

Including Human Dimensions Science in the MARES Conceptual Ecological Model Framework

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(Note: This is the first in an anticipated series of whitepapers on topics related to the implementation of the MARES project for goal setting in the marine and estuarine ecosystems of South Florida.)

Summary

The purpose of this whitepaper is to propose the use of the DPSIR (Drivers-Pressures-State-Impacts-Responses) framework to guide development of conceptual ecological models that incorporate human dimensions science for the MARES project.

Background

The MARES project will develop conceptual ecological models (CEM) for the South Florida Total Marine Ecosystem (SFTME) and for three sub-regions of the SFTME: the southwest Florida shelf, the Florida Keys/Dry Tortugas and the southeast Florida shelf. The intent is to use well-developed, documented tools and regionally accepted approaches that have proven successful in the Comprehensive Everglades Restoration Plan (CERP) and South Florida Ecosystem Restoration (SFER) and rely on the experience of individuals already familiar with these processes and procedures. However, initial discussions of the application of these prior approaches revealed that a change is required to fully address the human dimensions science aspects of the coastal ecosystems of South Florida.

Below, we recommend modifying the prior CEM framework (Gentile et al. 2001; Ogden et al. 2005), to incorporate elements of the widely used DPSIR framework (c.f. Christian et al. 2005). The following sections briefly review the related issues.

Conceptual Ecological Models in CERP

The Restoration Coordination and Verification (RECOVER) team developed a set of eleven regional CEMs, encompassing geographically distinct and largely contiguous domains that are intended to include the major cause-and-effect linkages within each modeled region.¹ RECOVER is one component of CERP, and the resulting models were published in a special issue of *Wetlands* (c.f. Ogden et al. 2005). These RECOVER models serve to guide the selection of performance measures and the parameters included in a regional monitoring plan. The models also help identify key uncertainties and knowledge gaps that must be addressed by research projects.

¹ c.f. <http://www.evergladesplan.org/pm/recover/cems.aspx>

The coordinated effort to develop CEMs in the RECOVER program standardized an approach, terminology and format for identifying major ecosystem components and processes in South Florida (Ogden et al. 2005). The standardized ecosystem components and processes are:

- **Driver** – an external factor that influences conditions in the entire ecosystem
- **Stressor** – changes to an ecosystem component or process directly caused by a driver
- **Ecological effects** – network of cause and effect relationships that link stressors to attributes
- **Attributes** – ecosystem components that have particular value, e.g. directly related to management objectives

Incorporating Human Dimensions Science

Recognizing that people and society are a part of our coastal ecosystems is a central tenet of regional-scale coastal management (Join Ocean Commissions Initiative 2009). Understanding the impact of humans on the coastal ocean and the impact of the coastal ocean on humans must be part of the scientific basis for regional management of coastal ecosystems. Coastal managers and researchers now acknowledge that humans are integral to coastal ecosystems. It is necessary to consider social, cultural, and economic factors, in both the research and management context, along with ecological variables (Weinstein 2009; Cheong 2008; Turner 2000; Lubchenco 1999; Visser 1999). Therefore, CEMs developed by the MARES project must incorporate interactions between human activities and natural processes in coastal ecosystems.

To accomplish this, the framework used previously to develop CEMs in CERP must be expanded to incorporate human dimensions of coastal ecosystems explicitly.² The **Drivers** and **Attributes** in the framework described by Ogden et al. (2005) represent human dimensions of the ecosystem to some degree, but they do so implicitly. A number of large-scale anthropogenic and natural drivers include regional population growth, changing land use patterns, and urban and suburban development. The selection of valued attributes of natural systems implicitly incorporates the idea of “ecosystem goods and services” and the associated trade-off values of those services, but the nature and value of these ecosystem services should be better articulated and evaluated.

Human Dimensions Science in the DPSIR Framework

The DPSIR (Driver-Pressure-State-Impact-Response) framework is an alternative framework for developing CEMs that is finding broad application in environmental assessments of terrestrial and aquatic ecosystems (Christian et al. 2005). Components of the DPSIR framework correspond with similar components of the CEM framework used in CERP, with the exception of the Response component, Figure 1.

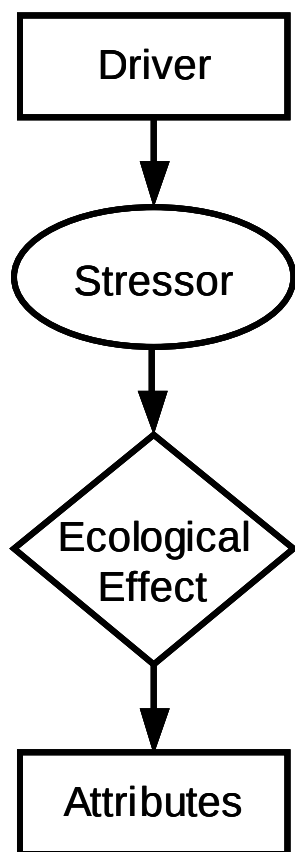
² The RECOVER program within CERP also recognizes the need to revise their approach to developing CEMs; c.f. RECOVER 2007. Human Dimensions Science - Ad-Hoc Sub-team Response to RLG Charge, 16 April 2007

