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PROJECT SUMMARY

SFL08: Marine and Estuarine Goal Setting for South Florida (MARES)

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Total Cost (8/1/08-7/31/11): $1,471,157
Per Year Cost (FY08; FY09; FY010): $493,145; $492,670; $485,342

Within South Florida's coastal marine ecosystem there are three major geographical domains which have received insufficient attention within the Comprehensive Everglades Restoration Plan (CERP) and South Florida Ecosystem Restoration (SFER). These include the Southwest Florida shelf, the Florida Keys and Dry Tortugas, and the Southeast Florida Shelf. There is an additional need for a Total Marine Ecosystem perspective to integrate these coastal domains.

To reach a much needed consensus with respect to quantitative goals for a sustainable and healthy regional marine ecosystem, we propose a series of facilitated workshops which will bring together a broad range of interested resource and social scientists, economists, managers, stakeholders, NGOs, and private individuals. Two types of workshops will be held for each of the four domains of interest. The first type will produce conceptual ecological models (CEMs) with supporting text and explicit qualitative goals similar to those developed for CERP. The second type will develop Quantitative Ecosystem Indicators (QEIs) similar to those developed by the Science Coordination Group (SCG) for the SFER Task Force. The PIs in this proposal are intimately familiar with the development of these products through their long term and continuing participation in both CERP and SFER.

Additional input will be acquired by conducting targeted briefings specifically for regional managers and planners, as well as US Environmental Protection Agency (EPA)-facilitated workshops specifically for stakeholder groups. Indicators and goals will be refined as a result of the input obtained at the targeted briefings and stakeholder workshops. As technical questions emerge, smaller, follow-up meetings will be held to produce supplementary white papers and topical reports. Whenever possible document production and follow-up meetings will be conducted "virtually", making use of advanced software tools available through the project website. The project website will also be used for outreach and education.

The broad agency and institutional collaboration, and the highly inclusive consensus-building process planned, will make possible timely and effective communication of the consensus to the appropriate management agencies, planning bodies, and the public-at-large. Additional final deliverables will include (1) an overall South Florida Coastal Ecosystem Report Card; and (2) the identification and prioritization of the critical uncertainties and information gaps that need to be addressed in order to further the development of the forecast tools that will enable NOAA's Ecosystem Approach to Management within the South Florida coastal region.

COP Project Summary Form

I. Introduction

The following proposal (MARES2008) would be carried out within the Cooperative Institute of Marine and Atmospheric Science of the UM/Rosenstiel School under CIMAS Theme Three: Coastal Oceans Ecosystems Processes. It directly addresses the NOAA Ecosystem Goal: *to protect, restore and manage the use of coastal and ocean resources through an ecosystem approach to management*.

Within South Florida's coastal marine ecosystem there are major geographical domains with distinct environmental threats and inherent tradeoffs that, for a variety of reasons, have received insufficient attention within the Comprehensive Everglades Restoration Plan (CERP) and South Florida Ecosystem Restoration (SFER). To reach a much needed consensus that management agencies can act upon with respect to quantitative goals for a sustainable and healthy regional marine ecosystem, we propose a series of facilitated workshops to bring together a broad range of interested individuals, agencies and institutions.

Two types of workshops will be held for each of the four domains of interest. These will be proceeded by rollout meetings introducing the concept to and obtaining input from key South Florida interagency management bodies. The task of the first type will be to produce Conceptual Ecological Models (CEMs) with supporting text and explicit qualitative goals, while that of the second workshop type will be to develop Quantitative Ecosystem Indicators (QEIs). Indicator workshop results will be disseminated and additional input acquired by conducting targeted follow-up briefings for resource managers and planners as well as facilitated workshops specifically for stakeholder groups. Indicators and goals will then be further refined as result of the input obtained at these additional briefings and workshops. As technical questions emerge (and they undoubtedly will), smaller non-facilitated meetings will be held to produce supplementary white papers and topical reports. Where possible, follow-up meetings and document production will be conducted "virtually", making use of advanced software tools available through the project website and server. The project website would also be used for outreach and education purposes**. The conclusion of the Marine and Estuarine Goal Setting for South Florida (MARES) project will represent not an endpoint but a starting point.** Both specific recommendations and the overall South Florida coastal ecosystem Report Card will be delivered to the funding agency (NOAA) and all the participating Federal and State agencies and non-governmental organizations (NGOs) both individually and through the interagency committees in which they participate. Because the managers were involved prior to and during the development process, and because the specific mechanisms to be employed have been vetted with and approved by those management bodies over the past few years, it is our expectation that the report card will become a biannual product and the indicators will be incorporated into the portfolio of information products being used to guide management decisions in South Florida.

To understand the approach being proposed it is important to understand what has (and has not) already been accomplished. For many sub-regions within the South Florida coastal ecosystem, particularly with respect in particular to those impacts most closely related to CERP implementation, considerable consensus already exists both within the marine science community and the responsible agencies. Yet in other sub-regions and with respect to other

significant issues, there remains a need for consensus development. To understand the approach proposed it will also be important to understand the needs and expectations of the resource management agencies and NGOs collaborating in this proposal submission. These topics are addressed in the following section, entitled Regional Context.

II. Regional Context

A. South Florida Ecosystem Restoration (SFER)

Efforts to build consensus for South Florida ecosystem restoration began to be formalized in the early 1990's, with the formation of the SFER Task Force and the Governor's Commission for a Sustainable South Florida. The Governor's Commission has worked to develop public support for both economic and ecological sustainability, including a healthy Everglades ecosystem. The Task Force works to build political consensus among the representatives of national, state and local government agencies and Native American tribes, and also works to coordinate science among the agencies involved in Everglades' restoration. Although neither of these groups was specifically tasked with building consensus on science issues, their early work led to the creation of two institutions designed to specifically address scientific consensus: the Science Coordination Group(SCG), and the Comprehensive Everglades Restoration Plan (CERP) Restoration Conservation and Verification (RECOVER).

B. Comprehensive Everglades Restoration Plan/RECOVER

Conceptual Ecological Models (CEMs)

CEMs, as used by the CERP RECOVER team, are heuristic planning tools that serve to identify (1) the major drivers and stressors upon natural ecosystems, (2) the ecological effects of these stressors, and (3) the indicators of the ecological responses to changes in those drivers and stressors. RECOVER developed a set of eleven such regional models, encompassing geographically distinct and largely contiguous domains that are intended to include the major cause-and-effect linkages within each modeled region. These, along with a "total system" model, were published in a special issue of Wetlands (2005), which served to both (1) guide the selection of performance measures and the parameters that were included in the development of a regional monitoring plan, as well as to (2) identify key uncertainties/knowledge gaps that were expected to be addressed by research projects. **The authors of the marine/estuarine CERP CEMs are among the PIs submitting this proposal. The CEMs are already serving CERP as a primary communication, planning and assessment link amongst scientists and policy-makers.** They are the principal organizing component in the CERP Applied Science Strategy (Ogden et al., 2003) and have served to build and cement consensus regarding the sources and effects of the major anthropogenic-induced changes in the natural systems of South Florida. Attached as an appendix is an example of such a CEM.

The Use of Performance Measures in the CERP

The performance measures developed by RECOVER scientific teams are used to evaluate the performance of proposed CERP projects, and to assess changes in the marine and estuarine ecosystem as a result of CERP implementation. These performance measures include specification of restoration targets, both in the modeling domain as well as in the field. For the coastal zone of South Florida, two sets of performance measures have been developed – the Southern Estuaries (Florida Bay, Biscayne Bay and Whitewater Bay) and the Northern Estuaries (St. Lucie Estuary, Loxahatchee River Estuary, Lake Worth Lagoon, and the Caloosahatchee River Estuary). The performance measures for the estuaries pertain to salinity conditions, water quality, submerged aquatic vegetation habitat, oyster reefs, and other major animal species.

The mandated Interim Goals and Targets report for CERP (RECOVER 2005) includes a subset of the performance measures developed for the estuaries. This subset includes those performance measures that were considered at the time to be particularly relevant to CERP success and for which models were sufficiently developed to provide forecasting capability.

