

Coastal and Marine Ecological Classification Standard (CMECS) Surface Geology and Geoform Components

Kathy Goodin, NatureServe
March 15, 2011





Outline

- Surface Geology Component
- Questions
- Geoform Component
- Questions
- Modifiers (if time)
- Discussion





Surface Geology Component (SGC)

Describes the geological composition and environment of

- the upper layer of the hard substrate
- the upper 15 cm of soft substrate
- structural (non-living) aspects of biogenic substrates such as coral reefs.

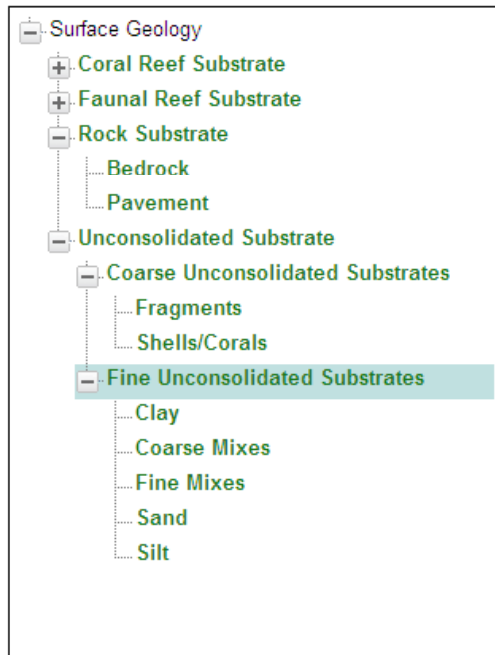




[Home](#) | [Search/Browse](#)

Surface Geology (SGC) Component

Drill down to browse hierarchy. Click link for description.



Search for

Refine Name Search by Level:

- ☐ **Class**
- ☐ **Subclass**
- ☐ **Group**
- ☐ **Biotope**

Website design and maintenance by [NatureServe](#) 



SGC Classes

- *Faunal Reef Substrate*
 - biogenic reef substrate formed by mollusks, polychaetes, or any fauna other than corals.
- *Coral Reef Substrate*
 - biogenic reef substrate formed by Corals
- *Rock Substrate*
 - >50% or greater cover of bedrock or pavement.
- *Unconsolidated Substrate*
 - <50% cover of bedrock or pavement.
Particles occurring at any range of size and composition.





Class Faunal Reef Substrate

- **Subclass: Mollusk Reef** – Consolidated structures built by mollusks, usually bivalves (e.g., oysters, mussels) or gastropods (e.g., vermetids)
 - Group: Fringing Reef
 - Group: Patch Reef
 - Group: Washed Shell
- **Subclass: Worm Reef** – Relatively stable ridge-like or mound-like aggregations formed by the colonization and growth of worm species (e.g., sabellariids).
 - Group: Fringing Reef
 - Group: Patch Reef





Coral Reef Substrate

Subclasses:

Reef Lagoon
Back Reef
Reef Flat
Reef Crest
Forereef
Deep Forereef
Pinnacle Reef
Mesophotic Reef
Deep Cold-Water Reef
Outlier Reef

Group=Reef Morphologies

Spur and Groove Reef
Patch Reef
Aggregate Patch Reef
Linear Reef
Aggregate Reef
Live Hardbottom
Live Hardbottom w' Sand Channels





Rock Substrate

- ***Subclass: Bedrock*** - Substrate with bedrock covering 50% or more of the surface.
- ***Subclass: Pavement***– Substrate has less than 50% aerial cover of bedrock, but pavement or flag alone or in combination with bedrock covers 50% or more of the area. Sand channels may or may not be present.





Unconsolidated Substrate

- Benthic substrates with less than 50% cover of bedrock or consolidated pavement.





Unconsolidated Substrate Subclasses

- **Coarse Unconsolidated Substrate** - 90% or more of the particles are 2 mm in diameter or larger, by volume.
(Groups: Shells/Corals and Fragments)
- **Fine Unconsolidated Substrate** – less than 90% of the particles are 2 mm in diameter or larger, by volume.
(Groups: Sand, Silt, Clay , Coarse Mixes, Fine Mixes,)





Coarse Unconsolidated Substrate Groups

- ***Shells/Corals*** – Surface layer in which over 90% of the total volume consists of particles larger than 2 mm, with 50% or more of these coarse particles (by volume) composed of shells or coral fragments.
- ***Fragments***– Surface layer in which over 90% of the total volume consists of particles larger than 2 mm, with 50% or more of these coarse particles (by volume) composed of rock fragments. (*Modifiers:* Pebble, Cobble, Stone, Boulder)





Fine Unconsolidated Substrate Groups

- **Sand**– Sediments composed of, in the fine particle fraction (< 2 mm), at least 75% sand-sized particles by weight. (modifiers: Very fine sand, Fine sand, Medium sand Coarse sand, Very coarse sand)
- **Silt**– Sediments that have, in the fine particle fraction (< 2 mm), less than 20% (by weight) sand sized particles and less than 35% (by weight) clay sized particles.
- **Clay**– Sediments that have, in the fine particle fraction (< 2 mm), 35% or more (by weight) clay sized particles.
- **Coarse Mixes**– Sediments composed of, in the fine particle fraction (< 2 mm), between 50 and 75% (by weight) coarser particles (0.05 to 2 mm) with $< 35\%$ clay (by weight).
- **Fine Mixes** – Sediments composed of, in the fine particle fraction (< 2 mm), between 50 and 75% (by weight) of mud-sized particles (< 0.05 mm) with $< 35\%$ clay (by weight).

