COASTAL AND MARINE SYSTEMS
OF
NORTH AMERICA

FRAMEWORK FOR AN ECOLOGICAL CLASSIFICATION STANDARD: VERSION II

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This document is a revision of the CMECS classification produced in 2004 (Madden and Grossman, 2004) incorporating recommendations from several outside reviewers. The viewpoints in this publication are those of NatureServe and may not necessarily reflect the views of NOAA.

NatureServe
1101 Wilson Boulevard, 15th Floor
Arlington, VA 22209
703-908-1800
www.natureserve.org

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Christopher J. Madden
Dennis H. Grossman
Kathleen L. Goodin

Collaborating Authors

Megan Dethier
Kathleen Sullivan Sealey
James Maragos
Rebecca J. Allee
Tom Hourigan
Stephen K. Brown
Dail Brown
Jonathan Higgins
Mark Costello
Kristin Snow
Carleton Ray
Pace Wilber
Michael Beck

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Workshop Participants

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Becky Allee
Program Advisor, NOAA
Silver Spring, MD
becky.allee@noaa.gov

Peter Auster
Science Director, National Undersea Research Center
University of Connecticut at Avery Point
Groton, CT
auster@uconnvm.uconn.edu

Dail Brown
Division Chief - Ecosystem Assessment/NMFS
Silver Spring, MD
dail.brown@noaa.gov

Mark Costello
The Huntsman Marine Science Centre
St. Andrews, New Brunswick, Canada
costello@huntsmanmarine.ca

Megan Dethier
Research Associate Professor, Zoology
University of Washington and Friday Harbor Labs
Friday Harbor, WA
mdethier@u.washington.edu

Bob Diaz
Virginia Institute of Marine Science
Gloucester, VA
diaz@vims.edu

Mark Finkbeiner
NOAA/CSC
Charleston, SC
mark.finkbeiner@noaa.gov

Fred Grassle
Director, Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, NJ
grassle@imcs.rutgers.edu

Gary Greene
Moss Landing Marine Laboratories
Moss Landing, CA
greene@mlml.calstate.edul

Denny Grossman
Vice President for Science
NatureServe
Arlington, VA
dgrossman@natureserve.org

John B. Heiser
Department of Ecology and Evolutionary Biology
Cornell University
Ithaca, NY
jbh7@cornell.edu

Jonathan Higgins
Senior Freshwater Ecologist
The Nature Conservancy
Chicago, IL
jhiggins@tnc.org

Tom Hourigan
Biodiversity Coordinator, NOAA
Silver Spring, MD
tom.hourigan@noaa.gov

Brenda Konar
Assistant Professor
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, Alaska
bkonar@ims.uaf.edu

Beth Lumsden
Coral Reef Program Manager, NOAA
Silver Spring, MD
beth.lumsden@noaa.gov

Christopher J. Madden
Senior Coastal Marine Ecologist
NatureServe
Arlington, VA
christopher_madden@natureserve.org

Jim Maragos
Coral Reef Biologist & Field Dive Officer
Pacific/Remote Islands National Wildlife Refuge Complex
U.S. Fish and Wildlife Service
Honolulu, HI
jim_maragos@fws.gov

Daniel Miller
Habitat Restoration Coordinator
Hudson River National Estuarine Research Reserve
Annadale, NY
demiller@gw.dec.state.ny.us

Mark Monaco
Manager - Biogeography Program, NOAA
Silver Spring, MD
mmonaco@seamail.nos.noaa.gov

Pete Parker
NMFS Beaufort Lab
Beaufort, NC
Pete.Parker@noaa.gov

Carleton Ray
Research Professor
Department of Environmental Sciences
University of Virginia
Charlottesville, VA
cr@virginia.edu

Phil Roni
Watershed Program Manager
National Marine Fisheries Services
Seattle, WA
phil.roni@noaa.gov

Bill Sargent
Florida Marine Research Institute
Florida Marine Conservation Community
St. Petersburg, FL
bill.sargent@fwc.state.fl.us

Carl Shoch
Kachemak Bay Research Preserve
Homer, AK
carl_schoch@fishgame.state.ak.us

Kathleen Sullivan Sealey
Associate Professor, Department of Biology
University of Miami
Coral Gables, FL
ksealy@miami.edu

Ken Sherman
Director, Office of Marine Ecosystems Studies
UDOC/NOAA National Marine Fisheries Service
Narraganset Laboratory
Narraganset, RI
kenneth.sherman@noaa.gov

Saundra Upchurch
ACE Basin National Estuarine Research Reserve
Charleston, SC
upchurchs@mrd.dnr.state.sc.us

Erik Van Dyke
Geographical Ecologist
Elkhorn Slough National Estuarine Research Reserve
Watsonville, CA
vandyke@elkhornslough.org

Betty Wenner
Marine Resources Research Institute
Charleston, SC
wennere@mrd.dnr.state.sc.us

Pace Wilber
NOAA Coastal Services Center
Charleston, SC
pace.wilber@noaa.gov

Nancy Wright
Department of Fish & Wildlife Resources
University of Idaho
Moscow, ID
nwright@uidaho.edu

Mark Zacharias
Assistant Professor, Environmental Science and
Resource Management
California State University Channel Islands
Camarillo, CA
mark.zacharias@csuci.edu

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Executive Summary

Coastal and marine planners and managers are faced with a complex environment in which to make difficult decisions about habitat conservation and resource management. There is an urgent and increasing need for a habitat classification system that can be used to develop strategies for coastal and ocean resource management and for evaluating conservation priorities. In recent decades, a variety of coastal classifications have been developed to describe local or regional ecological systems and address local objectives. The conservation and resource management community has recognized a strong need for a single classification standard that is relevant to all U.S. coastal and marine environments and that can be applied on local, regional and continental scales. This need has prompted NatureServe to develop a standard ecological classification system that is universally applicable for coastal and marine systems.

The framework for a Coastal and Marine Ecological Classification Standard (CMECS) was developed to meet this challenge. The classification is a framework for organizing knowledge about coasts and oceans and their living systems. It provides a structure for synthesizing data so that habitats can be characterized and reported in a standard way, and information can be aggregated and evaluated across the national landscape and seascape. Built on existing classification efforts and informed by a series of technical meetings and workshops, the CMECS framework integrates the current state of knowledge about ecological and habitat classification. The result is an ecosystem-oriented, science-based framework for the identification, inventory, and description of coastal and marine habitats and biodiversity.

A few of the many potential applications of the classification include:

- Development of a coastal marine biodiversity inventory for North America.
- Delineation of regions for Marine Protected Areas and developing guidelines for their management.
- Identification of important habitats and critical hotspots for conservation.
- Identification of Essential Fish Habitat.
- Forming a scientific basis for the development, implementation and monitoring of ecosystem-based. management strategies for coastal systems.

The CMECS framework is applicable on spatial scales of less than one square meter to thousands of square kilometers and can be used in littoral, benthic and pelagic zones of estuarine, coastal and open ocean systems. The hierarchical framework contains six nested levels; each containing clearly defined classes and units. Linkages between levels of the hierarchy are defined by ecosystem processes and by spatial relationships. The classification framework is based on simple sets of rules and is designed to be easy to use. The hierarchy uses the following structure:

Level 1 / Regime: differentiated by a combination of salinity, geomorphology and depth.
Level 2 / Formation: large physical structures formed by either water or solid substrate within systems.
Level 3 / Zone: the water column, littoral or sea bottom.
Level 4 / Macrohabitat: large physical structures that contain multiple habitats.
Level 5 / Habitat: a specific combination of physical and energy characteristics that creates a suitable place for colonization or use by biota.
Level 6 / Biotope: the characteristic biology associated with a specific habitat.

The CMECS is designed to provide a framework for developing a consistent and universally recognized inventory of all habitats of the North American coasts and oceans. The flexibility of this classification will support a variety of local and regional applications. This document provides a standard for identifying and naming both new and existing types. Although numerous habitat type descriptions are included in this report, it is not meant to provide a comprehensive list of all coastal types and classification units at the finer levels, and it is not a translator for existing data, classification units or systems. The majority of upper level types are described here, though additional classes will likely be identified as the classification is applied, particularly in new geographic areas. Approximately 30 % of the finer level habitats for North America are named. Population of the classification framework with data from a variety of coastal and marine ecosystems, following a standardized, rigorous methodology, will lead to development of a robust national database of coastal and marine habitats and associated biology.

A working draft of the classification, including the catalogue of currently defined units, is available on the NatureServe website (www.natureserve.org/getData/CMECS).

Introduction

This report describes a conceptual model and an associated classification framework for a Coastal and Marine Ecological Classification Standard (CMECS) that includes the estuaries, coasts and oceans of North America. The CMECS framework applies a uniform set of classification rules that function at multiple scales and across a great diversity of environments and habitats in all climatic, geologic and biogeographic regions of the continent. The scope of the classification framework extends from the head-of-tides in the coastal zone to the deep ocean. This encompasses estuaries, wetlands, rivers, shorelines, islands, the intertidal zone, the entire benthic zone, and the entire water column from the coast to the deep ocean. The classification was developed to allow effective identification, monitoring, protection, and restoration of unique biotic assemblages, protected species, critical habitat, and important ecosystem components.

This document provides a standard for identifying and naming both new and existing types. Although numerous habitat descriptions are included in this report, it is not meant to provide a comprehensive list of all coastal types and classification units at the finer levels, nor is it a translator for existing data, classification units or systems. The majority of upper level types are described here, though additional classes will likely be identified as the classification is applied, particularly in new geographic areas. Approximately 30% of the finer level habitats for North America are named, with the remainder to be identified and classified through various applications of this framework. A working draft of the classification, including the catalogue of currently defined units, is available in a searchable format on the NatureServe website (www.natureserve.org/getData/CMECS).

This product is the result of ongoing collaboration with scientific and management experts, and is based on recommendations from workshops conducted in Marathon, Florida in 1999 (Allee et. al. 2000), and Charleston, South Carolina, in March 2003 (Madden et al. 2003). This document is a revision of the CMECS classification produced in 2004 (Madden and Grossman, 2004) incorporating recommendations from several outside reviewers.

Guiding Principles

A goal of the CMECS classification is to integrate both existing data and ongoing data collection efforts to ensure that existing data and knowledge are reflected in the standard. Most existing classification systems have been developed for regional or local applications. The operative scales of these classifications, from tens of meters to thousands of meters, reflect the scale at which many state agencies monitor and manage resources. These local and regional classifications do not readily support the comparison of results across different systems, habitats and classifications. A national to global classification standard must incorporate the knowledge provided by local classifications and allow aggregation and assessment of diverse systems on a continental scale. Few continental-scale classifications currently exist. Examples include the EUNIS system in Europe (EEA 1999), the IMCRA for Australia (IMCRA 1998), the Classification of Wetlands and Deepwater Habitats of the U.S. (Cowardin, 1979) and the NOAA classification draft (Allee et al. 2002). The CMECS classification integrates existing classifications, types, methodologies, and definitions to the extent possible, to create strong links to these existing typologies.

The CMECS classification was designed to be applied at different scales to address different objectives. For example, a federal management agency seeking to identify and catalog all large estuaries in North America can restrict its analysis to the upper three levels of the classification hierarchy. A local agency classifying habitats within a single estuary may want to use the bottom two or three levels of the classification. Using CMECS as a common standard, both agencies will be able to organize and compare results using a unified vocabulary within a common and interoperable data framework. The framework provides the end-user with the tools to build the bottom levels of habitat and biology into the larger conceptual framework and into the database catalog of types.

The following set of guiding principles helped to guide the development of this CMECS standard:

Biophysical Classification

The classification for coastal and marine habitats identifies and categorizes the physical environment at different spatial scales in estuarine, coastal and marine regimes, and places the associated biology in the context of the physical habitat. Species and biological associations are attributed to different levels of the hierarchy depending on their size, the spatial scale of their distribution and movements, and their relationship with the physical landscape.

Geographic and Ecological Bounds

The classification is focused on North America and is applicable over large areas and a wide diversity of types, ranging from the coastal landscape to the marine seascape. The classification is three-dimensional, covering surface, water column and benthic features. The classification extends from the head of tides and/or the most inland encroachment of salinity to the deep oceans and is applicable to all tidal and/or saline wetland, estuarine, coastal, nearshore marine, neritic and oceanic systems.

Building on Existing Work

The classification incorporates or articulates with existing coastal and marine classifications as appropriate. Concepts, units and definitions from other classification frameworks provide the basis for this effort.

Relation to Terrestrial and Freshwater Standards

The classification has clearly defined "seams" where it will articulate with existing terrestrial (Grossman et al. 1998) and freshwater (Higgins et al. 1998) classification standards.

Hierarchy and Spatial Scale

The classification follows a progressive spatial scale from large units in the upper levels of the hierarchy to smaller units in the lower levels. All of the elements mapped at one level spatially sum to the next-higher level. The scale addressed by this classification ranges from <1m to 10^3 km linearly and 1 m^2 areally to 10^5 km^2 in area. A range of spatial scales is reported for each level as a criterion for the identification and classification of types.

Physical-Ecological Relationships

The classification describes and accounts for the mechanisms by which ecological relationships are shaped by physical factors.

Measurable and Repeatable Units

Each classification unit represents a measurable (mapped) space and can be ascribed to a specific place in the marine realm with defined geographic boundaries.

Uniqueness of Classification Units

Similar units found within different branches of the classification framework represent two different and distinct coastal habitat types.

Nomenclature and Terminology

The classification follows a rigorous set of nomenclature rules that is designed to constrain the meanings of classes and elements, to resolve ambiguous concepts and terms, and to firmly establish the exact definitions of terms and metrics. A glossary of terms representing the official classification nomenclature is an integral part of the classification standard. Universally recognizable and accepted terms for classification descriptors are used, and they replace or translate local vernacular or popular usages. The glossary is available online at www.natureserve.org/getData/CMECS.

