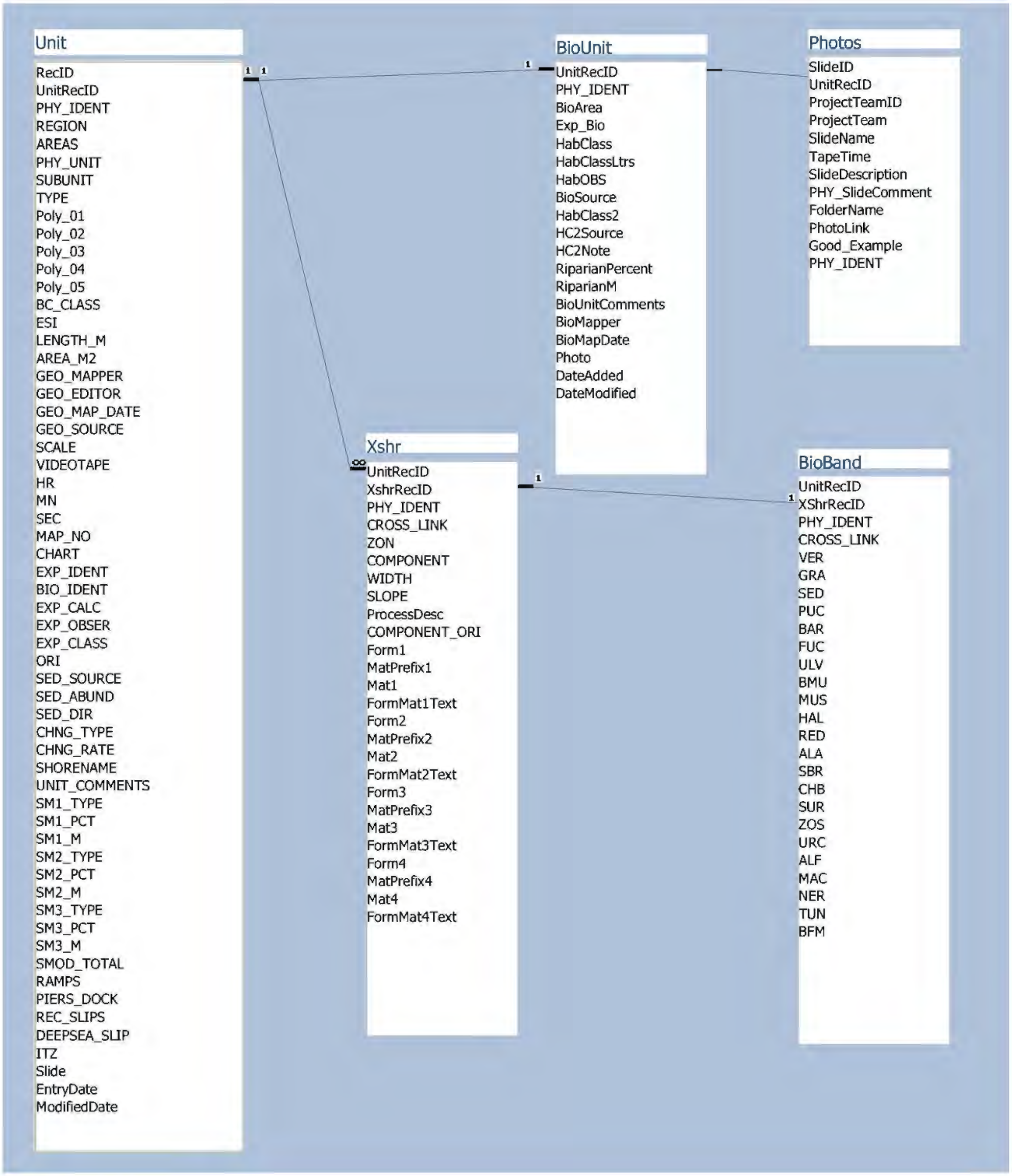

Figure 15. Diagram showing relationships between key data tables in ShoreZone mapping database.

3.3 Across-Shore and Bioband Tables

The XShr Table (Fig. 15) includes a record (row) for each across-shore *Components* within each zone. Attributes are entered in the database to describe morphology, sediment texture, width, slope, dominant coastal process, and estimated oil residence index observed by mappers for each zone and component. Further details for across-shore data entry procedures and guidelines are provided in Section 4.3.

The Bioband Table (Fig. 15) is the biological complement to the XShr Table. Observations of assemblages of biota are recorded in the Bioband Table in the corresponding zone/component record where they are observed. These assemblages of coastal biota are referred to as *biobands* and grow in a typical across-shore elevation, and at characteristic wave energies and substrate conditions. Bioband attributes are described further in Section 5.0.

3.4 Other Database Tables

The Photos Table (Fig. 15) is a list of all digital still photos collected during AVI surveys, providing the image name (e.g. SW11_SP_00001.jpg), the date and time that the photo was collected (in UTC time), and a photo description when appropriate. This table is initially prepared in the field by the biologist (photographer) as part of the image handling protocol (Section 2.2). During physical mapping, each photo in the list is viewed and tagged against a Unit Record (UnitRecID field) where possible. The same UnitRecID may be used for multiple photos. However, each photo may have only one unit with which it is associated. Not all photos will have a assigned to a Unit and those photos would have UnitRecID field of the table as "0", however all photos are assigned to survey trackline positions in web posted imagery.

The Ground Station Number Table (Fig. 15) provides information on pertinent records in a separate ground station database, if ground station data exists.

3.5 Spatial Data

All of the ShoreZone data are georeferenced to map features. Two types of spatial data are included in the spatial dataset: (a) a line file which represents the segmented alongshore Units and (b) a point file that represents features with a very limited linear extent (Variants).

Polygons were used in the earliest ShoreZone mapping efforts in Alaska, but were found to require considerable cartographic effort to produce because there is no digital low-water line (LWL), which had to be approximated. This approach also did not provide any additional searchable data. As such, polygons have not been used in subsequent Alaska ShoreZone projects.

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SHOREZONE PHYSICAL MAPPING 4.0

The overall goal of ShoreZone physical mapping is to provide a representation of the coastal morphology and a basic framework for the biophysical characterization of the coast. As previously described, ShoreZone breaks the shoreline into a series of alongshore units, represented by segmentation of the digital mean high water (MHW) line (Fig. 8) and then links a systematic description of the across-shore morphology (Fig. 9) to each of those line segments by using a standard set of codes. The resulting dataset is easily queried.

The basic premise of the method is that the morphology, substrate, and wave energy are the primary determinants of the shore-zone ecological system, and that a detailed categorization of these features can be summarized and used to describe coastal habitats.

This section of the protocol outlines the procedures used in the physical classification and mapping portions of the project, in sufficient detail so that other mappers can use the same information to develop standardized ShoreZone mapping products. ShoreZone users of the data will also find these descriptions useful to gain insight into the various assumptions that occur during mapping.

4.1 Principal Steps in ShoreZone Physical Mapping

The physical mapping takes place in four primary steps that are summarized in Table 5. The biological mapping is described separately in Section 5.0. An example of a typical office-based mapping station (in 2013) with a video monitor, data-entry screen, and photo screen is shown in Figure 16.

One of the most challenging steps in the mapping process is the delineation of the unit boundaries. Natural boundaries are commonly gradational and there are typically no sharp boundaries between one shore type and the next. Figure 8 shows a photograph of how a shoreline may be interpreted and then the how the units delineated on a digital shoreline. An example of a portion of a segmented shoreline paper map is shown in Figure 17. The trackline shows one-second fix marks from the GPS data recorded during the flight (small dots) and photo locations (large dots). The trackline is annotated with six-digit time codes that are burned on to each frame of the videography (Fig. 6). The mapper has manually segmented the mean high water line (MHW) on the paper copy of the flightline map into a series of alongshore units and added a unit ID for each segment (in pencil). These maps are then used to digitize unit breaks.

Once the unit boundaries are delineated, the mapper populates the database with attribute codes to characterize that unit, both along-shore (Unit Table) and across-shore (XShr Table). Specific data-entry procedures and guidelines are discussed below. Most mappers complete the across-shore component data fields first, because sediment characteristics and across-shore widths are important in classifying the overall unit type.

Table 5. Summary of Physical Mapping Steps.

TASK	ACTIVITIES
Assembly of Materials	• data entry reference tables and codes (Appendix A) • electronic base maps (digital shorelines in ArcGIS) • video and digital still photo imagery (DVDs) • aerial video imaging survey (AVI) flight report • trackline shapefiles (ArcGIS) • region and area shapefiles (ArcGIS) • MS_Access database front end containing data entry forms linked to back end on server
Mapping	• review video, digital still photos, and audio commentary to segment the shoreline into alongshore *units* (line segments) with occasional *variants* (point features) • shore unit breaks are delineated on paper maps and later digitized on the electronic shoreline • along-shore unit attribute data are entered into the Unit Table • across-shore attribute data (*Forms* and *Materials*) are entered into the XShr Table for each zone and component within the unit • each digital still image is viewed and linked to pertinent units by entering data into the tblBioSlideList table • 10% of the shoreline units are reviewed by another physical mapper as part of the QA/QC procedure (including Unit, XShr, and tblBioSlideList data) • database QA/QC is performed by the database manager • physical mapping database tables, paper maps, and GIS are transferred to biological mappers
Data Assembly	• database manager receives biological data tables into the master database; overall database QA/QC is performed • an ArcGIS Geodatabase is created from the master database • physical and biological thematic maps (shapefiles) and data summaries are created
Preparation of Deliverables	• access database and ArcGIS products are developed and QA/QC'd • summary report is prepared for the region, summarizing mapped attributes, physical themes, biological themes, the most recent version of the data dictionary, bioband descriptions of the region mapped, and database lookup tables

Figure 16. Photo of mapping station setup with video monitor (left), data entry forms (center screen), and still photo viewer (right). Headphones facilitate audio use. Segmentation (paper) map is at the left.

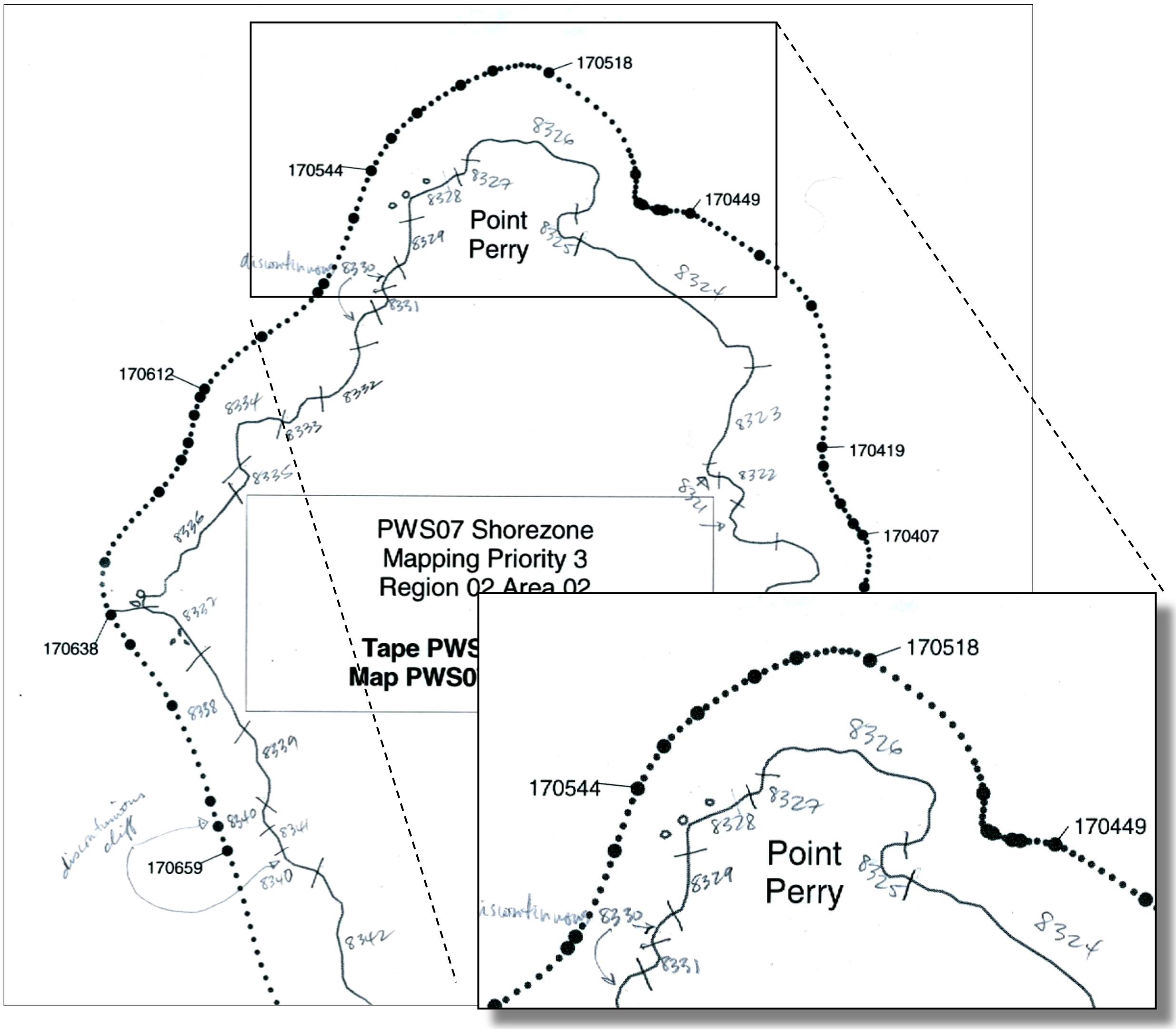

Figure 17. Example of annotated trackline and shoreline segmentation map.

4.2 Guidelines for Cataloging the Alongshore Unit

Unit Delineation

As mentioned previously, there are few abrupt boundaries in the real world – interpretation is required to delineate gradual transitions between different categories. Alongshore units are delineated primarily on the basis of physical characteristics, including:

- dominant coastal process (e.g., waves, fluvial/estuarine process)
- geomorphology
- sediment sizes
- degree of energy or wave exposure

If the *Shore Type* changes due to a significant change in the structuring process, morphology, or substrate, then a new unit is warranted. Similarly, if the exposure changes significantly due to a change in shoreline orientation, a new unit would be created.

Secondary characteristics that influence the location of unit breaks include:

- intertidal slope and width
- coastal process (e.g. mass wasting vs. fluvial)
- changes in patterns of biological features

The alongshore length of an individual unit varies with shoreline complexity, crenulations, and coastal processes. Over the past ten years of Alaska ShoreZone mapping, the average unit length has been about 300 m. The average unit length in British Columbia is about ~500 m. Soft sediment shorelines typically have longer unit lengths, from 700 to 1,000 m.

Imagery is linked to the interpreted and coded data via the UTC time code (Fig. 17), which is visible in each video frame (Fig. 6) and is also coded into the Unit Table. Guidelines for linking times are summarized in Table 6.

Table 6. Guidelines for Linking Images to Database.

Start time for unit: The six-digit UTC time code that is visible when the beginning of the unit break lies in the middle of the screen. If two segments of shoreline are visible in one frame, different units may have the same start time. In this case, a comment such as "unit in backshore" or "islet in foreground" is entered in the UNIT_COMMENTS field (discussed below).
End time for unit: While the ending time of a unit is not explicitly entered; it is generally considered the beginning of the next unit. There are cases when the end time of one unit will not be the start time of the next unit. An example of this would be an area of islets with flight line loops, often there is "dead" time between units in these cases while the helicopter is looping or while transiting between islets.

The Concept of Units and Variants

In the ShoreZone mapping protocol, a mapping unit can be a point, line, or polygon; all three have been used in some mapping projects. The vast majority of ShoreZone units are represented as line segments. The line segments are delineated on a digital shoreline and each unit is assigned a unique identifier that links the descriptive data (tabular info) and the spatial data (map info). Since the physical mappers delineate the units, the identifier is referred to as the PHY_IDENT code which is composed of 1) a *Region* identifier, 2) an *Area* identifier, 3) a *Unit* identifier, and 4) a *Subunit* identifier (e.g., 03/07/2451/00 is Region 03, Area 07, Unit 2451, Subunit 00).

The convention has been developed in ShoreZone that any *variant* point features are always mapped as a *subunit* of the line segment. There may be several variants within any one unit; Table 7 describes rationale for mapping variants and provides examples of these point features.

Table 7. Guidelines for Subunit Variants Data Entry (Unit Table).

<u>Subunit:</u> Subunits are set to '0' for line features (units) or non-zero for point features (also called *variants*). Variants are point features that are mapped and digitized within a linear unit segment. Usually variants indicate where streams or small rivers cross the shoreline but can also be point features such as lagoon outlets, or structures such as wharves. There may be more than one variant per unit, and if so, they are numbered sequentially in the unit, as the last two digits in PYH_IDENT (01, 02, 03…). The *Form* "R" for river can be mapped in the A zone or in both the A and B zones, depending on if the stream passes through both the supratidal and the intertidal. For a river to also be mapped as a variant (non-zero Subunit and "P" Unit type) it must show a river Form in *both* the A and B zones. If the river is intermittent (does not appear in any B zones), then it may be mapped as a Form of intermittent river (Ri) only and it would not be mapped as subunit point variant.

Assigning Shore Type to the Unit

The *Shore Type* is a general descriptor of the structuring process, morphology, and substrate of the unit as a whole and is an attribute that provides a summary descriptor of the overall character of the shore unit. The 'dominant structuring process' is the first decision in assigning Shore Type, and those categories are defined in Table 8. The same 'dominant structuring processes' are used to define Habitat Class (see Table 24).

In earlier ShoreZone protocols (including first ShoreZone in Alaska, and in British Columbia [BC] and Washington), the Shore Type attribute has been called *Coastal Class* or *BC Class*.

Wave-Structured Shore Types

The vast majority of coastal morphologies within Alaska are a result of waves impinging on the shoreline and causing either erosion or accretion such that a unique suite of coastal landforms is created. Examples of these landform classes include Rock Cliff, Rock Platform with Gravel Beach, and Mudflat. Table 9 summarizes the *Shore Types* that are typically associated with wave exposure as a dominant structuring process. Thirty wave-structured *Shore Types* are based on unique combinations of substrate type, across-shore width, and slope (Table 9). In order to improve mapping repeatability, a number of "rules" have been developed to minimize interpretative differences among mappers. These rules for classifying wave-structured *Shore Types* are summarized in Tables 10 and 11.

Table 8. General Guidelines for Assigning Structuring Processes in Shore Types.

Structuring Processes	Description
Wave Energy Processes Dominant	• wave energy is the dominant process controlling shore morphology • the dominance as a structuring process is evident from erosional shoreline landforms (e.g., cliffs, bluffs, or platforms) or accretional landforms (e.g., spits, barrier islands, swash bars, or berms) resulting from wave-generated sediment transport processes
Estuarine Processes Dominant	• freshwater input usually results in salt marsh and/or salt meadow areas in the upper intertidal and supratidal zones • sediment input to the unit from fluvial sources often creates deltaic landforms and features • substrates are commonly fine (e.g., muds) and also often includes organics such as peats • freshwater input likely to create brackish water conditions • usually an embayment with restricted wave fetch and a connection to the open sea
Anthropogenic Processes Dominant	• man-made structures, filled shoreline, shoreline armoring, or other modifications that comprise more than 50% of the intertidal zone area
Current Processes Dominant	• usually elongate channels with very restricted wave fetch • salt water, high current channels caused by tidal flow • often found between islands or at the constricted entrances to saltwater lagoons • water movement is generally visible within the channel but not outside it • intertidal zone widths are often narrow
Glacial Processes Dominant	• glacial ice fronts dominate the intertidal zone • restricted to a few locations in SE Alaska, Kenai Fjords, and Prince William Sound
Lagoon Processes Dominant	• an enclosed water body that is connected to salt water by either a permanent inlet, ephemeral inlet, or storm overwash such that the water body is permanently or at least occasionally salty • the tidal range is often restricted due to a sill height or narrow channel • wave fetches are limited and wave exposure low (*Protected* or *Very Protected*) • no significant fluvial input or landforms within the unit
Periglacial Processes Dominant	• permafrost and pore ice are dominant in controlling the shoreline morphology • thermokarst or periglacial features such as ground ice slumps, thermo-erosional gullies, and thaw pits may be present • degradation of permafrost resulting from thaw subsidence creates unique morphologies such as inundated tundra (e.g., submergence of the tundra surface below mean sea level)

Table 9. Classification for Wave-Structured Shore Types (BC_CLASS).

SUBSTRATE	SEDIMENT	WIDTH	SLOPE	SHORE TYPE	CODE
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 with gravel & sand beach, wide	11
			FLAT (<5°)	Platform with gravel & sand 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, narrow	23
	SAND & GRAVEL	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	n/a	
			FLAT (<5°)	Sand & gravel flat or fan, wide	24
		NARROW (<30 m)	STEEP >20°)	n/a	
			INCLINED (5-20°)	Sand & gravel beach, narrow	25
			FLAT (<5°)	Sand & gravel flat or fan, narrow	26
	SAND / MUD	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach, wide	27
			FLAT (<5°)	Sand flat	28
			FLAT (<5°)	Mudflat	29
		NARROW (<30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach, narrow	30
			FLAT (<5°)	n/a	n/a

Table 10. Classification of Wave-Structured Shore Types (BC_CLASS attribute).

Substrate: substrates are generally categorized in terms of either immobile *Rock* substrate, which often supports rich epibenthic biotic assemblages or *Sediment* substrate, which may be moved and re-deposited under the influence of currents, waves, or wind. There are, however, many locations in the Pacific Northwest where rock and sediment co-occur on the shoreline and this intermediate class of shoreline of combined immobile and mobile substrate has been designated as *Rock + Sediment* (Table 9). Sediment: a number of classes of sediment are used in classifying Shore Type. Sediment classes follow the sizes specified in the Wentworth sediment scale. Categories are: *Gravel* (particles >2 mm); *Sand* (particles 0.063 mm to 2 mm); *Sand & Gravel* where a mixture of sand and gravel sizes exists; *Mud* (particles<0.063 mm). Other categories are: *Organics*, where substrate is dominated by peat or organic matter; and, *Ice*, which occurs at tide-water glaciers. Width: The Zone width is the sum of the widths of each across-shore Components within the Unit. The total width is assigned in Shore Type as either Narrow (<30 m) or Wide (>30 m).

Table 11. Mapper Guidelines used for Assigning Wave-Structured Shore Types.

