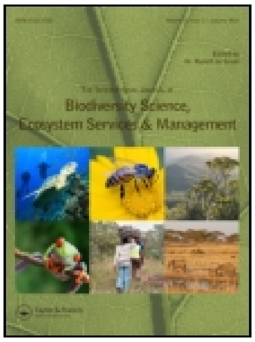

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RESEARCH LETTER

Linking the Coastal and Marine Ecological Classification Standard (CMECS) to ecosystem services: an application to the US Gulf of Mexico

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At the first Gulf of Mexico Ecosystem Services Workshop (2010), ecosystem services were linked to the Gulf of Mexico habitat types as defined in the Coastal and Marine Ecological Classification Standard (CMECS), recently endorsed as the first US standard for classifying coastal and marine ecosystems. Participants identified and classified the Gulf habitat types based on CMECS, linked ecosystem services to habitat types, and prioritized services using expert opinion. Only three categories of ecosystem services were considered: regulating, provisioning, and cultural. However, supporting services, such as biological interactions, were considered as part of reclassified services. Highly ranked services were distributed across all the three service categories for each Gulf habitat, except for mangroves and dune/beach (only regulating and cultural services). Predictably, the majority of the habitat types were linked to the service of food. The importance of this exercise lies in the utility of the results for resource managers conducting activities within the Gulf of Mexico coastal and marine environments and can be informative to other regions wishing to conduct a similar exercise. This is, as far as the authors are aware, the first inventory of habitat types and their associated ecosystem services within the Gulf of Mexico region.

Keywords: CMECS; ecosystem services; Gulf of Mexico; classification standard; habitat

Introduction

This research letter illustrates how ecosystem services, as described by Farber et al. 2006, were assigned to Gulf of Mexico habitat types as defined in the Coastal and Marine Ecological Classification Standard (CMECS). CMECS was recently endorsed by the US Federal Geographic Data Committee (FGDC) as the first national standard for classifying coastal and marine ecosystems. The standard underwent an extensive public review period prior to endorsement and it is now seeing wide-spread implementation throughout the United States (see http://www.fgdc.gov/standards/projects/FGDC-standards-projects/cmecs-folder/cmecs-index-page for a summary of the FGDC process and comment resolution).

The exercise described herein is focused on the northern Gulf of Mexico; hence, it is not inclusive of all habitats found in CMECS, but describes an expert-led process for linking coastal and marine habitats to ecosystem services. This application was carried out at the first Gulf of Mexico Ecosystem Services Workshop, held in Bay St. Louis, Mississippi, in June 2010 (c.f. Yoskowitz et al. 2010). A total of 31 participants were present, from US federal and state agencies, non-governmental organizations (NGOs), the private sector, and academic institutions representing diverse disciplines such as ecology, biology, economics, geology, oceanography, and fisheries and having an extensive knowledge of Gulf of Mexico issues or that had been working in the region for several years. Each of the five US Gulf states was represented to ensure equal consideration of all ecological units.

The workshop was supported by the Harte Research Institute at Texas A&M University - Corpus Christi, Texas, the Northern Gulf Institute, and the National Oceanic and Atmospheric Administration's (NOAA) Gulf Coast Services Center and Gulf of Mexico Regional Collaboration Team (Yoskowitz et al. 2010).

Workshop goals

The goals of this project were to (1) classify habitat types (ecological units) within the northern Gulf of Mexico according to the CMECS structure; (2) identify ecosystem services those habitat types might provide; and (3) rank those services within each habitat type. The assumption was made that a specific ecological unit (e.g., an oyster bed, CMECS Subclass Mollusk Reef; Table 1) has the potential to provide the same suite of ecosystem services (e.g., food, water quality through filtration) irrespective of its geographic location, condition, and presence of beneficiaries. The approach followed at this workshop was to use expert opinion (Teck et al. 2010; Burgman et al. 2011; Carollo et al. 2012) to assign ecosystem services to the habitat types identified within the northern Gulf of Mexico. It was not a mapping exercise whereby those habitat types were geospatially identified, nor was it an exercise to assign monetary or non-monetary values to the

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Table 1. Gulf of Mexico ecological units classified according to CMECS (except where noted otherwise). For the National Vegetation Classification standard L1, L2, L3, and L4 indicate levels.