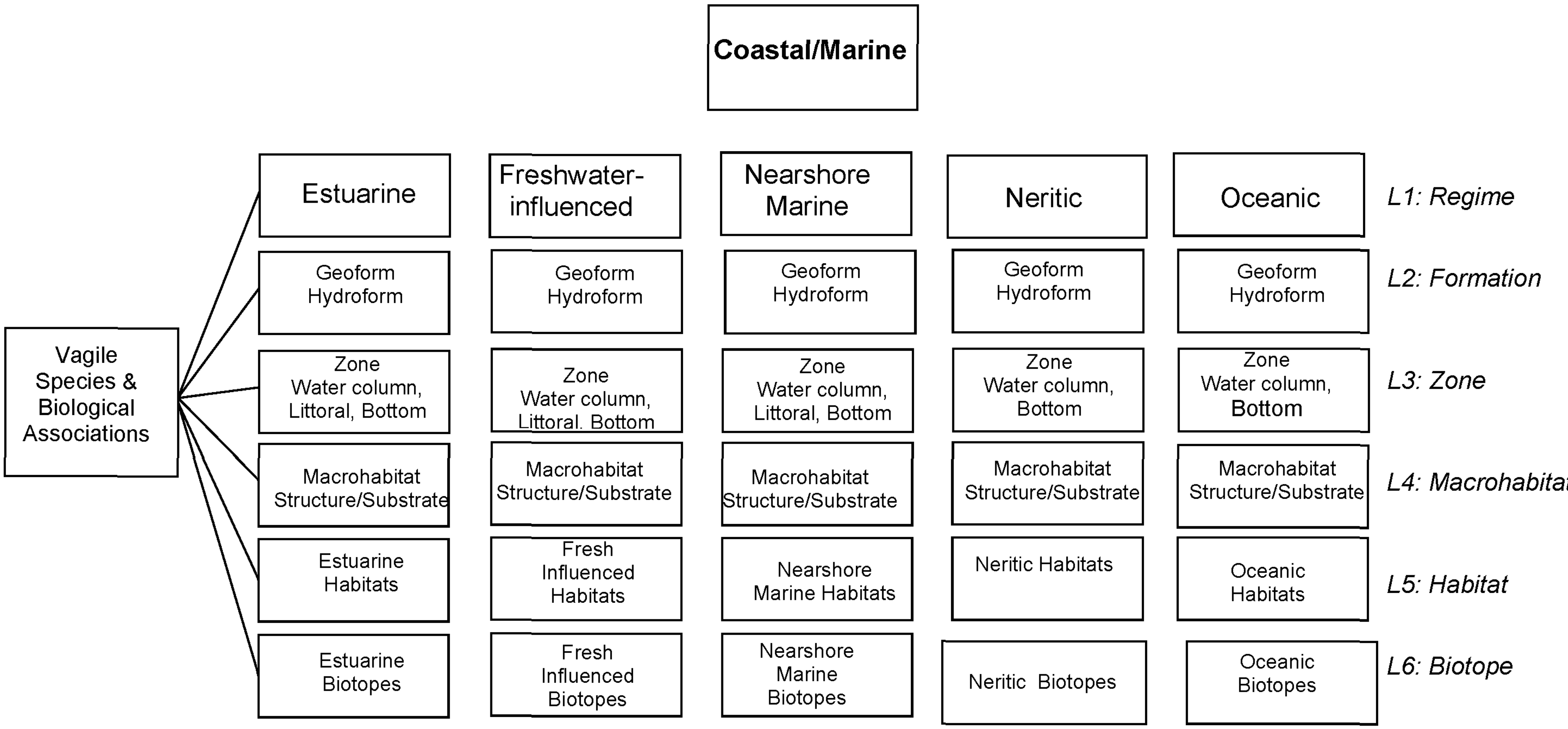
Accommodating Change and Growth

The classification structure, unit catalog, database and definitions will grow and evolve with use of the classification and associated development of new information. A formal mechanism will be established for submitting new terms, units, definitions, concepts or metric for review and acceptance into the classification.

The Classification Hierarchy

The classification for coastal and marine habitats identifies and categorizes the physical environment at different spatial scales in estuarine, coastal and marine regimes, and places the associated biology in the context of the physical habitat. The classification standard is organized into a branched hierarchy of six nested levels (Figure 1). The levels correspond to both a functional ecological relationships and a progressively smaller map scale from the order of 1:1,000,000 (Regime) to the order of 1:1 (Habitat/Biotope). The classification branches into five **Regimes** at the highest level: estuarine, freshwater-influenced marine, nearshore marine, neritic, and oceanic. Regimes are divided into large-scale physical structures, including geoforms and hydroforms called **Formations**. Each of these forms can be further compartmentalized according to its **Zone,** or position relative to the water: whether it is continuously submerged bottom or at the waterline (littoral), or within the water column. Each of these components further divides into **Macrohabitat** and then **Habitat**. The **Biotope** represents the quantum unit of the habitat combining both the physical habitat and its associated fixed biota. At each level, units are distinguished from each other by the application of classifiers that capture the defining differences among units. The classifiers are integral components of all levels of the classification; particularly the Habitat and Biotope levels that further define units based on such qualities as substrate, energy, salinity, turbidity or characteristic structural components.

Figure 1. Overview of the hierarchy of the CMECS classification

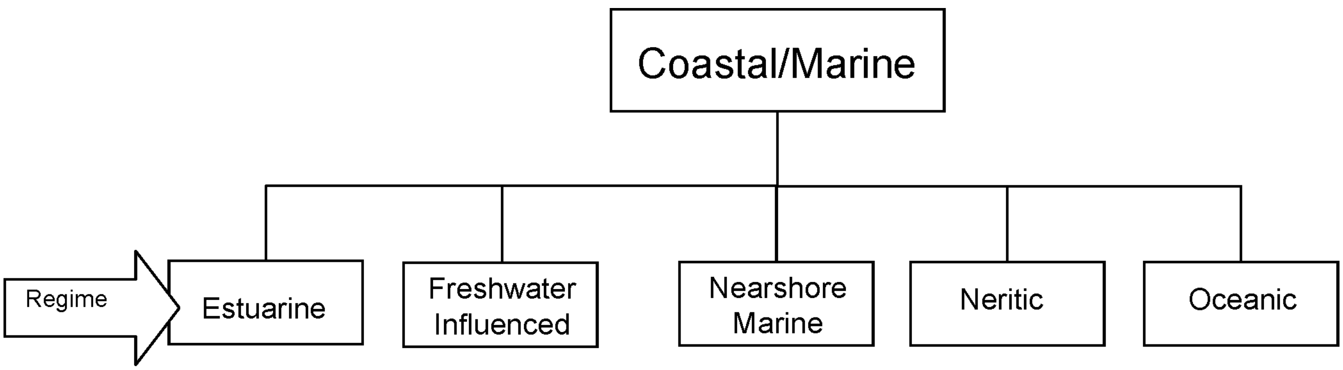


The hierarchy is conceptually divided into two parts based on the kinds of data required for applying the classification. The upper levels, Regime though Zone can be perceived from maps, bathymetry, remote imagery and existing historical data. In contrast, the lower levels, Macrohabitat though Biotope, exist at local spatial scales, and data collection is done through observation and direct measurement.

Level 1 Regime

Scale: 10 km^2 to > 1000 km^2

Figure 2. Level 1 – Regime



Brief Description

There are five coastal and marine regimes that form the main branches of the coastal/marine hierarchy (Figure 2), differentiated by a combination of salinity, geomorphology and depth. Two of the five regimes at this highest level of the hierarchy ("Estuarine" and "Freshwater-influenced") reflect the importance of salinity as a primary environmental influence on the ecological factors that define habitats' relationship to biology at a large scale. Freshwater inflow from land into the shallow coastal margins results in high variations in salinity in these shallow, nearshore regimes. If possessing significantly enclosed geomorphology, the regime is Estuarine. If open directly to the sea, such as a river plume, the regime is defined as Freshwater-influenced.

Depth is equally important in distinguishing among the three major regimes of the marine realm. Nearshore marine, neritic, and oceanic regimes are waters of full marine salinity (>30psu) and are distinguished from each other by depth. Nearshore marine regimes are those marine waters that extend from the coast to the 30 m isobath. Neritic regimes extend from 30 m to the continental shelf break, whose average depth is at approximately the 200 m isobath, although this boundary can vary by hundreds of meters. Oceanic regimes are waters beyond the shelf break, on average, deeper than approximately 200 m.

Detailed Description and Rationale

Estuarine Regime

Figure 3. Satellite view of the San Francisco Bay estuary.

Estuarine regimes are enclosed or semi-enclosed coastal water bodies that are influenced by freshwater input that reduces salinity to below 30 psu during at least two months of the year (Figure 3). Estuaries may exist on the margins of continents and large islands. The geomorphology and hydrology determine the degree of the physical enclosure, which in turn impacts the residence time of water within an estuary and the steepness of biological, physical and chemical gradients between terrestrial and marine end members. The degree of geomorphological enclosure defines the estuarine regimes, and determines the level of temporal, chemical, biological and ecological distinctiveness from the ocean regimes. A river flowing directly into the ocean is very different than a coastal estuarine system that slowly discharges into the ocean. Formations within the estuarine regime include lagoons, embayments, river mouths and deltas.

Estuarine regimes can occur on the continental land mass or on islands in waters of any depth, provided they have significant catchment area and significant freshwater flow into a semi-enclosed basin. Although they are coastal features by definition, many estuaries have water depths much greater than 30 m. In parts of the Puget Sound, Chesapeake Bay, and San Francisco Bay, depths > 30 m occur within the enclosed area of the estuary, and central channels can be much deeper than 30 m. All areas within the enclosing morphology that generally defines the estuary are classified as estuarine, regardless of depth. The depth of an estuarine water column can be significantly greater than 30 m and retain the characteristics of an estuary.

Freshwater-influenced Regime

Freshwater-influenced regimes are waters that have no distinctly enclosing morphology, yet receive a significant amount of freshwater input from land during at least part of the year.

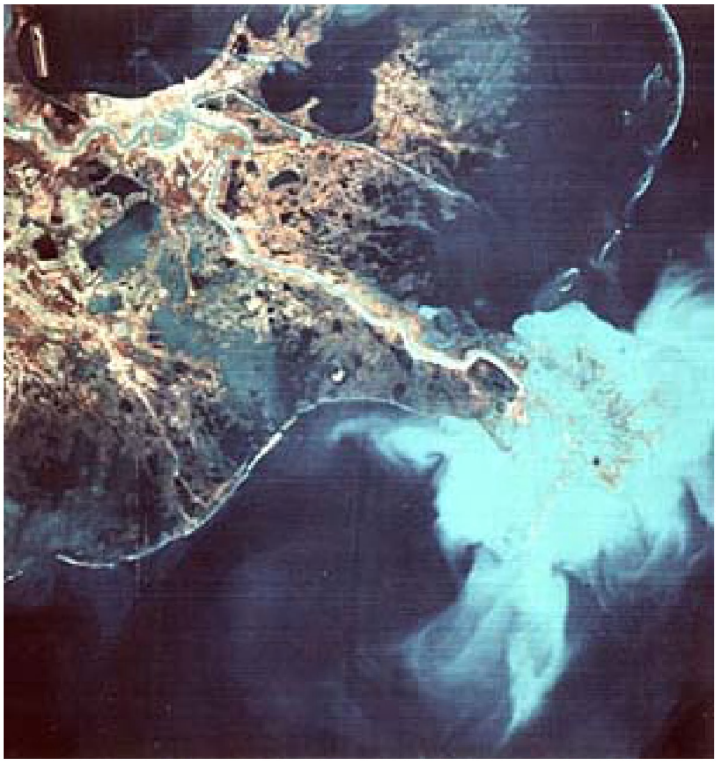


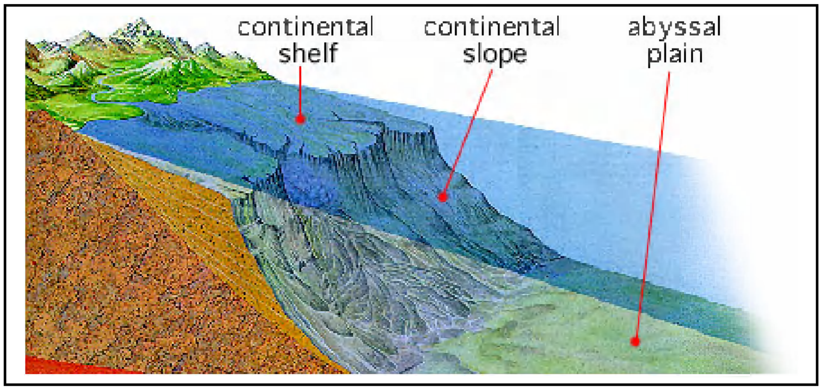
Figure 4. Mississippi River plume in the Gulf of Mexico. An example of a Freshwater-influenced Regime.

Figure 5. Mississippi River freshwater plume edge.

In such cases, an unenclosed marine water column may be influenced by freshwater in the form of an active river plume (Figures 4 and 5), an overlying freshwater lens or a ground water seep discharge. As with the estuary, the Freshwater-influenced regime can occur in nearshore, neritic or oceanic depths, provided the region is influenced by freshwater input that reduces salinity to below 30 psu during at least two months of the year. These regimes tend to be less well defined spatially and highly variable, determined by ocean currents and by wet season outflow from freshwater sources. They often may have surface characteristics of estuaries, but deeper waters may be completely marine. Because of the highly stratified nature of waters in this class, with fresher water generally concentrated in the surface layer, the water can be vertically diverse in terms of classification, switching from one branch in the classification to another with increasing depth. For example an area may map as a freshwater-influenced surface layer and a marine benthic zone if the characteristics of the fresh surface layer do not impact the bottom, as may be the case in very deep waters. However, often there is strong synchronization between the water column and the bottom. For example, the Mississippi River plume impacts the benthos of the Gulf of Mexico 30 meters deep by depositing sediments and organic material over vast areas, annually creating a high oxygen demand, bottom hypoxia and the widely-known benthic "dead zone." A similar phenomenon has been observed off the coast of Oregon in depths of 45-50 m.