Geographical Scope of the CERP

In the CERP context, an over-riding constraint was to keep the primary focus on parameters within those domains that were most likely to be affected by CERP implementation. This has meant, in practice, that geographic domains outside the CERP footprint were not addressed by the suite of CERP projects.

CERP modification of coastal ecosystems will largely be implemented via changing fresh water inflow, and thus restoration performance measures are spatially limited to those estuaries (or parts of these estuaries) that are directly and strongly influenced by this inflow. While some areas, such as the southern Indian River Lagoon and St. Lucie River Estuary, are receiving considerable attention, other estuaries, such as Estero Bay, are not included in CERP assessment. Furthermore, offshore areas that are less directly influenced by CERP, such as the Florida Keys and its coral reefs and the southwest Florida shelf, are likewise not included. The ecological dynamics that occur in these excluded areas, however, may be linked to the dynamics of areas monitored by CERP. For example, future trends in the region's pink shrimp population are not only dependent upon juvenile growth and survivorship in near-shore waters, but also upon growth, reproduction, and survivorship (including consideration of fisheries-related mortality) offshore. Harmful algal blooms along the southwest Florida coast are influenced by terrestrial nutrients, but may also form offshore and impact remote downstream systems such as the Florida Keys.

Another consequence of the CERP assessment's strong (and appropriate) focus on dynamics specifically related to fresh water flow is that stressors and drivers not likely to be altered by CERP have received comparatively little subsequent attention. The fate and effects of pesticides, petroleum hydrocarbons, and trace metals, the effects of atmospheric nutrient deposition, and the effect of exotic species expansion in these systems are examples of such non-CERP components and dynamics.

Given the strong physical connectivity of coastal ecosystems in South Florida – including its estuaries, shallow and expansive shelf, and the Florida Keys, a rigorous assessment of the influence of human activity in the region requires a larger scale and a more integrated approach toward environmental management. We propose to use CEMs and indicator development in the coastal ecosystems to build consensus goals for restoration and marine resource management. As noted in Ogden et al. (2005), *"Managers appreciate [CEMs] because of their role in organizing effective application of existing science in support of decision-making during the restoration process. Scientists value the intellectual and integrative processing of developing working hypotheses and laying out linkages … as a basis for identifying gaps in knowledge and setting research priorities"*. It is long past time to give both the management and scientific communities rigorous CEMs for those marine domains that have been unaddressed to date. Moreover, NOAA's Legislative Mandates assign it responsibility for some of the geographic domains and issues presently "missing in action" in the South Florida ecosystem restoration effort.

C. Science Coordination Group (SCG): Ecosystem Restoration Indicators

The SFER Task Force recognized that the execution of many of its duties required a clear ability to accurately assess whether restoration goals are being met. Thus, in 2005, the Task Force directed the SCG to develop a "suite" of system-wide indicators of ecosystem restoration. The timeline for this work was short (1 year), and the SCG recognized that "indicator gaps" might result; therefore, additional indicators may be developed in the future as new scientific information and findings become available. The Task Force will use these indicators to judge the performance of the CERP and non-CERP projects with respect to achieving restoration goals, by evaluating the ecological changes resulting from the implementation of the restoration projects.

A four-step process has been used to develop an initial suite of 13 system-wide indicators.

Step 1. Evaluate the effects of existing restoration efforts from various sources for indicators, for possible application to the Task Force suite of system-wide indicators

Step 2. Using established guidelines, select relevant indicators for Everglades ecosystem applicability and evaluate the list of indicators for individual and collective value and coverage of the Everglades' ecosystem regions, defining characteristics, trophic interactions, and functionality

Step 3. Identify "indicator gaps" and, where feasible, develop new indicators to fill the identified gaps

Step 4. Select final system-wide suite of indicators and develop indicator documentation and communication protocol

Since much work had already been accomplished under CERP, the SCG's leading sources for possible indicators were RECOVER's Interim Goals and Interim Targets for the CERP and

its Monitoring and Assessment Plan (MAP). The SCG indicator evaluation process included careful screening of each indicator for its application to the many Everglades "features" identified, and cross-comparisons of the features of each indicator to ensure that key features were not overlooked. This process allowed determination of gaps in the indicators and suggested how to fill particular gaps.

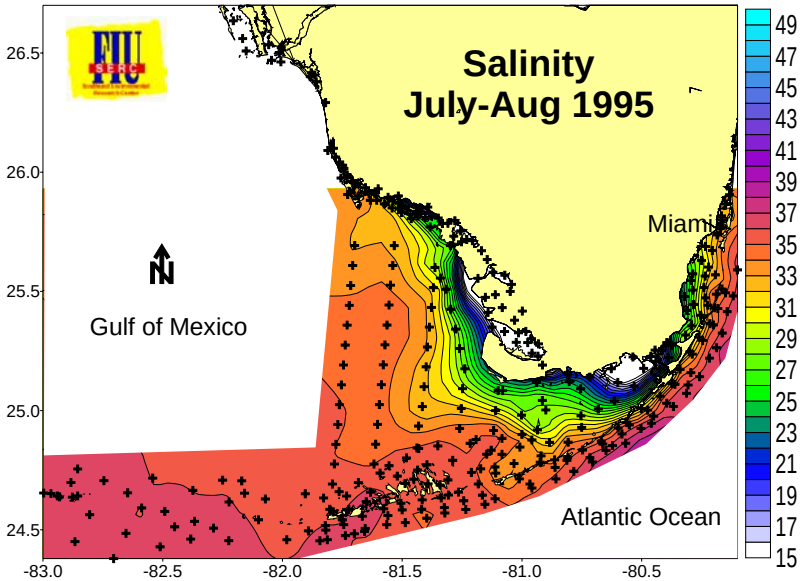
Effective communication of indicator results to the Task Force and Congress is as important as the performance of the indicators themselves. When assessing the performance of an indicator, scientists collect data related to the metrics that statistically link environmental parameters to indicator performance. These data are usually detailed and complex requiring various levels of analysis and interpretation even for use by other scientists. The role of the SCG is to work with the scientists involved in monitoring these indicators and to interpret their results into a more common framework and language for stakeholders and decision- and policymakers. In order to provide a common language for the Task Force system-wide indicators, the SCG has developed a "Restoration Stoplight Report Card" that provides a 2-page summation for managers and policy makers, of the results of the detailed indicator assessment reports. More information on the SCG and the status of its indicator formulation process can be found at www.sfrestore.org.

Development of marine and estuarine indicators for the SCG was lead by a number of the PIs on this proposal. Attached as an Appendix is a representative Indicator Report. That said, the coastal marine system is represented by only five SCG indicators and all of the present indicators (with one exception) are confined in their present form to the very near-shore environment. **What is most important to understand and appreciate is that the twelve federal and state agencies represented by the South Florida Ecosystem Restoration Task Force have repeatedly and publically stated their commitment to using these Indicators to guide their decisions. Moreover they have endorsed the specific process we would use to develop the new indicators and as well as the presentation format we would use. Moreover they have asked the SCG to specifically use such indicators to set their research priorities. It is our hope that our indicators will be similarly useful to and applied by NOAA.**

D. Coastal Domains that are "Missing in Action": Their Scope and Significance

The southwest Florida shelf (SWFS)

The inner southwest Florida shelf is dominated by alongshore flows that extend from Tampa Bay to the Florida Keys. Surface drifters deployed at the mouths of southwest Florida shelf estuaries can be retained within a few km of shore for periods of weeks to months (Lee et al.,



2002). Circulation in this region is primarily driven by winds and buoyancy, with a seasonal cycle in alongshore flow that is regulated by changes in the wind field (Lee et al., 2001). Significant changes in flow through the mangrove-fringed estuaries have occurred over the last century (Wingaard et al., 2006). The prolonged residence time of surface waters on the inner shelf, and their limited connectivity with outer shelf waters, implies that estuarine outflows may have a significant impact on the salinity and nutrient condition of the southwest Florida shelf. This has been well documented over twelve years of quarterly sampling (Boyer and Briceño, 2007). A good case in point was the very wet year of 1995, where the effects of water releases from Shark Slough are clearly evident all the way out to the Marquesas (Fig. 1).