Rock (Shore Types 1-5): Rock substrate dominates the intertidal zone of the unit, with little or no unconsolidated sediment or organics (<10% of the overall unit area). Rock and Sediment (Shore Types 6-20) vs. Sediment-Dominated (BC Classes 21-30): When a unit consists of a beach with rock outcrops/platforms, the Shore Type is coded to emphasize the beach sediment (Shore Type 21 to 30) unless the rock outcrops/platforms make up 25% or more of the total intertidal area of the unit. When the rock outcrops are 25% or more, the Shore Type is coded to reflect the influence that the rock has on the unit (Shore Type 6 to 20). Supratidal rock with intertidal beaches: When a unit consists of a supratidal cliff/ramp with an intertidal beach, the Shore Type is coded to reflect the importance of the beach (Shore Types 21 to 30) even if the cliff/ramp slightly infringes (<3 m) on the high intertidal zone. When the cliff/ramp significantly infringes on the intertidal zone (>3 m), a "Rock and Sediment" classification is applied (Shore Types 6 to 20). Shore Type 11: When a unit consists of a prominent cliff in the supratidal and > 3 meters in the intertidal, in conjunction with a beach face containing sand and gravel (>25% of unit) and an intertidal zone wider than 30 meters, slope is ignored and Shore Type 11 is used. Shore Type 13: When a unit consists of a significant cliff in the supratidal and > 3 meters in the intertidal, in conjunction with a beach face containing sand and gravel (>25% of unit) and an intertidal zone < 30 meters, slope is observed and Shore Type 13 is used. Sand Rule: To include *sand* in Shore Type assignment, particles that are 2 mm and finer must be observed as >10% of the sediment type, or when a patch of sand is 10 m or more in diameter. Veneers: When a boulder/cobble/pebble beach is observed in a protected or semi-protected area, these materials are almost always a *veneer* overlying sand. This should be taken into consideration when coding the materials and choosing a Shore Type. If the geologist's commentary mentions sand in nearby units with similar wave exposures, apply the presence of sand to the unit. Close examination of the lower intertidal in the digital still photos will often reveal the presence of sand, even if the commentary lacks mention of it. If there is no evidence or commentary regarding sand, do not assume it is present.

Non Wave-Structured Shore Types

Other types of shoreline that are not dominated by wave action include estuarine, anthropogenic, current-dominated, glacial ice, lagoon, and permafrost shore types. Specific descriptions are provided in Table 12.

Table 12. Shore Types Associated with Structuring Processes Other than Wave Action.

Structuring Processes	Guidelines for Classification	Shore Type
Estuarine Processes Dominant	***estuarine*** – organics, fines, and vegetation dominate the unit; may characterize units with large marshes in the supratidal zone (if the marsh represents >50% of the combined supratidal and intertidal area of the unit), even if the unit has another dominant intertidal feature such as a wide tidal flat or sand beach. This "50% rule" may be ignored and a Shore Type 31 applied if a significant amount of marsh (25% or more) infringes on the intertidal zone.	31
Anthropogenic Processes Dominant	***permeable man-made structures*** such as rip-rap, wooden crib structures where a surface oil from a spill will easily penetrate the structure. Man-made structure must comprise >50% of intertidal zone area.	32
	impermeable man-made structures such as concrete seawalls and steel sheet pile. Man-made structure must comprise >50% of intertidal zone area.	33
Current Processes Dominant	***current-dominated*** shore types occur in elongate channels where tidal currents are the dominant structuring process. In addition to obvious high currents, channel sides typically include anomalous vegetation types.	34
Glacial Processes Dominant	***glacial ice*** where tide-water glaciers are present in the intertidal zone. These locations are characterized by unstable ice fronts.	35
Lagoon Processes Dominant	***lagoons*** represent a special coastal feature that has some salt-water influence, but may be largely disconnected from other marine processes such as tides and high wave exposure. Intertidal zones are often restricted in elevation and narrow. Saltwater influxes may be only episodic.	36
Periglacial (permafrost) Processes Dominant	***inundated tundra*** occurs where thaw-subsidence on low-relief shorelines causes the tundra surface to sink below mean sea level. Often the polygonal patterns associated with periglacial ice-wedges are evident. Where the shallow ponds coalesce they may transition into lagoons. Usually there is > 25% water within the unit.	37
	ground ice slumps are areas where the thaw of high ice content shores causes mass-wasting via distinct mechanisms (e.g., ground ice slumps, thermo-erosional falls, solifluction lobes). Slump processes strongly influence (> 50%) of the intertidal zone morphology and texture.	38
	low vegetated peat are areas of low-lying peat-rich tundra bluff; usually vegetated in the supratidal zone, but not always vegetated in the intertidal zone. Minimal mineral sediment is present. Usually low energy (shown by an absence of storm wave features). No distinct intertidal zone.	39

Environmental Sensitivity Index (ESI) Category

Another unit-wide summary descriptor which is assigned to each shore unit is the Environmental Sensitivity Index (ESI). The ESI classification has been applied throughout the USA (Petersen *et al.* 2002) and is widely used by oil spill response personnel.

There are ten basic ESI shore types, with a number of sub-categories, which are defined by the shore segment's potential sensitivity to oil spills (Table 13). The rationales for assigning ESI to shore units, according to the Shore Types mapped, are listed in Table 14.

Table 13. Environmental Sensitivity Index (ESI) Shore Types (after Petersen et al. 2002).

ESI Number	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
10E	Inundated low-lying tundra

* Denotes that a category or definition applies only in Southeast Alaska

Table 14. Guidelines Used for Assignment of Environmental Sensitivity Index (ESI) within ShoreZone.

Substrate	Shore Type	ESI Designation Guideline *
Rock	1 2	• If Exposure >= SE then ESI 2A • If Exposure <= SP then ESI 8A (possible ESI 8B if sediment pockets present or lots of fissures)
	3 4 5	• If Exposure >= SE then ESI 1A • If Exposure <= SP then ESI 8A (possible 8B if sediment pockets present or lots of fissures)
Rock + Sediment	6 7	• If >=50% beach sediment then ESI 6A and 6B • If > 50% rock with beach pockets and Exposure >= SE then 2A • If > 50% rock with cobble/pebble beach pockets and Exposure <= SP then 8B (boulders can be present but less abundant than cobble/pebble) • If > 50% rock with boulder/rubble beach pockets and Exposure <= SP then 8D (cobble/pebble can be present but less abundant than boulder)
	8 9 10	• If >=50% beach in unit then ESI 6A and 6B • If mostly talus and Exposure >= SE then 1C • If mostly cobble/pebble talus and Exposure <= SP then 8B (boulders can be present but less abundant than cobble/pebble) • If mostly boulder/rubble talus and Exposure <= SP then 8D (cobble/pebble can be present but less abundant than boulder)
	11 12 13 14 15	[There must be >25% sand in the unit for these BC classes to be assigned.] • If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • Otherwise assign ESI 5. If sand is <25%, reassess the BC class.
	16 17 18 20	[There must be >25% sand in the unit for these BC classes to be assigned] • If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • Otherwise assign ESI 3A or 4. If sand is <25%, reassess the BC class. Refer to BC 27 for guidelines on sediment size.
Sediment	21 22 23	• If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • If it does not meet the above requirements then ESI 6A or 6B
	24	• If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • If it does not meet the above requirements then ESI 5
	25	• ESI 5
	26	• ESI 5
	27	• If sediment size if less than 2 mm then ESI 3A • If sediment size is greater than 2 mm up to pebbles then ESI 4 • If there are pebbles in the XShr then lean towards ESI 4; if there are no pebbles then lean towards ESI 3A.
	28	• If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • If it does not meet the above requirements then ESI 3A or 4. Refer to BC 27 for guidelines on sediment size.
	29	• If Exposure >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exposure <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A
	30	• ESI 3A or 4 (refer to BC 27)

Table 14 continued next page…

*** Wave Exposure Categories:** VE – Very Exposed; E – Exposed; SE – Semi-exposed; SP – Semi-protected; P – Protected; VP – Very Protected

Table 14, continued. Guidelines Used for Assignment of Environmental Sensitivity Index (ESI) within ShoreZone.

<table>
<tr><th>Substrate</th><th>Shore Type</th><th>ESI Designation Guideline</th></tr>
<tr><td>Estuarine</td><td>31</td><td>• If >50% marsh in the A and B zone combined then ESI 10A
• If the biologist comments on the marsh being predominately freshwater, ESI 10B can be used.
• If the ESI 9A requirements are met (see protocol), then 9A can be used for large tidal flats or deltas and 9B can be used in lagoon areas.
• If none of the above requirements are met, assign ESI class based on the dominant Form.</td></tr>
<tr><td rowspan="2">Anthropogenic</td><td>32</td><td>• If it is riprap then ESI 6C
• If Exposure <=SP then 8B
• If Exposure >=SE then 1B</td></tr>
<tr><td>33</td><td>• If Exposure <=SP then 8B
• If Exposure >=SE then 1B</td></tr>
<tr><td>Current-Dominated</td><td>34</td><td>• Decide what Shore Type you would assign if you did not assign a BC 34, then assign and ESI class based on that.</td></tr>
<tr><td>Ice</td><td>35</td><td>• ESI 8A (refers to “impermeable” scarps)</td></tr>
<tr><td>Lagoon</td><td>36</td><td>• ESI 9B</td></tr>
<tr><td rowspan="3">Periglacial/ Permafrost</td><td>37</td><td>• ESI 10E</td></tr>
<tr><td>38</td><td>• ESI 3C</td></tr>
<tr><td>39</td><td>• ESI 8E if peat dominated or 9B if other vegetation is present</td></tr>
</table>

*** Wave Exposure Categories:** VE – Very Exposed; E – Exposed; SE – Semi-exposed; SP – Semi-protected; P – Protected; VP – Very Protected

Assignment of Exposure Classes

The estimate of the wave exposure, as classified by the physical mapper, is termed *Observed Exposure* and is assumed to be a function of the fetch window of the unit (see specific details in Appendix A, Table A-5). It is a rare to have the exposure change directly from *Exposed* to *Protected* in adjacent units, although it does occasionally occur. In most cases there will be a transition zone that includes a few units of *Semi Exposed* to *Semi Protected* or both. For example, the entrance to a bay will tend to have a slightly higher exposure than the head of the bay due to its location and processes such as wave refraction. This transition zone needs to be recognized when mapping wave exposures.

After physical mapping is complete, biological mappers assign each unit a *Biological Wave Exposure* category on the basis of observed biota (see details in Section 5.0). The exposure estimated by the physical mapper and the exposure estimated by the biological mapper may differ.

Assignment of the Oil Residence Index

The Oil Residence Index (ORI) for each shore Unit is an overall assessment of *the potential persistence of a crude oil spill that strands on a shoreline* (Howes *et al* 1994). Other fuel types, such as diesel and bunker fuels, may have substantially different persistence periods. ORI is a relative index ranging from 1 to 5 where 1 indicates short persistence (days to weeks) and 5 indicates lengthy persistence (months to years). ORI is estimated from a lookup table that combines *Wave Exposure* and *Shore Type* (see Table A-7). The unit ORI classification uses the ‘best-available’ estimate of wave exposure class – in most cases the biological wave exposure (Appendix A Table A – 7). On bare sediment beaches, such as those on much of the Arctic coast, the best available wave exposure estimate is the physical mappers’ *Observed Exposure* and that is the category used in the ORI lookup. (See further explanation of determination of ‘best available wave exposure’ in Section 5.4)

An across-shore ORI is also assigned to each across-shore component, recognizing that the permeability of each component is different; therefore the retention characteristics will differ. Component ORI assignment is described in Section 4.3.

Assignment of Sediment Transport Properties to the Unit

There are three attributes that identify some of the sediment transport processes that may occur within the unit: the *Sediment Source, Sediment Abundance,* and *Sediment Transport Direction* (Appendix A Table A – 1). These attributes are meant to provide some indication of how sediment moves within the mapping unit. The *Sediment Source* is the mapper's best estimate of the sediment source to the unit (e.g. sediment comes primarily from alongshore sediment transport). If the sediment source can be determined, it may be classified as: alongshore, backshore, fluvial, or offshore. The *Sediment Abundance* is a general indication of the overall occurrence of sediment within the unit; in general, the rock shores will have 'scarce' sediment and the sandy beaches will be rated as 'abundant' sediment. The *Sediment Transport Direction* indicates the direction of sediment transport, assigned to one of eight cardinal compass points, based on morphological features within the unit; a classification is only assigned if a mapper can see some feature that indicates transport direction within the unit, not if transport is inferred from observation in adjacent units.

Estimating Shoreline Stability

Mappers estimate the stability of the shore unit from the morphology where change is defined as "measurable change" during a three-to five-year time span. Units are characterized as *Erosional, Stable,* or *Accretional*. Bare rock, for example, may be slowly eroding but the rate of change is so slow that the shore is classified as stable. *Accretional* units are indicated by an abundance of sediment and a prograding shoreline. *Erosional* units are indicated by scarps cut into backshore morphology or talus slopes indicating erosion due to over-steepening.

Modification of Previously Published Digital Shorelines

ShoreZone mappers are very familiar with morphologies of the coast and especially the location of the natural high water line, which is one of the significant features that mappers look for within each unit. It is not uncommon for the physical mappers to find errors of position in the digital shoreline, which may be due to mapping interpretation errors, anthropogenic modifications, shifting position of river deltas, or to coastal erosion. The physical mappers note in the *Shore_Prob* field the nature of the problem, which may result in a revised ShoreZone digital shoreline position.

The following guidelines are used for making changes to the digital shorelines being used for ShoreZone mapping:

> **Significant changes to the digital shoreline:** During mapping, the mapper will draw significant shoreline changes clearly on the paper map and make a comment in the UNIT_COMMENTS field of the Unit Table to explain the nature of the problem to users and to assist biomappers (such as "islet is attached headland"). If the discrepancy is significant enough to change in the GIS when digitizing, this is noted in UNIT_COMMENTS field (such as "islet is attached headland; fixed in GIS"). If the change is pertinent at the across-shore level, also enter a comment in the XShr Table (such as for tombolos connecting B zones).

"Missing" shoreline features: When digitizing shoreline changes, features present in the digital shoreline but not observed in the imagery are generally *not deleted* (these could be offshore reefs that were not flown but should remain part of the basemap). These features may be coded "9999" to indicate they are a part of the shoreline but not mapped.

Adding shoreline features: Features observed in imagery that are not part of the digital shoreline basemaps may be digitized on the basis of the imagery if they are significant (such as large accretion spits that are vegetated or otherwise appear intransient). Additions to the digital shoreline should be noted in the SHORE_PROB field in all cases, and in the UNIT_COMMENTS and XSHR_COMMENT field when appropriate.

Cataloging Anthropogenic Structures in the Coastal Zone

One of ShoreZone's strengths is the cataloging of human-modified or anthropogenic changes to the shoreline. This information is used to estimate statewide or regional trends in human-modification of shorelines. Appendix A, Table A - 1 outlines the details of the classification. The primary, secondary, and tertiary shore modification type is cataloged for each unit. For each type of shore modification (i.e., boat ramp, concrete bulkhead, dyke, landfill, sheet pile, rip rap, and wooden bulkhead), the percentage occurrence within the unit is also estimated. This allows maps to show locations of various shore modification and the density of occurrence. A total estimated of each type can be calculated for various regions (e.g., in SE Alaska, rip-rap is the most common shore modification and occurs along 145 km of shoreline or ~0.5% of the coast).

Pilings are not considered a shore modification unless they are driven in side-by-side to form a retaining wall, in which case the shore modification code for wooden bulkhead would be used. Floats also are not cataloged as part of the shore modification attributes. Fill and tailings placed deliberately at landings, industrial sites, or around structures are cataloged as landfill. Domestic trash and debris around a house is not considered a landfill.

Cataloging Coastal Vulnerability of Periglacial Shorelines

A *Coastal Vulnerability Module* (CVM) was introduced to the ShoreZone program in 2012 to index the potential sensitivity of permafrost shorelines to coastal change, especially to rising sea levels. The CVM records a number of key attributes for each shore unit that provide some measure of sensitivity to either erosion or to flooding by storm surge or sea level rise. The module was developed for soft-sediment, permafrost shorelines and is not normally applied to rocky or "hard" shorelines.

The CVM is based on categorical classification of observed features. For example, one means of estimating flooding potential is to estimate the severity of previous storm surge events from the position of the log-debris line relative to the present high-water line; in some cases the storm log line is more than 100 m inland from the high-water line, indicating the potential for extensive flooding during storm surge events. By using a variety of classes for the storm logline position relative to the high-water line (e.g., <10 m, 10-50 m, 50-100 m and >100 m), the sensitivity to coastal inundation can be categorized. Similarly, coastal erosion morphologies can be classified to provide measures of coastal erosion sensitivity. Attributes included in the CVM are summarized in Appendix D.

4.3 Guidelines for Cataloging Across-Shore Components

Each along-shore unit is further characterized by the mapper in terms of across-shore components (Fig. 9), which are geomorphic features (*Forms*) such as cliffs, beaches, and tidal flats, with associated substrate characteristics (*Materials*). The across-shore component attributes are entered into the Xshr Table of the database and are linked to the parent data in the Unit Table by a unique identifier, or PHY_IDENT.

The across-shore components are described in terms of:

- the tidal zone in which they occur (supratidal, intertidal, or subtidal).
- a landward to seaward sequence
- observed forms and substrates (e.g. a cobble berm)

Tidal Zones

In each unit there are three Zones (Fig. 9): the *Supratidal* (A zone), the *Intertidal* (B zone), and the *Subtidal* (C zone), normally with at least one component each (i.e. A1, B1, C1). Other Zone mapping guidelines are summarized in Table 15.

Across-Shore Components

Each zone is subdivided into a number of across-shore *Components*, which are delineated on the basis of morphology and substrate composition (Fig. 9). Features such as dunes, beach berms, beach faces, and beach terraces are examples of across-shore components. Appendix A Tables A – 16 and 17 include a complete listing of the Forms and Materials codes that are used to describe across-shore *Components*.

Components numbered from highest to lowest elevation along an across-shore profile (e.g. Component A1 is the highest supratidal component; A2 is next lower and closer to the intertidal; B1 is the highest intertidal component; B2 is lower intertidal). The presence of the Component boundaries are estimated from observed changes in slope and texture that define different morphologic forms. For example, the Component B1 could be dominated by a pebble-sand beach face (Form Bf), while the B2 is characterized by a wide tidal flat (Form Tt).

Table 15. Descriptions of the Supratidal, Intertidal and Subtidal Zones in Alaska.

Gulf of Alaska and Bering Sea coasts:

Supratidal (A) Zone: This zone lies between the upper limit of the marine influence and the mean-high water line. It is also known as the "splash zone" on rocky coasts. The top of the *Supratidal Zone* may be marked by the presence of a storm debris line of logs. On rocky substrates, it is characterized as the area between the black lichen *Verrucaria* and terrestrial vegetation (grass or trees). Grass and trees may be mapped as Materials in the *Supratidal Zone* when within a marsh or when overhanging, rooted in, or covering any part of the supratidal zone.

Intertidal (B) Zone: The *Intertidal Zone* lies between the mean high tide line (indicated by the upper wrack line or on rocky shores, at the base of the black lichen) and the lower low-water line. This region is completely inundated by daily tides. Estimating the position of the upper and lower limits of the intertidal zones are challenging in the Arctic where tidal ranges are often exceeded by wind-driven storm surges.

Subtidal (C) Zone: The *Subtidal Zone* is the zone below the lower low-water line (from chart datum and deeper); this is also known as the shallow nearshore zone. River channels do not extend into the *Subtidal Zone*. Vegetation in river channels not at the seaward delta edge would be considered part of the B zone and would be entered by biomappers against the component's River Form (Rs). Forms and Materials are occasionally entered in the C zone, including lagoons (Form Lo or Lc), tidal flats or channels (Form Tt or Tc), and anthropogenic features. Forms in the C zone do not require a Material but should include one if anthropogenic (e.g. pilings or breakwater). Floats should be mapped in the A and B zone but not in the C zone. Some units lack a true subtidal zone. In these cases, mappers delete the C zone row and enter "no C zone" in the XShr comment field of the LOWEST B ZONE. This procedure assists in database QA/QC and in biological mapping.

Chukchi Sea, Beaufort Sea, and Bering Sea Permafrost Coasts:

Supratidal (A) Zone: This area is infrequently submerged by extreme meteorological tides or storm surge (>1.5 m), and often marked at the uppermost edge by the landward-most log lines or by salt-damaged or dead vegetation.

Intertidal (B) Zone: This area is regularly submerged during the range of non-extreme water level fluctuations (<=1 m), and is often marked by a recent wrack line, by a difference in surface texture, or by a break in slope.

Component Forms

Each across-shore component has both *Form* and *Material* descriptive codes, which are entered in the ShoreZone dataset (see Appendix A, Table A-16 and 17); Figure 9 shows a schematic representation of different across-shore component Forms. The first letter of the code represents a general category, such as ‘C’ for Cliffs or ‘B’ for Beaches, and the following letters represent modifiers to the general category (for example, “Casl” represents a Cliff that is actively eroding, is steep, and is <5 m in height). This use of the coding system allows the dataset to be searched for specific features while providing the mapper with a flexible means of describing the wide-range of supratidal, intertidal, nearshore subtidal morphologies, and sediment textures.

The general assumption is that each component is uniform in the alongshore direction (Fig. 9). In reality, there may be some alongshore variation so each across-shore component has fields for the Primary form/material, the Secondary form/material, and the Tertiary form/material. If a form/material comprises less than 10% of the unit’s alongshore length, it usually will not be listed.

Other guidelines for mappers are summarized in Table 16. Special guidelines related to anthropogenic features are summarized in Table 17.

Component Materials

Definitions of the *Materials* codes are listed in Appendix A (Table A-17) and follow a rationale similar to that used to categorize Forms, with codes first for the major substrate category such as ‘R’ for Rock and ‘C’ for Clastics, followed by modifiers (for example Csp would be a Clastic material comprised of sand (dominant) and pebbles (secondary)). As with the coding system for the Forms, there can be Primary, Secondary, and Tertiary Materials. All Forms must have a Material code, unless it is a lagoon (L) or tidal channel (Tc) mapped in the subtidal zone.

Guidelines for coding Component Materials are summarized in Table 18.

Table 16. Guidelines for Mapping Selected Component Forms.

Anthropogenic features: When an anthropogenic feature is mapped as a Form, further data about this feature should be entered in the *Shore Modification* fields of the *Unit Table*. A few exceptions do apply: pilings (Aa) and floats (Af) do not require a *Shore Modification* field entry.

Cliffs: Active vs. Passive (Casl vs. Cpsl): A cliff is considered active when there is bare substrate showing (this is the most common case). A cliff is considered passive when it has substantial vegetation growing on it, suggesting a highly stable surface.

Beach berm vs. Beach storm ridge (Bb vs. Bs): A beach berm receives frequent marine influence, contains more recently mobilized sediment, and may be found in the intertidal zone or sometimes in the lower supratidal zone. A beach storm ridge receives occasional marine influence and is only mapped in the supratidal zone. There will often be terrestrial vegetation growing on a beach storm ridge (grasses and trees), suggesting it is stable. A beach berm will not have vegetation growing on it, owing to its more mobile nature.

Beach face vs. Beach veneer (Bf vs. Bv): A beach *face* is solely composed of mobile sediments and shows no evidence of underlying bedrock. A beach *veneer* code is used when a rock platform has a near continuous covering of sediment over it. The underlying rock platform will be obvious and poke through the sediment.

