OREGON SHOREZONE

Coastal Habitat Mapping Protocol

2013

ShoreZone

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ShoreZone Coastal Habitat Mapping Protocol for Oregon (v. 3) 2013

prepared for
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SUMMARY

The coastal zone is a crucial interface for terrestrial and marine organisms, human activities, and dynamic processes. ShoreZone is a coastal habitat mapping and classification system that specializes in (a) the collection of spatially-referenced aerial imagery of the intertidal zone and and classification of visible features in that imagery. ShoreZone provides an integrated, searchable inventory of geomorphic and biological features which can be used as a tool for science, education, management, and environmental hazard mitigation.

This report provides documentation of the ShoreZone Coastal Habitat Mapping Program in the State of Oregon. The protocol is meant to:

- Provide an overview of the ShoreZone program and its procedures.
- Specify standards for image collection and intertidal/nearshore habitat mapping so that users will have an understanding of the methodology and to ensure consistency in its use.
- Provide illustrated examples of mapped features from Oregon.

The ShoreZone system utilizes spatially referenced, oblique aerial video and digital still imagery of the coastal zone collected during the lowest daylight tides of the year. Image interpretation and mapping is accomplished by a team of physical and biological scientists. The mapping system (housed in ArcGIS and 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:

- flight survey reports with imagery (DVDs, still photos on external drives),
- spatially-referenced geomorphic and biological attribute data interpreted from aerial imagery,
- data summaries.

The ShoreZone system was developed in the 1980s and 1990s to map coastal habitat in British Columbia and Washington state (Howes 2001; Berry *et al* 2004). From 2001 to present, ShoreZone mapping has been conducted in Alaska with coverage from the BC-Alaska border to Bristol Bay Alaska (Harper and Morris 2004; Harney *et al* 2008, Harper and Morris 2011). ShoreZone imaging of the entire state of Oregon was conducted in June 2011, and this protocol provides the standard for the imagery collection and mapping (based largely on the Gulf of Alaska ShoreZone mapping protocol; Harney *et al* 2008). ShoreZone dataset presently includes over 100,000 km of imaged shoreline (Fig. 1), including almost 1,800 km in Oregon (Fig. 2).

The Oregon imagery is web-posted to allow easy agency and public access. Mapped data (such as eelgrass, canopy kelps, sediment type, and other features) will also be web-posted. The website is www.coastalatlas.net/shorezone.

ShoreZone imagery provides a useful baseline, while mapped resources (such as shoreline sediments, eelgrass occurrence, and wetland distribution) are an important tool for scientists and managers. ShoreZone coastal mapping data is routinely used for oil spill contingency planning, conservation planning, habitat research, development evaluation, mariculture site review, and recreation planning.

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1.0 OVERVIEW OF THE SHOREZONE MAPPING SYSTEM

1.1 Background

The coastal zone is a crucial interface for terrestrial and marine organisms, human activities, and dynamic processes, and the systematic documentation of these features is an important element of resource management. ShoreZone is a mapping and classification system that specializes in the collection and interpretation of aerial imagery of the coastal environment. ShoreZone provides an integrated, searchable inventory of geomorphic and biological features of the intertidal and nearshore zones which can be used as a tool for science, education, management, and environmental hazard planning.

ShoreZone imagery is the primary sources of mapped resources data (such as shoreline sediments, eelgrass and wetland distributions) and is an important tool for scientists and managers. The ShoreZone system was initially developed in the 1980s and 1990s to map coastal features in British Columbia and Washington State (Howes 2001; Berry *et al*. 2004). Between 2001 and 2013, ShoreZone imaging and mapping was initiated in the Gulf of Alaska and the ShoreZone program (Harney *et al* 2008) now extends from Oregon to the Bering Sea (Fig. 1).

The coastal mapping data and imagery are used for oil spill contingency planning, conservation planning, habitat research, development evaluation, mariculture site review, and recreation opportunities. The protocol is updated periodically as required.

1.2 ShoreZone in Oregon

The ShoreZone imaging in Oregon was completed in June 2011 (Fig. 2) and mapping was initiated following this protocol. Oblique low-altitude aerial video and digital still imagery of the coastal zone was collected during the lowest tides of the year from a helicopter flying at altitudes of 100-300m altitude. During image collection, the aircraft’s GPS position was recorded at 1-second intervals using electronic navigation software and was continuously monitored in-flight to ensure all shorelines have been imaged (Fig. 3). Video and still imagery were spatially-referenced and time-synchronized using a 6-digit UTC time code (Fig. 4 and 5). The video imagery is accompanied by continuous, simultaneous commentary by a geologist and a biologist aboard the aircraft.

Image interpretation and mapping is accomplished by a team of physical and biological scientists, who use the imagery and commentary to delineate along-shore coastal habitat *units* (Fig. 6) and to “map” their observations of physical, geomorphic, sedimentary, and biological across-shore *components* within those units (Fig. 7). Units are digitized as shoreline segments in ArcGIS, then integrated with the geological and biological data housed in a relational Microsoft Access database. Mapped habitat features include degree of wave exposure, substrate type, sediment texture, intertidal biota, and some nearshore subtidal biota.

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

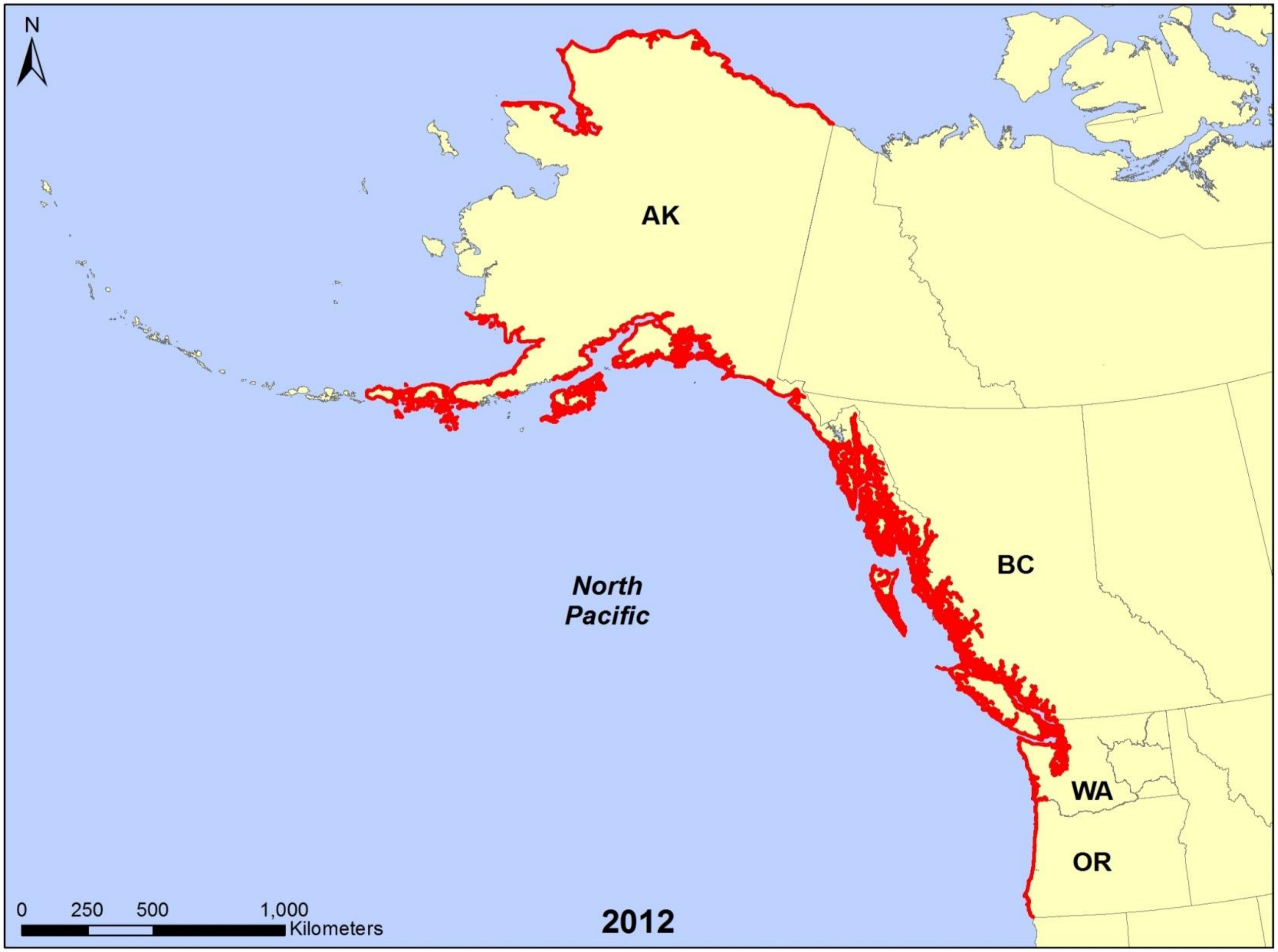


Figure 1. Extent of ShoreZone imagery/mapping in Alaska, British Columbia, Washington and Oregon: 104,000 km as of July 2012.

Figure 2. Extent of ShoreZone imagery and coastal habitat mapping in the State of Oregon (1,795 km as of 30 June 2013).

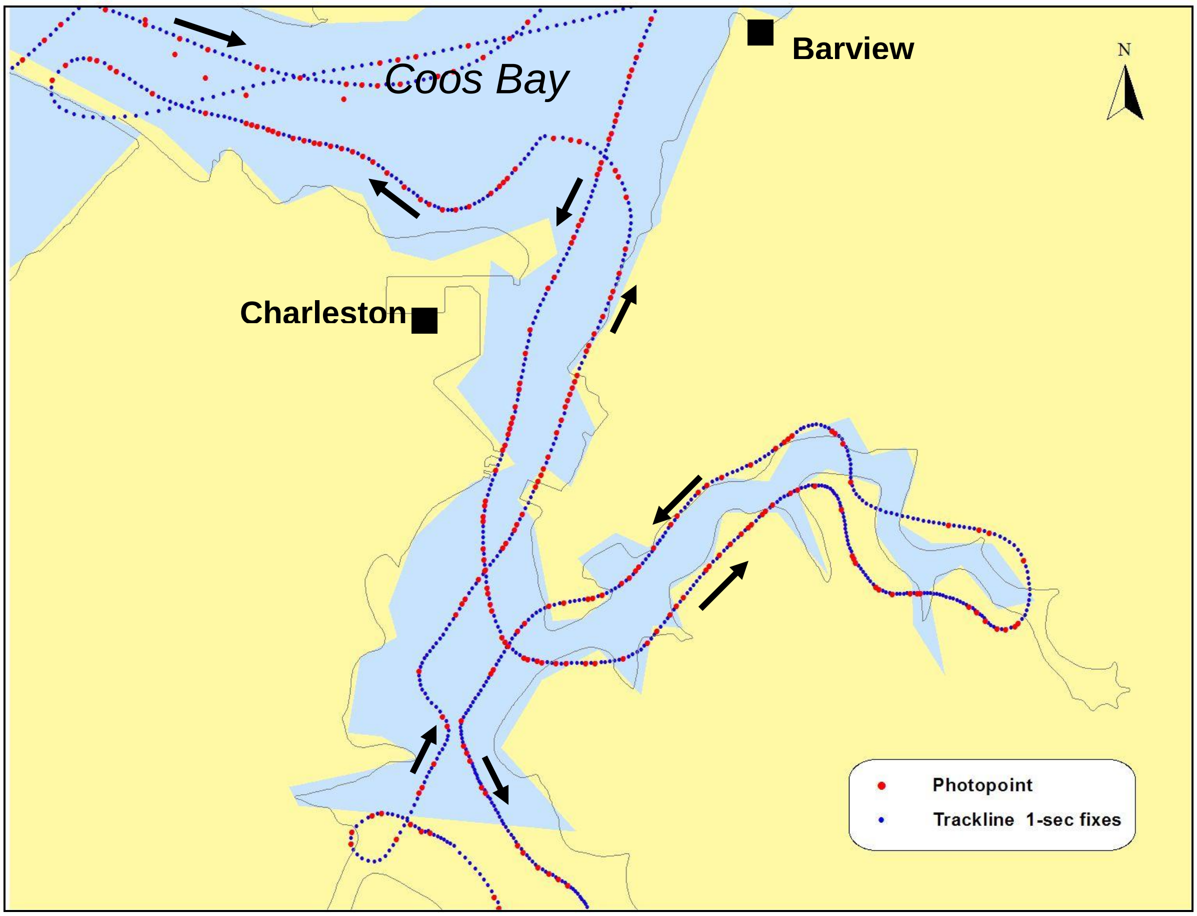


Figure 3. Example of recorded flight trackline from Coos Bay showing 1-second GPS navigation fixes in blue and the photograph locations in red. Imaging is conducted from the left side of the helicopter.

Figure 4. Example of frame capture from video imagery at Heceta Head north of Florence, Oregon. Latitude, longitude, and 6-digit UTC time stamp are burned onto each frame of video imagery.

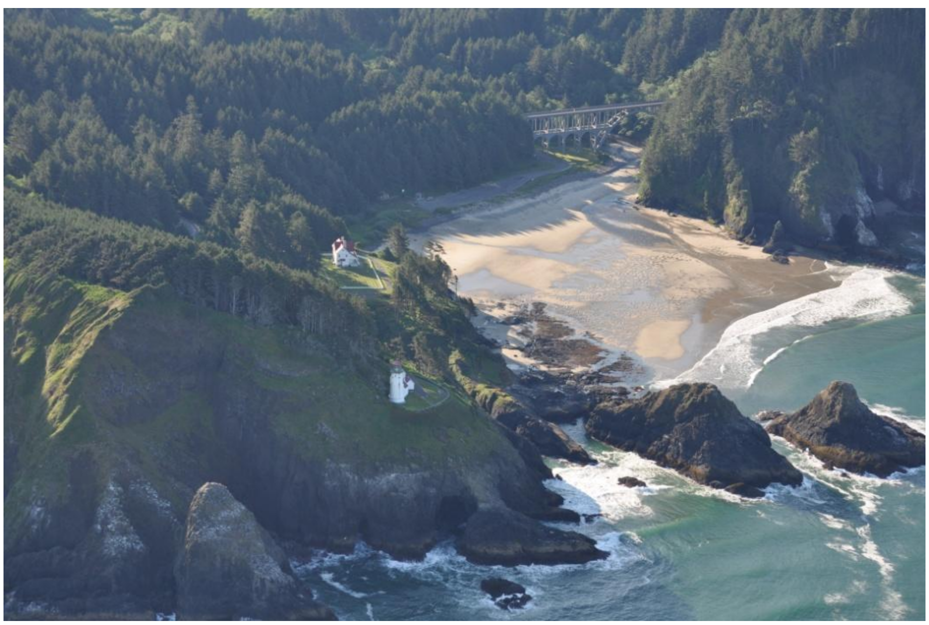


Figure 5. Example of digital still imagery at Heceta Head north of Florence, Oregon. The meta data associated with the digital imagery also includes the UTC time code so that each photo is georeferenced, providing a GPS position on the shoreline for each image. Digital images are 6 MB each so contain considerable resolution.

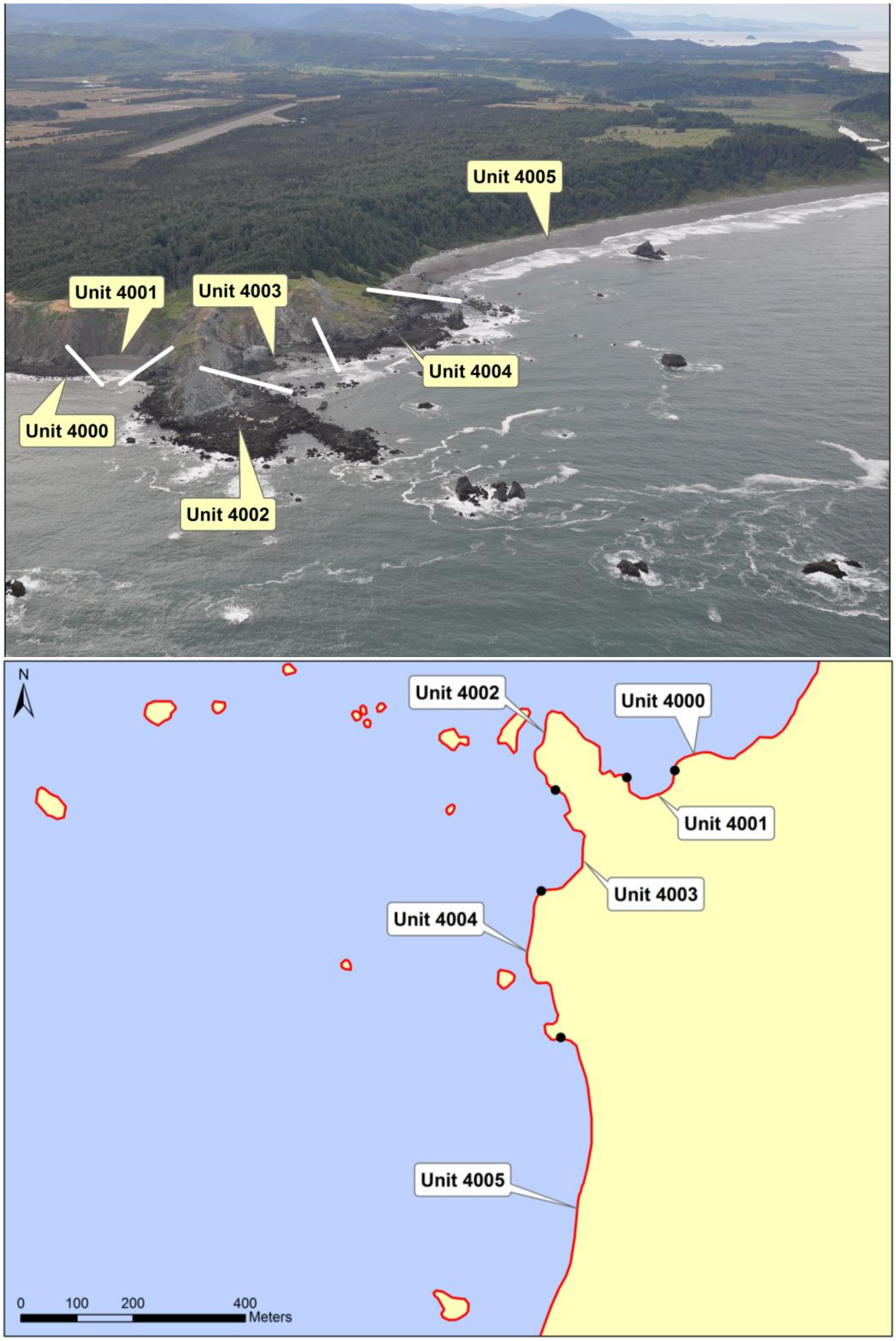


Figure 6. An example of shore-unit segmentation for a high-energy shoreline near Tower Rock (north of Port Orford). The associated maps illustrate how the shore units are interpreted from aerial imagery and transferred to maps.

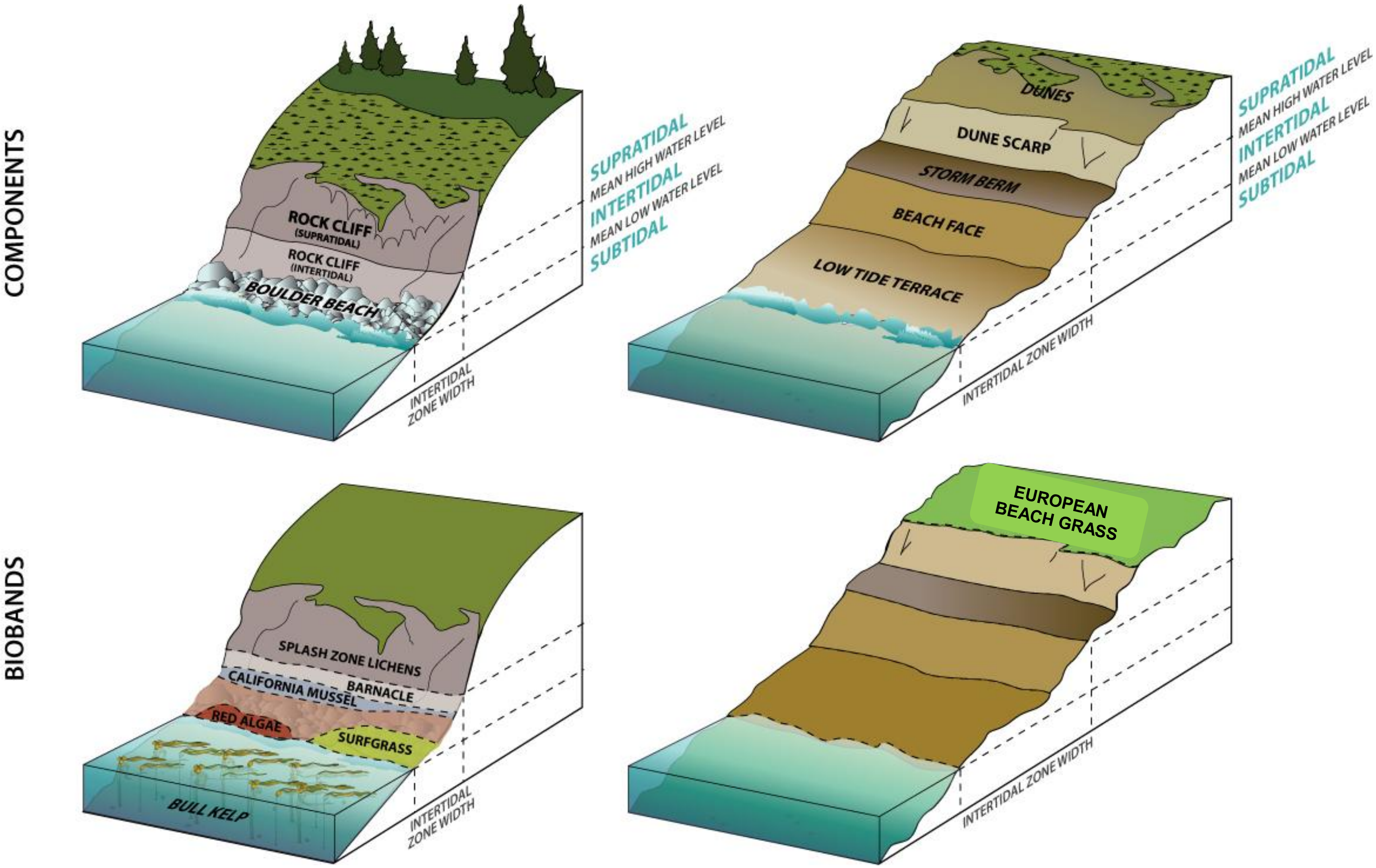


Figure 7. Schematic representation of across-shore *Components* and *Biobands* for two common shore types of the Oregon coast. *Components* are carefully referenced to the three tidal zones and *Biobands* are nested within *Components*. The stable substrate of the rock cliffs support a number of different biobands whereas the dynamic nature of the sand beaches are stable only in the vegetated dunes where the *European Beach Grass Bioband* is noted. The supratidal zone lies between the MHWL and the storm log line.

