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Data Cross-walk Between the ShoreZone Coastal Habitat Mapping System and Coastal and Marine Ecological Classification System (CMECS)

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This project tested the potential for transferring ShoreZone data to the new Coastal and Marine Ecological Classification System (CMECS; Madden *et al* 2009). ShoreZone is a relatively mature coastal habitat mapping system with nearly 100,000 km of contiguous coastline mapped in Alaska, British Columbia and Washington. If such a data cross-walk is possible, a substantial CMECS dataset could be created from existing data.

To test the cross-walk approach, three pilot areas from Sitka Sound were selected. These areas represented about 122 km of shoreline, 522 alongshore *units* and 1,966 across-shore *components*. A variety of exposures, landforms, substrate, biota and salinity regimes are represented within these three pilot sections.

A flat database was created to capture data using the CMECS classification protocol. ShoreZone data were transferred from five tables or databases to the CMECS database. An estimated 75 - 80% of the ShoreZone data was easily transferred. The 20-25% that could not be transferred relates primarily to the fundamentally different spatial mapping units of ShoreZone and CMECS. The primary ShoreZone mapping unit is an alongshore segment or *shore unit* (522 in the test sections); there are a number of ShoreZone attributes that apply to the entire unit (e.g., shore type, habitat type). The primary mapping unit of CMECS is a *depth ribbon*, including supratidal, intertidal and shallow subtidal zones (1,966 in the test sections). While the data from the ShoreZone *across-shore components* could be transferred to these CMECS depth ribbons (the 75-80% of the data), there is no summary indicator in CMECS for the across-shore suite of shore features cataloged in CMECS Geoform, Surficial Geology or Biotic Cover layers.

The spatial representation of ShoreZone units is a line segment, delineated by segmenting the digital high water line. All attribute data are linked to the line segments. Across-shore zonation of forms, material and biota are preserved within ShoreZone by using an indexing system; this indexing system explicitly links forms, materials and biota and is transferable to CMECS. CMECS may not have envisaged the use of line segment representation for mapping units as it was designed primarily as a classification system, but with the addition of indexing, CMECS appears to work well with line segments for spatial units.

One of the most challenging aspects of the cross-walk is how patchiness of surficial substrate is captured in CMECS. Small scale variability in horizontal and vertical substrates is common on glaciated shorelines. The categorization of all substrates as either *rock shore* or *unconsolidated shore* is problematic, especially at smaller mapping scales. For example in the 5,000 km mapping project of Prince William Sound, 45% of the shoreline is classified as some type of combination of rock <u>and</u> sediment. CMECS may wish to consider an intermediate *rock-<u>and</u> sediment shore* category in their substrate classification. Also, it is not clear what category *anthropogenic shores* should be categorized.

The overall assessment for data transfer between ShoreZone and CMECS is good – 75-80% of the data is transferable and data most commonly used in habitat capability modeling (e.g. predicting probable locations for invasive species) was moved to CMECS. An additional test of CMECS as a mapping system will be the interpretation of shoreline attributes directly from imagery into the CMECS data structure that was created for this cross-walk.

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1.1 Background

Coastal and marine resources are increasingly affected by anthropogenic changes including climate change, pollution and fishing activities. To effectively manage resources and document changing patterns of resources, it is essential to know both what exists (basic inventory) and where it exists (mapping). While there are numerous resource inventories, there is currently no nation-wide standard so various jurisdictions embrace a wide-variety of classifications and mapping scales. This project evaluates the ShoreZone coastal habitat mapping, where nearly 100,000 km of shoreline has previously been mapped, and the Coastal and Marine Ecological Classification System (CMECS), which has been proposed as a national standard.

CMECS

The Coastal and Marine Ecological Classification System (CMECS III; FGDC 2010) is a comparatively new coastal habitat classification system designed for both coastal and marine resource categorization. The CMECS III standard has recently been revised and adopted by the US federal government as a national standard that can be used by different agencies for management of coastal and marine resource management. The standard is designed to be used in both the marine environment (the shallow subtidal to abyssal depths) and the coastal environment (intertidal and supratidal). For this pilot, it was applied primarily in the intertidal zone.

CMECS III is hierarchical classification that includes Systems, Subsystems and Components (Table 1). For the region of southeast Alaska that was tested as part of this project, the majority is within Sitka Sound and as such falls within the Estuarine System and only a small portion of the test area has no "degree of enclosure by land" and is classified as a Marine System.

Table 1 Summary of CMECS Classification Hierarchy

Systems	Subsystems	Components
Marine	Nearshore nearshore supratidal nearshore intertidal nearshore subtidal (MLLW to 30 m isobath)	SGC, GFC, BBC
	Neritic	SGC, GFC, BBC
	Oceanic	SGC, GFC, BBC
Estuarine	Shallow Water (supratidal to 4 m isobath) shallow-water, supratidal shallow-water, intertidal shallow-water, subtidal	SGC, GFC, BBC
	Deep Water (>4 m isobath)	SGC, GFC, BBC
	Tidal Riverine shallow –water, tidal riverine (MLLW to extreme tide) Deep-water, tidal riverine (below MLLW)	SGC, GFC, BBC
Lacustrine	Littoral	SGC, GFC, BBC
	Limnetic	SGC, GFC, BBC

Note: SGC = Surficial Geology Component
GFC = Geoform Component
BBC = Benthic Biotic Component

CMECS was designed as a habitat classification and not initially intended as a habitat mapping system. This project was designed to evaluate CMECS as a *mapping system* so the project represents a pilot mapping approach for CMECS.

ShoreZone

ShoreZone is a coastal habitat mapping system that was developed in British Columbia in the 1980s (Owens 1980; Howes *et al* 1994; Howes 2001) and has been applied widely to the Pacific Northwest coast. As of 2011, ShoreZone mapping extends from the Columbia River mouth to Bristol Bay, Alaska. The mapping system uses oblique video and photographic imagery that is collected during the lowest tides of the year as the basis for habitat characterization. Using a systematic protocol (Harney *et al* 2008), geologists and biologists view the imagery, delineate *alongshore units* of homogenous substrate and morphology, and then assign physical and biological attributes to that unit (Fig. 1). Physical features such as cliffs, dunes, beaches and flats are mapped along with their associated substrate (*across-shore components*[1]). Biological features, characterized in terms of *biobands*[2], are mapped within each unit and include features like salt marshes, mussel beds, understory kelps, eelgrass beds and canopy kelps. The large datasets allow regional characterization of resources (e.g., eelgrass beds occur along 369 km of the 2,369 km shoreline of Baranof Island) for use in resource management.

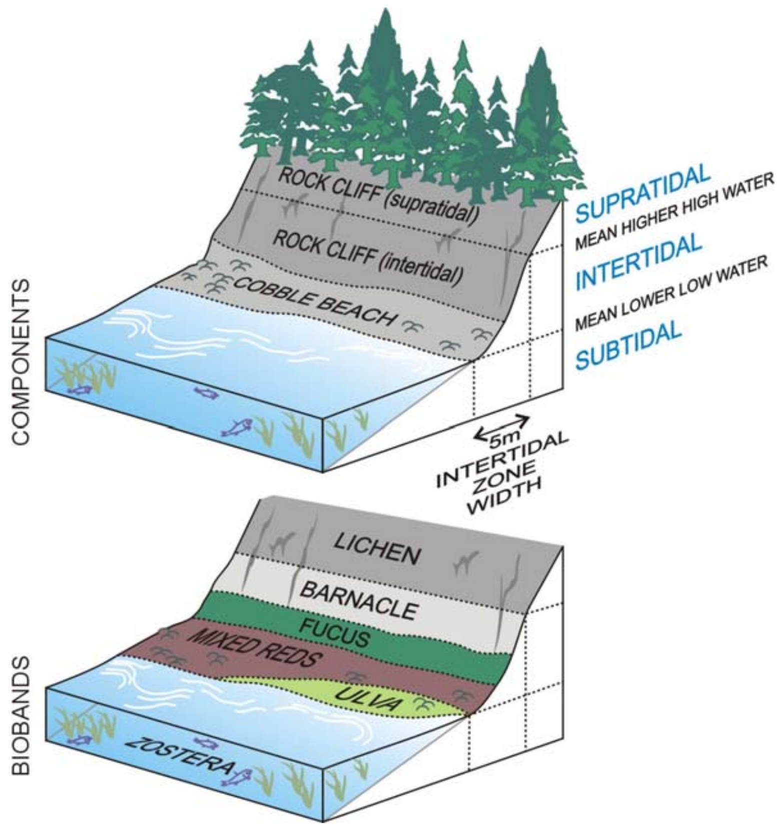


Figure 1. Schematic of the ShoreZone data organization. For each *alongshore* unit, across-shore physical *components* (forms & materials) and across-shore *biobands* are cataloged.

[1] an across-shore *component* is a geomorphic feature within the supratidal, intertidal or subtidal zones (Fig. 1). *Components* typically extend along the entire unit but have limited across-shore width. Cliffs, dunes, berms, beach faces, and swash bars are examples of *components* (see Fig. 1). Each component has an associated *material* or substrate.

[2] A *bioband* is an observed assemblage of coastal biota, which grows in a typical across-shore elevation and at characteristic wave energies and substrate conditions. Biobands are spatially distinct, with alongshore and across-shore patterns of color and texture that are visible in the aerial imagery. *Biobands* are named for the dominant species or group of species that best represents the entire band.

1.2 Statement of the Problem

ShoreZone is a comparatively mature coastal habitat mapping systems that has been widely applied along Pacific Northwest shorelines, including the entire Washington coastline, the entire British Columbia coastline and approximately half of the Alaska coastline. CMECS is a comparatively new coastal classification system (Madden *et al* 2009) being developed to provide a unified standard for coastal and marine inventories in the U.S. The CMECS classification system was not specifically designed as a mapping system (Madden *et al* 2009) but with appropriate mapping rules, could evolve to a mapping system. A more recent version of CMECS, which was not used in this evaluation, is proposed as a national standard (CMECS III; FGDC 2010).

The purpose of this project is to test a cross-walk of data between Alaska ShoreZone (Harney *et al* 2008) and CMECS using a small section (~120 km) of Alaska shoreline previously mapped with ShoreZone. The cross walk would identify where ShoreZone could easily be translated into CMECS as well as areas where there are challenges between the two systems. In that CMECS was not primarily designed as a mapping system, the cross-walk would highlight some of the issues in transferring the ShoreZone mapping to CMECS in terms of spatial representation.

1.3 Approach

Three areas of previously mapped shoreline near Sitka, Alaska were selected for the pilot cross-walk (Fig. 2). The three areas represented a variety of coastal habitats, including (a) very exposed shoreline in outer Sitka Sound and Kruzof Island (Kruzof South), (b) mostly protected shoreline within Sitka Sound that includes several large deltaic estuaries (Sitka Sound) and (c) a transitional area from very protected to very exposed at the northern tip of Kruzof Island, to the north of Sitka Sound (Kruzof North). The inner Sitka Sound section was also part of a ground verification survey in 2008 (Harper *et al* 2009) so there are also ground photos and verification data.

