Evaluation of CMECS III *for* Coastal Habitat Mapping

– a Pilot Project in Southeast, Alaska

CORI Project: 10-19

20 April 2012

Evaluation of CMECS III for Coastal Habitat Mapping – a Pilot Project in Southeast, Alaska

prepared for

NOAA/NMFS Southeast Alaska Regional Office
Juneau, Alaska

prepared by

John Harper and Sheri Ward
Coastal & Ocean Resources Inc.
Victoria, BC

Coastal & Ocean
Resources Inc.

This page intentionally left blank.

This project evaluates the Coastal and Marine Ecological Classification Standard Version 3 (CMECS III) mapping system (FGDC 2010) for mapping coastal habitat in Southeast Alaska. A pilot mapping project was conducted on ~60 km of shoreline in Sitka Sound, Alaska, where previously collected, oblique aerial videography and photography was used to delineate CMECS III habitat features for the pilot, The CMECS III habitat features are represented as lines features, created by segmenting the digital high water line.

CMECS III considers habitat features in three general categories: Surficial Geology Components (SGC), GeoForm Component (GFC) and Benthic Biotic Component (BBC). In this pilot ten SGC sub-classes are mapped, 13 GFC sub-classes and ten BBC subclasses for a total of 32 habitat features. There is basically a separate map for each feature, all represented by line segments.

Maps of these habitat features were created from the oblique imagery and represent the features as lines, where line segments are derived from a segmented high water line. Mapped data compares favorably with previously mapped ShoreZone data. CMECS generally provides greater resolution of features because the CMECS observational units average about 30 m in length whereas ShoreZone units average about 250m in length.

Surficial Geology Component (SGC)	GeoForm Component (GFC)	Benthic Biotic Component (BBC)
bedrock	anthropogenic	barnacle
boulder (large)	cliff	*Fucus*
boulder (small)	reef	*Ulva*
cobble	islet	blue mussels
pebble	platform	foliose red algae
sand	beach	coralline red algae
mud	delta	surf grass
shell	dune	eelgrass
organics	glacier	understory kelp
anthropogenic	lagoon	canopy kelp
	marsh/wetland	
	river	
	tidal flat	

Note: highly simplified summary of habitat features mapped.

The methodology used to map in CMECS required about twice the effort as ShoreZone to map the same amount of shoreline. Had the CMECS data been input as independently mapped polygons (e.g., 32 maps), we estimate that 10-20 times the effort would have been required to map the intertidal shoreline data. Even with the linear mapping simplification, the mapping process is cartographically complex (e.g., there are 32 maps or layers). The CMECS document itself does not specify a mapping approach, preferring to leave this decision to the users. The estimate above is based on the assumption that each CMECS layer is mapped independently which is one of several ways that CMECS could be applied.

As a result of working with CMECS in this pilot, we identify a number modifications that may help improve CMECS for mapping projects: (1) we suggest that CMECS incorporate a number of mapping "levels" or standards to facilitate seamless integration of maps from a variety of mapping agencies; (2) having independent layers (with independent units) for 32 or more resources creates considerable cartographic overhead – there are significant advantages to having a common observational units among component layers; (3) it would be helpful if CMECS would provide an explicit statement on what an observational unit can be and incorporate actual examples within the standard (point, line, polygon?); (4) in Alaska, and glaciated coasts in general, patchy substrates are common and not well categorized by CMECS at the *Class* level and (5) gravel (CMECS pebble, cobble, boulder) is very common on Alaska shores (and glaciated shores in general) and is poorly categorized by the CMECS substrate classification at the *Class*, *Subclass* and *Group* levels of the SGC. These substrate issues (Items 4, 5) have important ecological implications (i.e., substrate mobility is a determinant of epibenthic and infaunal communities).

This page intentionally left blank.

1.0 INTRODUCTION

2.0 METHODOLOGY

3.0 ANALYSIS

4.0 DISCUSSSION

LIST OF TABLES AND FIGURES

1.1 Background

CMECS III

Coastal and marine resources are increasingly affected by anthropogenic changes including climate change, pollution and coastal development. 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.

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 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 was designed as a habitat classification and was 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. Existing low-tide, georeferenced aerial coastal videography provided the base mapping information.

The Southeast Alaska Pilot

The pilot discussed in this report represents the second project that Coastal & Ocean Resources Inc (CORI) has conducted using CMECS. In the previous pilot, CORI cross-walked approximately 122 km of SE Alaska shoreline data from ShoreZone to CMECS (Harper and Ward 2010) and found that approximately 75-80% of the ShoreZone data could be transferred into a CMECS format. While the ShoreZone data could be transferred to CMECS, the classification and structure of the resulting CMECS dataset incorporates the fundamental organization of ShoreZone. In particular, an *a priori* assumption of ShoreZone is that all biotic features are nested within physical features. That is, habitat units are delineated based on physical characteristics and associated biology are considered biological attributes of the physical habitat units. In ShoreZone, these physical habitat units are spatially represented as line segments in recognition that the shoreline is narrow compared to its length. ShoreZone does include an across-shore width estimate to provide some insight into areal extent of the mapping units..

As a mapping system, the CMECS III system is fundamentally different in that there are no primary habitat mapping units to which attributes are attached. Each theme can be considered a separate layer and is independently mapped for this study. Using this approach to map ten themes, ten independent maps (GIS layers) are created. To map ten themes, ten independent maps (GIS layers) are created. The examples shown within CMECS III document suggest that ***the spatial representation of every mapped attribute will be a polygon*** and that a map or layer of seagrasses, for example, will consist as a series of elongated polygons within the lower intertidal zone and shallow subtidal zone.

The CMECS III protocol does not specify that independent layers *must* be created, although it is implied. So one could use the Surficial Geology Component layers or the GeoForm Component layers as a base mapping and nest other features (SGC or BBC) within those mapping units.

CMECS III is hierarchical classification that includes Systems, Subsystems and Components (Table 1). For the region of southeast Alaska that was tested in 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 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

1.2 Project Area

Portions of the shoreline in Sitka Sound on the west coast of Baranof Island, were selected for applying CMECS III classification (Fig. 1). This area was selected because (a) there is a diversity of hard and soft substrates, (b) there is a full range of exposures from open-Pacific to very protected bays and lagoons, (c) there is a gradient in salinity regimes from oceanic to strongly estuarine, (d) the area has been previously mapped with ShoreZone and (e) this was also the pilot area for cross-walking ShoreZone data to an earlier version of the CMECS system. Georeferenced high-resolution videography and photography available from the 2004 and 2005 low-tide ShoreZone surveys was utilized in the original ShoreZone mapping and in this subsequent CMECS III classification pilot.

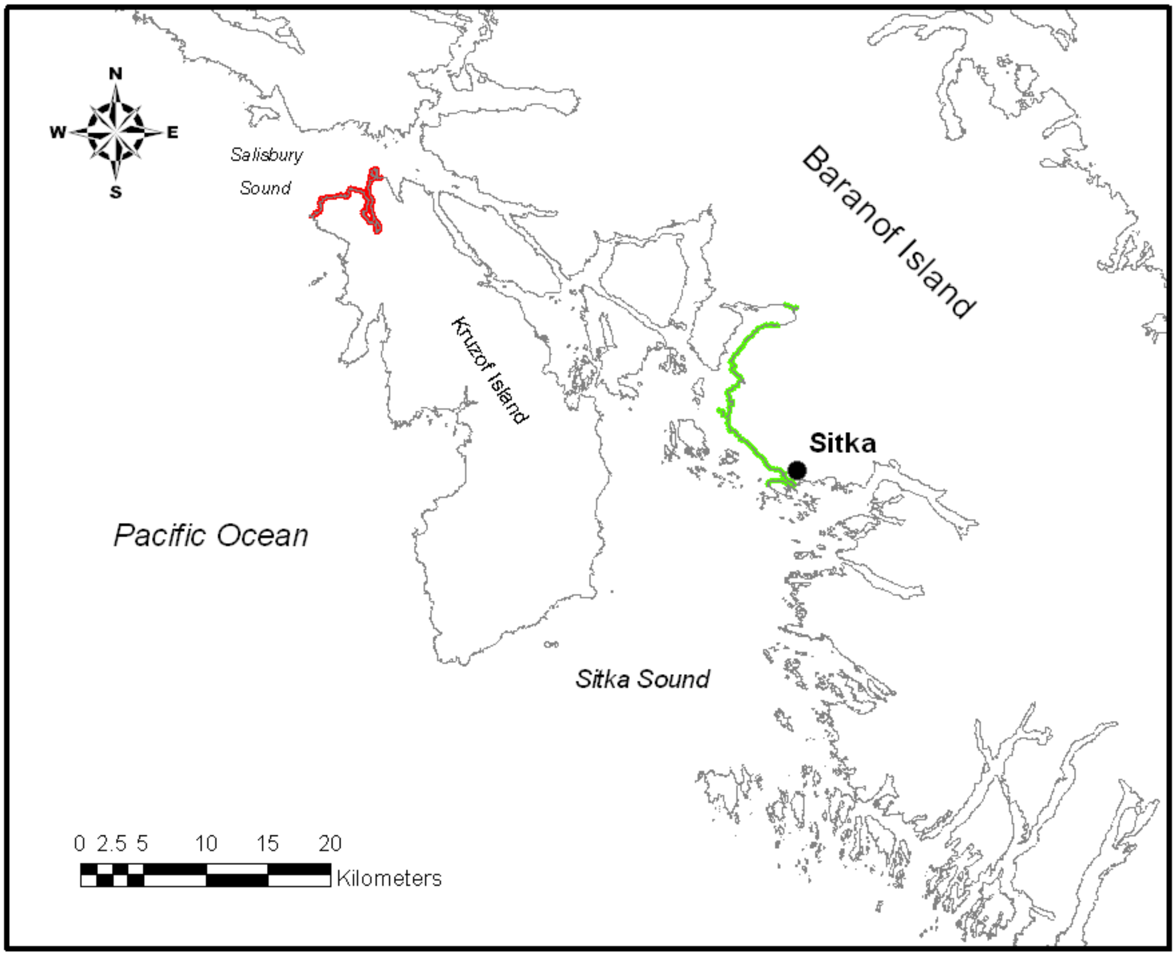
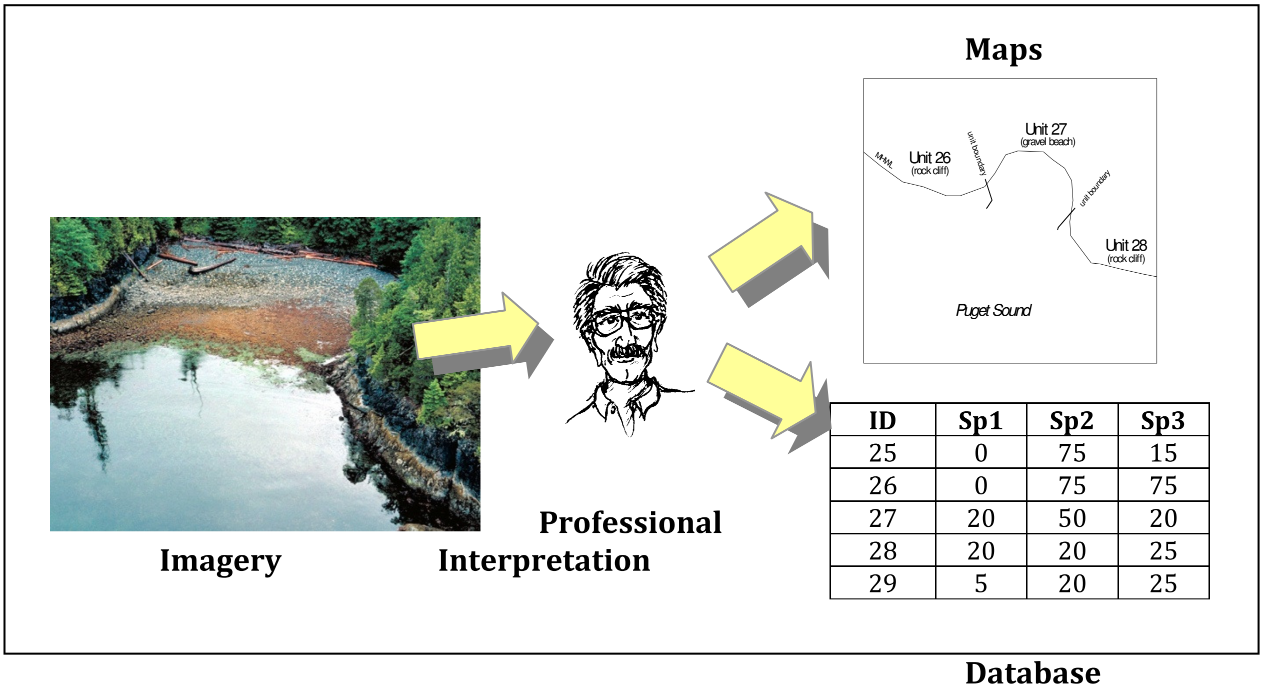


Figure 1. Map of Sitka Sound showing (a) the north Kruzof Island pilot area (red) and (b) the Sitka pilot area (green).

