Drivers and Pressures Identified for the South Florida Coastal Marine Ecosystem

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Summary

This whitepaper defines the terms *Driver* and Pressure and identifies the sets of *Drivers* and *Pressures* used by the MARES project to describe the South Florida coastal marine ecosystem. This set may change during the course of the project and if so updates to this whitepaper will track these changes. This update incorporates the results of review and comments received beginning with the All PIs meeting in August 2011 and continued through a poll of the project membership conducted in September 2011.

Background

Drivers and *Pressures* comprise two of the five elements of the DPSER framework (driver-pressures-state-ecosystem services-response) we use to formulate integrated conceptual models of the South Florida coastal marine ecosystem (c.f. MARES Whitepaper: Including HDS). The DPSER framework adopted for the MARES project derives directly from the DPSIR framework, most recently reviewed by Atkins et al. (2011) with respect to its applicability to coastal marine ecosystems. The MARES framework substitutes ecosystem services, the E in DPSER, for impacts, the I in DPSIR. Using the DPSER framework is intended to encompass a description of the ecosystem, the issues of concern, and the possible responses to those issues.

Definitions

The definition for *Drivers* used by the MARES project is as follows.

> *Drivers are human activities that are the underlying causes of change in the coastal marine ecosystem. Drivers can be any combination of biophysical, individual and institutional actions or processes.*

The definition for *Pressures* used by the MARES project is as follows.

> *Pressures are physical, chemical and biological mechanisms that directly or proximally cause change in the ecosystem. Pressures are the particular effects of Drivers within the ecosystem.*

Global, Regional, and Local Scales

The MARES project operates over a range of spatial scales. Issues of interest for ecosystem management are defined both at the larger scale of the South Florida region, essentially coincident with the geographic scope of the South Florida Ecosystem Restoration Task Force, and more narrowly, at smaller scales, by legal mandates and responsibilities of specific programs. Description of the coastal marine ecosystem occurs first at the sub-regional scales, which recognizes the distinctive character of the ecosystem along the southwest Florida Shelf, surrounding the Florida Keys, and along the eastern coast of South Florida. Changes in the ecosystem are the result of *Drivers* that operate on regional scales (essentially the larger management scale above) and even on global scales.

Managers are limited in what they can do by the resources available to them and by the authority given them in law or regulation. Therefore, they cannot always deal directly with factors affecting the ecosystem. Atkins et al. (2011) refer to "endogenic managed pressures" caused by factors that arise within the scope of a manager's influence and "exogenic unmanaged pressures" caused by factors outside their scope of influence. In the case of the later, managers can at best mitigate impacts in the ecosystem.

The MARES project uses the terms "local," "regional," and "global" to distinguish different spatial scales at which *Drivers* and *Pressures* act on the ecosystem as well as the scope of management actions. With respect to management, the ***local scale*** corresponds to the smallest scale of at which management occurs, i.e. within one of the seven coastal counties: Monroe, Miami-Dade, Broward, Palm Beach, Martin, Collier, and Lee. The ***regional scale*** corresponds to the area that contains the South Florida coastal marine ecosystem, as defined by the bounds of the MARES project. The ***global scale*** refers to factors arising from causes outside South Florida.

Drivers

The *Drivers* listed in Table 1 act on the entire South Florida coastal marine ecosystem including all the sub-regions MARES is characterizing. The list is intended to be comprehensive in that if a *Driver* is deemed to be important in any one sub-region it is included in the list. Global-scale *Drivers* exert influence from outside the South Florida regional ecosystem. Regional-scale *Drivers* arise from human activities within the bounds of the South Florida ecosystem.

Table 1: *Drivers* act on all areas of the South Florida coastal marine ecosystem

Drivers	Includes:
Global-scale Drivers:	
Climate change	Observed and anticipated impacts of increasing levels of greenhouse gases in the atmosphere
Pollution	Sources outside of region
Regional-scale Drivers:	
Population growth	Impacts of increased numbers of people living in South Florida and of changing patterns of resource consumption etc.
Tourism	The impact of people visiting from outside South Florida
Water-based recreation	Boating, diving, snorkeling, swimming, etc., but not including the effect of harvesting from recreational fishing
Fishing	Commercial, recreational, and subsistence fishing
Marine Industry/Shipping	Related operations of ports, navigation and dredging
Shoreline change/stabilization	Seawalls, canals, and beach renourishment
Building and infrastructure	Construction, maintenance, operations, waste disposal
Oil and gas	Exploration, extraction and transportation
Agriculture	Changes in landcover and usage that effect local precipitation patterns, pesticide and fertilizer use etc.
Regional water management	Effects on quantity, quality, timing and distribution of freshwater inflows to coastal waters
Pollution	Municipal and household waste, wastewater, atmospheric deposition of pollutants, industrial waste, solid waste, construction debris and chemical leakage from manufacturing,