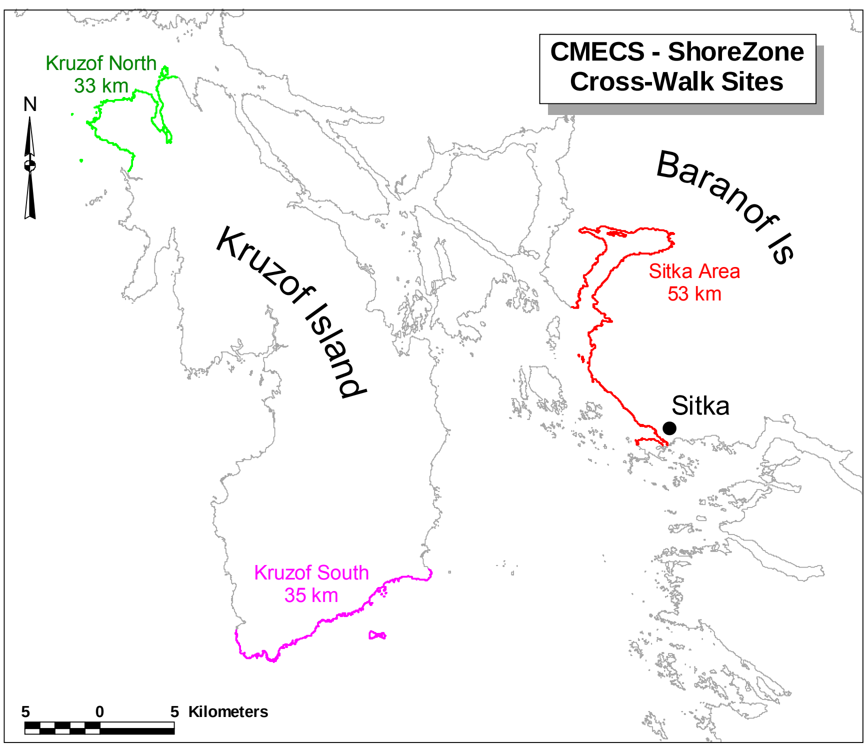


Figure 2. Location of the three test sections of shoreline used in the pilot cross-walk. For mapping elements of each section, refer to Table 1.

The ShoreZone data for each test section were extracted from the master SE Alaska ShoreZone dataset for use in the pilot. The three test sections involved 122 km of shoreline and cross-walk of nearly 2,000 mapping units of ShoreZone component data to the Biotic Cover Component (BCC), Surficial Geology Component (SGC) and Geoform Components (GFC) of CMECS (Table 2). It should be noted that the primary mapping unit of ShoreZone is the *alongshore unit* (e.g., Fig. 3 shows the line segments that represent *alongshore units*) whereas the primary mapping unit of CMECS is the *across-shore component* (Fig. 1). The *alongshore units* of ShoreZone do not translate to CMECS. While this is a fundamental difference between the two systems, the vast majority of the ShoreZone data could be cross-walked as the ShoreZone *across-shore components* are essentially equivalent to the CMECS mapping unit.

Table 2 ShoreZone to CMECS Cross-Walk Pilot Sections

Section	Shoreline Length (km)	Number. of Alongshore Units	Number of Across-Shore Components	Number of Biobands
North Kruzof Is	31.6	148	538	538
South Kruzof Is	36.5	105	435	435
Inner Sitka Sound	54.1	269	993	993
Totals:	*122.2*	*522*	*1,966*	*1,966*

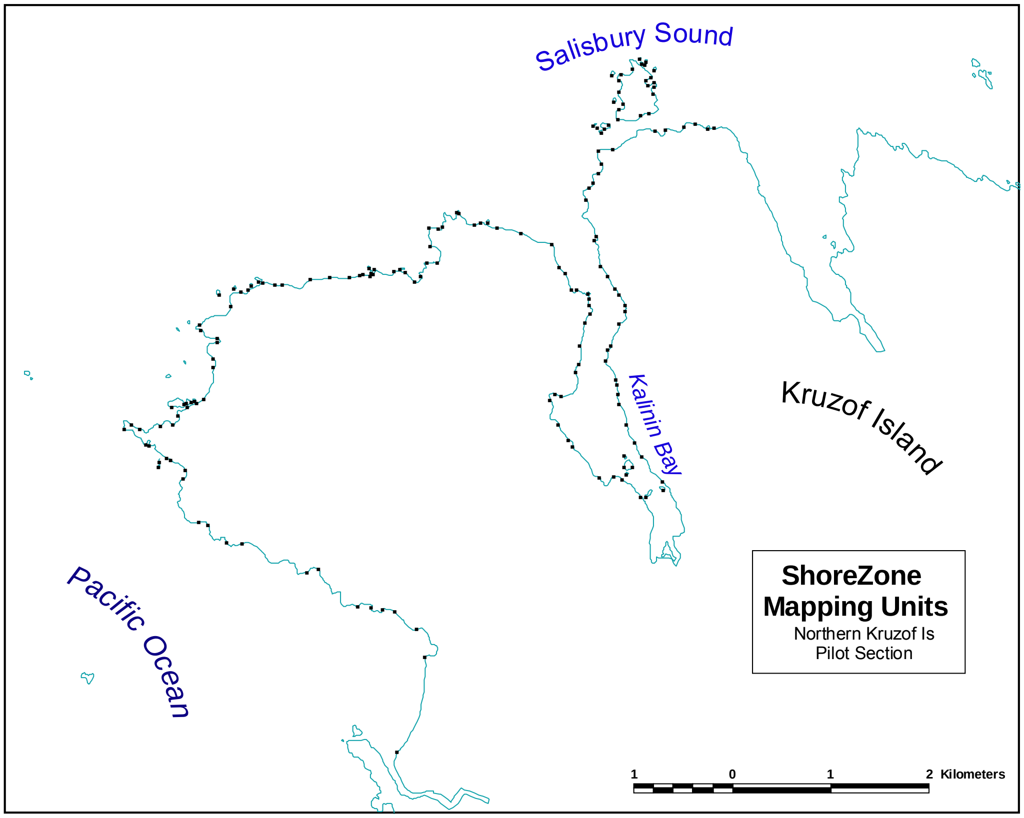


Figure 3. Expanded view of the northern Kruzof Island pilot section showing the 148 *shore units* that were mapped as part of ShoreZone. End points delineate lines segments or *shore units*.

2.1 General Book-keeping Considerations of the Cross-Walk

Spatial Mapping Units

As a classification system, CMECS was not initially designed fro mapping but some reference to spatial representation is included and the few maps used in the CMECS Manual show polygonal units. ShoreZone represents mapping units only as line segments and, in some cases, points. The line segments are based on USGS topographic maps using the digital high-water line as the basis for the line segments (Fig. 3). The approximation of using line segments vastly simplifies the "cartography" of the ShoreZone mapping data, while introducing some spatial uncertainty; the representation is that the mapping units (across-shore components) are thin with no width and have only length. For the lowest units in the intertidal zone or the subtidal units, this means that mapping unit is not precisely located, although it generally will be within the line thickness drawn on a map.

Linking SGC, GFC and BCC

As previously mentioned, the CMECS mapping units are equivalent to the ShoreZone *across-shore components* and the ShoreZone *biobands*. These features are schematically illustrated in Figure 1. In the ShoreZone system, the *forms* and *materials* are specified for the same mapping unit (Fig. 1) and are captured within the same database. In the CMECS system, the Geoform Component (GFC) and the Surficial Geology Component (SGC) are not necessarily the same and can be independent mapping units. As such, they will not necessarily be captured within the same database. We use a unique identifier to link the two within our CMECS cross-walk data - the cross-walked GFC and SGC are explicitly linked to the same spatial mapping unit by this identifier.

In some cases, our *biobands* can occur within more than one mapping unit (Fig. 1; a many-to-one relationship) but the linkage to specific GFC/SGC mapping units is maintained.

Relative Elevation of Mapping Units

Since the ShoreZone mapping units, line segments (Fig. 3), represent multiple CMECS map units, there is no spatial representation that can be used to infer relative tidal elevation (with polygonal mapping units, the unit closest to the subtidal, would be the lowest in the intertidal zone). The relative topographic position of each data unit is provided by the identifiers, where an ***A*** in the identifier indicates supratidal units, a ***B*** indicates intertidal units and a ***C*** indicates subtidal units. Further numbering indicates relative position with each tidal zone (e.g., ***B1*** is highest intertidal unit, ***B2*** is the next highest intertidal unit, etc.).

2.2 Geoforms Component (GFC)

The existing Geoforms list in CMECS (Madden *et al* 2009) includes only five geoforms appropriate for use in the *Subsystem* of CMECS classification (Table 1). These five forms are: delta fan, cliff, lagoon, rock outcrop, and tidepool as well as ten Anthropogenic geoforms (berm, dam or dike, dredge mound, harbour or marina, jetty, levee, pier, seawall, shipwreck, and pilings) (Madden *et al* 2009). This list was considered inadequate to describe the morphology of much of the Alaska coast and after discussions with the CMECS Technical Committee, it was suggested that the list of 14 ShoreZone cross-shore component forms be used as an alternative for the ShoreZone to CMECS cross-walk.

The ShoreZone *across-shore forms* (see Fig.1; Howes *et al* 1994; Harney *et al* 2008) are listed in Table 4 along with the standard ShoreZone modifiers; examples of the coding system are provided in Table 5. The ShoreZone *forms* can be broadly categorized into two general *Intertidal Geoforms Classes*, as described below:

Fixed Class: *features that are relatively permanent and unlikely to change in basic shape or form over period of a few years. This Geoform Class includes:*

Anthropogenic forms (A),
Cliffs (C), (unconsolidated cliffs may change position, but not form)
Reefs (F),
Offshore Islands (O),
Platforms (P).

Dynamic Class: *features that are inherently mobile and likely to change in space and time over a period of a few years. These are features that are usually actively being modified by shore processes such as wave action, tidal currents or in some cases wind. Dynamic features are more likely to be sensitive to anthropogenic impacts. The Dynamic Geoform Class includes:*

Beaches (B)
Deltas (D)
Dunes (E)
Ice Front (I)
Lagoons (L)
Marshes (M)
River Channels (R)
Tidal Flats (T)

Substituting ShoreZone cross-shore forms for the exiting CEMCS Geoforms is a proposed classification modification to CMECS v3 based on the existing ShoreZone system. The ShoreZone forms list has evolved for use on the west coast (a “collision” coast with generally high coastal relief and relatively small drainage basins as opposed to the “trailing edge” coasts [Inman and Nordstrom 1971] along the Gulf and Atlantic coasts of the US). It is also a classification system that has been developed for glaciated coasts.

ShoreZone includes an additional protocol for describing the *form* of each *across-shore component* (Fig. 1): primary, secondary and tertiary *form* fields. That is, the primary *form* of a component might be a rock platform, but the secondary *form* might be a veneer of boulder cobble over the platform and a tertiary *form* might be a beach berm on one portion of the rock platform (Appendix A). A feature must comprise at least 10% of the component to be included

Table 3 Suggested Coastal Geoform Categories (bold) and Associated Modifiers (from Harney *et al* 2008 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
m	marina
n	ferry terminal
o	log booms
p	port facility
q	aquaculture
r	boat ramp
s	seawall
t	landfill, tailings
w	wharf
x	outfall or intake
y	intake

B = Beach

b	berm (intertidal or supratidal)
c	washover channel
f	face
i	inclined (no berm)
m	multiple bars / troughs
n	relic ridges, raised
p	plain
r	ridge (single bar; low to mid intertidal)
s	storm ridge (occasional 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
f	drowned forest
h	high
l	mid to low (discontinuous)
o	pond
s	brackish, supratidal

O = Offshore Island

(not reefs)

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

elevation

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

P = Platform

(slope <20°)

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

R = River Channel

a	perennial
i	intermittent
m	multiple channels
s	single channel

T = Tidal Flat

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

Note: this table of proposed Geoforms is based on the ShoreZone *across-shore forms* from Howes *et al* 1994 and modified by Harney *et al* 2008.

as one of the ShoreZone *forms*. In discussions with the CMECS Technical Committee it appeared that such a protocol is appropriate within the CMECS system and *forms* data from ShoreZone was transferred in the same format (Appendix B).