- **Drivers:** Socio-economic sectors that fulfill human needs and drive human activities, often leading to intentional or unintentional changes in ecosystems. Drivers are affected if changes are made to alter human activities for protection of ecosystems.
- **Pressures:** Human activities that exert positive or negative pressure on ecosystems.
- **State:** Status of the environmental (physical & chemical) and ecological (biological) components of the ecosystem. Physical, biological, and chemical processes interact to affect different structures (chemicals, species) that are measured by their attributes. Attributes are characteristics that contribute to ecosystem services. Environmental processes can also affect drivers and pressures, e.g. drought influencing agriculture or storm events influencing non-point source pollution.
- **Impacts:** Changes in the quality and functioning of the ecosystem have an impact on the welfare (well-being) of humans. Services are the benefits that ecosystems can provide, and their value depends on human need and use (e.g., market value).
 - *Services:* Functions of the ecosystem that benefit humans in the short term or long term. Services depend on the attributes of the ecosystem.
 - *Value:* The economic, cultural, or ecological value of the services. Values depend on the attributes of the state and characteristics of the drivers and pressures. For example, corals can provide shoreline protection, but the value depends on the frequency of hurricanes and the number of hotels/houses near the coast. Values, in turn, can affect the drivers and pressures. For example, fish biomass can sustain fisheries and influence shipbuilding.
- **Response:** Humans make decisions in response to perceived value. Ecosystem values are too often ignored in decisions because they are viewed as ‘free’. Ecosystem services should change perceptions of value and alter human responses, which can create changes in drivers and pressures.

Human dimensions are incorporated into all components of the DPSIR framework, Table 1. The **Response** component incorporates the valuation of ecosystem services and the management activities undertaken in response to changes in the condition of the ecosystem. The effects of these management activities are represented by feedback from **Response** to **Drivers** and **Pressures**.

Figure 1: Comparison of conceptual model formats used by CERP and in the DPSIR framework (Levin et al. 2008)

Ogden et al. 2005



DPSIR Model

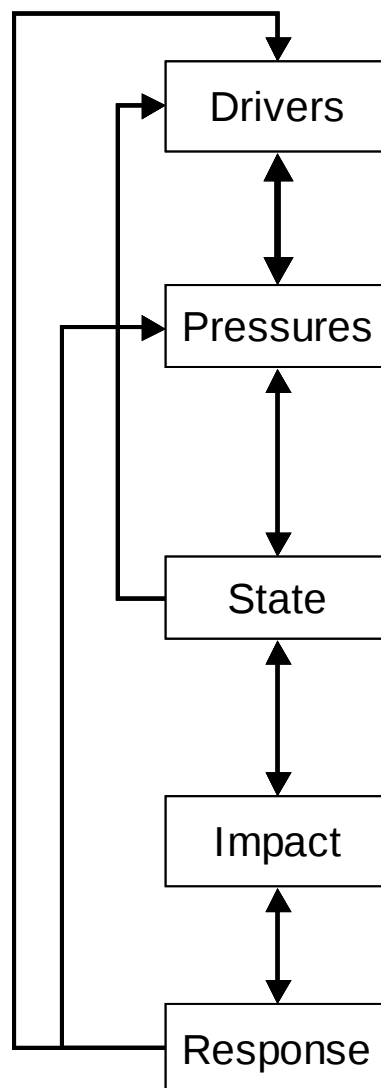


Table 1: Examples of DPSIR CEM components (from Levin et al. 2008)

Components	Human Dimensions	Natural
Drivers	Human population size in the coastal zone Per capita seafood demand Water-dependent international trade Coastal development	Temperature Precipitation Winds Ice cover Hydrodynamics
Pressures	Fishing effort Habitat loss and degradation Pollution transport and fate Marine transportation Effluent discharges Oil and hazardous material spills Pathogens Land use patterns	Extent of thermal habitat Nutrient regeneration Current speed and direction Habitat change Species range shifts
States	Commercial fishery landings Recreational fishery landings Aquaculture and fish farming production Water quality and quantity	Chlorophyll concentration Zooplankton biomass Benthic biomass Shellfish biomass Fish biomass Harmful algal blooms Pathogens Aquatic mammal abundance
Impacts	Fishery yield Aquaculture production Recreational income Nonindigenous species Human health risks Employment Loans at risk Commercial cash value	Biodiversity Changes in ecosystem function
Responses	Alter fishing mortality Alter stormwater regulations Require watershed buffers Restore habitat Contaminant mitigation	

Conclusion

The DPSIR framework offers a recognized approach for incorporating human dimensions science into CEMs that is similar to the existing method used in CERP. By adopting the DPSIR framework to guide development of CEMs the MARES project will incorporate human dimensions of the marine ecosystems explicitly in the resulting models. The success of this approach should be part of the project review planned for early in the second year of the project.

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