Figure 1. Surface salinity distribution during the summer of 1995.

Restricted flows may also affect the development of harmful algal blooms (Brand and Compton, 2006) and diatom blooms in western Florida Bay (Jurado et al., 2007). Our growing knowledge of spatial patterns and temporal trends of water quality indicates that some of the phenomena we observe are driven by large-scale factors such as advection of Gulf of Mexico waters along the coast, with entrainment of coastal rivers and runoff. A dramatic example was the "Blackwater" event of 2001-2002 (Hu et al., 2004), when satellite imagery and field data were successfully used to conduct a forensics-like analysis to identify the constituents and probable cause of this occurrence (Fig. 2).

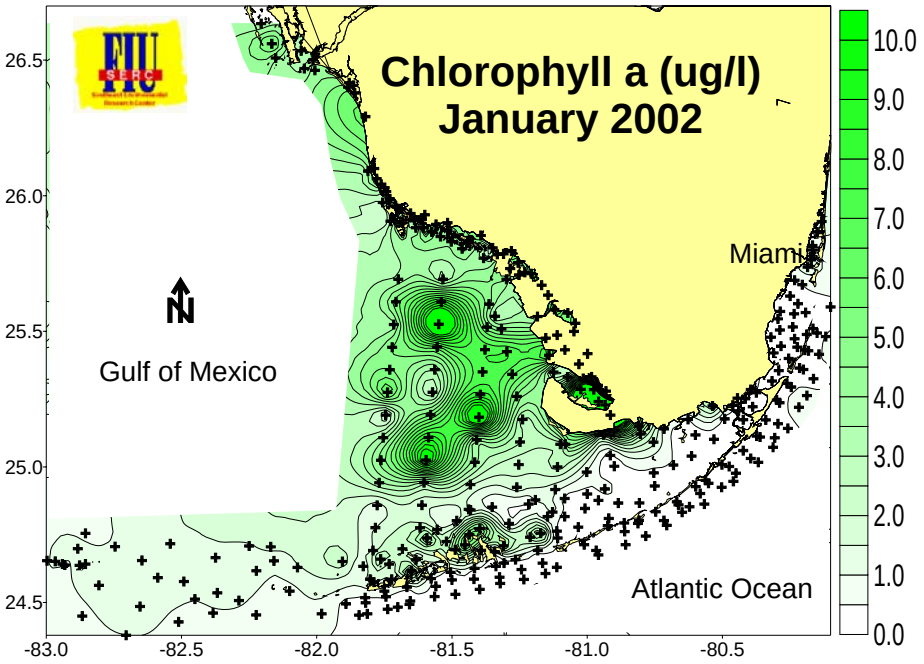


Figure 2. Surface chlorophyll distribution (ug/l) during January 2002.

The southwest Florida shelf is integrally connected with the main Everglades fresh water thoroughfare with respect to hydrology and ecosystem response. While the southwest Florida shelf was not included in CERP-related efforts, changes within the Kissimmee, Okeechobee, and Shark Slough are sure to have direct implications for the SWFS. The magnitude of the effects upon coastal estuaries is exemplified by current management issues concerning the Caloosahatchee River and the Ten Thousand Islands. Water released from Lake Okeechobee to adjust lake levels for storm water management causes extreme and prolonged freshets that have

detrimental effects upon estuarine ecosystems. The impacts upon seagrass beds and oyster physiology and ecology are well documented (Tolley et al., 2005; Volety et al., 2003; Volety 2007). The response of a variety of indicator organisms has been used to assess the impact prior to restoration (for example, see Savarese and Volety, 2001), and a comprehensive plan using ecosystem-based performance measures to monitor restoration effectiveness has been developed (Savarese et al., 2004a; 2004b; Popowski et al., 2004). These approaches need to be generalized and applied throughout coastal South Florida.

Among the marine areas expected to be most influenced by the CERP hydrological changes in South Florida are the mangrove-fringed estuaries adjacent to the SWFS. Alterations in fresh water inflows through these will affect the circulation, water quality and salinity patterns of the southwest Florida shelf. In turn, these changes will alter the structure and function of the mangrove ecosystems through tidal exchange and other processes. Not only will changes in upstream water management affect the southwest Florida shelf and the adjacent mangrove transition zone but the upstream counties are among the rapidly growing counties in the country. Development of a CEM with associated goals and quantitative indicators will significantly assist planning and resource management as well as scientific research prioritization within this sub-region. Such a CEM will need to incorporate not only these physical processes and their linkages to biogeochemical processes, but also the drivers and stresses associated with this rapidly-increasing human population pressure. Lastly, it has been well demonstrated that changes within the southwest Florida shelf can have enormous impacts downstream upon the Florida Keys and Dry Tortugas.

The Florida Keys and Dry Tortugas Reserve (FKDTR)

The Florida Keys ecosystem is one of this Nation's unique natural treasures. With the establishment of the Florida Keys National Marine Sanctuary (FKNMS), its preservation became NOAA's explicit responsibility. The marine component of the ecosystem is composed of tropical to subtropical waters that contain diverse benthic community types, including bank barrier coral reefs, patch reefs, hard bottoms, and sea grass. This diversity of community types results in high species richness. The Keys are a popular tourist destination, in part because the faunal richness provides interesting snorkeling and diving venues. Furthermore, the shallow water environments surrounding the Keys contain extensive nursery areas and fishing grounds for a variety of commercially and recreationally important marine species. It is becoming increasingly clear both that a multi-species approach needs to be taken to manage these resources and that many species are already severely over-fished (Ault et al., 1998; 2005).

An important driver of the marine system is the regional circulation pattern. Prevailing circulation patterns link the Florida Keys to the Everglades, Florida Bay, and the southwest Florida shelf. Thus, the health of the Florida Keys ecosystem requires that projects developed as part of the CERP need to factor in the effects that those projects will have downstream. Water generally flows from the Gulf of Mexico, through the Keys passes, to the Atlantic Ocean, and is eventually entrained by the Florida Current and flows northeastward.

A demonstration of this connection was the "Blackwater" event of 2001-2002 discussed above, which was shown to have originated with coastal runoff from the Everglades in the vicinity of Charlotte Harbor (Hu et al. 2004). These dark water patches contained elevated nutrients and both living and non-living colored materials. During this event the mass of dark water moved south into FKNMS waters and spread from the Middle Keys to the Dry Tortugas.

Upwelling of deep waters is another source of nutrients to the Keys (Leichter et al., 2003). Because of the volume of the water involved, upwelling events may overwhelm other sources of nutrients to the reef tract. Storm events may also result in changes in circulation patterns that can result in nutrient enrichment. Also, storm events may flush nutrients from land-based sources in the Keys to near-shore waters.

Conditions in Florida Bay have been linked to Everglades' runoff from both Taylor Slough (in eastern Florida Bay) and Shark River Slough (on the southwest Florida shelf). Salinity changes have been dramatic in the 20th century (Brewster-Wingaard et al., 1998). Tidal mixing through the Keys passes can result in a direct influence of Florida Bay water quality on the ecosystems of the FKNMS (Boyer and Jones, 2002). A recent dramatic example is the current cyano-bacterial bloom of 2007 (Fig. 3). This bloom originated in central Florida Bay but quickly spread southward through the Middle Keys and out to the reef tract. The bloom has been associated with sponge die-off within FKNMS waters and could potentially have harmful effects on corals (Mark Butler, pers. comm.).