Table 4 Examples of ShoreZone *Form* and *Material* Codes

Primary Form Code	*Form* Translation	Primary *Material* Code	*Materials* Translation
Pr	a platforms ramp (slope> 5° and <20°)	vCcb/R	a veneer of boulder-cobble over rock
Bs	storm berm	At/Ccp	cut logs over cobble-pebble
Casl	an actively eroding, steep (>35), low (<5m high) cliff	R	rock
Mh	a high marsh	Bgpo/Cspb	Biogenic grass, peat and organics over sand, pebble boulders.
Tt	tidal flat	Cfs	mud, sand

2.3 Surficial Geology Component

The CMECS Surficial Geology Component (SGC) includes two major shore substrate classes: *Rocky Shore* and *Unconsolidated Shore*. There are an additional three *Rocky Shore* subclasses (bedrock, boulder and pavement) and six *Unconsolidated Shore* subclasses (cobble/gravel, sands, muds, organic, shell and mixed sediments). Each of the ShoreZone across-shore components includes a primary, secondary or tertiary *materials* (Appendix B) field that is explicitly linked to the primary, secondary or tertiary *form*. The ShoreZone codes are summarized in Table 6. a few examples of the ShoreZone coding for across shore materials are provided in Table 5.

The SGC proved to be the most challenging component to which the ShoreZone material data were cross-walked. Our component characterization often includes a primary substrate type, a secondary substrate type and a tertiary substrate type. The substrate classes are occasionally a combination of rock and sediment substrates (see Table 5, first example where a veneer of cobble-boulder overlies a bedrock surface). While we can transfer the ShoreZone substrate description at the CMECS “sub-subclass” level to preserve the detailed description, assigning this unit to either the CMECS subclass level (e.g., bedrock, boulder or pavement) or class level (e.g., *Rock Shore*; *Unconsolidated Shore*) results in loss of information and a challenge to the mapper as to how to lump mapping data. Another challenge where to categorize man-made shorelines and associated man-made materials. Although such materials are rare in Alaska, they are not rare in other areas (e.g., 78% of the King County shoreline in Washington is characterized as man-modified shoreline).

2.4 Biotic Cover Component

The translation of ShoreZone *bioband* data to CMECS Biotic Cover Component was probably the most straightforward of the three coverages in CMECS. Table 7 shows the rationale that was used to load *biobands* to the CMECS BBC class level. We recommend that several additional biotic subgroups be created in CMECS (for example, to distinguish between understory kelps, which are comparatively common and canopy kelps that are much less common, Table 7).As mentioned in Section 2.1, we explicitly cross-link GFC, SGC and BCC data units with a unique identifier (Appendix C) and the identifier is also designed to maintain the relative elevation of each bioband in order from top to bottom (the elevation order is preserved by using the ShoreZone index number, which is sequenced from highest to lowest position within the littoral zone).

Table 5. 'Material' Code Dictionary (after Howes *et al* 1994; from Harney *et al* 2008)

A = Anthropogenic

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

B = Biogenic

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

C = Clastic

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

R = Bedrock

rock type:

i	igneous
m	metamorphic
s	sedimentary
v	volcanic

rock structure:

1	bedding
2	jointing
3	massive

SEDIMENT TEXTURE

(Simplified from Wentworth grain size scale)

GRAVELS

boulder > 25 cm diameter

cobble	6 to 25 cm diameter
pebble	0.5 cm to 6 cm dia.

SAND

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

FINES ("MUD")

includes silt and clay

silt	0.0039 to 0.063 mm
clay	<0.0039 mm

TEXTURE CLASS BREAKS

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

Note: The 'material' descriptor consists of one primary term code and associated modifiers (e.g. Cobs). 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. vs./R). Grayed items are not used in the Alaska ShoreZone program.

Table 6 Cross-Walk of Biobands to CMECS Biotic Groups

ShoreZone BioBand	Code	CMECS Class	CMECS Subclass	CMECS Biotic Group	CMECS Biotope	Notes
Lichen	VER	Aquatic Bed	Lichen/Moss?	?	*Verrucaria*	definitely occurs in littoral zone, as defined by CMECS; requires new subclass
Dune Grass	GRA	Emergent Wetland	Coastal saltmarsh	Emergent high salt marsh	Pac NW species not listed	add biotope with Pacific NW species, such as Dune Grass (*Leymus mollis*) assemblage
Sedges	SED	Emergent Wetland	Coastal saltmarsh	Emergent high salt marsh	Pac NW species not listed	add biotope with Pacific NW species, such as *Carex* spp
Salt Marsh	PUC	Emergent Wetland	Coastal saltmarsh	Emergent low salt marsh	Pac NW species not listed	add biotope with Pacific NW species, such as *Salicornia/ Triglochin/ Puccinella*
Barnacle	BAR	Faunal Bed	Sessile epifaunal	Barnacles		Bioband not separated to species at Biotope level
Rockweed	FUC	Aquatic Bed	Macro algae	Rockweeds	*Fucus* communities	
Green Algae	ULV	Aquatic Bed	Macro algae	Attached ephemeral algae	*Ulva/Enteromorpha* communities	
Blue Mussel	BMU	Faunal Bed	Sessile epifaunal	Mussel Bed	*Mytilus* community	
California Mussel	MUS	Faunal Bed	Sessile epifaunal	Mussel Bed	*Mytilus* community	add *M. californianus*
Oysters[1]	OYS	Faunal Bed	Sessile epifaunal	Oyster Bed	*Crassostrea* community	
Bleached Red Algae	HAL	Aquatic Bed	Macro algae			no CMECS biotic group
Diatoms[1]	DIA	Aquatic Bed	Microbial mat	Microphytobenthos	Diatoms	
Red Algae	RED	Aquatic Bed	Macro algae	leathery red macro algae		CMECS biotic group not exactly a match
Alaria	ALA	Aquatic Bed	Macro algae	separate from Kelp Forest to *Understory Kelp*	*Alaria* communities	in new Understory Kelp Biotic Group
Soft Brown Kelps	SBR	Aquatic Bed	Macro algae	separate from Kelp Forest to Understory Kelp	*Laminarian* kelp communities	in new Understory Kelp Biotic Group
Dark Brown Kelps	CHB	Aquatic Bed	Macro algae	separate from Kelp Forest to Understory Kelp	*Laminarian* kelp communities	in new Understory Kelp Biotic Group
Surfgrass	SUR	Aquatic Bed	rooted vascular	*Phyllospadix* seagrass bed	*Phyllospadix spp* seagrass bed	
Eelgrass	ZOS	Aquatic Bed	rooted vascular	Zostera seagrass bed	*Zostera marina* seagrass bed	
Dragon Kelp	ALF	Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Alaria fistulosa* community	add Dragon Kelp Biotope in canopy kelp Biotic group
Giant Kelp	MAC	Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Macrocystis* community	add Giant Kelp Biotope in canopy kelp Biotic group
Bull Kelp	NER	Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Nereocystis* community	add Bull Kelp Biotope in canopy kelp Biotic Group
Urchin Barren[1]	URC	Faunal Bed	Mobile epifaunal	add as Urchins	add as *Strongylocentrotus* community	add under Subclass Mobile Epifauna

Notes:[1] Washington and BC bioband

As previously mentioned, Shore Zone and CMECS have fundamentally different mapping units. The primary mapping unit in ShoreZone is the *alongshore shore unit*, represented spatially by line segments. Each *alongshore unit* is subdivided into *across-shore components*, each of which has form, materials and biotic attributes. ShoreZone also includes summary type attributes that apply to the entire *alongshore unit*. There is no equivalent alongshore unit within CMECS so some of the ShoreZone unit attributes can not be transferred to CMECS.

Table 7 shows a flattened version of the CMECS classification that is used to catalog the data from ShoreZone. In the case of ShoreZone data, the mapping unit is defined by the form/substrate unit so these are always explicitly linked. The ShoreZone biobands are always nested within a cross-shore component so the biotic features were easily cross-walked.

Table 8 shows actual data for the very simple schematic unit (from Fig. 1) that has four across-shore components. This shows how the data are transformed from ShoreZone to CMECS and the resulting four CMECS units with associated GFC, SGC and BCC. Had the ShoreZone information included secondary or tertiary form and materials data, these would also be included.

The full CMECS database is provided in an attached DVD. Data codes and fields are summarized in the data dictionaries (Appendices A, B and C).

Table 7. Schematic Representation of Data Schema Used in Cross-Walk

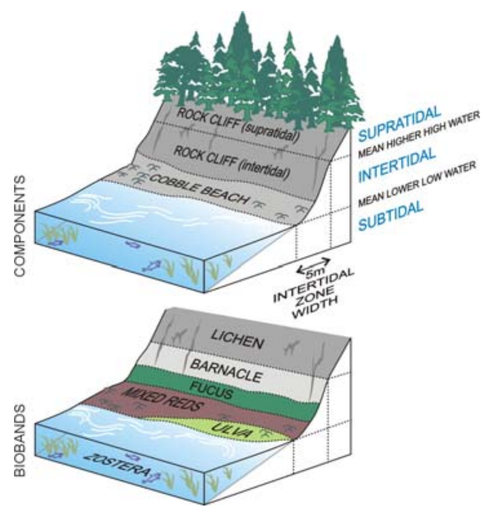
			Relative	GCC			SGC			BCC																
System	Subsystem	Sub-subsystem	Elevation	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	VER	GRA	SED	PUC	BAR	FUC	ULV	BMU	HAL	RED	ALA	CHB	SUR	ZOS	ALF	NER	MAC
Freshwater Influenced	Intertidal	supratidal, marine	A1																							
			A2																							
			A3																							
			A4																							
		Intertidal (HWL to LWL)	B1																							
			B2																							
			B3																							
			B4																							
	Subtidal	shallow (<5m)	C1																							
Estuarine	Intertidal	supratidal, marine	A1																							
			A2																							
			A3																							
			A4																							
		Intertidal (HWL to LWL)	B1																							
			B2																							
			B3																							
			B4																							
	Subtidal	shallow (<5m)	C1																							

Table 8. Completed Classification for Four Across-Shore CMECS Units

			Relative	GCC			SGC			BCC																
System	Subsystem	Sub-subsystem	Elevation	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	VER	GRA	SED	PUC	BAR	FUC	ULV	BMU	HAL	RED	ALA	CHB	SUR	ZOS	ALF	NER	MAC
Freshwater Influenced	Intertidal	supratidal, marine	A1	Casl			R			C																
		Intertidal (HWL to LWL)	B1	Casl			R							C	P											
			B2	Bf			Cc									P			C							
	Subtidal	shallow (<5m)	C1																				C			

The simple Shore Unit shown at right actually translates to four CMECS units with the following attributes:

Unit	GCC	SGC	BCC
A1	Cliff, active, steep, low	Rock	Verrucaria lichen, continuous
B1	Cliff, active, steep, low	Rock	Barnacles, continuous Fucus, patchy
B2	Beach face	Cobble	Ulva, patchy Reds algae, continuous
C1			Zostera, continuous



4. ALASKA SHORE FEATURES NOT REPRESENTED IN THE CROSS-WALK

The Alaska regional office requested that a number of landforms or shore types that may not be mapped within the pilot area near Sitka also be considered in terms of cross-walk potential. The specific features that were identified are: barrier islands, channels, dunes, glaciers, salt lakes (or "salt chucks"), tundra cliffs, and unconsolidated, high cliffs (Cook Inlet). Each of these features is illustrated with a photo and discussed in terms of cross-walk potential between ShoreZone and CMECS.