Particle Size Challenges

	FINE EARTH										ROCK FRAGMENTS						150	380	600 mm				
											channers			flagst.	stones	boulders							
USDA FGDC-STD-006	Clay ²		Silt		Sand						Gravel			Cob- bles	Stones	Boulders							
	fine	co.	fine	co.	v.fi.	fi.	med.	co.	v.co.	fine	medium	coarse											
millimeters:	0.0002	.002 mm		.02	.05	.1	.25	.5	1	2 mm	5	20	76	250	600 mm								
U.S. Standard Sieve No. (opening):				300 ³	140	60	35	18	10	4	(3/4")	(3")	(10")	(25")									
Cowardin FGDC-STD-004	Mud				Sand						Gravel			Cob- bles	Stones	Boulders							
millimeters:					.074						2 mm			76	254	604 mm							
phi #:	12	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-12
Modified Wentworth ⁸	← clay →				← silt →				← sand →				← pebbles →				← cobbles →	← boulders →					
millimeters:					.002 .004 .008 .016 .031 .062 .125 .25 .5 1 2 mm				8 16 32 64					256	4092 mm								
U.S. Standard Sieve No.:					230 120 60 35 18 10 5																		



Where We Stand on Particle Sizes

Clay	< 0.002 mm	> 9 phi
Silt	0.05 to 0.002 mm	4.3 to 9 phi
Mud	< 0.05 mm	< 4.3 phi
Sand	0.05 to 2 mm	4.3 to -1 phi
(very fine sand)	0.05 to 0.10 mm	4.3 to 3.3 phi
(fine sand)	0.10 to 0.25 mm	3.3 to 2 phi
(medium sand)	0.25 to 0.5 mm	2 to 1 phi
(coarse sand)	0.5 to 1 mm	1 to 0 phi
(very coarse sand)	1 to 2 mm	0 to -1 phi
Pebble	2 to 76 mm	-1 to -6.2 phi
Cobble	76 to 250 mm	-6.2 to -8 phi
Stone	250 to 600 mm	-6 to -9.2 phi
Boulder	> 600 mm	< -9.2 phi

SGC Revisions Issues

- Reconsider using the Wentworth Scale for sediments
- Find a better solution for mud, muddy sand, sandy mud and sand that are based on ocular or tactile assessments.
- Consider moving the reefs to the GFC (or consolidating the SGC and GFC)

Questions?



Geoform Component (GFC)

- Describes the major geomorphic or structural characteristics of the coast and seafloor at various scales
- Initial list of Geoforms derived from Greene et al. 2007 with modifications
- Three subcomponents:
 - **Coastal Region** – Ecological regions based on Spalding
 - **Physiographic Setting** – major components of seafloor geomorphology along the continuum from the spreading center to the coast. (e.g., fracture zone, abyssal plain, continental rise, continental shelf).
 - **Geoform** - seafloor structures that range in size from 100's of kilometers to less than a meter (e.g., delta, embayment, channel).
 - **Anthropogenic** (berm, harbor, artificial reef).
 - **Coastal**
 - **Marine**

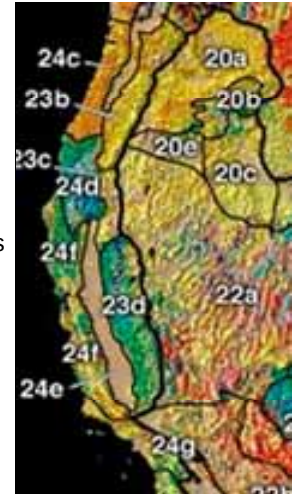




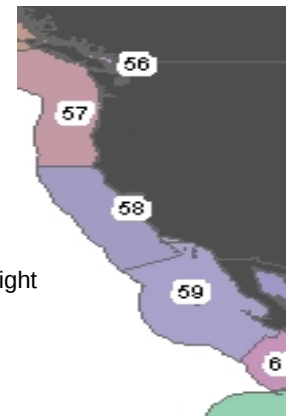
Coastal Region and Ecoregions

- Coastal Regions (USGS revision of Fenneman and Johnson 1946) provide coastal context for Geoforms
 - Based on coastal physiography and geography
- Ecoregions (Spalding et al, 2007) are provided as modifiers
 - Based on climate, physiography and biology

Klamouth Mountains
California Coast Ranges
Los Angeles Ranges
Lower California

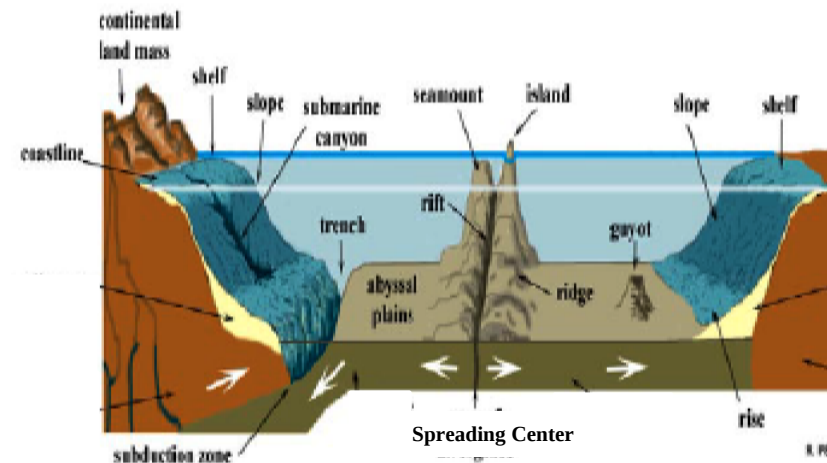


Northern California
Southern California Bight



Physiographic Setting

- Describes the broad geomorphology of the seafloor from the mid-ocean spreading center to the coast
 - Most the result of tectonic processes
 - Provide context for other units in GFC as well as other components
 - Very similar in scale and content to Greene et al. Megahabitats
 - Mappable at scales of 1:1,000,000 using bathymetry or remote sensing data.





[Home](#) | [Search/Browse](#)

GeoForm (GFC) Component

Drill down to browse hierarchy. Click link for description.



GFC Physiographic Setting

- [Abyssal plain](#)
- [Basin Floor](#)
- [Borderland](#)
- [Coast](#)
- [Continental/Island Rise](#)
- [Continental/Island Shelf](#)
- [Continental/Island Slope](#)
- [Fracture Zone/Spreading Center](#)
- [Inland/Enclosed Sea](#)
- [Mid-Ocean Ridge](#)
- [Ocean Bank/Plateau](#)
- [Shelf Break](#)
- [Trench](#)



Geoform

- Coastal and seafloor structures that range in size from hundreds of kilometers (bays, sounds & bights) to meters (tidepools)
- Provide structure, channel energy flows, regulate bioenergetics, control transfer rates of energy, material and organism
- Vertical structure and surface roughness is generally greater than one meter – otherwise SGC.
- Current version separates them into coastal and marine types for ease of maintaining the list.