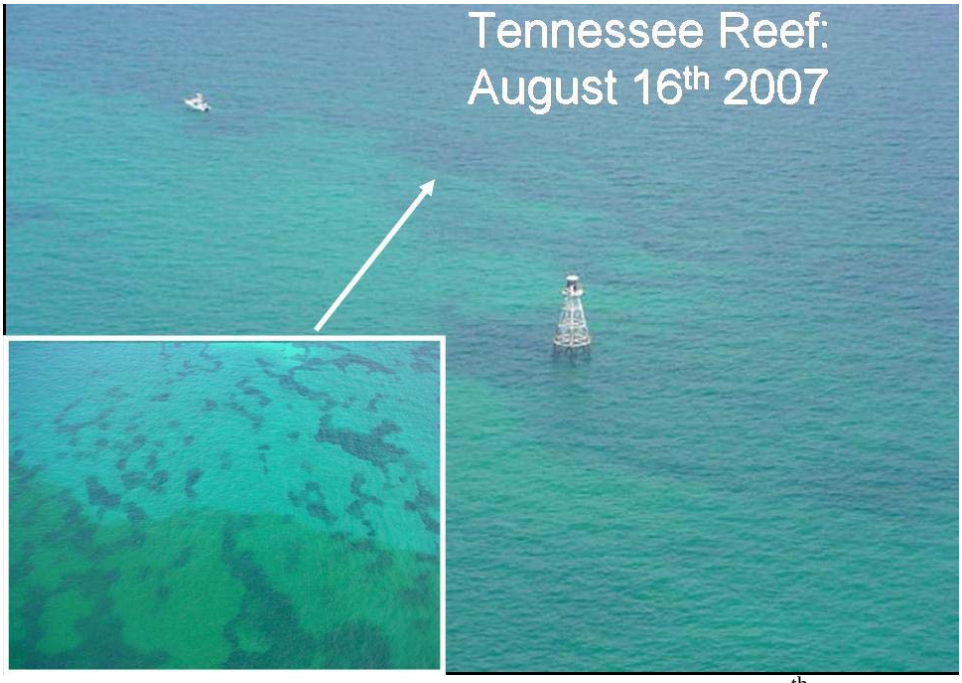


Figure 3. Photographs of Tennessee Reef and lighthouse on August 16th, 2007. Inset shows a close-up of the algal front moving across the reef (photo courtesy of the U.S. Coast Guard, acquired from Jon Fajans, Florida Institute of Oceanography).

The FKDTR domain, like the southwest Florida shelf, is integrally connected with respect to hydrology and ecosystem response with the main Everglades fresh water thoroughfare. Although the FKNMS was included in CERP under the Keys Tidal Flow Restoration Project and the Florida Bay-Florida Keys Feasibility Study, those projects have met neither deadlines nor expectations and it appears doubtful that either will ever come to fruition as originally contemplated. In fact, there are no CERP (or SCG) goals or performance measures for FKDTR ecosystems.

While Everglades' restoration efforts will primarily influence processes in the inshore and estuarine habitats of the FKDTR (Biscayne Bay, Florida Bay, and the lower Keys back country) as seen in the "Blackwater" event and the current 2007 algal bloom, these efforts can also have a profound impact on the entire FKDTR coastal ecosystem. A CEM with associated goals and quantitative indicators will significantly assist planning and resource management as well as scientific research prioritization within this sub-region.

The southeast Florida shelf (SEFS)

The coral reefs and hard bottom communities of the southeast Florida coral reef ecosystem are a northern extension of the reef tract of the FKNMS and Biscayne National Park. They are comprised of a complex of relict *Acroporid* reefs and limestone ridges forming hard bottom areas, patch reefs, and worm reefs (Lighty, 1977; Banks et al., 2007). The SEFS supports a rich and diverse biological community teeming with octo-coral, macro-algae, stony coral and sponge assemblages (Moyer et al., 2003).

Nearly one third of Florida's total population of 16 million resides in the southeast Florida region. The reefs are located less than 3 km from this highly urbanized coastal area. Despite their unique position as the highest latitude reefs along the western Atlantic seaboard, the reefs of southeast Florida have only recently received limited scientific research and resource management attention (Dodge and Helmle, 2003; Moyer et al., 2003; Collier et al., in prep.). The northward-flowing Gulf Stream is the dynamic eastern border of the SEFS. The front between coastal and Gulf Stream waters ranges from less than 5 km to as far as 30 or more km offshore. Eddies, shingles and countercurrents are common in southeast Florida shelf coastal waters, some propagating into the area from as far south as the middle Florida Keys. These physical processes link the southeast Florida shelf to the Florida Keys and Florida Bay ecosystems.

The explosive growth of population and resultant urban development within southeast Florida has resulted in significant increases in fresh water inputs to the coastal shelf. These inputs may contain a number of pollutants, including nutrients, fresh water, pesticides and herbicides, and pharmaceutical products. Nonpoint-sources of pollution to the coastal waters include surface water runoff, storm water discharge, and groundwater seeps. The nonpoint-source pollution may be delivered to the reef directly, as in the case of runoff, through navigational inlets and passes, and through the porous limestone substrate underlying South Florida (Andrews et al., 2004). A widely reported topic has been the issue of ocean wastewater outfalls and the impacts of effluent on the reefs. There are six wastewater outfalls with a

combined flow of up to 300 million gallons per day that pump minimally treated (secondary treatment) domestic wastewater directly into the Atlantic Ocean. The fate of these nutrients in this coastal setting is unknown but is currently under investigation by a State-Federal interagency program being led by NOAA/AOML (NOAA/AOML Keynotes 2006). The most recent data and analyses from this study (P. Swart, pers. comm.) indicate that the connection between this nutrient source and southeast Florida shelf may be tenuous.

Reef-based tourism and recreation (particularly recreational fishing) is a significant economic asset for the southeast Florida region. Results from two non-concurrent studies indicate that a total of $2.3 billion in sales were generated from natural reef related expenditures, providing $1.1 billion in annual income while supplying ~36,000 jobs in the region (Johns et al., 2001; Johns et al., 2004).

Fishing can stress coral reefs and hard bottom communities by removing targeted species and by killing non-target species as by-catch, both of which may result in cascading ecological effects. Because fishing is size-selective, concerns exist about ecosystem disruption by removal of ecologically important keystone species, top predators (groupers, snappers, sharks, and jacks), and prey (e.g., shrimps and baitfish). Habitat damage can occur from direct impacts from fishing gear, such as traps and monofilament line, and improper boating and anchoring practices. Fishing stress may be compounded when combined with other stressors such as pollution and habitat damage from other sources. As noted for the FKDTR region, over-fishing has been well documented for the Florida reef ecosystems (Ault et al., 1998; 2005).

Since 1964 the number of registered recreational boats in the southeast Florida region has grown approximately 350%. In the southeast Florida region alone, approximately 6 million person days were spent fishing on the natural reefs annually (Johns et al., 2001; Johns et al., 2004). The southeast Florida region has experienced a high number of vessel groundings and anchor and cable drag cases over the last 30 years. Most notably, Broward County has experienced eleven ship groundings and six known anchor drag cases from 1994 to 2006 (Collier et al., 2007). A majority of these cases were associated with the Port Everglades anchorage, which services cruise ships and cargo and petroleum carriers. However, damage to coral reefs and reef resources from recreational anchoring can be chronic, with cumulative impacts equaling those of large vessel groundings.

Macro- and micro-algal invasions also pose a risk to southeast Florida's coral reefs. Since 1990, a succession of native and non-native macro-algae in the genera *Caulerpa* and *Codium* formed blooms on reefs in Palm Beach and Broward Counties, purportedly resulting in mortality of reef biota (Lapointe et al., 2005). Cyano-bacterial blooms on the reefs of Broward County have lessened in extent of late, nonetheless periodic, short-lived blooms still continue to occur (Paul et al., 2005; Banks et al., in press).

The number of introduced species in Florida has steadily risen in recent decades. Two Indo-Pacific species of lion fishes have established themselves on the east coast of the United States (Whitfield et al., 2002; Semmens et al., 2004). Both the Red Lionfish (*Pterois volitans*) and its congener, the Devil Fire fish (*P. miles*), were imported extensively for the aquarium trade and were first reported on southeast Florida's reefs in 2002 (Whitfield et al., 2002). The Indo-Pacific

orange cup coral, *Tubastrea coccinea*, has become established on artificial reefs in southeast Florida but has not been observed on natural substrates (Fenner and Banks, 2004).