Thematic data (such as the distribution of eelgrass, canopy kelps, sediment type, and other features) can also be plotted (Fig. 8).

The ShoreZone mapping system provides a spatial framework for coastal habitat assessment on local and regional scales. Research and practical applications of ShoreZone data and imagery include:

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

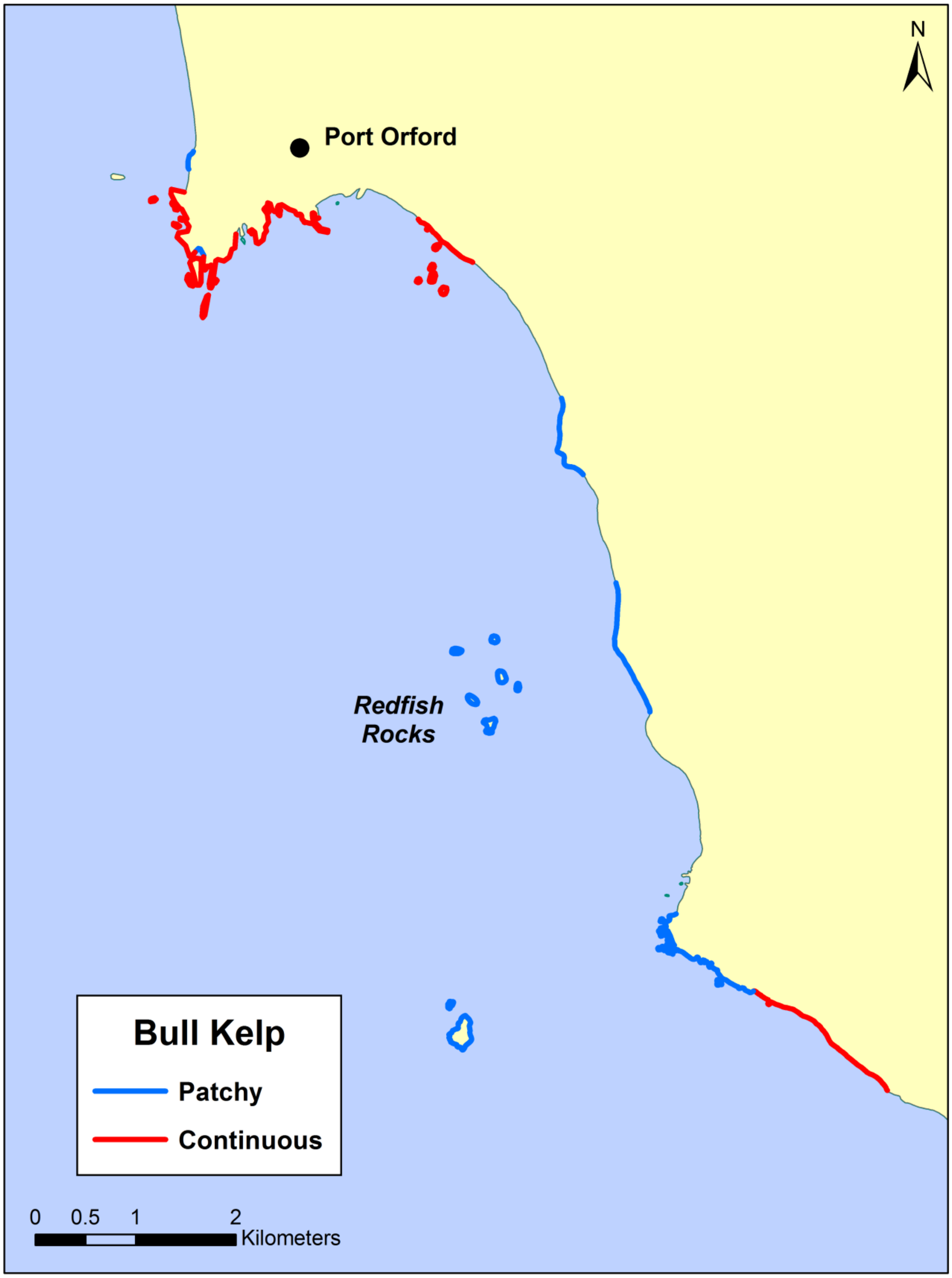


Figure 8. Example of mapping the Bull Kelp bioband in one of the initial mapping areas in Oregon. Bull Kelp was mapped as *Patchy* (27%) or *Continuous* (31%) in the 31 km of shoreline shown on the map.

2.0 SHOREZONE AERIAL VIDEO IMAGING (AVI) SURVEYS

2.1 AVI Survey Overview

Planning for an aerial survey program must begin well in advance (typically months) of the actual field work 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 “zero feet” 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).

Helicopters are typically limited to 2.5 hours of flight time so organizing for fuel stops is critical to optimize imagery acquisition during the low-tide window. The minimum amount of time required for refuelling is 20-30 minutes, which is ~10% of the potential imaging window.

Imaging is conducted from the left side of the aircraft, thus the survey 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 (Fig. 9). Typical personnel functions are summarized in Table 1. Pre- and post-flight responsibilities tend to be shared among personnel, but in-flight activities are generally assigned to a particular crew member. Table 2 provides guidelines for the videographer/geologist and Table 3 provides guidelines for the photographer/biologist

The Oregon survey team is identified with a name (Oregon) and a two-letter abbreviation (e.g. Team Oregon or “OR”) used in the video tape headers and navigation data files.

Team Oregon Time in PDT; height in meters;
Gauges: Tillamook ay, Barview; Tillamook Bay, Bay City; Yaquina Bay, Entrance; Coos Bay, Coos Bay; Coos Bay, Charleston; Bro

Day	Date	Time	Flight Time (hr)	Shoreline (km)	Total (km)	Transit (km)	Location
0	*31-May-11*	8:15 PM	1:00			90	Positioning Hillsboro to Astoria
1	*01-Jun-11*	5:29				12	Astoria liftoff at sunrise; transit to north sunset beach
	tide=	5:35		172			South Jetty to Netarts & Cape Lookout; skip Nehalem, Tillamook Bay
	3:20	7:15				20	Transit to Tillamook Airport for refuel
		7:45		25			Tillamook River, west Tillamook Bay
		8:00				10	transit to Nehalem Bay
		8:05		53			Nehalem Bay and estuary
		8:40				10	transit to Tillamook Bay
		8:45		120			East Tillamook Bay, Kilchis, Wilson, Trask Rivers, max. 15km to fuel
		9:50					Tide Closes
		10:00				5	Return to Tillamook Airport
	Total		*4:05*	370		57	
2	*02-Jun-11*	6:05				15	Tide Opens; Tillamook Bay
		6:15		46			Cape Lookout to Nestucca Bay, include Sand Lake
		6:45		37			Nestucca Bay, Pacific City Estuary
		7:10		85			Nestucca to Yaquina Bay, skip Salmon R, Siletz Bay
		8:00				1	Refuel at Newport Municipal Airport
	tide=	8:30				50	Transit to Salmon River
	4:20	9:05		19			Salmon River
		9:20				13	Transit to Siletz Bay Estuary
		9:25		74			Siletz Bay Estuary
		10:10				30	Transit and return to Newport Municipal Airport for possible refuel
		10:55		66			Yaquina Estuary
		11:35				5	Transit to Newport Airport
		10:35					Tide Closes
	Total		*4:25*	327		114	
3	*03-Jun-11*	6:30					Tide Opens; Newport; Yaquina Bay
		6:30		31			Alsea Bay
		6:50		47			Alsea Bay Estuary
		7:20		62			Siuslaw River
	tide=	7:55		128.5			Siuslaw River Estuary, max. 20km to fuel
	3:45	9:15					Refuel at Florence Municipal Airport
		9:45		47			Suislaw to Umpqua Bay
		10:15		140			Umpqua River Estuary
		11:40				30	Transit to North Bend Municipal Airport for Refuel
		11:55					
		10:10					Tide Closes
		11:00					Tide Closes
	Total		*5:00*	455.5		30	
4	*04-Jun-11*	7:00					Tide Opens; Coos Bay, Charleston
		6:55				4	transit to North Spit due west of North Bend
		7:00		114			North Spit to Cape Blanco, New R. and Sixmile R.
	tide=	8:10				32	Transit to Coquille River Estuary
	3:40	8:25		70			Coquille River Estuary
		9:10				10	Transit to North Bend Municipal Airport for Refuel
		9:40				27	transit to entrance Umpqua Bay
		9:50		27			Umpqua Bay to north Spit/Coos Bay entrance
		10:00		150			Coos Bay Estuary*Finish max. 20km from fuel
		11:30				15	transit to North Bend, refuel
		11:50		71			complete Coos Bay Estuary max. 20km from fuel
		12:30					set-down North Bend
		10:35					Tide Closes;
	Total		*4:40*	432		88	
5	*05-Jun-11*	6:45				66	Liftoff; Transit to Cape Blanco
		7:15					Tide Opens; Port Orford
	tide=	7:15		184			Cape Blanco to Brookings
		9:10					refuel at Brookings
		9:40		29			Chetco R. to Winchuck River*OR/CA Border
	3:30	10:00				150	Transit to North Bend Municipal Airport
		11:00					Refuel at North Bend Municipal Airport
		11:00					Tide Closes
			2:00			300	Helicopter Transit back to Portland
	Total		*4:50*	213		216	
	Total		*23:50*	1797.5		895	
				1796			heli cost: $1125/hr *23.5= ~26,500

Notes
- 100 km/h survey rate, 150 km/h transit rate (can be faster if clear)
- multiply km by 0.4 to get minutes for transit
- multiply km by 0.6 to get minutes for surveying; lots of islands, rate slower (mult by 0.7)
- push tides (schedule includes 5 min on each side of the window); can be longer in fjords
-estuary tides lag on average of one hour

Fuel Placement
- flight time in italics is difference between lift off and set down; geo must record actual heli hours at end of each day
- gallons of fuel based on flight time in italics (heli burns 30 gal/hr); sum gallons of fuel per day to estimate # of drums needed per site (1 e
- blue refuels are drums Jet-A in the field (4 drums each location); others are at base

Figure 9 Example of daily flight plan showing aircraft movements, tide windows.

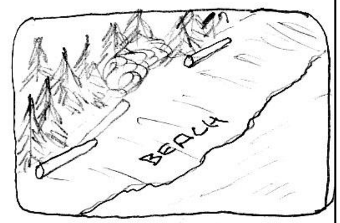
Table 1. Responsibilities of ShoreZone Aerial Video Imaging (AVI) survey personnel.

Personnel	Pre-Flight Activities	In-Flight Activities
Videographer Geologist	• responsible for setting up video camera • tests entire system prior to lift off • synchronizes video camera clock to GPS clock • synchronizes tape deck clock to GPS clock • labels and packs videotapes (with 1-min headers)	• video-imaging and continuous geological description • checks image framing • manually adjusts exposure if necessary • advises pilot re flying corrections • checks camera switches at regular intervals • check audio meters for sound level • checks “record” indicatorsr
Photographer Biologist	• sets up digital cameras • tests designated audio-sound track • synchronizes camera time to GPS clock	• provides continuous biological commentary • shoots digital still photos • organizes stores digital media • assists in navigation using paper charts • assists pilot in identification of sensitive biota
Navigator	• assists in design of flight track • prepares flight line maps • documents tide window • synchronizes computer clock to GPS clock • brings and uses paper charts	• checks monitor for framing and exposure • monitors electronic mapping and logging system • coordinates tape changes • directs pilot in general strategy (use clock face for directional instructions) • provides geographic reference points to the geologist for recording on audio track • provides feedback on quality of commentary to biologist and geologist

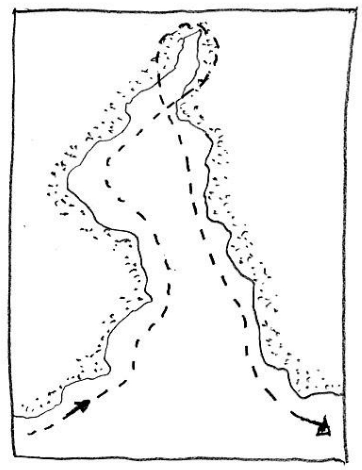
Table 2 Guidelines for Videographer (Geologist)

1. **Speed and Altitude:** Typical flight speed is 60 knots and altitude is 250' (100 km/h survey rate, 150 km/h transit rate). Be careful about the speed as often the pilots unconsciously speeds up or slows down and has to be refreshed. 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 gets the idea and automatically climbs as he approaches an estuary.

2. **Shooting Angles:** Keep the horizon level (using the treeline helps), 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 an interesting feature with a slight zoom in, holding the framing stationary on the feature as the helicopter passes over.



3. **Cornering:** Get the pilot used to always making counter-clockwise turns (see preferred trackline at right). This puts the left side of the helicopter down and allows for better filming, although the camera person will have to lift the camera during the turn. Some pilots persist on doing clockwise, "hover" turns at the end of long narrow inlets but it invariably doesn't work – the helicopter has to slow down more, is less stable and struts and skids fill the image.



4. **Framing:** Use the monitor to frequently check framing. You should also check that the little red dot is in the image (indicates recording) and that the tape-remaining counter is running. At the same time, make sure you camera is recording (little red light on back of handle). Minimize the sky in the image to avoid silhouetting the shore zone; too much sky will cause the shore zone to be almost black. This is very difficult to avoid in bright surf areas.

5. **Narration:** Generally the morphology doesn't 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 description from supra-tidal down to lower intertidal. The other thing to mention is widths, over and over. Be precise ("the beach face is 20 m wide.") Widths on all components (multiple A, B zones) are helpful but even if you can only provide a few, it is useful to the mappers. Let your enthusiasm be part of the narration – there will be an army of mappers working on this all winter. Geographic names provided by the navigator have to be repeated as the navigator's comments are not recorded.

6. **Camera settings:** Autofocus with filter adjustments off. Look out for: flashing "ND1" in video camera frame and adjust the filter setting to whatever the camera recommends. Toggle the "display" button to prevent red "REC" and other information appearing in recorder frame. Mate and tape all cables so they are neat and not loose. If recorder becomes black and white, cables are probably loose. If the recorder has lines running through it, recording for a few minutes at the beginning transit is helpful (or running the head cleaner). Make sure the "HiFi sound is set to "2" on both the recorder and the camera. (On the Narcissus / New GVD system, audio is set to "stereo.")

7. **Time:** Synchronize watch, digital camera, GPS, and laptop 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 (Casl vs Cail). Note if widths are more or less than the 30 m benchmark.

9. **Video camera and filming reminders:** Reset white balance according to 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 is around 100 km/h speed. Don't get too close or too far from shore. Try to shoot 45 degrees out the door and 45 degrees down to the ground.

Table 3 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.	**Bio-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. 10). Trackline position, video imagery, and digital photo times are linked to a GPS location using the six-digit UTC time code.

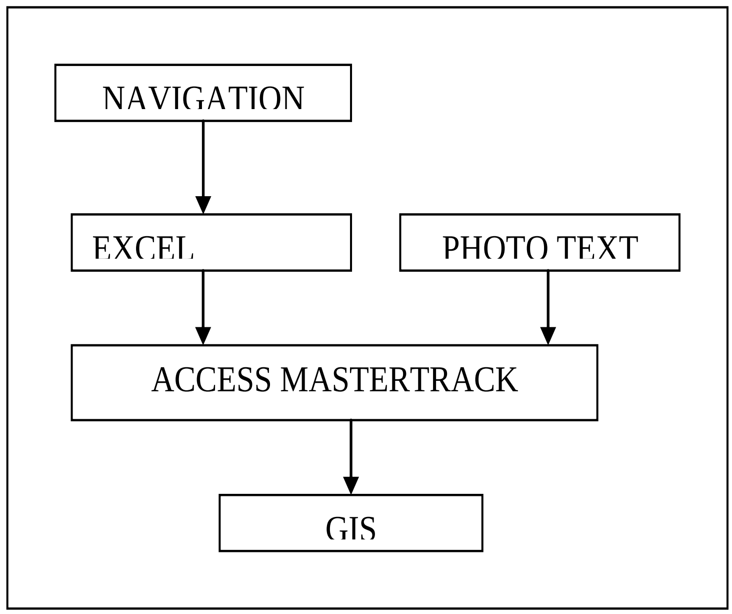


Figure 10. Schematic illustrating the processing of navigation data (Fugawi) and the linking to digital photos and video imagery using an MS Access database and GIS shapefiles.

Following the editing of the flight track to show only the “useable” imagery, a flightline manual is compiled. An example of the flight track map (Fig. 11) and the associated Tape Log (Fig.12) provide a summary of the survey. This flight track report is compiled within one week of the survey completion and usually accompanies the DVD video copies as part of the deliverables. The flight track report is used by anyone who wishes to view the video DVDs or locate and view the photographs.

Figure 11. Sample of a summary track log for a single videotape. Times noted on the map are UTC, which is seven hours ahead of PDT.

2011 Oregon Aerial Video Imaging Survey
Team Oregon (OR)

Tape: ORG11_OR_01 **Date** 01 June 2011

General Location: South Jetty Columbia River to Twin Rocks
Time Start (UTC): 12:44:40 **Geo:** Harper
Fuel Break: None **Bio:** Morris
Time End (UTC): 13:40:20 **Nav:** Still
Tape Length: 55 min 40 sec **Pilot:** Morris
Weather: Cloudy, high overcast, light winds, fog at Warrenton

Time (UTC)	Location	Photo
12:43:21	Transit to South Jetty, Columbia River	or11_or_00001
13:00:00	Seaside	or11_or_00217
13:09:51	Necanicum River	or11_or_00217
13:19:30	Tillamook Head	or11_or_00521
13:27:30	Castle Rock	or11_or_00655
13:31:00	Cape Falcon	or11_or_00708
13:36:31	Mouth of Nehalem Bay	or11_or_00803
13:40:20	North of Twin Rocks	or11_or_00863

Figure 12. Sample tape log compiled created for each tape of recorded imagery.

3.1 Overview of Database Structure

Data are stored in five separate tables within a relational database (Fig. 13). *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 comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/00).

Definitions of field names within each table are provided in the data dictionaries. 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.