Nearshore Marine Regime

Figure 6. Depiction of the continental shelf, continental slope and the abyssal plain. The shelf is separated from the slope by the shelf break, generally between 150-300 m depth.



Nearshore marine regimes are those coastal waters that are truly marine in character (> 30 psu throughout the year). The nearshore marine regime extends from the land margin to the 30 m depth contour. In these waters, benthic processes can strongly influence the ecology and biology throughout the water column, and the water column interacts strongly with the benthos. The photic zone, defined as the upper part of the water column where the average light level exceeds 2% of surface light intensity during daylight hours, generally extends through the entire water column in the nearshore marine regimes. This usually supports the growth of vegetation on the bottom, and significant seagrass and kelp beds are found in this regime. The vertical circulation of the water column generally distributes bottom nutrients and sediments throughout the water column.

Neritic Regime

The neritic regime is the region of marine waters (> 30 psu year round) between the 30 m depth contour and the continental shelf break, at approximately at 200 m water depth (Figure 6). Depending on shelf morphology, waters at the 30 m isobath can be quite distant from the continent or they may lie quite close to land. Depth is more important ecologically than the distance from land. An example of a neritic regime that begins far from the coast is found in the South Atlantic Bight offshore of South Carolina and Georgia, where the 30 m isobath is over 30 miles offshore in places. In comparison, the neritic regime along the California coast can occur within a few hundred meters of the coast.

Oceanic Regime

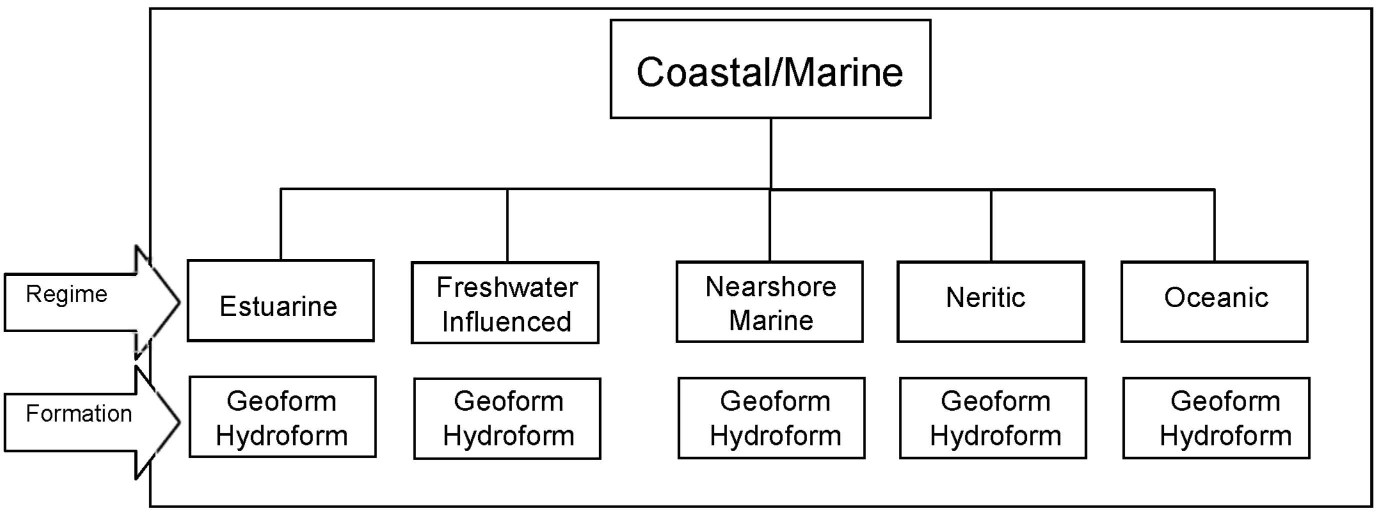
The oceanic regime represents the marine realm beyond the continental shelf break, generally occurring at 150m-300m of water depth at the edge of the continental shelf (Figure 6). These waters can range to several thousands of meters depth. The boundary created by the depth discontinuity at the shelf break establishes strong and identifiable constraints on the processes in the regime and represents a logical breakpoint for the division of major marine regimes between neritic and oceanic. In the case of large oceanic islands where a continental shelf is absent, the island itself possesses a nearshore regime to a depth of 30 m and a neritic regime to a depth of 200 m. The oceanic regime is defined in the case of steep-sided islands to begin where water depth exceeds the 200 m depth contour.

The marine waters of the oceanic regime are sufficiently distant from land and they receive little or no influence of freshwater, nutrient and sediment inputs, except around large islands. Due to the great water depths, there is little or no interaction of ocean bottom with the vast majority of the overlying water column. The sea bottom diminishes in importance in influencing pelagic processes. Light is greatly attenuated within the water column and does not reach the bottom. The upper water layer does not mix to the bottom and the mixing zone is separated from bottom waters by a density gradient or pycnocline generated by a temperature or salinity differential.

Level 2: Formation

Scale: 10,000 m2 to 100 km2

Figure 7. Level 2 – Formation



Brief Description

Major geomorphic and hydrographic features of coastal-marine regimes are called Formations (Figure 7). The Formations include geoform structures, which are geological formations on the continental margins, islands or seafloor formations on the order of 10,000 m^2 or larger in area. Examples include islands, peninsulas and seamounts. Hydroform formations are large physical features or boundaries created by water masses of 10,000 m^2 or larger in area. Examples include the Gulf Stream, large coastal fronts, the great ocean gyres and upwellings. Formations represent the geological and hydrological environments that define large scale patterns in the composition and dynamics of both the smaller scale physical worlds contained within them and the biota associated with its divisions. In the discussion below, examples of geoforms and hydroforms are presented. For the current list of these types, refer to the CMECS website (www.natureserve.org/getData/CMECS).

Detailed Description and Rationale

At the Formation level, the shape and size of the physical features of the Regime play important roles in determining the nature of the ecological and biological processes within them. The morphology of these features controls such processes as water exchange rates and water turnover times, hydrologic and energy cycling, shelter and exposure to energy inputs and migration and spawning patterns. In some cases a single feature, such as an embayment, encompasses both land (shore) and water (water column) components, while others can be solely geomorphological (e.g. a seamount) or hydromorphological (e.g. an upwelling). Formations shape the large scale seascape in repeatable and predictable ways by providing structure, channeling energy flows, regulating bioenergetics, and controlling transfer rates of energy, material and organisms.

Oceanic islands are separated from the continent by a deep water column and therefore are functionally and ecologically different than their continental and nearshore island coastal counterparts, even when the physical structures are similar. Islands can possess large geoforms themselves, such as embayments, rivers and even estuaries, all of which are at the same hierarchical level of the classification, or at a higher level in the case of estuaries. If the particular user-application requires classification of an oceanic island geoform to finer levels, the methodology is to identify the included geoform feature on the island (such as wetland) and adopted the estuarine freshwater-influenced or nearshore marine types of the classification (as appropriate) to continue delineation of the classification to finer levels. The procedure will produce a set of habitats that is similar to the analogous continental habitats in the estuarine and nearshore marine regimes. Yet the identification of the type as being within an island renders it separate and distinct from continental wetlands, leaving open the possibility for different biotopes to result, even within the same ecological region.

Geoforms and Hydroforms Common to all Regimes

Figure 8. Aitutaki atoll, an example of an atoll geoform in the oceanic regime.

Many formations are found in all branches of the classification, although not all geoforms or hydroforms exist in every branch. Some common geoforms are islands, fans, embayments, wetlands, river channels, channel banks, submerged banks, reefs, open shoreline and seabeds. Some geoforms, such as wetlands, can exist in neritic and oceanic regimes only on islands while in nearshore regimes (<30 m), wetlands can be found on both the continental land mass and on islands. Hydroforms common to all regimes include current systems, upwellings, downwellings, rivers, ice, turbidity flows and open waters.

Neritic and Oceanic Geoforms

In the neritic and oceanic regimes, large geomorphic formations or geoforms occur on the sea bottom, for example trenches, canyons, faults, seamounts and guyots. Emergent geoforms above the water surface include islands, atolls and reefs (Figure 8). These features correspond to the geological mega-habitat features in Greene et al's. (1999) classification of deep-sea habitats.

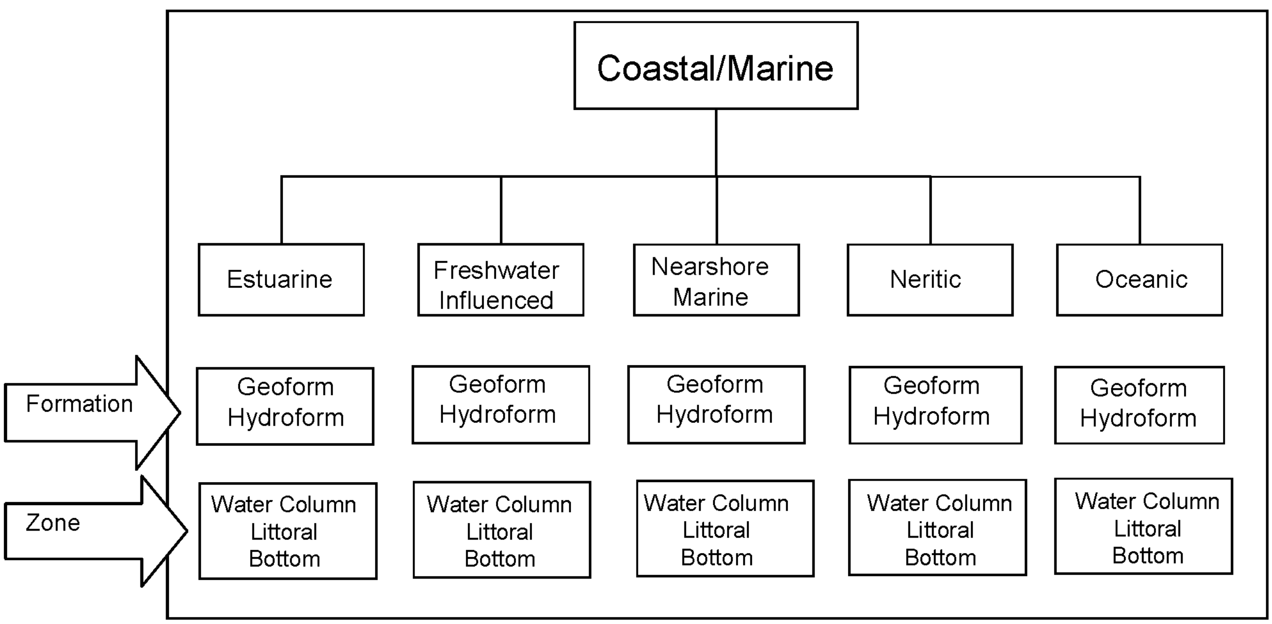
Neritic and Oceanic Hydroforms

Certain hydrographic features are found only in Neritic and Oceanic deeper waters, such as oceanic gyres, warm and cold core rings, and hydrothermal vents. A full listing of the hydroform and geoform units is found on the CMECS website (www.natureserve.org/getData/CMECS).

Level 3: Zone

Scale: 100 m2 to 10,000 km2

Figure 9. Level 3 - Zone



Brief Description

Zones of Coastal/Marine Regimes

The Zone characterizes the vertical zonation that exists in each of the coastal and marine regimes. These units incorporate the same information as captured by the Biomar classification within the EUNIS system. The vertical scope of this level extends from above the littoral in the supratidal area, to the deep ocean bottom and is comprised of three major zones: the littoral, the water column and the bottom (Figure 9). The Zone level integrates the vertical dimension into the classification hierarchy, creating relevant vertical ecological distinctions to the Regime level and certain Formations. The three zones are defined as:

> ***Water column zone:*** all estuarine and marine waters beyond the littoral zone and deeper than 1 m. The water column extends from the sea surface to the ocean bottom. For this classification, the water column near the coasts begins where the depth is greater than 1 m. In the region between the 1 m depth and point where the waterline intersects with the coast, water motions are too active and variable to be considered separate and the water column and bottom together are considered to be a single entity forming part of the littoral zone.
>
> ***Littoral zone*:** the land-water interface at the margins of continents and islands. The littoral zone includes the region between extreme lower low tide, as well as the splash and aerosol zone that extends above extreme higher high spring tide. The land margin at the interface between coast and ocean includes subtidal substrate and water components that are subject to tidal and wave motion (infratidal) and to periodic wetting and drying (intertidal), as well as the land environment influenced by periodic submersion, the splash zone and areas affected by sea spray and seafoam (supratidal). This zone also includes the non-tidal area of wetlands that are contiguous with tidal wetlands and rivers.
>
> ***Bottom zone:*** in the subtidal, the bottom of the ocean or coastal waters formed by the sea floor that is completely and continuously covered by water.

All formations incorporate at least one of the three vertical zones, and many of them (though not all) contain all three zones. For example, the geoform "lagoon" contains a water column, a benthic zone and a littoral zone. An atoll is an oceanic geoform that includes a bottom and littoral zone. In its interior lagoon, the atoll encloses a water column and therefore has all three vertical zones. The hydroform "upwelling" in the neritic has only a water column zone. Seamounts and guyots in the oceanic regime have only a benthic zone when submerged, yet an emergent seamount (forming an island) also possesses a littoral zone. These littoral units are different from the littoral units for the nearshore or estuarine branches of the hierarchy because we consider the distance of an island from the continental land mass to be relevant to the use of habitat by the biota.