The stresses being experienced by the southeast Florida shelf and its coral reef ecosystems are somewhat different than in the regions upstream, primarily due to the much greater population pressures and all the attendant environmental impacts as well as the lack of large areas of protected public trust lands and waters within the southeast Florida shelf sub-region. Development of a CEM, with associated goals and quantitative indicators, will significantly assist planning and resource management as well as scientific research prioritization within this sub-region. Such a CEM will need to incorporate not only these drivers and stresses, but will also need to take into account the somewhat different regulatory and jurisdictional environment prevailing within this sub-region.

The South Florida Total Marine Ecosystem (SFTME)

The SFTME includes five estuarine systems as well as the southwest Florida shelf, FKDTR, and the southeast Florida shelf. The estuaries included, the Caloosahatchee River, the Everglades mangrove estuaries including Whitewater Bay, Florida Bay, Biscayne Bay, and the St. Lucie River, are shallow and biologically productive. These estuaries are biogeographically distinct and their characteristics vary from river-dominated systems in the north to tropical lagoons in the south. As previously discussed, CEMs have been developed by the PIs collaborating in this proposal for all of these estuaries (Wetlands, 2004).

Hydrologic modifications over the last 100 years (including construction of over 2,500 km of canals and levees and hundreds of water control structures) have dramatically changed the Everglades (Light and Dineen, 1994; Sklar et al., 2002). The Everglades ecosystem is currently the focus of the largest watershed restoration effort ever implemented (CERP, http://www.evergladesplan.org/). The goal of this now $20 billion, 50-year project is to deliver the right amount of water, of the right quality, to the right places, at the right time in order to restore the health of the Everglades and adjacent estuarine and coastal ecosystems.

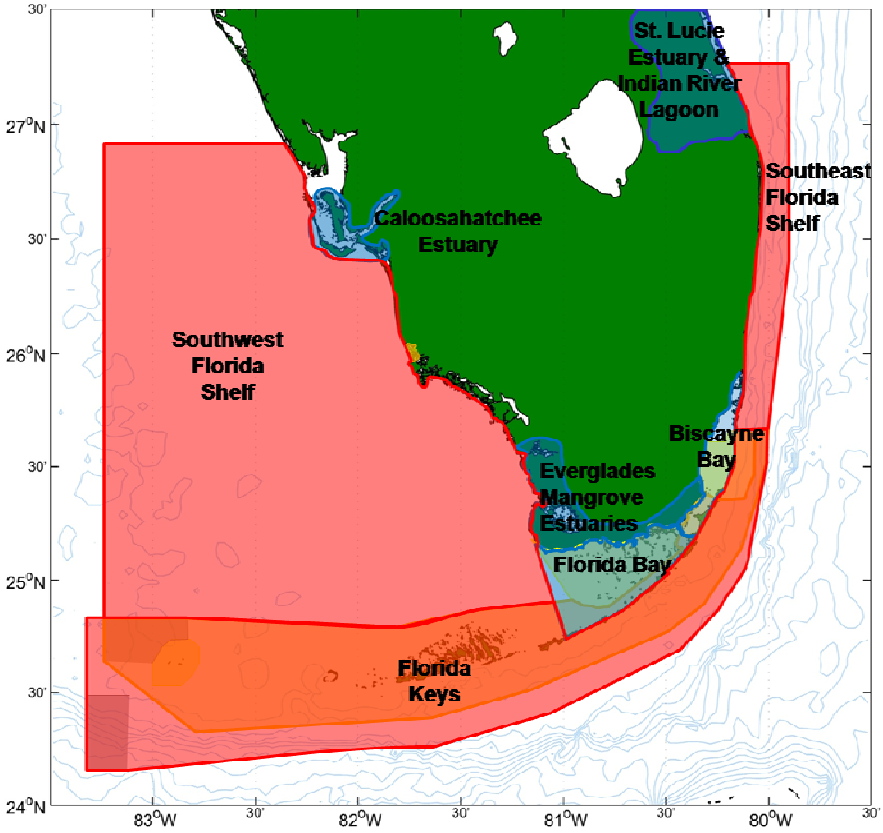


Figure 4. The Everglades and adjacent estuarine and marine areas.

The SFTME is downstream of all water management activities that have occurred since the late 19th century. CERP was developed to correct the damage caused by those activities via the design and implementation of a more ecologically supportive hydrologic system, including a more natural quantity, quality, timing, and spatial distribution of fresh water flow to estuaries and coastal waters. As part of CERP, pilot projects and/or feasibility studies were conducted in the FKNMS, Florida Bay, and SWFS. Current monitoring projects in CERP include performance measures for Biscayne Bay, Florida Bay, and the very near-shore region of the southwest Florida shelf.

Recognizing that successful management of coastal waters requires careful consideration of all terrestrial sources of fresh water, and an awareness of marine connectivity through circulation and advection, we believe that a CEM is required for SFTME to help integrate the coastal system and guide the setting of ecosystem goals and targets. The major purpose of a CEM is to identify and describe the defining characteristics of the pre-disturbance system and, through proposed causal linkages, develop a succinct and vigorous set of performance measures that will provide a quantitative measure of defining characteristics. Although a total ecosystem CEM was developed in CERP (Ogden et al., 2004), it does not provide adequate coverage and integration of the estuarine and marine areas of primary interest to NOAA, nor does it adequately link these areas to fresh water flow from the Everglades and water levels in the southern Everglades.

In addition to CERP modifications, the SFTME will be subject to numerous forcing phenomena over the next 50 years, both external and internal and at both large and small-scales. Global-scale forcing factors include climate change and related phenomena such as ocean acidification and sea-level rise. Episodic large-scale external forcing factors, for example El Niño, tropical cyclones and the downstream transport of Mississippi River water into the region, are known to exert significant influence over various components of the SFTME (Kelble et al., 2007; Manzello et al., 2007; Ortner et al., 1995). Local forcing processes include the passage of meso-scale gyres along the reef tract, which is known to affect fish recruitment and alter nutrient distributions (Hitchcock et al., 2005; Lee et al., 1995; Sponagle et al., 2005). Additional local forcing factors are runoff, coastal urbanization, land-use changes, and human management decisions regarding water releases, nutrient loading, and fishing regulations.

Examples of issues where better integration of the marine ecosystem is necessary to restore and/or protect coastal areas are: 1) How do we restore Florida Bay exchange with oceanic waters and interior circulation without jeopardizing near-shore reefs? 2) How do we address the connectivity of major die-offs of seagrass, *Diadema*, and sponges? 3) How do we quantify the ecological and socioeconomic disruption caused by upstream stressors? A start at a scientific consensus was made for Florida Bay (Hunt and Nuttle, 2007), but to comprehensively analyze the effect of CERP restoration and other external and internal forcing factors on the coastal marine environment this consensus must be extended to include the entire coastal ecosystem.

III. Agency Needs and Perspectives

The following subsections were provided by the agency PI's in this proposal and the final language used was vetted with and approved by regional management in the respective state or federal agencies.

A. NOAA/Florida Keys National Marine Sanctuary (FKNMS)

The FKNMS, through a co-trustee partnership between NOAA and the State of Florida, is responsible for management of natural and maritime heritage resources in a nearly 2,900-square-nautical-mile area surrounding the Florida Keys and extending west to Tortugas Bank. The Sanctuary works closely with other agencies that are responsible for managing natural resources in South Florida coastal waters and regulating water quality including the National Park Service, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the Florida Fish and Wildlife Conservation Commission, the Florida Department of Environmental Protection, and others. The FKNMS therefore has a keen interest in the proposed project's objectives and collaborative approach to developing goals for and indicators of a restored sustainable South Florida coastal ecosystem.