[Home](#) | [Search/Browse](#)

GeoForm (GFC) Component

Drill down to browse hierarchy. Click link for description.

GFC Geoform

- [Alluvial Fan](#)
- [Apron](#)
- [Aquaculture](#)
- [Artificial Levee](#)
- [Artificial reef](#)
- [Atoll](#)
- [Bank](#)
- [Basin](#)
- [Bay/Embayment/Sound/Bight](#)
- [Beach](#)
- [Berm](#)
- [Boulder Field](#)
- [Channel](#)
- [Dam](#)
- [Delta](#)
- [Depression](#)
- [Dredge Deposit](#)
- [Drilling platform](#)
- [Dune](#)
- [Fan](#)
- [Fish Pond](#)
- [Fjord](#)

- [Flat](#)
- [Fracture](#)
- [Guyot](#)
- [Harbor](#)
- [Hole/Pit](#)
- [Inlet](#)
- [Jetty](#)
- [Knob](#)
- [Lagoon](#)
- [Landslide](#)
- [Lava field](#)
- [Ledge](#)
- [Marsh Platform](#)
- [Moraine](#)
- [Mound](#)
- [Natural Levee](#)
- [Overhang \(Cliff\)](#)
- [Panne](#)
- [Pier](#)
- [Pilings](#)
- [Pinnacle](#)
- [Ridge](#)
- [Rill](#)

- [Rock outcrop](#)
- [Rubble Field](#)
- [Salt Pond](#)
- [Sand/Sediment Wave Field](#)
- [Scar](#)
- [Scarp](#)
- [Seamount](#)
- [Seawall](#)
- [Shoal](#)
- [Slough](#)
- [Solution pit](#)
- [Submarine Canyon](#)
- [Swale](#)
- [Terrace](#)
- [Tidal creek](#)
- [Tidepool](#)
- [Trawl disturbance](#)
- [Vent](#)
- [Wall](#)



Anthropogenic Geoforms

- Artificial Structures are a significant part of the environment – for good or for bad
 - Provide habitat and shelter
 - Destroy or alter habitat and disrupt ecological processes
- Anthropogenic Geoform list includes the continually or intermittently submerged portions of these features.
- Size varies greatly and are applied at scales appropriate to their size.



[Home](#) | [Search/Browse](#)

GeoForm (GFC) Component

Anthropogenic Geoforms

Drill down to browse hierarchy. Click link for description.

GFC Geoform

- ... Alluvial Fan
- ... Apron
- ... **Aquaculture**
- ... **Artificial Levee**
- ... **Artificial reef**
- ... Atoll
- ... Bank
- ... Basin
- ... Bay/Embayment/Sound/Bight
- ... Beach
- ... **Berm**
- ... Boulder Field
- ... Channel
- ... **Dam**
- ... Delta
- ... Depression
- ... **Dredge Deposit**
- ... **Drilling platform**
- ... Dune
- ... Fan
- ... **Fish Pond**
- ... Fjord

- ... Flat
- ... Fracture
- ... Guyot
- ... **Harbor**
- ... Hole/Pit
- ... Inlet
- ... **Jetty**
- ... Knob
- ... Lagoon
- ... Landslide
- ... Lava field
- ... Ledge
- ... Marsh Platform
- ... Moraine
- ... Mound
- ... Natural Levee
- ... Overhang (Cliff)
- ... Panne
- ... **Pier**
- ... **Pilings**
- ... Pinnacle
- ... Ridge
- ... Rill

- ... **Pilings**
- ... Pinnacle
- ... Ridge
- ... Rill
- ... Rock outcrop
- ... Rubble Field
- ... Salt Pond
- ... Sand/Sediment Wave Field
- ... **Scar**
- ... Scarp
- ... Seamount
- ... **Seawall**
- ... Shoal
- ... Slough
- ... Solution pit
- ... Submarine Canyon
- ... Swale
- ... Terrace
- ... Tidal creek
- ... Tidepool
- ... **Trawl disturbance**
- ... Vent
- ... Wall