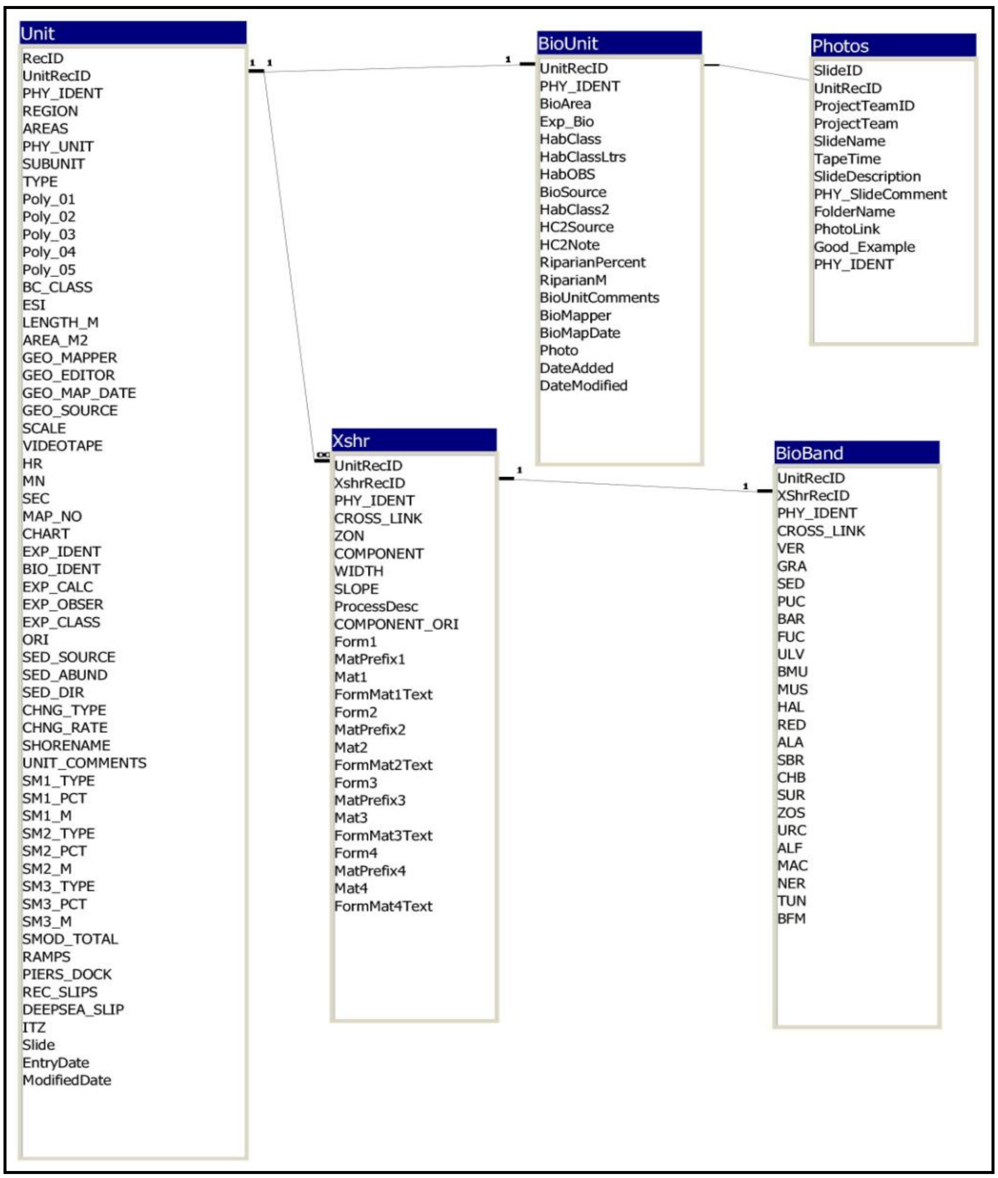


Figure 13. Schematic of the five data tables and their relationships housed in an Access relational database.

3.2 Unit Tables

The *Unit Table* (Fig. 13) includes physical information related to the entire unit, including geomorphic attributes such as overall coastal morphology type, coastal stability, sediment sources to the unit, wave exposure level, and potential oil residence. Administrative information such as the names of the mappers, editors, videotape number, and date entered are also included within the Unit table.

The *BioUnit Table* (Fig. 13) 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 information is also included in the *BioUnit Table*, including bio-mapper and editor names, digital photos for the unit, ground station number, and the sources of information used in the biological interpretations.

3.3 Across-Shore and Bioband Tables

The *XShr Table* (Fig. 13) includes a record (row) for each across-shore *Zone* (Supratidal [A], Intertidal [B] and Subtidal [C]) and *Component* (A1, B1, B2…) with attribute information regarding the morphology, sediment texture, width, slope, dominant coastal process, and estimated oil residence index for that particular intertidal zone and component (see schematic in Fig. 7). Further details are provided in Section 4.3 (*Component* data entry procedures and guidelines).

The *BioBand* Table (Fig. 13) is the biological complement to the *XShr Table*. It contains biological information related to each across-shore zone. Band-forming assemblages of biota are recorded in the corresponding zone in which 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. These attributes are discussed further in Section 5.0.

3.4 Other Database Tables

The *Photos Table* (Fig. 13) is an inclusive list of all digital still photos collected during AVI surveys, providing the image name (e.g. ORG11_OR_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 2.0). During physical mapping, each photo in the list is viewed and tagged against a Unit Record identifier (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 UnitRecID assigned, thus the UnitRecID field of the table may be “0.”

3.5 Spatial Data

All of the ShoreZone data are linked to map features, which are georeferenced. Two types of spatial data are included in the spatial dataset: (a) a line or arc file which represents the segmented alongshore units and (b) a point file or coverage that represents point features. The relation of the geomorphic features to the line and point coverages are shown in Figure 6.

The overall goal of the 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 segments, represented by segmentation of the digital high-water line and then links a systematic description of the across-shore morphology to each of those line segments. By using a standard set of codes, the resulting dataset is easily searchable.

The basic premise is that the morphology, substrate and energy are the primary determinants of the shore-zone ecological system. By providing a detailed categorization of these features, intertidal and subtidal biota will be relatively uniformly distributed within these habitat units. For example, exposed, stable rock ramps in the mid intertidal zone are likely to be dominated by a California mussel – goose barnacle assemblage. Such information is useful for habitat capability modeling, where one might be interested in predicting the location of invasive species.

This section of the protocol outlines the procedures used in the physical mapping portions of the project and should provide sufficient detail so that other mappers could use the same information to develop similar mapping products and the users of the data will have 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 4. The biological mapping is described separately in Section 5. An example of a typical mapping station with a video monitor, data-entry screen, photo screen is shown in Figure 14.

The mapper is confronted with real-world imagery and there are typically no sharp boundaries between one shore type and the next shore type – all natural boundaries are gradational. Hence, one of the most challenging steps is the delineation of the unit boundaries. Figure 15 shows a photograph of how a shoreline may be interpreted and then the interpreted units delineated on a digital shoreline. A partially completed segment map is shown in Figure 16.

Once the unit boundaries are delineated, the mapper fills the database with attribute codes to characterize the unit both along-shore (*Unit Table;* see also Fig. 15) and across-shore (*XShr Table;* see also Fig. 7). Specific data-entry procedures and guidelines are discussed below. Most mappers fill in the across-shore component data fields first, because sediment characteristics and across-shore widths are important in classifying the overall unit type.

Table 4 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 (SQL database) on server
Mapping	• physical mappers review video, digital still photos, and audio commentary to segment the shoreline into alongshore units (line segments) with occasional 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 (see Fig 7) • 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 • digitizing is synthesized by the GIS manager • physical mapping database tables, paper maps, and GIS are transferred to biological mappers
Data Assembly	• database manager receives and imports biological data tables into the master database; relationships are re-established; database QA/QC is performed • an ArcGIS Geodatabase is created from the master database • physical and biological thematic maps (shapefiles) are created and maps are produced
Preparation of Deliverables	• Access database and ArcGIS products are developed and QA/QC'd • ReadMe files are written and included with data products on Data DVD • a *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 14. Photo of mapping station setup with video monitor (left), data entry window (center screen), and still photo viewer (right). Headphones facilitate audio use. Segmentation (paper) map is at left.

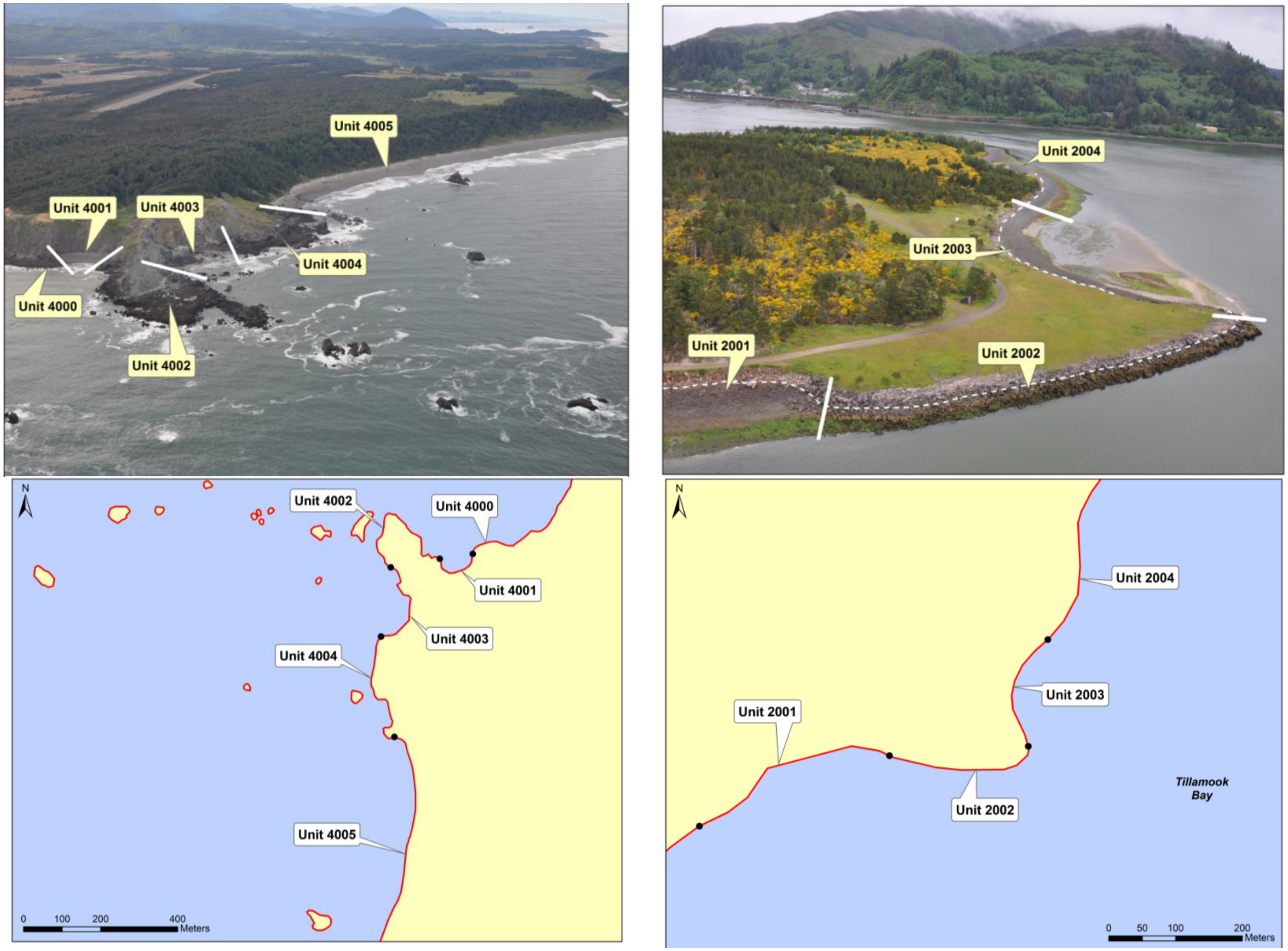


Figure 15. Two examples of shore-unit segmentation for (a) a high-energy shoreline (left) near Tower Rock (north of Port Orford) and (b) a low-energy, estuary shoreline (right) in Tillamook Bay. The associated maps illustrate how the shore segments are transferred into line segments within the spatial dataset.

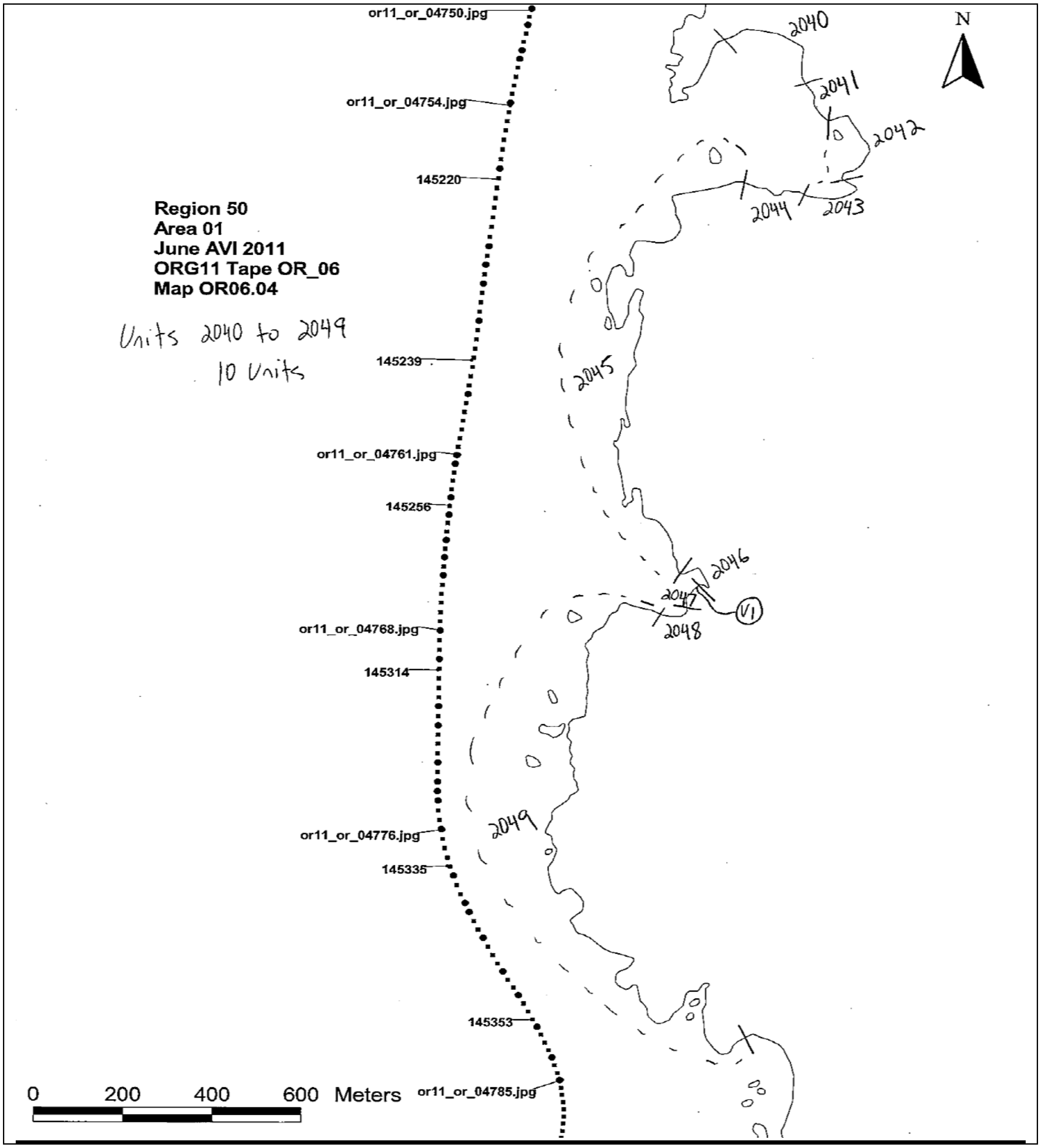


Figure 16. Example of annotated trackline map. Trackline shows 1-second fix marks from the GPS data recorded during the flight. The trackline is annotated with 6-digit time codes and a 5-digit photo numbers. The mapper has segmented the high-water line shoreline into a series of alongshore units and added a unit ID for each unit (in pencil). These maps are then used to digitize unit breaks.

4.2 Guidelines for Cataloging the Alongshore Unit

Unit Delineation

As mentioned previously, there are few boundaries in the real world – transitions between different categories are often gradational so delineating boundaries involves interpretation. Alongshore *units* are delineated primarily on the basis of physical characteristics, including:

- geomorphology
- sediment texture
- degree of wave exposure or energy

If either the morphology or substrate change significantly, a new unit would be created. 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)
- general biological patterns
- human alteration.

The alongshore length of an individual unit varies with shoreline complexity, crenulation, and coastal processes. The median length of the Oregon ShoreZone mapping is 350 m.

Smaller units always result in more precise mapping. But there is 'overhead' associated with the data entry for every single unit. Two 150-m units for a section of shoreline require twice as much data entry effort as does one single unit. If mapping budgets were unlimited, smaller units would be desirable but given that each mapping project has a firm budget, a standard of the smallest "practical units" has evolved. Over the past 10 years of a ShoreZone mapping, the average unit length has been about 250 m (based primarily of mapping in Alaska; Harney *et al* 2008). This average unit size appears satisfy most users of the dataset. The average unit length in British Columbia is ~500 m.

Imagery is linked to the interpreted and coded data via the UTC time code, which is visible in each video frame and is also coded into the Unit Table. Guidelines for linking times are summarize in Table 5.

Table 5 Guidelines for Linking Images to the 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 Subunits

In ShoreZone a mapping unit can be a point, line or polygon and all three have been used in some mapping projects. For the Oregon coast, only lines segments and points are used as the spatial representation of the mapping units. In practice, point features always lie on a line segment so represent a subset. The convention that has been developed within ShoreZone is that point features are always a subunit of the line segment (or unit). There may be several subunits within any one unit; Table 6 describes rationale for assigning subunits and provides examples of subunits.

Table 6 Guidelines for Along-Shore Physical Data Entry (Unit Table)

Subunit: 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 are streams or rivers 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 are thus numbered as "subunits," which becomes the last number in the PHY_IDENT string. Several variants in a unit are numbered sequentially (1, 2, 3…). The River Form "R_" 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. A river is mapped as a variant (non-zero Subunit and "P" Unit type) only when it is a Form in *both* the A and B zones. If the river does not appear in any B zones, then it may be mapped as a Form of intermittent river (Ri), but a variant (subunit) is not defined.

Assigning *Shore Types* to the Unit

The *Shore Type* is a general descriptor of the morphology and substrate of the unit and is an attribute that provides a good summary indicator of the overall morphology/substrate character of the shore unit. Examples include *Rock Cliff*, *Rock Platform with Gravel Beach* and *Mudflat*. Table 7 summarizes the *Shore Types* (also referred to as *Coastal Class* or *BC Class* of the unit). There are 35 *Shore Type*, based primarily on substrate type, across-shore width, and slope, and Figure 17 provides a schematic on how these attributes are used to classify this important attribute. Definitions for shore type classification criteria are summarized in Table 8 and additional guidelines are summarized in Table 9.

Assigning *ESI* to the Unit

Another descriptor that is applied to each unit is the shore descriptor from the Environmental Sensitivity Index (ESI) that has been widely applied throughout the USA (Petersen *et al* 2002). There are ten basic shore types within ESI that categorize shorelines in terms of potential sensitivity to oil spills (Table 10). The ESI shore type is widely used by oil spill response personnel so mappers classify each unit with an ESI descriptor. Table 11 summarizes the rationale used to assign ESI classes within ShoreZone units.

Assigning Exposure Classes to the Unit

An estimate of the wave exposure, as classified by the physical mapper, is assumed to be a function of the fetch window of the unit and specific details are provided in Appendix A (Table A-4). It is a rare to have the exposure change directly from *Exposed* to *Protected* in adjacent units, although it does occasionally happen. 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 bit 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 exposures.

Table 7 Classification Rationale for Assigning *Shore Type*

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 w gravel & sand beach, wide	11
			FLAT (<5°)	Platform with G&S beach, wide	12
		NARROW (<30 m)	STEEP (>20°)	Cliff with gravel/sand beach	13
			INCLINED (5-20°)	Ramp with gravel/sand beach	14
			FLAT (<5°)	Platform with gravel/sand beach	15
	SAND	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp with sand beach, wide	16
			FLAT (<5°)	Platform with sand beach, wide	17
		NARROW (<30 m)	STEEP (>20°)	Cliff with sand beach	18
			INCLINED (5-20°)	Ramp with sand beach, narrow	19
			FLAT (<5°)	Platform with sand beach, narrow	20
SEDIMENT	GRAVEL	WIDE (>30 m)	FLAT (<5°)	Gravel flat, wide	21
		NARROW (<30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Gravel beach, narrow	22
			FLAT (<5°)	Gravel flat or fan	23
	SAND & GRAVEL	WIDE (>30 m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	n/a	
			FLAT (<5°)	Sand & gravel flat or fan	24
		NARROW (<30 m)	STEEP >20°)	n/a	
			INCLINED (5-20°)	Sand & gravel beach, narrow	25
			FLAT (<5°)	Sand & gravel flat or fan	26
	SAND / MUD	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	27
			FLAT (<5°)	Sand flat	28
			FLAT (<5°)	Mudflat	29
		NARROW (<30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	30
			FLAT (<5°)	n/a	n/a
	ORGANICS	n/a	n/a	Estuaries	31
ANTHRO-POGENIC	Man-made	n/a	n/a	Man-made, permeable	32
			n/a	Man-made, impermeable	33
CHANNEL	Current	n/a	n/a	Channel	34
GLACIER	Ice	n/a	n/a	Glacier	35

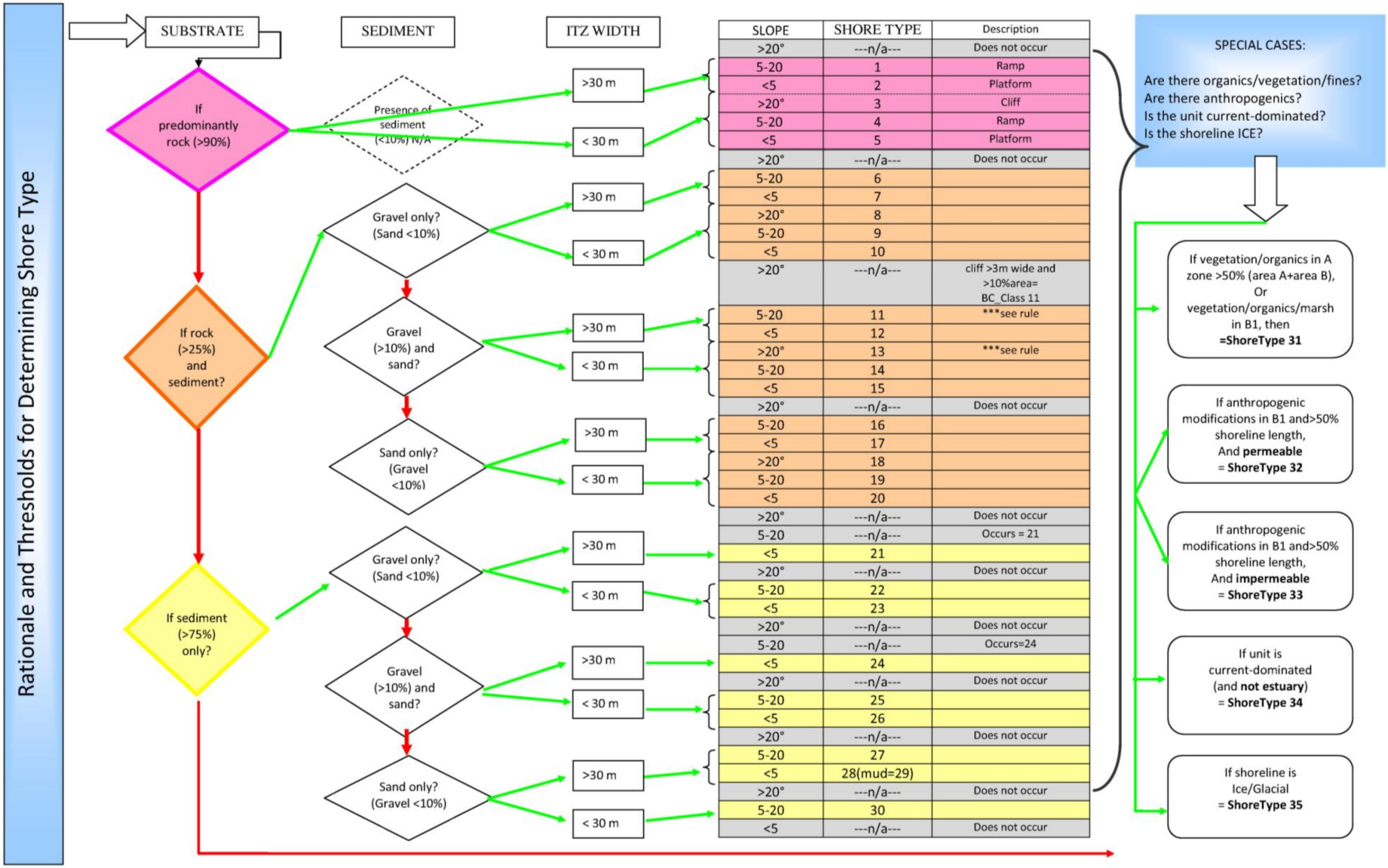


Figure 17. Schematic of the rationale and thresholds used in classifying shore types.