Pressures

The list of *Pressures* acting on the South Florida coastal marine ecosystem is intended to be similarly comprehensive; if a *Pressure* is significant in any one sub-region it is included in the list. Table 2 sorts these into pressures related to climate change, water-based activities, and land-based activities. Within each sub-region it has proven useful to distinguish between *Pressures* arising from far-field causes and those arising from near-field causes. Far-field *Pressures* alter environmental conditions at the boundary of each sub-regional ecosystem, and their effects propagate through the ecosystem. Near-field *Pressures* are generated internally, and their effect varies in intensity across the sub-regional ecosystem. The distinction between from far-field and near-field *Pressures* has practical implications in deciding how to respond to the resulting changes in the ecosystem.

Pressures Related to Climate Change:

On a global scale, human use of fossil fuels changes the chemistry of the atmosphere. Since the Industrial Revolution of the early 1800s, the widespread, and still growing, use of fossil fuels has contributed large quantities of carbon dioxide to both atmospheric and oceanic reservoirs around the globe. Present day atmospheric CO_2 concentrations of 385 ppm represent a near 30% increase over preindustrial values, with concentrations forecast to surpass 700 ppm by the end of the century (IPCC, 2007), Figure 1.

The effects of rising atmospheric CO_2 concentrations will become evident in the marine ecosystem of South Florida within decades (c.f. Twilley et al. 2001). Long-term changes in sea surface temperature, sea-level rise, hurricane severity and frequency, and other more recently discovered phenomena, such as a rise in ocean acidification, are expected to occur as a result of natural and anthropogenic global climate variability. South Florida, with its low elevation, high coastal population density, and unique, sensitive ecosystems, including the Everglades and the coral reefs, will likely be dramatically affected by these changes. It remains to be seen exactly how, and to what extent, the salinity, water quality, and coastal circulation of south Florida's coastal waters, bays, and estuaries will be affected by global climate change.

Ocean Acidification

Increasing concentration of CO_2 in the atmosphere affects the chemistry of ocean waters, Figure 1. Roughly 30% of the anthropogenically released CO_2 has been absorbed by the global oceans (Feely et al. 2004). Increased concentration of CO_2 lowers pH of seawater, i.e. making it more acidic, and decreases the saturation state of aragonite. This has the detrimental effect of making it more difficult for marine organisms like corals to build and support their skeletal structures (Kleypas et al. 2006, Manzello et al. 2008). Increased concentration of CO_2 and HCO_3^- also increases seagrass production (Hall-Spencer et al. 2008), leaf photosynthetic rates (Zimmerman et al. 1997), and plant reproductive output (Palacios and Zimmerman 2007). However, because acidification will occur slowly, allowing organisms to adapt, and the complex interaction among different ecosystem components (Hendriks et al. 2010), it is not yet clear what effects acidification will have on the coastal marine ecosystem of South Florida.

Table 2: *Pressures* defined for all areas of the South Florida coastal marine ecosystem

Pressures	Includes:
Pressures Related to Global Climate Change:	
Ocean acidification	
Increasing water temperature	
Increasing air temperature	
Altered regional rainfall and evaporation patterns	
Increasing tropical storm intensity, duration and/or frequency	
Accelerated sea level rise	
Pressures Related to Water-based Activities:	
Removal/harvesting fisheries species	
Damage from boating	Benthic habitat/community destruction, prop-scars, anchor damage
Dredging	Damage to bottom benthic habitat/community destruction, sedimentation, and altered circulation
Marine debris	Ghost traps
Pressures Related to Land-based Activities:	
Alteration of shorelines	
Changes in freshwater inflow	Quality (nutrient loading, contaminants), quantity, timing, or distribution, sedimentation, disease related to sewage outfalls and stormwater)
Contaminant spills	
Other pressures:	
Atmospheric deposition	Contaminants and nutrients
Invasive species introduction	Habitat modification
Disease	Systemic infections, region-wide

Increasing Temperature

Climate forecasts predict an increase in summer high temperatures of between 2 degrees and 4 degrees Celsius and an increase in winter low temperatures by 3 degrees Celsius over the next century. Warmer temperatures will be accompanied by changes in rainfall and the frequency and intensity of storms. Global sea surface temperatures are responding to these increases in CO_2 concentrations, with projected increases in sea surface temperatures of a few degrees C by the end of the century (IPCC, 2007).