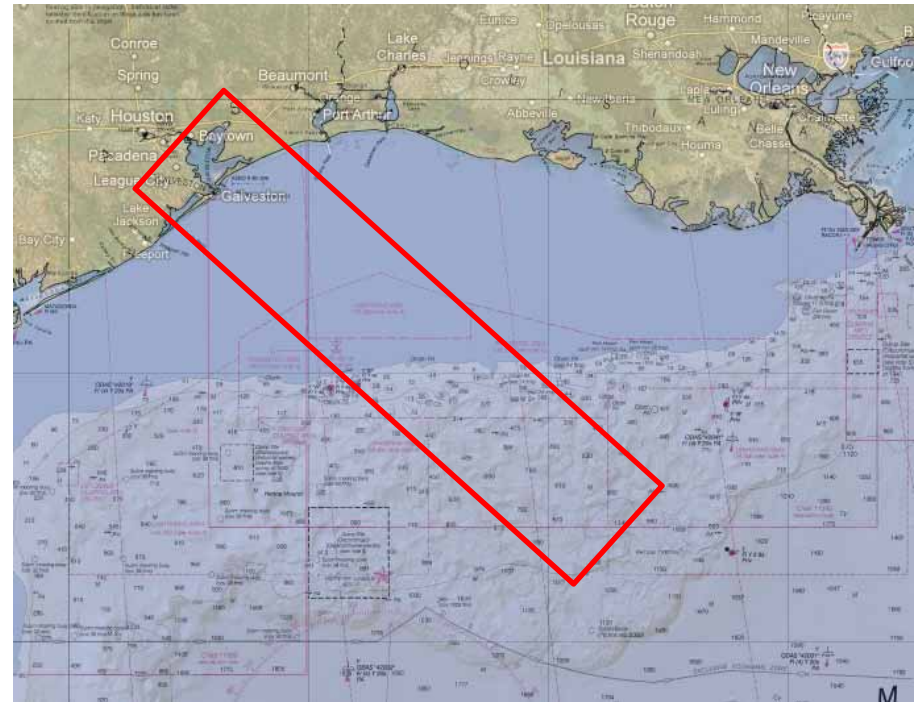


Relationship between CMECS and Greene et al. 2007

- Objectives are different
 - Greene et al., was developed as a mapping classification scheme – as a way of integrating and mapping seafloor characteristics to infer potential habitats. Prescribes map scales.
 - CMECS developed as an ecological classification and nomenclature with applications beyond mapping habitats. Not strictly a mapping classification, so map scales are user defined.
- Megahabitat (1st character) is similar to CMECS Physiographic Setting
 - mappable at the same scales
 - units vary somewhat
 - Like Greene et al., reported for all units as context, but not hierarchical.
- Induration (2nd character) relatable to SGC Classes
- Meso/Macrohabitat (3rd character) are akin to CMECS Geoforms
 - Started with the Greene et al list and added to it – grouping some of the nearly synonymous terms
- Modifiers (4th character) are distributed among the CMECS BBC and SGC - where hierarchical classifications account for refinement of conceptual scales.
- Seafloor slope (5th character) and Seafloor Rugosity (6th character) are CMECS modifiers.
- Observed large scale (directly sensed) geological and biological seafloor features are distributed among GFC geoforms, and lower levels or modifiers of the SGC, and BBC.

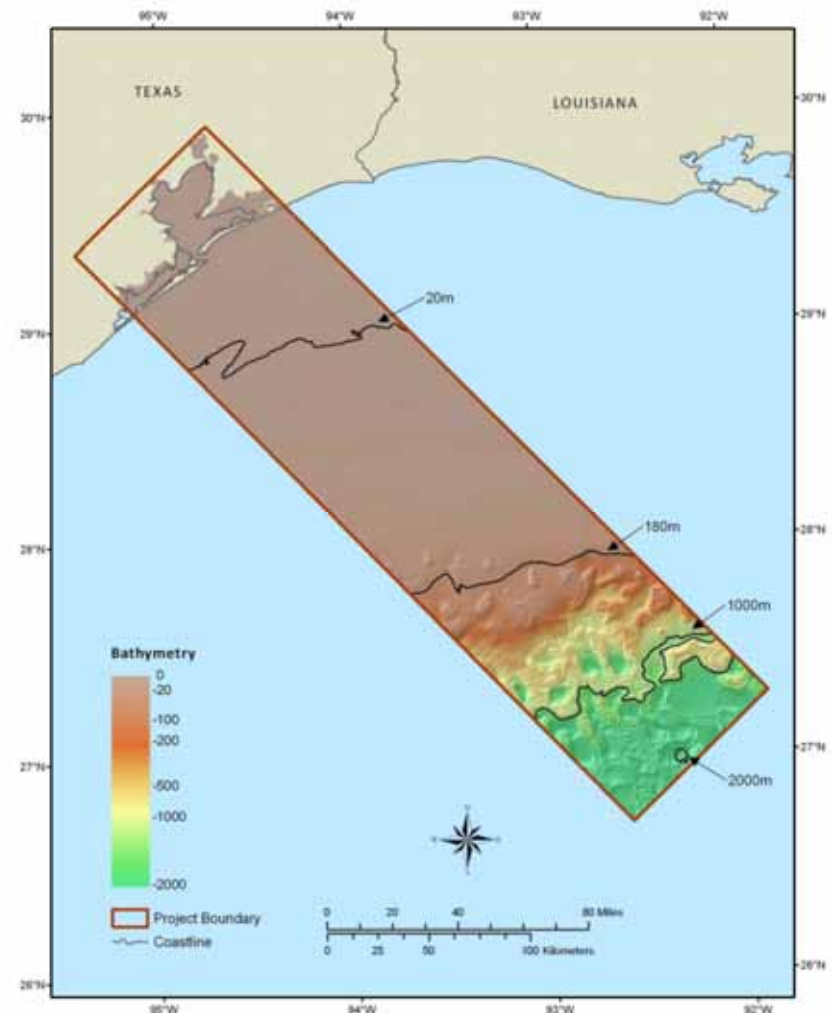
Piloting the GFC in the Gulf of Mexico

- “Bottom Up” pilot
- Both point and grid source data
- Quantitative methods
- Seabed form as proxy for habitat