Table 8 Factors Used for Classifying *Shore Types*

Substrate: substrates are generally categorized in terms of *Rock* substrate, which is not mobile and often supports rich epibenthic biotic assemblages and *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 has been designated as *Rock + Sediment*.
Sediment: a number of classes of sediment are used in classifying the shore type into one of the *Shore Type* categories. These include: *Gravel* (particles>2mm as per Wentworth sediment scale); *Sand* (particles 0.063mm to 2 mm); *Sand & Gravel* where a mixture of sand and gravel exists; *Mud* (particles<0.063 mm; *Organics* where substrate is dominated by peat or organic matter and *Ice*, which occurs at tide-water glaciers.
Width: The *intertidal zone width* is the sum of the widths of the intertidal components (B1+B2+B3…). The intertidal width is classified as either *Narrow* (<30 m) or *Wide* (>30 m).

Table 9 Mapper Guidelines used for *Shore Type* Classification

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 (*Shore Types* 21-31): When a unit consists of a beach with rock outcrops/platforms, the *Shore Types* should be coded to emphasize the beach sediment (*Shore Types* 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* should be coded to reflect the influence that the rock has on the unit (*Shore Types* 6 to 20).
Supratidal rock with intertidal beaches: When a unit consists of a supratidal cliff/ramp with an intertidal beach, the *Shore Types* should be 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 should be 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, it should be noted that 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.
Shore Types 31 (Organic Shorelines): Organics and vegetation dominate the unit; may characterize units with large marshes in the supratidal (A) 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 (B) zone.
Shore Types 32 and 33 (Anthropogenically-Altered): Units exhibit >50% human alteration the area of the intertidal (B) zone to be classified as anthropogenically-altered. Shore modifications may be mapped in the XShr Forms and Materials, and in the SHORE_MOD fields of the Unit table, without applying a *Shore Types* 32 or 33 to the entire unit.
Current-dominated (*Shore Type* 34): Usually occur in salt-water channels between islands or at constricted entrances to large lagoons, bays, or inlets. Water movement will be visible within the channel but not outside the channel. The biota tends to be lush within these channels. This *Shore Type* does not occur in estuaries.

Table 10 Environmental Sensitivity Index (ESI) Shore Types
(after Petersen et al. [2002])

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

Table 11 Guidelines Used for Assignment of ESI Classes within ShoreZone

Substrate	Shore Types	ESI Designation Guideline
Rock	1 2	• If Exp. >= SE then **ESI 2A** • If Exp. <= SP then **ESI 8A** (possible ESI **8B** if sediment pockets present or lots of fissures)
	3 4 5	• If Exp. >= SE then ESI 1A • If Exp. <= 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 Exp. >= SE then 2A • If > 50% rock with cobble/pebble beach pockets and Exp. <= SP then 8B (boulders can be present but less abundant than cobble/pebble) • If > 50% rock with boulder/rubble beach pockets and Exp. <= 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 Exp. >= SE then 1C • If mostly cobble/pebble talus and Exp. <= SP then 8B (boulders can be present but less abundant than cobble/pebble) • If mostly boulder/rubble talus and Exp. <= 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 *Shore Types* to be assigned.] • If Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • Otherwise assign ESI 5. If sand is <25%, reassess the *Shore Type*.
	16 17 18 20	[There must be >25% sand in the unit for these *Shore Types* to be assigned] • If Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A • Otherwise assign ESI 3A or 4. If sand is <25%, reassess the *Shore Types*. Refer to *Shore Type* 27 for guidelines on sediment size.
Sediment	21 22 23	• If Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= 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 Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= 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 Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= 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 *Shore Type* 27 for guidelines on sediment size.
	29	• If Exp. >= SE and it meets ESI 7 requirements (see protocol) then ESI 7 • If Exp. <= SP and it meets ESI 9A requirements (see protocol) then ESI 9A
	30	• ESI 3A or 4 (refer to *Shore Type* 27)
	31	• 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.
Man-Made	32	• If it is riprap then ESI 6C • If Exp. <=SP then 8B • If Exp. >=SE then 1B
	33	• If Exp. <=SP then 8B • If Exp. >=SE then 1B
Current-Dominated	34	• Decide what *Shore Type* you would assign if you did not assign a *Shore Type* 34, then assign an ESI class based on that.
Ice	35	• ESI 8A (refers to “impermeable” scarps)

Note: Other ESI Classes are not used in Oregon: 2B, 3B, 3C, 8E, 9C, 10C, 10D, 10E

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 not be identical. The *Oil Residence Index* (ORI) for the overall unit is assigned on the basis of *Biological Wave Exposure* (see description of *Biological Wave Exposure* in Section 5). But the ORI that is estimated for each of the across-shore components is based on the exposure estimated by physical mappers.

<u>Assignment of Sediment Transport Properties to the Unit</u>

There 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). 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 based on *morphological features within the unit*; that is, a mapper must actually see some feature that indicates transport direction and not infer it from adjacent units.

<u>Estimating Shoreline Stability</u>

Mappers estimate the stability of the shore unit from the morphology of the unit where change is defined as "measurable change" during a 3-5 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 cliffs or land-slides indicating continual over-steepening due to erosion.

<u>Issues with Digital Shorelines</u>

ShoreZone mappers are very familiar with morphologies of the coast and especially the location of the 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. In some cases these errors may the result of new construction since the date of interpretation of the digital shoreline. In other cases, the error may represent an interpretation error. The physical mappers note in the *Shore_Prob* field the nature of the problem, which may result in a revised ShoreZone digital shoreline. The following guidelines are used for making changes to the original digital shorelines:

Significant changes to the digital shoreline: During mapping, draw significant shoreline changes clearly on the paper map. Make a comment in the SHORE_PROB 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, make a note in both the SHORE_PROB and 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 but not present in either 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 Shore Modification

One of ShoreZone's strengths is the cataloging of man-modified or anthropogenic changes to the shoreline. This information is an important metric used to estimate total state-wide or regional trends in man-modified shores. Appendix A Table A-1 outlines the details of the classification and the primary, secondary and tertiary shore modification type is cataloged for each unit. For each type of shore modification (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 estimate of each types can be calculated for various regions (e.g., Coos Bay has 25% modified shoreline).

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 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*.

4.3 Guidelines for Cataloging Across-Shore Components

Each along-shore unit is further characterized by the geologist in terms of a collection of *across-shore components* (Fig. 7) which are geomorphic features (*Forms*) such as cliffs, beaches, and tidal flats, with associated texture 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

Each unit there are three *Zones* (Fig. 7) , 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 12.

Across-Shore Components

Each zone is subdivided into a number of across-shore *Components*, which are delineated on the basis of morphology and sediment texture (Fig. 7). Features such as dunes, beach berms, beach faces, beach terraces are examples of across-shore components. Appendix A Tables A-13 and A-14 include a complete listing of the Forms and Materials that may comprise across-shore *Components*.

Table 12 Descriptions of the Supratidal, Intertidal and Subtidal Zones

Supratidal (A) Zone: This zone lies between the upper limit of the marine influence and the estimated mean higher-high water line. It is also known as the “splash zone.” The top of the *Supratidal Zone* is often marked by the presence of log line. 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 estimated mean higher-high water line (indicated by a line of swash debris or on rocky shores, the base of the black lichen) and estimated the lower-low water line. This region is completely inundated by daily tides.

Subtidal (C) Zone: The *Subtidal Zone* is the zone below the estimated lower-low water line; 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 Rs Form. Forms and Materials are occasionally entered in the C zone, including 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.

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). One might think of the across-shore components as forming an across shore transect as a person would observe when walking form the terrestrial area (dominated by terrestrial vegetation seaward towards the low-water line). 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).

Component Forms

Each across-shore component has a corresponding *Form* and *Material* that is coded into the ShoreZone dataset using a series of codes (see Appendix A, Tables A-13 and A-14); Figure 7 shows a schematic representation of different across-shore *Forms* and *Materials*. 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 <5m in height). This use of the coding system allows the dataset to be searcher for specific features while providing the mapper with a flexible means of categorizing the wide-range of intertidal morphologies and sediment textures.

The general assumption is that each component is uniform in the alongshore direction (Fig. 7). 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 alongshore length, it usually will not be listed.

Other guidelines for mappers are summarized in Table 13. Special guidelines related to anthropogenic features are summarized in Table 14.

Table 13 Guidelines for Mapping 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), 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 mobile sediment, and may be found in the intertidal zone or sometimes in the lower supratidal zone. A beach storm ridge only receives occasional marine influence and is only mapped in the supratidal zone. There will often be 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 is places (use the washover fan modifier (w) in the coding, i.e. Bpw).
Beach inclined (Bi): Generally this code is not used because it is vague and lacks a clear definition.
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 there is 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: OI – 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 (O)ffshore Islet code 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 14. Special Notes on Anthropogenic *Forms*

Structure	Function
Breakwater (Form “Ab”)	barrier that provides wave protection for harbors and marinas
Bulkhead (Form “As”)	retaining structure of timber, steel, or reinforced concrete, used for shore protection. Sometimes referred to as seawalls.
Jetty (Form “Aj”)	pier or structure projecting into the sea or other body of water to protect a harbor, deflect energy
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.
Breached dyke (Form “Al”)	breached dykes are distinguished from unbreached dykes (Form “Ak”). See also Section 7.4.
Tidal gate (Form “Au”)	indicates that a tidal gate is present within a unit. See also Section 7.4.

Component Materials

Each across-shore *Component* has both a *Form* and *Material* assigned to it. Details on the material codes are provided in Appendix A (Table A-14). The *Materials* system is similar to that used to categorize *Forms* with major substrate categories 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 for the *Forms*, there can be Primary, Secondary and Tertiary *Materials*. All Forms must have a Material code, except a lagoon (L) or tidal channel (Tc) mapped in the supratidal zone.

Guidelines for coding Component Materials are summarized in Table 15.

Table 15. 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-14). The first letter is uppercase, followed by at least 1 and up 5 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 by 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 component width is defined as the average intertidal across-shore 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. For example, a unit with a B zone width <30 m has a different Shore Type than one wider than 30 m; see Table 7.

The component slope is defined as the estimated across-shore slope of the mapped primary geomorphic form (in degrees). Only the slope for the primary component (e.g. A1, B1) is entered, and the value must be consistent with the Form codes (Table A-13). 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 of the dominant processes 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. Wave processes are the mostly commonly identified process for the shore zone. There is also the flexibility to include “Other” processes where additional information is included within the comment field.

Component Oil Residence Index

There are two types of Oil Residence Indices 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” (*Shore Type* = 29) and as a result would have an assigned ORI of 3 (weeks to months). However, riprap would generally have a much longer potential residence with an ORI of 5 (months to YEARS). By assigning an ORI to each across-shore component, the true ORI is more precisely defined.

The Component Oil Residence Index (Appendix A Tables A-5 and A-6); 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 16.

Table 16. Guidelines for Assigning Component Oil Residence Index

- ORI is assigned for each subdivision (component) of the A and B zones but can only be entered for Form1.
- ORI and materials in Form1 should be consistent, rather than having the ORI refer to sensitive items in Form2 or Form3. 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 (Bl/Csp) in a semi-protected exposure (SP) will have an ORI of 5, owing to the grass in the component.
- Table A-6 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 (marshes and lagoons). In these cases, an ORI of 5 is assigned to recognize the existence of these organics.

Biological ShoreZone mapping is based on the observation of patterns of biota in the coastal zone, with data recorded for the occurrence and extent of species assemblages (called *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 to each unit.

5.1 Principal Steps in ShoreZone Biological Mapping

The biological mapping takes place in four main tasks, as outlined in Table 17. The mapping stations that are used for cataloguing the biota 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 14.

The along-shore coastal segments, the *Units*, delineated by the physical mappers (Fig. 15) are the framework to which biological attributes are attached. Biological mappers do not create additional units or change the spatial depiction of the unit, but instead classify the biological attributes within the spatial database provided by the physical mappers. The biobands observed are coded within the across-shore *Components* for each unit (Fig. 7), while the biological attributes that apply to the unit as a whole (i.e., *Biological Wave Exposure*, *Habitat Class*) are entered in the Unit table.

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 coded in each unit as if describing a profile across the shore, from the high supratidal to the shallow nearshore subtidal (Fig. 7). The biobands mapped in Oregon are listed in Table 18.

Biobands are named for the dominant species or group that best describes the band and each bioband is defined by a set of *indicator* and *associated* species. Some biobands are named for a single *indicator* species (such as the Eelgrass bioband [ZOS]), 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. Further description of Oregon biobands are listed in Appendix A, Table A-16; and 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 (*narrow, medium* or *wide*). A distribution of *patchy* is defined as *'visible in less than half of the along-shore unit length*' and *continuous* is defined as '*visible in more than half of the unit's along-shore length'*.

Table 17 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	• biological mappers 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-7) • across-shore attribute data (*Biobands*) are entered into the *Bioband Table* for each zone and component within each unit (Table A-15). • 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	• a *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.

Additional guidelines for categorizing bioband occurrence are summarized in Table 19.

Figure 18. Example of biobands, seen as alongshore bands of color and texture formed by biological assemblages of species along the coast. (near Depoe Bay, Oregon).

Table 18 Oregon Biobands

Zone	Bioband Name	Bioband Code
Supratidal	Splash Zone	VER
	Shrub Meadow	MSH
	High Grass Meadow	MAG
	Dune Grass	GRA
	European Beach Grass	AMM
	Sedges	SED
	Salt Marsh	TRI
Upper to Mid-Intertidal	Barnacle	BAR
	Rockweed	FUC
	Green Algae	ULV
	Blue Mussel	BMU
	California Mussel	MUS
	Bleached Red Algae	HAL
	Oyster	OYS
	Red Algae	RED
Lower Intertidal and Nearshore Subtidal	Alaria	ALA
	Soft Brown Kelps	SBR
	Mud Flat Shrimp	CAL
	Dark Brown Kelps	CHB
	Surfgrass	SUR
	Eelgrass (from ShoreZone)	ZOS
	Eelgrass (from EPA mapping)	ZOS2
Subtidal	Giant Kelp	MAC
	Bull Kelp (from ShoreZone)	NER
	Bull Kelp (from ODFG mapping)	NER2

Table19 Guidelines for Identification of Biobands

Bioband Name and Code	Guidelines for Classification
Splash Zone (VER)	• Is recorded by width: Narrow (N -- less than 1m); Medium (M -- 1 to 5m); or Wide (W – greater than 5m). • Is only mapped if dense enough cover to be visible in at least one-quarter to one-half of the along-shore length of the unit (~"Patchy"). • Colour 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.
Shrub Meadow (MSH)	• Coastal riparian fringe vegetation at uppermost marsh in estuary, above Salt Marsh bioband (TRI) but can intermingle with Salt Marsh species (see Appendix D). • Mixture of meadow grasses, herbs and sedges with shrubs and small Sitka spruce
High Grass Meadow (MAG)	• beige-green of mature grass seed head, in high marsh areas. • patches of tall grass-dominated meadow, at generally higher elevation than adjacent Salt Marsh (TRI) but can intermingle (see Appendix D).
Dune Grass (GRA)	• Blue-green in colour, tall beach grass • Large patches of *Leymus* on coastal dunes are uncommon in Oregon. Usually seen as clumps in mixed assemblages with other salt-tolerant grasses and herbs in salt meadow.
European Beach Grass (AMM)	• Pale green to beige in colour • Is mapped primarily on high-energy beach dunes, where it is the dominant species of dune-stabilizing beach grass • Is only mapped in the A zone
Sedges (SED)	• Bright green in colour and tall. May turn orange-brown colour in the late summer/ early fall. • Found in thick expansive stands, associated with freshwater and riverine systems, at the heads of estuaries; and considered an indicator of estuarine habitats • Often appear to be in circular clumps. • Generally only mapped in large estuaries where stand of pure sedge are observed. Note that sedges are also considered component of mixed salt-tolerant herbs, sedges and grasses described by TRI biobands
Salt Marsh (TRI)	• Represents any species assemblage of salt-tolerant grasses, sedges and herbs. • Primary indicator of estuarine habitats • Rooted vascular vegetation typical of low marsh elevations, in A zone; however can be mapped in the first B zone in a low marsh (form Ml). • Often appears as patch-work 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 TRI.
Barnacle (BAR)	• Visible as a white, cream or yellow band. • 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 colours depending on the species of barnacle.
Rockweed (FUC)	• Brown band ranging from golden-brown to orangey-brown. • Found in the upper intertidal, sometimes mixed with the BAR band, sometimes a distinct band below the BAR. • Observed at all but the highest wave exposures
Green Algae (ULV)	• Bright to dark green in colour • Can include both foliose and filamentous green algae species • Occurs at moderate to lower wave exposures • May be present on low energy mudflats as 'haze' of green filamentous species, often intermingled with eelgrass (ZOS)
Oyster (OYS)	• Limited occurrence in Oregon, as shellfish aquaculture areas on lower intertidal mudflats • Often associated with filamentous brown or red algae on shell debris

Table19 (continued). Guidelines for Identification of Biobands

Bioband Name and Code	Guidelines for Classification
Bleached Red Algae (HAL)	• Colour of pale yellow-green to orange • Represents bleached filamentous and foliose red algae • May be mixed with and indistinguishable from bleached filamentous green algae • Uncommon occurrence in Oregon, mostly on outer rocky coast
Blue Mussel (BMU)	• Colour varies from dark black to blue-grey. • BMU usually occurs below the FUC and BAR bands but above the ULV or RED bands. Often blue mussels are common in the intertidal however not dense enough to be observed as a distinct bioband.
California Mussel (MUS)	• Distinct and dense bioband found at Exposed and Semi-exposed wave energies, and common on high energy rocky outer coasts in Oregon. • Closely associated with abundant gooseneck barnacles and thatched barnacle, making the band appear dusky blue-grey in colour • Often includes distinctive sea palm brown alga (*Postelsia*)
Red Algae (RED)	• Red algae include filamentous, foliose and coralline algae, and different species assemblages occur at different wave exposures. Often mixed with and obscured by other biobands. • Foliose and coralline RED algae occur at higher exposures and disappear in Protected wave exposures; and are good indicators of this transition when they are present. • At higher Protected / Semi-Protected wave exposure environments, a low turf of filamentous RED may be present, often mixed with diatom haze • Coralline RED algae almost always found in the highest exposures (Exposed) but is often obscured under other lower intertidal biobands (i.e., ALA, Dark Brown Kelps (CHB) and/or foliose RED).
Alaria (ALA)	• Named for the monoculture of ribbon kelp (*Alaria* sp.) 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) • Appears to be of limited distribution in Oregon.
Soft Brown Kelps (SBR)	• SBR typical form is ruffled, wide brown benthic kelp fronds • Observed in the lower intertidal and nearshore subtidal, and characteristic of stable substrates in Semi-Protected and Protected wave exposure. May also occur in low Semi-Exposed • Appears to be of limited distribution in Oregon.
Mud Flat Shrimp (CAL)	• Observed in sand/mud estuary flats as dimpled texture of mud surface, indicating presence of burrowing infauna, in particular in lower reaches of larger estuaries • Also described as bioband in Washington state ShoreZone
Dark Brown Kelps (CHB)	• Dark, shiny brown kelps, often stalked species observed in the lowest intertidal. • Usually a mixture of species of large brown algae, although it can be monoculture of single species at the highest wave exposure (i.e., *Lessoniopsis*).
Surfgrass (SUR)	• Bright green in colour. Always attached to hard substrate (i.e., bedrock or immobile boulder/cobble) and is considered a good indicator of Semi-Exposed wave exposure • Can be observed as bleached white on upper elevation of wide rock platforms (surfgrass bleaches, while eelgrass does not).
Eelgrass (ZOS) (From EPA mapping)	• Bright green in colour. • Only found on soft substrate such as sand or fines. • Found at lower wave exposures (Semi-protected and Protected)
Eelgrass (ZOS2) (From EPA mapping)	• From EPA mapping in selected estuaries • Eelgrass beds (polygons) manually snapped to ShoreZone units

Table19 (continued). Guidelines for Identification of Biobands

Bioband Name and Code	Guidelines for Classification
Giant Kelp (MAC)	• Always seen as canopy kelp species, in nearshore subtidal. • Distinctive pattern of large plants, with fronds and small floats. • Limited distribution in Oregon • Indicates Semi-Exposed or Semi-Protected wave exposures.
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.
Bull Kelp (NER2) *(from ODFG mapping)*	• From ODFG mapping data • Manually snapped to adjacent ShoreZone units.