The Sanctuary's science program is defined in its management plan and further refined in a Comprehensive Science Plan. The science plan includes a conceptual model of major drivers

affecting a set of ecological attributes, and identifies a set of management objectives and associated research and monitoring needs. This plan was completed in 2002 and is critically in need of an update. Developing CEM's, goals and indicators not only for the Florida Keys and Dry Tortugas but also the areas upstream of the FKNMS and hydro-dynamically connected to it will be of great utility to reformulating scientific and management plans for the FKNMS. In particular this would permit expanding the scope of the Sanctuary's science plan to more explicitly address external influences on the condition of sanctuary resources. These include effects of Everglades restoration on Florida Bay and the southwest Florida shelf, both of which adjoin the Sanctuary. In addition, the Sanctuary has a long-standing program of socioeconomics and human dimensions research and will contribute to and benefit from inclusion of the human dimensions perspective in the proposed research.

B. NOAA/National Marine Fisheries Service (NMFS)

A focal point of the NMFS/Southeast Fisheries Science Center (SEFSC) mission is to determine the needs for and develop the scientific information base required for regional fisheries resource conservation, applied habitat conservation, and both environmental and ecosystem assessments for long-term management of local coastal resources. These resources do not respect the boundaries between arbitrary jurisdictions and regions within the coastal ecosystem. What is needed for fisheries purposes is a total coastal and marine CEM linking fresh water flow changes associated with CERP, northern and southern estuarine ecosystems, adjacent coastal habitats, and the South Florida shelf areas. Such a CEM with associated goals and indicators would contribute significantly to our understanding of the impacts of changing ecosystem dynamics on economically important managed resources. This is essential to enable an Adaptive Management approach to mandated protection of marine mammals and sea turtles and other protected species in South Florida waters. The SEFSC fully supports the development in particular of an integrated total South Florida coastal CEM with associated goals and quantitative indicators as a complementary and supporting project for our long-term coastal ecosystem management and habitat conservation mission in South Florida.

C. U. S. Department of the Interior (DOI)/National Park Service (NPS)

The South Florida Natural Resources Center at Everglades National Park is responsible for providing scientific tools to NPS managers of Everglades, Biscayne, and Dry Tortugas National Parks, as well as to Big Cypress National Preserve. Science information and tools are used by managers in support of the NPS mission of preserving natural resources for future generations.

Documents that convincingly articulate the scientific consensus on specific quantifiable ecosystem goals for the near-shore coastal system of South Florida will serve as an important reference for Everglades and Biscayne National Parks during their involvement in CERP and SFER. Quantifiable ecosystem goals, and their relationship to management actions via conceptual ecological models, are a critical component of the CERP. They are important for estimating the potential benefit of restoration projects to the National Parks using computer models, and for assessing the actual progress of restoration through monitoring of NPS

resources. This will be of great service not only to the South Florida Natural Resources Center but also to the upper management of the NPS.

Goals and conceptual ecological models developed for the southwest Florida shelf and the FKDTR will be of particular use to Everglades and Dry Tortugas National Parks in identifying specific resource indicators and their links to management actions such as those in NPS General Management Plans, Resource Stewardship Plans, and Science Plans. Given that marine resources frequently pay no attention to protected area boundaries, identification of actions that could be coordinated among the community of protected areas managers would be important. A Florida Keys focus would link specifically to ongoing interagency science planning for the Dry Tortugas National Park Reserved Natural Area (managed by the NPS and the Florida Fish and Wildlife Commission). Finally, attaining the project goals will contribute to answering the overarching restoration questions posed in the DOI Science Plan (DOI, 2007).

D. U. S. DOI/Fish & Wildlife Service (FWS)

In order for the FWS to attain its goals and objectives for the CERP at both the project and system-wide planning and assessment levels, a total coastal marine CEM model is required to tie together all the estuarine systems and adjacent waters affected by CERP. An integrating CEM is essential to compare and contrast the various drivers, stressors, effects, and attributes of these estuarine and coastal systems and to investigate what tradeoffs are possible or necessary. Other estuarine CEMs developed for South Florida have played an important role in determining how CERP is monitored and assessed. Additional CEMs are necessary to help the Service's Coastal Program meet its primary goal of conserving habitat for fish and wildlife species. Such information will help determine where and to what extent the Service's Coastal Program should focus its efforts in South Florida. Lastly, establishing feasible and quantifiable goals and targets for South Florida will aid the Service's efforts in the recovery and protection of the Service's Trust resources, including Federally-listed threatened and endangered species. Moreover they would help set realistic management goals for Ding Darling, Ten Thousand Islands, Crocodile Lakes, National Key Deer, Great White Heron and Key West National Wildlife Refuges, for which the Service is responsible.

E. U. S. Environmental Protection Agency (EPA)

The EPA South Florida Geographic Initiative targets efforts to protect and restore various communities and ecosystems impacted by environmental problems. Under this initiative, EPA is working with stakeholders to develop and implement community-based approaches to mitigate diffuse sources of pollution and cumulative risk.

EPA's Office of Research and Development is responsible for the research and development needs of the Agency's operating programs and the conduct of an integrated research and development program for the Agency. The Office of Research and Development is working collaboratively with Region 4 on research, integrated monitoring, and assessment related to Florida's coral reef ecosystems in Monroe, Miami-Dade, Broward, Palm Beach, and Martin Counties, including *inter alia*:

- Scale-appropriate models to forecast future condition
- Assessment of individual and multiple stressors and their prioritization
- Benefits analysis of potential policy decisions
- Management strategies to restore areas and reduce risk that are cost-effective and stakeholder-driven

EPA's challenge is how to improve environmental decision making in South Florida and thus result in measurable environmental and socioeconomic outcomes. Collaboration is key: science combined with the collaborative process increases the probability of reaching desirable environmental outcomes. The development of CEMs for the southwest Florida shelf, the FKDTR, the southeast Florida shelf, and the SFTME is essential to understanding these complex ecosystems. In addition, manager and stakeholder workshops to identify objectives and questions are essential to make research relevant to the managers' needs, and will help connect the science effort to the user community. Such input is essential to assure that quantitative indicators developed by natural and social scientists truly address the needs of the managers and stakeholders.

F. South Florida Water Management District (SFWMD)

The vast majority of citizens in the SFWMD's 16 county area reside along the coastline of the Atlantic Ocean or Gulf of Mexico. A goal of the District, as part of its mission to improve water quality and natural systems, is the protection and restoration of estuarine ecosystems along this coastline. Environmental science provides a basis for defining the environmental needs of these systems and identifying targets for improved water management. Specific programs and projects concerning the management of coastal systems include the internationally prominent CERP (for the benefit of not only the Everglades wetlands, but also Biscayne Bay, Florida Bay, Whitewater Bay, Caloosahatchee River Estuary, St. Lucie River Estuary, and Indian River Lagoon), Minimum Flows and Levels (for management decisions regarding the balance of ecosystem needs and human water supply needs), planning of water management operations, and water quality improvement projects (e.g. storm treatment area design, construction and operation, and pollutant load reduction goal setting).

It is critical to the District that a consensus be achieved as to the essential characteristics of sustainable and restored coastal ecosystems as well as coastal ecosystem restoration targets and indicators. The District needs a comprehensive integrated framework for evaluation of the South Florida coastal ecosystems. To date, the District's efforts to evaluate these systems have largely been localized, focused on individual estuaries and their watersheds (for example, Florida Bay and the Everglades). Such an approach is valid and necessary, but neglects potential interactions of estuarine dynamics with more offshore areas. While estuaries may be strongly affected by water management, other management actions (e.g. fisheries) affect broader-scale dynamics and can directly or indirectly affect the state of our estuaries. It is essential that multiple agencies integrate their management strategies. A large-scale inclusive interagency approach could enable analysis of the interactions of different portions of the greater coastal system and potential

trade-offs regarding management decision making. Finally, progress is needed towards improving our ability to assess ecosystem services as part of a broad consideration of environment and society to help the District improve benefits analysis, an essential step in many of our large-scale environmental projects (especially those being done in partnership with the U.S. Army Corps of Engineers).