Brackish marsh
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: emergent wetland
Biotic subclass: emergent tidal marsh
Biotic group: brackish marsh

Coral reef
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: reef biota
Biotic subclass: deepwater/coldwater coral reef biota and shallow and mesophotic coral reef biota

Dune/Beach
CMECS geoform component
Level 1 geoform: dune field
Level 2 geoform: dune
Levels 1 and 2: beach
Note: Dune and Beach are separate geoforms

Fresh submerged aquatic vegetation
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: aquatic vegetation bed
Biotic subclass: aquatic vascular vegetation
Biotic group: freshwater and brackish tidal aquatic vegetation and seagrass bed

Freshwater marsh
Note: Inland freshwater marsh is beyond the scope of CMECS
National vegetation classification standard
L1. Formation class: mesomorphic shrub and herb vegetation
L2. Formation subclass: temperate and boreal shrubland and grassland
L3. Formation: temperate and boreal freshwater marsh
L4. Division: North American freshwater marsh

Forested coastal ridge
Note: Beyond the scope of CMECS
National vegetation classification standard
L1. Formation class: mesomorphic tree vegetation
L2. Formation subclass: temperate forest
L3. Formation: warm temperate forest
L4. Division: Southeastern North American warm temperate forest

Intertidal sand/mud
CMECS substrate component
System: marine, estuarine
Subsystem: marine nearshore intertidal; estuarine coastal intertidal; tidal riverine coastal intertidal
Substrate class: unconsolidated mineral substrate
Substrate subclass: fine unconsolidated substrate

Macroalgae
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: aquatic vegetation bed
Biotic subclass: benthic macroalgae

Mangroves
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: forested wetland
Biotic subclass: tidal forest/woodland
Biotic group: tidal mangrove forest

(*Continued*)

Table 1. (Continued).

Non-fresh submerged aquatic vegetation
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: aquatic vegetation bed
Biotic subclass: aquatic vascular vegetation
Biotic group: freshwater and brackish tidal aquatic vegetation and seagrass bed

Offshore shoals and banks
CMECS geoform component
Level 1 geoform: bank/shoal

Open water
CMECS water column component
System: marine, estuarine
Subsystem: marine nearshore, offshore, and oceanic; estuarine open water; tidal riverine open water

Oyster reef
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: reef biota
Biotic subclass: mollusk reef biota
Biotic group: oyster reef

Saline marsh
CMECS biotic component
Biotic setting: benthic/attached biota
Biotic class: emergent wetland
Biotic subclass: emergent tidal marsh
Biotic group: high salt marsh and low and intermediate salt marsh

Subtidal sand/mud
CMECS substrate component
System: marine, estuarine
Subsystem: marine oceanic, offshore and nearshore subtidal; estuarine coastal subtidal; tidal
riverine coastal subtidal; estuarine open water; tidal riverine open water
Substrate class: unconsolidated mineral substrate
Substrate subclass: fine unconsolidated substrate

Swamp/bottomland hardwood
NOTE: Swamps are not a separate biotic group in CMECS
National vegetation classification standard
L1. Formation Class: mesomorphic tree vegetation
L2. Formation Subclass: temperate forest
L3. Formation: temperate flooded and swamp forest
L4. Division: Southeastern North America flooded and swamp forest

ecosystem services. We were only interested in what services regional experts believed the identified habitat types would provide and, of those services, which they perceived ranked the highest in priority. The underlying idea was that if we had this basic information from experts in the resource management community, we could better focus future studies on needs and information gaps.

Considering that the conceptual framework of ecosystem services implies that any given point in a landscape supplies multiple ecosystem services (Ericksen et al. 2012), here we present a bundle of services attached to specific ecological units. It is, therefore, beyond the scope of our exercise to create geospatially explicit maps representing the source of ecosystem services at different scales.