This page intentionally left blank.

2.1 General Approach

The general approach used in the CMECS III classification of coastal habitats is summarized in Figure 2. Georeferenced coastal imagery was interpreted by coastal geomorphologists and coastal ecologists, delineated in terms of alongshore extent by dividing the high-waterline into unique line segments and attaching attribute data (e.g., species name and cover categories). The approach follows the general approach used in ShoreZone (Harney *et al* 2008).



ID	Sp1	Sp2	Sp3
25	0	75	15
26	0	75	75
27	20	50	20
28	20	20	25
29	5	20	25

Figure 2 Schematic of the interpretation process used to map and catalog CMECS attributes.

2.2 Mapping Assumptions

The coastal habitat features mapped as part of this project are summarized in Table 2. Each of the listed attributes includes a number of cover classes (% cover). We took the approach that each CMECS III attribute would be independently mapped. As such, our mappers reviewed the imagery several times, cataloging data independently for each attribute.

An additional assumption to simplify the mapping was that intertidal attribute data would be mapped as line segments on the digital high-water line (HWL). In practice, all of the data have an areal spatial extent with both length and width,

Tablei 2CMECS Attributes Mapped in the SE Alaska Coastal Pilot

Surficial Geology Component (SGC)	GeoForm Component (GFC)	Benthic Biotic Component (BBC)
bedrock	anthropogenic	barnacle
boulder (large)	cliff	*Fucus*
boulder (small)	reef	*Ulva*
cobble	islet	blue mussels
pebble	platform	foliose red algae
sand	beach	coralline red algae
mud	delta	surf grass
shell	dune	eelgrass
organics	glacier	understory kelp
anthropogenic	lagoon	canopy kelp
	marsh/wetland	
	river	
	tidal flat	

although generally attributes are narrow in the across-shore dimension and long in the alongshore dimension; widths of features were recorded as part of this pilot so areal estimates are possible. Only a few resources are associated with the HWL and some misrepresentation occurs by snapping all the data to this line (e.g., eelgrass generally occurs in the subtidal zone) but the assumption does greatly simplify the cartography, especially when 32 separate maps are being generated.

One final technique that we used to simplify the cartography was to “snap” our flight track to the shoreline (Fig. 3). By transferring the one-second fix marks of the flight track, we essentially establish a time mark on the shoreline and could relate information seen in the time-stamped video to the shoreline; this is effectively “rasterizing” the HWL into very short line segments (~30m/segment)

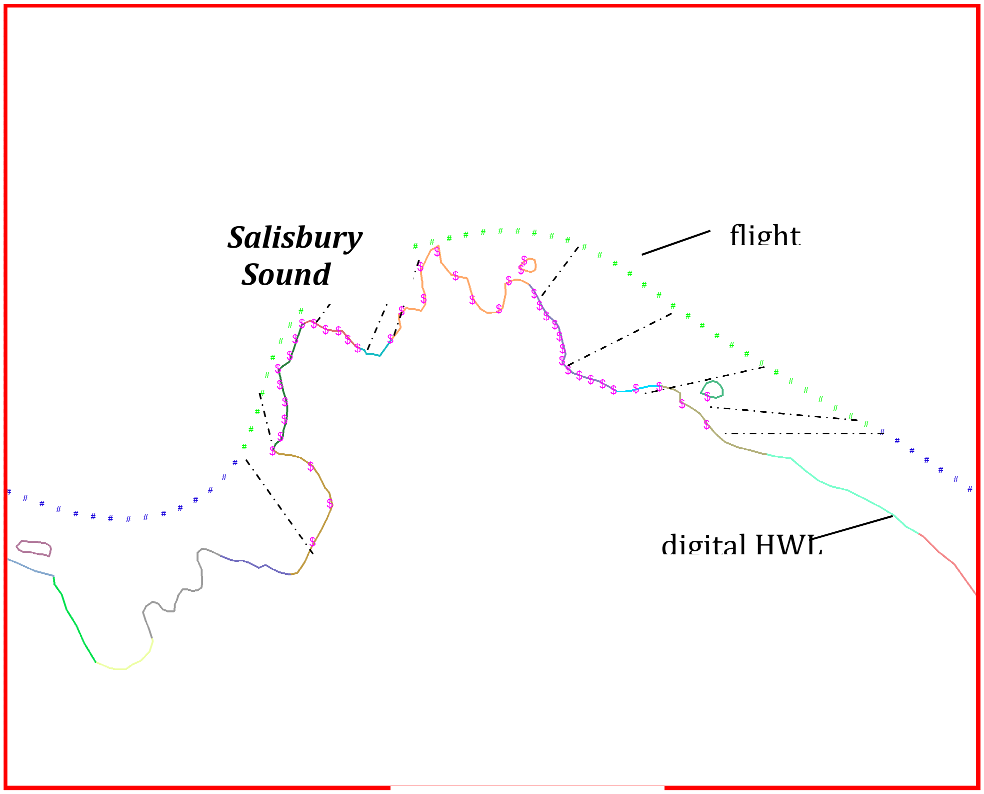


Figure 3. Schematic illustrating how x points (green and blue dots) were transferred to the d es) to create a “rasterized” HWL of line segments.

2.3 Database Development

The first step in the database development was in grooming the spatial data file. As mentioned previously, the 1-sec fix marks from the flightline track were snapped to the digital HWL. Overlaps in flight tracks were manually resolved to a single flight track segment. A short line segment was created in GIS by centering each fix mark. These short line segments are considered the ***observational units*** and correspond to the shoreline visible in 1 sec duration of video imagery***.*** Table 3 summarizes the number of observational units (that is, spatial units) for the two test areas. There are a total of 60.2 km of shoreline mapped and 1,903 observational units. Observational units averaged ~30 m in length.

Tablei 3Summary of Mapping Areas

Metric	North Kruzof Area	Sitka Area	Total
Shoreline Length (km)	25.0	35.2	60.2
Number of Video Points	736	1,167	1,903
Observational Unit Length (m)	33.9	30.2	31.6

Tablei 4Surficial Geology Classifications

SGC	Classification
bedrock cover	Cover Categories (8) 0%, <1%,1-10%,10-25%,25-50%,50-75%,75%-90%,>90%
boulder cover	
stone cover	
cobble cover	
pebble cover	
sand cover	
mud cover	
shell cover	
organics cover	
anthropogenic cover	
sediment pattern	14 unique combinations of: “deltaic”, “fluvial”, ‘irregular”, physical”, “smooth”, “swash”, “tidal”
organics type	14 unique combinations of: “grass”, “trees”, “organics”, “peat”
anthropogenic type	37 unique combinations of: “concrete”, “debris”, “fill”, “logs”, “metal”, “rubble”, “wood”
anthropogenic impact	29 unique combinations of: “aqua”, “developed”, “dredged”, “filled”, “impounded”, “scarred”,

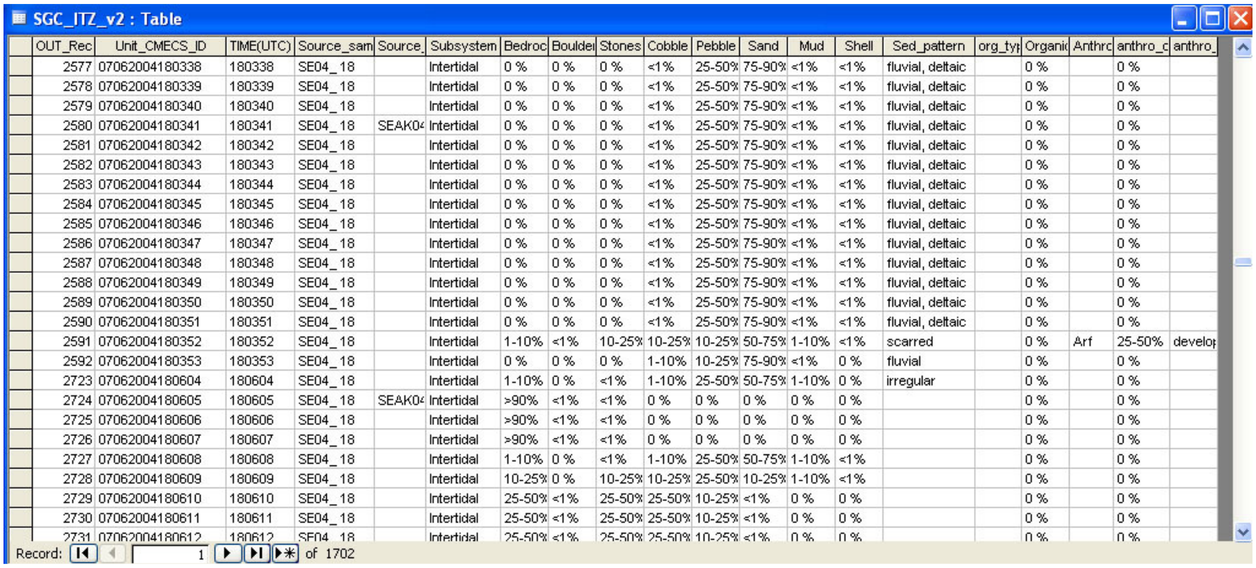
Three databases were created: the SGC, the GFC and the BBC. The databases include a data record for each observational unit. In practice, a mapper would review the video imagery, concentrating on a particular attribute (e.g., canopy kelps) and would be noting the start and stop times of canopy kelp in the imagery, then transferring those observations to database codes for stretches of shoreline. As such, each section of shoreline was reviewed multiple times to compile the classification for the 32 attributes. Tables 4, 5 and 6 provide an overview of the categories used for each attribute. A screen clip of the Access database is provided in Figure 4.

Tablei 5Summary of Classified Geoform Classification

Geoform	Cover Categories	Modifiers	Slope
Anthropogenic	0% [none], <1% [bare], 1-10% [Sprs], 10-25% [MdSp], 25-50% [Modt], 50-75% [MoDe], >75-90% [Dens], >90% [Cmpl]	ShoreZone coding for cross-shore Forms were used (see Harney *et al* 2008)	estimated of the Geoform slope in degrees
Beach			
Cliff			
Delta			
Dune			
Ice			
Lagoon			
Marsh			
Offshore Islet			
Ramp			
Reef			
River			
Tidal Flat			

Table 6 Benthic Biotic Cover Classes and Codes

BBC Attribute	Cover Classes	Width
barnacles	**C**ontinuous >50% cover ; **P**atchy <50% cover ; **A**bsent – not visible	across-shore width estimated to the nearest meter
rockweed cover		
green algae cover		
mussel bed cover		
red algae cover		
coralline red algae cover		
understory kelp bed cover		
surfgrass cover		
eelgrass cover		
canopy kelp bed cover		
urchin barrens cover		



OUT_Rec	Unit_CMECS_ID	TIME(UTC)	Source_sam	Source_	Subsystem	Bedroc	Boulde	Stones	Cobble	Pebble	Sand	Mud	Shell	Sed_pattern	org_ty	Organi	Anthro	anthro_c	anthro_
2577	07062004180338	180338	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2578	07062004180339	180339	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2579	07062004180340	180340	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2580	07062004180341	180341	SE04_18	SEAK04	Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2581	07062004180342	180342	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2582	07062004180343	180343	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2583	07062004180344	180344	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2584	07062004180345	180345	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2585	07062004180346	180346	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2586	07062004180347	180347	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2587	07062004180348	180348	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2588	07062004180349	180349	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2589	07062004180350	180350	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2590	07062004180351	180351	SE04_18		Intertidal	0 %	0 %	0 %	<1%	25-50%	75-90%	<1%	<1%	fluvial, deltaic		0 %		0 %	
2591	07062004180352	180352	SE04_18		Intertidal	1-10%	<1%	10-25%	10-25%	10-25%	50-75%	1-10%	<1%	scarred		0 %	Arf	25-50%	develo
2592	07062004180353	180353	SE04_18		Intertidal	0 %	0 %	0 %	1-10%	10-25%	75-90%	<1%	0 %	fluvial		0 %		0 %	
2723	07062004180604	180604	SE04_18		Intertidal	1-10%	0 %	<1%	1-10%	25-50%	50-75%	1-10%	0 %	irregular		0 %		0 %	
2724	07062004180605	180605	SE04_18	SEAK04	Intertidal	>90%	<1%	<1%	0 %	0 %	0 %	0 %	0 %			0 %		0 %	
2725	07062004180606	180606	SE04_18		Intertidal	>90%	<1%	<1%	0 %	0 %	0 %	0 %	0 %			0 %		0 %	
2726	07062004180607	180607	SE04_18		Intertidal	>90%	<1%	<1%	0 %	0 %	0 %	0 %	0 %			0 %		0 %	
2727	07062004180608	180608	SE04_18		Intertidal	1-10%	0 %	<1%	1-10%	25-50%	50-75%	1-10%	<1%			0 %		0 %	
2728	07062004180609	180609	SE04_18		Intertidal	10-25%	0 %	10-25%	10-25%	25-50%	10-25%	1-10%	<1%			0 %		0 %	
2729	07062004180610	180610	SE04_18		Intertidal	25-50%	<1%	25-50%	25-50%	10-25%	<1%	0 %	0 %			0 %		0 %	
2730	07062004180611	180611	SE04_18		Intertidal	25-50%	<1%	25-50%	25-50%	10-25%	<1%	0 %	0 %			0 %		0 %	
2731	07062004180612	180612	SE04_18		Intertidal	25-50%	<1%	25-50%	25-50%	10-25%	<1%	0 %	0 %			0 %		0 %	

Figure 4. Screen clip of the SGC database showing (a) a record for each “observational unit” and (b) cover estimates for bedrock, boulder, cobble, sand, mud, shell, organic and anthropogenic covers and (c) miscellaneous other data including time stamp on the videography, zone of interest (intertidal) and sediment pattern classes.