G. Florida Fish and Wildlife Conservation Commission (FWC)

The FWC does not actively conduct restoration activities in the coastal areas. However, they are responsible for the management of fisheries throughout state waters. Today, they focus their management actions on single species, but recognize more and more that the overarching ecosystem changes being experienced by coastal areas and coral reefs are critical factors in the health of the fisheries for which the FWC is responsible.

One of FWC's internal goals is to move management activities toward the broader issues of managing the fisheries within an ecosystem context. A consensus building process and the prospect of improved benchmarks for South Florida ecosystem restoration will be an important step in moving FWC management activity to better include ecosystem processes. Furthermore, to the extent that setting these benchmarks aids in restoration, they will likely also serve the fundamental FWC goal of sustainable fisheries in State waters.

IV. Non-Governmental Organization (NGO) Involvement

NGOs need to be involved in consensus building with respect to the South Florida coastal ecosystem and have a significant stake in the success of the effort proposed. As a consequence, two major NGOs, the National Audubon Society (Audubon) and The Nature Conservancy (TNC), have collaborated in developing this proposal and have become funded PIs participating on the Project Management Committee and/or as conceptual ecological model development workshop leaders. We are committed to bringing other relevant regional NGOs, large and small, into the process via participation in one or more of the conceptual ecological model development workshops, the public stakeholder meetings(s) and the goal/indicator workshops.

NGOs whose missions or activities involve conservation of the Florida Everglades, Biscayne Bay, rivers and estuaries of the south Florida mainland, Florida Bay or the Florida Keys, or any of these regions' component natural systems, ecological processes or the species that depend upon them, will find innumerable ways to use the outputs of the proposed project. Other NGOs that are likely to engage in the project and to utilize its outputs include, but are not limited to, the Everglades Foundation, National Parks Conservation Association, World Wildlife Fund, Reef Environmental Education Foundation, Sanctuary Friends of the Florida Keys, Reef Relief, Mote Marine Laboratory, Ocean Conservancy, the Monroe County Commercial Fishermen's Association and the Keys Association of Dive Operators.

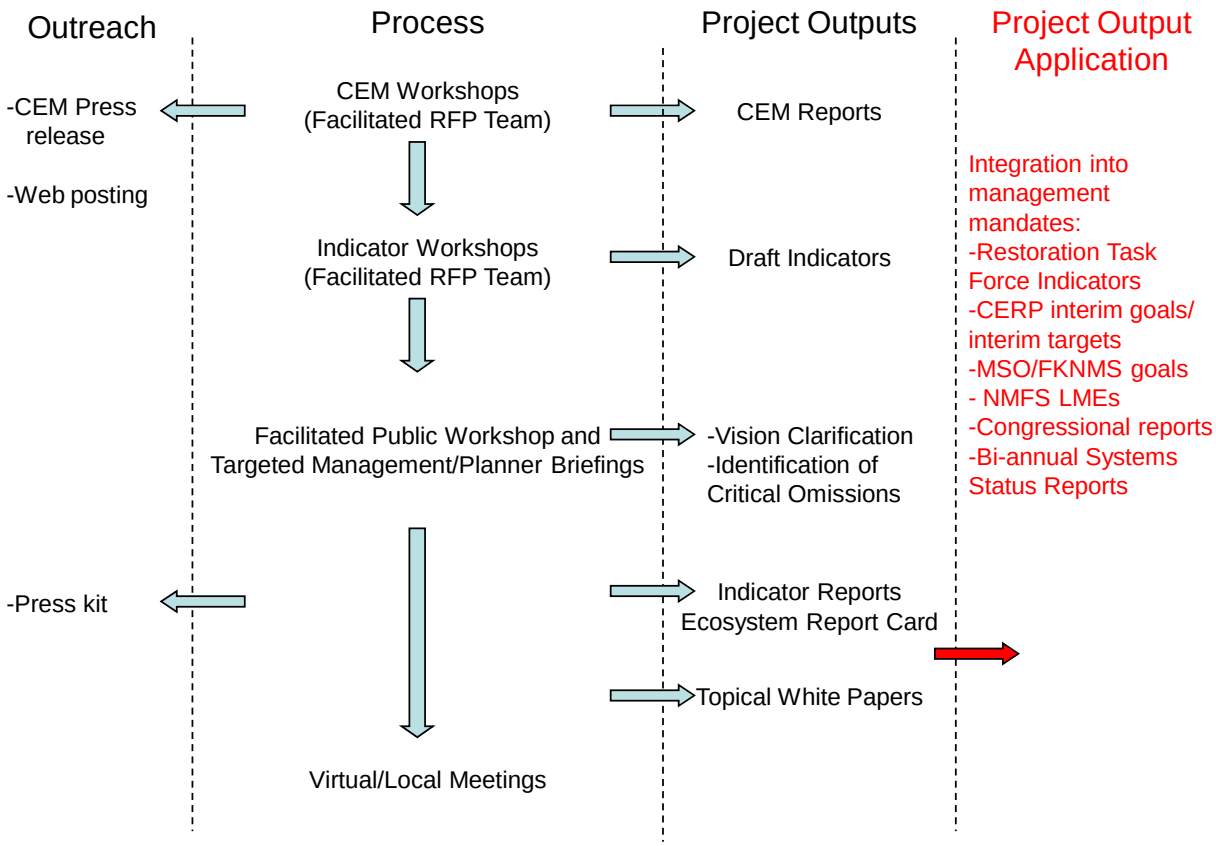
TNC staff will serve as a conceptual ecological model/indicator workshop leaders and expect to take part in most of the other project activities as well. TNC's mission is to preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting

the lands and waters they need to survive. The organization has been active in South Florida since the early 1960's, utilizing science-based conservation approaches ranging from direct land acquisition in the Everglades watershed to studying and promoting advanced wastewater treatment technologies to identifying novel coral reef management strategies via coordination of the Florida Reef Resilience Program. TNC believes that stony corals may be one useful indicator of overall system condition and would like to explore this possibility within the facilitated process contemplated by the project. The organization is keenly interested in improving collective understanding of the interrelationships between biophysical resource conditions and the human dimensions of resource use and management. TNC would like to be able to apply the outcomes of the proposed project as metrics of the organization's progress towards improving management of South Florida's marine managed areas, and it expects to learn lessons from the project that will be applicable throughout Florida and around the world.

Audubon staff will serve both as a member of the Project Management Committee, and as a conceptual ecological model/indicator development workshop leader. Audubon's mission is to conserve and restore natural ecosystems, focusing on birds and other wildlife for the benefit of humanity and the earth's biological diversity. The organization has been active in South Florida since 1935 when renowned ornithologist Robert Porter Allen established the Tavernier Science Center to study Roseate Spoonbills in Florida Bay. The project that he founded is ongoing today and is one of myriad projects that have been performed at the Tavernier Science Center since its inception. The foci of these studies range from corals, to sea grass and mangrove based fish production, to the causes of nesting failure in various bird species and the importance of migratory birds to tropical forests. Currently, Audubon in general, and the Tavernier Science Center in particular, are focused on how Everglades Restoration efforts will affect the estuarine and marine habitats of Florida Bay, Biscayne Bay, the southwest Florida shelf, and the marine habitats of the Florida Keys. Its priorities are to perform scientific research that leads to policy decisions that ensure that restoration efforts have a positive benefit, not only on the Everglades, but on the downstream marine environment as well. Audubon will use outcomes of the project to direct its research efforts in South Florida and to help advance sound policy decisions in restoring America's Everglades.

V. The Marine and Estuarine Goal Setting for South Florida (MARES) Strategic Approach to Consensus Building

In essence we propose to engage agency scientists/managers/policymakers, academics, and environmental organizations in a systematic process to collaboratively develop conceptual ecological models, ecological indicators, and quantitative goals for the entire coastal ecosystem of South Florida. The process we will follow is depicted in the chart below:



Scientists have long sought a system for measuring the general health, ecological integrity (*in sensu* Parrish et al., 2003) and restorative capabilities and trends of ecosystems (Griffith and Hunsaker, 1994; Karr and Chu, 1997). National Indicators for pollution and the economy have been used for many years to convert complex scientific and economic principles and data into easily understandable concepts (Bennett, 2000).