4.1 Barrier Islands

ShoreZone does not specifically catalog barrier islands in either the Unit or Cross-shore datasets. Since both sides of the barrier island (Fig. 4) are independently mapped (exposed ocean shore and protected lagoon shore) it is not possible to extract the barrier island feature from the ShoreZone mapping, and such a feature would not be cataloged in the CMECS cross-walk. If the mapping were done directly into CMECS, "barrier islands" would not be specifically cataloged in CMECS (no "barrier island" Geoform).

That being said, ShoreZone does capture all the features that might be of interest in habitat modeling (e.g., washover fans, relict dune ridges and the dune grass cover). These attributes would be transferred in a cross-walk to CMECS.

Figure 4. Photograph of a barrier spit on Tugidak Island, southeast Kodiak Island. The photo shows a sand beach face, washover fans and flats (upper part of image) and relict beach ridges (left). A discontinuous dune grass cover is present.

4.2 Channels

Channels are characterized by elongate water bodies with limited fetch and often high tidal currents (Fig. 5). Channels may dry during low tide (Fig. 6). ShoreZone has a specific Unit attribute code for channel morphologies so Channels would be represented at a unit level; there is also a specific Habitat Type identified in the Bio Unit table. The channel attribute does not transfer directly to CEMCS.

Figure 5 Aerial photo of tidal channel during the ebb, Kootznahoo Lagoon near Angoon in southeast Alaska.

Channels typically represent less than 1% of the ShoreZone mapping. The code could be added to CMECS but it is a relatively rare feature.

Channels are usually dominated by tidal energy, rather than wave energy and this occurrence is captured in the ShoreZone cross-shore dataset where the dominant controlling process is indicated for each geomorphic feature (e.g., waves, tides, mass-wasting, fluvial). If a process code is transferred to CMECS (see Appendix A for proposed methodology), it would be possible to identify areas of low wave exposure and dominant tidal currents within a search query.

4.3 Dunes

Dunes are captured in the ShoreZone across-shore database and dune grass is one of the Biobands. The dune shown in Figure 7 is in the northern Kruzof Island pilot area. As CMECS is currently written, the dunes shown in Figure 6 would not be included in the CMECS classification because they are technically above the marine limit. As such, these dunes are not classified within CMECS.

Figure 6. Aerial photo of drying tidal channel in Kootznahoo Lagoon near Angoon in Southeast.

Figure 7. Vegetated dune field on the western shore of Kruzof Island. The vegetated portion of the dune field is estimated to be 30-40m across.

Not all dunes will necessarily be captured in ShoreZone. Figure 8 shows a dune field at the top of the cliffs near Anchorage airport; these dunes are created by winds blowing up the cliff face and deposited at the top of the cliff; they would not be captured in ShoreZone mapping because they are above the "marine limit".

Figure 8. Photo of Fire Island, Cook Inlet showing the large dune complex above the shore cliffs on Fire Island. This dune field would not be cataloged in either ShoreZone or CMECS.

4.4 Glaciers

Glaciers, such as that shown in Figure 9 are cataloged in ShoreZone in both the Unit and Cross-shore datasets. They are not presently cataloged in CMECS but there is no other category in which to class such shoreline so it is suggested that CMECS add a glacier category to the Surficial Geology and Geoform layers.

Figure 9. Glacial shoreline in the Kenai Fiords National Park.

4.5 Salt Lakes ("Salt" Chucks")

Salt Lakes are basins connected to the ocean but with elevated sills so that the salt lake has a limited tidal range that is often less than 1 m. Figure 10 shows an example of a "salt chuck" at the head of Hobart Bay. This particular salt chart is ecologically important as there is a salmon run to the river within The Salt Chuck. During the ShoreZone aerial survey, there were dozens of seals within the bay, presumably feeding on returning salmon.

Salt Lakes are not cataloged in ShoreZone as the mapping scale is characterizing features a few hundred meters in length of smaller. There is no way to tease this out of the ShoreZone dataset. CMECS might be capable of capturing these features with a modification of "degree of enclosure" but presently does not capture salt lakes.

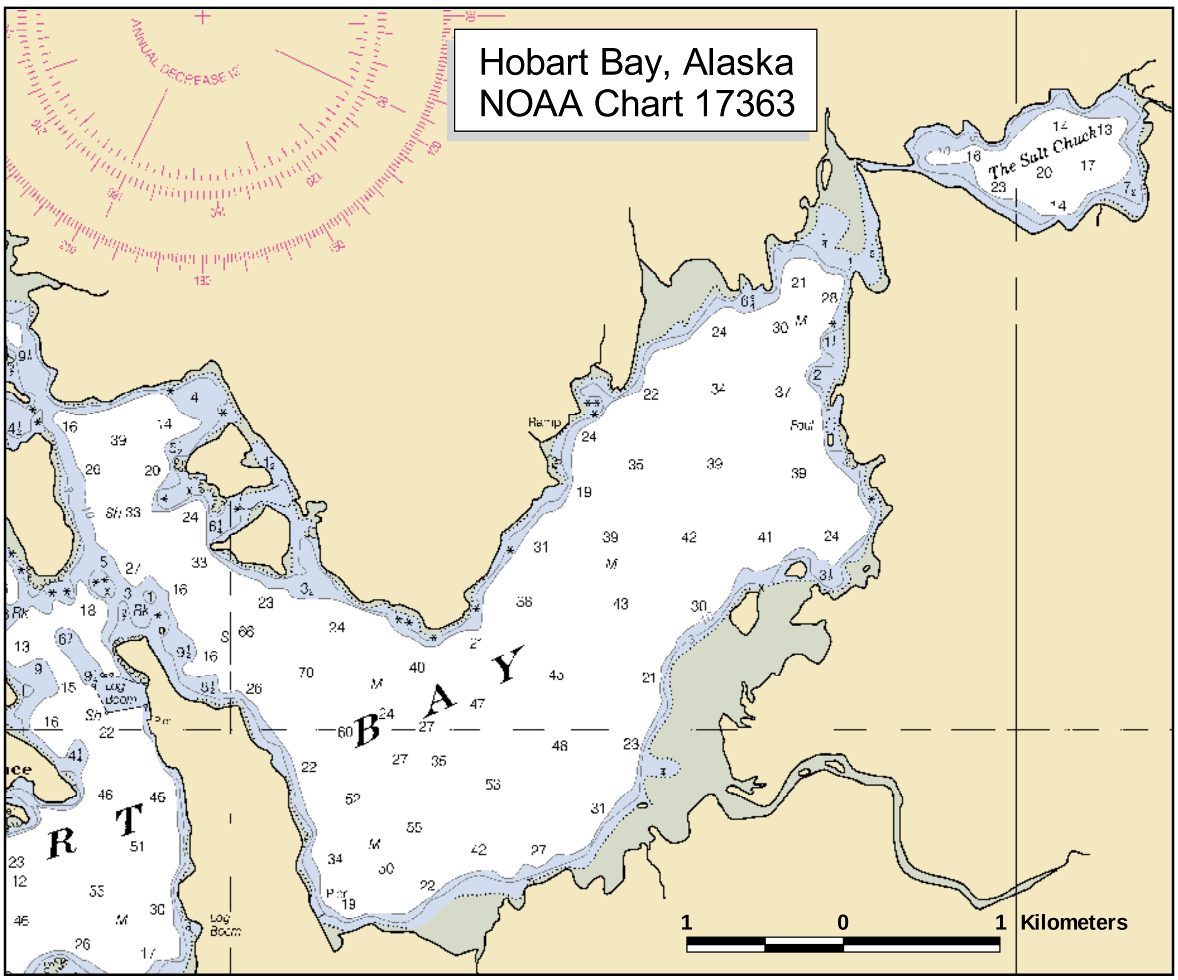


Figure 10. Section of NOAA chart 17363 in Southeast Alaska showing Hobart Bay and the associated "salt chuck" at the northeast corner of the Bay.

4.6 Tundra Cliffs

A large portion of the Alaska coast, probably >5,000 km of shoreline, is underlain by permafrost and coastal erosion often causes unique landforms (Fig. 11). There is presently no unique identifier in either the ShoreZone Unit or Cross-shore datasets that would distinguish such cliffs from any other unconsolidated cliff. It would, however, be easy to add a process modifier ("permafrost") into the cross-shore descriptors so that such features could be distinguished.

As there is presently no process modifier in CMECS, it would not be possible to capture "tundra cliffs" in CMECS unless some modification to the cataloging is made.

Figure 11. Oblique aerial photo of thermo-erosional slumps on the North Slope of Alaska (courtesy of Bruce Richmond, USGS).

4.7 Unconsolidated High Cliffs

There are some locations of Alaska with extremely high, eroding cliffs, particularly along the east shore of Cook Inlet (Fig. 12). While much of the actual cliff form is above the marine limit, the feature is clearly the result of wave erosion at the base of the cliff. ShoreZone does not distinguish these cliffs from any other cliff in the Unit dataset but most of the elements are cataloged in the Cross-shore dataset. One could identify these cliffs with the following query:

look for *form* = "Cash" and *material* = "Cd or Csp" and *slope* = ">20° but < 40°"

where Cash is a Cliff, actively eroding, steep and high and where Cd or Csp indicates the substrate is Clastic diamicton (till) or pebbly sand and where the slope is near the angle of repose (20-40°). If the ShoreZone cross-shore coding is transferred to CMECS, as is proposed, then it is possible to capture the feature in CMECS also.

Figure 12. Oblique photo of rapidly eroding cliff in Cook Inlet. A pickup truck is on the lower portion of the beach. The cliff height is approximately 30m and the beach width is approximately 50m.

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5.1 Overall Data Transfer between ShoreZone and CMECS

The overall transferability of ShoreZone to CMECS is summarized in Table 10. The totals of "fields transfers" suggests that only about 60% of the data transferred. However, a number of fields in the ShoreZone Unit tables are rarely used (sediment abundance, sediment sources, sediment transport direction) or are duplicated elsewhere (e.g., the unit ORI is provided in more detail as a cross-shore component ORI, which does translate). There are about nine "important" fields that do not translate between ShoreZone and CMECS bringing the total transferability to about 75%. If the Shore Modification data fields (7 fields) are arbitrarily assigned to the CMECS supratidal zone as modifiers, then the vast majority of fields that we use for habitat capability modeling are within the transferable fields. ShoreZone also includes meta data for each unit (video imagery and photos used in interpretation) for each unit and these field were not included in this CMECS translation, but could be included.

Table 9 Summary of Transfers from ShoreZone to CMECS

Shore-Zone Data Table	ShoreZone Attribute Fields Transferred to CMECS	Name of Fields Transferred	ShoreZone Attribute Fields Not Transferred to CMECS	Names of Fields
Unit	0 (10)[1]		21 (10)	BC Class, ESI Class, length, exposure, ORI, sediment source, sediment abundance, sediment transport direction, change type, change rate, intertidal zone width, shore modification type (x3), shore modification % (x3), shore modification total, # docks, #ramps, #boat slips
BioUnit	1	exposure	2	Habitat Class, riparian overhang %,
Cross-shore	16	form (x3) ,materials (x3), width, slope, process, ORI	0	
Bioband	18	VER, PUC, GRA, SED, BAR, FUC, ULV, HAL, BMU, RED, ALA, SBR, CHB, SUR, ZOS, ALF, MAC, NER	0	
Totals:	*35* *(46)*		*23* *(12)*[1]	

Note: [1] if Shore Modification attribute fields are assigned to CMECS supratidal units.