This pilot attempts to answer a number of questions about the CMECS III classifications system as applied as a mapping system. In particular, this pilot evaluates the efficacy of CMECS compared to the ShoreZone system, which has been widely used in the Pacific NW with nearly 100,000 km of shoreline mapped. We provide a comparison in terms of the mapping methodology and data products as well as the degree of ecological characterization.

3.1 CMECS and ShoreZone Mapping Methodology Comparison

Our existing ShoreZone mappers estimated that the CMECS system required approximately twice the effort to map the same amount of shoreline. Part of this difference may be attributed to unfamiliarity with the system but two obvious reasons are:

1. the observational units that we developed for CMECS are nearly one tenth the size (mean length 30m) of the ShoreZone units (mean length 250m). As such, there is more data entry in CMECS.

2. each CMECS attribute is independently mapped so the “boundaries” of each observational unit must be independently mapped. In ShoreZone, once the unit boundaries are delineated (the first step in mapping), all other attribute data are then tagged to those units.

We used a cartographic “trick” to create the observational units in CMECS by snapping our tracklines to the digital shoreline (Fig. 3); then our one-second fix points become potential end points to mapping segments. This technique greatly simplified the mapping but did require some initial investment of a GIS analyst to create the 1-sec observational units. Once the digital HWL units were created, all the mapping could be conducted within the database. This technique is probably best referred to as “rasterizing” the HWL and the result is that finer units are created without a corresponding increase in “cartographic overhead”.

Mappers required several “fly-bys” on the same sections of shoreline to capture all 32 of the attribute fields. In the case of the intertidal biota, mappers found it easier to make three passes to catalog data: one for the upper intertidal, one for the mid- to lower-intertidal and one for the shallow subtidal. Physical mappers typically conducted two fly-bys, one to record SGC attributes and one for the GFC attributes.

3.2 CMECS and ShoreZone Mapping Data Comparison

The two sections of coast evaluated in this pilot comprise about 60 km of shoreline and there are previously mapped ShoreZone data for both sections. The two datasets are compared spatially and statistically.

Biological Mapping Comparisons

Three biological attributes are selected for comparison as these are virtually identical features within the two systems:

rockweed, a mid to upper intertidal brown algae (the ShoreZone *bioband* and the CMECS *Biotic Group*) and typical in lower energy, rock or boulder-cobble environments;

eelgrass (ShoreZone *bioband* and CMECS *biotic group*)***,*** a lower intertidal to subtidal seagrass associated with low energy, soft bottoms of sand and mud;

canopy kelps (CMECS *biotic group*), an entirely subtidal assemblage of *Alaria*, *Macrocystis* and *Nerocystis* (ShoreZone *biobands*) that require stable rock or boulder surfaces for holdfasts.

Rockweed

Rockweed occurrence for the two pilot areas is shown in Figure 5 which shows percentages of rockweed occurrence along the two sections of coast. Rockweed is more common on the lower energy Sitka shoreline than on the higher energy northern Kruzof shoreline. The CMECS mapping of the Sitka shoreline shows higher cover of rockweed than does ShoreZone although the alongshore extent is about the same (95% in CMECS and 85% in ShoreZone). This difference is mostly likely due to differences in mappers between the two classifications rather than fundamental differences in mapping systems. The extent of rockweed on the north Kruzof shoreline (Fig. 5) is about 15% different with higher covers mapped in CMECS; again, this difference appears to be due to differences in mappers interpretation rather than an artifact of the two systems.

Maps of rockweed comparison for Sitka Sound are shown in Figures 6 and 7. While the overall distribution is similar, a point-by-point comparison indicates that CMECS mapping shows higher densities of rockweed overall in comparison the ShoreZone mapping. This is likely due to the higher resolution afforded by ~30m CMECS “observational units” as compared to ~250m SZ units.

Map comparisons for northern Kruzof Island are shown in Figures 8 and 9. While the plots show good comparison within Kalinin Bay, the open-coast comparison for Salisbury Sound, where energy levels are moderate, show the CMECS mapping picked up a few areas that were not mapped in ShoreZone. We attribute the difference to mapper interpretation and the higher spatial resolution of CMECS (~30m observational units compared to ~250 m units).

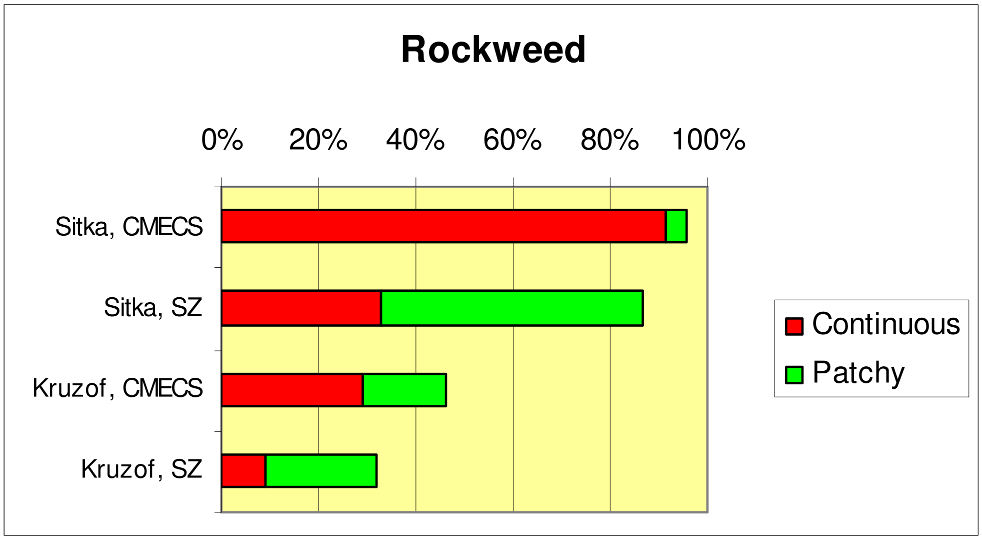


Figure 5. Summary of shoreline occurrence of CMECS and ShoreZone (SZ) mapping data for rockweed.

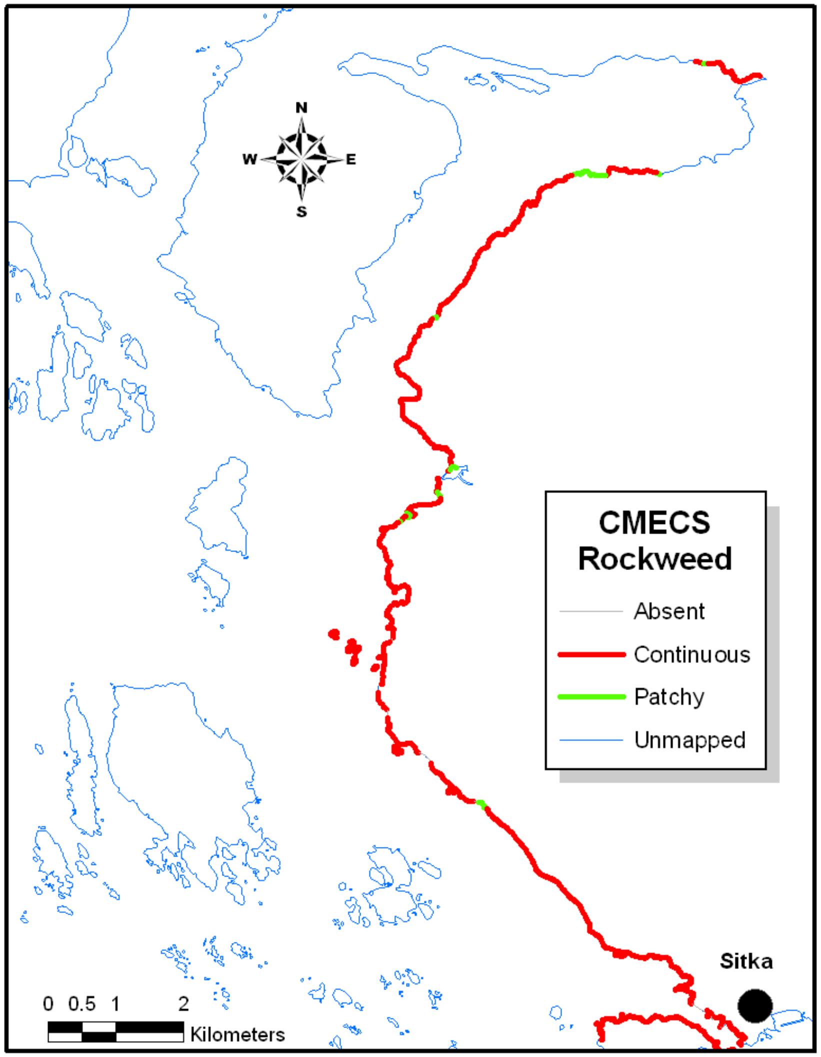


Figure 6. CMECS mapping of rockweed biotic grouping the Sitka pilot area.

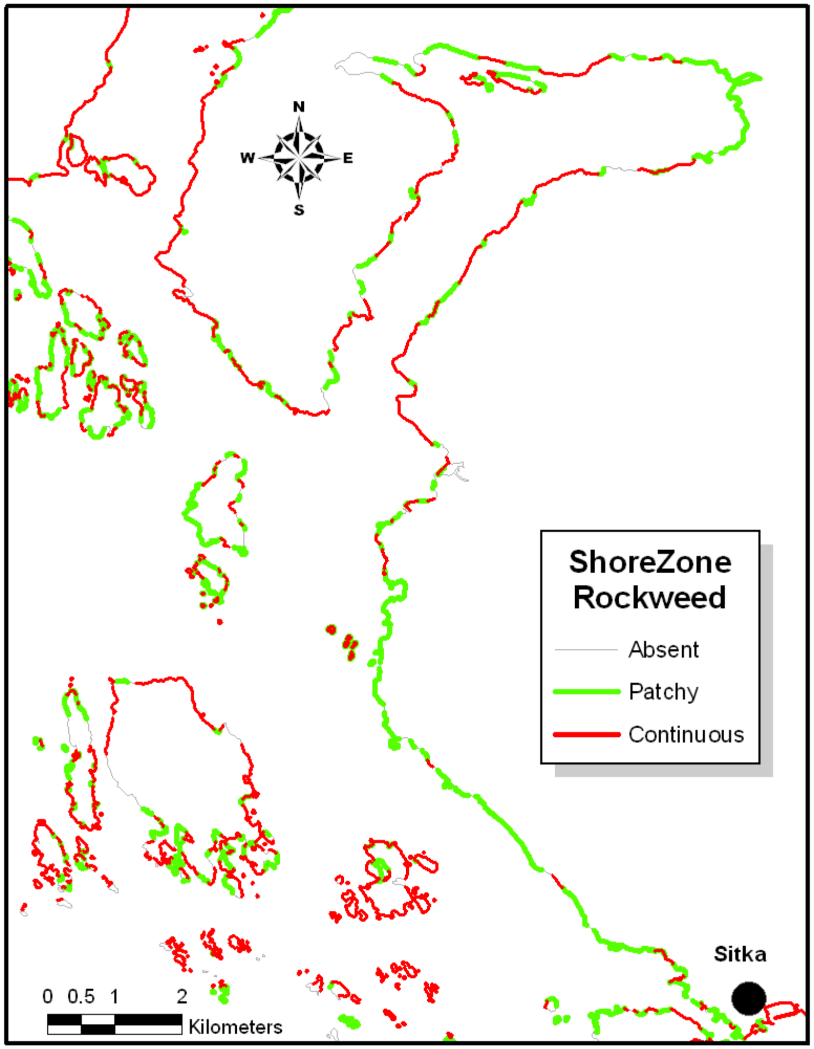


Figure 7. ShoreZone mapping of the rockweed or FUC bioband in the Sitka pilot area