Beach low-tide terrace vs. Tidal flat (Bt vs. Tt): A Bt can be used for flat beaches (<2 degrees) that occur in the upper B zone. It can also be used in the lowest B zone IF the width of that zone is <10% of the overall intertidal zone width. Typically a Tt is used when the width of that B zone is >30 m.

Beach plain (Bp): A beach plain is a supratidal feature and should not be used as a code in the intertidal zone. Generally they are rare features but can be found on outer exposed coastlines. Beach plains are wide, flat features that show coastal progradation, as evidenced by a series of shore-parallel, vegetated ridges in the supratidal zone. Washover features may cut across the beach plain in places (use the washover fan modifier (w) in the coding, i.e. Bpw).

Tidal channel vs. River single channel: (Tc vs. Rs): Most rivulets that occur on tidal flats are Rs or Ri, but not Tc. A Tc should be mapped only when the tidal flat is wide (>200 m), flat (<3°) and shows no visible fluvial source.

Offshore Island (O): This code is only used when a main shore unit has an offshore islet grouped with it. For example: If the islet consists of a low cliff with a boulder veneer it will be mapped as follows: Form 1: Ol – Cb/R. When mapping the same islet as a separate unit it will be mapped as follows: Form 1: Cail – Cb/R. If islets are shown on the electronic shoreline, they will normally be mapped as their own unit (several islets can be grouped together as one unit), unless the islets have no vegetation in the Supratidal Zone (in which case they are considered a reef, Form R). If islets are not on the electronic shoreline they can be mapped as a form on the main shoreline unit using the Offshore Island (O) code. Generally the Offshore islet code (O) is avoided, because a better characterization is achieved using the appropriate geomorphic form code.

Reefs vs. Islands: Islands that are vegetated are mapped according to the aforementioned rules. Reefs are not vegetated and are thus mapped as a secondary form of the main shore unit using the reef (F) code.

Table 17. Special Notes on Certain Anthropogenic Forms *.

Structure	Function
Breakwater **(Form "Ab")**	barrier that provides an area of reduced wave energy, commonly for harbors and marinas
Bulkhead **(Form "As")**	retaining structure of timber, steel, or reinforced concrete, used for shore protection; sometimes referred to as a seawall
Jetty **(Form "Aj")**	pier or structure projecting perpendicular from the shore with the purpose of stabilizing a channel, inlet, or harbor
Sheet pile **(Form "As")**	usually flat, steel panels driven side by side to retain earth or to prevent seepage into an excavation
Wharf **(Form "Aw")**	structure built on the shore of or projecting into a harbor, stream, etc., so that vessels may be moored alongside to load or unload or to lie at rest; also called a quay or a pier

* see complete list in Appendix A, Table A - 16

Table 18. Guidelines for Mapping Component Materials.

Material: (substrate and/or sediment type) The Mat1 field is the class of substrate that best characterizes Form1, and is described by a specific set of codes (Table A-17). The first letter is uppercase, followed by at least one and up to five lowercase modifiers (e.g. Cbc or Btg). All Forms must have a Material code, unless it is a lagoon (L) or tidal channel (Tc) mapped in the C zone. In these cases it is acceptable to leave the Material code out because the material is often not obvious.

Clastic Materials (C): Sediments should be listed in the order of abundance. For example, a sand and gravel beach comprised of mostly sand, some pebbles, and occasional cobbles should be coded as Cspc. If it is obvious that one type of material overlies another, use the veneer modifier (e.g. v Cbc/Cps).

Veneer (v): Layers of sediment over top of other sediment should also be coded in order of abundance. For example, if there is an abundance of boulders and some cobbles overlying sand, this would be coded as v Cbc/Cs. The lowercase v is not used for organics (such as trees, grass, or logs) overlying substrate. If there are logs in the supra-tidal zone overlying boulders and cobbles, which are overlying rock, code as follows. Form 1: Pr - At/Cbc, Form 2: Pr – v Cbc/R. In general the logs should be mapped in Form 1 unless the logs are very scarce. Note that there is a special veneer indicator on the data entry where the *Veneer Indicator* field is either "blank" = no veneer or "v" = veneer; use "v" when unconsolidated sediment overlies rock or other sediment (e.g. v Cbc/Cps); do not use when organics overlie substrate (e.g. Bt/Cps or At/Casl).

Biogenic Logs (Bl) vs Anthropogenic Logs (At): *Biogenic Logs* (Bl) have eroded or fallen from a forested shoreline owing to coastal, fluvial, or mass wasting processes. In most cases, these logs will have a root ball or some portion of the roots still attached, indicating that they have not been cut. In other cases they may be lying across the intertidal zone while still being attached to the ground in the supratidal zone. *Anthropogenic Logs* (At): Logs that have been cut due to logging activities. These logs have most likely escaped from log booms and will not have any roots or branches attached. Most logs that are in the supratidal and high intertidal zones are *Anthropogenic Logs* and should be coded as such. When there are also living trees and grasses, avoid trying to lump the logs into the biogenic code by using a Bltg code. For example: when both trees and logs over boulders and cobbles are present, and the logs are the most abundant/significant, use the following coding for *Materials*: Mat1 = At/Cbc, Mat2 = Bt/Cbc. When trees and organics are most abundant/significant, use the following coding for *Materials*: Mat1 = Bt/Cbc, Mat2 = At/Cbc. Note that no veneer (v) is used for either of these Material codes.

Component Widths and Slopes

The average across-shore component is input as the width (in meters). Only the width for the primary component (e.g. A1, B1) is entered, and it must be consistent with the Shore Type assignment (that is, the sum of B zones <30 m are different classes than those >30 m; see Table 9).

The estimated across-shore slope of the mapped primary geomorphic form is input as slope (in degrees). Only the slope for the primary component (e.g. A1, B1) is entered, and it must be consistent with the Form codes (Table A-16). For example, a flat platform (Pf) must have <5° slope; a ramp (Pr) must have slope between 5° and 19°; an inclined cliff (Cail) must have a slope between 20° and 35°; a steep cliff (Casl) must have a slope >35°.

Component Processes

ShoreZone mappers also provide an estimate that indicates the dominant process affecting each of the components. This information helps users to identify the processes that are most likely to be modifying the component. Processes that are cataloged include: fluvial, mass-wasting (landslides), currents, waves, or winds (aeolian). Wave processes are the mostly commonly identified process for the shore zone. There is also the flexibility to include other processes where additional info is included within the comment field.

Component Oil Residence Index

There are two types of Oil Residence Indices (ORI) provided in ShoreZone – one index for the entire unit and a more detailed index for each across-shore component. The practice evolved because we noticed that the Unit ORI did not always capture some of the detail important for spill response. For example, we noted that mudflats backed by rip-rap would typically be coded as a “mudflat” (BC_CLASS = 29) and as a result would have an assigned ORI of 3 (persistence = weeks to months). However, rip-rap would generally have a much longer potential residence with and ORI of 5 (months to years). By assigning an ORI to each across-shore component, the ORI can be more precisely defined.

One subtle difference between the unit ORI and the component ORI is that the unit ORI uses *Biological Wave Exposure* when available and the component ORI uses *Observed Exposure* (estimated by physical mappers from fetch). These values are generally the same but can differ and this difference may explain variance between the unit and component ORI estimates.

The Component Oil Residence Index (Appendix A Tables A-6 and A-8); defines the persistence of oil residence on the basis of substrate type on scale of 1 to 5, in which ‘1’ reflects probable short oil residence (days to weeks) and ‘5’ reflects the potential of long oil residence (months to years). Additional guidelines for applying ORI are included in Table 19.

Table 19. Guidelines for Assigning Component Oil Residence Index.

- ORI is assigned for each *Component* of the A and B zones but refers only to Form 1.
- ORI and materials in Form1 should be consistent, rather than refer to sensitive items in Form 2 or Form 3. If necessary, move the sensitive items to Form 1 or break the unit accordingly.
- ORI code is determined by the most sensitive material in the component. For example: Biogenic grass over sand and pebbles (BI/Csp) in a semi-protected exposure (SP) will have an ORI of '5', owing to the grass in the component.
- Table A-7 does not provide an ORI code for organics and vegetation when the exposure is SE, E, or VE. There are some occasions when organics do occur in the supratidal zone within these exposures (as marshes or lagoons). In these cases, an ORI of '5' is assigned to recognize the existence of these organics.

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SHOREZONE BIOLOGICAL MAPPING 5.0

Biological ShoreZone mapping is based on the interpretation of patterns of biota observed in the aerial imagery, with data recorded on the occurrence and extent of species assemblages or *biobands*. The observations of presence, absence, and relative distribution of the *biobands* are recorded in the mapping within each alongshore unit. Based on those observations, two interpreted classifications for *Biological Wave Exposure* and *Habitat Class* are assigned.

ShoreZone mapping in Alaska started in Cook Inlet and expanded to include most of the coasts of the Gulf of Alaska (Fig. 1) following biological definitions adapted from those written during mapping of the British Columbia coast, where attached coastal biota are similar.

As the ShoreZone program moved onto Arctic coasts of Alaska, the biological protocols needed to be updated to include attributes for the biota on coastline structured by periglacial/ permafrost processes, where most of the shoreline is dominated by mobile sediment. The coastal habitats in Western Alaska and along the North Slope are essentially different than habitats further south.

5.1 Principal Steps in ShoreZone Biological Mapping

The biological mapping takes place in four main tasks, as outlined in Table 20. The mapping stations that are used include dual monitors for reviewing video and still imagery simultaneously, together with data entry screens, and are similar to the physical mapper stations shown in Figure 16.

Units delineated as along-shore coastal segments by the physical mappers (Fig. 8) are the framework to which biological attributes are attached. Biological mappers do not create additional units or change the spatial depiction of the unit, and all biological attributes are recorded within the spatial database provided by the physical mappers. The biobands observed are coded within the across-shore Components for each unit (Fig. 9), while the biological attributes that apply to the unit as a whole (i.e., Biological Wave Exposure, Habitat Class) are entered in the Biounit Table.

Table 20. Summary of Biological Mapping Steps.

Task	Activities
Assembly of Materials	• data entry reference tables and biological codes (Appendix A) • video and digital still photo imagery for project region • paper copies of unit breaks and shoreline classified and mapped by physical mapping team • MS_Access database front end containing data entry forms linked to back end master SQL database • region and area shapefiles (ArcGIS) • aerial video imaging survey (AVI) flight report
Mapping	• review video, digital still photos, and audio commentary, and use the shore unit breaks delineated on paper maps with time stamp on video to identify unit breaks • along-shore unit attribute data are entered into the Biounit Table (Table A-9) • across-shore attribute data (Biobands) are entered into the Bioband Table for each zone and component within each unit (Table A-18) • 10% of the shoreline units are reviewed by another biological mapper as part of the QA/QC procedure (including all biological tables)
Data Assembly	• database manager checks final biological data tables in the master database; final QA/QC is performed, themes reviewed in GIS • biological mapping database tables are transferred to physical mappers • physical and biological thematic maps (shapefiles) are created and maps are produced
Preparation of Deliverables	• summary report is prepared for the region, summarizing mapped attributes, physical themes, biological themes, the most recent version of the data dictionary, bioband descriptions of the region mapped, and database lookup tables

5.2 Bioband Descriptions, Guidelines

A *Bioband* is an observed assemblage of coastal biota, found on the shoreline at characteristic wave energies, 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 (Fig. 18). Biobands are described across the shore, from the high supratidal to the shallow nearshore subtidal, and are named for the dominant species or group that best describes the entire bioband.

Some biobands are named for a single *indicator* species (such as the Blue Mussel bioband [BMU]), while others represent an assemblage of co-occurring species (such as the Red Algae bioband [RED]). Indicator species are the species that are most commonly observed in the band. Other species that are also likely to be found in the bioband are listed as *associate* species. Observations from ground station surveys have confirmed that many common species may be found in more than one bioband, and the *indicator* and *associated* species listed in the bioband definitions are those which best describe the overall appearance and assemblage present for the band.

Alaska biobands are listed in Table 21 and further details for each bioband are listed in Appendix A, Tables A – 19, 20, and 21. Aerial photo examples for selected biobands are presented in Appendix C.

The distribution of each bioband observed in every unit is recorded in the database. Bioband occurrence is recorded as *patchy* or *continuous* for all biobands except for the Splash Zone bioband (VER), which is recorded from an estimate of the across-shore width (as *narrow, medium,* or *wide*). A distribution of *patchy* is defined as 'visible in less than half (approximately 25 - 50%) of the along-shore unit length' and *continuous* is defined as 'visible in more than half (50 - 100%) of the unit's alongshore length'.

Additional guidelines for categorizing bioband occurrence are summarized in Table 22.

Some biobands are generally observed with higher confidence than others, and may be visible as discrete patches of biobands at lower density than less obvious biobands. For example, the Red Algae (RED) bioband is usually in low turf and mixed with other larger algae dominated bands and therefore can be hidden by larger seaweeds. Often the Eelgrass (ZOS) and Surfgrass (SUR) biobands are easier to see, even if present as scattered patches, as they are usually colour contrast to the lower intertidal seaweed (often the large browns of the Soft-brown Kelps (SBR) or the Dark Brown Kelps (CHB)). The nearshore canopy kelps (Bull Kelp (NER), Dragon Kelp (ALF), and Giant Kelp (MAC)) are also generally observed with higher confidence, as they all have large sized individuals and are easier to see even when bioband is patchy.

Further discussion of mapper confidence limits is presented in Section 6.0 and in Harney *et al.* (2009) and Harney and Morris (2007).

Figure 18. Biobands on a Semi-protected shoreline in Prince William Sound.

Biobands which have been described and mapped for the coasts of Alaska are listed in Table 21. As mapping has continued through different regions of the Alaska coast, new biobands have been added to the protocol. For example the California Mussel band (MUS) and the Urchin Barren band (URC) are only mapped in southern Southeast Alaska. Two new biobands were added for mapping on the permafrost coasts of Western Alaska and the North Slope – the Tundra (TUN) and Biofilm (BFM) biobands (Table 21).

Table 21. Alaska Bioband Definitions.

Zone	Bioband Name	Bioband Code
Supratidal	Tundra	TUN *
	Splash Zone	VER
	Dune Grass	GRA
	Sedges	SED
	Salt Marsh	PUC
Upper to Mid-Intertidal	Biofilm	BFM *
	Barnacle	BAR
	Rockweed	FUC
	Green Algae	ULV
	Blue Mussel	BMU
	California Mussel	MUS **
	Bleached Red Algae	HAL
Lower Intertidal and Nearshore Subtidal	Red Algae	RED
	Alaria	ALA
	Soft Brown Kelps	SBR
	Dark Brown Kelps	CHB
	Surfgrass	SUR
	Eelgrass	ZOS
Subtidal	Urchin Barrens	URC **
	Dragon Kelp	ALF
	Giant Kelp	MAC
	Bull Kelp	NER

* Tundra (TUN) and Biofilm (BFM) biobands are only mapped in the permafrost shorelines of the Arctic coasts.

** California Mussel (MUS) and Urchin Barrens (URC) biobands are observed only in the southernmost outer coast of Southeast Alaska, however they are common on the British Columbia coast.

Table 22. Guidelines for Identification of Biobands.

Bioband Name and Code	Guidelines for Classification
Tundra (TUN)	• On permafrost coasts, where permafrost is present. • Low turf of herbs, grasses, sedges, and dwarf willow in coastal fringe vegetation, supratidal. • Intermingles with salt marsh on low elevation coastal plains, and on inundating tundra. May extend inland considerable distance.
Splash Zone (VER)	• Is recorded by width: Narrow (N -- less than 1 m); Medium (M -- 1 to 5 m); or Wide (W – greater than 5 m). • Is only mapped if considered to be present with dense enough cover to be visible in less than half of the along-shore length of the unit (i.e., 'Patchy' coverage minimum). • Color is dark grey to black on bedrock or boulders. • Is only mapped in one A zone (the one that most closely matches it) even if it stretches across multiple zones it would, for example, only get mapped as wide (W) in the A1.
Dune Grass (GRA)	• Blue-green grey in color, tall grass. • Distribution of monoculture clumps of *Leymus*. • In A zone, often associated with driftwood, storm berm.
Sedges (SED)	• Bright green in color and tall. May turn orange-brown color in the late summer/early fall. • Found in thick expansive stands, associated with freshwater and riverine systems, at the heads of estuaries, and may appear as circular clumps. • Often mapped in large estuaries where stand of pure sedge are observed. *(Note that sedges may also be a significant part of mixed salt-tolerant herbs, sedges, and grasses described by PUC bioband.)*
Salt Marsh (PUC)	• Represents any species assemblage of salt-tolerant grasses, sedges, and herbs. • Rooted vascular vegetation typical of low marsh elevations, in A zone; however can be mapped in the upper B zone in a low marsh (form Ml). • Often appears as patchwork of species, can be low-turf, showing little to no shadow or height, and a mixture of species. • Sedges are included in this band and when observed in combination with other salt marsh species are mapped as PUC.
Biofilm (BFM)	• Very low organic mat or stain in particular in drying ponds or salt marsh swales. • May include blue green algal mat.
Barnacle (BAR)	• Visible as a white, cream, or yellow band, a 'frosting' of attached barnacles. • Often found in the upper intertidal but can be in the middle and lower (usually covered by algae and not visible). • Sometimes visible as two separate bands that can be slightly different colors depending on the species of barnacle.
Rockweed (FUC)	• Color ranges from bright golden-brown to orangey-brown to dark. • Found in the upper intertidal, sometimes mixed with the BAR band, sometimes a distinct band below the BAR. Often mixed with Blue Mussel (BMU). • Observed at all but the highest wave exposures.
Green Algae (ULV)	• May be bright green or dark emerald color. • Usually in mid to lower intertidal, and includes both filamentous or foliose greens. • Low turf, often mixes with RED or with eelgrass (ZOS).
Blue Mussel (BMU)	• Color varies from dark black to blue-grey. • Usually occurs below the FUC and BAR bands but above the ULV or RED bands. • May form continuous inky black band, in particular on rock walls and in fjords, or be observed as scattered clumps on boulders.
California Mussel (MUS)	• In Alaska, only occurs in southwestern-most portions of Southeast Alaska. • Found at Exposed and Semi-exposed wave energies on the open west coast of Southeast Alaska coasts. • Closely associated with abundant gooseneck barnacles and thatched barnacle, making the band appear light grey in color.

Table 22, continued. Guidelines for Identification of Biobands.

Bioband Name and Code	Guidelines for Classification
Bleached Red Algae (HAL)	• Pale yellow-gold-green color. • Represents bleached filamentous and foliose red algae, similar species to RED bioband. • Indicator of Semi-protected wave energy when present.
Red Algae (RED)	• Red algae include filamentous, foliose and coralline algae, and different species assemblages occur at different wave exposures and in different bioareas. • Foliose and filamentous RED assemblages often intermingle with SBR and CHB. • Foliose and coralline RED algae disappear before the exposure drops to Protected and are some very good indicators of this transition when they are present. • A low turf of filamentous RED is often mixed with diatom scum and is found in higher Protected / Semi-Protected wave exposure environments. It is not a strong indicator of the transition from Semi-Protected to Protected. • Coralline RED algae is found at a wide range of exposures. It is almost always found in the highest exposures (Exposed) but is often obscured under other lower intertidal biobands (i.e., Alaria (ALA), Dark Brown Kelps (CHB), and/or foliose Red Algae (RED)).
Alaria (ALA)	• Named for the monoculture of *Alaria* that is observed as a bioband at upper elevation edge of Soft Brown Kelps (SBR) or Dark Brown Kelps (CHB) biobands. • The species *Alaria* also occurs as a component of the Soft Brown Kelps (SBR) or Dark Brown Kelps (CHB) .
Soft Brown Kelps (SBR)	• SBR biobands is typically formed by a dense cover of large-bladed, understory benthic kelps. Blades are usually ruffled, and are observed in the lower intertidal and nearshore subtidal. • Characterize Semi-Protected and Protected wave exposure, but also are seen in low Semi-Exposed.
Dark Brown Kelps (CHB)	• Dark, shiny brown stalked kelps, observed in the lowest intertidal and nearshore subtidal. • Indicator of higher wave exposures. • Usually a mixture of species of large brown understory kelps, although it can be monoculture of single species at the highest wave exposure in some bioareas (i.e., *Lessoniopsis*).
Surfgrass (SUR)	• Bright green in color, grassy-like blades. Always attached to hard substrate (i.e., bedrock or immobile boulder/cobble). • Good indicator of Semi-Exposed wave exposure. • Can be observed as bleached beige-white on upper elevation of wide rock platforms (surfgrass bleaches, while eelgrass does not).
Eelgrass (ZOS)	• Bright green in color, grass-like blades. • Only found on soft substrate such as sand or fines, in lower intertidal. • Found at lower wave exposures.
Urchin (URC)	• In Alaska, only mapped in southernmost Southeast Alaska. • Appears as bare subtidal white or pinkish coralline algae on immobile substrate, and often as a sharp change in algal cover at lower intertidal, from lush SBR/CHB or canopy kelp biobands to bare coralline algae. • May or may not see red sea urchins.
Dragon Kelp (ALF)	• Always seen as canopy kelp species, in nearshore subtidal. • Distinctive ribbony appearance to fronds, with floating mid-rib and long, linear blades. • Indicates Semi-Exposed or Semi-Protected wave exposures. • In Southeast Alaska, seen in waters influenced by tidewater glacier, and also common in Kodiak archipelago and westward.
Giant Kelp (MAC)	• Always seen as canopy kelp species, in nearshore subtidal. • Distinctive pattern of large plants, with fronds and small floats. • Indicates Semi-Exposed or Semi-Protected wave exposures. • Most Alaska distribution is in Southeast Alaska; however a recently-discovered population is established at the northeast end of the Kodiak archipelago.
Bull Kelp (NER)	• Always seen as canopy kelp species, in nearshore subtidal. • Distinctive single long stipe, with bulb float and multiple fronds. • Occurs in current-affected and current-dominated areas. • Occurs in Semi-Protected and up to the highest wave exposures. • Wide geographic distribution.

5.3 Biological Wave Exposure

Biological Wave Exposure is assigned based on the observations of the presence and abundance of biota in each alongshore unit. Exposure categories are defined with a typical set of biobands, using the known wave energy tolerances for indicator species, as compiled from scientific literature and expert knowledge. The assemblages of species and/or biobands present in each shore unit are essentially used as a 'proxy' for estimating the energy in each shore unit. Values range from Very Protected (VP) to Very Exposed (VE) and the category is recorded in the EXP_BIO field in the database.

The six biological wave exposure categories have the same names as those used in the physical mapping to characterize wave exposure (Table A-5), however, the physical wave exposure is based on fetch estimates and coastal geomorphology, (EXP_OBSER in the Unit Table of the database). The biological wave exposure category is considered to be a better index of exposure than are estimates derived from fetch measurements, and is used as '*best available wave exposure estimate*' when available.

On many of the Arctic coasts, extended sections of shoreline are dominated by mobile sediment beaches where attached biota are largely absent, and using observations of biota to estimate wave exposure categories is not possible. On those bare sediment beaches, the best available wave exposure estimate is the attribute assigned by the physical mappers from wind fetch observation (EXP_OBSER), and that is deemed to be equivalent to the biological wave exposure. The best available wave exposure estimate is the one used in the look up matrix for assigning the unit's Oil Residence Index (Table A-8) as well as for determining each unit's Habitat Class (Table A–14).