5.2 Differences in Basic Mapping Unit

The primary mapping unit of ShoreZone is the alongshore unit or segment (Fig. 3). CMECS first breaks the shore into across-shore units (supratidal, intertidal and shallow subtidal) and then each zone is independently subdivided. While the description of features in both ShoreZone and

CMECS is ultimately similar, although subdivided somewhat differently, the concept of an *alongshore unit* has had resonance with users. It appears that the concept is easily grasped – people understand the concept of a “rock cliff” unit or a “sand and gravel beach” unit. The Washington DNR ShoreZone manager (Berry, pers. comm. 2003) has indicated that one of the most utilized attributes is the *BC Class* (Table 10), which is a summary indicator of the morphology/substrate for each alongshore segment.

It would be possible to have a GIS interface that integrates the three CMECS zones into a single shore class to create some type of form and substrate aggregation but search strings would be relatively complicated and without some type of percent cover attribute, an automated aggregation process would be challenging.

Two other ShoreZone attributes that apply to an entire alongshore unit are: *Habitat Class* and *Shore Modification* attributes. *Habitat Class* is a summary indicator of substrate and exposure that applies to the entire unit to provide a more generalized level of habitat. *Habitat Classes* are defined by a “repetitive suite” of biobands, where certain biobands are associated with exposed shorelines (e.g., the goose-barnacle bioband) and certain are associated with low-exposure shorelines (e.g., the eelgrass bioband). *Shore Modification* is an attribute introduced in the Washington ShoreZone mapping and is heavily utilized (Berry, pers comm.. 2003); this attribute applies to the unit as a whole and will not easily transfer to any of the three zones defined in CMECS, although the *Shore Modification* fields could arbitrarily be assigned to the CMECS supratidal unit.

ShoreZone Shore-Modification Attribute

catalogs shore modification such as seawalls, docks, landfill including a percent occurrence within unit so estimates can be converted to hard units (e.g., 210 m of concrete seawall, 420 m of rip rap).

In summary, fundamentally different mapping units are used in ShoreZone and CMECS. Most mapping data (all across-shore component data and bioband data) can be migrated to CMECS, but some general levels attributes (BC Class, Habitat Class and Shore Modification type/amount) can not be transferred (Table 11). It is our experience that the concept of *alongshore units* that have repeatable assemblages of forms/materials and habitats appeals to infrequent or non-technical users of the data; the ESI mapping system, applied to every state in the US, utilizes similar alongshore units in describing morphology and habitat.

5.3 The Marine Limit

The marine limit (upper limit of splash zone) is always challenging to delineate. In much of the Pacific Northwest, we utilize two commonly visible features to define marine limit: (1) the seaward limit of shrubs/trees (Fig. 6 and 7)and (2) the upper logline, which defines storm surge elevation. Cliffs (Fig. 12) and dunes (Fig. 7) provide a more challenging features on which to visualize marine limits. For marine cliffs, we normally consider the “marine limit” to be the upper edge of the cliff because the *process* that is creating the cliff (wave erosion at the cliff toe) is responsible for modifying the cliff morphology all the way to the upper cliff edge. Similarly, dune systems whose formation is clearly related to the adjacent coastal processes (Fig. 7) are considered to be a coastal feature that is cataloged within ShoreZone.

Table 10. ShoreZone Unit Classification (derived from the Howes et al. [1994] "BC Class" system in British Columbia)

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

While the primary definition of marine limit within CMECS (Madden *et al* 2009, p. 16) is similar to that used in ShoreZone, there may have to be a few exceptions to accommodate the upper limit of cliffs and dunes.

5.4 Substrate Classification and Patchiness

Shorelines in the Pacific Northwest commonly have patchy substrates – mixtures of bedrock, various gravel components and sand (Fig. 13) and while the CMECS hierarchical system allows detailed descriptions of substrate at some levels, higher levels of the classification will require aggregation of substrate observations. The aggregation will be linked to mapping scales where large scale mapping (e.g., 1:1,000 scale) can accommodate considerable detail but where small scale mapping e.g., at 1:250,000) such as used in regional management strategies will be much less detailed.

Figure 13. Photo of one of the Sitka Sound shore units looking to the west towards Kruzof Island. The image is a good example of spatial variability of substrate with bedrock (center), pebble (foreground), cobble (right) and sand (upper middle frame) occurring within the same mapping unit.

As an example of regional mapping, the substrate summary for 5,000 km of ShoreZone mapping in Prince William Sound is shown in Figure 14. Note that almost half of the coastline in Prince William Sound was considered a combination of rock ***and*** sediment (e.g., a beach berm over a rock platform).

CMECS should consider a combination class for rock ***and*** sediment substrates as opposed to the current two class system where all mapping units are lumped into either rock or sediment at the "class level" (Madden et al 2009, p. 19). Glaciated coastlines, which may include as much as half of the US coastline (when the 75,000 km shoreline length of Alaska is considered along with the shoreline of the other 14 glaciated, coastal states in the US).

As a further illustration of the substrate complexity, we reviewed the substrate classification of the 993 CMECS units in the Sitka Sound mapping section. Of the 993 mapping units, 31% are *combinations* of rock *and* sediment and 61% are *mixtures* of two or more of the CMECS sediment classes. The point is that while no data is actually lost in the aggregation process, there are large portions of the shore that do not lump into the existing categories of *rock shores* and *unconsolidated shores.* As we also point out in previous discussions glacial shore and anthropogenic shores are not accommodated by any of the existing CMECS substrate classes.

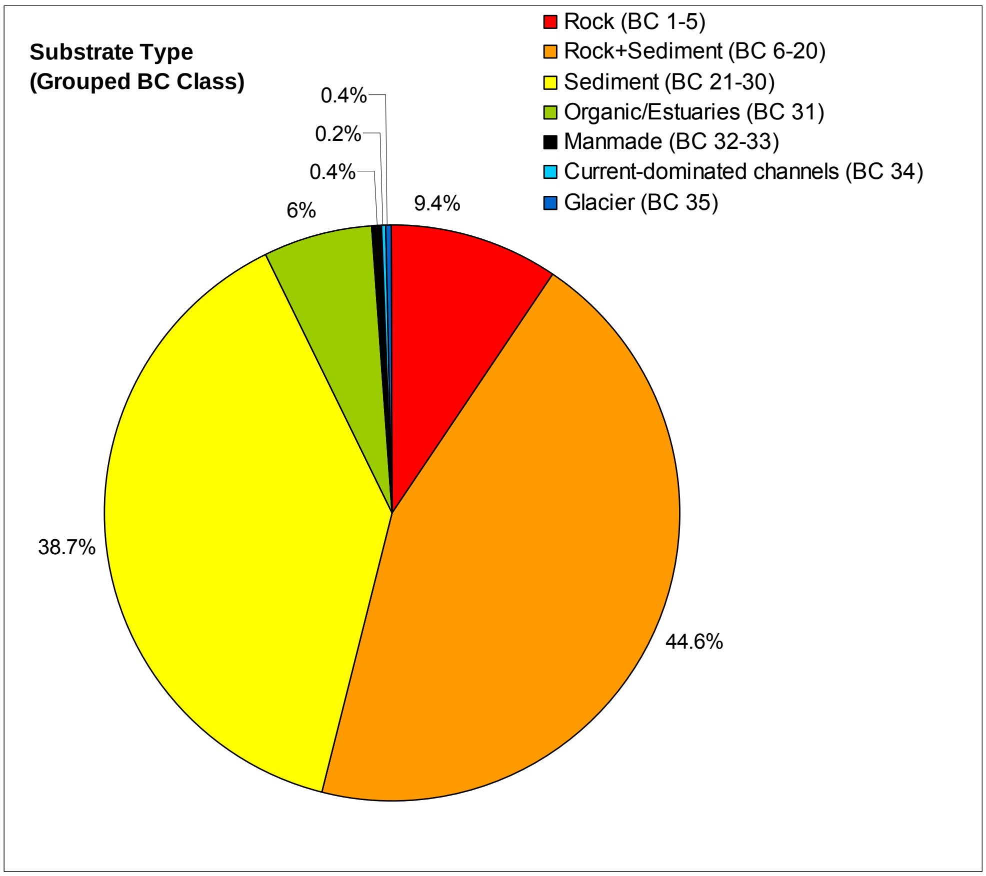

Figure 14. Relative abundance of principal substrate types (BC Classes 1-35) in Prince William Sound.

5.5 Coastal Riparian

Resource managers are increasingly encouraged to make management decisions on an "ecosystem basis" and while that concept is somewhat nebulous, the CMECS may want to consider the addition of a coastal riparian module to be coupled with their ecological classification. If coastal resources are to be managed on an "ecosystem" basis is it realistic to bound the system with an arbitrary line, drawn at the marine limit? This important transition zone between marine and terrestrial environments should incorporate the "terrestrial side" as equally as the "marine side" (i.e., the littoral zone) by including the riparian vegetation/landscape zone.

When mapping in Gwaii Haanas National Park (Haida Gwaii or Queen Charlotte Islands; Harper *et al* 1994), the coastal riparian was mapped to bridge the gap between the terrestrial terrain units (basically landscape and forest cover maps) and the shoreline. There is typically a vegetation fringe here that is not like the forest or the shore. Wildlife and fisheries managers recognize the importance of such riparian ecosystems in river systems but the significance has not generally been considered in coastal systems. Much of the low-energy shoreline includes significant terrestrial vegetation overhang above the intertidal zone and some mechanism for capturing this important ecotone should be considered by CMECS.

5.6 Use of Descriptors

CMECS seems to be advocating the use of *descriptors* to identify their mapping units (Madden *et al* 2009, p. 77). However, the classification and mapping data will need to be cataloged in a database, and data fields are much easier to search than alpha-numeric descriptors, especially for complex queries that may reach into several of the covers as well as GIS criteria (e.g., proximity of attribute A to attribute B). It is hard for us to imagine how the database would ever become separate from the spatial representation so it is unclear what advantage there is to the use of descriptors.

6.1 Conclusions

1. Overall much of the ShoreZone data could be transferred into the CMECS system. We estimate that about 75-80% of the information can be transferred. Portions of ShoreZone that can not be transferred are summary-indicator type attributes.

2. The two systems have fundamentally different mapping units – in ShoreZone line segments are the primary mapping *unit* and *across-shore components* are a secondary mapping subdivision. The *component* data were transferable to the CMECS units. Relative position of the CMECS units within the intertidal zone is preserved with a sequential indexing system because the CMECS unit data are represented as a single line segment.

3. A challenging aspect of the mapping in Alaska is the patchiness of intertidal substrate. While the detailed substrate characterization of ShoreZone can be transferred to CMECS at one classification level, a significant proportion (30%) of the intertidal zone is a combination of rock *and* sediment which does not roll up conveniently into the more general levels of the CMECS surficial geology classification.

6.2 Recommendations

1. CMECS is designed as a classification system and there is little mention of the spatial units types and mapping scales. This topic will require considerable discussion if CMECS moves towards being compatible with mapping systems.

2. The CMECS classification is somewhat east-coast centric and a number of additions are required for implementation in Alaska:

- add "ice" as a substrate (to accommodate glacial ice fronts).
- add anthropogenic as a substrate.
- add permafrost into classification, possibly in process section.
- many Alaska species are missing in the biotic group and biotope descriptions.
- consideration of previously glaciated coasts as having unique geological stratification that is important to be accommodated by the Surficial Geology Component.