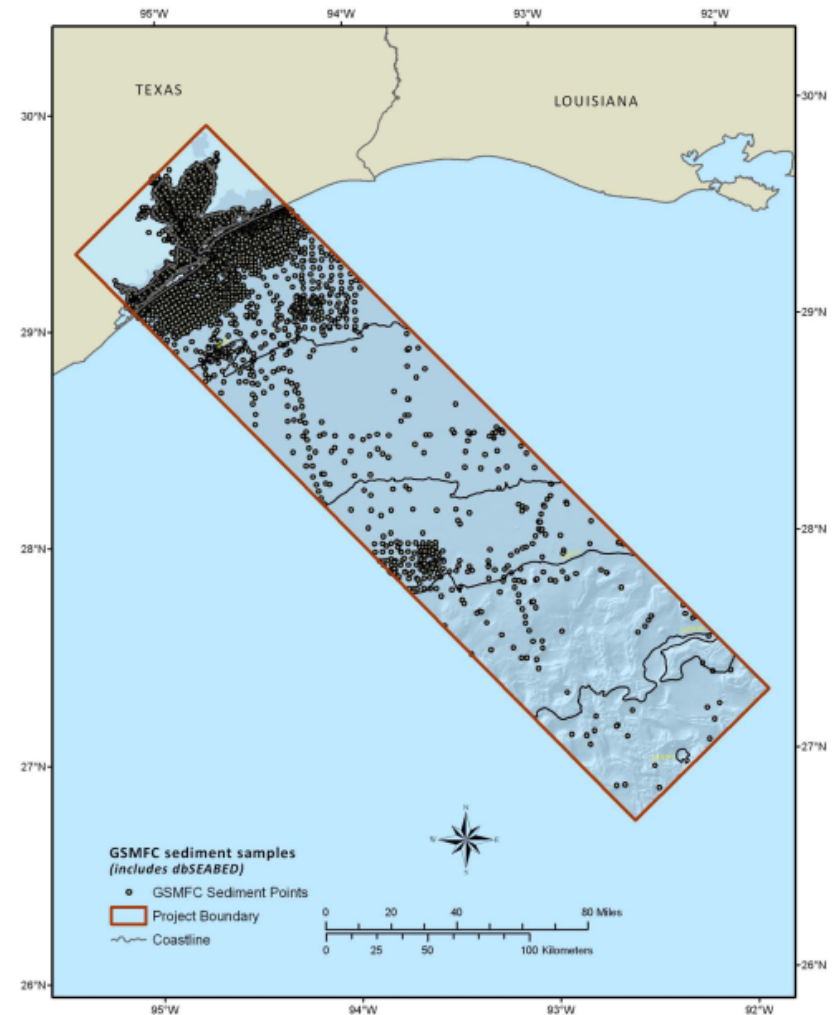
Bathymetry

- NOAA Coastal Relief Model
- Interpolated to ESRI grid



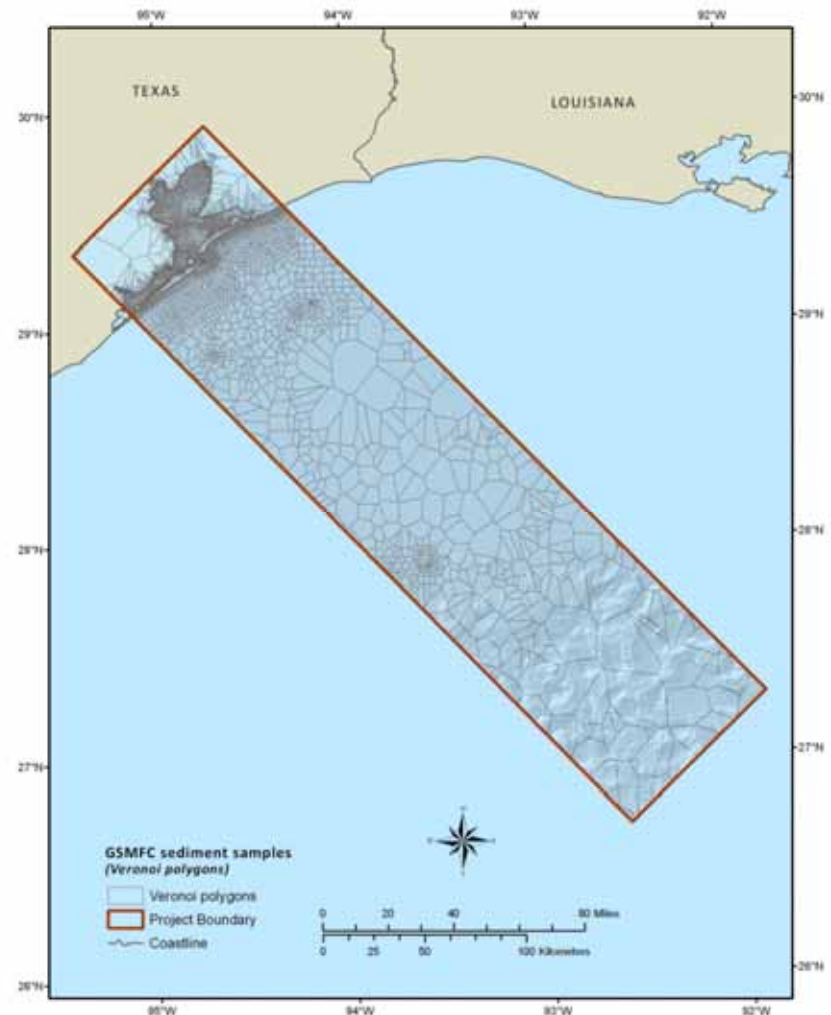
Sediment Data

- USSeabed database
- Grab samples
- Variable density



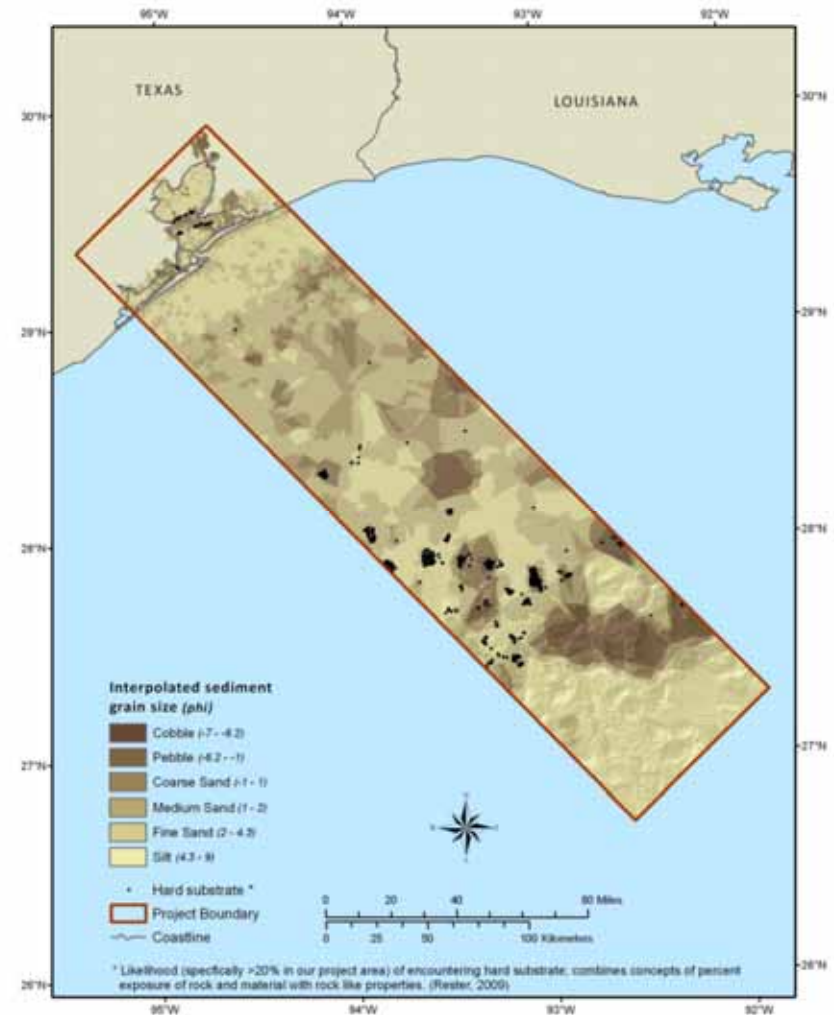
Data Integration

- Interpolation to grid
 - Voronoi polygons
 - Kriging to a raster