Accelerated Sea Level Rise

The IPCC 2007 projections for sea level rise range from 20 to 60 cm during the 21st century; however, these rates do not include factors such as ice sheet flow dynamics that could significantly increase the rate. The more recent Copenhagen Report (Allison et al., 2009) states that the IPCC (2007) report underestimated sea level rise and that it may be as much as twice what has been projected. "For unmitigated emissions [sea level rise] may well exceed 1 meter" by 2100, with an upper limit at approximately two meters.

The Southeast Florida Regional Climate Change Compact Counties (2011) have developed a consensus trajectory for sea level projected until 2060, Figure 2. The consensus sea level projections are based on "(1) global and local sea level measurements which document an accelerating rate of sea level rise, (2) the preponderance of scientific evidence that recent land-based ice loss is increasing and (3) global climate models that conclude the rate of sea level rise will continue to accelerate." The projected trajectory is enveloped by an upper and lower rate projection, reflecting the underlying scientific uncertainties. Sea level in South Florida is projected to rise one foot above the 2010 reference level, relative to land surface, sometime between 2040 and 2070. A two-foot rise is considered possible by 2060. Sea level rose at an average rate of 0.88 inches per decade between 1913 and 1999. By 2060, it is expected that the rate of sea level rise will have increased to between two and six inches per decade.

Figure 1: (from Doney 2010)