Typical species and corresponding biobands are summarized for each biological wave exposure category in Table A–12. Guidelines for assigning the biological exposure category to each unit are listed in Table 23. Biobands (and species in the biobands) listed for each wave exposure are considered 'typical' but are not 'obligate'; that is, not all of the indicator biobands (or species) occur in every unit classified with a particular biological wave exposure.

The upper intertidal biota tends to be made up of similar species assemblages in different wave exposure categories and geographic areas and are thus considered weak indicators of exposure. For example, the ubiquitous Barnacle bioband (BAR) is found across all exposure categories. In contrast, lower intertidal biobands are more diagnostic of particular wave exposures. For example, the Surfgrass band (SUR) is indicative of Semi-Exposed (SE) settings, while the Eelgrass band (ZOS) is indicative of Semi-Protected (SP) and Protected (P) environments.

Generally, the lower intertidal biobands are those which are the strongest indicators of differences between different wave exposures. On rocky coasts of the Gulf of Alaska, the highest energy coastlines are generally indicated by the co-occurrence of Dark Brown Kelps (CHB) and Red Algae (RED) biobands, while a lush Soft Brown Kelps (SBR) bioband is one of the indicators of Semi-Protected wave exposures. Combinations of the Red Algae (RED) or Alaria (ALA) biobands with either of the brown kelps bands occur in areas of transition between Semi-protected and higher wave exposure categories.

The 'Very Exposed' biological exposure category has only been applied in biological mapping of the Outer Kenai coast, in Kenai Fjords National Park Alaska, and on the southwest coast of Moresby Island, British Columbia. Species assemblages are a subset of those found in Exposed shorelines. In these Very Exposed locations, the shoreline morphology consists of vertical, high cliffs, and the coastline is open to the full force of ocean waves from abyssal depths in nearshore waters of the north Pacific.

Table 23. Guidelines for Assigning Biological Exposure from Observed Biobands.

Biological Wave Exposure	Guidelines for Classification
Very Exposed (VE)	• This exposure category is used only for areas of extreme high wave energy, where shoreline is vertical rock cliff and there is no moderation of open ocean swells in nearshore. • Splash Zone is extremely wide.
Exposed (E)	• The Splash Zone is wide to very wide. • Upper intertidal usually bare-looking, with only a thick Barnacle (BAR) bioband visible. • Lower intertidal tends to have lush Dark Brown Kelp (CHB) mixed with Red Algae (RED). • Nearshore canopy kelp (if present) is Bull Kelp (NER).
Semi-Exposed (SE)	• The Splash Zone will usually be medium to wide in width. • Exposure category with the highest species diversity. • Indicated by the presence of Dark Brown Kelps (CHB), lush Red Algae (RED), Alaria (ALA) and in some locations, Surfgrass (SUR) biobands.
Semi-Protected (SP)	• The Splash Zone is medium to narrow in width. • Indicated by Barnacle, Rockweed, and Green Algae (BAR, FUC, and ULV) where they may appear as lush cover. In higher SP, Red Algae and Alaria biobands (RED and ALA) are often observed. • Eelgrass (ZOS) occurs in the lower Semi-Protected areas and Surfgrass (SUR) can be in the higher Semi-Protected areas.
Protected (P)	• Limited attached biota present observed. • Indicated by patchy Barnacle, Rockweed, and Green Algae (BAR, FUC and ULV) in the intertidal and Eelgrass (ZOS) or sparse Soft Brown Kelps (SBR) in the subtidal. • If the Splash Zone is present it is narrow. • The riparian overhang is often 100%. • No canopy kelps present. Canopy kelps in otherwise Protected areas indicate a current dominated Habitat Class.
Very Protected (VP)	• Use of this category is limited to areas of very low wave exposure and limited diversity of biota, as are seen at the extremely sheltered heads of inlets or in ponded lagoons with a limited intertidal range. • Often only the wetland biobands will be present, and the intertidal is bare of attached biota.
Note: The Biological Wave Exposure is recorded as the highest exposure category observed in the unit, according to the indicator species and biobands present. In units where shoreline is complex, or where there are wide intertidal platforms, there may actually be a range of exposures and associated indicator species spanning the across-shore width of the unit, from the waterline (where the energy is highest) to the splash zone (where it is the lowest).	

5.4 Habitat Class Descriptions, Guidelines and Examples

Habitat Class is a summary attribute that combines both physical and biological characteristics observed for a particular shoreline unit. The species assemblages present at on the shore are a reflection of both the wave exposure and the physical characteristics of that shore segment. Thus, the Habitat Class assigned to an Exposed shore with a mixture of rock and mobile sediment will be different from that of a Protected shore with a wetland complex.

Where the dominant structuring process in the shore unit is wave energy (Table 24), the interaction of the wave exposure and the substrate type determines the *substrate mobility,* which in turn determines the presence and abundance of attached biota. Where the substrate is stable, (i.e., bedrock or large boulder), epibenthic assemblages can establish. Where the substrate is mobile, attached biota will likely be sparse or absent, such as on higher energy sand or pebble beaches.

Most units have the *Habitat Class* category determined by wave energy as the dominant structuring process (Table 24). The three classes of substrate mobility used in ShoreZone habitat characterization are:

- **Immobile or Stable**: Substrates such as bedrock, boulders, and cobbles (could even be pebbles on a low energy coast).
- **Partially Mobile**: Mixed substrates such as a rock platform with a beach or sediment veneer, or units where energy varies across the beach. The partial mobility of the sediment limits the presence of attached biota that would likely occur on a stable rock shoreline.
- **Mobile**: Substrates such as sandy beaches where coastal energy levels are sufficient to frequently move sediment, thereby limiting the presence of epibenthic biota.

Table 24. Guidelines for Assigning Habitat Class Categories.

Structuring Processes		Guidelines for Classification
Wave Energy	*Immobile, Six Wave Exposures*	• Usually bedrock platforms or cliffs. • Depending on the exposure, this category may include units with bedrock and large boulders covered in algae or even sediment only beaches (if the sediment size is large and the wave exposure is low; e.g. a boulder beach). • If the area of the unit contains <10% mobile sediment it is still classified as immobile (this should assure that the Habitat Class matches Coastal Class).
	Partially Mobile, Six Wave Exposures	• Can range from totally mobile beaches with bedrock outcrops to bedrock platforms with pockets of sediment. • Units are categorized as Partially Mobile if sediment areas of the unit are bare of attached biota.
	Mobile, Six Wave Exposures	• Bare beaches. • Can have supratidal biobands (i.e., Dune Grass) or nearshore subtidal biobands (e.g., Soft Brown Kelps) but the intertidal is mostly bare of attached biota. • If the area of the unit contains <10% immobile sediment it is still classified as mobile (this should assure that the Habitat Class matches Coastal Class).
Non-wave Energy Structured Habitats		
Estuaries		• A combination of Salt Marsh, Dune Grass, and Sedges biobands which are usually associated with the river or stream. (Supratidal zones consisting of Dune Grass exclusively do not qualify as estuarine wetlands) • Usually a *flowing* river or stream as fresh water source (mapped as an Rs; intermittent streams (Ri) would not provide enough freshwater influence). • Smaller estuaries may show a delta fan morphology.
Current Dominated Channels		• Salt-water, high current channels caused by tidal flow. Current dominated tidal channels are usually found between islands or at the constricted entrances to saltwater lagoons. Generally water movement is visible within the channel but not outside it. • The biota tends to be highly diverse and lusher within the channel than outside the channel, indicating higher energy conditions in the channel (which are due to the current flow, rather than wave exposure). • The biology associated with current channels is anomalous from the surrounding environment and includes assemblages that may be rare within a particular region. These features are usually rare habitats that are limited in distribution.
Anthropogenic		• Man-made structures or filled shoreline (i.e. wharves, piers, log sorts). • Influence the biology of the unit (i.e. dredged ponds, recovering marsh vegetation). • Majority of the features observed are permeable, such as wooden docks and pilings. Impermeable structures include concrete walls, sheet pile piers, and land filled areas. • For *shoreline* modifications only. Does not include modifications occurring only in the C zone, such as log booms (unless the actual shoreline is modified as well).
Lagoons		• Limited or no outlet to the open water, brackish, or salty water. • In supratidal, standing water pond at low tide, usually low or very low wave energy. • A combination of one or more of the Dune Grass, Sedges, or Salt Marsh biobands. • Arctic coast lagoon Shore Types mapped as Lagoon Habitat Class 2 (Note description of HAB_CLASS2 in Table A-13 and 14). • Single units classified as lagoons often have the lagoon form in the supratidal zone; however, some lagoons are large and may encompass several units when the lagoon form is mapped as the subtidal zone.
Periglacial Processes		• Permafrost dominated tundra, showing tundra polygon ice fractures. • Inundating tundra, may include reticulated lagoons or salt-killed vegetation. • Melting tundra cliffs.

Habitat classes determined by dominant structuring processes other than wave energy (Table 24) have limited occurrence along the coast and, except for the anthropogenic shorelines, are usually highly valued habitats. These habitat classes are:

- **Estuary**: Wetland and salt marsh vegetation along low energy sediment shores influenced by freshwater, where the dominant structuring force is 'fluvial'; wave exposure is low, and habitat has 'estuarine function.'
- **Current-Dominated**: Channels where high tidal current is the dominant structuring energy. Current areas cause sections of shoreline with anomalous assemblages of biota, compared to those found at adjacent lower wave exposure units.
- **Anthropogenic**: Features where the shoreline has been modified or disturbed. This category distinguishes between permeable and impermeable anthropogenic material. Examples include wharves, piers, or areas of rip rap or fill.
- **Lagoon**: Enclosed or constricted area of brackish or salty water, often found in the supratidal where wave energy is very low, there is no fluvial energy (distinguishing Lagoons from Estuaries). Lagoons are mapped only as 'secondary habitat classes' (HAB_CLASS2). On Arctic coasts, a new Shore Type (Table 12) was added to describe Lagoon units, and the Lagoon Habitat Class is assigned those units. (See Appendix A, Table A-13 for further description of HAB_CLASS2 definition.)
- **Periglacial/ permafrost Processes:** Occur along Arctic shorelines where permafrost is present. Three types of coastal habitats forms have been defined by physical mappers:
    - inundated tundra
    - ground ice-slumps
    - low vegetated peat

Further descriptions about *Habitat Class* definitions and attribute tables are listed in Appendix A, Tables A–13 and 14. Photo examples of habitat classes observed in Alaska are illustrated in Appendix C.

5.5 Bioareas

As ShoreZone biological mapping has been completed throughout Alaska, broad-scale differences in the coastal habitats have been observed. To recognize these, as well as the region-specific species assemblages noted during ground surveys, a number of bioareas have been described in Alaska. These bioarea boundaries are based on general qualitative observations compiled during surveys and biomapping (Fig. 19 and Appendix A, Table A-10). A similar approach was applied in British Columbia where seven bioareas were defined for the province-wide ShoreZone dataset.

Bioarea boundaries follow broad regional patterns of coastal habitats, the distribution of biobands (and in particular, those biobands in the lower intertidal), and in some areas, the distribution of nearshore canopy kelp biobands. For example, the 'Southeast Alaska – Sitka' bioarea (Fig. 19) has wave exposures ranging from Exposed to Very Protected, has several species of dense nearshore canopy kelps and a diverse array of coastal morphologies; where the Cook Inlet bioarea has wave exposures nearly all Semi-exposed and lower, much of the shoreline is comprised of wide, sediment-dominated shore types, with limited patches of nearshore canopy kelps present.

The differences in the indicator species observed in the lower intertidal biobands (the Bleached Red Algae (HAL), Red Algae (RED), Soft Brown Kelps (SBR), and Dark Brown Kelps (CHB) biobands) are also are used to help define bioarea boundaries. Where ground station surveys have been done, species observations are recorded by biobands, and then can be used to describe the occurrence of indicator and associated species, and to add qualitative description to definitions of biobands (Appendix A, Table A– 19, 20, and 21).

Limits to geographic ranges of species have been precisely mapped by ShoreZone for several biobands. For example the northern limit of the California Mussel bioband (MUS) is shown by the mapping in southern Southeast Alaska, as is the southern limit of Dragon Kelp (ALF). A range extension for Giant Kelp (MAC) was observed during ShoreZone surveys in Kodiak.

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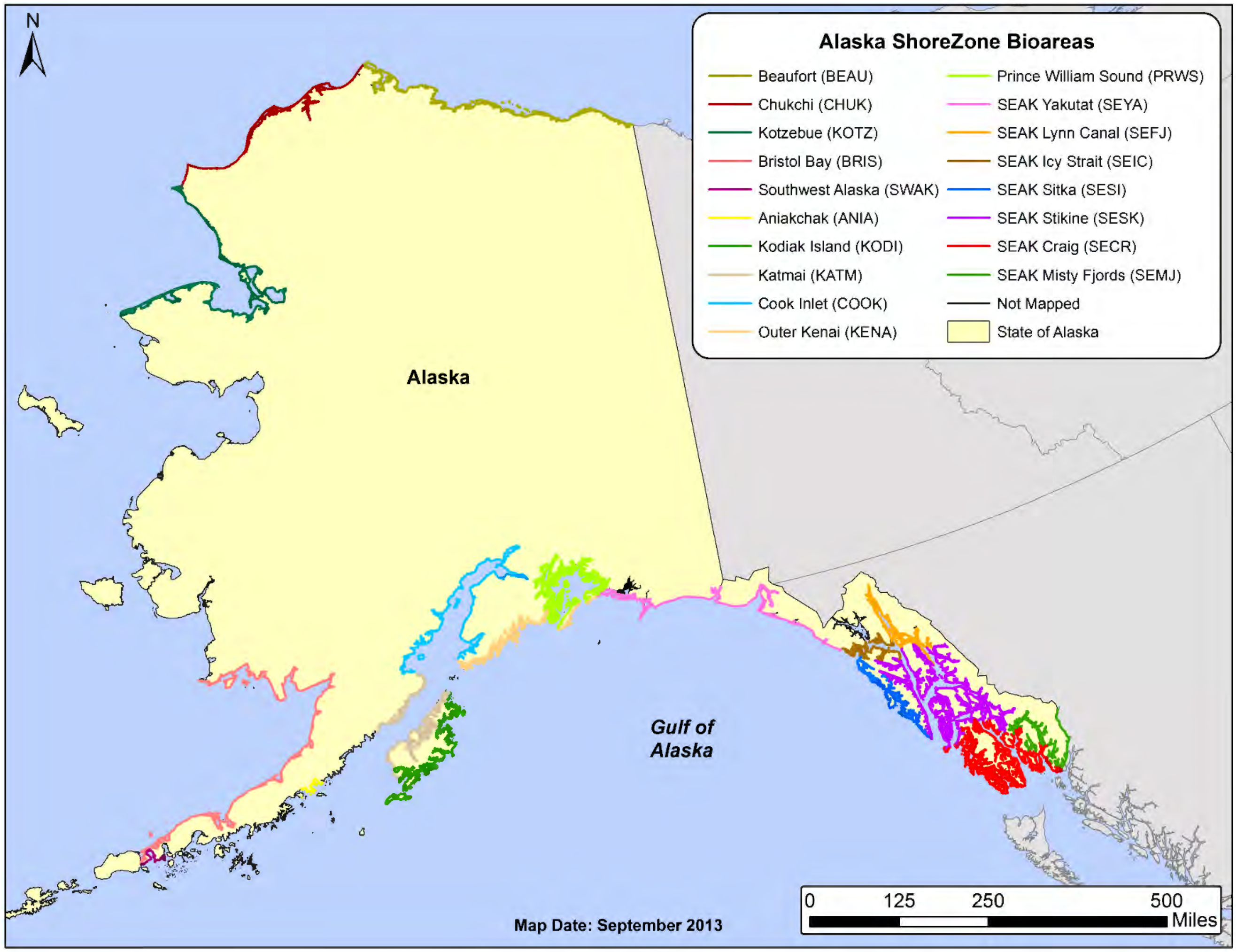

Figure 19. Distribution of ShoreZone bioareas identified in Alaska to date. Bioareas are delineated on the basis of observed regional differences in the distribution of biota and coastal geomorphology.

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SHOREZONE DATASET QUALIFICATIONS 6.0

ShoreZone Coastal Habitat Mapping is accomplished through the interpretation of oblique aerial video and digital still imagery of the coastal zone collected during summer low tides, usually from a helicopter flying at <100 meters altitude. Image interpretation and mapping is performed by a team of physical and biological scientists with formal academic science degrees and experience in geography, mapping, and environmental projects. Junior mappers undergo a three- to six-month training internship during which their work is supervised by a senior mapper with at least one year of experience. A quality assurance and control (QA/QC) protocol requires 10% of each physical and biological mappers' work to be reviewed by another mapper. Database QA/QC and data-entry integrity is ensured by a database manager with two years of ShoreZone mapping experience.

A number of factors influence the complexity of shoreline mapping, including: the natural geomorphology, the coastal crenulations, the quality of the imagery and associated commentary, the quality of the digital shoreline basemap, and the experience of the physical and biological mappers.

The ShoreZone mapping technique has been assessed to establish qualitative and quantitative confidence levels in ShoreZone maps and data: (1) a study of the repeatability of mapping in Southeast Alaska and (2) field verification studies in Victoria, British Columbia (2007) and Sitka, Alaska (2008). This section summarizes the principal findings of each study.

6.1 Mapping Quality Studies

Repeatability Study

The Nature Conservancy provided funding for a study of the repeatability of physical and biological mapping procedures (performed by Coastal and Ocean Resources, Inc. and Archipelago Marine Research, Ltd., respectively). The principal objective of this study was to examine the repeatability of ShoreZone mapping techniques using imagery collected in Southeast Alaska in 2005 and 2006 (Harney and Morris 2007). Three 10-km test sections in Southeast Alaska were randomly selected and mapped by three physical mappers and three biological mappers. Variability between mappers was assessed with respect to:

- segmentation (unit breaks) delineated by physical mappers
- along-shore unit classifications
- across-shore component data within units
- geomorphic feature inventory
- bioband inventory, biological exposure, and habitat class categories

Sources of variability identified in this study included:

- delineation of along-shore unit boundaries according to mapper interpretation
- digitizing of unit breaks on the digital shoreline
- mappers' individual decision-making, recognition, and experience
- human error

The principal conclusions of this study included:

- Shoreline segmentation (unit boundary delineation) by physical mappers showed the most variability, but did not preclude the ability to inventory the geomorphic and biologic features of the shoreline.
- Poor matches or mismatches between physical data attributes were not common, but the sources of variability for such cases included: discerning the relative importance (abundance) of sand in the intertidal, the interpretation of slope in rock outcrops, and decision-making in transitional units (such as those dominated by rock but with some gravel).
- The consistency in interpretation of biological exposure categories (mapped at the unit level) was high, with nearly all units mapped in all three sections scoring as matches. Similarly, the interpretation of the habitat class categories (also mapped at the unit level) showed 77% match or better in all three Test Sections.
- Much of the consistency in biological data was attributable to the nature of data entry, in which bioband observations were restricted to three choices (blank/absent, patchy, or continuous). Unit-level classifications were assigned on the basis of these presence/absence observations of biota. In addition, fields left blank by more than one mapper (indicating an absence of that bioband) were included in the evaluation and considered matches.
- Nearshore canopy kelp biobands (Giant Kelp (MAC), Bull Kelp (NER), and Dragon Kelp (ALF)) were easily identified in aerial imagery, were recorded with the most confidence, and were highly consistent between mappers. Similarly, Eelgrass (ZOS) and Surfgrass (SUR) were recorded with confidence, and observations of these biobands were highly consistent between mappers.
- The lowest bioband match scores were for the Red Algae (RED) and the Soft Brown Kelps (SBR), particularly in habitats with low wave exposure.

External Review

An external review conducted by Carl Schoch (Schoch 2009) suggested the following principal sources of error in the ShoreZone mapping technique:

1) Segmentation errors caused by human subjectivity in the determination of alongshore unit boundaries.
2) Non-standardized resolution GIS vector basemaps and trying to join ShoreZone data to existing low resolution shoreline delineations.
3) Classification errors caused by ambiguity of feature descriptors and the overall qualitative nature of ShoreZone.
4) Inability of the ShoreZone classification to consistently describe actual shoreline features within a specified minimum (or maximum) mapping unit.

6.2 Field Verification Studies (Victoria, BC and Sitka, AK)

Victoria, BC Field Verification Study

The Integrated Land Management Bureau of the Province of British Columbia provided funding for a study on Vancouver Island to collect ground data using the same codes, individual mappers, and protocols as specified in aerial mapping. The principal objective of this study was to compare aerial mapping interpretations to ground survey observations in order to evaluate detection limits of physical and biological attributes. Ground crews were provided with unit boundaries so unit delineation was not compared. Site selection was not random because of the need to meet several requirements: shoreline accessibility; walk-able, contiguous sections of units; as many different exposure categories as possible; maximize time during the low tide window.

The principal conclusions of this study included:

1) Coastal class assignment (to along-shore units, by different mappers on the ground and using aerial data) matched in 80% of cases.
2) Shore modifications mapped using aerial imagery underestimated by 12% compared to ground observations, owing to seawalls covered by vegetation that were indistinct during flight.
3) Across-shore component data matched in 85% of comparisons.
4) Wide, spatially-complex shorelines were most commonly mismatched, reiterating the findings of the repeatability study.

Sitka, Alaska Field Verification Study

The National Oceanic and Atmospheric Administration (NOAA) and The Nature Conservancy (TNC) funded a field verification survey in Sitka, Alaska that followed similar protocols to the Victoria, BC survey (Harney *et al.* 2009). The principal conclusions of this ground verification survey are:

1) Wave exposure estimates were closely matched between aerial interpretations and ground interpretations.
2) Sediment mobility estimated matched 88% between aerial and ground observations.
3) Intertidal width estimates matched in 63% units. Aerial mappers tended to underestimate widths.
4) Estimates of shore modifications were highly consistent between aerial and ground observations.
5) Coastal class matched about 58% between aerial and ground observations; the relatively poor match score is attributed to a large number of possible classes (35) and the spatial complex nature of the foreshore.
6) Across-shore geomorphology and substrate matched in 80% of the observations.
7) Aerial and ground observations of *Barnacle, Rockweed, Green Algae, Alaria, Soft Brown Kelps, Surfgrass, Eelgrass,* and *Giant Kelp* biobands showed good matches whereas *Dune Grass, Blue Mussels, Bleached Red Algae, Red Algae,* and *Dark Brown Kelp* biobands showed poorer agreement between ground and aerial observations.

6.3 Implications of Reviews

As a result of these studies, a substantial number of procedural updates were implemented in the ShoreZone program. In particular "rules of thumb" or guidelines were incorporated into the protocol (see Sections 4.0 and 5.0) and a revised Gulf of Alaska protocol re-issued (Harney *et al.* 2008). In addition, some qualifications have been added to specific feature classes and biobands to indicate lower confidence levels may apply to selected features.