5.3 Bioareas

To recognize region-specific species assemblages, as well as to identify broad-scale trends in coastal habitats, two **bioareas** have been defined in Oregon (Appendix A, Table A-8), the high-energy outer Oregon coast and the protected, estuary dominated inner Oregon coast. All mapped units have been assigned to one of these two bioareas. The outer coast units are primarily high energy sand beaches and rocky headlands, while the inner coast has low energy, salt marshes, estuaries and river deltas.

A similar approach for assigning bioareas has been used in ShoreZone mapping in British Columbia and Alaska to recognize the broad-scale eco-regional differences (Harney *et al* 2008, Harper and Morris 2011). In BC and Alaska, bioareas are delineated on the basis of observed regional differences in the distribution of lower intertidal biobands, nearshore canopy kelps, and coastal habitats.

5.4 Biological Wave Exposure

Biological Wave Exposure is an interpreted attribute that is estimated from observations of the presence and abundance of biota in each alongshore unit. Exposure categories are defined on the basis of 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 (Appendix A, Table A-7).

Typical species and corresponding biobands are summarized for each biological wave exposure category in Appendix A, Tables A-18 to A-21; and guidelines for applying the biological wave exposure category are listed in Table 20. In units where little or no attached biota was visible, the biological wave exposure was inferred from biota observed in adjacent units. The species listed as indicators of exposure (Appendix A, Tables A-18 to A- 21) were compiled from expert knowledge, literature review and an overview of observations from the detailed long-term monitoring site data conducted at several Oregon locations by MARINe and PISCO surveys (R. Gaddam and P. Raimondi, pers. comm.).

Biobands and species in the biobands listed for each wave exposure category are considered ‘typical’ for each category 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. Substrate type and its ‘mobility’ at each wave exposure also determine which biota are present in the unit. For example, in a *Semi-Exposed* wave energy a cobble beach in the intertidal zone would likely be too ‘mobile’ to permit the establishment of attached biota, whereas an adjacent rock platform could have a lush assemblage of typical *Semi-Exposed* indicators. Or in *Semi-Protected* wave exposures on an sand/mud substrate, such as those typical in lower estuaries in Oregon, indicator biobands which might be expected to occur on stable substrate (i.e., Rockweed [FUC], or Red Algae [RED]), would likely be sparse or absent on this mobile substrate. It is the combination of biobands, species, and interpretation by biological mappers that is used to determine the biological wave exposure category for each unit.

Some biobands are observed in all wave exposure categories and are considered weak indicators in determining the wave exposure category (e.g., the Barnacle band [BAR]), while other biobands are considered strong indicators because they are closely associated with particular exposures. For example, the Dark Brown Kelps band (CHB) is consistently associated with higher wave exposures (*Semi-Exposed* to *Exposed*): and the Surfgrass band (SUR) is indicative of *Semi-Exposed* settings, while the Eelgrass band (ZOS) is indicative of *Semi-Protected* and *Protected* environments.

The six biological wave exposure categories have the same names as those used in the physical mapping to characterize wave exposure (Appendix A, Table A-4 and A-9), however, the physical wave exposure is based on fetch window 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 it is the biological wave exposure value which is used in the look up matrix for determining each unit’s Oil Residence Index (Appendix A, Table A-6).

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 very deep nearshore waters of the north Pacific Ocean.

5.5 Habitat Class Descriptions, Guidelines and Examples

Habitat Class is a summary classification that combines both physical and biological characteristics observed for a particular shoreline unit, and it is determined from the biological wave exposure and geomorphic characteristics. The habitat class category is intended to provide a single attribute to summarize the biophysical features of the unit, based on an overall classification made from the detailed attributes that have been mapped.

Where the dominant structuring process in the shore unit is wave energy (Table 21), the interaction of the wave exposure and the substrate type determines the *substrate mobility*. Stability of the substrate determines the presence and abundance of attached biota. Where the substrate is stable, such as bedrock, well-developed epibenthic assemblages occur. Where the substrate is mobile, such as on sandy beaches, the epibenthic community will likely be sparse or absent.

Table 20. Guidelines for Assigning Biological Exposure

Biological Wave Exposure	Guidelines for Classification
Very Exposed (VE)	• This exposure category is used only for areas of extreme high wave energy, where there is no moderation of open ocean swells in nearshore and shoreline is vertical rock cliff. • 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 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 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. Soft brown kelps (SBR) observed in the subtidal. • Eelgrass (ZOS) occurs in the lower Semi-Protected areas and Surfgrass (SUR) can occur 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 often narrow. • The riparian overhang is often 100%. • No canopy kelps present. Canopy kelps in otherwise Protected areas indicate a current dominated Semi-Protected Habitat Class. • In the case riverine systems, where energy from river water flow and tidal variation influence the intertidal shoreline, *Protected* is the lowest exposure category recorded. .
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 water movement or 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 seen in the unit. Where shoreline is complex, or where there are wide intertidal platforms, there may be a range of exposures and indicators 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).

Most units have the *Habitat Class* category determined by wave energy as the dominant structuring process (Table 21). The three categories of wave energy-structured habitat classes, based on substrate mobility, are as follows:

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

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

- **Estuary** complexes, with freshwater stream or river flow, delta form at the stream mouth and fringing wetland or salt marsh biobands;
- **Current-Dominated** channels where high tidal currents support assemblages of biota typical of higher energy sites than would be found at the site if wave energy was the structuring process (these units are usually associated with lower wave exposure conditions in adjacent shore units);
- **Anthropogenic** features where the shoreline has undergone human modification (e.g., areas of rip rap or fill, dyked fields, marinas and landings);
- **Lagoons**, which have enclosed coastal ponds of brackish or salty water

Further definition and explanation of Habitat Class codes are listed in Appendix A, Tables A-10 and A-11. Examples of habitat classes observed in Oregon are illustrated in Appendix C.

Table 21. 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	• Most units in this Mobile category are bare sediment beaches. • Can have supratidal biobands (i.e., European Beach Grass) or nearshore subtidal biobands (e.g., Soft Brown Kelps) but the intertidal is often bare of attached biota or has only drift algae. Sparse to patchy of one or two biobands is acceptable. • 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 *flowing* river or stream as fresh water source (mapped as an Rs; intermittent streams (Ri) would not provide enough freshwater influence). • A combination of Sedges, Salt Marsh, or High Grass Meadow biobands which are associated with the river or stream. (Supratidal zones consisting of Dune Grass or European Beach Grass exclusively do not qualify as estuarine wetlands) • Some (especially 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 and human modified beaches (i.e. wharves, piers, log sorts) which influence the B zone. Modifications which only impact the A zone are not assigned to Anthropogenic habitat class. This includes units with habitat restoration (i.e., breached dyke) where the modification is affecting only the A zone. • Influence the biology of the unit (i.e. dredged ponds, disturbed or recovering marsh vegetation). • Majority of the features observed are permeable, such as landfill or wooden docks and pilings. Only concrete features are mapped as impermeable. • For *shoreline* modifications only. Does not include modifications which occur only in the C zone, such as log booms (unless the actual shoreline is modified as well). • Archaeological features, such as village sites, canoe runs and fish-traps or ponds, are not classified as anthropogenic features.
Lagoons		• Limited or no outlet to the open water. • A combination of one or more of the Sedges, High Grass Meadow or Salt Marsh biobands. • Standing water at low tide. Note: 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.

6.0 SHOREZONE DATASET QUALIFICATIONS

ShoreZone Coastal Habitat Mapping is accomplished through the interpretation of oblique aerial video and digital still imagery of the coastal zone. 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 the work of each physical and biological mapper to be reviewed by another mapper. Database QA/QC and data-entry integrity is ensured by a database manager with five years of ShoreZone mapping experience.

A number of factors influence the complexity of shoreline mapping, including: natural geomorphology, coastal crenulation, quality of the imagery and associated commentary, quality of the digital shoreline basemap, and 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

Alaska 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, and
- 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; and
- 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.

<u>External Review</u>

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)

<u>Victoria, BC Field Verification Study</u>

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 (Harper and Morris 2008). 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

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:

- *wave exposure* estimates were closely matched between aerial interpretations and ground interpretations
- *sediment mobility* estimated matched 88% between aerial and ground observations.
- *intertidal width* estimates matched in 63% units. Aerial mappers tended to underestimate widths.
- estimates of *shore modifications* were highly consistent between aerial and ground observations.
- coastal class matched about 58% between aerial and ground observations; the relatively poor matches is attributed to a large number of possible classes (35) and the spatially complex nature of the foreshore.
- across-shore geomorphology and substrate matched in 80% of the observations.
- 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 Section 4 and 5) 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.

7.0 SPECIAL FEATURES OF THE OREGON DATASET

There are presently four different protocols or standards for ShoreZone mapping in the Pacific Northwest: Alaska (2011), British Columbia (1994), Washington (2004) and Oregon (2013). Although the vast majority of data attributes are similar (and transferable), there are some features of the Oregon dataset that make it unique. In addition, the Oregon dataset is the most recent of the ShoreZone datasets so it incorporates the most updates from the original 1994 protocol. Also, since ShoreZone was developed, the Coastal and Marine Ecological Classification System (FGDC 2012) has evolved as an important US classification system, and we include a cross-walk table to identify linkages between CMECS and ShoreZone wetland types.

These descriptions of special features are organized from the most-general to the more specific.

7.1 Coastal Ecoregions

The *outer* coast and *inner* coast of Oregon are fundamentally different regions where the *outer coast* is dominated by high wave exposure, marine salinity regimes and rock and/or sand substrates whereas the *inner coast* is dominated by low wave exposure, brackish salinity and turbid water qualities and "soft" sedimentary substrate types. Consequently, intertidal and shallow, subtidal biota assemblages are very different.

The two major bio-regions are distinguished by the BIOAREA field in the BioUnit database so searches can use this field to discriminate the *outer* from the *inner coast*. The criteria are fully explained in Appendix A, Table A-8 and the field values in the BioUnit table are:

BIOAREA	**OREO**	Outer coast of Oregon, all tidal waters
	OREI	Inner coasts of Oregon, including tidal influenced waters in estuaries and lower river mouths

7.2 Coastal and Marine Ecological Classification System (CMECS)

For the past decade, researchers in the US have been developing a coastal classification system that will serve as a standardized coastal classification protocol and applicable to many project. In 2010, the Federal Geographic Data Committee (FGDC 2012) endorsed this classification as federal standard. While the system was initially developed as a classification system, it has also been used as a mapping standard.

Coastal & Oceans has conducted several pilot projects where ShoreZone data was cross-walked to the CMECS system (Harper and Ward 2010) and also conducted primary mapping directly into CMECS classification standard and compared that to mapping data to ShoreZone (Harper and Ward 2011). These reports are available for review at www.coastalandoceans.com.

A cross-walk table was developed by ODFW (D. Fox, ODFW, 2012, pers.comm.) to summarize how various wetland mapping standards, including ShoreZone, relate to CMECS wetland classification (Figure 19).

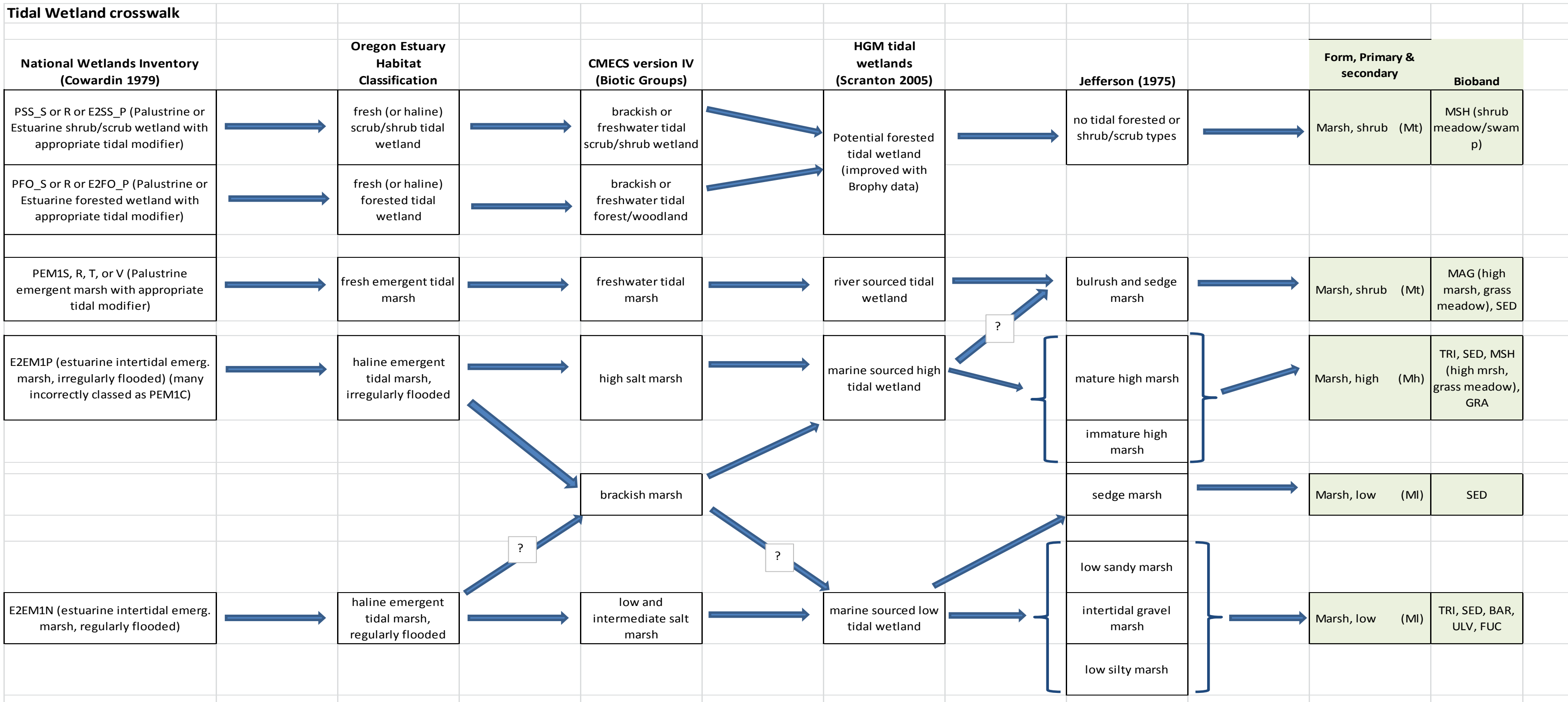


Figure 19 Schematic of Cross-Walk of Wetland Types amongst Various Classifications (cross-walk compiled by David Fox, ODFW, Newport, OR)

7.3 "Lost Coast" Protocol

During the ShoreZone mapping process, it became evident that the BLM digital shoreline (in theory, the MHHWL), missed many small estuaries and wetland areas, especially those blocked by a dyke with a culvert. It was clear that a considerable portion of "sensitive" shoreline, including many tidal marsh areas, would be missed in the mapping if the BLM digital shoreline was the only reference. It was also beyond the scope of the ShoreZone project to re-digitize these "missing" areas.

In attempt to capture this "lost shoreline", ShoreZone mappers delineated very short units, associated with the culvert and cataloged all the information in the "lost" section of shoreline. An estimate of the approximate shoreline length is included in the comment field. This procedure allows these shoreline sections to be searched, although the associated shoreline length is only estimated. Should a revised digital shoreline be available in the future, it would be relatively easy to snap the unit boundaries to the new shoreline and correct the shoreline lengths; the ShoreZone mapping attributes will not require updating, except for the unit length field.

Figure 20 shows an oblique aerial photo illustrating the issue of "lost shoreline", where a fairly sizeable wetland has been omitted from the BLM digital shoreline.

7.4 Wetland Types

Estuarine wetlands are a critical part of the Oregon coastal landscape and greater resolution wetlands types was desired. As such, the following attributes have been added to facilitate wetlands mapping in ShoreZone:

Physical, Across-Shore Forms and Materials (Table A-13)

- Mt — *Marsh with shrub* vegetation; such marsh is higher elevation than a *High Marsh* (Mh).
- Al — *Breached dykes* are distinguished from *unbreached dykes* (Ak).
- Au — Indicates that a *tidal gate* is present within a unit.

Biobands (Tables A-15, A-16)

- MSH — bioband code for *Shrub Meadow*, upper salt marsh shrub fringe
- MAG — bioband code for *High Grass Meadow*, upper salt marsh grass meadow
- AMM — bioband code for *European Beach Grass* (AMMophillia spp)
- OYS — biobands for OYSter, primarily cultured on mudflats, mid-intertidal.

Figure 20. Oblique view of "lost shoreline" (marsh area in backshore) in the Yaquina Estuary that has been dyked with a road bed and is connected only by a culvert. The position of three mapped ShoreZone units is shown relative to the BLM digital shoreline (dashed yellow line). The short middle unit (Unit 3545; 19 m in length) is centered on the culvert and the marsh area is coded into the ShoreZone dataset for this unit. Should the digital HWL be updated to include the marsh shoreline (dotted white line; est. length 350 m), only the ShoreZone length will require updating.

7.5 Combining Other Datasets with ShoreZone (Kelp and Eelgrass)

During the ShoreZone mapping process, a question arose as to whether other datasets would be used to complement the ShoreZone videography and photography, which are the primary sources of mapping data. Since other data sources were not available for the entire coast (e.g., the EPA eelgrass mapping dataset), it was decided that the addition of this information would make the ShoreZone interpretations inconsistent throughout the mapping area. Hence, ShoreZone mapping is based strictly on interpretation of what can be viewed in the ShoreZone imagery.

However, there were two datasets of high interest, to see how they would compare to ShoreZone. To facilitate these comparisons, two "special" fields were added: one to accommodate the EPA eelgrass mapping dataset, which is derived from satellite imagery, and the other for the Oregon Department of Fish and Wildlife (ODFW) kelp mapping database. The additional BIOBAND data fields are:

ZOS2 eelgrass visible on EPA classification images were “visually” snapped to the nearest ShoreZone unit. Three classes of attribute are included: area not mapped (X), area mapped but no eelgrass present (A) and area mapped and eelgrass present (Z).

NER2 bull kelp polygons were snapped via GIS tools to the nearest ShoreZone unit. Three classes of attribute are included: area not mapped (X), area mapped but no kelp present (A) and area mapped and bull kelp present (K).

An example of the relationship between the EPA eelgrass mapping dataset and the ShoreZone dataset is given in Figure 21.