To accomplish this, more data and interdisciplinary efforts will be required (Naindoo et al. 2008).

Approach

The Coastal and Marine Ecological Classification Standard

The first step in the workshop was to identify all the habitat types in the northern Gulf of Mexico and classify those habitats into CMECS ecological units. As workshop organizers, we presented a preliminary list of habitat types (CMECS ecological units) commonly found in the northern Gulf of Mexico to participants then asked them to identify the missing units; these were then added to the list. The habitat types that were considered for this exercise along with their respective CMECS classification are presented in Table 1. In some instances, important habitat types identified by workshop participants fell outside the scope of CMECS; in those instances the National Vegetation Classification Standard (FGDC 2008) was applied as noted in Table 1.

Developed by a collaboration of multiple federal and state agencies, academia, and NGOs, and led by NOAA and NatureServe, CMECS provides a national standard for consistent depictions of coastal and marine ecological characteristics (FGDC 2012). National consistency has been lacking in the past, as most habitat classification practitioners have relied on systems which were either highly habitat-specific or developed for a given location. Having a national, standardized classification ensures habitats are referenced using a common language, thus eliminating confusion (e.g., saline marsh is the CMECS ecological unit for the commonly known salt marsh).

The domain of the CMECS includes waters from the head of the tide or inland incursion of ocean salinity to the splash zone of the coasts to the deepest portions of the oceans and the deep waters of the Great Lakes (FGDC 2012) (Figure 1). While CMECS was developed specifically to address a need for a standard application in the United States, it is applicable to all coastal and marine environments and has been applied or is currently being considered by other countries (e.g., Iran has applied the standard in the Oman Sea; Norway and Australia have expressed interest and are in correspondence with CMECS developers; R. Allee, personal communication). CMECS is a comprehensive standard encompassing both the biogeographic and aquatic features that form the settings in which all waters lie (Figures 1 and 2). The larger systems within the aquatic settings were drawn largely from the *Classification of Wetlands and Deepwater Habitats in the United States*, FGDC-STD-004 (FGDC 1996); however, the systems were redefined within CMECS to address the needs of a coastal and marine standard. The Lacustrine system includes all deepwater areas of the Great Lakes, and shoreline areas of the Great Lakes with less than 30% areal coverage by trees, shrubs, and persistent emergents; the Estuarine system includes tidally influenced waters that have an open-surface connection to the sea, are regularly diluted by freshwater runoff from land, and exhibit some degree of land enclosure. The Marine system is defined by salinity (typically around 35 ppt) and has little or no significant dilution from fresh water except near the mouths of estuaries and rivers; it includes all non-estuarine waters from the coastline to the central oceans (Figure 1; NOAA Coastal Services Center Web site link: http://www.csc.noaa.gov/digitalcoast/publications/cmecs).