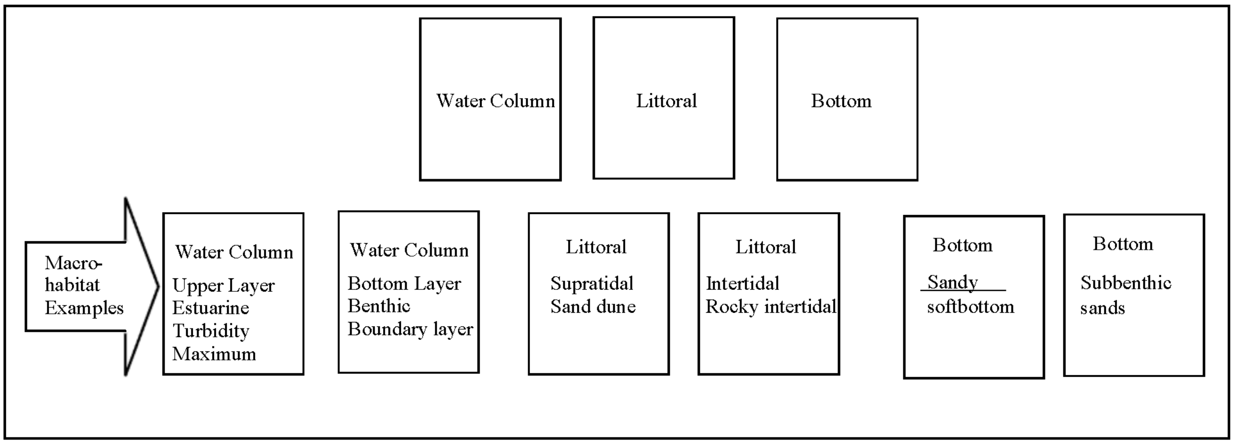
Detailed Description and Rationale

A littoral zone can exist in any of the five regimes in the CMECS classification, including the deep Oceanic regime. In the cases of estuarine, freshwater-influenced and nearshore marine regimes, the littoral zone may refer to a shoreline of a continent, a large island or of an iceberg. In the neritic and oceanic regimes, the littoral zone only refers to large islands, icebergs, ice shelves, and other hard structures in oceanic waters. This feature of the classification has two consequences. It presents an opportunity to identify differences in littoral habitat function attributable solely to the regime branch (e.g. oceanic island coast is different than a neritic island coast), and it allows efficient mapping of surface features across all five regimes in the landscape. It also presents a decision point in the hierarchy- the oceanic regime occurs in waters beyond the shelf break, although this does not preclude formations therein from having a littoral zone. The presence of islands and icebergs, ice shelves, and floating mats creates littoral zones in the deepwater regime, which are not associated with the continental shelf or slope as in the nearshore zone. The littoral zones of these formations carry a number of features associated with the shallow water branches of the hierarchy. Rather than treat mid-ocean features as though they were on the continent however, they are classified as part of the oceanic regime, as distinct units.

Level 4: Macrohabitat

Scale: 100 m2 to several 1000 m2

Figure 10. Level 4 – Macrohabitat



Brief Description

Figure 11. Example of a red mangrove forest macrohabitat.

Macrohabitats are spatially large and complex geomorphic, hydromorphic or vegetative structures of the coastal and marine environment that support multiple distinct biological associations (Figure 10). These physically complex entities contain multiple habitats and can structure the distribution of communities along gradients or at discontinuities. Macrohabitat units are specific, recognizable, repeatable structural units of the physical environment at a landscape-scale within a homogeneous local climate, hydrology and chemistry. They can be observed, measured and mapped using direct sampling. Macrohabitats are subunits of larger formations (Level 2), defined by smaller scale physical gradients, discontinuities, and/or vertical zone position (Level 3). A rocky shore macrohabitat, for example, is a littoral intertidal component of an island geoform.

Macrohabitats have components and sub-structures analogous to geologic structures in their complexity, persistence, durability and heterogeneity. Each macrohabitat type represents a different physical setting that supports one or more distinct biological associations.

A mangrove forest is an example of a macrohabitat (Figure 11). This neo-tropical macrohabitat generally is comprised of several characteristic habitats that occur together, including a submerged prop root zone, exposed prop roots, pneumatophore zone, the forest canopy, coastal ridge forest, basin forest, and tidal creeks. The distinction between the Formation level and the Macrohabitat level derives from macrohabitat units being of a size scale that more closely matches the biology utilizing the structure.

The macrohabitat generally occupies a single vertical Zone (Level 3) of the formation unit. For example, an oyster reef macrohabitat in a coastal plain estuary could be strictly intertidal. This vertical partitioning occurs because of the overriding structuring action of the processes forming the zone (tide, water depth, exposure to air). A rocky hardbottom macrohabitat is different from the rocky intertidal macrohabitat.

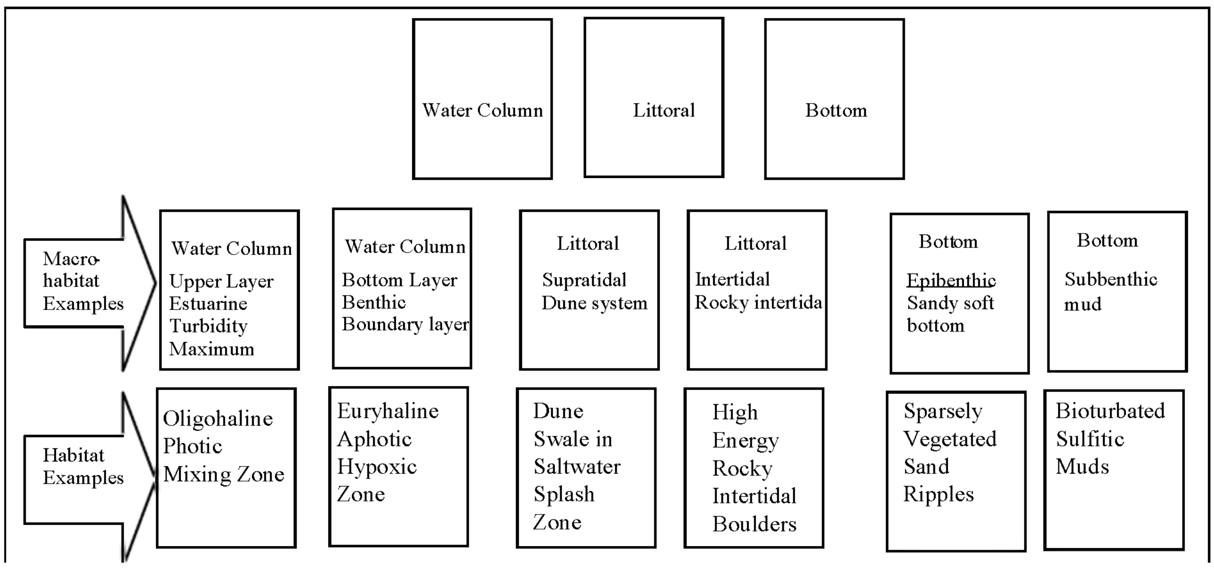
Detailed Description and Rationale

Conceptually, large geoforms can be compartmentalized into macrohabitats by considering that any physical feature in the environment possesses a complexity imparted by its three dimensional geometry. Generally these forms possess a distinguishable upper surface, flanks, and a base which tend to be structurally different from each other. This is true whether the large formation is geomorphological (a seamount) or hydromorphological (the Gulf Stream current). Additionally a geoform feature may have several bands or zones based on further structural complexity (interior vs. exterior of a warm core ring), on depth, or on the presence of some resource such as light or energy that differentially impacts the structure along its geometry. All of these factors create different zones of structure and/or energy interaction with the biota and these subdivisions are the basis of macrohabitat units. For example, the lava field macrohabitat is a benthic component of the seamount geoforms. The turbidity maximum macrohabitat is an upper water column, upper estuary component of the river hydroform.

Level 5: Habitat

Scale: 1 m2 to 100 m2

Figure 12. Level 5 – Habitat



Brief Description

The habitat is the physical unit of the environment that is directly used by the biota for food, shelter, spawning and/or refuge (Figure 12). The habitat unit is described as a geomorphological or hydromorphological type and includes specific substrate, energy, composition and biological classifiers.

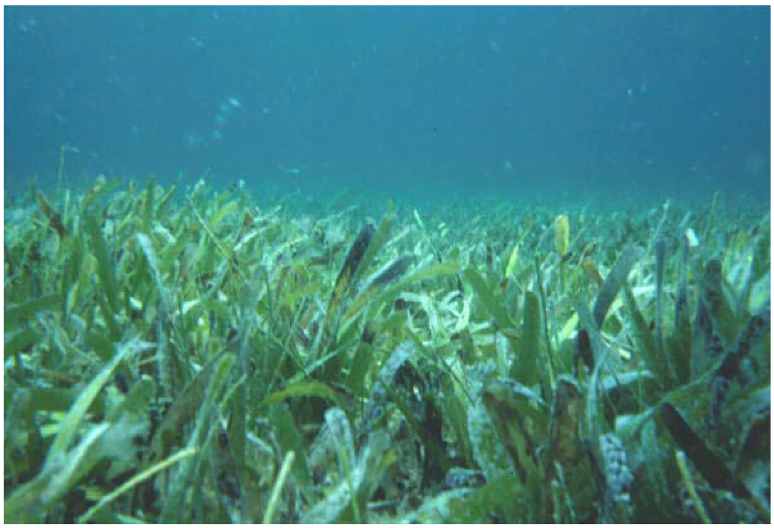
Figure 13. Prop root habitat in a mangrove macrohabitat.

Habitat units can be classified and mapped by direct observation of the relationship between biota to the habitat. The size range for the habitats is determined by the spatial range of the biology that uses the habitat. The organisms considered to recognize these habitat units range from 1 mm to tens of meters, and the corresponding habitats range from tens of millimeters to thousands of square meters. Due to the technological constraints of detecting habitats, a lower unit spatial bound of 1 m^2 was established. The habitat units within the macrohabitat are interconnected by physical or ecological processes. For example, the hydrology and geology of a sandy beach littoral macrohabitat incorporates the tidepool, beach face, and surf zone habitats. The mangrove macrohabitat integrates the prop root habitat (Figure 13), the basin forest habitat and macrohabitat and the biology associated with them may interact across habitats or may be isolated and distinct from each other, while still being physically part of the whole macrohabitat.

Detailed Description and Rationale

Habitat units are defined as the biotic and abiotic, physical features of the environment that are critical sites for biological and ecosystem health and function on a local scale. The habitat has a geomorphologic or hydromorphologic basis that is modified by at least one and usually several environmental variables (e.g. local geology, wave exposure, substrate composition, trophic status, impoundment). The local geo/hydromorphology of the habitat unit occurs at a much smaller spatial scale than the large Formation level units, and at a scale similar to or smaller than the Macrohabitat level units.

Figure 14. Example of a tropical seagrass bed habitat.



Observation and knowledge of biology at the habitat level is important in defining habitat units. Units at the habitat level are constrained to the size scale of the biological processes of a particular species or association that are in routine and intimate contact with the physical unit. These include areas directly suited for spawning, for refuge, for photosynthesis or for feeding. Many biological processes of a single organism are conducted in different parts of the physical environment, either simultaneously or in sequential life stages, and so several different habitats may be critical to the health and survival of specific species. The habitat types that populate this classification will be developed with input from regional and local experts knowledgeable about the species and ecology of the local environment.

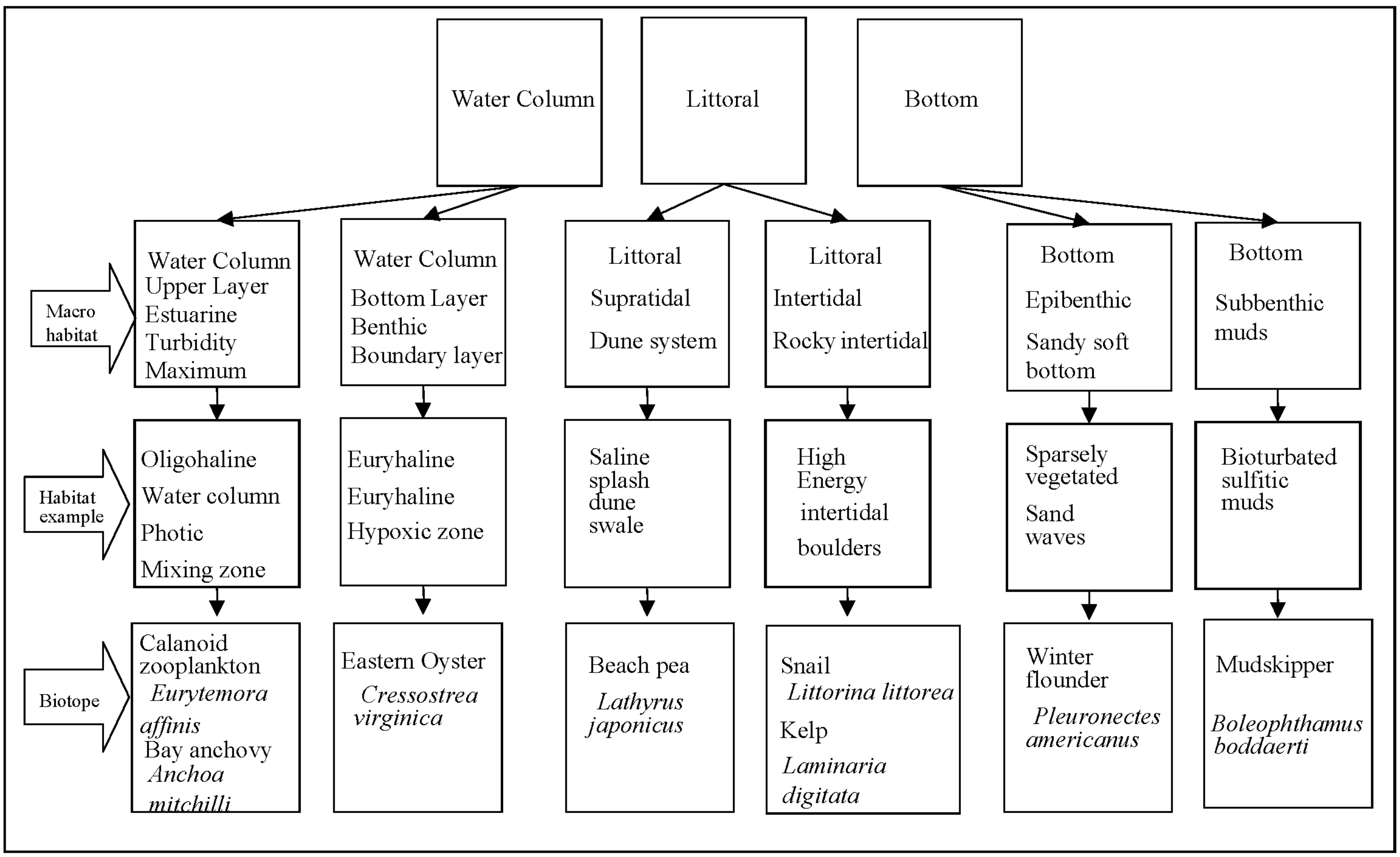
Both faunal and floristic distributions and associations help define habitats. For example, the biological difference between a salt flat and a salt marsh is the colonization of the latter by emergent halophyte vascular vegetation. Both habitats are classified as intertidal unconsolidated sediments, one unvegetated and the other vegetated by emergent macrophytes (and defined as marsh). The type of vegetation (salt marsh- e.g. *Spartina alterniflora*), would introduced at the biotope level. This physically-based approach to habitat classification, similar to the Dethier (1990) and BCMEC (Zacharias et al. 1998) classifications, enables systematic assessment of the factors responsible for differences in (or the absence of) distributions of vegetation as well as of fauna in response to physical attributes of the environment.