6.4 ShoreZone Data Updates

Data provided are derived from large, regional databases that are continually being updated and modified. The accuracy of some information is subject to change. Any published data sets utilizing ShoreZone products (printed, digital, or online) should clearly indicate their source. If the user has modified the data in any way, the user is obligated to describe the types of modifications performed. The user specifically agrees not to misrepresent these data, nor to imply that changes made were approved by the ShoreZone program or its partners.

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This manual is based on input from many researchers in British Columbia, Washington, and Alaska. The basic schema is taken from early work in BC (see Howes *et al.* 1994; Howes 2001). Previous versions of this manual (Harper and Morris 2004; Harney *et al.* 2008) were incorporated into this version of the manual.

Tim Robertson of Nuka Research and Planning Group of Seldovia, Alaska is the project manager for the North Slope ShoreZone mapping project and his advice contributed considerably to the manual. Staff of Coastal & Ocean Resources Inc. (CORI) and Archipelago Marine Research Ltd (Archipelago) provided numerous suggestions and input to this manual. The ShoreZone project has benefitted from a diverse group of funding agencies and a diverse group of supporters. An updated list of project supporters is included on www.ShoreZone.org.

The report cover was designed by Kathleen George of Nuka Research and Planning Group. Photos included within the cover were collected by the ShoreZone project, Kathleen George, and Brentwood Higman.

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APPENDICES 9.0

APPENDIX A – Data Dictionary
APPENDIX B – Physical Illustrations
APPENDIX C – Biological Illustrations
APPENDIX D – Coastal Vulnerability Module

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APPENDIX A – DATA DICTIONARY

Table	Description
A-1	Definitions for fields and attributes in the UNIT Table
A-2	Wave-Structured Shore Types
A-3	Shore Types for Non-Wave Structured Processes
A-4	Definitions of the ESI (Environmental Sensitivity Index)
A-5	Definitions for estimating the OBSERVED PHYSICAL EXPOSURE
A-6	Definition of the OIL RESIDENCE INDEX (ORI)]
A-7	Unit ORI (OIL RESIDENCE INDEX) lookup table
A-8	Component ORI (OIL RESIDENCE INDEX) Component Lookup Matrix
A-9	Definitions of the attributes in the BIOUNIT Table.
A-10	Definitions of the BIOAREA Attribute
A-11	BIOLOGICAL WAVE EXPOSURE Codes
A-12	Definitions of BIOLOGICAL WAVE EXPOSURES by Bioband
A-13	HABITAT CLASS, SECONDARY HABITAT CLASS, and RIPARIAN
A-14	Codes for HABITAT CLASS, SECONDARY HABITAT CLASS
A-15	Definitions of the XSHR Components
A-16	Definitions of FORMS in XSHR Table
A-17	Definitions of the MATERIALS XSHR Table
A-18	Definitions for Fields in the BIOBAND Table.
A-19	Definitions for BIOBANDS for Gulf of Alaska
A-20	Species in HAL, RED, SBR, CHB Biobands, Gulf of Alaska
A-21	Shoreline Vegetation of Arctic, by Bioband
A-22	Definitions of Occurrences in Biobands
A-23	Definitions for Photo Fields
A-24	Ground Station Data

Table A-1. Definitions for Fields and Attributes in the UNIT Table.

Field Name	Description
UnitRecID	**Unit Record ID:** An automatically-generated number field; the database "primary key" for unit-level relationships.
PHY_IDENT	**Physical Ident:** 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.
REGION	**Region:** assigned during mapping, makes up first two digits of the PHY_IDENT. (See PHY_IDENT description for example.)
AREAS	**Area:** assigned during mapping, makes up the third and fourth digits of the PHY_IDENT. (See PHY_IDENT description for example.)
PHY_UNIT	**Unit:** Four digit **along-shore unit number**; assigned during mapping, unique within Region/Area mapping section. (See PHY_IDENT description for example.)
SUBUNIT	**Subunit:** assigned during mapping, is '0' for unit line features. Subunit field is used to identify Point features (if any, also called 'Variants') within Units, and are numbered sequentially (1, 2, 3…) according to the order occurring within the unit. (See PHY_IDENT description for example.)
TYPE	**Unit Type:** A single-letter description for Unit as either: a (L)ine (linear unit) or (P)oint feature (variant). Related to SUBUNIT attribute, where each numbered SUBUNIT 'variant' would be TYPE 'P'.
SHORE TYPE	**Shore Type:** Code number for Shore Type classification for the unit. Definitions of codes in Table A-2, A-3. Determined by the Physical mapper and based on: overall substrate type, sediment size (if sediment is present), across-shore width, and across-shore slope for the unit.
ESI	**Environmental Sensitivity Index:** Classification for the shore unit, using unit-wide interpretation of ESI. Definitions in Table A-4.
LENGTH_M	**Unit Length:** Along-shore unit high waterline, in meters; calculated in ArcGIS, from digitized shoreline.
GEO_MAPPER	**Physical Mapper Name:** Last name of the physical mapper.
GEO_EDITOR	**Physical Mapper Reviewer:** Last name of the physical mapper who QA/QCs the work (10% of all units are reviewed by a different Physical mapper than did original mapping).
VIDEOTAPE	**Videotape Name:** Unique code for title of the videotape used for mapping; Naming convention example is SE07_SO_08, where first four characters identify the main survey region and year, (where SE07 is 'Southeast Alaska 2007'), two letter code for survey team (where SO is 'Sockeye') and two digit code '08' is for consecutively numbered tape.
HR	**Hour:** From the first two digits of the six-digit UTC time burned on video image, identifying video frame at which the unit starts; with the unit start frame at center of viewing screen.
MIN	**Minute:** From the third and fourth digits of the six-digit UTC time burned on video image at which unit starts; with the unit start frame at center of viewing screen.
SEC	**Second:** From the last two digits of the six-digit UTC time burned on video image at which unit starts; with the unit start frame at center of viewing screen.
EXP_OBSER	**Physical Wave Exposure:** Estimate of wave exposure as observed by the physical mapper, estimated from observed fetch and coastal processes; categories listed in Table A-5.

Table A-1, continued. Definitions for Fields and Attributes in the UNIT Table.

Field Name	Description
ORI	**Oil Residency Index:** Code indicating the potential persistence of oil within the shore unit. Based on unit substrate type and biological wave exposure categories. Definitions and lookup matrix in Table A-6 and A-7.
SED_SOURCE	**Sediment Source:** Code to indicate estimated sediment source for the unit: (A)longshore, (B)ackshore, (F)luvial, (O)ffshore, (X) not identifiable.
SED_ABUND	**Sediment Abundance:** Code to indicate the relative sediment abundance within the shore-unit: (A)bundant, (M)oderate, (S)carce.
SED_DIR	**Sediment Transport Direction:** 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	**Change Type:** Code indicating the estimated 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	**Shorename:** Name of a prominent geographic feature near the unit (from nautical chart or gazetteer).
UNIT_COMMENTS	**Unit Comments:** Text field for comments and notes during physical mapping.
SM1_TYPE	**Primary Shore Modification:** Two-letter code indicating the primary type of shore modification occurring within the unit: BR = boat ramp; CB = concrete bulkhead; LF = landfill; SP= sheet pile; RR = rip rap and WB = wooden bulkhead.
SM1_PCT	**Primary Shore Modification Percent Unit Length:** Estimated % occurrence of the primary shore modification type in tenths (i.e. “2” = 20% occurrence with the unit alongshore).
SM2_TYPE	**Secondary Shore Modification:** Two-letter code indicating the secondary type of shore modification occurring within the unit.
SM2_PCT	**Secondary Shore Modification Percent Unit Length:** Estimated % occurrence of the secondary type of shore modification occurring within the unit.
SM3_TYPE	**Tertiary Shore Modification:** Two-letter code indicating the tertiary type of shore modification occurring within the unit.
SM3_PCT	**Tertiary Shore Modification Percent Unit Length:** Estimated % occurrence of the tertiary seawall type in tenths (i.e., “2” = 20% occurrence within the unit).
SMOD_TOTAL	**Total Shore Modification % Unit Length:** Total % occurrence of shore modification in the unit in tenths.
RAMPS	**Boat 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	**Piers or Wharves:** 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	**Dock Slips:** Estimated number of recreational slips at docks or marinas within the unit; based on small boat length ~<50’.
DEEPSEA_SLIP	**Ship Dock Slips:** Estimated number of slips for ocean-going vessels within the unit; based on ship length ~>100’.
ITZ	**Intertidal Zone Width:** Sum of the across-shore width of all the intertidal (B Zone) components within the unit.
SLIDE	**Still Photo in Unit**: Yes/No tick box to indicate if high resolution photo is available for the Unit.
EntryDate ModifiedDate	**Date/Time Mapped or Modified:** Date and time the unit was physically mapped (or modified).

Table A-2. Definitions of the Wave-Structured Shore Types (after Howes et al. 1994).

Substrate	Sediment	Width	Slope	SHORE TYPE	
				Description	Code
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 (>30 m)	Steep (>20°)	n/a	-
			Inclined (5-20°)	Sand beach	27
			Flat (<5°)	Sand flat	28
			Flat (<5°)	Mudflat	29
		Narrow (<30 m)	Steep (>20°)	n/a	-
			Inclined (5-20°)	Sand beach	30
			Flat (<5°)	n/a	-

Table A-3. Shore Types Associated with Structuring Processes Other than Wave Action.

Structuring Processes	Description	BC Class
Estuarine Processes Dominant	***estuarine*** – organics, fines and vegetation dominate the unit; may characterize units with large marshes in the supratidal zone (if the marsh represents >50% of the combined supratidal and intertidal area of the unit), even if the unit has another dominant intertidal feature such as a wide tidal flat or sand beach. This “50% rule” may be ignored and a Shore Type 31 applied if a significant amount of marsh (25% or more) infringes on the intertidal zone.	31
Anthropogenic Processes Dominant	***permeable man-made structures*** such as rip-rap, wooden crib structures where a surface oil from a spill will easily penetrate the structure. Man-made structure must comprise >50% of intertidal zone area.	32
	impermeable man-made structures such as concrete seawalls and steel sheet pile. Man-made structure must comprise >50% of intertidal zone area.	33
Current Processes Dominant	***current-dominated*** shore types occur in elongate channels with restricted fetches and where tidal currents are the dominant structuring process. In addition to obvious high currents, channel sides typically includes anomalous vegetation types.	34
Glacial Processes Dominant	***glacial ice*** dominates a few places on the Alaska coast where tide-water glacial are present. These location are characterized by unstable ice fronts.	35
Lagoon Processes Dominant	***lagoons*** represent a special coastal feature that has some salt-water influence but may be largely disconnected from other marine processes such as tides and high wave exposure. Lagoons are distinguished from estuaries, which must have fluvial or deltaic landforms. Intertidal zones are often restricted in elevation and narrow. Saltwater influxes may be only episodic.	36
Periglacial (Permafrost) Processes Dominant	***inundated tundra*** occurs where thaw-subsidence on low-relief shorelines causes the tundra surface to sink below mean sea level. Often the polygon fracture patterns associated with ice-wedges polygons are evident. Where the shallow ponds coalesce they may transition into lagoons. Usually there is > 25% water within the unit.	37
	ground ice slumps are areas where the thaw of high ice content shores causes mass-wasting in distinct patterns (e.g., ground ice slumps, thermo-erosional falls, solifluction lobes that dominate coastal morphology). Slump processes strongly influence (> 50%) of the intertidal zone morphology and texture.	38
	low vegetated peat are areas of low-lying tundra peat banks; usually vegetated in the supratidal zone, but not always vegetated in the intertidal zone. Minimal mineral sediment is present. Usually low energy (shown by an absence of storm wave features). No distinct intertidal zone.	39

Table A-4. Definitions of the Environmental Sensitivity Index Codes (ESI) (after Petersen et al. 2002).

ESI Number	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
10E	Inundated low-lying tundra

* Denotes that a category or definition applies only in Southeast Alaska

Table A-5. Definitions for OBSERVED EXPOSURE.

Maximum Fetch (km)	Modified Effective Fetch (km)				
	<1	<1	<1	<1	<1
<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-6. Definition of the Oil Residence Index (ORI)*.

Persistence	Oil Residence Index (ORI)	Estimated Persistence
Short	1	Days to weeks
Short to Moderate	2	**Weeks** to Months
Moderate	3	Weeks to **Months**
Moderate to Long	4	**Months** to Years
Long	5	Months to **Years**

* after Howes *et al.* (1994)

Table A-7. UNIT Oil Residence Index (ORI) Lookup Matrix * .

Shore Type	Bio or Observed Exposure					
BC_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	3	4	4
16	1	2	3	4	5	5
17	1	2	3	4	5	5
18	1	2	3	4	5	5
19	1	2	3	4	5	5
20	1	2	3	4	5	5
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	999	999	999	3	3	3
30	2	2	3	3	4	4
31	999	999	5	5	5	5
32	2	2	3	3	5	5
33	1	1	1	2	2	2
34	999	999	999	4	4	4
35	1	1	1	1	1	1
36	999	999	999	5	5	5
37	999	999	999	5	5	5
38	999	999	2	3	3	3
39	999	5	5	5	5	5

Note: 999 should not occur; requires operator override
* after Howes *et al.* 1994

Table A-8. COMPONENT Oil Residence Index (ORI) Lookup Matrix *.

	Bio or Observed Exposure					
Component 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 with pebble, cobble or boulder	1	2	3	4	5	5
sand without pebble, cobble or boulder	2	2	3	3	4	4
mud	999	999	999	3	3	3
organics/peat/vegetation	999	999	999	5	5	5
man-made, permeable	2	2	3	3	5	5

Note: 999 should not occur, requires operator override
* after Howes *et al.* 1994

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

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Table A-9. Definitions of the Attributes in the 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:** 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-10).
EXP_BIO	**Biological Wave Exposure:** A classification of the wave exposure category within the Unit, **On Arctic coasts:** assigned by the Biological mapper, based on physical wave exposure category [EXP_ OBSER] when biological indicators were not present (Table A-11 and A-12).
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-13 and A-14). (**On Arctic coasts:** EXP_BIO = EXP_OBSER)
HAB_CLASS_LTRS	**Habitat Class:** in alphabetic code: translation from number codes in the HAB CLASS lookup table (Table A-14)
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-13 and A-14).
HC2_SOURCE	**Secondary Habitat Class Source:** Source used to interpret the Secondary Habitat Class (HAB_CLASS2) "lagoon": OBServed as viewed from video, LooKUP referring to 'Form' Code (Table A-13 and Table A-14) Lo or Lc in across-shore physical component table (Table A-15 and A-16).
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-13).
RIPARIAN_M	**Riparian Overhang Meters:** Calculated from GIS, the portion of the unit length in meters (from RIPARIAN_PERCENT and Unit length) of riparian overhang in the intertidal (B) zone; all substrate types;
BIO_UNIT_COMMENT	**Biological Comments**: regarding the along-shore unit as a whole. Included as note field in deliverable data.
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-10. Definitions of the Alaska BIOAREA Attribute.

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 energy. 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, high-energy 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 four lower intertidal biobands (HAL, RED, SBR, CHB) to distinguish between regional differences in species composition of these bands in different bioareas. See Section 5.3 and Figure 19 for further explanation of bioareas.

Table A-10, continued. Definitions of the Alaska BIOAREA Attribute.

Bioarea Name	Bioarea Code	Bioarea Suffix*	Geographic Extent	Characteristics
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.
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 affects of Copper River. Absence of Giant Kelp and 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-10, continued. Definitions of the Alaska BIOAREA Attribute.

Bioarea Name	Bioarea Code	Bioarea Suffix *	Geographic Extent	Characteristics
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.
Beaufort Sea coast	BEAU	15	Point Barrow to Canadian border	Tundra cliffs and flats, extensive offshore barrier sand islands, permafrost dominated shore.
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 high energy beaches and rock platforms on mainland peninsula and offshore islands. Some lower wave exposures lagoons with eelgrass. Nearshore kelps Dragon Kelp.
Kotzebue Sound	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.	Wide high energy bare beaches - large tidal lagoon complexes, extensive salt marsh. Most of coast is sediment dominated. Selawik Lake section includes large areas of near-freshwater marsh and shallow nearshore.

*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. See Section 5.3 and Figure 19 for further explanation of bioareas.

Table A-11. List of the BIOLOGICAL WAVE EXPOSURE codes, in BIOUNIT table.

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

Note: The same exposure names and codes are used for the EXP_BIO as are used for EXP_OBSER, however biological wave exposure is based on biomappers observation of biota in the unit, while the observed physical exposure is based on the physical mappers observations of exposure determined by effective wave fetch.

Table A-12. Definitions of BIOLOGICAL WAVE EXPOSURES for Gulf of Alaska, by Bioband, Indicator and Associated Species.*

Exposure	Zone	Indicator Species	Associated Species	Bioband Name	Bioband Code
Very Exposed (VE) & Exposed (E)	Upper Intertidal		*Leymus mollis*	Dune Grass	GRA
		Verrucaria		Splash Zone	VER
			Balanus glandula *Semibalanus balanoides*	Barnacle	BAR
		Semibalanus cariosus		Barnacle	BAR
		Mytilus trossulus		Blue Mussel	BMU
	Lower Intertidal & Nearshore Subtidal		*Mytilus californianus*	California Mussel	MUS
		Coralline red algae		Red Algae	RED
		Alaria 'nana' morph		Alaria	ALA
		Lessoniopsis littoralis		Dark Brown Kelps	CHB
		Laminaria setchellii		Dark Brown Kelps	CHB
		Nereocystis luetkeana		Bull Kelp	NER
Semi-Exposed (SE)	Upper Intertidal		*Leymus mollis*	Dune Grass	GRA
		Verrucaria		Splash Zone	VER
			Balanus glandula *Semibalanus balanoides*	Barnacle	BAR
			Fucus distichus	Rockweed	FUC
		Semibalanus cariosus		Barnacle	BAR
		Mytilus trossulus		Blue Mussel	BMU
	Lower Intertidal & Nearshore Subtidal	mixed filamentous and foliose red algae		Red Algae	RED
		Alaria 'marginata' morph		Alaria	ALA
		Phyllospadix sp.		Surfgrass	SUR
		Laminaria setchellii		Dark Brown Kelps	CHB
		Saccharina subsimplex		Dark Brown Kelps	CHB
		Saccharina sessile smooth morph		Dark Brown Kelps	CHB
		Eularia fistulosa		Dragon Kelp	ALF
			Strongylocentrous fransciscanus	Urchin Barrens	URC
			Macrocystis integrifolia	Giant Kelp	MAC
		Nereocystis luetkeana		Bull Kelp	NER

* Note that only a few of these species and associated biobands occur north of the Alaska Peninsula.

Table A-12, continued. Definitions of BIOLOGICAL WAVE EXPOSURES for Gulf of Alaska, by Bioband, Indicator and Associated Species.*

Exposure	Zone	Indicator Species	Associated Species	Bioband Name	Bioband Code
Semi-Protected (SP)	Upper Intertidal		*Leymus mollis*	Dune Grass	GRA
			Carex spp.	Sedges	SED
			Puccinellia sp.	Salt Marsh	PUC
			Plantago maritima	Salt Marsh	PUC
			Glaux maritima	Salt Marsh	PUC
		Verrucaria		Splash Zone	VER
	Lower Intertidal & Nearshore Subtidal		*Balanus glandula* *Semibalanus balanoides*	Barnacle	BAR
		Semibalanus carriosus		Barnacle	BAR
			Fucus distichus	Rockweed	FUC
		Mytilus trossulus		Blue Mussel	BMU
			Ulva spp.	Green Algae	ULV
		Bleached mixed red algae		Bleached Red Algae	HAL
		Mixed red algae including *Odonthalia*		Red Algae	RED
		Alaria 'marginata' morph		Alaria	ALA
		Zostera marina		Eelgrass	ZOS
		Saccharina latissima		Soft Brown Kelps	SBR
			Nereocystis luetkeana	Bull Kelp	NER
		Macrocystis integrifolia		Giant Kelp	MAC
Protected (P) & Very Protected (VP)	Upper Intertidal		*Leymus mollis*	Dune Grass	GRA
			Carex spp.	Sedges	SED
			Puccinellia sp.	Salt Marsh	PUC
			Plantago maritima	Salt Marsh	PUC
			Glaux maritima	Salt Marsh	PUC
		Verrucaria		Splash Zone	VER
			Balanus glandula *Semibalanus balanoides*	Barnacle	BAR
			Fucus distichus	Rockweed	FUC
		Mytilus trossulus		Blue Mussel	BMU
	Lower Intertidal & Nearshore Subtidal	*Ulva* spp.		Green Algae	ULV
		Zostera marina		Eelgrass	ZOS
		Saccharina latissima		Soft Brown Kelps	SBR

* Note that only a few of these species and associated biobands occur north of the Alaska Peninsula.

Table A-13. HABITAT CLASS, SECONDARY HABITAT CLASS, and RIPARIAN.

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 wave exposure together with the geomorphology. On the Gulf of Alaska coast, 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. For the Beaufort and Chukchi Sea coasts, Kotzebue Sound and other Arctic coasts where biobands are largely absent and shoreline is dominated by bare intertidal zone, the physical mappers exposure category (EXP_OBSER) is used to assign Habitat Class. Within the database, both a numeric code and an alpha code are used. Both codes for Habitat Class are listed in Table A-14 in which the matrix includes all combinations of Dominant Structuring Process, with associated substrate mobility and general geomorphic type on the vertical axis, and Exposure category on the horizontal axis. Note that a few combinations (e.g., Very Exposed Estuary) are rare or do not occur.
HAB_CLASS2	The '**Secondary Habitat Class**' was added as an attribute in the BioUnit table to highlight backshore lagoon Forms, a common feature observed in the Kodiak region (2006). Since then, **'Lagoon'** was added as a new **Shore Type** (2012) to describe Units on the Arctic coasts. By definition, Units classified as Shore Type 36 Lagoons (see Table A-3) are assigned a Secondary Habitat Class Lagoon as well. **Secondary Habitat Class** 'lagoon' is always associated with a Unit's primary Habitat Class. Although lagoons may include salt marsh, the overall feature is different than in Estuaries. Lagoons usually contain brackish or salt water in a pond with limited drainage. They are often associated with wetlands and may include wetland biobands in the upper intertidal. Single units classified as lagoons may 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 or the Unit is assigned to Shore Type 36.
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.