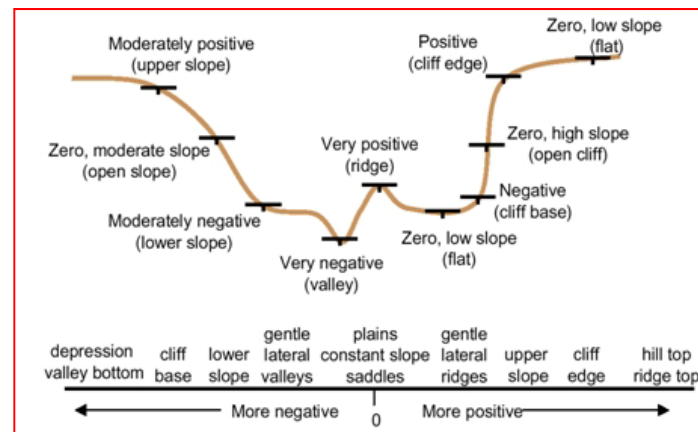
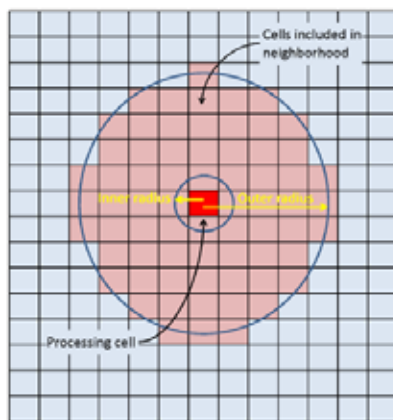
Data Integration

- Interpolation to grid
 - Voronoi polygons
 - Kriging to a raster



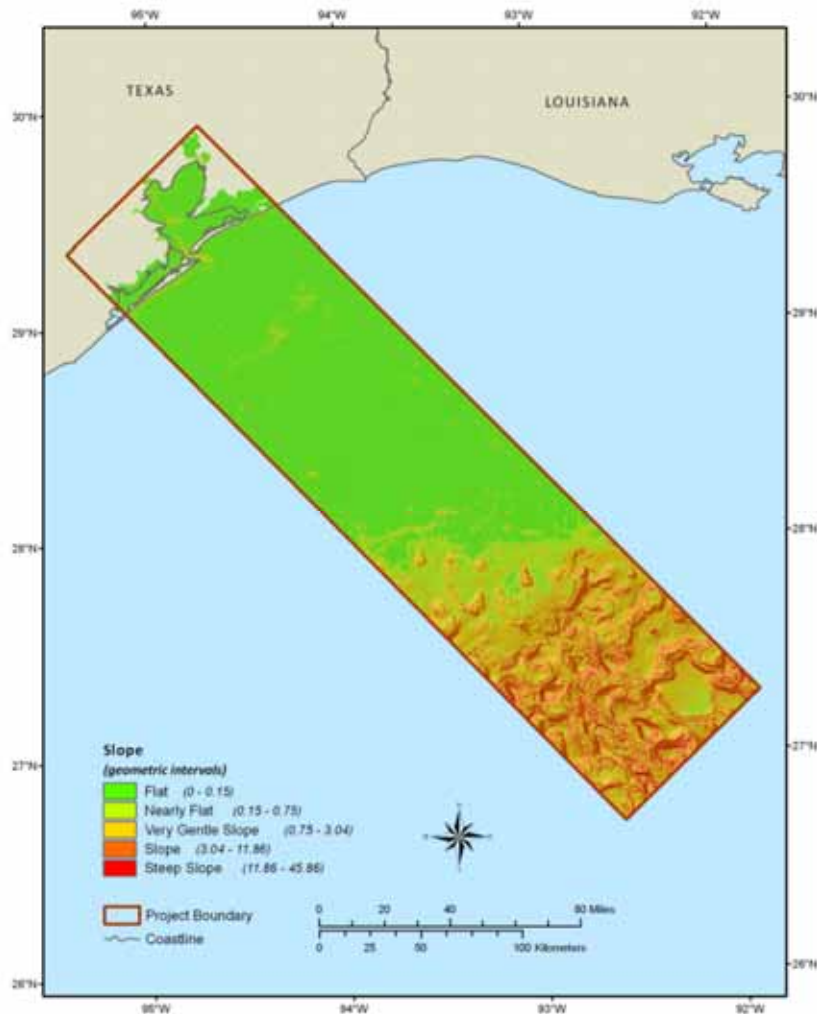
BPI/BTM Analysis

- Bathymetric Position Index – Broad and Fine Scale
- Standardized to mean = 0 and standard deviation = 1