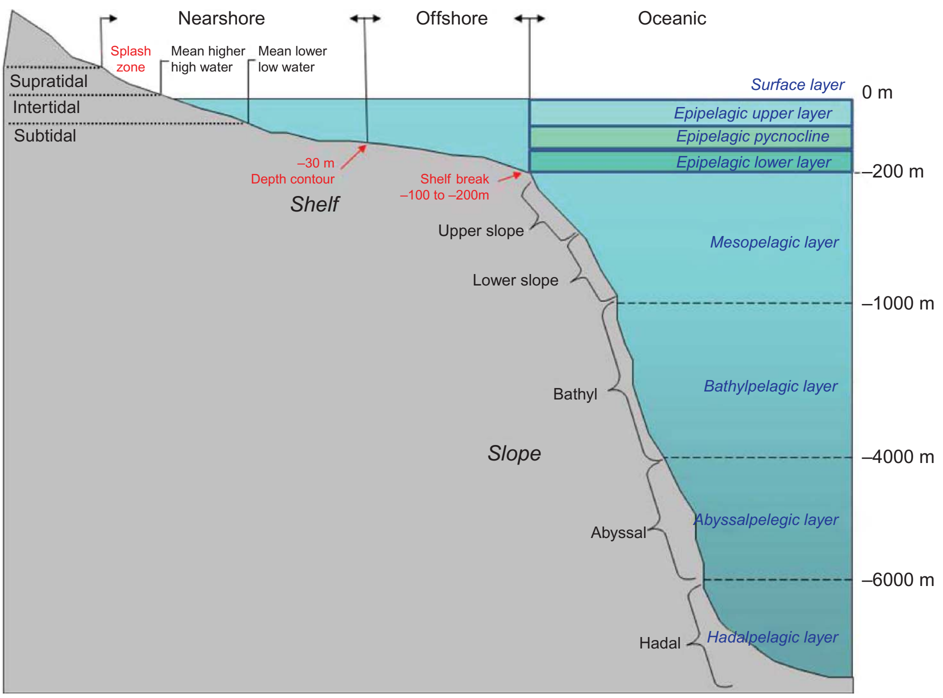

Figure 1. Marine subsystems, oceanic water column layers, and oceanic benthic depth zones. From FGDC-STD-018–2012.

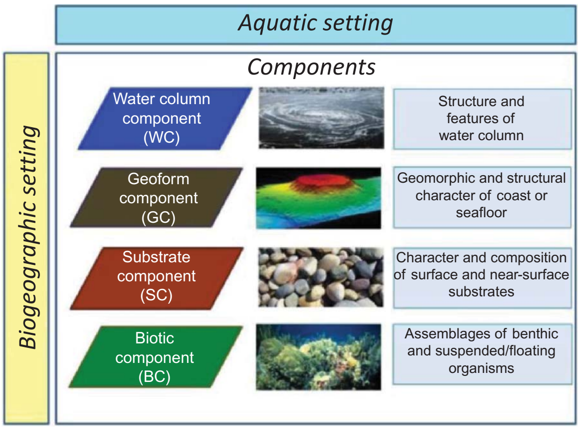

Figure 2. Diagram of the Coastal and Marine Ecological Classification Standard's organizational structure. From FGDC-STD-018–2012.

CMECS consists of four components: water column, substrate, geoform, and biotic (Figure 2), and is applicable at different geographic scales, allowing users to tailor their use based on their own study needs and goals. For example, while this study applied all the four CMECS components, some users may find that their study goals are met by applying only the biotic component. The biotic component is a hierarchical decision-tree classification that identifies (a) the composition of floating and suspended biota and (b) the biological composition of coastal and marine benthos and attached fauna (FGDC 2012). In this exercise, Class and Subclass were the preferred levels; however, at times finer levels were chosen (example: the CMECS Biotic Group oyster reef was used, since it is a significant habitat type within the Gulf of Mexico). The Substrate Component describes the composition and size of the estuary bottom and the sea bed materials in all the CMECS systems. This component is hierarchical and encompasses substrates of geologic, biogenic, and anthropogenic origin (FGDC 2012). The Geoform Component describes the major geomorphic and structural characteristics of the coast and seafloor. This component is divided into four subcomponents that describe tectonic and physiographic settings and two levels of geoform elements that include geologic, biogenic, and anthropogenic features (FGDC 2012). The Water Column Component describes the water column in terms of vertical layering, water temperature, and salinity conditions, hydroforms, and biogeochemical features (FGDC 2012).

While the workshop participants identified and classified Gulf of Mexico habitat types based on CMECS Version 3.1.(released for public review in August 2010), the results herein are presented following the final version of CMECS (i.e., revised to address public comments) recently endorsed by the FGDC (June 2012). In this application, when possible, the CMECS Biotic Component was applied to classify the ecological units (Table 1). However, in a couple of instances, the Geoform, Substrate, and Water Column Components had to be applied (Table 1). For habitat units beyond the scope of CMECS, specific terrestrial geo-environments were added (Table 1). For freshwater marsh, swamp/bottomland hardwood, and forested coastal ridge a characterization according to the National Vegetation Classification Standard was provided (Table 1).