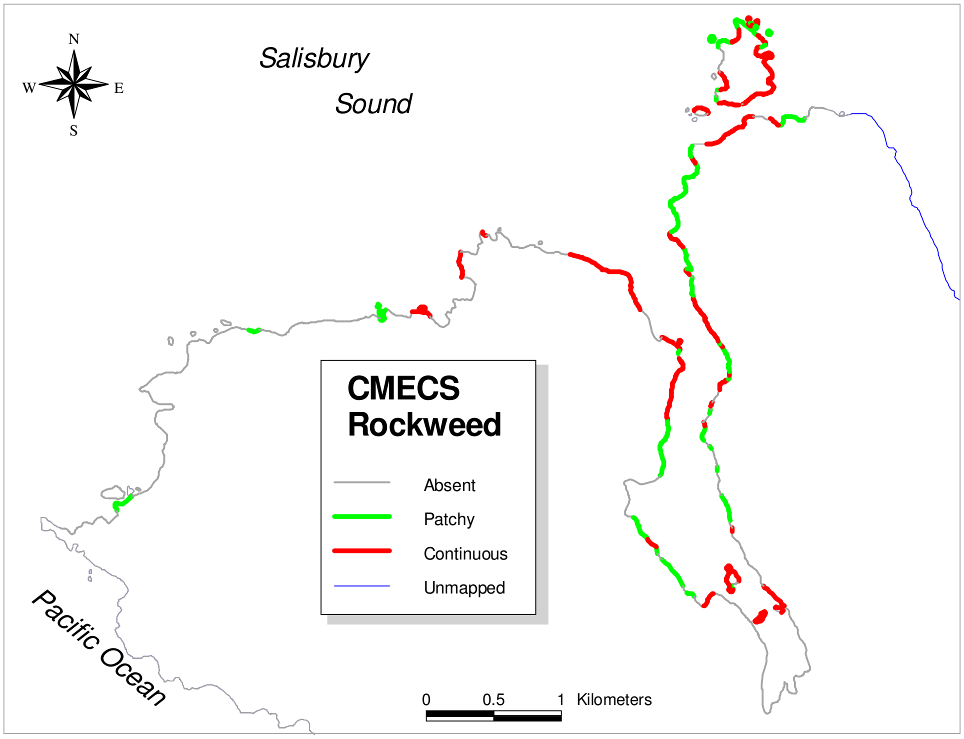


Figure 8. CMECS mapping of the rockweed biotic group in the northern Kruzof Island pilot area

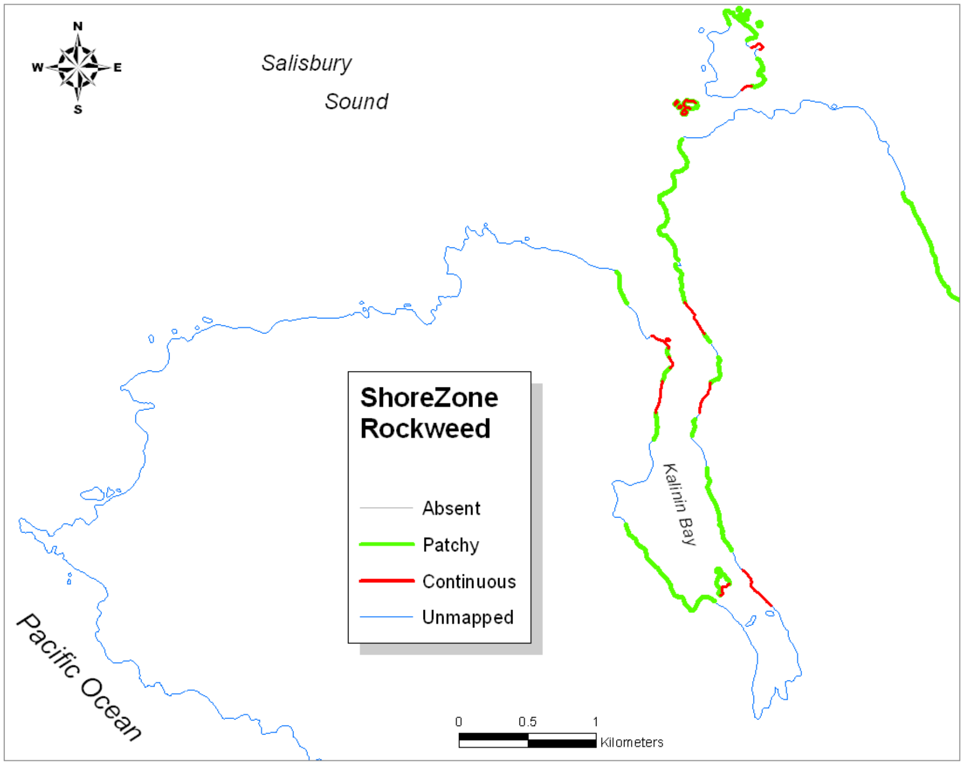


Figure 9. ShoreZone mapping of rockweed or the FUC bioband in the northern Kruzof Island pilot area

Eelgrass

The occurrence of eelgrass within the two pilot areas is summarized in Figure 10. This summary is based on 40 km of mapping near Sitka and 23 km of mapping on northern Kruzof Is. While the north Kruzof shoreline compares well, the Sitka shoreline values differ by about 10% between CMECS and ShoreZone, although CMECS maps more high-cover eelgrass. This may be an example of the higher resolution of CMECS more precisely capturing a truer distribution of eelgrass whereas some of the high-density beds in ShoreZone extend only partially into adjacent units and are categorized as *patchy* within those units.

The Sitka eelgrass comparison maps are shown in Figure 11 and 12. The spatial comparison of eelgrass distributions mapped in these two systems is nearly identical, although it is apparent that CMECS maps higher densities.

The north Kruzof Island eelgrass comparisons are shown in Figures 13 and 14. The spatial comparison of the eelgrass mapping is virtually identical between the two systems.

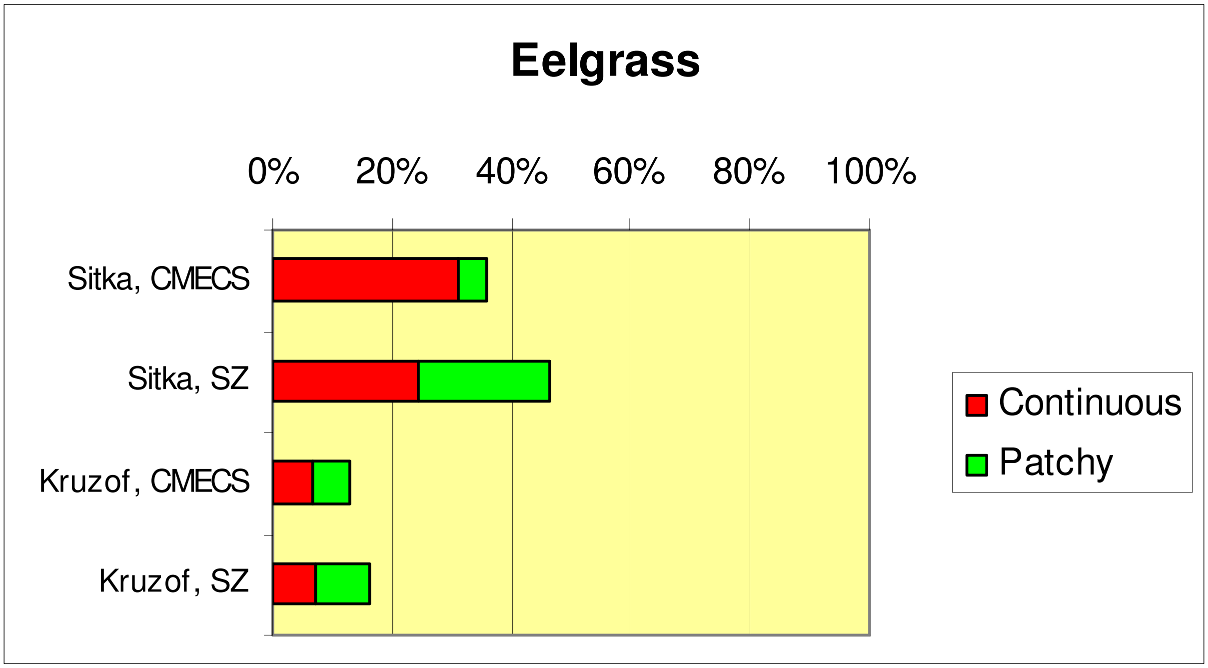


Figure 10. Summary of shoreline occurrence of CMECS and ShoreZone mapping data for eelgrass.

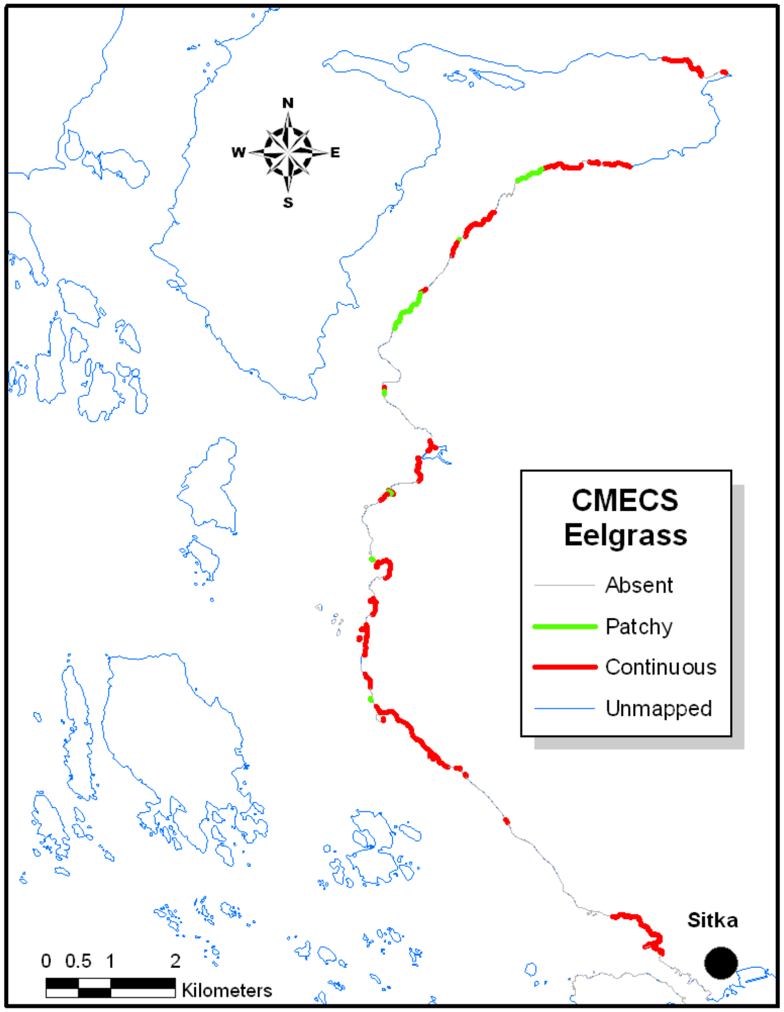


Figure 11. CMECS mapping of the eelgrass biotic group in the Sitka pilot area.