The presence of exceptional structural units built by biogenic processes that were noted for macrohabitat units holds true for habitat units. The mangrove swamp forests and coral reefs were classified as macrohabitats due to their function as persistent structuring agents in the environment. These living structures are similarly recognized as containing smaller structural habitat units such as the prop root zone and basin forest (for mangrove macrohabitats) and reef halo and reef crown (for reef macrohabitats).

Level 6: Biotope

Scale:1 m2 to 100 m2

Figure 15. Level 6 – Biotope



Brief Description

The finest level of the classification is the Biotope. The biotope is a specific area of a habitat that includes recurring, persistent, and predictable biological associations. The biological associations can include plants, attached sessile fauna and unattached but relatively non-motile fauna and bacterial colonies. A biotope is environmentally uniform in structure, environment, and is defined by the dominant biota. The primary characteristic of the biotope is the relationship between the physical habitat and a strongly associated or fixed "high fidelity" plant and animal species. "Fixed" is defined as an individual organism that cannot move beyond the frame of reference of the habitat boundary within one day.

Epibenthic organisms like anemones, sponges, hydroids, and benthic infauna such as polychaetes would be considered part of a biotope complex.

While much of the sedentary or fixed biota defines a particular biotope, other organisms demonstrate less fidelity to any specific biotope. More vagile organisms can be associated with multiple biotopes or interact with the physical structure of the environment at any number of classification levels and spatial or temporal scales. Larger animals, such as blue whales, may interact with elements defined in the classification at a level of Formations, such as the shelf break or submarine canyon. Smaller animals interact with Macrohabitats, Habitats or Biotopes. This report does not attempt to document the motile species associated with each habitat and biotope, although there are provisions for identifying them and numerous cases are described. As the classification matures, the linkages of species and biological associations to different classification units at different levels will become better known and documented.

Detailed Description and Rationale

The biotope concept has been employed for several years in Europe and is defined as the "physical habitat… and its community of animals and plants (Costello, 2003)." This refers to the dominant biological inhabitant(s) of a specific habitat, whether the species are "diagnostic," as in the terminology of Cowardin (1979) and Dethier (1990), or if they are "commonly associated." A species is considered to be part of a biotope if it is conspicuous, dominant, and physically linked to the habitat. The concept and nomenclature for the biotope follow the BioMar system (Costello, 2003; Connor, 1997), which has been integrated into the EUNIS classification for European habitats (Davies and Moss 1999) and into this classification, although some of the terminology has been changed here.

Vegetation units such as specific algal and rooted plant species, salt marsh and other vegetation are recognized at the biotope level. This biota is recognized as being associated with a particular habitat, rather than defining the habitat. This is an important departure from several widely used classifications such as those developed by Cowardin (1979), Ferren et al. (1996) and Madley et al. (2002) but follows the same logic as the Dethier (1990) and the Costello (2003) classifications.

Descriptors and Classifiers

Descriptors are attributes that are used to describe units and provide insight to the functioning of the ecosystem and the environmental conditions that make a habitat favorable or unfavorable for an organism. Descriptors can be physico-chemical, physical, spatial, geomorphologic, biological, anthropogenic, and biogeographic. The CMECS classification provides a standard list of descriptors that are used for characterizing and classifying units.

Within the descriptors is a subset of characters, called classifiers, which are *required* to define units in the classification. They are the attributes that are used to separate one unit in the classification from another. Classifiers can be applied at any level of the classification hierarchy. The available descriptors that can be used as classifiers vary with the level of the classification and the specific characteristics of the units themselves. A specific descriptor, such as temperature, may be used as a classifier in some parts of the hierarchy, but only used as a general descriptor in others. The characteristics of a classification unit will determine how classifiers are applied. For example, a bar-built estuary formation can be sufficiently large that it encompasses multiple salinity (fresh, mesohaline, euhaline) and temperature (temperate, warm) regimes. In this case, salinity and temperature are the classifiers necessary to define different macrohabitats within the bar-built estuary formation.

The classifiers required for the upper levels of the hierarchy (Regime through Zone) have largely been defined and are described in the "Classification Hierarchy" section of this report. The classifiers at the lower levels of the hierarchy (Macrohabitat through Biotope) are more numerous and variable and cannot be defined succinctly for the entire level, and so have been fully described in this section on Descriptors and Classifiers. At the habitat level, substrate classifiers are generally required to define benthic habitat units other important classifiers are salinity, depth, temperature, oxygen, trophic status and turbidity. At the biotope level, classifiers that describe the spatial distribution, patchiness or density of the vegetation or colonizing fauna are important distinguishing features.

The list of standard descriptors in the CMECS framework is provided below. All new units added to the classification will use these standard values.

Physico-chemical Descriptors

Suites of classifiers can more fully characterize the water mass associated with an ecological unit. In addition to its physical structure, the water mass type can be characterized by salinity, depth, oxygen, temperature and turbidity. These dynamic water quality parameters are variable on both temporal and spatial scales. As classifiers, these qualities are represented as an average type, summarized by a single descriptive name, which captures the broad range of variation experienced by the biota in these locations on an annual basis. In practice repeated sampling will add definition to the true character of these parameters and provide valuable information on the variability of the system, which can be critical to describing the impact of the physical environment on biology.

The appropriate scale for use of these classifiers is wide-ranging. They are applicable in areas where low variability of these fluid characteristics renders them meaningful. In the open ocean, which is homogeneous over large spatial scales, classifiers are applicable at the highest levels of the classification.

Bottom water anoxia, for example, covers thousands of km^2 in the Gulf of Mexico and persists for many months of the year. Typing of this water mass can be done at the Zone and Macrohabitat levels of the classification with a high degree of significance. In highly dynamic and variable estuaries, water mass parameters are meaningful only on an averaged basis or on smaller spatial and temporal scales.

Salinity

Salinity is grouped into the classes in units of PSU (practical salinity units, nearly equivalent to PPT, parts per thousand) following Cowardin (1979), Dethier (1990) and with ranges slightly modified from Howes (1994, 2002):

Salinity Class	Salinity Level
fresh	0 psu
oligohaline	>0-5 psu
mesohaline	5-18 psu
polyhaline	18-30 psu
euhaline	30-40 psu
marine	=35 psu
hyperhaline	>40 psu
freshwater-influenced	<=30 psu for two months or more
marine	>30 psu for ten months or more
seawater	35 psu

As for all of the water quality characteristics presented here, the classes defined for the upper water mass can be applied to the underlying bottom layer as well. An underlying benthic area subjected to overlying waters of a particular regime will be designated according to the category of the overlying water. For example, salinity of a benthic habitat will be classed as that of the overlying water's salinity. Particularly in the case of salinity, this will require measurement of bottom water characteristics, as the tendency of the coastal water column to stratify will often ensure that water mass characteristics at the surface are not the same as at the bottom.

Oxygen

Oxygen is critical to aerobic organisms and aerobic processes, such as chemical oxidation and microbial respiration. Lack of oxygen can cause motile organisms to swim or move away and can kill organisms that cannot move. The significant "dead-zone," a large area virtually devoid of life in the bottom waters of the northern Gulf of Mexico off of coastal Louisiana is an example of the effect of low oxygen conditions on an ecosystem. Oxygen classes are difficult to establish because solubility of O_2 in water changes with temperature and salinity. However, the selected ranges indicated below represent an average classification of the waters and conditions that will be encountered by application of this classification. The oxygen regime classifier is determined according to the following ranges:

Oxygen Class	Concentration
anoxic	0-2 mg/L
hypoxic	2-4 mg/L
oxic	4-10 mg/L
oxygen saturated	10-12 mg/L
oxygen supersaturated	>12 mg/L
oxygenated	>= 4 mg/L
unoxygenated	< 4 mg/L

Temperature

The classification must encompass a large climatic range to cover the range of temperatures on the North American continent. Temperature classes are established in intervals of 10°C, deemed sufficient in range and resolution to provide meaningful differences yet yielding a parsimonious number of classes. Temperature categories are based on the BCMEC classification for Canada (Howes, 1994, 2002; Zacharias et al., 1998), modified to add the higher temperature ranges typical of the subtropics and tropics. The caveat that differential surface and bottom characteristics occur in the water column holds for temperature as well as salinity.

Classes for water mass temperature are established as follows:

Table 3. Temperature Class

Temperature Class	Degrees
frozen	≤ 0° C with surface ice
superchilled	≤ 0° C without ice
cold	0-10° C
temperate	10-20° C
warm	20-30° C
hot	>30° C

Turbidity Class

Turbidity is important for organisms that hunt for prey or escape using visual cues, and of course for photosynthetic organisms. Classes for the turbidity descriptor have not previously been established in a coastal-marine classification system. The proposed classes for turbidity based on simple secchi depth readings are:

Turbidity Class	Secchi Depth Reading
extremely turbid	0-1 m
highly turbid	0-2 m
moderately turbid	2-4 m
clear	5-20 m
extremely clear	>20 m
turbid	>=2 m
non-turbid	< 2m

Turbidity Type and Turbidity Provenance

An important qualitative characteristic of turbidity is the provenance of the attenuating substance- whether the reduced water clarity is derived from chlorophyll pigments (i.e. phytoplankton blooms), from color due to dissolved substances in the water (gelbstoffe, tannin), from mineral imported terrigenous sediments or from carbonate particulates in resuspension. It is proposed that this qualitative assessment be classified in addition to a qualitative or quantitative evaluation of the degree of turbidity in the water column. The following qualitative classification of turbidity type and provenance should be applied to the degree best discernable in the field:

Turbidity Type

Chlorophyll: attenuation produced by chlorophyll a, b, c or d as constituents of live phytoplankton in the water column
Mineral particulates: attenuation produced by suspended inorganic sediments derived from soil and rock weathering
Carbonate particulates: attenuation produced by suspended precipitated $CaCO_3$ in the water column, generally creating an opaque "milky" appearance
Colloidal precipitates: dispersed particulates which precipitate out of the dispersion medium (water) to form aggregations such as marine snow
Dissolved color: substances dissolved in water that have color and absorb light within a specific wavelength band depending on the color
Detritus: attenuation due to larger organic detritus particles in suspension
Mixed: attenuation due to a variety of the above sources and substances

Turbidity Provenance

Autochthonous: (e.g. bloom) generated in situ by biogenic processes
Allochthonous: originating outside of the system and transported into the system
Resuspended: deposited materials mixed into the water column by currents (e.g. bottom sediments)
Precipitated: solutes such as $CaCO_3$ that precipitate out of solution
Terrigenous origin: materials, water or energy in a water body in land drainage
Marine origin: materials, water or energy originating in the ocean

Physical Descriptors

Energy Type

Classifiers are used to describe the energy regime of the macrohabitat unit. CMECS follows a simplification of the concept introduced by Dethier (1990), and as employed in several subsequent classifications (Holthus and Maragos 1995, Howes 1994, 2002, Schoch 1999, Allee et al. 2000). The work of Schoch (1999) provides the basis for a detailed near-shore classification of energy intensity and type on land-sea margins. This classification utilizes a very simple energy classification related to the force of water movement, whether tidal, wave or current. This force is an important sieve that determines the kinds of animals and flora that can maintain attachment or position in a particular habitat. Energy level also determines the substrate type by suspending, transporting and sorting fractions of substrate particulates of smaller grain size. A winnowing of, or absence of, fine sediments characterizes high current and wave energy areas. Finally, energy can shape the bed form (sand waves, sand ripples) and erode or accrete geoforms. Highly impacted areas are typified by the presence of erosive features, such as beach scarps or bare rock substrates.