Linking ecosystem services to regional CMECS habitat types

In addition to the goals previously identified, we wanted to gain consensus on definition(s) of ecosystem services in the northern Gulf of Mexico. Workshop attendees initially agreed upon defining ecosystem services using the combination of two existing but different definitions (MEA 2005; US EPA 2009) as follows:

> *Ecosystem services in the Gulf of Mexico are the direct or indirect contributions that ecosystems make to the well-being of human populations. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.*

The definition was then shortened and refined to be: *Ecosystem services are the contributions from Gulf of Mexico marine and coastal ecosystems that support, sustain, and enrich human life* (Yoskowitz et al. 2010). It was agreed that this definition is comprehensive enough to capture the major values of coastal ecosystems, workable in that ecosystem services could be quantified and valued with a reasonable amount of research and data acquisition, scalable from local sites to regional evaluations, and logical to policy-makers and the concerned public, i.e., expressed in terms that reflect intuitive values (Yoskowitz et al. 2010).

Once workshop participants were satisfied with the modified, comprehensive list of habitat types (Table 1) and had reached consensus on a definition of ecosystem services, we asked them to identify the ecosystem services those habitat types might provide. This started with a review of and changes to the ecosystem services naming convention adopted by Farber et al. (2006). Farber et al. (2006) classified ecosystem services into four categories: supporting, regulating, provisioning, and cultural. Workshop participants were broken into groups to discuss the Farber et al. (2006) descriptions of ecosystem services and assign them to CMECS ecological units. The revised classification of ecosystem services provided by Gulf of Mexico ecological units is presented in Table 2 together with definitions and examples.

Some ecosystem services in the Farber et al. (2006) publication were renamed or reclassified to better fit the cultural and political environment within the Gulf of Mexico. Specifically, the ecosystem services biodiversity and the one described as biological regulation by Farber et al. (2006) were grouped under the name biological interactions. The word 'regulation' was replaced by 'balance'

Table 2. Classification of ecosystem services (modified from Farber et al. 2006) provided by Gulf of Mexico ecological units as determined by workshop participants.

	Definition	Coastal and marine examples
Regulating/balance services	Maintenance of essential ecological processes and life support systems for human well-being	
Biological interactions	Species interactions	Keystone species. Starfish keeping a tidal pool in balance
Climate balance	Regulation of local to global climate processes	Influence of the ocean on temperature and precipitation
Gas balance	Regulation of the chemical composition of the atmosphere and the oceans	Sequestration of atmospheric carbon dioxide in the ocean
Hydrological balance	Movement, storage, and flow of water through the biosphere	Evapotranspiration and modulation of the drought-flood cycle
Nutrient balance	Maintenance of major nutrients within acceptable bounds	Bivalves (oysters and mussels) reduce water column nutrients; phytoplankton and primary productivity; clean water
Pollutant attenuation	Removal or breakdown of non-nutrient compounds and materials	Sequestration of heavy metals in sediments
Soil and sediment balance	Erosion control and sediment retention	Sediment stabilization, creation of shell hash and sand as shells break down
Water quality	Filtering of biotic and abiotic substances	Marsh, mangrove, seagrass, and oyster reefs removing sediment and excess nutrients and clarifying water
Hazard moderation	Dampening of environmental fluctuation and disturbance	Protection from hurricane storm surge by barrier islands and wetlands
Provisioning services	Provisions of natural resources and raw materials	
Air supply	Production of oxygen	Phytoplankton production of oxygen in the ocean
Food	Provisioning of edible plants and animals for human consumption	Commercial and subsistence harvesting of shellfish and finfish
Water quantity	Retention and storage of freshwater	Coastal freshwater wetlands providing drinking water. Desalination of seawater for human consumption
Medicinal resources	Biological and chemical substances for use in drugs and pharmaceuticals	Antibiotic molecules in deep ocean sediments. Toxins provided by coral reefs
Ornamental resources	Resources for fashion, handicraft, jewelry, decoration, worship, and souvenirs	Belt buckles and ornamental construction from shells
Raw materials	Materials for building and manufacturing. Fuel and energy. Soil and natural fertilizers	Road base, chicken calcium supplement, cosmetics from bivalves. Wave energy
Cultural services	Enhancing emotional, psychological, and cognitive well-being	
Aesthetic and existence	Sensory enjoyment of the natural environment	Enjoying a view of the ocean. Protecting marine mammals
Recreational opportunities	Opportunities for rest, refreshment, and recreation	Fishing, bird watching
Science and education	Use of natural areas for scientific and educational enhancement	Research about oysters and natural reefs provide metrics for restoration
Spiritual and historic	Spiritual and historic sites and information	Oyster middens of Native Americans, seafood festivals