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Table A-14. 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 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	Units classified as the 'estuary' types always include salt marsh vegetation in the upper intertidal, are usually associated with a freshwater stream or river which often show a delta form. Estuary units are usually in lower wave exposure categories.	dno	23 E_E	33 SE_E	43 SP_E	53 P_E	63 VP_E
Current energy		Current-Dominated	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.	dno	dno	34 SE_C	44 SP_C	54 P_C	dno
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.	dno	dno	dno	45 SP_G	55 P_G	65 VP_G
Anthropogenic		Impermeable	Impermeable modified Habitats are intended to specifically note units classified as Coastal Class 33. These Habitat Classes are rare and include a small percentage of the shoreline length.	dno	dno	36 SE_X	46 SP_X	56 P_X	66 VP_X
		Permeable	Permeable modified Habitats are intended to specifically note shore units classified as Coastal Class 32. These Habitat Classes are rare and include a small percentage of the shoreline length.	dno	dno	37 SE_Y	47 SP_Y	57 P_Y	67 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.	dno	dno	38 SE_L	48 SP_L	58 P_L	68 VP_L
Periglacial Processes		Permafrost	Units consist of forms structured by permafrost at the coast, such as inundated tundra, tundra sea cliffs or other periglacial features	dno	29 E_T	39 SE_T	49 SP_T	59 P_T	69 VP_T

Notes: 1. Habitat Class codes in shaded boxes are very infrequent and in most cases, do not occur.

2. For mobile bare beaches with no attached biota, as are found on Arctic coasts, the Habitat Class is determined from the ***physical exposure estimate***, in combination with the 'dominant structuring process'.

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Table A-15. Definitions of the XSHR Component (after Howes* et al. *1994).

Field Name	Description
UnitRecID	**Unit Record ID:** An automatically-generated number field; the database "primary key" for unit-level relationships.
XshrRecID	**Across-shore Record ID:** Automatically-generated number field; the database "primary key" for across-shore relationships.
PHY_IDENT	**Physical Ident:** 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).
CROSS_LINK	**Crosslink code:** Unique identifier for each across-shore record, consisting of 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	Across-shore **Zone:** Code indicating the across-shore position (tidal elevation) of the Component: (A) supratidal, (B) intertidal, (C) subtidal. See detailed description of Zones in Table 15 and in Figure 9.
COMPONENT	Across-shore **Component:** a 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	**Form1:** The principal geomorphic feature within across-shore Component, described by a specific set of codes (Table A-16).
MatPrefix1	**Material Prefix:** 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-17).
FormMat1Txt	**Form/Material Text:** Automatically-generated field that is the translation of codes used in Form1 and Mat1 into text.
Form2	**Form2:** Secondary geomorphic feature within across-shore Component, described by a specific set of codes (Table A-16).
MatPrefix2	**Material Prefix:** 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-17).
FormMat2Txt	**Form/Material Text:** Automatically-generated field that is the translation of codes used in Form2 and Mat3 into text.
Form3	**Form3:** Tertiary geomorphic feature within each across-shore component, described by a specific set of codes (Table A-16).
MatPrefix3	**Material Prefix:** 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-17).
FormMat3Txt	**Form/Material Text:** Automatically-generated field that is the translation of codes used in Form3 and Mat3 into text.
Form4	**Form4:** Fourth-order geomorphic feature within each across-shore component, described by a specific set of codes (Table A-16).
MatPrefix4	**Material Prefix:** 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-17).
FormMat4Txt	**Form/Material Text:** Automatically-generated field that is the translation of codes used in Form4 and Mat4 into text.
WIDTH	**Width:** Estimated mean across-shore width of the component (e.g. A1) in meters.
SLOPE	**Slope:** Estimated across-shore slope of the mapped geomorphic Form in degrees; must be consistent with Form codes (Table A-16).
PROCESS	**Coastal Process:** dominant in affecting the morphology: (F)luvial, (M)ass wasting (landslides), (W)aves, (C)urrents, (E)olian (wind, as with dunes) (O)ther (P)eriglacial.
COMPONENT_ORI	**Component Oil Residence Index:** on the basis of substrate type; 1 is least persistent, 5 is most persistent (Tables A-6 and A-8).

Table A-16. Definitions of FORMS, in XSHR Table (after Howes et al. 1994).

A = Anthropogenic

a	pilings, dolphin
b	breakwater
c	log dump
d	derelict shipwreck
f	float
g	groin
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 (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 (occurs as marine influence; supratidal)
t	low tide terrace
v	thin veneer over rock (also use as modifier)
w	washover fan

C = Cliff

stability/geomorphology	
a	active/eroding
p	passive (vegetated)
c	cave
slope	
i	inclined (20°-35°)
s	steep (>35°)

[continued]

Cliff continued

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 from saltwater inundation of tundra
e	levee
f	drowned forest
h	high
l	mid to low (discontinuous)
o	pond
s	brackish, supratidal

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
w	plunge pool

U = Tundra

g	ground ice slump
i	inundated
o	isolated thaw ponds
p	plain or level surface
r	ramp

Table A-17. Definitions of the MATERIALS in XSHR Table (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)
z	permafrost

C = Clastic

a	angular blocks (>25cm diameter)
b	boulders (rounded, subrounded,>25cm)
c	cobbles
d	diamicton (poorly-sorted sediment containing a range of particles in a mud matrix)
f	fines/mud (mix of silt/clay, <0.0.63 mm diameter)
k	clay (compact, finer than fines/mud, <4 micron diameter)
p	pebbles
r	rubble (boulders>1 m diameter)
s	sand (0.063 to 2 mm diameter)
t	tephra (volcanic pumice and ash)
$	silt (0.0039 to 0.063 mm)
x	angular fragments (mix of block/rubble)
v	sediment veneer (used as modifier)
z	permafrost

I = Ice

i	ice (e.g., ice wedges in permafrost)

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 diameter

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 micron (0.063 mm)
pebble / granule	0.5 cm (5 mm)
cobble / pebble	6 cm
boulder / cobble	25 cm

SHORE MODIFICATIONS

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

% are 0-10 (default value 0)

Note: The 'Material' descriptor consists of one primary term code, followed by codes for associated modifiers (e.g. Cbc). If only one modifier is used, the material described comprises 75% of the volume of the layer (e.g. Cb); if more than one modifier is used, they are ranked in order of volume.

A surface layer can be described by prefix *v* for veneer, followed by Material descriptor for the veneer, with a slash (/) over the underlay Material code (e.g. vCs/R).

Table A-18. Definitions for Fields in 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
TUN	Bioband for **TUN**dra vegetation in coastal fringe or supratidal (Table A–19)
VER	Bioband for Splash Zone (black lichen **VER***ucaria*) in supratidal (Table A-19)
GRA	Bioband code for Dune **GRA**ss in supratidal (Table A-19)
SED	Bioband for **SED**ges in supratidal (Table A-19)
PUC	Bioband for Salt Marsh grasses, including **PUC***cinellia* and other salt tolerant grasses, herbs and sedges, in supratidal (Table A-19)
BAR	Bioband for **BAR**nacle (*Balanus/Semibalanus*) in upper intertidal (Table A-19)
BFM	Bioband for **BioFilm** mat, upper intertidal (Table A–19)
FUC	Bioband for Rockweed, the **FUC***us*/barnacle in upper intertidal (Table A-19)
ULV	Bioband for Green Algae, including mixed filamentous and foliose greens (**ULV***a* sp., *Cladophora, Acrosiphonia*) in mid-intertidal (Table A-19)
BMU	Bioband for **B**lue **MU**ssel (*Mytilus trossulus*) in mid-intertidal (Table A-19)
MUS	Bioband for California **MUS**sel/gooseneck barnacle assemblage (*Mytilus californianus/Pollicipes polymerus*) in mid-intertidal (Table A-19)
HAL	Bioband for Bleached Red Algae, including mixed filamentous and foliose reds (*Palmaria, Odonthalia*, **HAL***osaccion*) in mid-intertidal (Table A-19)
RED	Bioband for **RED** Algae, including mixed filamentous and foliose reds (*Odonthalia, Neorhodomela, Palmaria*) in lower intertidal (Table A-19)
ALA	Bioband for ribbon kelp, ALA*ria* spp. (Table A-19)
SBR	Bioband for **S**oft **BR**own Kelps, including unstalked large-bladed laminarians, in lower intertidal and nearshore subtidal (Table A-19)
CHB	Bioband for Dark Brown Kelps, including stalked bladed dark **CH**ocolate-**B**rown kelps in lower intertidal and nearshore subtidal (Table A-19)
SUR	Bioband for **SUR**fgrass (*Phyllospadix*) in lower intertidal and nearshore subtidal (Table A-19)
ZOS	Bioband for **ZOS***tera* (Eelgrass) in lower intertidal and subtidal (Table A-19)
URC	Bioband for **URC**hin Barrens (*Strongylocentrotus fransicanus*) in nearshore subtidal (Table A-19)
ALF	Bioband for Dragon Kelp (*Eularia* (formerly **AL***aria*) **F***istulosa*) in nearshore subtidal (Table A-19)
MAC	Bioband for Giant Kelp (**MAC***rocystis integrifolia*) in nearshore subtidal (Table A-19)
NER	Bioband for Bull Kelp (**NER***eocystis luetkeana*) in nearshore subtidal (Table A-19)

Distribution code for biobands observed are listed in Table A-19 to A-21.

Table A-19. Definitions for BIOBANDS attributes for Alaska, in BIOBAND table.*

Zone	Bioband		Color	Indicator Species	Physical Description	Biological Wave Exposure	Associate Species
	Name	Code					
A	Tundra	TUN	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.	n/a	*Eriophorum sp.* *Dryas integrifolia* *Artemisia spp.* Lichens**
A	Splash Zone	VER	Black or bare rock	*Verrucaria* sp. Encrusting black lichens	Visible as a dark stripe, on bare rock, marking the upper limit of the intertidal zone. This band is observed on bedrock, or on low energy boulder/cobble shorelines. This band is recorded by width: Narrow (N), Medium (M) or Wide (W).	VP to VE	*Littorina* sp.
A	Dune Grass	GRA	Pale blue-green	*Leymus mollis*	Found in the upper intertidal zone, tall grasses observed as clumps continuous on dunes, in logline or on beach berms. This band may be the only band present on high-energy beaches.	P to E	**
A	Sedges	SED	Bright green, yellow-green to red-brown.	*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. Often the PUC band forms a fringe below. *Carex spp.* present with TUN and/or PUC in Arctic bioareas.	VP to SE	*Carex* spp.**
A	Salt Marsh	PUC	Light, bright, or dark green, with red-brown	*Puccinellia* sp. *Plantago maritima* *Glaux maritima*	Appears around estuaries, marshes, and lagoons. Usually associated with freshwater. Often fringing the edges of GRA and SED bands. In GoA coasts, PUC can be sparse *Puccinellia* and *Plantago* on coarse sediment or a wetter, peaty meadow with assemblage of herbs and sedges (including *Potentilla, Spergularia, Achillea, Dodecatheon* and other associated species).	VP to SE	*Carex* spp. *Potentilla anserine* *Honckenya peploides* *Salicornia depressa* *Triglochin maritima* **
A & upper B	Biofilm	BFM	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	
upper B	Barnacle	BAR	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 E	*Endocladia muricata* *Gloiopeltis furcata* *Porphyra* sp. *Fucus distichus*
upper B	Rockweed	FUC	Golden-brown	*Fucus distichus*	Appears on bedrock cliffs and boulder, cobble or gravel beaches. Commonly occurs at the same elevation as the barnacle band.	P to SE	*Balanus glandula* *Semibalanus cariosus* *Ulva* sp. *Pilayella* sp.

* Note that four lower intertidal biobands (Red Algae, Bleached Red Algae, Soft Brown Kelps, Dark Brown Kelps) have slightly different species compositions in Gulf of Alaska bioareas. See Table A-20 for species lists for those bands.
** Note Arctic coast assemblages described by Taylor (1981) in Table A-22

Table A-19, continued. Definitions for BIOBANDS attributes for Alaska, in BIOBAND table. *

Zone	Bioband Name	Bioband Code	Color	Indicator Species	Physical Description	Exposure	Associate Species
B	**Green Algae**	**ULV**	Bright or dark 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*
B	**Blue Mussel**	**BMU**	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
B	**California Mussel**	**MUS**	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*
B	**Bleached Red Algae**	**HAL**	Olive, golden or yellow-brown	Bleached foliose or filamentous red algae *Palmaria* sp. *Odonthalia* sp.	Common on bedrock platforms, and cobble or gravel beaches. Distinguished from the RED band by color, although may be similar species. The bleached color usually indicates lower wave exposure than where the RED band is observed.	P to SE	*Halosaccion glandiforme* *Mazzaella* sp. *Porphyra* sp. Filamentous green algae
B	**Red Algae**	**RED**	Corallines: pink or white Foliose or filamentous: Dark red, bright red, or red-brown.	*Corallina* sp. *Lithothamnion* sp. *Odonthalia* sp. *Neorhodomela* sp. *Palmaria* sp. *Neoptilota sp.* *Mazzaella* sp.	Appears on most substrates except fine sediments. Lush coralline red algae indicates highest exposures; diversity of foliose red algae indicates medium to high exposures, and filamentous species, often mixed with green algae, occur at medium and lower exposures.	P to VE	*Ulva* spp. Brown kelps of the SBR and CHB biobands
B & C	**Alaria**	**ALA**	Dark brown or red-brown	*Alaria marginata*	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.	SP to E	Foliose red algae *Saccharina* sp. *Laminaria* sp.
B & C	**Soft Brown Kelps**	**SBR**	Yellow-brown, olive brown or brown.	*Saccharina latissima* *Cystoseira sp.* *Sargassum muticum*	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 with diatoms and bryozoans giving the blades a 'dusty' appearance.	VP to SE	*Alaria* sp. *Cymathere* sp. *Saccharina groenlandica* *Saccharina sessilis* (bullate)

* Note that four lower intertidal biobands (Red Algae, Bleached Red Algae, Soft Brown Kelps, Dark Brown Kelps) have slightly different species compositions in Gulf of Alaska bioareas. See Table A-20 for species lists.

Table A-19, continued. Definitions for BIOBANDS for Alaska, in BIOBAND table.

Zone	Bioband Name	Bioband Code	Color	Indicator Species	Physical Description	Exposure	Associate Species
B & C	**Dark Brown Kelps**	**CHB**	Dark chocolate brown	*Laminaria setchelli* *Lessoniopsis littoralis* *Laminaria longipes* *Laminaria yezoensis*	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.	SE to VE	*Alaria sp.* *Cymathere sp.* *Saccharina groenlandica* *Saccharina sessilis (smooth)* *Costaria sp.* Filamentous and foliose red algae
B & C	**Surfgrass**	**SUR**	Bright green	*Phyllospadix* sp.	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.	SP to SE	Foliose and coralline red algae
B & C	**Eelgrass**	**ZOS**	Bright to dark green	*Zostera marina*	Commonly visible in estuaries, lagoons or channels, generally in areas with fine sediments. Eelgrass can occur in sparse patches or thick dense meadows.	VP to SP	*Pilayella* sp.
C	**Urchin Barrens**	**URC**	Coralline white, underwater	*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 SE	Encrusting invertebrates
C	**Dragon Kelp**	**ALF**	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	SP to SE	*Nereocystis luetkeana*
C	**Giant Kelp**	**MAC**	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.	P to SE	*Nereocystis luetkeana* *Eularia fistulosa*
C	**Bull Kelp**	**NER**	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*. Often indicates higher current areas if observed at lower wave exposures.	SP to VE	*Eularia fistulosa* *Macrocystis pyrifera*

Note that four lower intertidal biobands (Red Algae, Bleached Red Algae, Soft Brown Kelps, Dark Brown Kelps) have slightly different species compositions in Gulf of Alaska bioareas. See Table A-20 for species lists.

Table A-20. Species in HAL, RED, SBR, and CHB Biobands by Bioarea, in the Gulf of Alaska.

Bioarea		Bioband			
		Bleached Red Algae (HAL)	**Red Algae (RED)**	**Soft Brown Kelps (SBR)**	**Dark Brown Kelps (CHB)**
Outer Kenai (KENA)	Indicator Species	*Pterosiphonia bipinnata* *Odonthalia floccosa*	*Corallina* sp. *Lithothamnion* sp. *Odonthalia floccosa* *Mazzaella* sp. *Pterosiphonia bipinnata*	*Saccharina groenlandica* *Saccharina latissima*	*Laminaria setchellii* *Saccharina groenlandica* *Laminaria yezoensis* *Lessoniopsis littoralis*
Outer Kenai (KENA)	Associate Species	*Mazzaella* sp. *Halosaccion glandiforme* *Ulva* spp.	*Ulva* spp. Soft and Dark Brown Kelps species	*Costaria costata* *Cymathere triplicata* *Alaria marginata* *Agarum* sp.	*Alaria marginata* *Costaria costata* *Cymathaere triplicata*
Cook Inlet (COOK)	Indicator Species	*Neorhodomela oregona* *Cryptosiphonia woodii* *Palmaria* spp. *Pterosiphonia bipinnata*	*Lithothamnion* sp. *Palmaria* spp. *Pterosiphonia bipinnata* *Cryptosiphonia woodii*	*Saccharina groenlandica* *Saccharina latissima*	*Saccharina groenlandica*
Cook Inlet (COOK)	Associate Species	*Halosaccion glandiforme* *Porphyra* sp. *Ulva* spp.	*Halosaccion glandiforme* *Ulva* spp. Soft and Dark Brown Kelps species	*Alaria marginata* *Saccharina sessilis* (bullate) *Agarum clathratum* *Cymathere triplicata*	*Alaria marginata* *Cymathere triplicate* *Saccharina sessilis* (smooth) *Saccharina latissima* *Costaria costata*
Kodiak Island (KODI)	Indicator Species	*Pterosiphonia bipinnata* *Neorhodomela aculeata* *Palmaria* sp. *Odonthalia* sp.	*Corallina* spp. *Lithothamnion* sp. *Pterosiphonia bipinnata* *Odonthalia* spp. *Palmaria hecatensis* *Mazzaella splendens* *Cryptosiphonia woodii* *Porphyra* spp.	*Saccharina latissima* *Saccharina groenlandica*	*Saccharina groenlandica* *Laminaria yezoensis* *Laminaria longipes* *Lessoniopsis littoralis* *Laminaria setchelli*
Kodiak Island (KODI)	Associate Species	*Halosaccion glandiforme* *Mazzaella parksii* *Porphyra* spp. *Ulva* spp.	*Halosaccion glandiforme* *Ulva* spp. Soft and Dark Brown Kelps species	*Alaria marginata* *Costaria costata* *Saccharina sessilis* (bullate) *Cymathere triplicata* *Agarum* sp.	*Alaria marginata* *Costaria costata* *Saccharina sessilis* (smooth) *Cymathere triplicata* *Agarum clathrum*

Note: see also Table A–19

Table A-20, continued. Species in HAL, RED, SBR, CHB Biobands, in the Gulf of Alaska.

Bioarea		Bioband			
		Bleached Red Algae (HAL)	Red Algae (RED)	Soft Brown Kelps (SBR)	Dark Brown Kelps (CHB)
Katmai/Shelikof Strait side of Kodiak Island (KATM)	Indicator Species	*Cryptosiphonia woodii* *Palmaria* spp. *Odonthalia floccosa* *Pterosiphonia bipinnata*	*Lithothamnion* sp. *Corallina* sp. *Odonthalia floccosa* *Pterosiphonia bipinnata* *Porphyra* spp. *Palmaria* spp.	*Saccharina groenlandica* *Saccharina latissima* *Pleurophycus gardneri*	*Saccharina groenlandica* *Laminaria longipes*
	Associate Species	*Halosaccion glandiforme* *Ulva* spp.	*Ulva* spp. Soft and Dark Brown Kelps species	*Alaria marginata* *Cymathere triplicata* *Costaria costata* *Saccharina sessilis* (bullate)	*Alaria marginata* *Costaria costata* *Cymathere triplicata* *Agarum clathratum*
Southeast Alaska (all SEAK bioareas)	Indicator Species	*Cryptosiphonia woodii* *Neorhodomela* spp. *Palmaria hecatensis*	*Lithothamnion* sp. *Pterosiphonia bipinnata* *Cryptosiphonia woodii* *Odonthalia floccosa* *Mazzaella* sp. *Palmaria* spp. *Neorhodomela larix*	*Saccharina latissima* *Saccharina groenlandica*	*Saccharina groenlandica* *Pleurophycus gardneri* *Lessoniopsis littoralis*
	Associate Species	*Halosaccion glandiforme* *Mazzaella* sp. *Ulva* spp.	*Ulva* spp. Soft and Dark Brown Kelps species	*Costaria costata* *Alaria marginata* *Cymathere triplicata*	*Alaria marginata* *Costaria costata* *Saccharina sessilis* (smooth)
Prince William Sound (PRWS)	Indicator Species	*Cryptosiphonia woodii* *Pterosiphonia bipinnata* *Neorhodomela oregona*	*Lithothamnion* sp. *Pterosiphonia bipinnata* *Porphyra* sp. *Palmaria hecatensis* *Odonthalia floccosa* *Neoptilota asplenioides* *Neorhodomela* spp. *Mazzaella* sp.	*Saccharina latissima* *Saccharina groenlandica*	*Saccharina groenlandica* *Pleurophycus gardneri* *Lessoniopsis littoralis*
	Associate Species	*Halosaccion glandiforme* *Ulva* spp.	*Ulva* spp. Soft and Dark Brown Kelps species	*Agarum* sp. *Costaria costata*	*Alaria marginata* *Costaria costata* *Saccharina sessilis* (smooth)

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Table A-21. Shoreline Vegetation of the Arctic Coast, by Bioband, after Taylor (1981).

Bioband	Habitat Description from Taylor (1981)	Dominant species from Taylor (1981)	Associated species from Taylor (1981)
Tundra (TUN)	coastal bluff	*Artemisia tilesii* *Salix pulchra*	*Equisetum arvense* *Salix ovalifolia* *Arlix arctica* *Artemisia arctica* *Polygonum bistorta* *Poa eminens* *Oxyria digyna* *Phippsia algida* *Stellaria humifusa*
Tundra (TUN)	upper storm zone salt marsh	*Dupontia fisheri*	*Arctagrostis latifolia* *Arctophila fulva* *Carix aquatilis var. stans* *Eriophorum angustifolium* *Saxifraga cernua* *Saxifraga hirculus* *Salix ovalifolia* *Salix arctica* *Bryophytes*
Salt Marsh (PUC)	lowest and mid elevation tidal salt marsh	*Puccinellia phryganodes* *Carex subspathacea*	*Carex ramenskii* *Stellaria humifusa* *Cochlearia officinalis* *Carex ursina* *Dupontia fisheri*
Sedge (SED)	upper elevation tidal salt marsh	*Carex subspathacea* *Carex ramenskii*	*Stellaria humifusa* *Dupontia fisheri* *Puccinellia phryganodes* *Carex ursina*
Dune Grass (GRA)	gravelly beach	*Leymus mollis*	*Mertensia maritima* *Honckenya peploides* *Lathyrus maritimus* *Equisetum arvense* *Cochlearia officinalis*
Dune Grass (GRA)	raised beach – coastal bench	*Leymus mollis* *Salix ovalifolia*	*Lathyrus maritimus* *Equisetum arvense* *Artemisia tilesii* *Festuca brachyphylla* *Androsace chamaejasme* *Potentilla villosa* *Salix arctica* *Cnidium cnidiifolium* *Astragalus alpinus* *Oxytropis campestre* *Artemisia arctica* *Stellaria longipes* *Myosotis alpestris* *Bryophytes*
Dune Grass (GRA)	coastal dune	*Leymus mollis*	*Equisetum arvense* *Poa artica* *Salix ovalifolia* *Artemisia borealis* *Chrysanthemum bipinnatum* *Festuca rubra* *Stellaria laeta* *Taraxacum ceratophorum* *Poa glauca* *Alopecurus alpinus*

Table A-22. Definitions for Occurrences of Biobands.