The terminology of "degree of exposure" common in many other classifications is not used in the CMECS in favor of the more accurate term "energy." Exposure is a subjective term that includes qualification of both the direction of the feature relative to hydrodynamic energetics and the energy of the system at a given point in time. An exposed and open coast may in fact be very quiescent depending on the season or direction facing. "Energy," along with a quantitative scale, is a more accurate indicator of the actual force with which a particular coastal or marine feature is impacted.

The energy classifier applies to all three zones in the classification (littoral, water column and bottom). Within the littoral and subtidal benthic zones the energy acts on shaping the geoforms. Within the water column, the energy is related to current speeds (in knots), wave intensity and tidal motions. The concept is modified from Dethier (1990) and Zacharias et al. (1998) with type categories as follows:

Energy Type	Description
wind	coherent directional motion of the atmosphere
current	coherent directional motion of the water
surface wave	vertical and transverse oscillating surface water motion due to wind or seismic energy
internal wave	vertical and transverse oscillating water motion below the surface due to seismic energy or pressure differential
tide	periodic horizontally oscillating water motion

Energy Intensity

Energy intensity classified according to the following scale:

Energy	Intensity
no energy	no detectable waves or current motion
low energy	very weak currents (0-2 kn) or wave action (gentle swell)
Moderate energy	wind waves or moderate tidal currents (2-4 kn)
high energy	strong currents (>4 kn), oceanic swell, breaking waves

Energy Direction

Energy can also be classified according to its principal direction of travel or influence. In the case of tidal energy, this is generally an oscillation between onshore and offshore motions. In the case of currents and waves, the energy is directions. The following energy direction categories are used:

Energy Direction	Description
upward	ascending and perpendicular to the sea surface or bottom
downward	descending and perpendicular to the sea surface or bottom
horizontal	parallel to the sea surface or bottom
baroclinic	motion along lines of equal pressure within the water column
seaward	on land, water currents following topographic gradient toward the sea
circular	motion in a closed circular form
mixed	combination of more than one of above directions

Tide Range

The tide range descriptor refers to the difference between mean high tide and mean low tide at the coast. While the intertidal subzone is defined by the area submerged by tide between the extreme high and low tides, the mean range gives a more consistent idea of the energy and amplitude of the average tide. Tide range is classed as:

Tide Class	Range
microtidal	<0.1 m
small tide range	0.1- 1 m
moderate tide range	1-5 m
large tide range	>5 m

Primary Water Source

The primary water source descriptor refers to the provenance of water flowing through or into a formation. This can range from freshwater inputs from river watersheds or sloughs to local exchanges through tidal passes. The classes are as follows:

Primary Water Source	Provenance
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

Enclosure

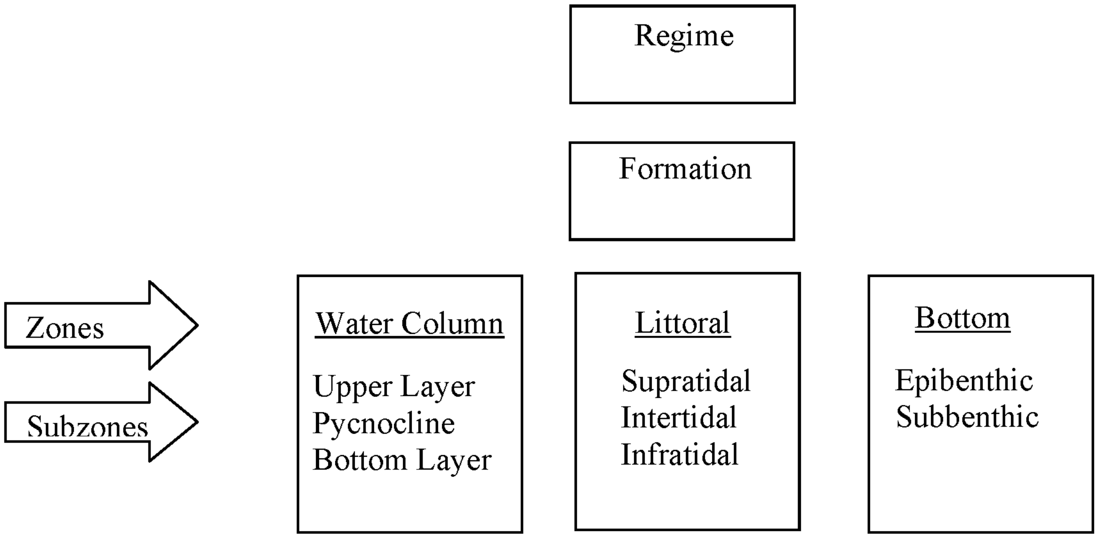
Enclosure represents the degree of isolation of a water body due to enclosure by a land mass. In estuaries, enclosure determines the degree of exchange of water, materials, energy and biota between the estuary and the sea. More enclosed waterbodies have longer water residence times, can tend to be more evaporative and hypersaline, and can more readily trap and retain materials within them.

Enclosure	Degree
unenclosed	no detectable isolation of a water mass by land form
semi-enclosed	25%-50% of the area of the water body is encircled by land
partially enclosed	50%-75% of the area of the water body is encircled by land
largely enclosed	75%-90% of the area of the water body is encircled by land
enclosed	normally completely cut off from ocean

Subzone

The Zones (littoral, water column, bottom) designated at Level 3 can be sub-divided into subzones using classifiers. Such classifiers enable specification within the zone to a greater degree of resolution.

Figure 16. Subzone classifiers for all regimes.



Littoral Subzone Classifiers

The subzones of the littoral fall into intertidal, infratidal and supratidal classes. Most regimes, macrohabitats and habitats in the coastal/marine realm such as wetlands, estuaries, lie in the intertidal subzone, which is the default definition for the littoral zone. However, where coastal features interact with the sea with periodicity on longer timescales than the tides, such as storms, hurricanes, flood events which produce such features as overwash fans, dune systems and high beaches, the supratidal classifier is useful.

Though it is part of the bottom, it is also useful to distinguish that part of the littoral bottom that is close to the land-water interface as distinct from deeper subtidal bottoms. The infratidal classifier refers to that area of the subtidal littoral zone that is influenced by littoral wave action, tidal currents and the littoral landform itself. It generally extends to 5-10 m water depth below the low tide line.

Subzones of the Littoral

The littoral zone can be divided into three subzones. These apply to continental land margins and island land margins in all regimes.

> ***Supratidal***: the area above the high tide line in the splash zone that is affected by spray, splash, aerosols and overwash. This interface is regularly exposed to the air by tidal movement. Aquatic organisms inhabiting these physically demanding habits are adapted to periods of exposure to the air and to wave action. Included in this subzone is the region of non-tidal wetlands and uplands that are saturated by coastal waters below the soil surface.
>
> ***Intertidal:*** the area of littoral land at the land-sea interface that is periodically covered by water between extreme low and extreme high tide.

Infratidal: the area of littoral land below the waterline that is completely covered by water (subtidal) but feels the effects of waves and tides.

Subzones of the Water Column

The water column can be subdivided into an upper mixed layer and a bottom layer, separated by a pycnocline. This is often ecologically relevant in terms of habitat, although two layers are not always present. An important functional distinction is created by temperature or salinity differences in the upper and bottom layers of the water column. When present, the upper layer is separated from the lower layer by a difference in density, which results in a barrier to mixing between the layers. The two water layers define separate mixing zones and energy regimes, and create barriers to movement of materials and fauna. These waters may maintain this stratification for many months. Stratified water masses are usually highly stable, and layer separation is broken down by wind or current energy input.

Upper water column layer: in a two-layer water column, the area above the sharp density gradient (pycnocline) which includes the air-water interface. Pycnoclines are generally formed by salinity or temperature differences between the upper and lower water layers and create effective barriers to transport across layers. The water layers remain largely distinct even having current regimes that flow in opposite directions in certain estuaries.

Pycnocline layer: layer of rapid density transition between the upper and bottom layers.

Bottom water column layer: in a two-layer water column, the waters below the pycnocline or mixed layer.

Subzones of the Bottom

The bottom for all regimes is resolved into two subzones:

Epibenthic: the surface of the benthic zone, at the interface of the bottom of the water column and the seabed.

Subbenthic: in soft unconsolidated sediments the substrata below the surface of the sediments. The subbenthic zone is often inhabited by burrowing organisms and other infauna, such as polychaetes, bivalves, and certain nekton. Bioturbation of the sediments by infauna is an important process for aeration and improves the transfer of sediment and nutrients from the benthos to the water column.

Depth Class

Depth Classes for the non-Oceanic Regimes

In addition to the subzone descriptors, it is often useful to apply a descriptor that refers to a specific depth or range of depths in the water column or on the bottom. Dethier (1990) introduced depth as a classifier in nearshore systems and that use is adopted here for the littoral and infralittoral zones. The descriptor has been expanded with two additional classes in CMECS: "exposed," meaning exposed to air on a regular basis and "very shallow." Depth classes for shallow water columns are as follows:

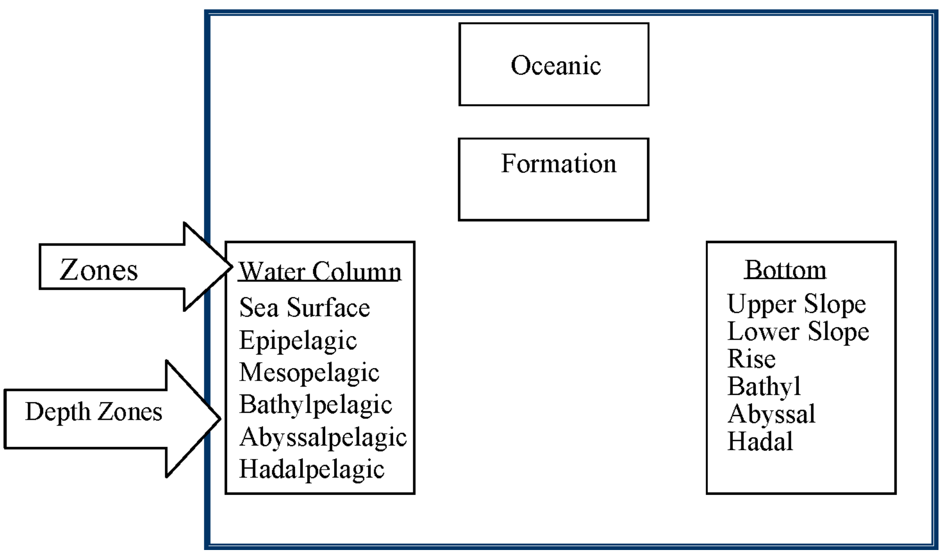
Depth Class	Range
exposed	< 0
very shallow	0-5 m
shallow	5-15 m
deep	>15 m

These depths are relevant only for small scale features in shallow water columns for all regimes. In the oceanic regime these classes are only applicable to littoral zones around island-like features. Another set of depth descriptors is used for the oceanic regime that accounts for the scale of great depths associated with that regime exclusive of islands and other small oceanic surface features.

Depth Class of the Oceanic Regime

Depth zones for much of the oceanic regime are more complex and numerous owing to the vast depths involved and to the diverse bottom topography of the ocean basins. CMECS uses one set of descriptors for the deep water column and another for the deep bottom. Littoral depth zones for oceanic islands and atolls are exactly the same as described previously for the non-oceanic regimes.

Figure 17. Level 3 Depth Classes for the Oceanic Regime



Depth Classes of the Oceanic Water Column

The oceanic regime is distinguished by a proliferation of subzones in the vertical, each subzone being determined by water depth range. The relationship of the subzones to the hierarchy in the oceanic regime is shown in Figure 17, and the depth characteristics are:

Subzone	Depth
sea surface	0 m
epipelagic	0-200 m
mesopelagic	200-1000 m
bathylpelagic	1000-4000 m
abyssalpelagic	4000-7000 m
hadalpelagic	>7000 m

Depth Classes of the Oceanic Bottom

This category of depth zone classifiers for the bottom is also highly resolved based on the importance of the continental platforms and their associated features. On the oceanic bottom, vertical depth zones of the bottom are defined by the depth and slope ranges listed below. The depths of these zones vary depending on regional geology.

Subzone	Gradient	Depth
continental Platform	usually less than 1:500 or 1-0.1^{o}	<~200 m
upper Slope	4-25^{o}	200-1000 m
lower Slope	1-6^{o}	1000-3000 m
continental Rise	4^{o}	2000-5000 m
bathyl	less than 1:1000	1000-4000 m
abyssal	less than 1:1000	4000-7000 m
hadal	trenches	>7,000 m

Photic Quality

Photic quality is a highly variable parameter. In many nearshore cases, light penetrates deeply, and the photic zone extends to the bottom of the water column; in others, almost the entire water column is dark. All systems are aphotic for at least part of every day, during nighttime. Degree of exposure of a particular place to light depends on the depth, sun angle, time of year etc. Moreover, the depth of the shift from photic to aphotic occurs at different points in the water column, depending on the ecosystem, watershed, the amount of turbidity in the water, etc. The important functional distinction of the photic regime is between the part of the water column within which plants can photosynthesize and animals can feed and defend visually, and where they cannot.

Vertical subclasses are relative to the penetration of light: photic and aphotic, for both water column and benthic zones:

Photic: that region of the water column that is lighted, i.e. ambient light is > 2% of surface light. This is ecologically significant because it is considered the photosynthetic compensation point, where respiration equals autotophic production

Aphotic: that part of the water column below the compensation depth that receives less than 2% of the surface light, and where plants cannot achieve positive photosynthetic production

Seasonally photic: regularly varies between photic and aphotic

Spatial Patterns

A set of classifiers is established to fully describe the configuration of spatial elements that form a habitat unit or other classification unit. These classifiers indicate such characteristics as the degree of complexity of the unit and the relationship of elements within the unit, such as one being included within another, or two elements of equal scale that interact. These classifiers provide information that may be useful in determining functionally why a particular habitat unit is of importance and how it provides an ecological service to the associated biota.