3. Although the GFC, SGC and BCC are developed as independent layers in the *classification* system, geomorphology and substrate are likely to be used together for delineating spatial units in *mapping* applications. CMECS may want to provide some guidance for explicitly linking the various components in the system.

4. ShoreZone has documented that *rock and sediment* combinations are quite common on the Alaska coast. It would be quite realistic to revise the higher level Surficial Geology Component classes to include three classes of substrate: *rock shores*, *sediment shores* and *rock and sediment shores* to reflect the relatively common occurrence of all three coastal habitats. Also, it is not clear what classes *Ice* (as per glacial ice fronts) and *Anthropogenic substrate* falls.

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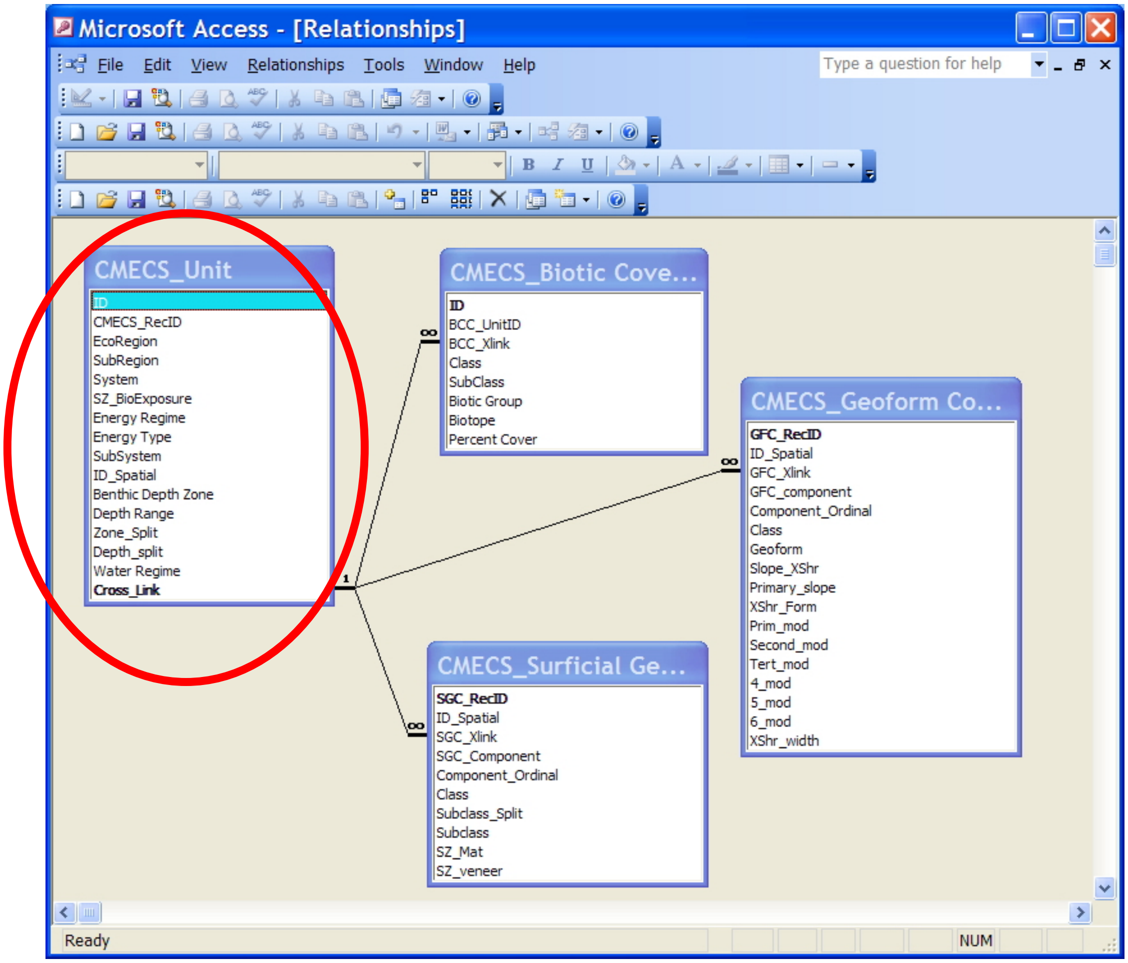
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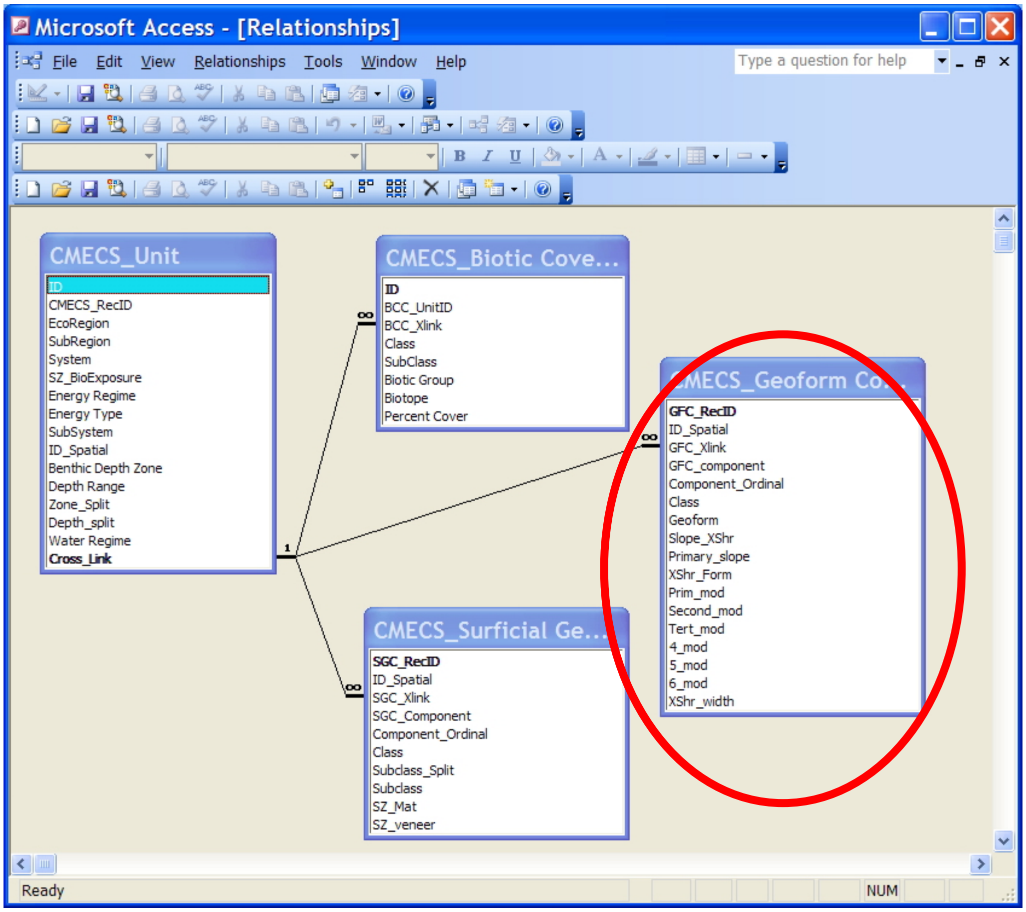
Depth Range
Zone_Split
Depth_split
Water Regime
Cross_Link
CMECS_Biotic Cove...
ID
BCC_UnitID
BCC_Xlink
Class
SubClass
Biotic Group
Biotope
Percent Cover
CMECS_Geoform Co...
GFC_RecID
ID_Spatial
GFC_Xlink
GFC_component
Component_Ordinal
Class
Geoform
Slope_XShr
Primary_slope
XShr_Form
Prim_mod
Second_mod
Tert_mod
4_mod
5_mod
6_mod
XShr_width
CMECS_Surficial Ge...
SGC_RecID
ID_Spatial
SGC_Xlink
SGC_Component
Component_Ordinal
Class
Subclass_Split
Subclass
SZ_Mat
SZ_veneer
Ready
NUM

Table A-1 Unit Data Dictionary

Field	Field Type	Descriptions
Ecoregion	Text	Assign from CMECS, e.g. 55. Northeast Pacific Fjordland
SubRegion	Text	Identify locale e.g. SZ BioArea (or Icy Strait, Cook Inlet?)
System	Text	Marine, Freshwater Influenced, Estuarine
SZ_BioExposure	Text	SZ BioExposure, (or use Habitat Class?)
Energy Regime	Text	Translation to CMECS categories: VP=[VLEn], P=[LoEn], SP=[MoEn], >=SE=[HiEn]
Energy Type	Text	category, coded for combinations of any type e.g. SWav+Curr+Tide
Subsystem	Text	Intertidal, Subtidal, etc.
ID_Spatial	Text	links Geoform unit to spatial units in Geodatabase. Taken from ShoreZone "PHY_IDENT"
Benthic Depth Zone	Text	CMECS class lookup: Littoral, Shallow Infralittoral, ***defines "mapping unit" depth ribbon.***
Depth Range	Text	category lookup table e.g. 0-5m
Zone_Split	Text	split ITZ: A, B, C, =XShr.Zone. ***defines "observational unit" depth ribbon***
Depth_Split	Text	=XShr.Component ***defines "mapping unit" depth ribbon***
Water Regime	Text	As per Cowardin: A= irregularly flooded, B1=UITZ(regularly flooded), B2=LITZ(irregularly exposed), C=subtidal
Cross_Link	Text	provides link to BCC and SGC, explicitly links GFC, SGC and BCC; taken from ShoreZone "CROSS_LINK"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Depth_split
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Cross_Link
CMECS_Biotic Cove...
ID
BCC_UnitID
BCC_Xlink
Class
SubClass
Biotic Group
Biotope
Percent Cover
CMECS_Geoform Co...
GFC_RecID
ID_Spatial
GFC_Xlink
GFC_component
Component_Ordinal
Class
Geoform
Slope_XShr
Primary_slope
XShr_Form
Prim_mod
Second_mod
Tert_mod
4_mod
5_mod
6_mod
XShr_width
CMECS_Surficial Ge...
SGC_RecID
ID_Spatial
SGC_Xlink
SGC_Component
Component_Ordinal
Class
Subclass_Split
Subclass
SZ_Mat
SZ_veneer
Ready
NUM

Table B-1 GeoForm (GFC) Data Dictionary

Field	Field Type	Descriptions
ID_Spatial	Text	links Geoform unit to spatial units in Geodatabase. Taken from ShoreZone “PHY_IDENT”
GFC_XLink	Text	provides link to BCC and SGC, explicitly links GFC, SGC and BCC; taken from ShoreZone “CROSS_LINK”
GFC_Component	integer	one-to-many, ***each unit may have more than one class of geoform*** (more than 1 SZform/mat),
Component_Ordinal	Text	primary, secondary, tertiary, etc.
Class	Text	primary classes of geoforms: *Fixed* (A, C, F, O, P) ,or *Dynamic* (B,D,E,I,L,M,R,T)
Geoform	Text	Geoform subclass descriptor (Table A-2) taken directly from ShoreZone component *form* codes. =X_Shr from main codes: A, B, C, D, E, F, I, L, M, O, P, R, T
Slope_XShr	number	the slope of the primary component (expressed in degrees). [keep to compare with calculated slope?]
Primary_slope	Text	modifier per Slope Modifer (p. 67)in CMECSvIII Appendix, SZ is average for all forms, in general can only apply to primary form
XShr_Form	Text	SZ morphology, directly from X_Shr (kept to show how XWalk works)
Prim_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
Second_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
Tert_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
4_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
5_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
6_mod	Text	=X_Shr ***form specific modifiers:*** beach berm, storm berm, etc. for now keep all modifiers
XShr_width	Number	keep to calculate CMECS slope?