Value		Applicable Bioband	Definition
Name	**Code**		
Patchy	P	All biobands *except* VER	Bioband visible in less than half (approximately 25 – 50%) of the along-shore unit length
Continuous	C	All biobands *except* VER	Bioband visible in more than half (approximately 50-100%) of the along-shore unit length
Narrow	N	VER *only*	Bioband visible at an across-shore width of up to 2 meters
Medium	M	VER *only*	Bioband visible at an across-shore width of between 2 and 5 meters
Wide	W	VER *only*	Bioband visible at an across-shore width of greater than 5 meters

Note that a 'Blank' or 'Null' value for the bioband indicates that band was not observed within the unit.

Table A-23. Definitions for Photos Fields.

Field Name	Description
SlideID	**SlideID**: A unique numeric ID assigned to each slide or photo
UnitRecID	**Unit Record ID**: Automatically-generated number field; the database "primary key" required for relationships between tables, links to Unit table
SlideName	**Photo Name:** A unique alphanumeric name assigned to each slide or photo
ImageName	**Full Photo Name:** Full image name with .jpg extension (required to enable "PhotoLink")
TapeTime	**Photo Time:** Exact time during aerial video imaging (AVI) survey when digital image was collected; used to link photo to digital trackline and position
SlideDescription	**Photo Comment:** Text field for biological comments regarding the digital photo or slide
Good Example?	**Yes/No** field, which when set to "Yes," indicates the photo is good representative of a particular biological feature or classification type
ImageType	**Photo Image Type:** Media type of original image: "Digital" or "Slide"
FolderName	**Photo Folder Name:** Name of the folder in which digital images are stored (required to enable "PhotoLink")
PhotoLink	**Photo Hyperlink:** Enables linkage to photos placed in directories near the database
PHY Good Example?	**Yes/No** field, which when set to "Yes," indicates the photo is representative of a particular geomorphic feature or classification
PHY SlideComment	**Physical Photo Comment:** Text field for geomorphological comments regarding the digital photo or slide

Table A-24. Ground Station Data

Field Name	Description
StationID	**StationID:** A unique numeric ID given to each ground station
UnitRecID	**Unit Record ID**: Automatically-generated number field; the database "primary key" required for relationships between tables
Station	**Ground Station ID Code:** Unique alphanumeric name assigned to each ground station
StationDescription	**Station Description:** Text field for comments regarding the ground station
Location	**Station Geographic Location:** General location of each ground station

APPENDIX B – PHYSICAL ILLUSTRATIONS

The following pages provide illustrated examples of shore types and geomorphic features.

Shore Types
Rock (Shore Types 1-5)
Rock and Sediment (Shore Types 6-20)
Sediment (Shore Types 21-30)
Organic Shorelines, Marshes, and Estuaries (Shore Type 31)
Human-Altered Shorelines (Shore Types 32-33)
Current-Dominated Channels (Shore Type 34)
Glacier Ice (Shore Type 35)
Lagoon (Shore Type 36)
Periglacial/Permafrost (Shore Type 37-39)

Geomorphic Features
Marshes and Wetlands
Deltas, Mudflats, and Tidal Flats
Beach Berms and Ridges
Lagoons
Glaciers

Anthropogenic Features
Coastal Structures and Seawalls

Shore Type: Rock (Shore Types 1-5)

Shore Type 1 (wide rock ramp)
West Hinchinbrook Island, Prince William Sound (Unit 02/06/1165)
pws07_mm_00527.jpg

Shore Type 3 (steep rock cliff)
Glacier Island, Prince William Sound (Unit 02/03/3572)
pws07_mm_06093.jpg

Shore Type: Rock (Shore Types 1-5)

Shore Type 4 (narrow rock ramp)
North Prince of Wales Island, Southeast Alaska (Unit 11/04/8496)
se07_mm_08431.jpg

Shore Type 5 (narrow rock platform)
Behm Canal, Southeast Alaska (Unit 12/01/8133)
se06_mm_04299.jpg

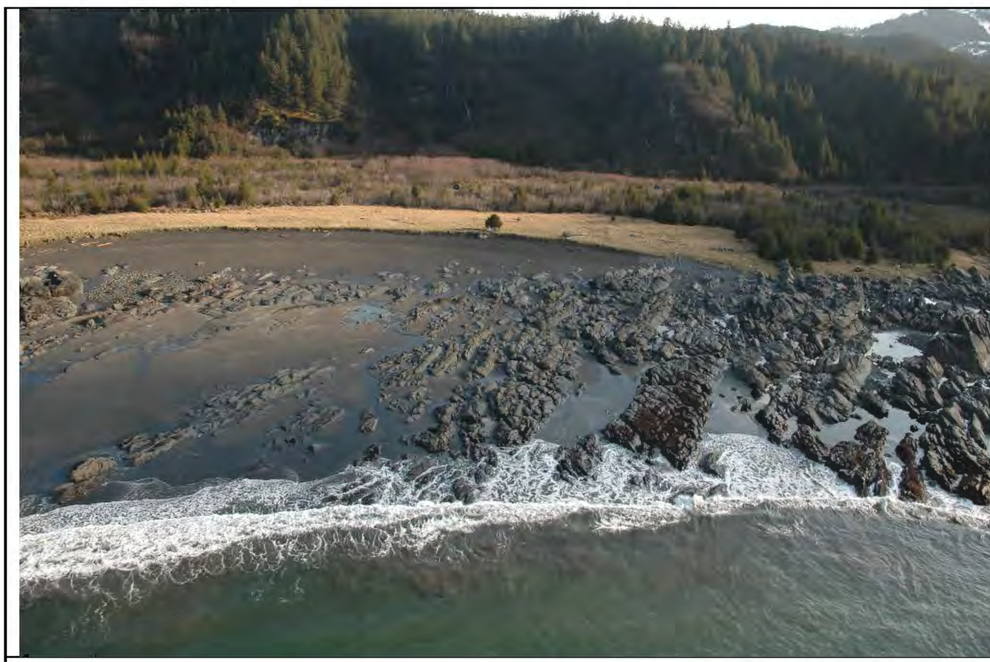
Shore Type: Rock and Sediment (Shore Types 6-20)

Shore Type 9 (narrow ramp with gravel beach)
Point Liscombe, Dall Island, Southeast Alaska (Unit 12/06/1169)
se07_ha_08068.jpg

Shore Type 11 (wide ramp with gravel and sand beach)
Yale Arm, Prince William Sound (Unit 02/02/7537)
pws07_ml_08301.jpg

Shore Type: Rock and Sediment (Shore Types 6-20)

Shore Type 14 (narrow ramp with gravel and sand beach)
West Crawfish Inlet, Southeast Alaska (Unit 10/07/1362)
bnf07_mm_03198.jpg



Shore Type 17 (wide platform with sand beach)
West Montague Island, Prince William Sound (02/06/0768)
pws07_ml_01084.jpg

Shore Type: Sediment (Shore Types 21-30)

Shore Type 21 (wide gravel beach)
Yakobi Island, Southeast Alaska (Unit 10/01/3530)
se05_mm_0902.jpg

Shore Type 24 (wide sand and gravel flat or fan)
Ban Island, Kodiak Island (Unit 06/01/1128)
kdkavi05_1879.jpg

Shore Type: Sediment (Shore Types 21-30)

Shore Type 25 (narrow sand and gravel beach)
Weasel Cove, Spiridon Bay, Kodiak Island (Unit 06/03/5003)
kdkavi05_3932.jpg

Shore Type 25 (narrow sand and gravel beach)
Will Roger-Wiley Post Monument, Barrow AK
USGS A509AK_DSC_6138.jpg

Shore Type: Sediment (Shore Types 21-30)

Shore Type 28 (wide sand flat)
Southeast Hinchinbrook Island, Prince William Sound (Unit 02/06/7048)
pws07_mm_10851.jpg

Shore Type: Organic Shorelines, Marshes, and Estuaries (Shore Type 31)

Shore Type 31 (organic shorelines, marshes, and estuaries)
Thorne Arm, Revillagigedo Island, Southeast Alaska (Unit 12/01/2049)
se06_mm_06819.jpg

Shore Type 31 (organic shorelines, marshes, and estuaries)
Kosciusko Island, Southeast Alaska (Unit 11/05/0261)
se07_mm_17130.jpg

Shore Type: Human-Altered Shorelines (Shore Types 32-33)

Shore Type 32 (man-made, permeable)
Coffman Cove, Prince of Wales Island, Southeast Alaska (Unit 11/04/9453)
se07_mm_03968.jpg

Shore Type 32 (man-made, permeable)
Steffanson Lagoon near Prudhoe Bay
USGS A106AK_IMG_7565.jpg

Shore Type: Current-Dominated Channels (Shore Type 34)

Shore Type 34 (current-dominated channel)
Big Salt Lake, Prince of Wales Island, Southeast Alaska (12/07/0758)
se06_mm_19974.jpg

Shore Type: Glacier Ice (Shore Types 35)

Shore Type 35, Form Ig (glacier)
Harvard Glacier, College Fjord, Prince William Sound (Unit 02/02/7485)
pws07_ml_08154.jpg

Shore Type: Lagoon (Shore Type36)

Shore Type 36, Form Lc (closed lagoon)
Near Northeast Cape, Saint Lawrence Island
bs13_sq_01085.jpg

Shore Type 36, Form Lc (closed lagoon)
Northern Kasegulak Lagoon near Wainwright, AK
USGS A509AK_DSC_5604.jpg

Shore Type: Permafrost Landforms (Shore Types 37, 38)

Shore Type 37. Inundated Tundra
Beaufort Sea Coast, North Slope Alaska
ns12_bs_006579.jpg

Shore Type 38 Ground Ice Slump
Beaufort Sea Coast, North Slope Alaska
ns12_bs_006351.jpg

Shore Type: Permafrost Landforms (Shore Type 39)

Shore Type 39. Low Vegetated Peat
Inside Arctic Lagoon, near Shishmaref
nw12_kz_01984.jpg

Shore Type 39. Low Vegetated Peat
Inside Lagoon near Point Hope
nw12_kz_12340.jpg

Geomorphic Features: Marshes and Wetlands

Shore Type 31, Forms high marsh ponds (Mho), low marsh ponds (Mlo), multiple river channels (Rm), tidal flat (Tt), and tide pools (Tp).
Tuxecan Passage, Southeast Alaska (Unit 11/05/4952)
se07_mm_18954.jpg

Shore Type 31, Forms Mhoc (high marsh with ponds and tidal creeks)
Prince of Wales Island, Southeast Alaska (Unit 11/04/4189)
se07_mm_06248.jpg

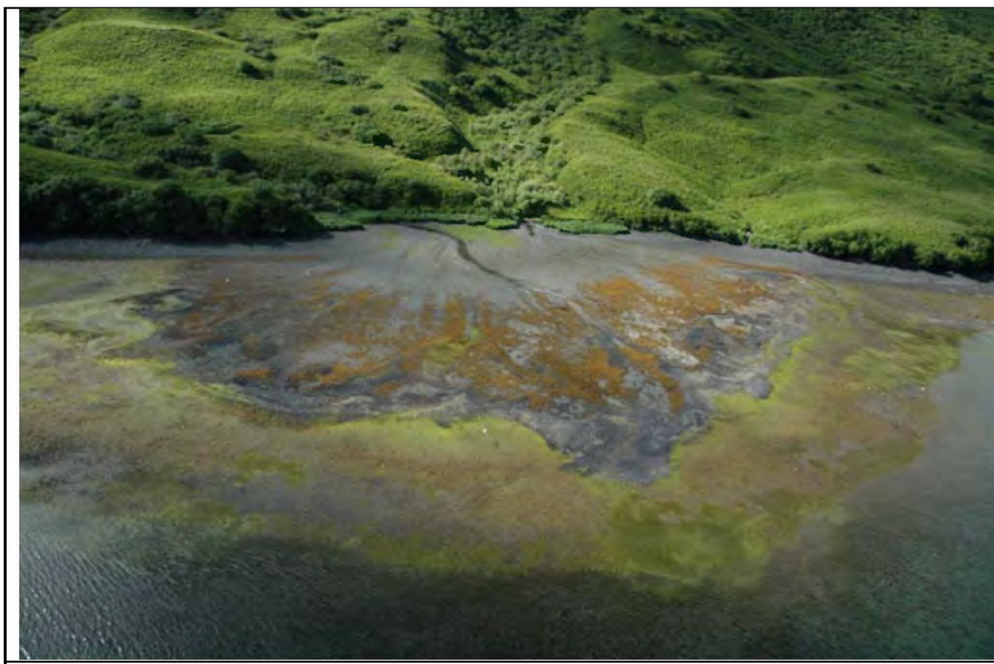
Geomorphic Features: Deltas, Mudflats, and Tidal Flats

Shore Type 24, Forms Tt (tidal flat) Tp (tide pools) Bt (beach low tide terrace)
Portage Arm, Southeast Alaska (Unit 10/08/2509)
bnf07_mm_13527.jpg

Shore Type 28, Forms Tt (tidal flat), Bf (beach face), Bb (beach berm)
Southeast Ice Bay, Southeast Alaska (Unit 09/01/0044)
se05_ml_3437.jpg

Geomorphic Features: Deltas, Mudflats, and Tidal Flats

Shore Type 24, Form Dfmb (delta fan with multiple bars)
Rakovai Bay, Southeast Alaska (Unit 10/07/2967)
bnf07_mm_06312.jpg



Shore Type 24, Forms Tt (tidal flat) Df (delta fan)
Shuyak Island, Kodiak Island (Unit 06/01/3733)
kdkavi05_10125.jpg

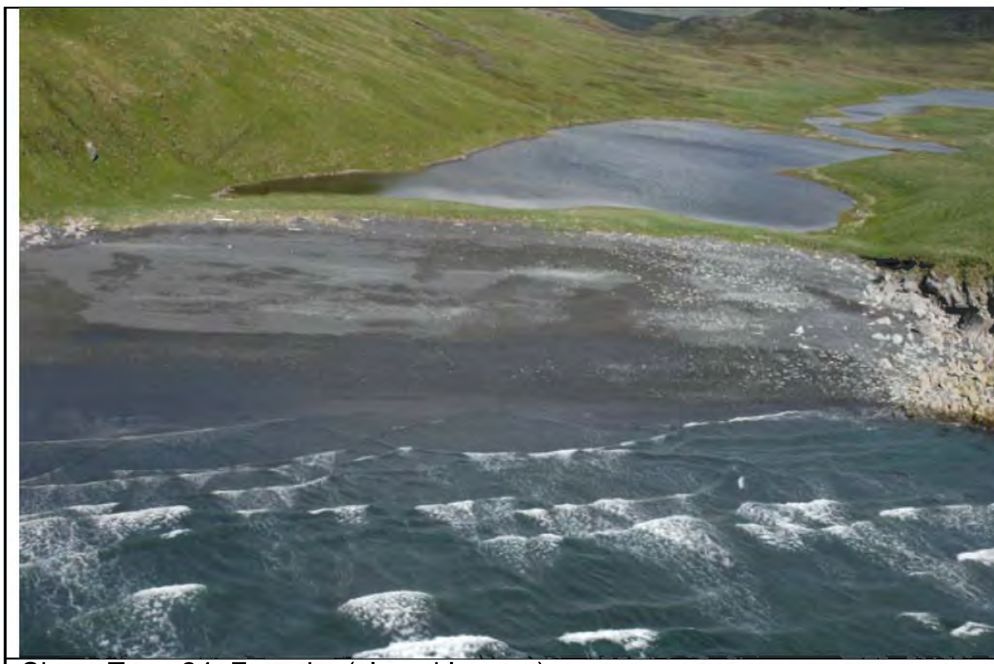
Geomorphic Features: Beach Berms and Ridges

Shore Type 25, Forms Bn (relic beach ridge) Bs (storm berm) Bb (beach berm) Bf (beach face)
Tatoosh Islands, Southeast Alaska (Unit 12/01/8412)
se06_mm_05217.jpg

Shore Type 25, Form Bf (beach face)
Gnat Cove, Southeast Alaska (Unit 12/01/1797)
se06_mm_06356.jpg

Geomorphic Features: Lagoons

Shore Type 31, Form Lo (open lagoon)
Revillagigedo Island, Southeast Alaska (Unit 12/01/2117)
se06_mm_06881.jpg



Shore Type 24, Form Lc (closed lagoon)
Tanner Head, Kodiak Island (Unit 05/02/0065)
kdkavi05_5959.jpg

Anthropogenic Features: Coastal Structures and Shore Modifications

Shore Type 32, Form Ab (breakwater)
Port Chilkoot, Lynn Canal, Southeast Alaska (Unit 10/04/3064)
se05_ml_0778.jpg

Shore Type 32, Forms Aw (wharf), As (seawall), and Af (floats)
Revillagigedo Island, Southeast Alaska (Unit 12/01/0140)
se06_mm_00191.jpg

APPENDIX C – BIOLOGICAL ILLUSTRATIONS

The following pages provide illustrated examples of biobands, biological wave exposures and habitat classes.

Biobands
Tundra (TUN)
Splash Zone (VER)
Dune Grass (GRA)
Sedges (SED)
Salt Marsh (PUC)
Barnacle (BAR)
Rockweed (FUC)
Biofilm (BFM)
Green Algae (ULV)
Blue Mussel (BMU)
California Mussel (MUS)
Bleached Red Algae (HAL)
Red Algae (RED)
Alaria (ALA)
Soft Brown Kelps (SBR)
Dark Brown Kelps (CHB)
Surfgrass (SUR)
Eelgrass (ZOS)
Urchin Barrens (URC)
Dragon Kelp (ALF)
Giant Kelp (MAC)
Bull Kelp (NER)

Biological Wave Exposures
Exposed (E)
Semi-Exposed (SE)
Semi-Protected (P)
Protected (P)
Very Protected (VP)

Habitat Classes
Immobile
Partially Mobile
Mobile
Estuary
Current-Dominated
Anthropogenic
Lagoon
Glacier

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Biobands: Tundra (TUN)

Tundra (TUN) Bioband, Semi-protected (SP), Permafrost Habitat Class
Harrison Bay, Beaufort Sea
A106AK_IMG_9280.jpg

Tundra (TUN) Bioband, Semi-protected (SP), Permafrost Habitat Class
Inside Lopp Lagoon, near Wales, Chukchi Sea
nw12_kz_07673.jpg

Biobands: Splash Zone (VER), Dune Grass (GRA) and Salt Marsh (PUC)

Splash Zone (VER) Bioband, Semi-Exposed (SE), Immobile Habitat Class
Round Islands, Cordova Bay, Southeast Alaska (Unit 12/05/3010)
se06_ml_01339.jpg

Dune Grass (GRA) and Salt Marsh (PUC) Biobands
Nulavik, Arctic Ocean
A106AK_IMG_9280.jpg

Biobands: Dune Grass (GRA), Tundra (TUN), Sedges (SED) and Salt Marsh (PUC)

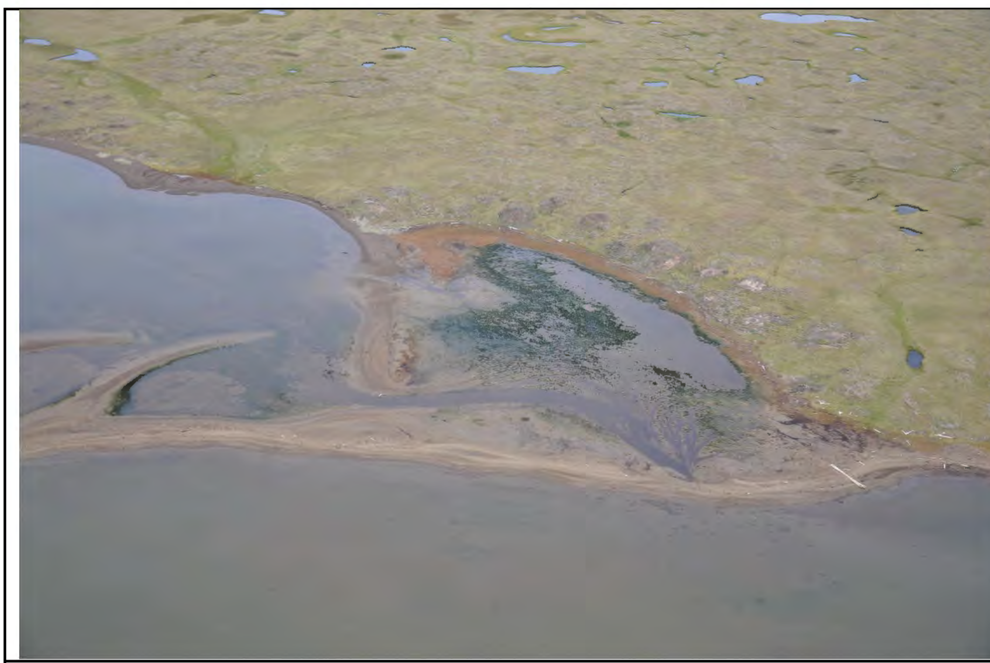
Dune Grass (GRA), Sedges (SED) and Salt Marsh (PUC) Biobands, Protected (P), Estuary Habitat Class
Frederick Cove, Prince of Wales Island, Southeast Alaska (Unit 12/08/0513)
se06_mm_12046.jpg

Sedges (SED) Bioband, Protected (P), Estuary Habitat Class
Uyak Bay, Kodiak Island (Unit 06/03/0691)
kdkavi05_4444.jpg

Biobands: Sedges (SED) and Salt Marsh (PUC)

Salt Marsh (PUC) Bioband, Protected (P), Partially Mobile Habitat Class
Port Banks, Whale Bay, Baranof Island, Southeast Alaska (10/07/3081)
bnf07_mm_06470.jpg

Biobands: Biofilm (BFM)



Biofilm (BFM) Bioband, Protected (P), Habitat Class Permafrost
north Chukchi Sea coast
ns12_cs_001651.jpg

Biobands: Barnacle (BAR) and Rockweed (FUC)

Barnacle (BAR) Bioband, Semi-Exposed (SE), Immobile Habitat Class
Alitak Bay, Kodiak Island (Unit 05/02/1513)
kdkavi05_06980.jpg