Primary element: the dominant physical structure within a classification unit
Homogeneous: an element that entirely comprises a single classification unit
Heterogeneous: mixture of different elements that comprise a single classification unit
Complex unit: two or more interacting elements that form a single classification unit (eg. tidal creek in a salt marsh is a salt marsh tidal creek, a complex unit)
Dominant: in a complex classification unit, if one of the elements within a unit is spatially dominant, that unit is identified as the dominant element of the mixture, and further qualified by the secondary element(s)
Matrix: if a classification element that lies within an undifferentiated substrate (e.g. cobble in a sand matrix)
Inclusion: a small element embedded within a spatially dominant type
Variable: units that change significantly through time in one or more attributes (e.g. a sand spit with highly variable morphology)
Highly structured: high degree of physical complexity and heterogeneity (e.g. a coral reef)
Moderately structured: have a high degree of physical complexity but are generally homogeneous (e.g. a mangrove prop root zone)
Unstructured: exhibit a low degree of physical complexity and are homogeneous (e.g. a soft sand bottom)
Solitary: single unit
Multiple: multiple repeating units

Geomorphologic Descriptors

In littoral and bottom zones, in all systems, the set of classifiers used to further describe local structure of macrohabitats and habitats is: **profile, slope, relief, substrate, size**.

Profile

Profile refers to the elevation of the feature relative to surrounding level of the water or bed:

Profile	Relative Height
none	0
low	0-2 m
medium	2-5 m
high	>5 m

Slope

Slope refers to the angle of the substrate; Greene`s (1999) geological classification is followed here to characterize slope as:

Slope	Vertical Angle
flat	0-5°
sloping	5-30°
steeply sloping	30-45°
vertical	45-90°
overhang	>90°

Relief

Relief is a qualitative variable that refers to the texture or roughness of the geomorphic structure. The quality is somewhat scale dependent because the method of perception, the resolution and the spatial scale will bear on the apparent relief. However, in practice, the roughness will be most applicable at the lowest levels of the hierarchy where it will impact the behavior of individual organisms- the macrohabitat, habitat and biotope. Therefore, the definitions of relief are set to the spatial context of a 1-1000 m^2 scale:

Smooth: no perceptible texture
Irregular: perceptible texture or feature that is heterogeneous and non-regular in either frequency, direction or amplitude
Variable: perceptible texture or feature that is regular in either frequency pattern but irregular in direction and/or amplitude
Rippled: closely spaced, regular, repeating vertical variations in height of a sandy or muddy bottom with a very short wavelength (cm)
Waves: regular, repeating vertical variations in height of a sandy or muddy bottom with an intermediate wavelength (<1m)
Undulating: regular, repeating vertical variations in height of a sandy or muddy bottom with a long wavelength (>5 m)

Large Scale Relief

Relief on a large scale for formations is a qualitative variable that refers to the aspect ratio of the geomorphic structure. The classifier is used to distinguish those units that are tall with respect to their "footprint" such as a seamount, from those that are flat, such as the abyssal plain. The categories in this classifier for features that are >1000 m^2 scale:

Large Scale Relief	Aspect of height:width
flat	~0
low	0.1
moderate	0.5
high	1
extreme	>1

Substrate Type

General class of substrate material, mixture and state due natural processes include:

Substrate Type	Description
unconsolidated	loose, non-diagenetic sediments, sands and shell
hardpan	particles fused into a hard flat substrate at or above the littoral
hardbottom	subtidal corals, hardpan and rock
biogenic	formed by biological action
deposit	loose unconsolidated material deposited by current or slumping
ice	polnya, iceberg, pack ice, ice floe and fast ice

Substrate Size

The substrate type describes the particle size of the primary material of which the substrate is composed, based on its grain size:

Substrate	Grain Size
mud	<0.07 mm
sand	0.07-2 mm
gravel	2-4 mm
pebble	4-74 mm
cobble	74-257 mm
boulder	>257 mm

Substrate Composition

The surface composition of the substrate is defined as follows:

Peat: organic material laid down and consolidated into sediment

Clay: fine mineral particulates of kaolin with high cohesiveness
Silt: very fine mud particles laid down after water transport and deposition
Carbonate muds: fine particulates of calcium carbonate with high cohesiveness
Carbonate rock: sedimented or biogenically deposited carbonates which have undergone diagenetic transformation into rock
Limestone: generic class of calcium carbonate rock
Organic: dead plant and animal tissue that partially decomposes to form sediments
Pavement: hard rock substrate that is flat with low profile
Shell hash: substrate that is substantially composed of small bits of broken shell remnants
Igneous: rock that is volcanic in origin
Metamorphic: rock that is formed from several distinct rock types that are fused through great pressure and temperature

Sedimentary: rock that is formed from gradual deposition of sediments, dewatering and diagenesis
Ooze: decomposed tests of sedimented microscopic organisms deposited on the bottom. Types of oozes include globagarina, diatomaceous and siliceous.
Mix: combination of two or more substrate types
Abiotic: physical substrate lacking a current or past living component

Temporal Persistence

The temporal persistence descriptor describes the permanency or variability of a hydromorphic or geomorphic feature. Though qualitative and relative, it is useful is distinguishing between features that are similar in morphology but are temporally diverse in terms of stability. An example is a mud shoal versus a mudbank. The former tends to be moved by changing currents or storms, while the latter is more stable and persistent. Classes are:

Persistence	Stability
low	weeks to months
medium	months to years
high	decadal
permanent	stable
variable	varies regularly
stochastic	varies stochastically

Biological Descriptors

Trophic Status

Trophic status is a general categorization of the abundance of dissolved macronutrients (DIN and DIP) and level of primary productivity of a unit. In broad terms, the trophic status gives an indication of the health of the system via the balance of production and consumption and is measured by chlorophyll concentration in water columns and by total biomass in macroalgal and rooted vascular plant communities. For water column phytoplankton communities, the classifier classes are:

Trophic Status - Phytoplankton	Chlorophyll Level
oligotrophic	< 5 µg/L chlorophyll a
mesotrophic	5-50 µg/L chlorophyll a
eutrophic	> 50 µg/L chlorophyll a

The trophic classes were derived, with modification, from the NOAA Estuarine Eutrophication Survey (NOAA 1997).

For macrovegetation in littoral zones, emergent in wetlands and in benthic zones, the classifier classes are:

Trophic Status - Macrovegetation	Biomass
oligotrophic	<50 mg dry wt/m^2
mesotrophic	50-1000 mg dry wt/m^2
eutrophic	>1000 mg dry wt/m^2

Cover Type

For vegetation and faunal distribution within a particular habitat the following cover type classifiers are available:

Vegetated: a habitat or biotope unit that is characterized by a cover of rooted or attached vegetation
Colonized: a habitat or biotope unit that is characterized by a growth, colonization or encrustation of a specific fauna or faunal community
Mixed: a unit that is significantly covered by vegetation and colonies of animals
Bare: a substrate that is unvegetated and uncolonized*.
Grazed: vegetation cover that exhibits obvious consumption by herbivores
Hole: within a vegetation bed, a discrete section of vegetation that is devoid of cover
Scour: area that is eroded by water action

* methodology will determine threshold for unvegetated and for uncolonized

Cover Class

The degree of vegetative cover for each is assessed using the following classes (after the Scheme classification of Madley et al. 2003):

Bare: operationally 0% cover
Sparse cover: a cover of < 10%
Moderately sparse cover: cover of 10- 25%
Moderate cover: a cover of 25-75 %
Moderately dense cover: a cover of 75%-90%
Complete cover: a cover of 90-100%
Patchy cover: a distribution of vegetation that is non-heterogeneous resulting in large spatial variation in density of cover.

Anthropogenic Descriptors

Anthropogenic Impact

Impounded: areas that are cut off from natural hydrological flow by building or placing barriers such as levees or dams, either to retain water or to prevent inundation
Polluted: waters or substrates that receive nutrient, sewage, heavy metal or pesticide inputs from anthropogenic sources that are significantly above natural loading levels or abundances (e.g. EPA standards or local total maximum daily loads-TMDLs)

Dredged: bottom that is mechanically dredged specifically for mining sediments or other materials (e.g. shell), for deepening or widening channels (e.g. for navigation or alteration to hydrology), or for other bathymetric modification.
Artificial structure: large, solid and persistent human constructions in the littoral, bottom or water column zones
Developed: coastal or marine areas that are modified and on or in which artifical structures are constructed (e.g. residences, drilling platforms).
Deposited: materials such as sand or shell that are placed on or in an area of coast or a water body.
Artificial reef: large, solid and persistent structures or items placed on the sea bottom specifically for colonization by reef-dwelling biota.

Biogeographic Descriptors: Ecological Region

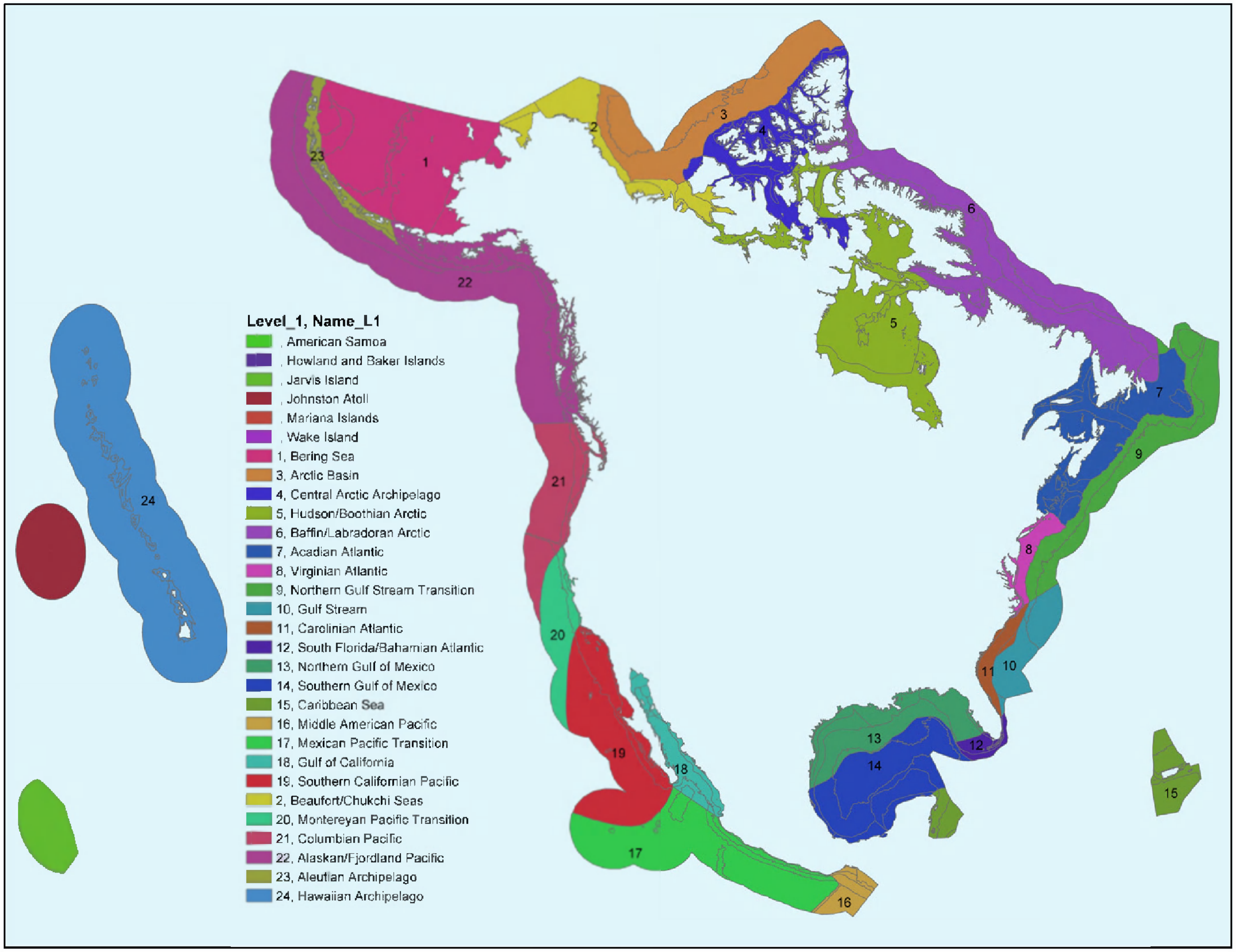
The Coastal and Marine Ecological Classification Standard provides a means to identify the ecological region within which a particular unit resides via the use a biogeographic descriptor called Ecological Region. Ecological regions are defined as very large areas of the coasts and oceans that are relatively homogeneous with regard to physical and biological variables and reflect ecological boundaries determined by climate (temperate, tropical, polar), physical structure, such as major currents or ocean basins, and the characteristics of the biological associations, such as isolation or endemism. Marine ecological regions are defined by large seas, currents and regions of coherent sea surface temperature or ice cover. The spatial scales of these classifiers are lengths of 100 km to 1,000 km and areas of 100 km^2 to more than 1,000 km^2.

The ecological region descriptor is based on biogeographical delineations described in the report Ecological Regions of Coastal North America (Wilkinson et al. in press). The Commission for Environmental Cooperation (CEC) developed this report through several workshops on marine biogeography and in collaboration with the technical experts that developed the CMECS through a process similar to that for delineating terrestrial ecoregions (CEC 1997). The ecological regions for North America are listed in Table 1 followed by further descriptions of the regions and their spatial boundaries.

Table 1. The Ecological Regions of Coastal North America.