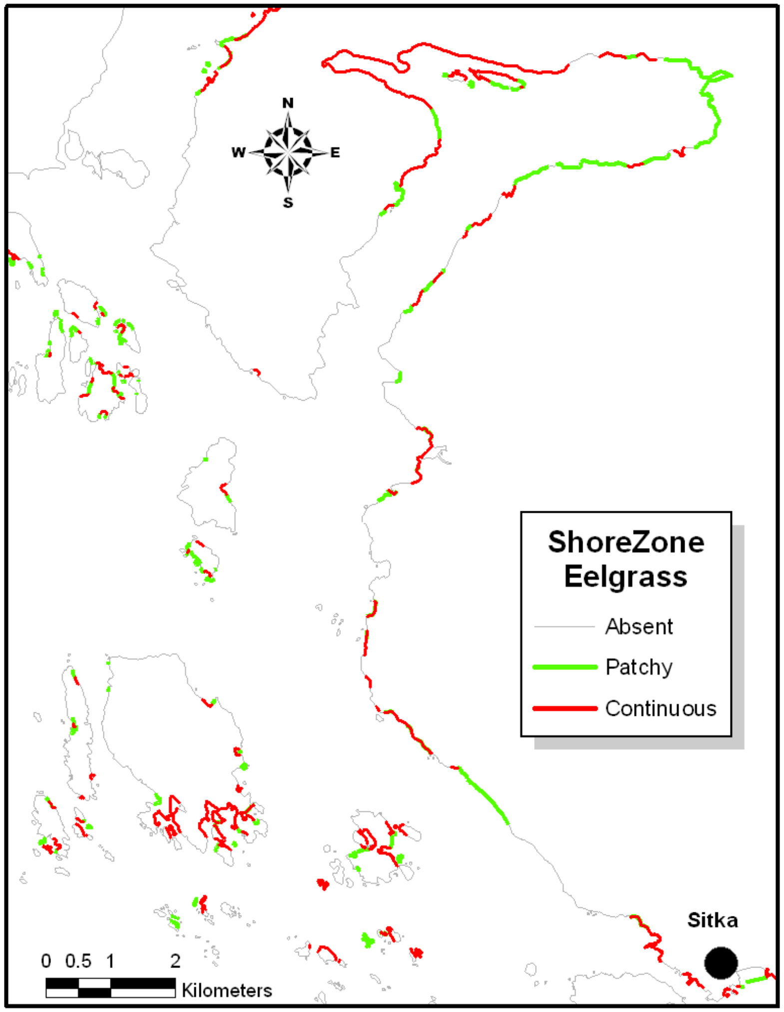


Figure 12. ShoreZone mapping of the eelgrass or ZOS bioband in the Sitka pilot area

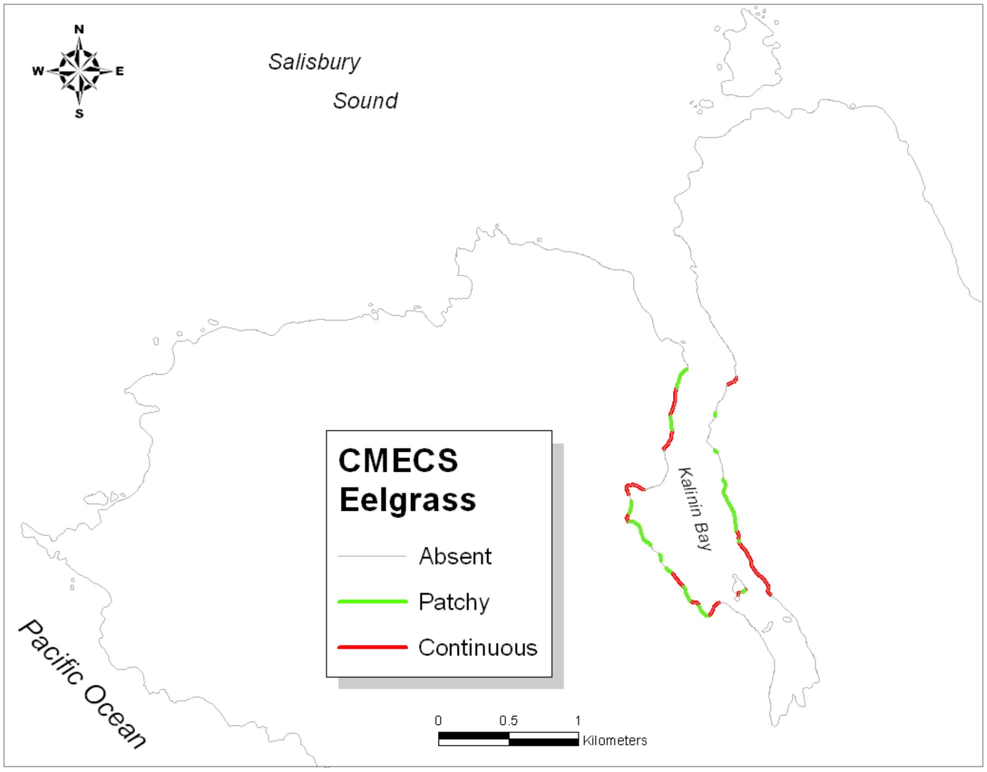


Figure 13. CMECS mapping of the eelgrass biotic group in the northern Kruzof Island pilot area

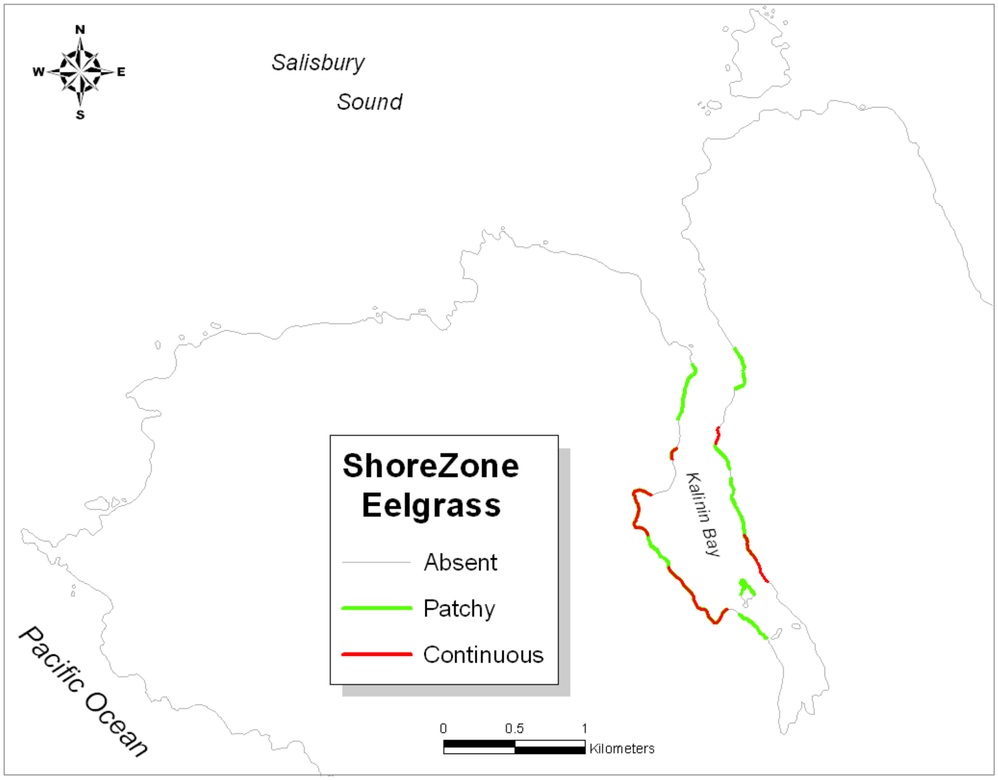


Figure 14. ShoreZone mapping of eelgrass or the ZOS bioband in the northern Kruzof Island pilot area

Canopy Kelps

The CMECS system maps to "canopy kelps" at the biotic group level whereas the ShoreZone system maps to a species level. The three canopy kelp species mapped in ShoreZone, *Alaria fistulosa, Macrocystis* and *Nerocystis* were combined into a single ShoreZone canopy kelp category to facilitate comparison. The statistical comparison of the CMECS and ShoreZone mapping for canopy kelps is summarized in Figure 15 and shows nearly identical patterns. The low-energy, estuarine Sitka shoreline has very little kelp (<5%) whereas the higher energy, marine shoreline of north Kruzof Island shows considerable canopy kelp occurrence (55-60%) with higher covers mapped in the CMECS system.

The comparative maps for the Sitka canopy kelps are shown in Figures 16 and 17. Much of this shoreline is low energy and canopy kelps are not present. In the few locations where canopy kelps do occur, the agreement of the maps is quite good.

Maps for north Kruzof Island are shown in Figures 17 and 18. The overall *extent* of the canopy kelp distribution is nearly identical between the two maps (i.e., 55% from ShoreZone and 59% from CMECS – Fig. 15) but it is apparent that the *cover* in the CMECS map is greater (see also Fig. 15). Given that the mapping density thresholds are identical, the difference attributed to differences in mapper interpretation.

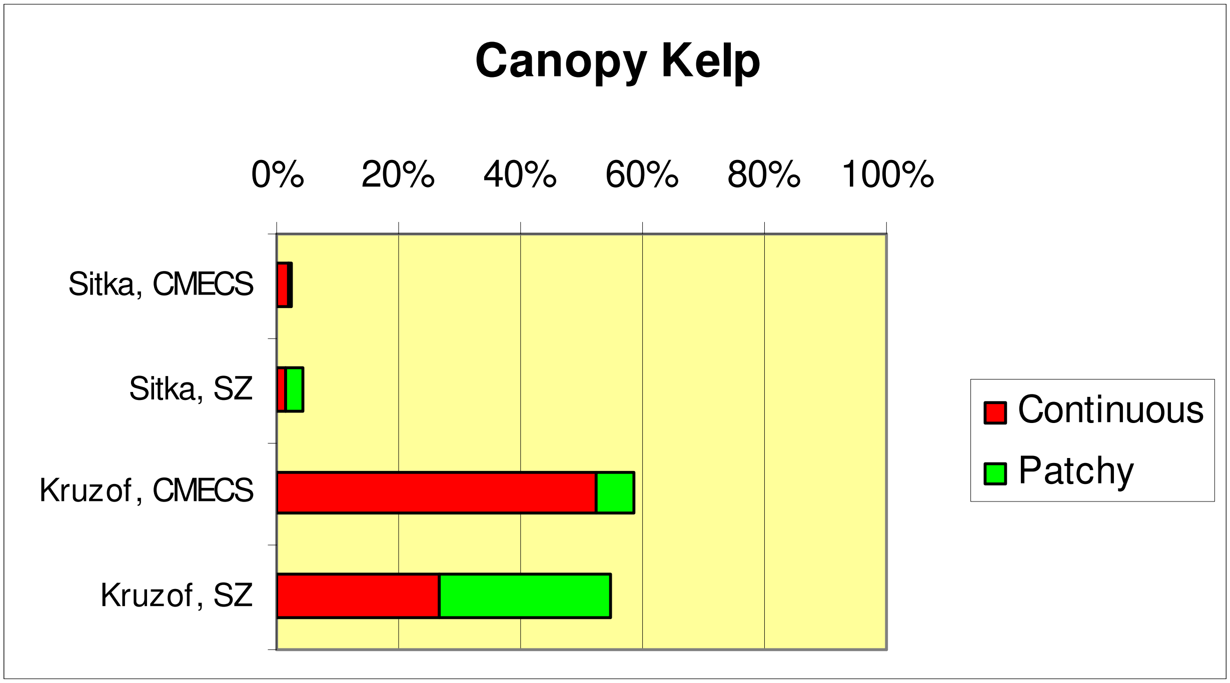


Figure 15. Summary of shoreline occurrence of CMECS and ShoreZone (SZ) mapping data for canopy kelps.

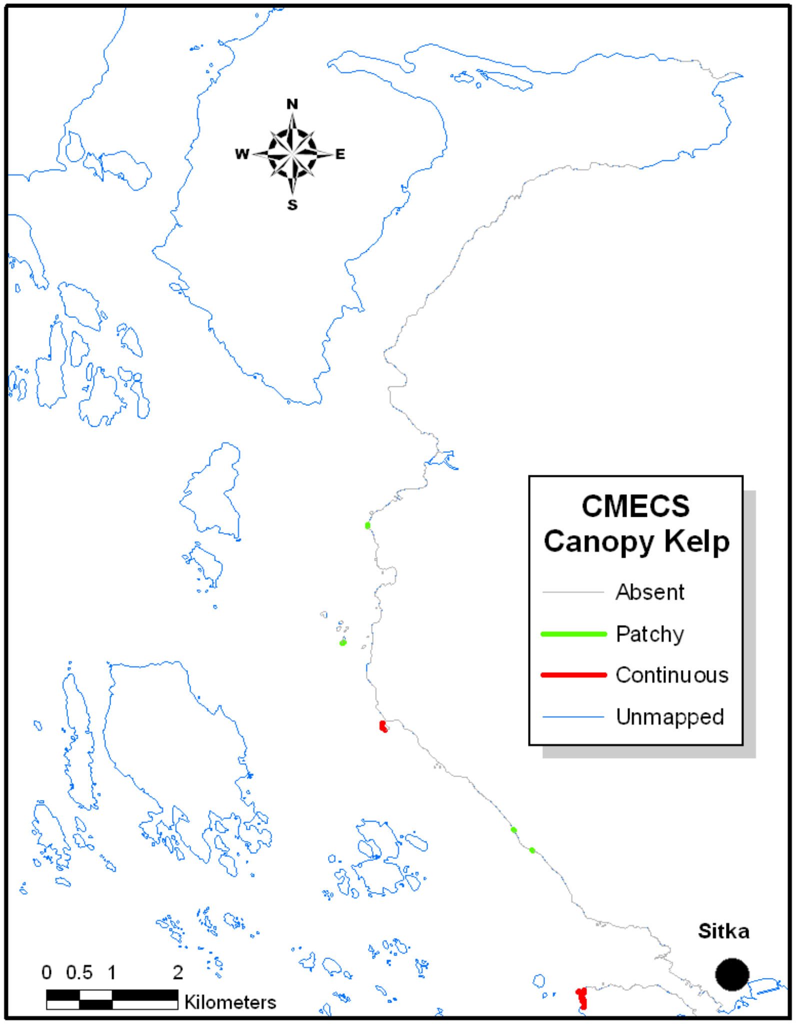


Figure 16. CMECS mapping of canopy kelps biotic group in the Sitka pilot area.