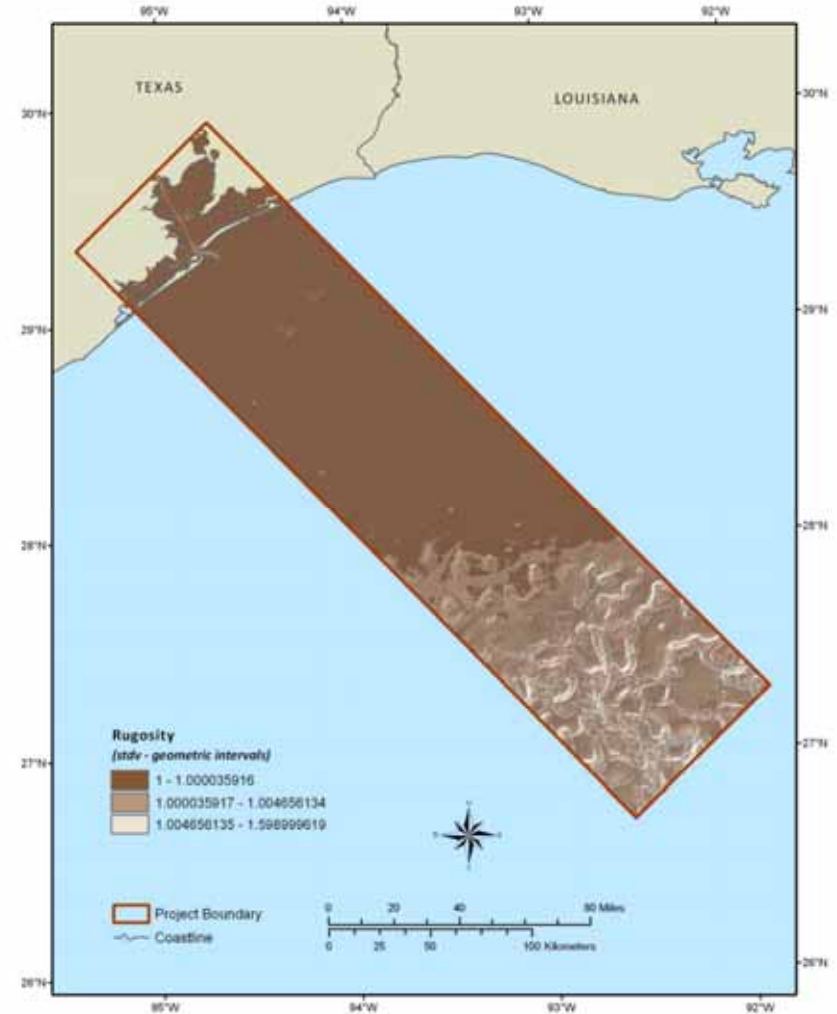


- Rugosity – Surface Area vs. Planimetric Area
- Standard deviation values

Habitat Proxies



Slope



Rugosity

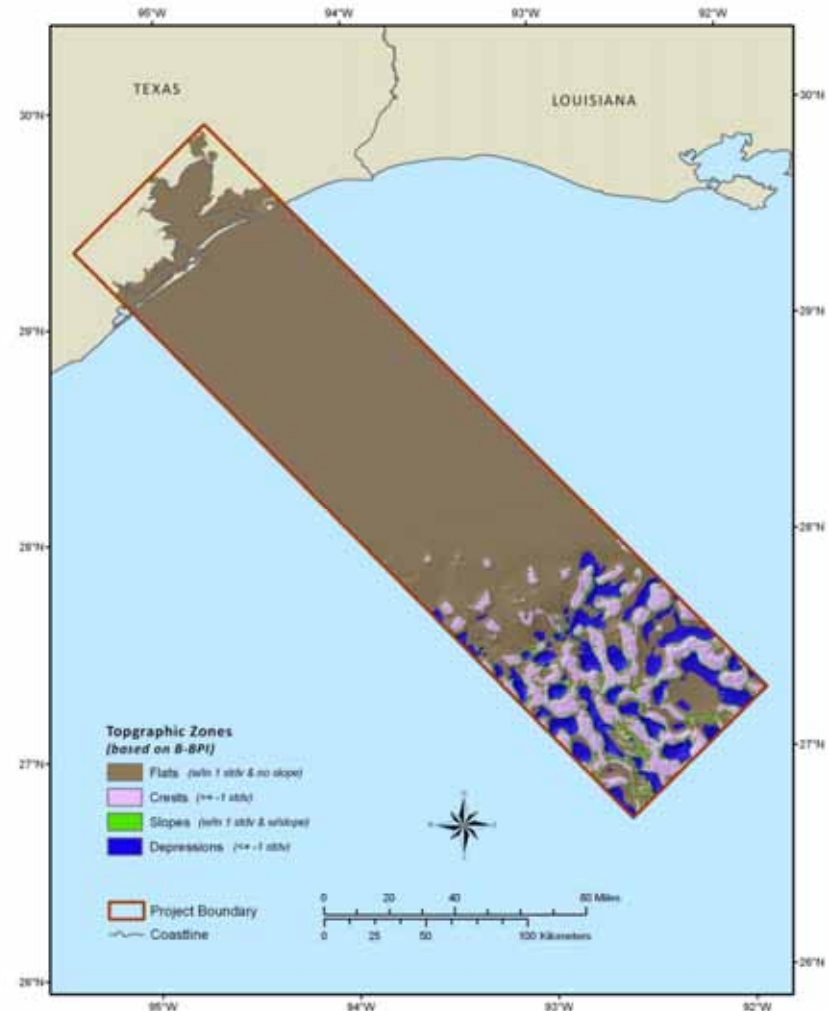
Cross-Walk to CMECS

Successes

- 8 GFC units translated reasonably

Challenges

- Units with context (mid-slope crest) did not translate
- Sediment data density still a challenge
- Rugosity modifier units may need more fine scale increments



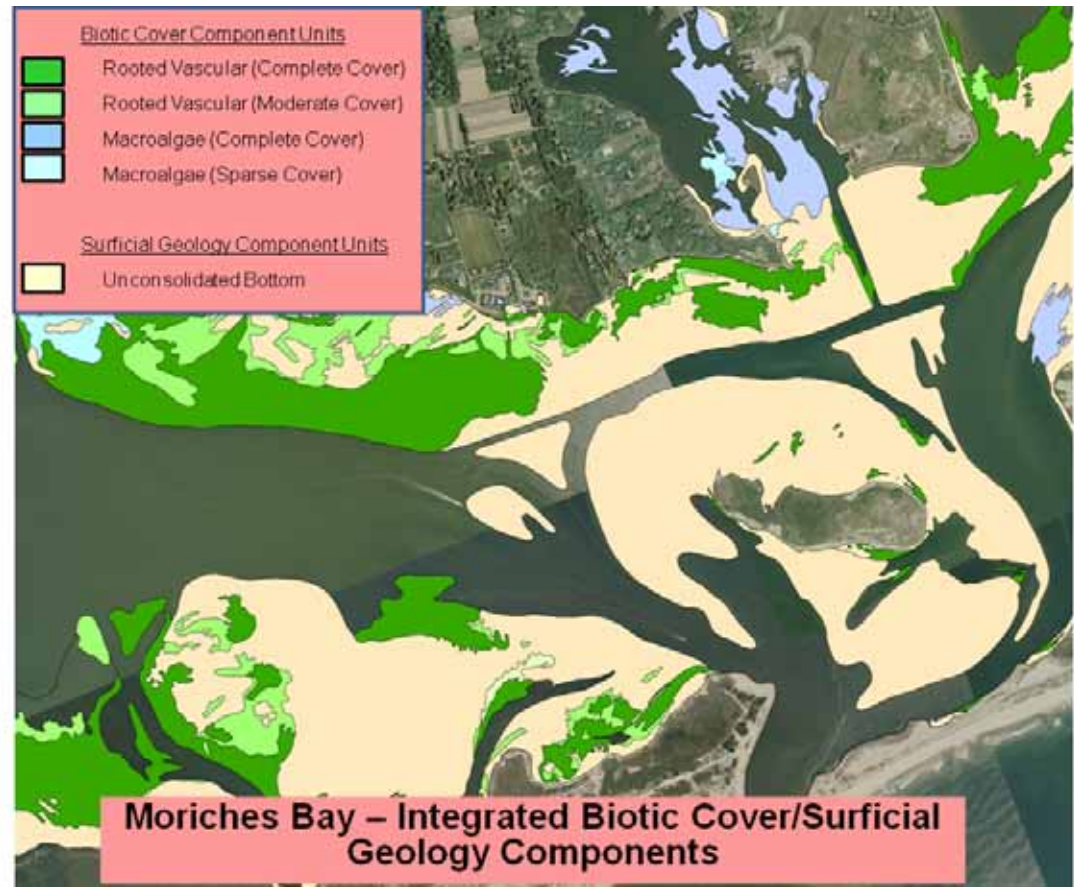
Questions?