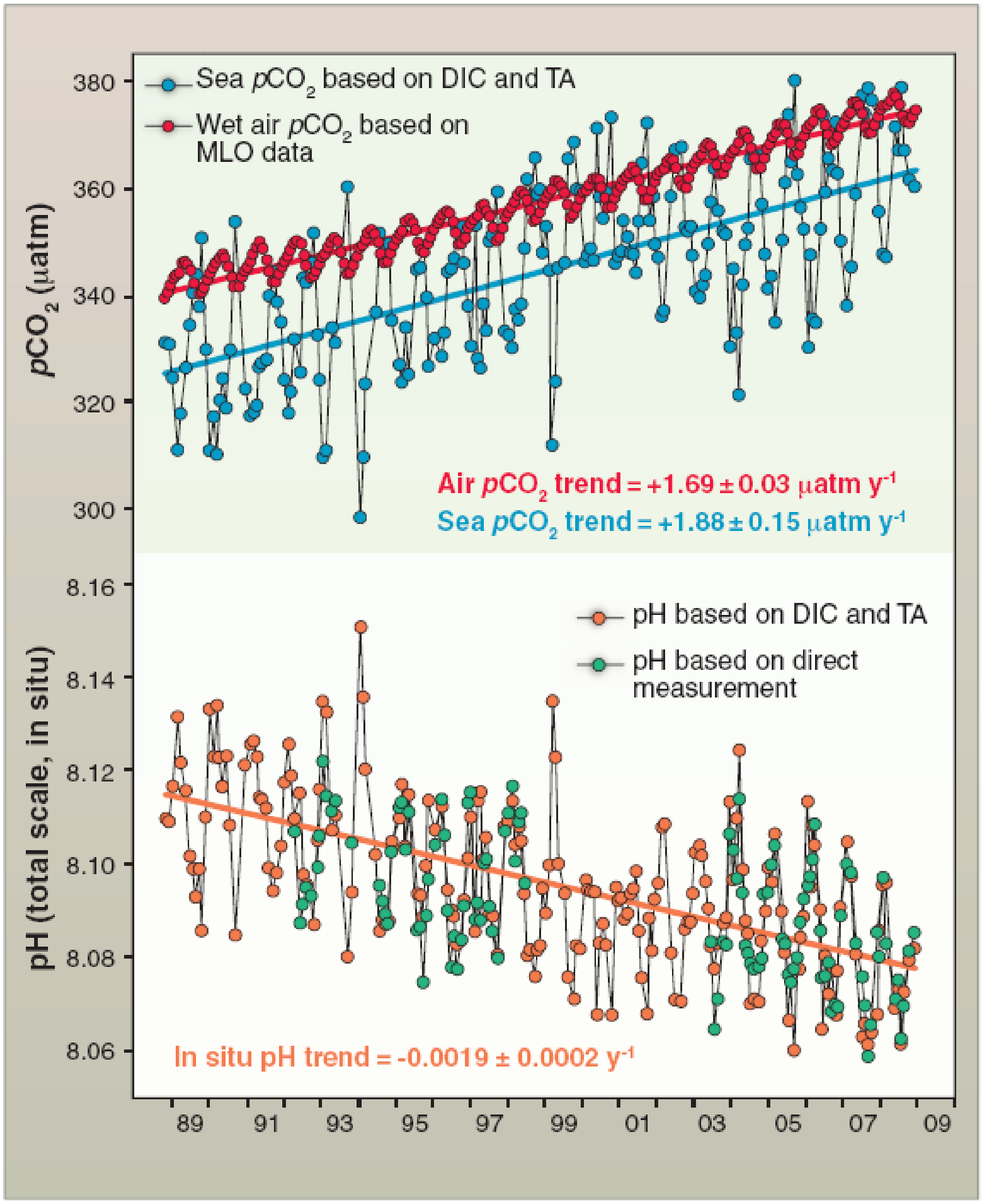

Fig. 2. Time series of (**top**) atmospheric CO_2 and surface ocean pCO_2 and (**bottom**) surface ocean pH at the atmospheric Mauna Loa Observatory (MLO) on the island of Hawai'i and Station ALOHA in the subtropical North Pacific north of Hawai'i, 1988–2008. [Adapted from (*26*)]

Figure 2: Unified southeast Florida seal-level rise projection for regional planning. (Southeast Florida Regional Climate Change Compact Counties, 2011; calculations courtesy of K. Esterson, USACOE).

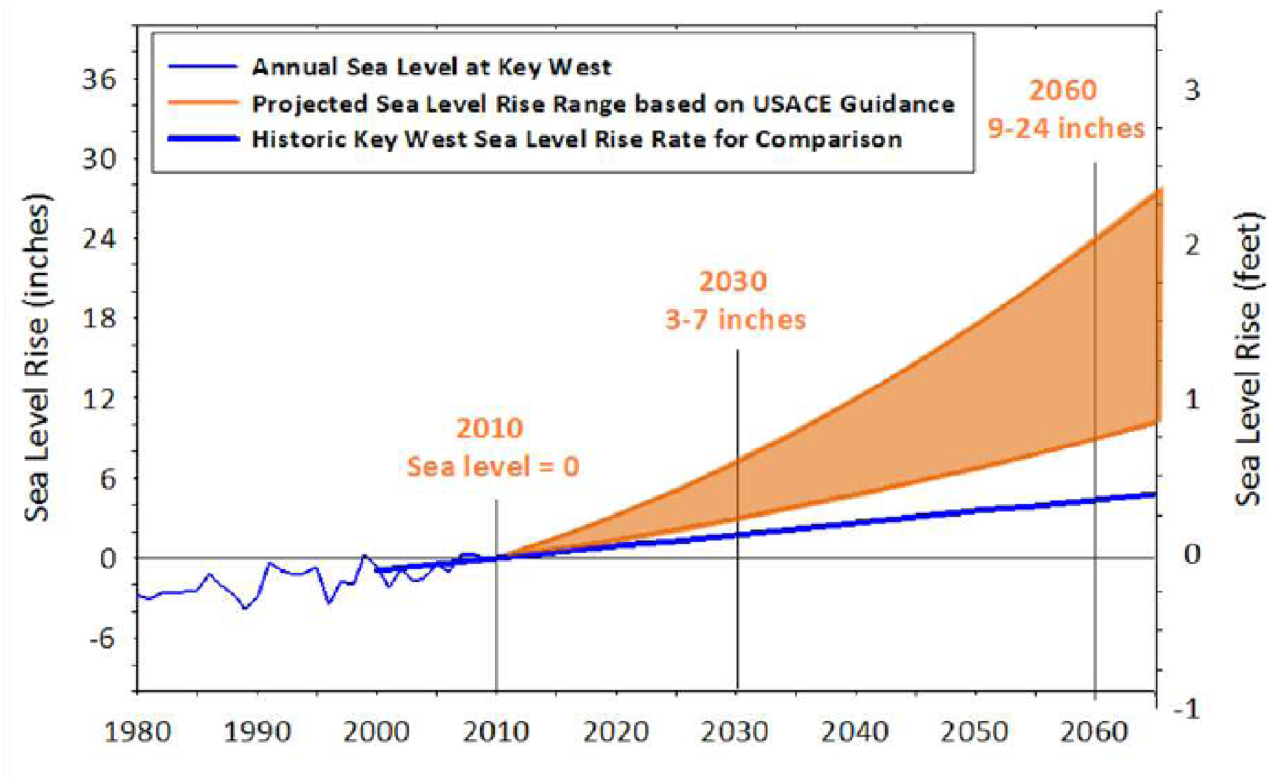

Figure 2. Unified Southeast Florida Sea Level Rise Projection for Regional Planning Purposes. This projection uses historic tidal information from Key West and was calculated by Kristopher Esterson from the United States Army Corps of Engineers using USACE Guidance (USACE 2009) intermediate and high curves to represent the lower and upper bound for projected sea level rise in Southeast Florida. Sea level measured in Key West over the past several decades is shown. The rate of sea level rise from Key West over the period of 1913 to 1999 is extrapolated to show how the historic rate compares to projected rates.

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