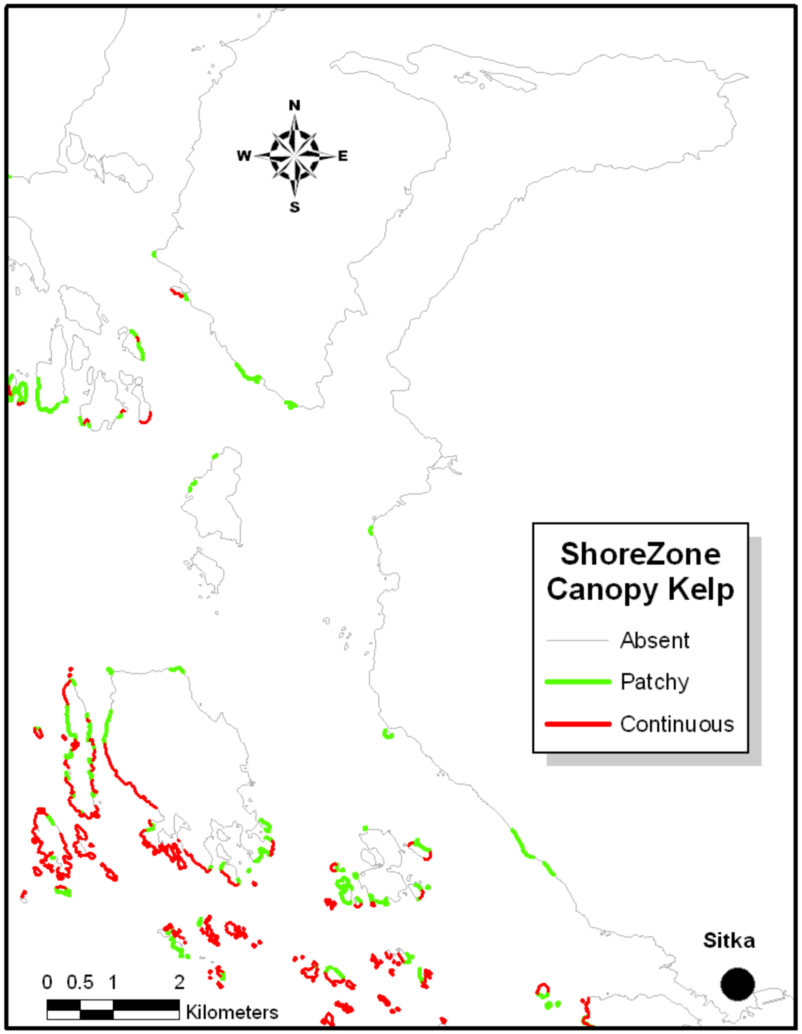


Figure 17. ShoreZone mapping of the canopy kelps or the ALF, MAC and NER biobands in the Sitka pilot area

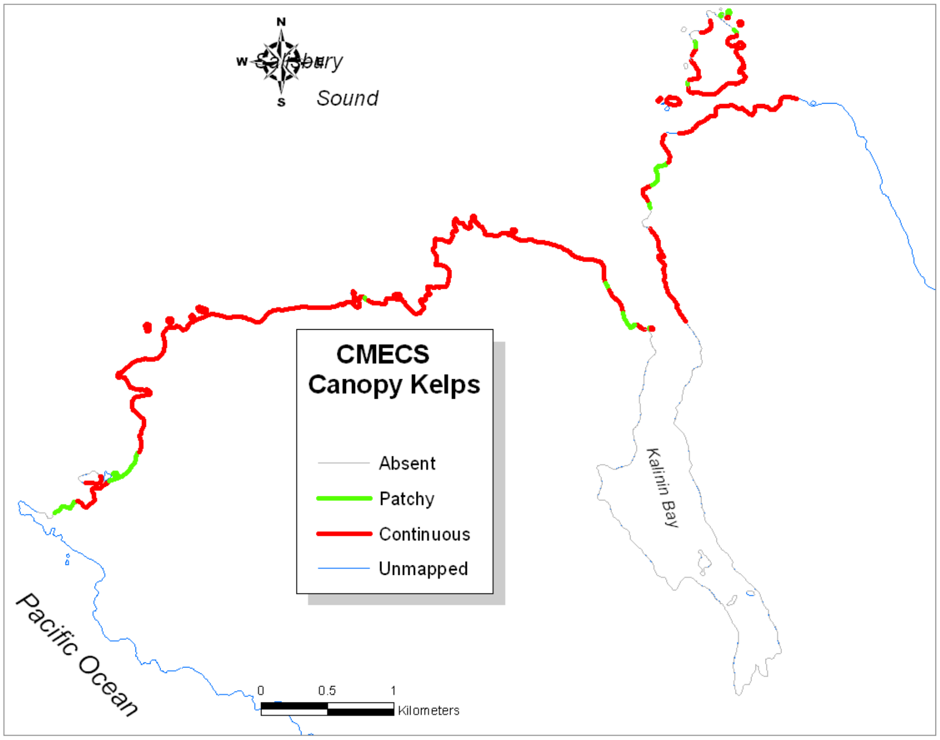


Figure 18. CMECS mapping of canopy kelps biotic group in the northern Kuzof Island pilot area

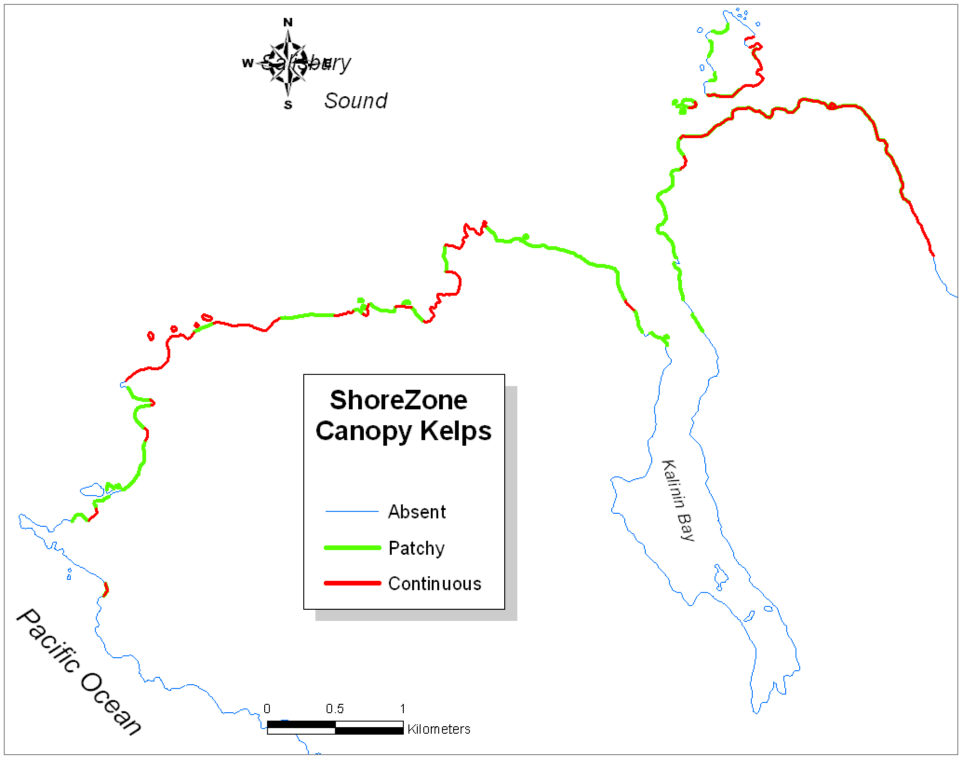


Figure 19. ShoreZone mapping of canopy kelps or the ALF, MAC and NER biobands in the northern Kuzof Island pilot area

Physical Mapping Comparisons

The comparison between CMECS and ShoreZone mapping for physical characteristics is more difficult than the comparison of biological characteristics. The systems have a very different way of cataloging information about coastal habitat. As mentioned previously, ShoreZone uses physical attributes (morphology, substrate and exposure) to define habitat units (spatial mapping unit) and then attaches attribute information to the spatial unit. Consistent with the approach taken with the biotic component, each resource is independently mapped so there would be separate mapping units for bedrock, for boulders for sand, etc. There will be separate mapping units for different morphologies, such as cliffs, beaches, dunes and tidal flats. In CMECS, the *substrates* can only be associated with the *Geoforms* spatially. This comparison focuses on the SZ substrate and CMECS Surficial Geology Component.

Figures 20 to 23 provide a basis for comparison and highlighting some of the differences between CMECS and ShoreZone in terms of mapping results. The two pilot areas are somewhat different in that the Sitka area is more developed, has more estuarine shoreline and has less bedrock shoreline than does the north Kruzof area (Fig. 20 and 22).

Sitka ShoreZone and CMECS Comparison

Some of the differences between CMECS and ShoreZone are highlighted by comparison of Figures 20 and 21. First, the ShoreZone system identifies that a significant proportion of the Sitka shoreline (14%) is a mixture of bedrock and sediment – these may be rock platforms covered with veneers of sediment or small pocket beaches separated by headlands that are too small to be individually mapped. In the CMECS system, if the observational unit contains more than 50% of a substrate, the entire observational unit is then cataloged as either all rock or all sediment. In the case of the Sitka mapping, most of this mixed category fell into the bedrock class of CMECS.

Another difference in mapping in this pilot is that the CMECS classes shown in Figure 21 are based on *intertidal* mapping only whereas the ShoreZone classes consider the whole across-shore width from low-waterline to the terrestrial vegetation boundary (storm-surge elevation). As a result, the supratidal marshes present within the estuaries were not cataloged in CMECS but were cataloged in ShoreZone (~20% of the shoreline length). Technically the difference is because different areas are being compared but this result does illustrate how the CMECS independent mapping of features disassociates some ecological processes; in this case, the marshes in the supratidal zone are disassociated from the tidal flats of the intertidal.

While both systems captured the anthropogenic shoreline, ShoreZone cataloged a much higher percentage (Fig. 20 and 21). The reasons for this is that ShoreZone considers both supratidal and intertidal areas whereas CMECS was only mapped within the intertidal for this pilot. So the difference in this case is an artifact of different areas being compared.

N. Kruzof ShoreZone and CMECS Comparison

Comparison of the ShoreZone and CMECS mapping for the northern Kruzof Island mapping (Fig. 22 and 23) illustrates some of the same points. CMECS does not capture mixtures at this general scale of mapping – to capture the mixtures (27% of the shoreline is a combination of rock and sediment), one would have to assemble each component within a GIS system and associate them (e.g., plot locations where rock, cobble and pebble co-occur). And again, because the CMECS mapping was only the intertidal zone, organics substrate and marshes were not captured whereas in ShoreZone, the aggregation of substrates and morphologies within a mapping unit does capture the ecological association of marshes and unconsolidated tidal flats.

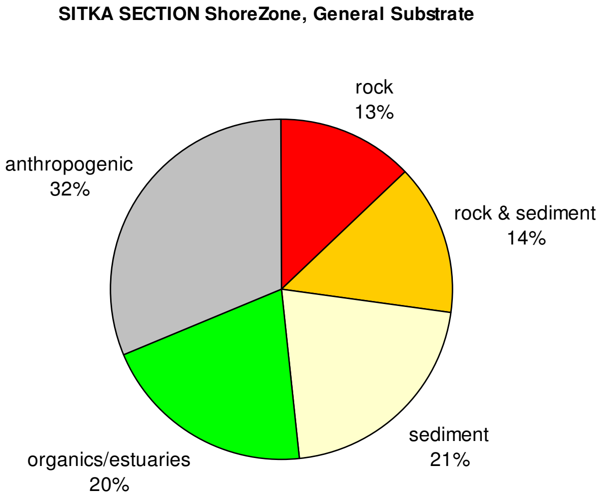


Figure 20. Summary of ShoreZone major substrate types for Sitka pilot area (~30 km of shoreline).