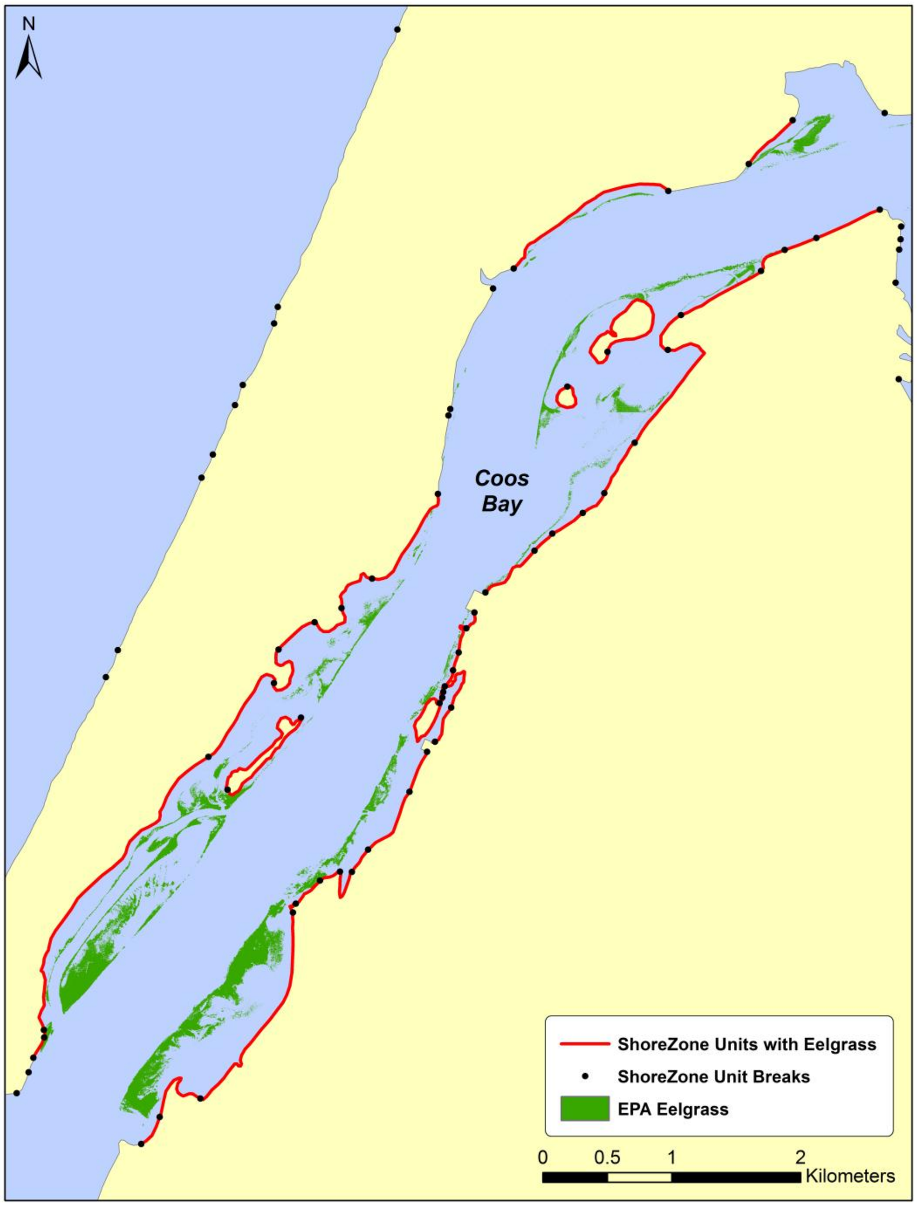


Figure 21. Example showing how EPA eelgrass mapping (raster data) in Coos Bay was “snapped” to adjacent shore units.

8.0 REFERENCES

Berry, H.D., Harper, J.R., Mumford, T.F., Jr., Bookheim, B.E., Sewell, A.T., and Tamayo, L.J. 2004. Washington State ShoreZone Inventory user's manual, summary of findings, and data dictionary. Report prepared for the Washington State Dept. of Natural Resources Nearshore Habitat Program. Available online at: www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_nrsh_inventory_projects.aspx

Christy, J.A., J.S. Kagan and A.M. Wiedemann. 1998. Plant associations of the Oregon Dunes National Recreation Area. US Dept of Agriculture, Forest Service, Pacific NW Region. Technical Paper R6-NR-ECOL-TP-09-98.

Federal Geographic Data Committee 2012. Coastal and marine ecological classification standard. Federal Geographic Data Committee, Marine and Coastal Spatial Data Subcommittee, Technical Report FGDC-STD-018-2012, 353p. http://www.csc.noaa.gov/digitalcoast/_/pdf/CMECS_Version%20_4_Final_for_FGDC.pdf

Gaddam, R. 2011. Long Marine Lab, UC Santa Cruz, Santa Cruz, CA. Pers. comm. (June 2011) PISCO: http://osu.piscoweb.org/ Coastal Biodiversity Survey (SWAT): http://cbsurveys.ucsc.edu/index.html

Harney, J.N. 2007. Modeling habitat capability for the non-native European green crab (*Carcinus maenas*) using the ShoreZone mapping system in Southeast Alaska, British Columbia, and Washington state. Report prepared for NOAA National Marine Fisheries Service (Juneau, AK), Aug. 2007. 75 p.

Harney, J.N. 2008. Modeling habitat suitability for the invasive salt marsh cordgrass *Spartina* using ShoreZone coastal habitat mapping data in Southeast Alaska, British Columbia, and Washington State. Report prepared for Alaska State Department of Fish and Game (Juneau, AK), Nov. 2008. 50 p.

Harney, J.N., and Shaw, L. 2007. Modeling habitat capability using the ShoreZone mapping system. Marine Science in Alaska Symposium (Anchorage, AK), Jan. 2007 [abstract].

Harney, J.N., and Morris, M. 2007. Analysis of the repeatability of ShoreZone coastal habitat mapping. Contract Report prepared by Coastal & Ocean Resources Inc, Sidney, BC for The Nature Conservancy, Juneau, AK and NOAA-NMFS, Juneau, AK 107 p.

Harney, J.N., Morris, M., and Harper, J.R. 2008. ShoreZone coastal habitat mapping protocol for the Gulf of Alaska. Contract Report prepared by Coastal & Oceans Resources Inc. of Sidney, BC for The Nature Conservancy, Juneau, AK, NOAA-NMFS, Juneau, AK, and the Alaska State Department of Natural Resources, Juneau, AK 137 p.

Harney, J.N., J.R. Harper and M.C. Morris 2009. ShoreZone ground verification study conducted in Sitka, Alaska, May 2008. Contract Report by Coastal & Oceans Resources Inc. of Sidney, BC for NOAA-NMFS, Juneau, AK and The Nature Conservancy, Juneau, AK, 62 p.

Harper, J.R., and Morris, M.C. 2004. ShoreZone mapping protocol for the Gulf of Alaska. Contract Report prepared by Coastal & Oceans Resources Inc. of Sidney, BC for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. 61 p.

Harper, J.R. and M.C. Morris 2008. BC ShoreZone verification project. Contract Report by Coastal & Ocean Resources Inc., Sidney, BC for the Integrated Land Management Branch, Ministry of Forestry, Victoria, BC 39 p.

Harper, J.R. and S. Ward 2010. Data cross-walk between the ShoreZone coastal habitat mapping system and Coastal and Marine Ecological Classification System (CMECS). Contract Report by Coastal & Ocean Resources Inc of Victoria, BC for NOAA/NMFS Southeast Regional Office, Juneau, Alaska, 50p.

Harper, J.R. and S. Ward 2011. Evaluation of CMECS III for coastal habitat mapping – a pilot project in Southeast Alaska. Contract Report by Coastal & Ocean Resources Inc. of Victoria, BC preprared for NOAA/NMFS Southeast Regional Office, Juneau, Alaska, 35p.

Harper, J.R. and M.C. Morris. 2011 (DRAFT). Alaska ShoreZone coastal habitat mapping protocol. Prepared by Nuka Research and Planning Group, Seldovia, AK, for Bureau of Ocean Energy Management, Anchorage AK. 143 p.

Howes, D.E., J.R. Harper and E.H. Owens 1994. Physical shore-zone mapping system for British Columbia. Technical Report by Coastal & Ocean Resources Inc, Sidney, BC for the Coastal Task Force of the Resource Inventory Committee (RIC), RIC Secretariat. Victoria, BC 71p.

Howes, D.E. 2001. British Columbia biophysical ShoreZone mapping system – a systematic approach to characterize coastal habitats in the Pacific Northwest. Puget Sound Research Conference, Seattle Washington, Paper 3a, 11p.

Jefferson, C.A. 1974. Plant Communities and succession in Oregon coastal salt marshes. Ph.D. Thesis. Oregon State University, Corvallis, OR, 200p.

Petersen, J., J. Michel, S. Zengel, M. White, C. Lord, C. Plank. 2002. Environmental Sensitivity Index Guidelines. Version 3.0. NOAA Technical Memorandum NOS OR&R 11. Hazardous Materials Response Division, Office of Response and Restoration, NOAA Ocean Service, Seattle, Washington 98115 89p + App.

Raimondi, P. 2011. Department of Ecology and Evolutionary Biology, UC Santa Cruz, Santa Cruz, CA. Pers. comm.. June 2011. PISCO: http://osu.piscoweb.org/   Coastal Biodiversity Survey (SWAT): http://cbsurveys.ucsc.edu/index.html

Schoch, G.C. 2009. The evaluation and analysis of ShoreZone intertidal habitat mapping in Cook Inlet. Contract Report by Coastwise Service, Homer, AK for the Cook Inlet Regional Citizens Advisory Council, Kenai, AK. 25 p.

Scranton, R.W. 2004. The application of Geographic Information Systems for delineation and classification of tidal wetlands for resource management of Oregon's coastal watersheds. MS. Thesis, Marine Resources Management Program, Oregon State University, Corvallis.

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This protocol builds on several decades of previous work in British Columbia (see Howes 2001) and Washington (Berry *et al* 2001). The Oregon protocol is based primarily on the most recent version of the Gulf of Alaska ShoreZone Coastal Habitat Mapping Protocol (Harney *et al* 2008, Harper and Morris 2011) produced by CORI and AMRL and funded by a diverse group of NGOs, trust funds and government agencies.

The report cover was designed by Kathleen George of Nuka Research and incorporates three of her personal photos (background, birds, house). All other photos were collected as part of the ShoreZone aerial imaging survey in June 2011.

Appendix Table	Description
A-1	Data dictionary for UNIT table
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A-3	Environmental Sensitivity Index (ESI) Shore Type classification
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Table A-1. Data dictionary for UNIT table

Field Name	Description
UnitRecID	Automatically-generated number field; the database “primary key” for unit-level relationships
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0); this field is completed by the database manager using an update query
REGION	2-digit coastal region number (see reference maps and GIS materials)
AREAS	2-digit coastal area number (see reference maps and GIS materials)
PHY_UNIT	4-digit physical along-shore unit number; segmented during physical mapping and delineated on paper maps and in GIS
SUBUNIT	Set to 0 for line features (units) or non-zero for point features (also called variants); several subunits in a unit are numbered sequentially (1, 2, 3…) according to the order occurring within the unit (based on UTC time)
TYPE	Single-letter description of Unit type: a (L)ine [unit] or (P)oint feature [variant]
SHORE_TYPE	Shore Type or Coastal class of the unit based primarily on substrate type, across-shore width, and slope (Table A-2)
ESI	Environmental Sensitivity Index shore unit classification (Table A-3)
LENGTH_M	Along-shore length in meters; calculated after digitizing using ArcGIS and updated using database query
GEO_MAPPER	Last name of the physical mapper
GEO_EDITOR	Last name of the physical mapper who QA/QCs the work (10% of all units are reviewed by an editor)
VIDEOTAPE	Title of the videotape (DVD imagery) used for mapping; naming convention for Oregon is ORG11_OR_02, in which ORG11 is the region and year, OR is the team, 02 is tape
HR	Hour at which unit starts; based on the first two digits of the 6-digit UTC time on video when start of unit is at center of screen
MIN	Minute at which unit starts; based on third and fourth digits of 6-digit UTC time on video when start of unit is at center of screen
SEC	Seconds at which unit starts; based on the last two digits of the 6-digit UTC time on video when start of unit is at center of screen
EXP_OBSER	Estimate of wave exposure as observed by the physical mapper, as a function of the relative fetch (Table A-4), with a consideration of geomorphology.
ORI	Oil Residence Index indicates a possible residence time of heavy oils stranded on the shore. It is largely determined by wave exposure (or energy) levels and shore substrate types (see Tables A-5, A-6 and A-7)
SED_SOURCE	Estimated sediment source for the unit: (A)longshore, (B)ackshore, (F)luvial, (O)ffshore, (X) not identifiable
SED_ABUND	Code indicating the relative sediment abundance within the shore-unit, (A)bundant, (M)oderate, (S)carce

[continued]

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

Field Name	Description
SED_DIR	One of the eight cardinal points of the compass indicating dominant sediment transport direction (N, NE, E, SE, S, SW, W, NW). (X) Indicates transport direction could not be discerned from imagery.
CHNG_TYPE	Code indicating the stability of the shore unit, reflecting the relative degree of “measurable change” during a 3-5 year time span: (A)ccretional, (E)rosional, (S)table
SHORENAME	Name of a prominent geographic feature near the unit (from nautical chart or gazetteer)
UNIT_COMMENTS	Text field used for miscellaneous comments and notes during physical mapping
SM1_TYPE	2-letter code indicating the *primary* type of shore modification occurring within the unit: BR = boat ramp; CB = concrete bulkhead; DK = dyke; LF = landfill; SP= sheet pile; RR = rip rap and WB = wooden bulkhead
SM%	Estimated % occurrence of the primary shore modification type in tens (i.e. “2” = 20% occurrence) within the unit.
SM2_TYPE	2-letter code indicating the *secondary* type of shore modification occurring within the unit
SM2%	Estimated % occurrence of the *secondary* type of shore modification in tens (i.e., “2” = 20%) within the unit
SM3_TYPE	2-letter code indicating the *tertiary* type of shore modification occurring within the unit
SM3%	Estimated % occurrence of the *tertiary* type of shore modification in tens (i.e., “2” = 20%) within the unit.
SMOD_TOTAL	Total % occurrence of shore modification in the unit in tens
RAMPS	Number of boat ramps that occur within the unit; ramps must impact some portion of the shore-zone and generally be constructed of concrete, wood or aggregate
PIERS_DOCK	Number of piers or wharves that occur within the unit; piers or docks must extend at least 10 m into the intertidal zone; does not include anchored floats
REC_SLIPS	Estimated number of recreational slips at docks of the unit; based on small boat length ~<50’
DEEPSEA_SLIP	Estimated number of slips for ocean-going vessels in the unit; based on ship length ~>100’
ITZ	Sum of the across-shore widths in meters of all the intertidal components (B zones) within the unit
EntryDate	Date and time the unit was physically mapped
ModifiedDate	Date and time the unit was physically or modified
SALINITY_REGIME	Inferred from mapping data of Scranton (2004) where **MR** = marine salinity regime, **ER** = estuarine salinity regime, **RR** = riverine salinity regime and **Null** = could not determine salinity regime (primarily variants) from Scranton.

Table A-2. Classification of Shore Types in ShoreZone (after Howes *et al* [1994]

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

Table A-3. Environmental Sensitivity Index (ESI) Shore Type Classification

(after Petersen *et al* 2002)

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

Table A-4. Exposure Matrix for Estimating "Observed" Physical Exposure (EXP_OBSER) on the basis of fetch distance

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

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

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

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

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

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

Table A-7 Unit 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

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

Table A-8. Data Dictionary for Biounit Table

Field Name Code	Description
UnitRecID	**Unit Record ID:** Automatically-generated number field; the database “primary key” required for relationships between tables
PHY_IDENT	**Physical_Ident** is a unique code to identify each unit, assigned by physical mapper; defined as an alphanumeric string determined by the codes for: Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0), where ‘12’ is Region 12, ‘03’ is Area 3, ‘0552’ is the Unit number, and ‘0’ is the Subunit number.
BIOAREA	**Bioarea:** Geographic division used to describe regional differences in observed biota and coastal habitats (Bioarea codes and descriptions listed in Table A-9)
EXP_BIO	**Biological Wave Exposure:** A classification of the wave exposure category within the Unit, assigned by the Biological mapper, based on observed indicator species and biobands (Table A-10)
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-11 and A-12).
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-11 and A-12)
HC2_SOURCE	**Secondary Habitat Class Source:** Source used to interpret the Secondary Habitat Class (HAB_CLASS2) as: OBS(erved) as viewed from video, L(oo)KUP referring to ‘Form’ Code Lo or Lc in XSHR table
HC2_Note	**Secondary Habitat Class Comment:** comment field for Secondary Habitat Class (HAB_CLASS2)
RIPARIAN_PERCENT	**Riparian Percent Overhang:** Estimate of the percentage of alongshore length of the intertidal zone, in which the shoreline is shaded by overhanging riparian vegetation; all substrate types (Expanded definition in Table A-11)
RIPARIAN_M	**Riparian Overhang Meters:** Calculated portion of the unit length, in meters, of riparian overhang in the intertidal (B) zone, using LENGTH_M field of UNIT table, and RIPARIAN_PERCENT of BIOUNIT table; all substrate types.
BIO_UNIT_COMMENT	**Biological Comments**: regarding the along-shore unit as a whole. Included as deliverable data, as note format.
BIO_MAPPER	**Biological Mapper:** The initials of the biological mapper that provided the biological interpretation of the imagery
PHOTO	Still Photo in Unit: 1 = high resolution photo is available for the Unit and 0 = no photos for unit. (see also Table A18)
DateAdded	Date and time the unit was physically mapped
DateModified	Date and time the unit was physically modified

Table A-9. Definitions of the BIOAREA Attribute in BIOUNIT Table.

Bioarea Name	Bioarea Code	Geographic Extent	Characteristics
Oregon – Outer Coast	OREO	Outer coast of Oregon, all tidal waters	*Semi-Exposed* to *Exposed* wave exposures, broad sandy beaches with extensive dune formations and high energy rocky headlands, rock reefs and offshore islands.
Oregon – Inner Coast	OREI	Inner coasts of Oregon, including tidal influenced waters in estuaries and lower river mouths	*Semi-Protected* and lower wave exposures, primarily estuarine and riverine systems. Broad salt marsh features at river mouths, usually enclosed by barrier bar and sand spit features at ocean confluences. Much of the estuary shoreline is modified by dykes, fill and pilings with extensive marsh and meadow areas converted to agricultural uses.
Note that ShoreZone mapping in British Columbia and Alaska define over a dozen regional 'bioareas' based on geographic differences in lower intertidal species assemblages and overall geomorphic features of the regions. For example, the Strait of Georgia in BC is mapped as a separate bioarea to the outer coast of Vancouver Island; and Southeast Alaska is mapped as several different bioareas to reflect differences in lower intertidal indicator species and canopy kelp distributions. A suffix number is 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 the ShoreZone Alaska protocol (Harney 2008; Harper and Morris 2011) and recent summary reports for Alaska ShoreZone mapping, (available for download at www.shorezone.org) for further description of bioareas in other ShoreZone regions.			

Table A-10. *Biological Wave Exposure* Codes

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

Table A-11. Expanded Descriptions for HABITAT CLASS, SECONDARY HABITAT CLASS, and RIPARIAN Fields

Attribute	Description
HAB_CLASS	**Habitat Class** attribute is a classification of the biophysical characteristics of an entire unit, and provides a single attribute that describes the typical intertidal biota and the associated biological wave exposure together with the geomorphology. That is, a typical example of a Habitat Class includes a combination of biobands, and their associated indicator species (which determine the Biological Exposure category) and the geomorphological features of the Habitat Class. The biological mapper observes and records the biobands in the unit, if any, and determines the Biological Exposure Category (EXP_BIO). The Habitat Class is determined on the basis of presence/absence of biobands, exposure category, geomorphology, and spatial distribution of biota within the unit. Within the database, an alpha code provides a summary indicator of habitat. (Table A-12), in which the matrix includes all combinations of Dominant Structuring Process, with associated substrate mobility and general geomorphic type on the vertical axis, and Biological Exposure on the horizontal axis.
HAB_CLASS2	The '**Secondary Habitat Class**' was added as an attribute in the BioUnit Table during biological mapping of the Kodiak Archipelago in Alaska in order to specifically identify lagoon habitats. Many backshore lagoons were observed in the Kodiak region, and they represent an unusual coastal habitat that differs from other estuaries and marshes. Backshore lagoons are also a coastal feature in Oregon. Units classified as lagoons contain brackish or salt water contained in a basin with limited drainage. They are often associated with wetlands and may include wetland biobands in the upper intertidal. Single units classified as lagoons often have the lagoon form in the A zone; however, some lagoons are large and may encompass several units when the lagoon form is mapped as the C zone.
RIPARIAN_PERCENT	As an attribute in the BIOUNIT table, the **Riparian_Percent** value is intended to be an index for the potential habitat for upper beach spawning fishes. The value recorded in the **Riparian_Percent** field is an estimate of the percentage of the unit's total alongshore length in which riparian vegetation (trees and shrubs) shades the upper intertidal zone. Shading of the highest high water line is a good estimate of riparian shading; therefore, shading of wetland herbs and grasses is not included in the estimate, nor is any shading of the splash zone alone. Shading must be visible in the upper intertidal zone, and the shading vegetation must be woody trees or shrubs. Riparian overhanging vegetation is also an indicator of lower wave exposures, in which the splash zone is narrow. Shading may occur in on sediment-dominated or in rocky intertidal settings.