due to the political and legal connotation of the original word (Table 2). The term balance, as used in this research letter, should not be interpreted as the ability of ecosystems to rectify any human impact. According to workshop participants, the term balance includes retention, provision, and transportation and better expresses the services the ecosystem provides in sequestering, releasing, absorbing, and/or modulating nutrients, gas, and sediment. Climate regulation and gas regulation were renamed climate balance and gas balance respectively; soil retention was renamed soil and sediment balance (Table 2). Nutrient cycling, a supportive service, and nutrient regulation, a regulating service, were grouped and the service was renamed nutrient balance (Table 2). Waste regulation was renamed pollutant attenuation. Water supply was divided into two services, namely water quality and water quantity; water regulation was included in hydrological balance. Additionally, air supply was added to the list (Table 2). Aesthetics was defined as the use of natural ecosystem resources for sensory enjoyment and appreciation; sensory experience of ecosystems; direct or indirect appreciation of ecological systems. In spite of this re-naming exercise, the description for each service was not modified; therefore, we followed the definitions provided by the Millennium Ecosystem Assessment (MEA 2005) and Farber et al. (2006) (Table 2).

In a first attempt to identify and order ecosystem services provided by the Gulf of Mexico habitats, we used a majority voting mechanism to allow participants to indicate their priorities. As previously mentioned, the assignment of ecosystem services to identified, regional habitat types was based on expert opinion of what services a specific habitat *might* provide, not from any analytical study of those habitats. Results are shown in Table 3 (a full list of ecosystem services linked to each habitat type is available within the workshop proceedings at http://www.harteresearchinstitute.org/images/research/socioeconomics/eservicesproceedings.pdf, page 9–12). In this exercise, only the ecosystem services listed in Table 2 were considered. These services belong to the regulating, provisioning, and cultural categories. However, supporting services were considered as part of reclassified services, such as biological interactions, which includes biodiversity and biological regulation, and nutrient balance, which includes nutrient cycling and nutrient regulation. Supporting services were regarded as an ecosystem's own functions and structures and, therefore, intrinsic components of all the ecological units identified in the Gulf of Mexico (Yoskowitz et al. 2010) and were not considered separately. Barbier et al. (2011) provide a strong review of the estuarine and coastal ecosystem structure and function and resulting ecosystem services for some of the habitats under consideration here.

Workshop results

For 12 of the 16 identified habitat types, 'biological interactions' was among the top three services (Table 3). This could be due to the fact that workshop participants assumed biological interactions are embedded within every coastal and marine ecosystem. In the majority of the cases, highly ranked services were distributed across the three categories for each Gulf habitat type. However, for two habitats, mangroves and dune/beach, only services within the regulating and cultural categories were amongst the top five (Table 3); i.e., no provisioning services were highly ranked for these two habitat types. In contrast, for brackish marsh only regulating and provisioning services were amongst the top five. For subtidal sand/mud, provisioning and regulating services were the most highly ranked (Table 3). Predictably, the majority of the habitats (13 out of 16) were identified as sources of food for human consumption (e.g., shellfish, seafood). The Gulf of Mexico is a high producer of seafood and many of its coastal residents actively participate in seafood-related activities as part of their culture. In 11 instances, recreational opportunities were among the highest ranked services (Table 3); this can be perceived as a reflection of the importance that coastal and marine habitats within the Gulf of Mexico have in offering a way to fill people's free time with activities such as recreational fishery, boating, swimming, surfing, diving, and so on. Hazard moderation and aesthetic and existence services were among the top five (Table 2) for eight ecological units, which indicates a recognition that Gulf of Mexico ecosystems play an important role in storm protection, in addition to their intrinsic value.