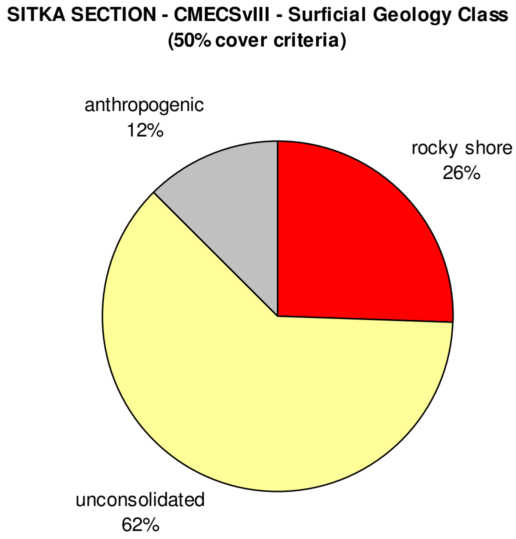


Figure 21. Summary of CMECS SFC class for Sitka pilot area (~30 km of shoreline).

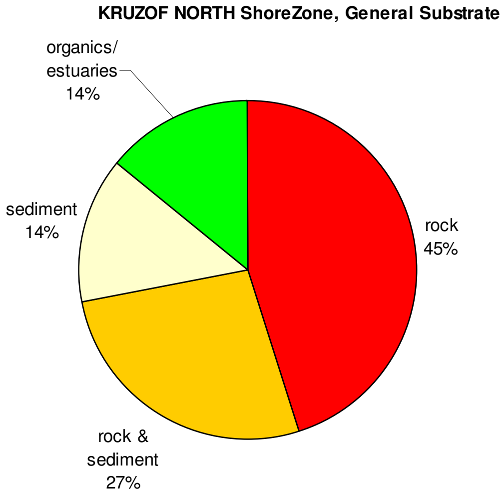


Figure 22. Summary of ShoreZone major substrate types for N Kruzof pilot area (~23 km of shoreline).

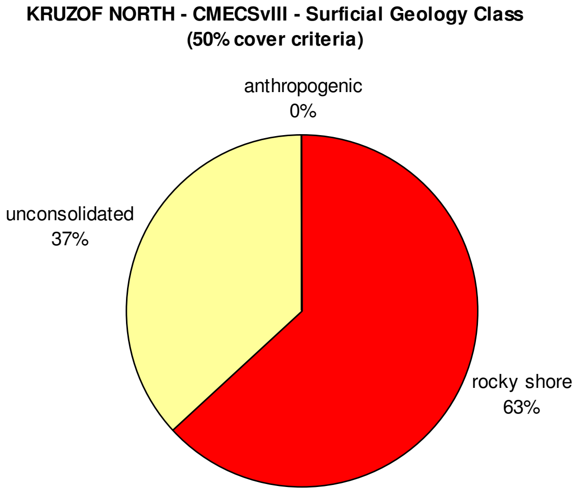


Figure 23. Summary of CMECS SFC class for N Kruzof pilot area (~23 km of shoreline).

General Overview

Figure 24 provides a different summary of the CMECS substrate mapping for 10 substrate themes on the Sitka mapping section. Eight of the ten categories occur on more than 50% of the shoreline so there is obviously a significant amount of co-occurrence of substrates within the intertidal zone. This plot indicates a wide variety of substrate mixtures occur within the intertidal zone of this pilot area.

Figure 25 is a sample map of bedrock cover (>1% bedrock) that occurs in each of the observational units whereas a bedrock cover map is displayed in Figure 25. Both are examples of differing summaries of mapping data.

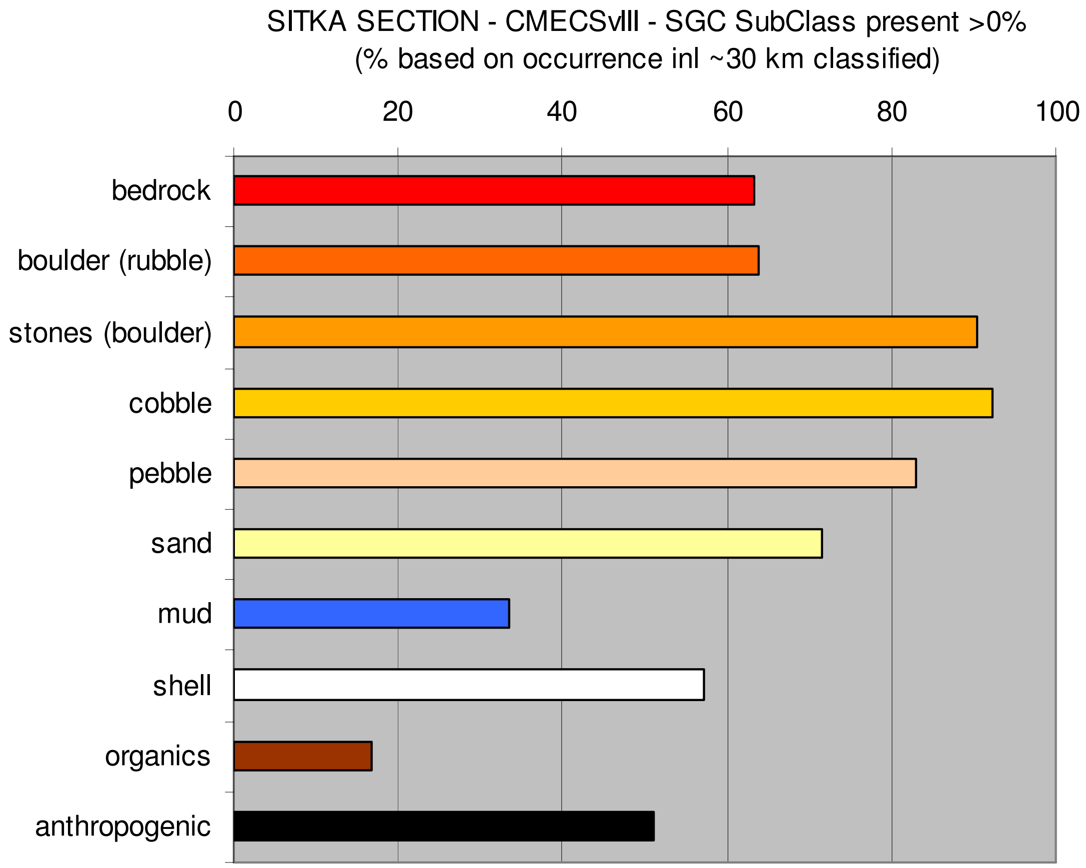


Figure 24. Plot of various CMECS substrate occurrences from the Sitka mapping area, showing that quite a number of themes co-occurred along the shoreline, as indicated by the eight classes that occurred along more that 50% of the coast.

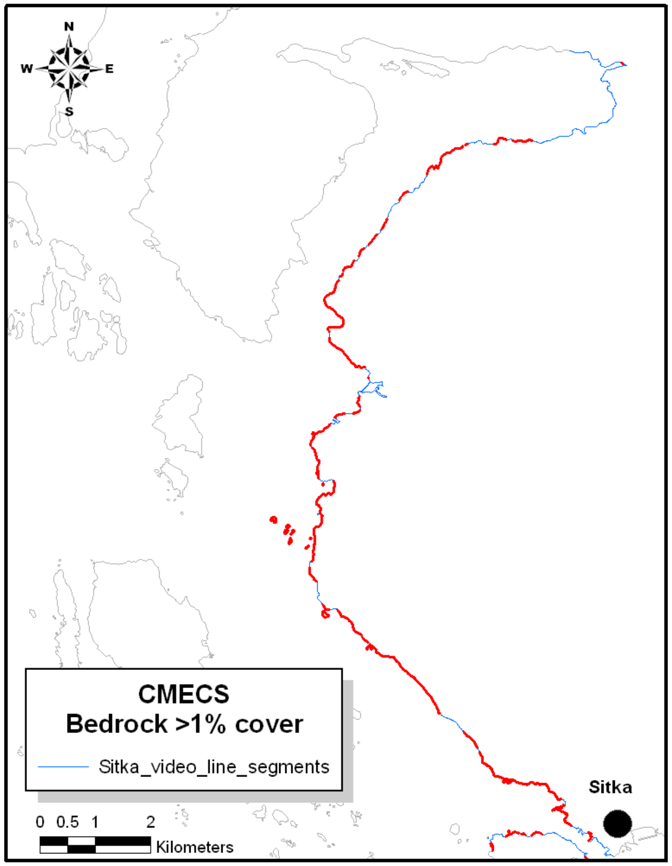


Figure 25. Map of Sitka shoreline with >1% bedrock cover (as per CMECS), approximately 62% of the shoreline mapped as bedrock (see Fig.24).

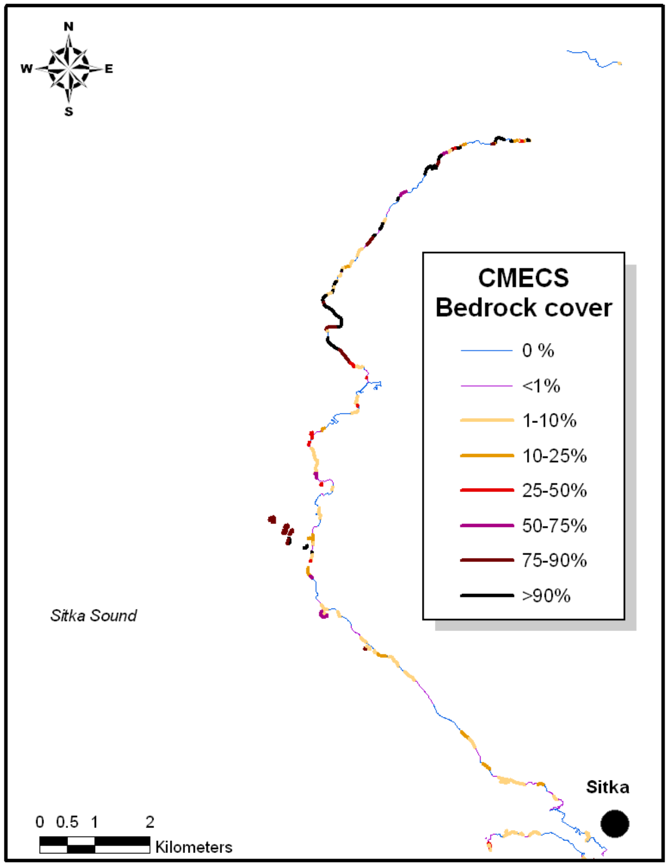


Figure 26. Map of Sitka shoreline with bedrock cover categories (as per CMECS; see Fig.24).

3.3 Use of CMECS in Habitat Management

In general, habitat management questions will require a number of attributes to be identified and assembled for co-occurrence to identify habitat capability. The independent nature of the spatial themes makes this somewhat challenging in CMECS. The following example illustrates that challenge.

One application of ShoreZone has been to identify locations with high-probability of sand lance spawning potential. Pacific Sandlance is a small forage fish that is an important trophic level of the food chain in the Pacific Northwest and that spawns in the intertidal zone. The preferred spawning habitat is in the upper intertidal zone, with protected to semi-protected exposures in well-sorted sand or pebbly sand. In addition, there appears to be a preference for spawning locations on progradational beaches as opposed to erosional beaches.

We have prepared a schematic of what an ideal CMECS classification and mapping of intertidal substrate (Fig. 27) with the distributions of four substrates independently mapped as six polygons within 150 m length of intertidal zone. These are actually simplified, as the seven cover classes within the polygons are not included; if they had been, there would be around 42 unique polygons for each cover class of each substrate. The overlap of the six polygons creates a complex of 18 unique combinations (Fig. 27). If we were searching for just sand or pebbly sand habitats, this search would have to be conducted within an GIS environment and four suitable polygons would be identified. Additional GIS analysis would be required to identify if any of the suitable substrate polygons occurred in the upper intertidal zone. So the appropriate habitat could be identified with the CMECS data, although the spatial analysis is considered moderately complex and require a GIS analyst to complete. In contrast, the same query in ShoreZone can be completed entirely within the Access database as the data are already spatially associated within the same mapping unit.