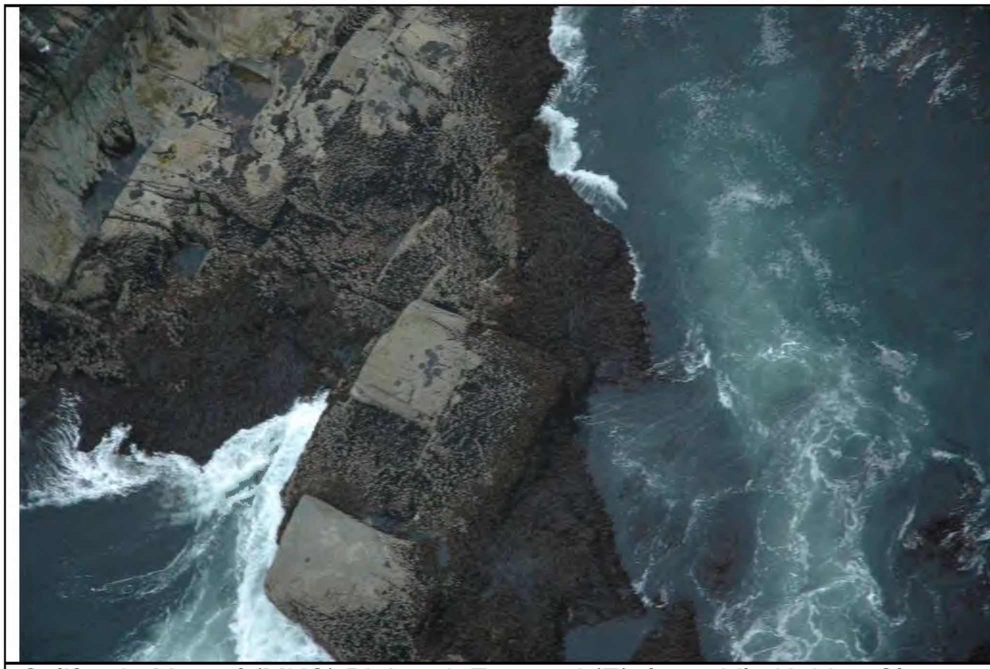
Rockweed (FUC) Bioband, Semi-Protected (SP), Partially Mobile Habitat Class
Little Branch Bay, Baranof Island, Southeast Alaska (Unit 10/07/3812)
bnf07_mm_08182.jpg

Biobands: Green Algae (ULV) and Blue Mussel (BMU)

Green Algae (ULV) Bioband, Semi-Protected (SP), Immobile Habitat Class
Entrance Island, Dall Island, Southeast Alaska (Unit 12/06/5755)
se07_ha_03467.jpg

Blue Mussel (BMU) Bioband, Semi-protected (SP), Immobile Habitat Class
Speel Arm, Port Snettisham, Southeast Alaska (Unit 10/05/1239)
se05_ml_9353.jpg

Biobands: California Mussel (MUS) and Bleached Red Algae (HAL)



California Mussel (MUS) Bioband, Exposed (E), Immobile Habitat Class
Baker Island, Prince of Wales Island, Southeast Alaska (Unit 12/07/3217)
se06_mm_23948.jpg

Bleached Red Algae (HAL) Bioband, Protected (P), Partially Mobile Habitat Class
Salmo Point, Hawkins Island, Prince William Sound (Unit 02/04/7233)
pws07_mm_11732.jpg

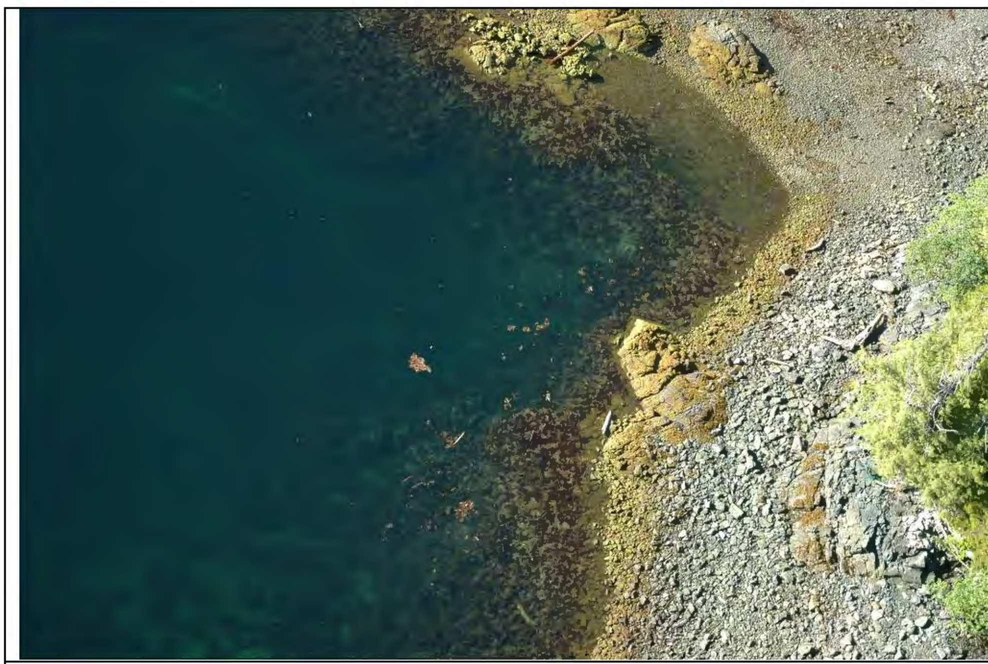
Bioband: Red Algae (RED)

Red Algae (RED) Bioband, Semi-Protected (SP), Partially Mobile Habitat Class
Montague Island, Prince William Sound (Unit 02/06/0337)
pws07_ml_02579.jpg

Red Algae (RED) Bioband, Exposed (E), Immobile Habitat Class
Herbert Graves Island, Southeast Alaska (Unit 10/01/9195)
se05_mm_2668.jpg

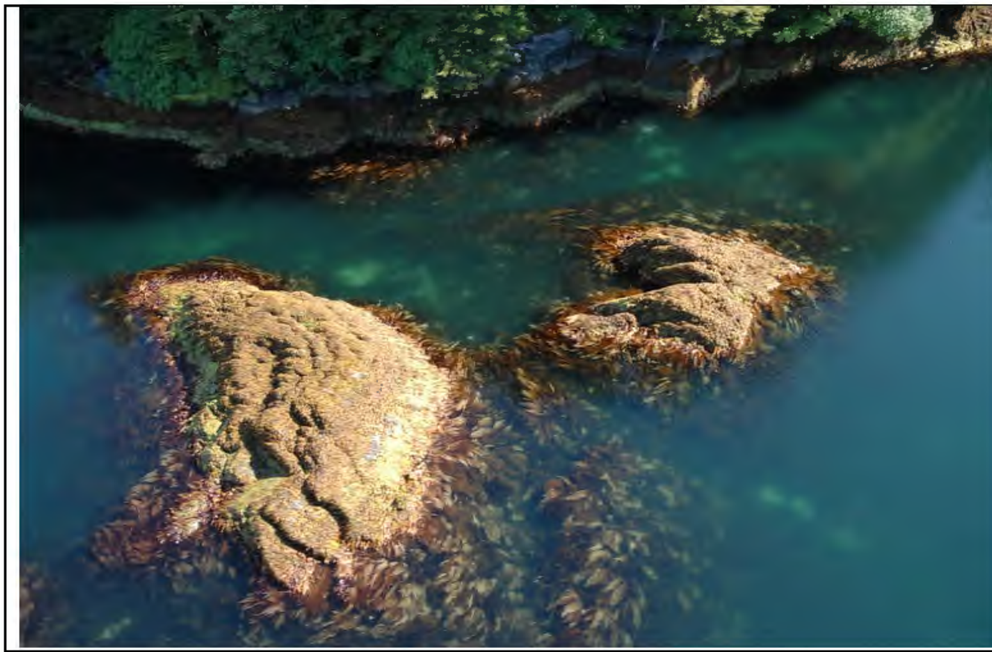
Biobands: Alaria (ALA) and Soft Brown Kelps (SBR)

Alaria (ALA) Bioband, Semi-Exposed (SE), Immobile Habitat Class
Little Branch Bay, Baranof Island, Southeast Alaska (Unit 10/07/3827)
bnf07_mm_08218.jpg



Soft Brown Kelps (SBR) Bioband, Protected (P), Partially Mobile Habitat Class
Kendrick Bay, Prince of Wales Island, Southeast Alaska (Unit 12/05/0114)
se06_mm_10623.jpg

Biobands: Soft Brown Kelps (SBR) and Dark Brown Kelps (CHB)

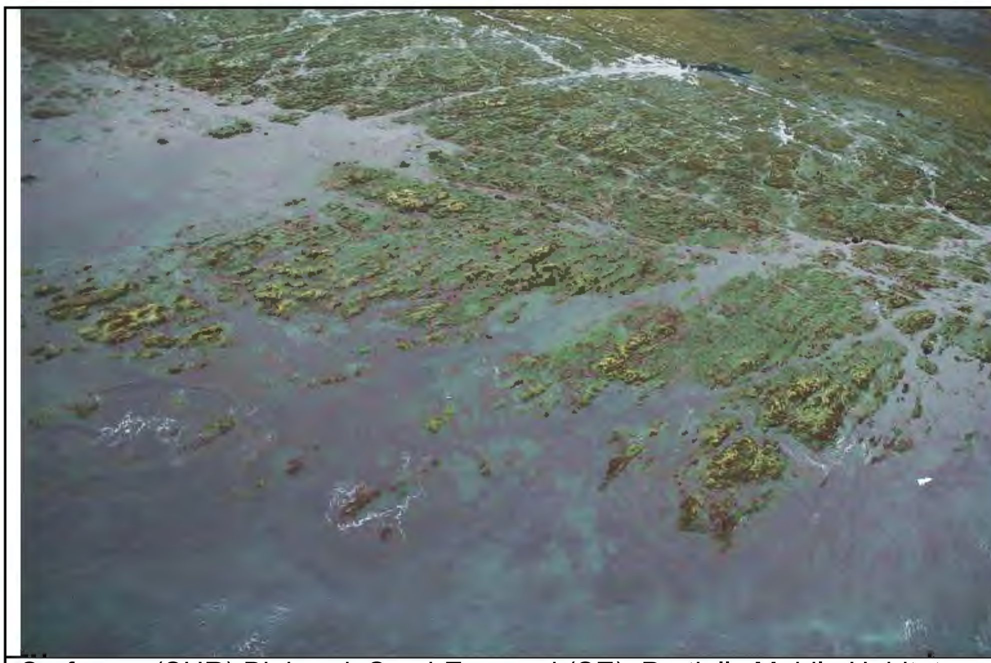


Soft Brown Kelps (SBR) Bioband, Semi-Protected (SP), Immobile Habitat Class
Krishka Island, Baranof Island, Southeast Alaska (Unit 10/07/3037)
bnf07_mm_06396.jpg

Dark Brown Kelps (CHB) Bioband, Exposed (E), Immobile Habitat Class
Little Branch Bay, Baranof Island, Southeast Alaska (Unit 10/07/3827)
se07_mm_08220.jpg

Bioband: Surfgrass (SUR)

Surfgrass (SUR) Bioband, Semi-Protected (SP), Partially Mobile Habitat Class
Discovery Point, Knight Island, Prince William Sound (Unit 02/05/1022)
pws07_ml_02736,jpg



Surfgrass (SUR) Bioband, Semi-Exposed (SE), Partially Mobile Habitat Class
Jeanie Point, Montague Island, Prince William Sound (Unit 02/06/0802)
pws07_ml_01294.jpg

Bioband: Eelgrass (ZOS)

Eelgrass (ZOS) Bioband, Protected (P), Mobile Habitat Class
Surge Bay, Yakobi Island, Southeast Alaska (Unit 10/01/3383)
se05_mm_0791.jpg

Eelgrass (ZOS) Bioband, Protected (P), Partially Mobile Habitat Class
Lodge Island, Baranof Island, Southeast Alaska (Unit 10/07/1661)
bnf07_mm_03772.jpg

Biobands: Urchin Barrens (URC) and Dragon Kelp (ALF)

Urchin Barrens (URC) Bioband, Semi-Protected (SP), Immobile Habitat Class
Edge Point, Mary Island, Southeast Alaska (Unit 12/08/1221)
se06_mm_12922.jpg

Dragon Kelp (ALF) Bioband, Semi-Protected (SP), Partially Mobile Habitat Class
Lemesurier Island, icy Strait, Southeast Alaska (Unit 10/02/7855)
se10_hb_00912.jpg

Biobands: Giant Kelp (MAC) and Bull Kelp (NER)

Giant Kelp (MAC) Bioband, Semi-Protected (SP), Immobile Habitat Class
Point Mirraballis, Prince of Wales Island, Southeast Alaska (Unit 12/07/1043)
se06_mm_21102.jpg

Bull Kelp (NER) Bioband, Semi-Protected (SP), Immobile Habitat Class
Cat Island, north of Duke Island, Southeast Alaska (Unit 12/04/10044)
se06_mm_10044.jpg

Biological Wave Exposures: Exposed (E) and Semi-Exposed (SE)

Exposed (E), Immobile Habitat Class
Bear Island, Kodiak Island (Unit 06/03/1153)
kdkavi05_4824.jpg

Semi-Exposed (SE), Immobile Habitat Class
Kelp and Duke Island, Southeast Alaska (Unit 12/04/5299)
se06_mm_09563.jpg

Biological Wave Exposure: Semi-Protected (SP)

Semi-Protected (SP), Immobile Habitat Class
Kashevarof Islands, Prince of Wales Island, Southeast Alaska (Unit 11/04/8089)
se07_mm_07616.jpg

Semi-Protected (SP), Partially Mobile Habitat Class
Duke Island, Southeast Alaska (Unit 12/04/6173)
se06_mm_15536.jpg

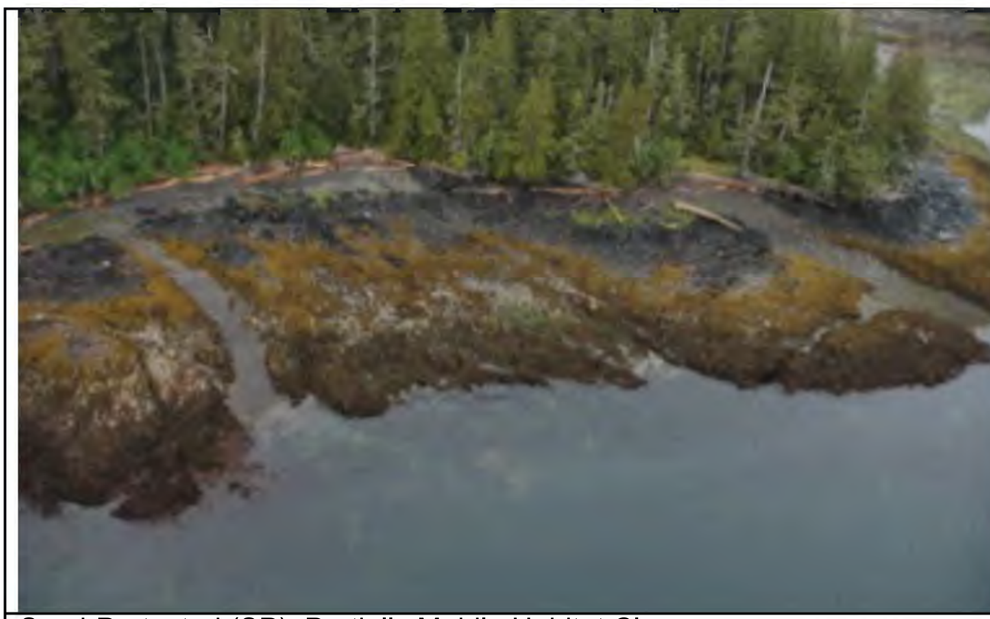
Biological Wave Exposure: Protected (P) and Very Protected (VP)

Protected (P), Partially Mobile Habitat Class
Necker Bay, Baranof Island, Southeast Alaska (Unit 10/07/2444)
se07_mm_05324.jpg

Very Protected (VP), Estuary Habitat Class
Biscuit Lagoon, Prince of Wales Island, Southeast Alaska (Unit 12/05/7537)
se07_ha_4895.jpg

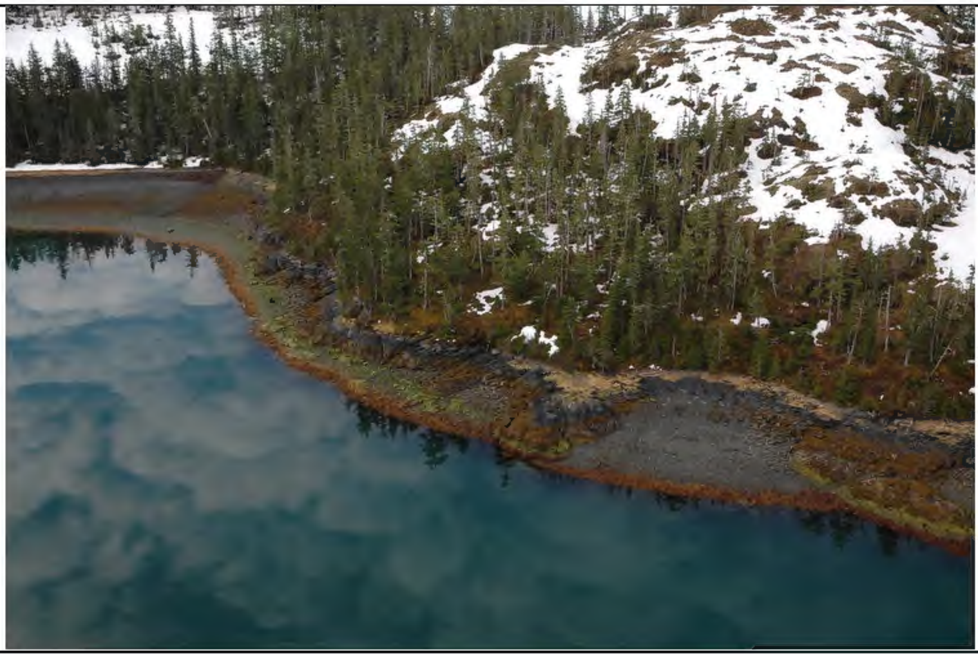
Habitat Classes: Immobile and Partially Mobile

Exposed (E), Immobile Habitat Class
Aspid Cape, Baranof Island, Southeast Alaska (Unit 10/072218)
se07_mm_04868.jpg



Semi-Protected (SP), Partially Mobile Habitat Class
Annette Point, Annette Island, Southeast Alaska (Unit 12/04/1734)
se06_mm_08514.jpg

Habitat Classes: Partially Mobile and Mobile



Semi-Protected (SP), Partially Mobile Habitat Class
Heather Bay, Prince William Sound (Unit 02/03/4223)
pws07_mm_06856.jpg

Semi-Exposed (SE), Mobile Habitat Class
Middle Bay, Kodiak Island (Unit 06/03/1623)
kdkavi05_5438.jpg

Habitat Class: Estuary

Protected (P), Estuary Habitat Class
Klakas Inlet, Prince of Wales Island, Southeast Alaska (Unit 12/05/7131)
se07_ha_04049.jpg

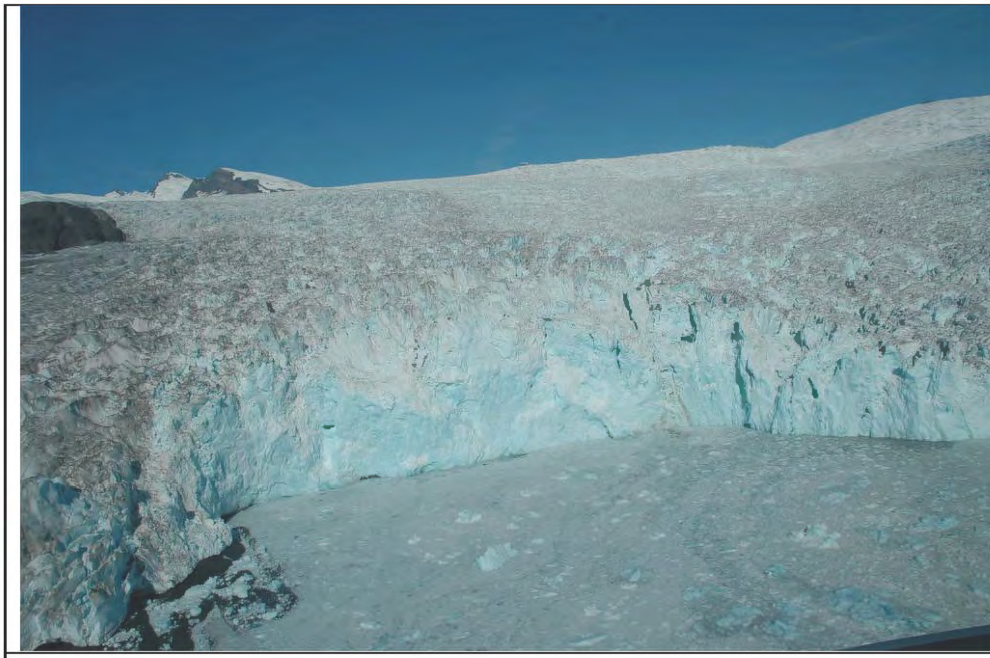
Protected (P), Estuary Habitat Class
Traitors Cove, Southeast Alaska (Unit 12/01/8041)
se06_mm_04099.jpg

Habitat Classes: Current-Dominated and Anthropogenic

Semi-Exposed (SE), Current-Dominated Habitat Class
Traitors Cove, Southeast Alaska (Unit 12/01/8067)
se06_mm_04152.jpg

Protected (P), Anthropogenic Habitat Class
Old Harbor, Kodiak Island (Unit 05/04/8485)
kdkavi05_09115.jpg

Habitat Classes: Glacier and Lagoon



Protected (P), Glacier Habitat Class
Taku Glacier, Taku Inlet, Southeast Alaska (Unit 09/01/0302)
se05_ml_3878.jpg

Semi-Exposed (SE), Lagoon Habitat Class
Uyak Bay, Kodiak Island (Unit 06/03/5193)
kdkavi05_4014.jpg

Habitat Classes: Periglacial Processes/Permafrost

Periglacial/Permafrost Habitat Class
east Beaufort Sea coast
ns12_bs_003162.jpg

Periglacial/Permafrost Habitat Class
Baldwin Peninsula, south of Kotzebue
nw12_kz_08456.jpg

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APPENDIX D – COASTAL VULNERABILITY MODULE

Table	Description
B-1	Coastal Stability Index
B-2	Flooding Sensitivity Index
B-3	Thaw Sensitivity Index
B-4	Coastal Mass-Wasting and Wetland Features

The Coastal Vulnerability Module (CVM) for Arctic shorelines mapped with 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.

The Coastal Vulnerability Module provides an estimate 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 description of stability, (as erosional, stable or accretional) along with additional modifiers for sediment, wetland and other shoreline types.
>
> ***Flooding Sensitivity Index*** (Table B-2) that provides an estimate of flooding extent in one of five categories.
>
> ***Thaw Sensitivity Index*** (Table B-3) that provides an estimate of thaw sensitivity in one of five categories, defined by percentage of standing water, ponds or thaw lakes in the backshore and used as an indirect indicator of further thaw settlement potential.

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

Table B-1. Coastal Stability Index.

	Code	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 vegetation “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 ↑ ↑ Minor	Flooding >100 m inland from HWL as indicated by the highest logline
F3		Flooding 50-100 m inland from HWL as indicated by the highest logline
F2		Flooding 10-50 m inland from HWL as indicated by the highest logline
F1		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 ↑ Low	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		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.)