Table A-12. Codes for HABITAT CLASS and SECONDARY HABITAT CLASS

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.	VE_I	E_I	SE_I	SP_I	P_I	VP_I
	Partially Mobile	Rock & Sediment or Sediment	These units describe the combination of sediment mobility observed. That is, a sediment beach that is bare in the upper half of the intertidal with biobands occurring on the lower beach would be classed as 'partially mobile'. This pattern is seen at moderate wave exposures. Units with immobile bedrock outcrops intermingled with bare mobile sediment beaches, as can be seen at higher wave exposures, could also be classified as 'partially mobile'.	VE_P	E_P	SE_P	SP_P	P_P	VP_P
	Mobile	Sediment	These categories are intended to show the 'bare sediment beaches', where no epibenthic macrobiota are observed. Very fine sediment may be mobile even at the lowest wave exposures, while at the highest wave exposures; large-sized boulders will be mobile and bare of epibiota.	VE_M	E_M	SE_M	SP_M	P_M	VP_M
Fluvial/ Estuarine processes		Estuary	Units classified as the 'estuary' types always include salt marsh vegetation in the upper intertidal; are always associated with a freshwater stream or river and often show a delta form. Estuary units are usually in lower wave exposure categories.	VE_E	E_E	SE_E	SP_E	P_E	VP_E
Current energy		Current-Dominated	Species assemblages observed in salt-water channels are structured by current energy rather than by wave energy. Current-dominated sites are limited in distribution and are rare habitats.	VE_C	E_C	SE_C	SP_C	P_C	VP_C
Anthropogenic		Anthropogenic – Impermeable	Impermeable modified Habitats are intended to specifically note units classified as Coastal Class 33. These Habitat Classes are mapped to specifically inventory modified shoreline.	VE_X	E_X	SE_X	SP_X	P_X	VP_X
		Anthropogenic – Permeable	Permeable modified Habitats are intended to specifically note shore units classified as Coastal Class 32. These Habitat Classes are mapped to specifically inventory modified shoreline.	VE_Y	E_Y	SE_Y	SP_Y	P_Y	VP_Y
Lagoon		Lagoon	Units classified as Lagoons in the Secondary Habitat Class contain brackish or salty water that is contained within a basin that has limited drainage. They are often associated with wetlands and may include wetland biobands in the upper intertidal. LAGOON HABITAT CLASS ALWAYS CODED AS SECONDARY HABITAT TYPE. See Table A-11.	VE_L	E_L	SE_L	SP_L	P_L	VP_L

Shaded boxes indicate Habitat Classes which do not occur in Oregon

Table A-13. Data Dictionary for Across-shore Component Table (XShr)
(after Howes *et al* 1994)

Field Name	Description
UnitRecID	Automatically-generated number field; the database "primary key" for unit-level relationships
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0)
CROSS_LINK	Unique across-shore identifier; an alphanumeric string comprised of the PHY_IDENT followed by the Zone and Component separated by slashes (e.g. 12/03/0552/0/A/1)
ZONE	Code indicating the across-shore position (tidal elevation) of the component: (A) supratidal (from storm log line to estimated MHWL), (B) intertidal (from estimated MHWL to MLWL) , (C) subtidal (below the estimated MLWL).
COMPONENT	Subdivision of zones, numbered from highest to lowest elevation in across-shore profile (e.g. A1 is the highest supratidal component; B1 is the highest intertidal; B2 is lower intertidal)
Form1	Principal geomorphic feature within each across-shore component, described by a specific set of codes (Table A-14)
MatPrefix1	Veneer indicator field; blank = no veneer; "v" = veneer
Mat1	Material (substrate and/or sediment type) that best characterizes Form1, described by a specific set of codes (Table A-15)
FormMat1Txt	Automatically-generated field that is the translation of codes used in Form1 and Mat1 into text
Form2	Secondary geomorphic feature within each across-shore component, described by a specific set of codes (Table A-14)
MatPrefix2	Veneer indicator field; blank = no veneer; "v" = veneer
Mat2	Material (substrate and/or sediment type) that best characterizes Form2, described by a specific set of codes (Table A-15)
FormMat2Txt	Automatically-generated field that is the translation of codes used in Form2 and Mat3 into text
Form3	Tertiary geomorphic feature within each across-shore component, described by a specific set of codes (Table A-14)
MatPrefix3	Veneer indicator field; blank = no veneer; "v" = veneer
Mat3	Material (substrate and/or sediment type) that best characterizes Form3, described by a specific set of codes (Table A-15)
FormMat3Txt	Automatically-generated field that is the translation of codes used in Form3 and Mat3 into text
Form4	Fourth-order geomorphic feature within each across-shore component, described by a specific set of codes (Table A-14)
MatPrefix4	Veneer indicator field; blank = no veneer; "v" = veneer
Mat4	Material (substrate and/or sediment type) that best characterizes Form4, described by a specific set of codes (Table A-15)
FormMat4Txt	Automatically-generated field that is the translation of codes used in Form4 and Mat4 into text
WIDTH	Mean across-shore width of the component (e.g. A1) in meters
SLOPE	Estimated across-shore slope of the mapped geomorphic Form in degrees; must be consistent with Form codes (Table A-14)
PROCESS	Dominant coastal process affecting the morphology: (F)luvial, (M)ass wasting (landslides), (W)aves, (C)urrents, (E)olian (wind, as with dunes) (O)ther
COMPONENT_ORI	Oil Residence Index on the basis of substrate type; 1 is least persistent, 5 is most persistent (Tables A-5 and A-6)

Table A-14. 'Form' Code Dictionary (after Howes *et al* 1994)

A = Anthropogenic

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

B = Beach

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

C = Cliff

stability/geomorph

a	active / eroding
p	passive (vegetated)
c	cave

slope

i	inclined (20°-35°)
s	steep (>35°)

Cliff cont.

height

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

modifiers (optional)

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

D = Delta

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

E = Dune

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

F = Reef

(no vegetation)

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

I = Ice

g	glacier

L = Lagoon

o	open
c	closed

M = Marsh

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

O = Offshore Island

(not reefs)

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

elevation

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

P = Platform

(slope <20°)

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

R = River Channel

a	perennial
i	intermittent
m	multiple channels
s	single channel

T = Tidal Flat

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

Table A-15. 'Material' Code Dictionary (after Howes *et al* 1994)

A = Anthropogenic

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

B = Biogenic

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

C = Clastic

a	angular blocks (>25.6cm diameter)
b	boulders (rounded, subrounded,>25.6 cm)
c	cobbles
d	diamicton (a poorly-sorted sediment mixture containing a range of particle sizes in a mud matrix)
f	fines/mud (mix of silt/clay, <0.625 mm diameter)
g	gravel (unsorted mix pebble, cobble, boulder >2 mm)
k	clay (compact, finer than fines/mud, <4 µm diameter)
p	pebbles
r	rubble (boulders>1 m diameter; used in ShoreZone to distinguish v. large blocks)
s	sand (0.063 to 2 mm diameter)
$	silt (0.0039 to 0.063 mm)
x	angular fragments (mix of block/rubble)
v	sediment veneer (used as modifier)
z	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	> 25.6 cm dia..
cobble	6.4 to 25.6 cm dia.
pebble/granule	0.2 cm to 6.4 cm dia.

SAND

very fine to very coarse:
0.0625 mm to 2 mm diameter

FINES ("MUD")

includes silt and clay

silt	0.0039 to 0.0625 mm
clay	<0.0039 mm

TEXTURE CLASS BREAKS

sand / silt	62.5 µm (0.0625mm)
pebble / granule	0.4 cm (4 mm)
cobble / pebble	6.4 cm
boulder / cobble	25.6 cm

SHORE MODIFICATIONS

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

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

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

Table A-16. Data Dictionary for the *Bioband* Table

Field	Description
UnitRecID	Automatically-generated number field; the database "primary key" required for relationships between tables
XshrRecID	Automatically-generated number field; the database "primary key" required for relationships between tables
PHY_IDENT	Unique physical identifier; an alphanumeric string comprised of the Region, Area, Unit, and Subunit separated by slashes (e.g. 12/03/0552/0)
CROSS_LINK	Unique alphanumeric identifier of component made up of: REGION, AREA, PHYS_UNIT, SUBUNIT, ZONE and COMPONENT fields
VER	Bioband for Splash Zone (black lichen **VER***ucaria*) in supratidal (Table A-17)
MSH	Bioband code for Shrub Meadow, upper salt marsh shrub fringe (Table A-17)
MAG	Bioband code for High Grass Meadow, upper salt marsh grass meadow (Table A-17)
GRA	Bioband code for Dune **GRA**ss in supratidal (Table A-17)
AMM	Bioband code for European Beach Grass (**AMM**ophilia spp) (Table A-17)
SED	Bioband for **SED**ges in supratidal (Table A-17)
TRI	Bioband for Salt Marsh grasses, including ***TRI****glochin* and other salt tolerant grasses, herbs and sedges, in supratidal. Same bioband included in Washington ShoreZone. (Table A-17)
BAR	Bioband for **BAR**nacle (*Balanus/Semibalanus*) in upper intertidal (Table A-17)
FUC	Bioband for Rockweed, the **FUC***us*/barnacle in upper intertidal (Table A-17)
ULV	Bioband for Green Algae, including mixed filamentous and foliose greens (**ULV***a* sp*., Cladophora, Acrosiphonia*) in mid-intertidal (Table A-17)
BMU	Bioband for **B**lue **MU**ssel (*Mytilus trossulus*) in mid-intertidal (Table A-17)
MUS	Bioband for California **MUS**sel/gooseneck barnacle assemblage (*Mytilus californianus/Pollicipes polymerus*) in mid-intertidal (Table A-17)
HAL	Bioband for Bleached Red Algae, including mixed filamentous and foliose reds in mid-intertidal (Table A-17)
OYS	Bioband code for **OYS**ter, primarily cultured on mud flats, mid-intertidal (Table A-17)
RED	Bioband for **RED** Algae, including mixed filamentous and foliose reds (*Odonthalia, Neorhodomela, Mazzaella,* coralline algae) in lower intertidal (Table A-17)
ALA	Bioband for ribbon kelp, **ALA***ria* spp. (Table A-17)
SBR	Bioband for **S**oft **BR**own Kelps, including unstalked large-bladed laminarians, in lower intertidal and nearshore subtidal (Table A-17)
CAL	Bioband for infaunal mud flat shrimp (***CAL****lianassa*), in sand/mud flats in larger estuaries. Same bioband included in Washington ShoreZone. (Table A-17)
CHB	Bioband for Dark Brown Kelps, including stalked bladed dark **CH**ocolate-**B**rown kelps in lower intertidal and nearshore subtidal (Table A-17)
SUR	Bioband for **SUR**fgrass (*Phyllospadix*) in lower intertidal and nearshore subtidal (Table A-17)
ZOS	Bioband for **ZOS***tera* (Eelgrass) in lower intertidal and subtidal (Table A-17)
ZOS2	Presence or absence of eelgrass based on EPA eelgrass mapping of Selected estuaries where X = *not mapped*; Z = *observed* and A = *absent or not observed*. All of the EPA mapping of eelgrass tagged to subtidal (C-zone).
MAC	Bioband for Giant Kelp (**MAC***rocystis spp*) in nearshore subtidal (Table A-17)
NER	Bioband for Bull Kelp (**NER***eocystis luetkeana*) in nearshore subtidal (Table A-17)
NER2	Presence or absence of bull kelp based on ODFW kelp mapping where X = *not mapped*; K = *observed* and A = *absent or not observed*.

Table A-17. Oregon Bioband Definitions*

Zone	Bioband Name	Bioband Code	Color	Indicator Species	Physical Description	Biological Wave Exposure	Associate Species
A supratidal	**Splash Zone**	**VER**	Black or bare rock	*Verrucaria* sp. Encrusting black lichens Bare rock substrate	Visible as a dark stripe, on bare rock, marking the upper limit of the intertidal zone. This band is recorded by width: Narrow (N), Medium (M) or Wide (W)	Very Exposed to Very Protected	*Littorina* sp.
A supratidal	**Shrub Meadow ***	**MSH**	Pale green	*Picea sitchensis* *Deschampsia caespitosa*	A narrow strip at the uppermost marsh edge, next to the tree line; usually a transition to spruce forest, including small spruce, shrubs and mixed grasses, sedges and herbs.	Very protected to Protected	*Heracleum lanatum* *Achillea millefolium* *Rumex maritimus* *Grindelia integrifolia* *Hordeum brachyantherum*
A supratidal	**High Grass Meadow ***	**MAG**	Pale grassy green or beige	*Deschampsia caespitosa* *Trifolium wormskjoldii*	Mixed grassy meadow, on uppermost salt marsh, interfinger with Salt Marsh (TRI) or Sedge (SED) at lower elevation transition.	Very protected to Protected	*Distichlis spicata* *Juncus gerardii* *Juncus leuceurii* *Agrostis alba*
A supratidal	**Dune Grass ***	**GRA**	Pale blue-green	*Leymus mollis*	Native dune grass found in small patches in undisturbed sand dunes and in salt marsh. This band is often associated with driftwood log line on beaches or as clumps in upper salt marsh elevations	Exposed to Protected	*Lathyrus japonica* *Juncus lesueurii*
A supratidal	**European Beach Grass ***	**AMM**	Beige-green	*Ammophila* spp.	Outer coastal sand dunes, forming clumps and stabilizing active dunes. Non-native species which is displacing native dune grass species.	Exposed to Semi Exposed	*Hypochaeris radicata* *Lupinus littoralis* *Fragaria chiloensis* *Aira praecox* *Aira caryophyllea*
A & B supratidal & intertidal	**Sedges ***	**SED**	Bright green to yellow-green	*Carex lyngbyei*	Appears in wetlands around lagoons and estuaries. Always associated with freshwater. This band often seen as patches, usually at upper elevation of TRI band	Semi Protected to Very Protected	*Carex* spp.
A & B supratidal & intertidal	**Salt Marsh ***	**TRI**	Light, bright, or dark green, with red-brown	*Triglochin maritimum* *Distichlis spicata* *Deschampsia caespitosa.* *Plantago maritima* *Scirpus americanus* *Salicornia virginica*	Appears around estuaries, marshes, and lagoons. Always associated with freshwater. Separated as ‘high marsh’ and ‘low marsh’ as gradation of assemblages according to elevation/salt water inundation. TRI can be sparse grasses and herbs on coarse sediment or a wetter, peaty meadow with assemblage of herbs, grasses and sedges	Semi Exposed to Very Protected	*Carex* spp. *Potentilla pacifica* *Spergularia marina* *Juncus* spp *Eleocharis* sp *Atriplex patula*
upper B intertidal	**Barnacle**	**BAR**	Grey-white to pale yellow	*Balanus glandula* *Chthamalus* spp. *Semibalanus cariosus*	Visible on bedrock or large boulders. Can form an extensive band in higher exposures where not overtopped by algal canopy.	Exposed to Protected	*Hildenbrandia* spp *Endocladia muricata* *filamentous green algae* *Porphyra* sp. *Fucus distichus*

Continued on next page

*Associated species listed supratidal biobands have been assembled from literature review, including Christy *et al*, (1998); Hoffnagel and Olson (1974); Jefferson (1974). See Appendix D for further summary of salt marsh communicates and species assemblages from Jefferson (1974). ..

Table A-17 (continued). Oregon Bioband Definitions*

Zone	Bioband Name	Bioband Code	Color	Indicator Species	Physical Description	Exposure	Associate Species
upper B intertidal	**Rockweed**	**FUC**	Golden-brown	*Pelvetiopsis* spp. *Fucus* spp. *Mastocarpus* spp	Appears on bedrock cliffs and boulder, cobble or gravel beaches. Commonly occurs at the same elevation as the barnacle band.	Semi Exposed to Protected	*Balanus glandula* *Mazzaella cornucopiae* *Semibalanus cariosus* *Ulva sp.* *Endocladia muricata*
B intertidal	**Green Algae**	**ULV**	Green	*Ulva sp.* *Enteromorpha* spp.	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.	Exposed to Protected	*Filamentous red algae*
B intertidal	**Blue Mussel**	**BMU**	Black or blue-black	*Mytilus trossulus* *M. galloprovincialis*	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.	Very Exposed to Protected	*Balanus glandula* *Semibalanus cariosus* Filamentous red algae
B intertidal	**California Mussel**	**MUS**	Grey-blue	*Mytilus californianus* *Pollicipes polymerus*	Dominated by a complex of California mussels (*Mytilus californianus*) and gooseneck barnacles (*Pollicipes polymerus*), with thatched barnacles (*Semibalanus cariosus*).	Very Exposed to Semi Exposed	*Postelsia palmaeformis* *Semibalanus cariosus* *M. trossulus*
B intertidal	**Bleached Red Algae**	**HAL**	Olive, golden or yellow-brown	*Mazzaella* spp. *Ondonthalia* spp. *Other foliose & filamentous red algae*	Common on bedrock platforms, and cobble or gravel beaches. Distinguished from the RED band only by color, and often is same species as RED	Exposed to Semi Protected	Other filamentous and foliose red algae Filamentous green algae
B intertidal	**Oyster**	**OYS**	Dark beige to brown	*Crassostrea gigas*	Generally inconspicuous and of limited extent, intertidal areas of oyster aquaculture on mudflats, in particular in Coos Bay and Yaquina Bay. Subtidal mariculture not included in classification.	Very protected to Protected	Filamentous brown algae Filamentous green algae
B intertidal	**Red Algae**	**RED**	Corallines: pink or white Foliose or filamentous: Dark red, bright red, or red-brown.	*Corallina* sp. *Lithothamnion* sp. *Neoptilota* sp. *Odonthalia* sp. *Neorhodomela* sp. *Mazzaella* sp.	Appears on most substrates except fine sediments. Lush coralline 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.	Very Exposed to Semi Protected	Other foliose and filamentous red algae *Pisaster ochraceus* *Nucella* sp. *Katharina tunicata* Large brown kelps of the CHB bioband
B & C intertidal, subtidal	**Alaria**	**ALA**	Dark brown or red-brown	*Alaria marginata*	Common on bedrock cliffs and platforms, and on boulder/cobble beaches. This often single-species band has a distinct smooth, shiny, ribbon-like texture.	Exposed to Semi Protected	Foliose red algae *Saccharina* sp. *Laminaria* sp.

Continued on next page

* Indicator and associated species from intertidal biobands determined in part from MARINe and PISCO surveys (R.Gaddam and P. Raimondi, per comm.).

Table A-17 (continued) Oregon Bioband Definitions.

Zone	Bioband		Color	Indicator Species	Physical Description	Exposure	Associate Species
	Name	Code					
B & C intertidal, subtidal	**Soft Brown Kelps**	**SBR**	Yellow-brown, olive brown or brown.	*Saccharina latissima* *Sargassum muticum*	This band is defined by non-floating large bladed browns kelps and appears to be of limited distribution on the Oregon coast.	Semi Exposed to Very Protected	Other filamentous brown algae and bladed kelps
B & C intertidal, subtidal	**Mud Flat Shrimp**	**CAL**	mottling on sand flats, burrows	*Neotrypaea californiensis* *Upogebia pugettensis*	On sand/mud flats in larger estuaries, where textured surface of flats indicates presence of infauna	Protected to Very Protected	bivalves and worms
B & C intertidal, subtidal	**Dark Brown Kelps**	**CHB**	Dark chocolate brown	*Laminaria setchelli* *Lessoniopsis littoralis* *Saccharina sessile (smooth)* *Egregia menziesii*	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.	Very Exposed to Semi Exposed	*L. sinclairii.* *Costaria costata* *Alaria sp.* Filamentous and foliose red algae Coralline red algae
B & C intertidal, subtidal	**Surfgrass**	**SUR**	Bright green (may bleach to beige at upper extent)	*Phyllospadix scouleri* *Phyllospadix torreyi.*	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.	Semi Exposed to Semi Protected	Foliose and coralline red algae
B & C intertidal, subtidal	**Eelgrass**	**ZOS** [ZOS2]	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.	Semi Protected to Very Protected	*Zostera japonica* *Ulva spp.* *Porphyra sp.* *Ruppia maritima*
C subtidal	**Giant Kelp**	**MAC**	Golden-brown	*Macrocystis* spp.	Canopy-forming giant kelp, long stipes with multiple floats and fronds. If associated with NER, it occurs inshore of the bull kelp.	Semi Exposed to Protected	*Nereocystis luetkeana*
C subtidal	**Bull Kelp**	**NER** [NER2]	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. Often indicates higher current areas if observed at lower wave exposures.	Very Exposed to Semi Protected	*Egregia menziesii* *Macrocystis* spp *Stephanocystis geminata*

* Indicator and associated species from intertidal biobands determined in part from MARINe and PISCO surveys (R.Gaddam and P. Raimondi, per comm.).