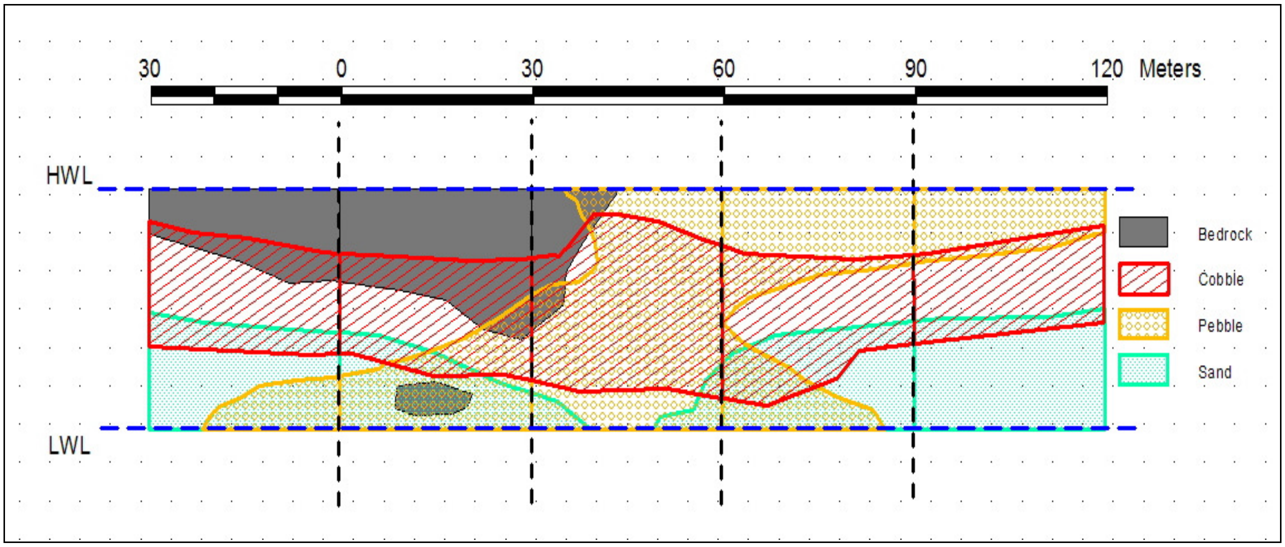


Figure 27. A hypothetical map of intertidal substrates, using the CMECS schema to independently map the extent of each of four substrate types. There are actually six polygons used to define the intertidal distribution of four substrates within the intertidal zone. Overlapping substrates create 18 unique units of various substrate combinations. Had the six CMECS cover categories also been included for each substrate, there would literally be hundreds of unique polygons of substrate.

This page intentionally left blank.

CORI has now worked with the CMECS classification system on two separate projects: a cross-walk of ShoreZone data to CMECS and an independent mapping project developed from field imagery using CMECS III; so we have considerable first-hand experience with the system for characterizing intertidal habitats. There are two fundamental aspects of CMECS that contribute significantly to complexity as a mapping system. These assumptions are:

1. the CMECS III system has been designed a scale-independent system.
2. data attributes within CMECS III may be independently mapped.

4.1 Scales of Mapping Systems

While the CMECS III classification system is considered scale-independent, as a mapping system, this goal may not be achievable. CMECS is intended to provide a *standard* for bringing together disparate projects by a wide range of agencies so that there is some coherency in mapping and that data from a state agency in one state could be combined with data from a federal agency in another state to manage an ecoregion that transcends state boundaries, for example. However, a disparity in mapping scales and mapping attributes is likely to inhibit the combination of such datasets; unless the two agencies have agreed on a set of common mapping scales and attributes, it is highly unlikely that the two datasets would be combined into a single system. So the goals of *coherency* and *scale-independence* may be incompatible.

If CMECS is refined further as a mapping system, it is suggested that a series of levels or standards be identified within the system and that mapping products indicate that they have been completed to a certain CMECS level. For example, Level I mapping might be completed to a mapping scale of 1:100,000 and completed to at least CMECS system level of classification. Level III might indicate a minimum mapping scale of 1:10,000 and be completed to at least a subclass level of classification. By providing a scale and attribute classification standard, datasets theoretically could be combined from a variety of mapping sources. Without such standards, it is unlikely that mapping products from different agencies could ever be seamlessly combined.

The tradeoff with defining “levels” or “standards” is the erosion of the scale-independence goal but there would be a gain in mapping coherency.

> *Recommendation – it would be useful for the CMECS III Standard Working Group to define a series of Levels within CMECS that would facilitate combination of mapping by different agencies. The definition of such levels would include a mapping scale and minimum list of CMECS attributes for each Level. This approach would allow separate mapping projects, conducted to a CMECS Level III standard for example, to be combined into a seamless coverage/dataset.*

4.2 Mapping of Attributes

Independent Resource Mapping

The CMECS III approach for mapping features is that each feature or attribute is independently mapped. This is in contrast to ShoreZone (Harney *et al* 2008) and the Green *et al* (1999, 2007) systems that delineate spatial map units based primarily on textural/geomorphic character (that is, something that can easily be seen on imagery). Other attributes, such as primary epiflora or primary epibenthos are then attached to those mapping units as attributes. This method of delineating spatial units (the *observational units* of CMECS III) greatly simplifies mapping and "cartographic overhead". Some precision in delineating resources may be lost with such an approach but the trade-off is that greater total extents of mapping can be realized for the same effort.

The CMECS III system does not explicitly indicate that all mapping layers must be independently mapped but it is implied within the suggested mapping approaches and examples. By using a single mapping unit and attaching attributes to the unit, the cartography of delineating a single set of map units is greatly simplified.

One of the principal objectives of any mapping system should be to improve management of coastal and marine resources. To be useful for management, it is important that maps be clear and data features obvious. In general, we find users more receptive to maps that incorporate a number of attributes into a single map unit. For example, - *an eelgrass-covered sand flat* or a *rock-platform with mussel-barnacles*. These aggregate descriptors provide some insight into the ecological function of the unit. CMECS refers to these as biotopes (see also Connor *et al* 2004), and they are frequently referred to as habitat units. Managers appreciate the visual picture provided by the aggregation of biota and substrate/morphology into a limited number types that are intuitively obvious. Independent mapping of resource data as prescribed by CMECS will require a GIS analyst to recombine data into these biotopes (e.g. see Fig. 27) and they may not always be intuitively obvious.

> *Recommendation: CMECS III should make a clear statement about how observational units can be defined (i.e., must observational units for each component layer be independent?). Other mapping approaches often use sediment texture, depth or geomorphic form to delineate observational units. Attribute data are then attached to those units to create benthic habitat maps. Such a mapping approach has the advantage of reducing cartographic overhead and is consistent with biotope mapping anticipatedb y (CMECS III, p. 48).*

CMECS Observational Units

The CMECS III report implies that all observational units must be polygons. There is no mention or examples of points or lines used as observational units. The ShoreZone system uses line segments as the basis for observational units, an approximation that takes advantage of the fact that shoreline units are usually narrow in comparison to their length. The approach of using line segments as an approximation of unit extent is easily displayed and widely accepted.

> *Recommendation: an explicit statement about the delineation of observational units with CMECS III would be helpful. All examples of observational units in CMECS III report show polygons, with the implication that polygons are the only acceptable unit representation (are lines and points acceptable?).*

4.3 Substrate Classification

There are several aspects of the CMECS III classification that provided challenges for mapping within Alaska, where virtually all the shorelines have been recently glaciated. Two of the most important issues are: (1) sediment distributions are very patchy with spatial extents often a few tens of meters and (2) surficial substrates are often dominated by coarse gravel (we use the Wentworth definition of gravel, which are clasts >2mm). Boulder-cobble-pebble beaches are common in all exposures within our pilot area.

Substrate Mixtures

Our analysis suggests that a significant amount of the spatial variation of substrate is not captured at the *Class* level of the SGC component. The comparison of the ShoreZone data and the CMECS data (e.g., Fig. 22, 23) illustrates this point. A substantial portion of the north Kruzof shoreline is a mixture of Rock and Unconsolidated substrates (Fig. 22; approximately 30%) but the CMECS classification criteria forces all the classes into either bedrock or unconsolidated (Fig. 23). These mixtures of substrate have very different ecological communities, and the significance of the ecological function may be misrepresented with CMECS at the SGC Class level. It may be challenging to capture this significance at subclass levels (e.g., Fig. 27).

> *Recommendation: the CMECS III Standards Working Group should consider an intermediate Class within the SGC to accommodate mixtures. For example adding a Mixture Class for units where bedrock cover is 20-80% and unconsolidated cover is 20-80%.*

Gravel Classifications

Probably the most common feature of glaciated shorelines is a boulder-cobble armor overlying bedrock or unconsolidated sands and gravels. Within our pilot shoreline area, 43% of the shoreline is mapped with gravel (boulder-cobble-pebble) within the intertidal zone. Depending on the exposure, some or all of the gravel may be considered mobile substrate (i.e., does not support epibenthos cover), which is critical to determination of ecological function. CMECS III includes 10 pages of discussion on unconsolidated sediments with virtually no mention of gravel in the unconsolidated sediment classification hierarchy. Given that the Alaska coast alone accounts for almost half of the total US coastline length, it is important to capture the gravel substrate within the CMECS III classification system at the *Subclass* and *Group* levels. The Folk (1968) classification system is one widely used system that incorporates gravel as a critical classification component. (Fig. 28).

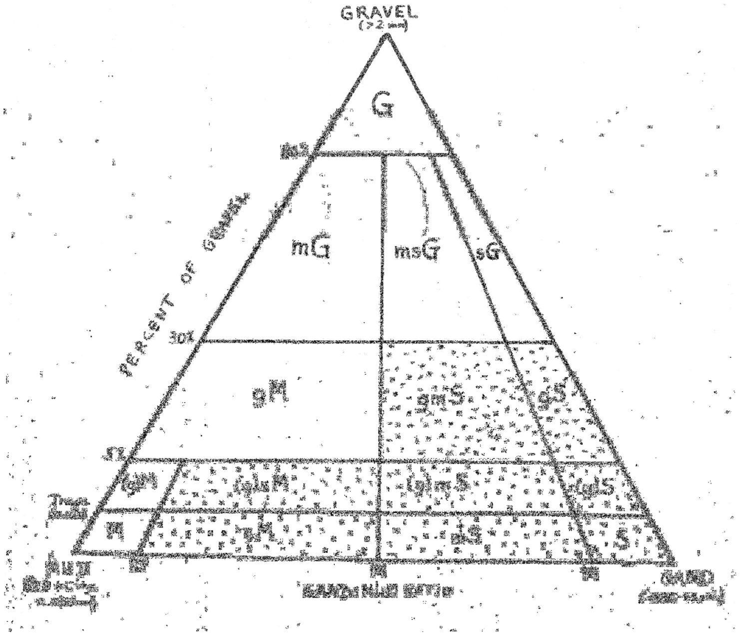


Figure 28. A classification rational for gravel-sand-mud from Folk (1968).

Recommendation: gravel (pebble-cobble-boulder) should be incorporated into the CMECS III classification at the Subclass and Group levels. Gravel is an important constituent of most glaciated-coastlines and is often a significant constituent of man-modified shorelines. Appropriate identification of gravel components is an important ecological determinant.

5.0 REFERENCES

Connor, D.W., J.H. Allen, N. Golding, K.L. Howell, L.N. Lieberknecht, K.O. Northen and J.B. Reker 2004. The marine classification for Britain and Ireland (Ver. 04.05). Joint Nature Conservation Committee, Peterborough, 49p. www.jncc.gov.uk/MarineHabitatClassification

Federal Geographic Data Committee (FGDC) 2010. Coastal and Marine Ecological Classification Standard Version III (Working Draft). Standards Working Group, Federal Geographic Data Committee, US Geological Survey, Reston, Virginia, FGDC Document Number XX, 233p.

Folk, R.L. 1968. Petrology of sedimentary rocks. Hemphills Publishing, Austin, Texas.170p.

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea, Jr. and G.M Caillet 1999. A classification scheme for deep seafloor habitats. Oceanolgia Acta 22(6): 663-678.

Greene, H.G., J.J. Bizzarro, V.M. O'Connell and C.K. Brylinski 2007. Constructions of a digital potential marine benthic habitat maps using a coded classification scheme and it applications. In B.J. Toff and H.G. Green (eds) Mapping the Seafloor for Habitat Characterization, Geological Association of Canada, Special Paper 47, p. 147-162.

Harney, J.N, M.C. Morris and J.R. Harper 2008. ShoreZone coastal mapping protocol for the Gulf of Alaska. Technical Report to NOAA National Marine Fisheries Service, Auk Bay Laboratory. Juneau, AK. 157 p. http://alaskafisheries.noaa.gov/habitat/shorezone/goa_protocol.pdf

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 National Marine Fisheries Service, NOAA, Juneau, Alaska, 50p.

Madden, C. J., K. Goodin, R.J. Allee, G. Cicchetti, C. Moses, M. Finkbeiner, and D. Bamford, 2009. Coastal and Marine Ecological Classification Standard. NOAA (Charleston, SC) and NatureServe (Arlington, VA), 107 p.