Region #	Ecological Region
Region 1	Bering Sea Region
Region 2	Beaufort/Chukchi Seas Region
Region 3	Arctic Basin Region
Region 4	Central Arctic Archipelago Region
Region 5	Hudson Boothian Arctic Region
Region 6	Baffin/Labrador Arctic Region
Region 7	Acadian Atlantic Region
Region 8	Virginian Atlantic Region
Region 9	Northern Gulf Stream Transition Region
Region 10	Gulf Stream Region
Region 11	Carolinian Atlantic Region
Region 12	South Florida/Bahamian Region
Region 13	Northern Gulf of Mexico Region
Region 14	Southern Gulf of Mexico Region
Region 15	Caribbean Sea Region Region
Region 16	Middle American Pacific Region
Region 17	Mexican Pacific Transition Region
Region 18	Gulf of California Region
Region 19	Southern Californian Pacific Region
Region 20	Montereyan Pacific Transition Region
Region 21	Columbian Pacific Region
Region 22	Alaskan Fjordland Pacific Region
Region 23	Aleutian Archipelago Region
Region 24	Hawaiian Archipelago Region

Figure 18. Ecological Regions of North America
(Wilkinson et al. in press).



1. Bering Sea

The Bering Sea is the world's third largest semi-enclosed water body, bounded by the Bering Straight in the north and the arc of the Aleutian Island chain in the south. It is divided in half by physiography, with a broad shelf to the east, and much deeper oceanic plains to the west. Noted in particular for its wide coastal shelf and high productivity, the Bering Sea is of special conservation importance to marine mammals, and fisheries, and is a unique sub-polar ecosystem.

2. Beaufort/Chukchi Seas

The Beaufort and Chukchi Seas border the Arctic Ocean and is shared by the U.S., Canada, and Russia. It is bounded by the Bering Straight in the southwest, permanent sea ice of the Arctic Basin (Region 3), and follows the Arctic coastal shelf along the north shore of Alaska and Canada's Yukon and Northwest Territories to Amundsen Gulf. This sparsely populated region, particularly well known for its coastal oil and gas activities, is also home to 40 species of fish and significant concentrations of marine mammals like the beluga whale, polar bear and ringed seal.

3. Arctic Basin

The Arctic Basin region is essentially the core northern parts of the Arctic Ocean that remain under permanent ice cover. This region encompasses the northwesterly most part of the Canadian Arctic and the central core of the Arctic Archipelago, north of the Boothia Peninsula. The two sub-divisions share climatic characteristics such as ice cover. The Arctic Basin is a large, deep depression that reaches 3,600 meters in depth, with no coasts. The Arctic Archipelago is composed of waters mostly 200 to 500 meters deep, and includes thousands of islands with jagged coastlines making it one of the biggest archipelagos in the world with one of the longest coastlines.

4. Central Arctic Archipelago

The Central Arctic Archipelago includes thousands of islands with jagged coastlines making it one of the biggest archipelagos in the world and one of the longest coastlines. This region's very cold sea water and northern latitude, as well as the little influence warmer southern waters have on the realm, make for its relatively constant cover of ice sheets and ice pack. The boundary of the region is a complicated border that winds around a series of Arctic islands. Its northwestern-most border includes Prince Regent and Peel Sounds (Canada). The region is composed of waters mostly 200 to 500 meters deep, and includes most of the Arctic Islands east of the Arctic Basin Region, such as Ellesmere Island, the Queen Elizabeth Islands and the northeastern part of Victoria Island.

5. Hudson/Boothian Arctic

The primary characteristic of the Hudson Boothian Arctic region is its Arctic water mass with seasonal ice regimes. The Hudson Bay tidal flats and inland marsh areas harbor some of the world's largest concentrations of breeding, molting and migrating shorebirds and waterfowl. Aside from Hudson Bay, vast and open seascapes are rare in much of this region. It is generally comprised of a patchwork of interconnecting bays, fjords, channels, straits, sounds, basins, shoals, sills and gulfs.

6. Baffin/Labradoran Arctic

The Baffin/Labradoran Arctic region forms a transition between the cold northern waters and the more temperate southern waters of the Northwest Atlantic. Sea ice is common throughout much of the region, depending on the season and latitude. Ice begins to form off the coast of Labrador in November or December. By February or March, ice regularly reaches the northeast coast of Newfoundland, accompanied by thousands of icebergs.

7. Acadian Atlantic

The Acadian Atlantic Region extends along the eastern North American continent from Cape Hattaras northward around the Scotian Shelf and Newfoundland, then northwestward into Baffin Bay. The region crosses climate zones from temperate to sub-Arctic to Arctic, hugging the east coast as far north as Newfoundland, then separated from the Canadian coast by the Baffin/Labradoran Arctic coastal region (Region 6). On its seaward boundary, this region borders the offshore zone that is influenced by the Gulf Stream. The area encompasses a coastline formed by and heavily influenced by glacial processes, resulting in complex geomorphologies, rocky coastal zones and resistant bedrock formations. Numerous coastal watersheds deliver freshwater to important estuaries, and the region supports key ecological assemblages and commercially important fisheries.

8. Virginian Atlantic

The Virginian Atlantic region supports key ecological assemblages and commercially important fisheries with ranges that extend northward to Canada. Chesapeake Bay, the largest estuary in the United States, lies within this region. The region is also home to a historically enormous oyster fishery that has dwindled in recent years due to pollution, overfishing and disease. The region extends along the eastern North American continent from Cape Hattaras northward to Cape Cod. The region lies within the temperate climatalogical zone, and is interposed between the east coast and the Northern Gulf Stream Transition Region offshore (Region 9).

9. Northern Gulf Stream Transition

The Northern Gulf Stream Transition region is an area of the Western North Atlantic offshore of the Acadian Atlantic and the Virginian Atlantic regions. The waters of the Northern Gulf Stream Transition Region consist of open ocean and do not border any continental land mass. The region is influenced by the Gulf Stream current to the east and south, the coastal waters of northeastern North America to the west, and the Labrador Current to the north and west. Region 9 extends from offshore of the tip of Cape Hatteras in North Carolina northward to offshore of Labrador and is completely marine in character. The area overlays several important bathymetric features of the northwestern Atlantic including the Canyon Lands.

10. Gulf Stream

The Gulf Stream region is defined by and dominated by the Gulf Stream current. The region starts at the Straits of Florida (USA) at its southern extreme, and continues northward and seaward of the coastal Atlantic Bight following the Gulf Stream current to the Outer Banks of North Carolina (USA) and Cape Hatteras (USA), where the region terminates as the current veers northeastward (out of the area of study).

11. Carolinian Atlantic

The Carolinian Atlantic region extends from the southern Atlantic coast of Florida, where the continental shelf and the Gulf Stream diverge from the coast, north to the Outer Banks and Cape Hatteras. The region is defined by a broad shelf, which extends up to 150 km from the coast at Georgia, and by several coastal plain watersheds that terminate at the coastal margin. The region extends to the edge of the Continental Shelf at the Florida- Hatteras Slope, also the nominal western boundary of the Gulf Stream.

12. South Florida/Bahamian Region

The South Florida/Bahamian Region is a small region with generally clear waters, coral reef formations, and carbonate substrate—generally tropical in its ecological character. Climate, substrate and biota are influenced primarily by the Gulf Stream and the warm waters the current carries adjacent to and through the region. The region includes coastal waters off southern Florida, the Florida Keys, Florida Bay, The Florida Keys Reef Tract, Biscayne Bay, and the nearshore region where the Continental Shelf break and the Gulf Stream most closely approach (five kilometers) the coast.

13. Northern Gulf of Mexico Region

The Gulf of Mexico is a semi-enclosed sea encompassing about 630,000 square miles. The Northern Gulf of Mexico region extends from Gullivan Bay on the west coast of Florida to Rio Panucho in the state of Tamaulipas in northern Mexico, a coastline of about 30,000 km. Most of the oceanic input to the Gulf is from the Caribbean Sea through the Yucatan Channel, forming the Loop Current, which winds north then east through the Gulf, outflowing through the Straits of Florida. A broad Continental Shelf covers about a third of the entire Gulf. Mangroves, salt marshes and beds of submersed aquatic vegetation (SAV) dominate the coastal floral communities. The Gulf of Mexico contains over 60% of the tidal marshes of the U.S.

14. Southern Gulf of Mexico

The Southern Gulf of Mexico region includes the southern tropical portion of the Gulf, a semi-enclosed sea basin with tropical currents and high nutrient load. Waters off the states of Veracruz, Tabasco, Campeche and Yucatan, Mexico are included in this region.

15. Caribbean Sea

The Caribbean Sea is a semi-enclosed tropical sea formed by the arc of the Greater and Lesser Antilles and the Atlantic coasts of Venezuela and Colombia, Central America and the Yucatan Peninsula. Waters off the States of Quintana Roo, Mexico, and U.S. waters around the Commonwealth of Puerto Rico, the Territory of the U.S. Virgin Islands (USVI), and Navassa Island are included in this region.

16. Middle American Pacific Region

The Middle American Pacific region—largely free of the southernmost winter influence of the California current and therefore described as a year-round tropical sea—supports important fisheries such as yellowfin and skip jack tuna, as well as shrimp. Although relatively small, the region has bathymetry that is quite complex and diverse, including a narrow continental shelf, a continental slope, part of the Mesoamerican Trench, part of the Guatemala Basin, and the Tehuantepec Ridge. Waters off the Mexican states of Oaxaca and Chiapas are included in this region.

17. Mexican Pacific Transition

The Mexican Pacific Transition region is basically a tropical sea that is seasonally affected by the southernmost winter influence of the California Current. The Mexican Pacific Transition is a fairly complex, with a narrow shelf that drops off steeply to great ocean depths close to the coast. It is incised by several canyons and the Mesoamerican Trench that drops to depths between 4000 and 5,000 meters. In addition, the region is dotted by numerous submarine hills and mountains, and includes a rift system and volcanic cones that have emerged from the depths of the ocean. The region also has a great diversity of coastal systems and subsequently high species diversity. Waters off the states of Jalisco, Colima, Michoacán, Guerrero and Oaxaca and Mexico are included in this region.

18. Gulf of California Region

The Gulf of California is a semi-enclosed sea with tropical characteristics during summer and temperate through winter. The region is known for its exceptionally high rates of biodiversity and primary productivity, due to a combination of its topography, southern latitude and upwelling systems. Waters off the states of Nayarit, Sinaloa, Sonora, Baja California and Baja California Sur, Mexico, are included in the region. The southern border is generally considered to stretch from Cabo Corrientes (Jalisco) on the mainland to the tip of the Baja California Península.

19. Southern Californian Pacific

The Southern Californian Pacific region stretches along the Pacific Coast from the Southern tip of Mexico's Baja California at Cabo San Lucas north to Point Conception, California in the United States. It is influenced by the north-south flow of the California Current, local upwelling, and the California Countercurrent, and extension of the Equatorial Countercurrent bringing warmer subtropical waters.

20. Montereyan Pacific Transition Region

The Montereyan Pacific Transition stretches along the central California coast from Point Conception to Cape Mendocino. The region has moderately high productivity associated with the seasonal upwellings that occurs along its coasts. The Montereyan Pacific Transition includes a series of submarine canyons and seamounts, including one of the largest canyons on the Pacific coast of North America. It's proximity to shore attracts deep-water species of whales, dolphins and seabirds to the coastal areas of the region.

21. Columbian Pacific

The Columbian Pacific region stretches along the Pacific coast from Cape Mendocino in the South, northward to include the Straight of Juan de Fuca and end at northern tip of Vancouver Island, in the North. The region is home to abundant plant and wildlife, but also has one of the fastest growing human populations in North America.

22. Alaskan Fjordland Pacific

The Alaskan Fjordland Pacific region is home to abundant plant and wildlife and includes the complex, crenelated fjord coastline along western Canada. The region is shared by Canada and the United States and extends from Cape Cook on Vancouver Island north through the Gulf of Alaska and out to the end of the Aleutian Island chain (the latter shared with the Bering Sea Region).

23. Aleutian Archipelago

The Aleutian Archipelago Region contains the longest archipelago in the world as well as the Aleutian Trench 3700 km long and 7,680 meters deep. High-velocity currents move through straits and passes that connect the temperate North Pacific Ocean in the Alaskan Fjordland Pacific region to the subpolar Bering Sea. Along the Archipelago the greatest flow is northward from the lower latitude Pacific Ocean toward the Arctic Ocean. The region is considered a transition zone between the polar seas of the Bering and the Arctic and the temperate waters of the mid-latitude, northern Pacific Ocean.

24. Hawaiian Archipelago

The Hawaiian Archipelago region follows the Hawaiian archipelago, which stretches 2450 km from the Big Island of Hawaii northwest to Kure Atoll. It is composed of 8 main volcanic oceanic islands, 124 smaller islands, atolls, banks, and numerous seamounts. It is among the most isolated island systems in the world. The region also includes Johnston Atoll 800 km southwest of Hawaii.

Additional ecological regions not mapped but that include U.S. possessions:

25. Central Pacific

The Central Pacific region lies in the central insular area of the Pacific consisting of small coral islands and atolls from the near the Equator to the north. The region includes islands and atolls within the U.S. EEZ (Exclusive Economic Zone) stretching from Wake Atoll (northernmost of the Marshall Island

Archipelago) to Howland and Baker Islands (northwestern-most of the Phoenix Islands), west to Jarvis Island (Equatorial Line Islands), north to Palmyra Atoll and Kingman Reef (Northern Line Islands), and west-northwest to Wake Atoll.

26. Samoan Region

Southwest Pacific region includes the volcanic and corals islands of eastern half of the Samoan Archipelago within the EEZ of the U.S. encompassing American Samoa. This region stretching from Swains Island (south southwest of Hawaii), southeast to Rose Atoll, northwest to Tutuila Island, and north to Swains Island.

27. Mariana Region

The Northwest Pacific region includes all the volcanic and raised limestone islands and submerged banks of the Mariana Archipelago to the limits of the EEZ of the U.S. and stretches from Guam Island north to Farallon de Pajaros.

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