Table 3. Top five prioritized ecosystem services for each habitat type as determined by workshop participants.

	Ecosystem service and prioritization													
Habitat type	AE	BI	CB	FD	HM	HB	MR	NB	RM	RO	SE	SH	SS	WQ
Brackish marsh		2	4	5				1					3	
Coral reef	2	3		5			4			1				
Dune/beach	2				1					4	5		3	
Fresh submerged aquatic vegetation		1		5				4		3				2
Freshwater marsh	5	2		4	3			1						
Forested coastal ridge				5	2					1		4	3	
Intertidal sand/mud		2		4				5		3			1	
Macroalgae		1		3				2		5			4	
Mangroves	4	1			2					5			3	
	AE	BI	CB	FD	HM	HB	MR	NB	RM	RO	SE	SH	SS	WQ
Non-fresh submerged aquatic vegetation		2		1						5			4	3
Offshore shoals and banks	4	3		2	5					1				
Open water	5		3	1		4				2				
Oyster reef	5	3		1	4									2
Saline marsh	5	1		4	2					3				
Subtidal sand/mud		1		5				2	4				3	
Swamp/bottomland hardwood					1			2	5			4		3

Note: Aesthetic and Existence = AE, Biological Interactions = BI, Climate Balance = CB, Food = FD, Hazard Moderation = HM, Hydrological Balance = HB, Medicinal Resources = MR, Nutrient Balance = NB, Raw Materials = RM, Recreational Opportunities = RO, Science and Education = SE, Soil and Sediment Balance = SS, Spiritual and Historic = SH, Water Quality = WQ.

Hydrological balance, medicinal resources, and science and education were amongst the most highly ranked services for only one habitat type, open water, coral reef, and dune/beach, respectively. Gas balance, pollutant attenuation, water quantity, air supply, and ornamental resources were not amongst the top five ranked ecosystem services for any identified regional ecological unit.

Critical interpretation, limitations, and application of workshop results

Regardless of the workshop results, the authors believe, in agreement with the literature, that 'biological interactions' have a fundamental role in maintaining the services provided by coastal and marine ecosystems, and are not services per se but rather basic processes that contribute to an ecosystem's functioning. The fundamental role of biodiversity is discussed in Balvanera et al. (2006); their study concludes that biodiversity has a positive effect on several ecosystem services. It has been analyzed by Worm et al. (2006) that changes in marine biodiversity are the cause of change of several ecosystem services. For example, in coastal ecosystems, the loss of economically and ecologically important species has negative impacts on the number of viable fisheries, provision of nursery habitats, and filtering, thus affecting food, recreational opportunities, and water quality. The issue of whether or not 'biological interactions' should be considered ecosystem services was discussed minimally at the workshop, but participants decided to keep it as an ecosystem service. As such, the authors of this research letter kept it in the list (Tables 2 and 3) to more accurately reflect the outputs of the workshop and to also illustrate the challenges that can arise when soliciting expert opinion in an exercise similar to this.

Since at the workshop supportive services were only marginally considered, it is no surprise that the service habitat provision was never discussed. However, the authors recognize that the identified regional ecological units such as oyster reefs, saline marsh, and non-fresh submerged aquatic vegetation provide nursery habitat (Barbier et al. 2011) to several commercial and recreational fishery species, like brown and pink shrimp, blue crab, snappers, and drums to name a few. The linkage between ecological units and fisheries is undeniable and can only be maintained through the provision of breeding and nursery habitat (Barbier et al. 2011).