Table A-18. Data Dictionary for the Photos Table

Field Name	Description
SlideID	A unique numeric ID assigned to each slide or photo
UnitRecID	Automatically-generated number field; the database “primary key” required for relationships between tables
PhotoName	A unique alphanumeric name assigned to each slide or photo
ProjectTeamID	A unique ID number assigned to each survey team (e.g., 36)
ProjectTeam	An alpha numeric descriptor, usually the prefix for photo file names
SlideName	Full image name with .jpg extension (required to enable “PhotoLink”)
TapeTime	Exact UTC time during aerial video imaging (AVI) survey when digital image was collected; used to link photo to digital trackline and position
SlideDescription	Comment by the biological mapper on notable features in photo
ImageType	Media type of original image: “Digital” or “Slide"
PHY_SlideComment	Comment by physical mapper on notable features in photo
FolderName	Name of the folder in which digital images are stored (required to enable “PhotoLink”)
PhotoLink	Enables linkage to photos placed in directories near the database
Good_ Exam	1 = good is good example of geomorphological feature or classification type
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)

Table A-19. Biobands and Indicator Species for Biological Exposures: *Very Exposed* (VE) and *Exposed* (E)

Zone	Species	Bioband Name	Bioband Code
Supratidal & Upper Intertidal	*Ammophila sp* *****	European Beach Grass	AMM
	Verrucaria	Splash Zone	VER
	Balanus glandula	Barnacle	BAR
	Semibalanus carriosus	California Mussel	MUS
Lower Intertidal & Subtidal	*Postelsia palmaeformis*	California Mussel	MUS
	Mytilus californianus	California Mussel	MUS
	Pollicipes polymerus	California Mussel	MUS
	Coralline red algae	Red Algae	RED
	Lessoniopsis littoralis	Dark Brown Kelps	CHB
	Laminaria setchellii	Dark Brown Kelps	CHB
	Nereocystis luetkeana	Bull Kelp	NER

* Associated with open coast sand dunes at Exposed wave energies

Table A-20. Biobands and Indicator Species for Biological Exposures: *Semi-Exposed* (SE)

Zone	Species	Bioband Name	Bioband Code
Supratidal & Upper Intertidal	*Ammophila* sp.*****	European Beach Grass	AMM
	Verrucaria	Splash Zone	VER
	Balanus glandula	Barnacle	BAR
	Pelvetiopsis spp.	Rockweed	FUC
	Semibalanus carriosus	California Mussel	MUS
	Mytilus californianus	California Mussel	MUS
	Pollicipes polymerus	California Mussel	MUS
	Postelsia palmaeformis	California Mussel	MUS
Lower Intertidal & Subtidal	mixed filamentous and foliose red algae	Red Algae	RED
	Phyllospadix sp.	Surfgrass	SUR
	Laminaria setchellii	Dark Brown Kelps	CHB
	Saccharina subsimplex	Dark Brown Kelps	CHB
	Saccharina sessile (smooth morph)	Dark Brown Kelps	CHB
	Nereocystis luetkeana	Bull Kelp	NER

* Associated with open coast sand dunes at Semi-exposed wave energies

Table A-21. Biobands and Indicator Species for Biological Exposures: *Semi-Protected* (SP)

Zone	Species	Bioband Name	Bioband Code
Supratidal & Upper Intertidal	*Triglochin maritimum* *****	Salt Marsh	TRI
	Deschampsia caespitosa *****	Salt Marsh	TRI
	Plantago maritima *****	Salt Marsh	TRI
	Carex lyngbyei *****	Sedges	SED
Intertidal & Subtidal	*Balanus glandula*	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
	Saccharina latissima	Soft Brown Kelps	SBR
	Zostera marina	Eelgrass	ZOS

***** Associated with estuaries and fringing salt marsh at this wave exposure.

Table A-22. Biobands and Indicator Species for Biological Exposures: *Protected* (P) and Very Protected (VP)

Zone	Species	Bioband Name	Bioband Code
Supratidal & Upper Intertidal	*Triglochin maritimum* *****	Salt Marsh	TRI
	Deschampsia caespitosa *****	Salt Marsh	TRI
	Plantago maritima *****	Salt Marsh	TRI
	Carex lyngbyei. *****	Sedges	SED
	Glaux maritima *****	Salt Marsh	TRI
Intertidal & Subtidal	*Balanus glandula*	Barnacle	BAR
	Fucus distichus	Rockweed	FUC
	Ulva spp.	Green Algae	ULV
	Zostera marina	Eelgrass	ZOS

***** Associated with estuaries and fringing wetlands at this wave exposure.

Table A-23 Codes for Special Features in the Oregon Dataset

Special Feature	Bio Area	BioGeog1 Code	BioGeog1 Description	BioGeog2
Biographic Regions	*Ocean (Outer Coast)*	H1	Major headland	Geographic name
		H2	Minor headland	"
		R1	Reef (rocky shoreline)	"
		RS	Rock & beach (partially mobile substrate)	"
		S1	Beach (mobile substrate)	"
		MM	Man made	"
	Estuary (Inner Coast)	E1	Highly river-dominated drowned river mouth	"
		E2	Moderately river-dominated drowned river mouth	"
		E3	Tide-dominated drowned river mouth	"
		E4	Blind – Drowned river mouth	"
		E5	Bar built	"
		E6	Tidally restricted coastal creek	"
		E7	Marine Harbor/Cove	"
Salinity Regime	**Code**		**Description**	
	MR		Marine salinity regime	
	ER		Estuarine salinity regime	
	RR		River salinity regime	

Special Feature	Bio Area	BioGeog3 Code	BioGeog3 Description
Biogeographic Regions	*Ocean (Outer Coast)*	Littoral Cell Name	Names indicate shoreline extent of coastal littoral cells
	Estuary (Inner Coast)	CON	Conservation Estuary
		DDD	Deep Draft Development Estuary
		NAT	Natural Estuary
		SDD	Shallow Draft Development Estuary

Notes: 1. Special Oregon Features are catalogged in the Unit Table of the Geodatabase
2. The features have a 1:1 relationship with the Unit Lines. That is, each feature occurs only once for each unit line.
3. Biogeographic regions and features were assigned by ODFW
4. Salinity regimes were assigned using maps by Scranton.
5. BioGeog1 estuary types based on Lee II, H.; Brown, C.A. (eds.) 2009. Classification of regional patterns of environmental drivers and benthic habitats in Pacific Northwest estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09/140. 298 pp.
6. BioGeog3 littoral cells based on "Littoral Cells of the Oregon coast, Oregon Coastal Management Program (2001) (provided by Oregon Department of Land Conservation and Development, 2014).
7. BioGeog3 estuary types represent Oregon Statewide Planning Goal 16 estuary classification.

APPENDIX B EXAMPLE PHOTOS OF PHYSICAL ATTRIBUTES

Figure B-1. Steep high cliff; *Shore Type* 3
Cape Foulweather (Unit 50/01/2049/0)
or11_or_04763.jpg

Figure B-2 Low-tide, rock platform; *Shore Type* 1
Boiler Bay (Unit 50/01/2010/0)
or11_or_04647.jpg

Figure B-3. Wide ramp with gravel beach; *Shore Type* 6
Port Orford (Unit 50/01/4032/0)
or11_or_13375.jpg

Figure B-4. Ramped shoreline; *Shore Type* 4
Humbug Mountain (Unit 50/01/4051/0)
or11_or_13607.jpg

Figure B-5. Narrow ramp with gravel beach
Cape Foulweather (Unit 50/01/2051/0)
or11_or_04782.jpg

Figure B-6. Wide Ramp with sand and gravel beach; *Shore Type* 11
Bob Creek (Unit 50/01/5062/0)
or11_or_07013.jpg

Figure B-7. Wide platform with sand beach; *Shore Type* 17;
Otter Rock (Unit 50/01/2064/0)
or11_or_04849.jpg

Figure B-8. Wide Platform with sand and gravel beach; *Shore Type* 12;
Cape Perpetua (Unit 50/01/3026/0)
or11_or_06926.jpg

Figure B-9. Wide sand beach; *Shore Type* 27;
Depoe Bay (Unit 50/01/2034/0)
or11_or_04722.jpg

Figure B-10. Wide sand and gravel beach; *Shore Type* 24;
South of Cape Blanco (Unit 50/01/4004/0)
or11_or_13250.jpg

Figure B-11. Wide sand flat; *Shore Type* 28;
Lincoln City (Unit 50/01/1073/0)
or11_or_04433.jpg

Figure B-12. Wide mud flat; *Shore Type* 29;
Jordan Cove, Coos Bay (Unit 50/01/5012/0)
or11_or_11037.jpg

Figure B-13. Marsh; *Shore Type* 31;
Siuslaw River (Unit 50/02/0000/0)
or11_or_07440.jpg

Figure B-14. Marsh; *Shore Type* 31;
Pony Slough, Coos Bay (Unit 50/01/5015/0)
or11_or_11372.jpg

Figure B-15. Man-made, permeable shoreline; *Shore Type* 32;
Coos Bay (Unit 50/01/5010/0)
or11_or_11016.jpg

Figure B-16. Man-made, permeable shoreline; *Shore Type* 32;
Coos Bay (Unit 50/01/5034/0)
or11_or_11516.jpg

Figure B-17. A vegetated dune in the foreground (Form “Ew”) *Shore Type* 28
Florence area of the outer coast.
or11_or_07971a.jpg

Figure B-18. Cliffs with sea caves (Form “Cashc) *Shore Type* 3;
Port Orford (Unit 50/01/4014/0)
or11_or_13333.jpg

Figure B-19. Sea Wall (Form “As”), Marina (Form “Am”); *Shore Type* 33 ;
Depoe Bay (Unit 50/01/2027/0)
or11_or_04698.jpg

Figure B-20. Beach access (Form “Az”); *Shore Type* 28;
South of Cape Blanco (Unit 50/01/4005/0)
or11_or_13254.jpg

APPENDIX C EXAMPLE PHOTOS OF BIOLOGICAL ATTRIBUTES

BIOBANDS

Figure C–1. Bioband: ***European Dune Grass*** **(AMM)** bioband on sand dunes, near Manzanita, outside of Nehalen Bay.
or11_or_00769.jpg

Figure C–2. Bioband: **Swamp Marsh Fringe** (MSH) along the backshore (outlined), **Salt Marsh** (TRI), and **Green Algae** (ULV) on the mudflats, lower Yaquina River outside of Toledo.
or11_or_05679.jpg

Figure C–3. Bioband: **High Grass Meadow** (MAG) (outlined), and **Salt Marsh** (TRI), lower Yaquina River near Toledo.
or11_or_05737.jpg

Figure C–4. Bioband: ***Salt Marsh* (TRI)** bioband in northern Coos Bay, with sand dune and dredged channels.
or11_or_11090.jpg

Figure C-5. Bioband: ***Salt Marsh*** **(TRI)** and ***Sedge*** **(SED),** with ***Green Algae*** **(ULV)** on mudflat, Coos Bay.
or11_or_11207.jpg

Figure C-6. Bioband: ***Mud Flat Shrimp*** **(CAL)** as dimpled texture on mudflat, along the Alsea river near Waldport.
or11_or_06596.jpg

Figure C-7. Bioband: ***Oyster*** **(OYS)** showing areas of oyster mariculture on mudflat, Netarts Bay.
or11_or_01304.jpg

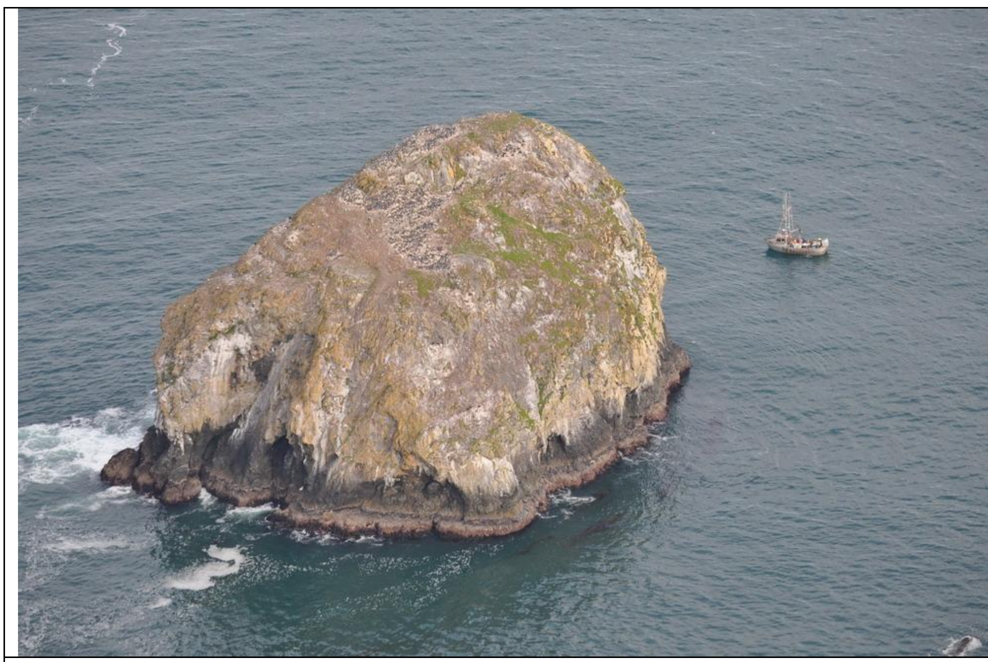

Figure C-8. Biobands: ***Splash Zone*** **(VER),** ***Barnacle*** **(BAR),** ***California Mussel*** **(MUS),** ***Dark Brown Kelps*** with ***Red Algae*** **(CHB and RED).** Typical biobands for Exposed, Immobile, on islet in Redfish Rocks group, south of Port Orford.
or11_or_13471.jpg

Figure C–9. ***California Mussel*** **(MUS)** Bioband**:** Dense, mid-intertidal California Mussel bioband (MUS). Note sea palm alga *Postelsia* on the lower platform, and low turf of Bleached Red Algae (HAL) along the upper edge of the MUS. Rock platform near Government Point, Depoe Bay.
or11_or_04628.jpg

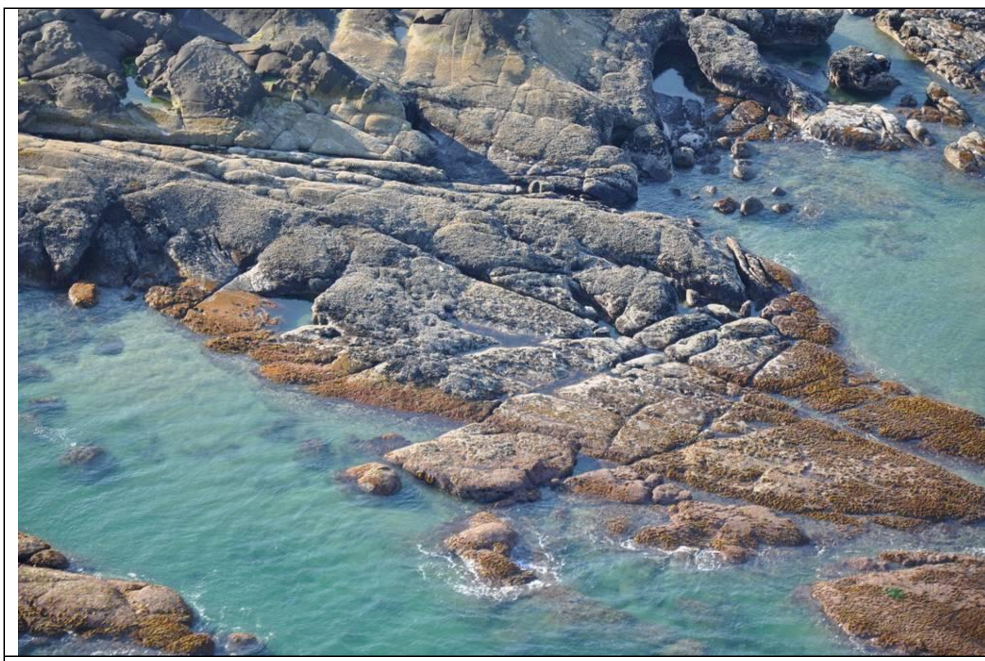

Figure C-10. Bioband: ***Red Algae*** **(RED)** bioband on lower platform. Note mix of low turf of small red algae, together with pink encrusting coralline algae, on lower intertidal platform near Yachats.
or11_or_06834.jpg

Figure C-11. Bioband**: *Surfgrass*** (SUR) on lower intertidal platform, near Government Point, Depoe Bay
or11_or_04618.jpg

Figure C-12. Bioband: ***Eelgrass* (ZOS)** along river channel, lower Coos Bay
or11_or_10955.jpg

Figure C-13. Biological Wave Exposure: ***Exposed***
Habitat Class: *Exposed,* ***Immobile;***
North of Neahkahnie Beach, Manzanita
or11_or_00730.jpg

Figure C-14. Biological Wave Exposure: ***Exposed***
Habitat Class: *Exposed,* ***Mobile;***
Hecata Beach, looking south.
or11_or_07197_.jpg

Figure C-15. Biological Wave Exposure: ***Semi-Exposed***
Habitat Class: *Semi-Exposed,* ***Partially Mobile;***
North of Searose Beach, Yachats
or11_or_07006.jpg

Figure C-16. Biological Wave Exposure: ***Semi-Exposed***
Habitat Class: *Semi-Exposed,* ***Anthropogenic*** (on left) & ***Mobile*** (on right)
Port Orford harbor
or11_or_13345.jpg

Figure C-17. Biological Wave Exposure: ***Semi-Protected*** (on left, sheltered side of breakwater); Habitat Class: *Semi-Protected,* ***Anthropogenic***
South jetty at entrance to Nehalem Bay
or11_or_00804.jpg

Figure C-18. Biological Wave Exposure: ***Protected***
Habitat Class: *Protected,* ***Mobile.*** Also see Eelgrass bioband (ZOS) along edge of channel.
North Bend, Coos Bay
or11_or_11325.jpg

Figure C-19. Biological Wave *Exposure:* ***Protected***
Habitat Class: *Protected,* ***Estuary***
Shorewood, Coos Bay
or11_or_11218.jpg

Figure C-20. Biological Wave Exposure: ***Protected;***
Habitat Class: Protected, ***Anthropogenic***
North Spit, Coos Bay
or11_or_10985.jpg

APPENDIX D SUMMARY OF VEGETATION TYPES AND ASSOCIATED PLANT COMMUNITIES

Described by Jefferson (1974) PLANT COMMUNITIES AND SUCCESSION IN OREGON COASTAL SALT MARSHES.

Jefferson (1974) describes the plant communities and succession in Oregon coastal salt marshes and summarized plant communities by elevation into six vegetation types:

(1) low sand marsh,
(2) low silt marsh,
(3) sedge marsh,
(4) immature high marsh,
(5) mature high marsh, and
(6) bulrush and sedge.

Each vegetation type is characterized by a set of plant communities, which often share similar species assemblages but are generally stratified by elevation The communities associated with the Jefferson vegetation types are listed below in Table D-1, and each assemblage has been assigned to an associated ShoreZone bioband. These plant communities identified by Jefferson can then be considered as expanded definition of indicator and associated species for the estuarine biobands mapped in Oregon.

Communities observed in both the Low Sand Marsh and Low Silt Marsh vegetation types include species which are in the lower Salt Marsh (TRI), Sedge (SED), Green Algae (ULV) and Eelgrass (ZOS) biobands (Table D-1).

For the Sedge communities, Jefferson states: "*Carex lyngbyei* is an intermediate in all modes of succession, and this sedge comprise probably the most extensive vegetation type in Oregon's estuaries" and "*Carex lyngbyei* forms a continuous cover between the clumps [of *Triglochin* and *Salicornia*] and on the low marsh the sedge is the dominant plant, occupying 60% of the cover; however small stands of [the Sedge] community are found in all the other types of salt marshes."

Jefferson (1974) also describes the *Scirpus americanus* community as "a mono-specific community on the outer edge of sandy marshes, where vegetation cover is usually continuous. The plant grows in large clones, as shown by patterns visible from the air and by the continuous network of subsurface rhizomes." *Ruppia, Zostera* and the green alga *Cladophora* occur in the channels and lowest elevations of this type.

The Immature and Mature High Marsh plant vegetation types have a mixture of salt-tolerant herbs and grasses (Table D-1). The *Deschampsia-Potentilla-Trifolium-Juncus* community, is found at the extreme high water level (Jefferson 1974) and is considered part of the High Grass Meadow (MAG) bioband (Table D-1).

Indicator species for the Shrub Meadow bioband (MSH) are listed by Jefferson (1974) in the *Potentilla Deschampsia* community "which normally occupies a narrow strip between the top of the general mature high marsh community and Sitka spruce forests" and includes other indicators for the Mature High Marsh vegetation types as *Agrostis alba, Grindelia integrifolia, Potentilla pacifica, Juncus lesueurii and Deschampsia caespitosa*.

The Bulrush and Sedge vegetation type “occurs along tidal creeks and dikes or on islands where freshwater largely dilutes salt water” and marks the transition to freshwater vegetations.

Table D-1. Vegetation Type, Associated Plant Communities and ShoreZone Bioband, adapted from Jefferson (1974).

Vegetation Type	Associated Plant Communities	Bioband *
Low Sand Marsh	1. *Cyanophyta-Puccinellia-Spergularia macrotheca*	TRI
	2. *Distichlis-Cladophora-Salicornia*	TRI, ULV
	3. *Jaumea-Salicornia-Distichlis*	TRI
	4. *Jaumea-Salicornia-Triglochin maritimum-Distichlis*	TRI
	5. *Jaumea-Salicornia-Triglochin concinnum-Triglochin maritimum-Distichlis*	TRI
	6. *Scirpus americanus*	SED, TRI
	7. *Ruppia*	ZOS
Low Silt Marsh	1. *Cladophora*	ULV, ZOS
	2. *Salicornia-Triglochin maritimum*	TRI
	3. *Spergularia marina-Salicornia*	TRI
	4. *Salicornia-Cotula*	TRI
	5. *Eleocharis-Salicornia*	TRI
	6. *Carex-Triglochin maritimum*	TRI, SED
	7. *Deschampsia-Carex-Triglochin maritimum*	TRI, SED
	8. Salicornia-Cotula-Scirpus validus-Triglochin maritimum	TRI, SED
	9. *Scirpus maritimus*	SED
Sedge Marsh	*1. Carex*	SED
Immature High Marsh	*1. Salicornia-Distichlis-Plantago-Scirpus americanus-Glaux-Spergularia canadensis*	TRI
	2. Deschampsia-Potentilla-Trifolium-Juncus	TRI, MAG
	3. Distichlis	TRI
	4. Distichlis-Salicornia	TRI
	5. Carex-Salicornia-Trglochin maritimum	TRI, SED
	6. Salicornia-Distichlis-Triglochin, maritimum	TRI
	7. Distichlis-Deschampsia-Carex	MAG, TRI
Mature High Marsh	*1. Potentilla-Deschampsia*	MAG
	2. Salicornia-Distichlis-Juncus	MAG, TRI
	3. Juncus gerardii-Deschampsia-Juncus lesueurii	MAG, TRI
Bulrush and Sedge Marsh (note: this vegetation type is more freshwater marsh than estuarine)	*1. Scirpus validus*	SED, MSH
	2. Scirpus validus-Carex	SED, MSH

* See Appendix A, Table A-16 for list of bioband names, codes and descriptions.