Table B-1 Coastal Geoform Categories (bold) and Associated Modifiers (from Harney *et al* 2008 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
- m marina
- n ferry terminal
- o log booms
- p port facility
- q aquaculture
- r boat ramp
- s seawall
- t landfill, tailings
- w wharf
- x outfall or intake
- y intake

B = Beach
- b berm (intertidal or supratidal)
- c washover channel
- f face
- i inclined (no berm)
- m multiple bars / troughs
- n relic ridges, raised
- p plain
- r ridge (single bar; low to mid intertidal)
- s storm ridge (occasional 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
- f drowned forest
- h high
- l mid to low (discontinuous)
- o pond
- s brackish, supratidal

O = Offshore Island

(not reefs)
- b barrier
- c chain of islets
- t table shaped
- p pillar/stack
- w whaleback

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

P = Platform

(slope <20°)
- f horizontal
- g surge channel
- h high tide platform
- i irregular
- l low tide platform
- r ramp (5-19°)
- t terraced
- s smooth
- p tidepool

R = River Channel
- a perennial
- i intermittent
- m multiple channels
- s single channel

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

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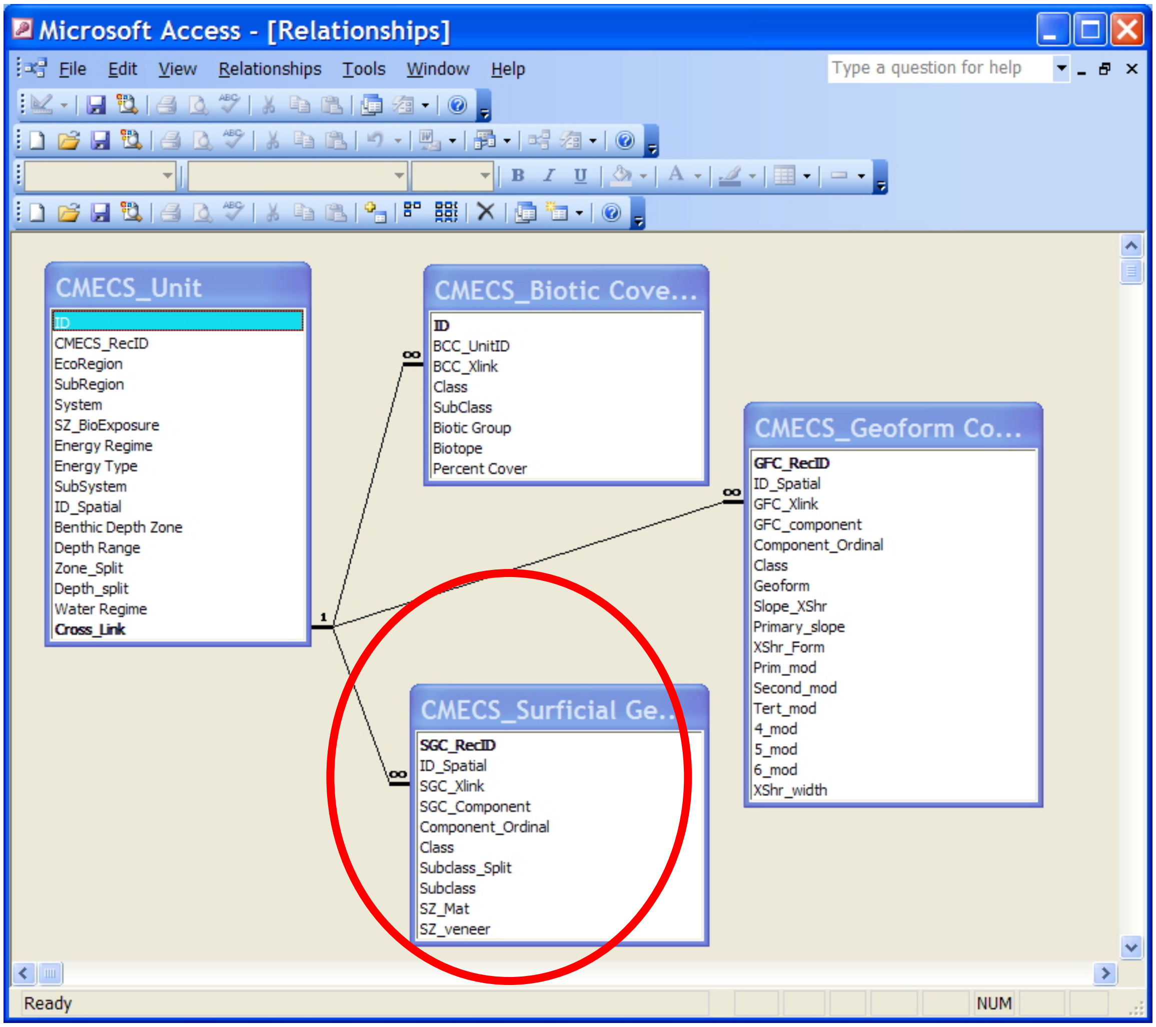
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CMECS_Biotic Cove...
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BCC_UnitID
BCC_Xlink
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CMECS_Geoform Co...
GFC_RecID
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GFC_Xlink
GFC_component
Component_Ordinal
Class
Geoform
Slope_XShr
Primary_slope
XShr_Form
Prim_mod
Second_mod
Tert_mod
4_mod
5_mod
6_mod
XShr_width
CMECS_Surficial Ge...
SGC_RecID
ID_Spatial
SGC_Xlink
SGC_Component
Component_Ordinal
Class
Subclass_Split
Subclass
SZ_Mat
SZ_veneer
1
∞
∞
∞
Ready
NUM

Table C-1 Surficial Geology (SGC) Data Dictionary

Field	Field Type	Descriptions
ID_Spatial	Text	links Geoform unit to spatial units in Geodatabase. Taken from ShoreZone "PHY_IDENT"
SGC_XLink	Text	provides link to BCC and GFC, explicitly links GFC, SGC and BCC; taken from ShoreZone "CROSS_LINK"
SGC_Component	integer	one-to-many, ***each unit may have more than one class of surficial geology*** (more than 1 material),
Component_Ordinal	Text	primary, secondary, tertiary, etc.
Class	Text	either *Rocky Shore*, *Rock and Sediment Shore*, or *Sediment Shore (Anthropogenic?)*
SubClass_Split	number	each unit may have more than one subclass (Layers Option?), eg Bgol/Csp=subClass1Mat1:US.Sand, subclass2Mat1:US.Organic
SubClass	text	Substrate subclass descriptor (Table B-2) taken directly from ShoreZone component *materials* code. CMECS lookup tables: Bedrock, Boulder, Cobble/Gravel, Sand, Mud, Organic, Shell, Mixed Sediments, (Anthropogenic??), Faunal Reef, Coral Reef
SZ_Mat	Text	Substrate subclass descriptor (Table B-2) taken directly from ShoreZone component *materials* code =SZ.XSHR.Mat
SZ_veneer	Text	the veneer modifier indicate if the layer is a thin, discontinuous veneer over another substrate .=SZ.XShr.MatPrefix veneer modifier

Table C-1. 'Material' Code Dictionary (after Howes *et al* 1994; from Harney *et al* 2008)

A = Anthropogenic

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

B = Biogenic

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

C = Clastic

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

R = Bedrock

rock type:

i	igneous
m	metamorphic
s	sedimentary
v	volcanic

rock structure:

1	bedding
2	jointing
3	massive

SEDIMENT TEXTURE

(Simplified from Wentworth grain size scale)

GRAVELS

boulder > 25 cm diameter	
cobble	6 to 25 cm diameter
pebble	0.5 cm to 6 cm dia.

SAND

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

FINES ("MUD")

includes silt and clay

silt	0.0039 to 0.063 mm
clay	<0.0039 mm

TEXTURE CLASS BREAKS

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

Note: The 'material' descriptor consists of one primary term code and associated modifiers (e.g. Cobs). 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. vs./R). Grayed items are not used in the Alaska ShoreZone program.

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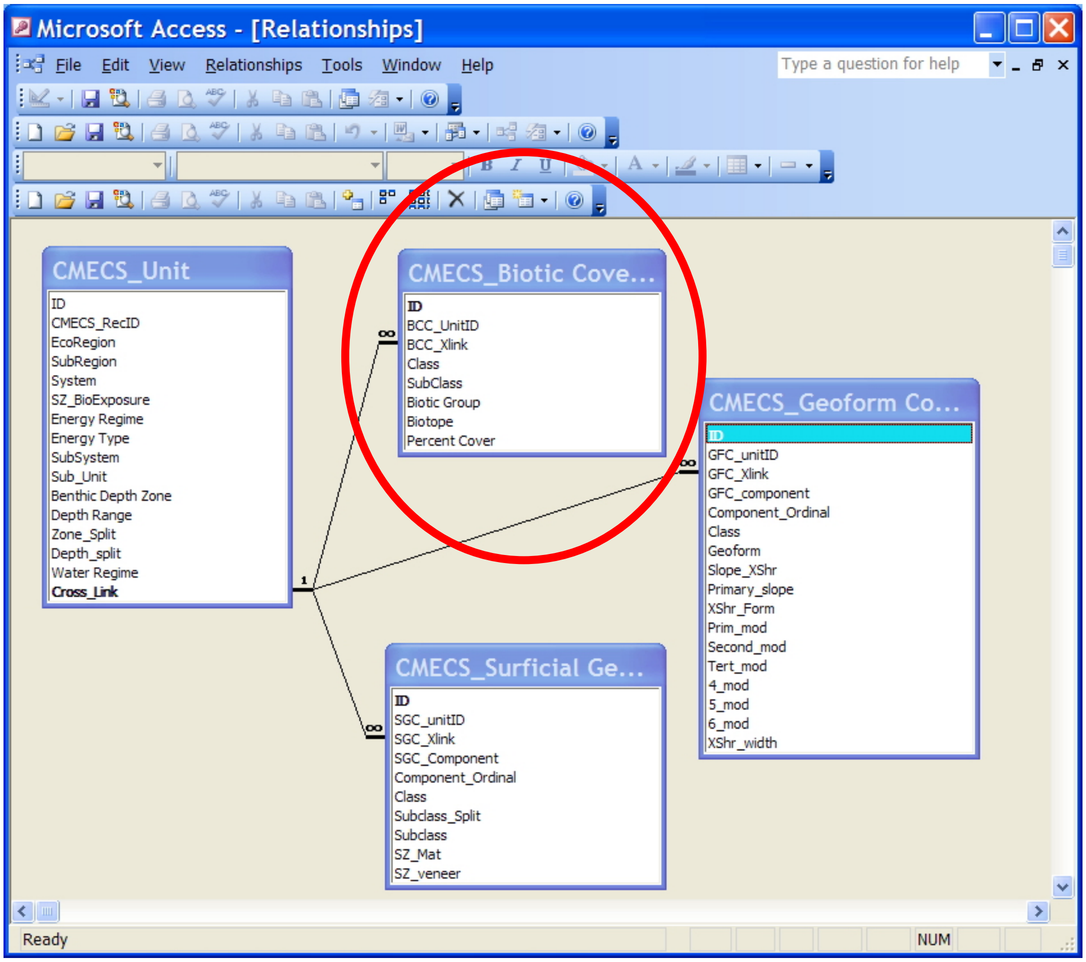