Modifiers

- A consistent set of variables used to further describe a standard unit and allow users customize their application of the classification in a standardized way
- Examples:
 - Energy Level
 - Percent Cover
 - Slope
 - Rugosity



[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

[Anthropogenic](#)
[Biogeographic](#)
[Biological](#)
[Geological](#)
[Physical](#)
[Physio-chemical](#)
[Spatial](#)
[Temporal](#)

Biogeographic Modifiers

Modifier	Components
Ecological Region	all
<u>Primary Water Source</u>	BBC, WCC, GFC
Coastal Region	GFC

Primary Water Source Values

Modifier Value	Definition
Watershed	For flowing freshwater, the upstream watershed
Local Estuary Exchange	Tidal exchange that is primarily estuarine water
Local Ocean Exchange	Tidal exchange that is primarily marine water
River	Tidal exchange or plume flow that is primarily river water
Estuary	Plume flow that is from the estuary
Marine	Unidirectional flow that is primarily marine

[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

Anthropogenic
Biogeographic
Biological
Geological
Physical
Physio-chemical
Spatial
Temporal

Biological Modifiers

Modifier	Components
Associated Species	BBC
Terrestrial/Wetland Biogenic Origin	SBC
Aquatic Biogenic Origin	SBC
Community Stage	SGC, SBC
Organism Mobility	BBC Class Faunal Bed, Subclass Epifauna
Organism Size	BBC Faunal Bed Class

Website design and maintenance by [NatureServe](#) 

[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

[Anthropogenic](#)
[Biogeographic](#)
[Biological](#)
[Geological](#)
[Physical](#)
[Physio-chemical](#)
[Spatial](#)
[Temporal](#)

Geological Modifiers

Modifier	Components
Rugosity	SGC, BBC, GFC
Sediment and Soils Secondary Elements	SGC, SBC surface layer
Sediment and Soil Composition	SGC
<u>Subgeoform</u>	GFC

Subgeoform Values

Modifier Value	Definition
Head	
Mouth	
Floor	
Base	
Top	
Crown	
Flank	
Crest	
Edge	
Side	

[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

[Anthropogenic](#)
[Biogeographic](#)
[Biological](#)
[Geological](#)
[Physical](#)
[Physio-chemical](#)
[Spatial](#)
[Temporal](#)

Physical Modifiers

Modifier	Components
Energy Direction	WCC
Energy Intensity Regime	SGC, BBC, GFC, WCC
Energy Type	GFC, WCC
Temperature	WCC

Energy Intensity Regime Values

Modifier Value	Definition
Very Low Energy	Area experiences little wave or current motion under most conditions
Low Energy	Area typically experiences very weak currents (0 to 1 knots) and only gentle wave action
Moderate Energy	Area regularly experiences significant wind waves or moderate tidal currents (1 to 3 knots)
High Energy	Area regularly experiences strong currents (> 3 knots), large oceanic swells, or breaking waves

Website design and maintenance by [NatureServe](#) 

[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

Anthropogenic
Biogeographic
Biological
Geological
Physical
Physio-chemical
Spatial
Temporal

Physio-chemical Modifiers

Modifier	Components
Light Attenuation Agent	WCC
Light Attenuator Provenance	WCC
Oxygen Regime	WCC
Photic Quality	WCC
Phytoplankton Productivity	WCC
Macrovegetation Productivity	BBC
apparent Redox Potential Discontinuity	SGC
Surface Layer Composition and Texture	SBC
Turbidity	WCC
Turbidity Type	WCC
Turbidity Provenance	WCC

Oxygen Regime Values

Modifier Value	Definition
Anoxic	0 - 0.1 mg/L
Severely Hypoxic	0.1 - 2.0 mg/L
Hypoxic	2.0 - 4 mg/L
Oxic	4 - 10 mg/L
Oxygen Saturated	10 - 12 mg/L
Oxygen Supersaturated	>12 mg/L

[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

[Anthropogenic](#)
[Biogeographic](#)
[Biological](#)
[Geological](#)
[Physical](#)
[Physio-chemical](#)
[Spatial](#)
[Temporal](#)

Spatial Modifiers

Modifier	Components
Benthic Depth Zones	SGC, BBC, GFC
Enclosure	SGC, GFC
Percent Cover	BBC, SBC, SGC
Position Relative to Shelf Break	
Elevation Profile	SGC, BBC, GFC
Slope	SGC, BBC, GFC
Surface Pattern	SGC
Tidal Range	SGC, GFC and BBC

Slope Values

Modifier Value	Definition
Flat	0 - 5° vertical angle
Sloping	5 - 30° vertical angle
Steeply Sloping	30 - 45° vertical angle
Vertical	45 - 90° vertical angle
Overhang	>90° vertical angle

Website design and maintenance by [Nature Serve](#) 



[Home](#) | [Search/Browse](#)

Modifiers

Modifier Types

Anthropogenic
Biogeographic
Biological
Geological
Physical
Physio-chemical
Spatial
Temporal

Temporal Modifiers

Modifier	Components
Temporal Persistence	SGC, BBC, GFC and WCC

Temporal Persistence Values

Modifier Value	Definition
Stochastic	
Hours	
Days	
Weeks	
Months	
Seasons	
Years	
Inter-annual	
Decades	
Centuries	