The authors realize that replacing the term 'regulation' with the term 'balance' may cause confusion in that it suggests a state of equilibrium. This was not the intent of the workshop participants, who wanted the newly adopted term 'balance' to indicate the ability of ecosystems to maintain chemical composition, climate processes, and erosion under control and in a dynamic equilibrium so to be able to provide ecosystem services. In retrospect, the workshop organizers and authors of this note would have argued against re-naming conventionally accepted terms for ecosystem services in order to ensure the outputs of the workshop were more easily integrated into practice. For example, the splitting of water supply into water quantity and water quality might be problematic given the numerous ways in which you could describe water quality. Is it related to water clarity, presence or absence of harmful microbes, or pollution? Despite the issues caused by the renaming and reclassification that took place, the National Research Council's committee studying the impact of the Deepwater Horizon oil spill on ecosystem services did utilize the ecosystem services classification resulted from the workshop (Table 3) in their interim report (NRC 2012).

The importance of this exercise lies in the utility of the results for resource managers conducting activities within the Gulf of Mexico coastal and marine environments. As far as we are aware, this is the first attempt to create an inventory of habitat types and their associated ecosystem services within the northern Gulf of Mexico.According to several studies (Daily 1997; MEA 2005; Fisher et al. 2009) and by our own definition, ecosystem services are considered as such only when there are beneficiaries who are able to enjoy them. However, the exercise described above provides an indication to practitioners about which habitat types can potentially provide which services (that would be characterized as such if humans were present). Having an inventory of this information may be of use to decision-makers who now have a way of organically looking at specific habitat types and the services they provide, particularly knowing how those services were ranked in order of importance. We believe this information will be useful for prioritizing habitat types for conservation and management of services provided. Also, the link between a specific ecological unit and ecosystem services could be beneficial for natural resource managers to understand changes in services due to changes in habitat.

However, this exercise does not account for the quality of the service provided by the identified habitats. That is, while the ecosystem services were identified, there was no assessment of how well the habitat would provide those services. For example, marsh can provide varying levels of disturbance regulation depending upon its condition (fragmented vs. continuous). Initiating studies to assess the quality of these services would yield additional information for use in management practices. These studies would probably be carried out at different scales than the one used for this exercise (regional) and result in gathering specific biophysical (ecosystem structure and function) and socio-economic (ecosystem services and human well-being) data that would allow refining the list of services provided by ecological units created at the workshop.

The results of the workshop could also be utilized to develop a user-friendly, interactive Web-based tool that represents the spatial distribution of ecological units in the Gulf region, together with the linked ecosystem services. However, this would be a data-intensive exercise and, currently, information is not available Gulf-wide for all the identified habitat types. The authors are aware of regional coverage for oyster reefs and wetlands (through the NOAA

Gulf of Mexico Atlas, http://gulfatlas.noaa.gov/), but not for other habitat types. If this exercise were to be carried out in the future, it would provide easily accessible and critical information to resource managers and decision-makers in the Gulf of Mexico.

The main limitation of our application is the assumption and generalization that a specific ecological unit within the Gulf of Mexico (e.g., oyster reef) produces the same services regardless of its geographic location, quality, and the presence of beneficiaries. For the extent of our exercise, the links between habitat types and ecosystem services should be interpreted simply as indications for potential service provision. This implies that for the discussed ecological units, no analyses of ecosystem functions were performed to link habitat types and ecosystem services, as done instead by Schulp et al. (2012).

Traditionally, the ecosystem services have not been part of the decision-making process. The exercise discussed here highlights the expert opinion process of linking northern Gulf of Mexico ecosystems and the benefits people derive from them. The goal of any conservation project can be framed in terms of ecosystem services to allow their inclusion in the decision-making process. However, a better understanding of how ecosystem structure and function, ecosystem services, and human well-being are linked is needed (Rosenberg & McLeod 2005; Jordan et al. 2010; Maynard et al. 2010), particularly in coastal and marine environments, for incorporation into management plans. The explicit, conceptual links presented in this letter may be considered the first necessary step towards integrating ecosystem services into conservation decision, thus strengthening the process by making it more complete and defensible. If natural resource managers and decision-makers followed this application method and included ecosystem services into their decision-making process then this would ensure sustainment, support, and enrichment of human well-being.

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