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Zone_Split
Depth_split
Water Regime
Cross_Link
CMECS_Biotic Cove...
ID
BCC_UnitID
BCC_Xlink
Class
SubClass
Biotic Group
Biotope
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CMECS_Geoform Co...
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GFC_unitID
GFC_Xlink
GFC_component
Component_Ordinal
Class
Geoform
Slope_XShr
Primary_slope
XShr_Form
Prim_mod
Second_mod
Tert_mod
4_mod
5_mod
6_mod
XShr_width
CMECS_Surficial Ge...
ID
SGC_unitID
SGC_Xlink
SGC_Component
Component_Ordinal
Class
Subclass_Split
Subclass
SZ_Mat
SZ_veneer
Ready
NUM

Table D-1 Biotic Cover (BCC) Data Dictionary

Field	Field Type	Descriptions
ID_Spatial	Text	links Geoform unit to spatial units in Geodatabase. Taken from ShoreZone "PHY_IDENT"
BCC_XLink	Text	provides link to SGC and GFC, explicitly links GFC, SGC and BCC; taken from ShoreZone "CROSS_LINK"
BCC_Component	integer	one-to-many, ***each unit may have more than one class of Biotic Cover*** (more than 1 bioband/biotope),
Component_Ordinal	Text	primary, secondary, tertiary, etc.
Class	Text	from CMECSv3, including *Faunal Bed* [FB], *Aquatic Bed* [AB], *Emergent Wetland* [EM], *Scrub-Shrub Wetland* [SS], *Forested Wetland* [FO] *(Coastal Riparian??)*
SubClass	Text	From table D-2:.Sessile, Mobile, MacroAlgae, Rooted Vascular, Microbial Mat, Coastal Salt-Marsh, (Salt-Tolerant??)
Biotic Group	Text	From table D-2:emergent high marsh, Barnacles, kelps, (lichen??)etc.
Biotope	Text	=BioBand, ***regionally characterized assemblages***: HAL12, Red8, CHB5,(VER??) as listed in Table D-2 but using ShoreZone Bioband codes (Table D-2)
Percent Cover	Text	approx=patchy or continuous, P=10-25%[ModSp], C=75-90%[Dens]

Table D-1 Hierarchy of Biotic Cover Component Codes and ShoreZone Equivalents

CMECS Class	CMECS Subclass	CMECS Biotic Group	CMECS Biotope	ShoreZone BioBand	Code	Notes
Aquatic Bed	Lichen	?	*Verrucaria*	Lichen	VER	requires new CMECS subclass, biotic group
Emergent Wetland	Coastal saltmarsh	Emergent high salt marsh	Pac NW species not listed	Dune Grass	GRA	add biotope with Pacific NW species, such as Dune Grass (*Leymus mollis*) assemblage
Emergent Wetland	Coastal saltmarsh	Emergent high salt marsh	Pac NW species not listed	Sedges	SED	add biotope with Pacific NW species, such as *Carex* spp
Emergent Wetland	Coastal saltmarsh	Emergent low salt marsh	Pac NW species not listed	Salt Marsh	PUC	add biotope with Pacific NW species, such as *Salicornia/ Triglochin/ Puccinella*
Faunal Bed	Sessile epifaunal	Barnacles		Barnacle	BAR	Bioband not separated to species at Biotope level
Aquatic Bed	Macro algae	Rockweeds	*Fucus* communities	Rockweed	FUC	
Aquatic Bed	Macro algae	Attached ephemeral algae	*Ulva/Enteromorpha* communities	Green Algae	ULV	
Faunal Bed	Sessile epifaunal	Mussel Bed	*Mytilus* community	Blue Mussel	BMU	
Faunal Bed	Sessile epifaunal	Mussel Bed	*Mytilus* community	California Mussel	MUS	add *M. californianus*
Faunal Bed	Sessile epifaunal	Oyster Bed	*Crassostrea* community	Oysters[1]	OYS	
Aquatic Bed	Macro algae			Bleached Red Algae	HAL	no CMECS biotic group
Aquatic Bed	Microbial mat	Microphytobenthos	Diatoms	Diatoms[1]	DIA	
Aquatic Bed	Macro algae	leathery red macro algae		Red Algae	RED	CMECS biotic group not exactly a match
Aquatic Bed	Macro algae	separate from Kelp Forest to *Understory Kelp*	*Alaria* communities	Alaria	ALA	in new Understory Kelp Biotic Group
Aquatic Bed	Macro algae	separate from Kelp Forest to Understory Kelp	*Laminarian* kelp communities	Soft Brown Kelps	SBR	in new Understory Kelp Biotic Group
Aquatic Bed	Macro algae	separate from Kelp Forest to Understory Kelp	*Laminarian* kelp communities	Dark Brown Kelps	CHB	in new Understory Kelp Biotic Group
Aquatic Bed	rooted vascular	*Phyllospadix* seagrass bed	*Phyllospadix spp* seagrass bed	Surfgrass	SUR	
Aquatic Bed	rooted vascular	Zostera seagrass bed	*Zostera marina* seagrass bed	Eelgrass	ZOS	
Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Alaria fistulosa* community	Dragon Kelp	ALF	add Dragon Kelp Biotope in canopy kelp Biotic group
Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Macrocystis* community	Giant Kelp	MAC	add Giant Kelp Biotope in canopy kelp Biotic group
Aquatic Bed	Macro algae	change from Kelp Forest to Canopy Kelp	*Nereocystis* community	Bull Kelp	NER	add Bull Kelp Biotope in canopy kelp Biotic Group
Faunal Bed	Mobile epifaunal	add as Urchins	add as *Strongylocentrotus* community	Urchin Barren[1]	URC	add under Subclass Mobile Epifauna

Notes:[1] Washington and BC bioband

APPENDIX E – Technical Review by Megan Dethier, University of Washington

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April 11, 2010

Review of report by Harper and Ward, "Data Crosswalk between the ShoreZone Coastal Habitat Mapping System and CMECS."

This report describes a very useful exercise testing the feasibility of linking data between ShoreZone (a coastal mapping system) and CMECS (a classification system). Because these two systems have different purposes and structures, I was initially dubious that a crosswalk would be possible – but the CORI team has found a reasonable way to do this, and in the process has highlighted some issues both with their own ShoreZone data and with the utility of CMECS for mapping purposes. Below I detail what I regard as the key issues needing consideration.

The intrinsic difficulty with the effort of creating a crosswalk is that classification systems are not necessarily useful for mapping, and vice versa. CMECS lists some of its goals as "to map each classification unit" and to "permit the classification of ecological and habitat units within a simple standard format"; the v3 report says that "CMECS component structure forms an organizing bridge between spatial map data on one hand and ecological assessment on the other". In my view, there is some clashing of these goals – because the 'classification units' (=habitat units=descriptor units?) are rather vaguely defined and the system is non-hierarchical, it is difficult to achieve a "simple standard format", as seen below in the attempt to crosswalk data. In my view, it would help users of the CMECS system, and simplify future crosswalks, if the 'units' could ultimately be assigned summary-labels (like the BC Coastal Classes in the CORI report).

Much of the crosswalk chaos, and my personal difficulty following the current CMECS system, stems from the Geoform component, with its range of scales from deltas to tidepools or sand ripples. The attempt to create a common terminology is essential to any classification system, but I don't see how terminology can ever be clear if spatial scales are not defined. If there were hierarchies within the GFC, it would readily accommodate morphological features at different spatial scales within different hierarchical levels.

All this is as background to the hardest aspect of creating a data crosswalk, which is finding a way to link the basic mapping units of the two systems. The ShoreZone system has a distinct mapping unit, a linear stretch of shoreline and the associated shallow subtidal zone. The CMECS does not really have a mapping unit, since it is not designed as a mapping system, although the 'lowest' unit is presumably something like the 'habitat units' discussed, which are generally illustrated as polygons. For shoreline work, as shown by this exercise, it is possible (with a little shoving) to make these data compatible, because the 'alongshore units' of ShoreZone are really representations of polygons (since the shoreline has width) and beach polygons of CMECS can be mapped onto an alongshore unit. Because ShoreZone was designed explicitly for shoreline use, its structure is not useful for genuinely polygonal areas, such as seafloor bottoms or coral reefs – nor would the crosswalk method here work in such systems. Thus this crosswalk system will not be applicable to some other environments and mapping efforts. However, for shorelines that are basically linear (i.e. not large deltas or marsh systems), the 2 systems can be made moderately compatible.

The crosswalk described here also uses a workaround to what I see as an illogical disconnect (i.e. lack of explicit connection) between the Geoform and Surficial Geology components in CMECS – i.e. the crosswalk forces a linkage between them by assigning a unique identifier to each 'unit' that applies to both the GFC and SGC. If this is broadly feasible for other sorts of mapping efforts, then it will make CMECS much easier to use for mapping.

One of the major elements that made the crosswalk work was somewhat downplayed in the CORI report – the substantial alteration of the CMECS Geoform list because the available terms "were inadequate to describe the morphology" of the shorelines under consideration. If that is true for this effort, I can imagine it being equally true for many others. This became even more clear in Section 4; it worries me that for this one little corner of the world they had to add 7 new geoforms on top of the 9 or so already added in Section 2.2 (or maybe that was a whole new list – I didn't delve too deeply into that). This again suggests to me that returning to a hierarchical system for geomorphological features (as existed in some of the precursors to CMECS v3), especially if these included scale limits, would greatly improve the applicability and thus utility of CMECS to the world at large. I did a fair amount of looking at both the ShoreZone and CMECS details when I read the section on Barrier Islands (4.1) – it seems like these are somewhat covered in ShoreZone under "Offshore Island: Barrier", but this is one of those polygonal features that SZ isn't so good at. In contrast, CMECS does not even have (I was surprised to see) a Beach word in their geoform list – it has "unconsolidated shore" but that is an SGC component, not a Geoform. Seems like a rather large piece of the world to not have a geoform term!

I found the section 5 Discussions to be of particular interest, as they really highlight some key issues. Given all the inconsistencies mentioned above, a surprising amount of the data was cross walked, and with some changes, this number would be even higher. It would be great, for many potential users of CMECS, if the concept of linear shoreline units could be incorporated somehow. I interact a lot with shoreline managers – with the state, counties, cities, people who write Shoreline Master Programs, etc. – and for them, alongshore units are the basis of their work. These units tie the marine world to the land, relating ownership, impacts of upland development, importance of riparian corridors, etc. This clear land-sea linkage is what has made the ShoreZone data so widely used in Washington state. Similarly, the concept-terminology of "habitat classes" is widely used, as a straightforward way to summarize a lot of information (about general morphology, waves, etc). It can be a quick way to talk about relatively sensitivity to oil spills of different types of shorelines, for example. Thus if CMECS has some relatively shorthand descriptors for their 'habitat units', it would help.

The Marine Limit is also a tricky issue – I didn't delve deeply into either system, but have become increasingly aware that oligohaline forested wetlands, where there is no salinity but there is still tidal influence, are important habitats – I suspect that these are better covered in CMECS, since they were a Cowardin category. Likewise, coastal riparian zones are recognized in Washington as increasingly important and in need of protection – I agree that these need to be added as a category somehow.

And finally, it is not only in Alaska that the mixed-substrate category emphasized in this report is important. Such shorelines are very common in Washington, and also in New England – thus I concur that added rock-and-sediment as a category somewhere in CMECS is very important.

I appreciate being given the opportunity to review and ponder this report. If I can provide further input, let me know.

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