Ecological systems are complex, and efforts to select and implement easily understood indicators of change are extremely difficult. Some key questions are: Exactly what is an indicator? What is the indicator supposed to indicate? What makes a good indicator? Will this indicator be explicable to managers and policy makers? How do these indicators integrate into the "big picture" – the vision of a restored, sustainable ecosystem?

Indicators can help evaluate the ecological changes resulting from management actions and provide information and context by which to adapt and improve, add, replace or remove as projects are implemented and new scientific information becomes available. If one seeks to restore or sustain a large, complex regional ecological landscape like South Florida it is essential for scientists, managers and stakeholders to agree upon how well they are meeting their goals. Indicators are a critical part of goal measurement.

Ecological indicators come in many different formats, forms, levels of detail or resolution, organizational schemas, and environmental metrics. They also have many different purposes and applications and no one set or method of application or means of developing indicators seems to work or apply in all situations or ecosystems. However, each individualized set of indicators is designed to capture the "essence" or defining set of features of the ecosystem. The features of the marine and coastal components of the SFTME include those characteristics distinctive of its biological, chemical and physical properties and their close relationship to the adjacent watershed.

We propose to use well developed and documented tools and regionally accepted approaches that have already proven successful within CERP and SFER, and to rely upon the experience of individuals intimately familiar with these successful processes and procedures. We have no intention of re-inventing the wheel. Perhaps surprisingly given the slow pace of SFER implementation, the public has not yet lost faith in the overall regional goal and has a general understanding of the relationship between upstream water management and downstream coastal ecosystem health, and a belief that they are in fact closely coupled.

CEMs will be developed for those geographical areas that currently lack them (the southwest Florida shelf, the Florida Keys/Dry Tortugas and the southeast Florida shelf) as well as for the complete SFTME. This last domain would integrate the three new models with the Biscayne Bay, Florida Bay, Mangrove Transition Zone, Caloosahatchee and St. Lucie CEMs already developed by CERP/RECOVER. A vision statement including qualitative statements about defining sub-regional ecosystem characteristics would be a component of each CEM.

As the CERP/RECOVER and SCG efforts have demonstrated, CEMs are essential to establish consensus, set goals and define those ecological indicators one must measure to assess the productivity, diversity, stability, and resilience of the ecosystem (i.e. the health and status of that ecosystem.) The suite of indicators produced will be used to develop quantitative desired conditions for the ecosystem (targets), to identify gaps in current scientific understanding, and to prioritize subsequent research, modeling, and monitoring activities.

A number of large scale anthropogenic and natural drivers are becoming vividly apparent in South Florida, and are already stressing coastal ecosystems. A well publicized example is global climate change with respect to sea level rise, decreases in precipitation, and increases in Atlantic hurricane intensity. Others include dramatic regional population growth, changing land use patterns, and virtually unchecked urban and suburban development. Current fresh water management minimizes storage, and has resulted in the dichotomy of having a fresh water surplus the northern estuaries (Caloosahatchee/St. Lucie) and a fresh water deficit in the southern estuaries (Florida and Biscayne Bays). Large restoration (CERP and other) project sequencing therefore has enormous implications for the coastal ecosystems.

Yet another issue is the inherent difficulty of the CERP project benefits analysis that is a requirement for expenditure of federal restoration funds. The utility of "ecosystem services valuation" in this context is one means of quantifying the social-ecological relationship to assist

in natural resource management decision-making as well as to provide a useful tool for public education purposes.

We are calling these issues and concepts "touchstone issues", and intend to make a conscious effort to include touchstone issues in all aspects of conceptual ecological model development, indicator development, and goal setting.

A. Rollout Briefings

Over the first two months (and prior to the workshops discussed below), the project management team will be conducting Rollout Briefings with each of the key interagency management bodies responsible for different aspects of the South Florida coastal marine ecosystem. This include inter alia: the South Florida Ecosystem Restoration Task Force's Working Group and Scientific Coordination Groups, the FKNMS Scientific Advisory Committee, the CERP RECOVER Leadership Group etc. Members of our project management team are members of one or more of the relevant management bodies and can readily secure a place on the agenda of the first meetings to be held after inception of the MARES project. We will be preparing a brief 2-3 page synopsis to handout and a Power Point presentation to be used at each of these meetings**. At the conclusion of the briefings we will solicit suggestions as to how our process can be improved and what additional personnel from each of their agencies need to be included to make our efforts successful and assure the information generated is useful to and used by their agencies.**

B. Conceptual Ecological Model (CEM) Workshops

These models will be developed during 2-day facilitated workshops that draw together agency scientists, academics, and scientists from NGOs working in the specific geographic area in South Florida. In addition to project PIs, other technical experts in the fields of economics and sociology will also be invited. At the conclusion of each CEM workshop, a conceptual model graphic with a draft outline of the necessary supporting text will be produced. The text will be further developed, refined, and vetted with all the workshop participants over the following months resulting in a final CEM report.

Outputs of each of the CEM workshops are expected to include:

- CEMs, with accompanying text and a contextual qualitative vision statement
- Identification of an initial suite of defining characteristics/ecological parameters to serve as the starting point for the Indicator Workshops
- Identification of scientific needs and gaps (critical uncertainties)

B. Quantitative Ecosystem Indicators Workshops

When a consensus has been reached upon the CEM, a corresponding Indicator Workshop will be held. This will be another two-day facilitated workshop amongst the project PIs and invited technical experts. Given the change in focus, the participation might change. Additional PIs (and outside experts) who had not participated in the CEM workshop may be invited.

While the CEM workshops were modeled closely on the CERP/RECOVER process, the Indicator workshops are modeled more closely upon the SCG Indicator process.

Starting from the vision statement and the CEMs, the indicator workshop participants will agree upon criteria and select an appropriate subset of parameters representing logical potential indicators. This group will discuss and analyze stressors and drivers affecting specific indicators, and assess the availability of the information (including any pertinent numerical models) needed for the assessment of that indicator. The goal will be explicit quantification of the desired condition of realistic and useful indicators, which could then be the starting point for specific quantifiable ecosystem goals. Workshops will only be the beginning of the process; as with the CEM workshops, refinements will be continued by a smaller group as required over the subsequent months.

Outputs of this suite of activities will be a substantial technical product for each possible indicator that includes at a minimum:

- Scientific consensus on the quantitative desired future condition. This quantitative description is equivalent to the development of a performance measure target (in the language being used in CERP)
- A description of the current trajectory (status/trends), using available monitoring data
- Analysis of the relevant stressors/drivers, using available field data, or numerical models
- An explicit discussion of the gaps in the information required to rigorously assess the degree of change in an indicator and the cause of that change

C. Management and Public Input

The work of developing the CEMS and identifying indicators and science needs will be conducted primarily by the natural and social science communities of South Florida. In order to establish a consensus amongst the decision-makers, stakeholders, and scientists, **we propose to interact with natural resource managers, policymakers, and the public not only through the Rollout Briefings previously described but again and again during the post-Indicator Workshop process of refining the quantitative desired conditions/goals**. Interaction with resource managers and policymakers will take place through established forums, such as the Florida Keys National Sanctuary Advisory Committee, the South Florida Water Resources Advisory Council, the Southeast and Southwest Florida Regional Planning Councils, the SFER Working and Scientific Coordination Groups, and the RECOVER Leadership Group. We will brief them on progress to date and ask them for their input in particular with regard to whether we have been able to capture the most important factors in natural resource decision-making. These briefings will be repeated in increasing detail as indicators and goals are "finalized.

The identification of a comprehensive well-defined set of "issues of concern" will be critical to project success. Once developed, such issues can be translated into a set of specific assessment questions that can be addressed scientifically. These assessment questions can then be used to select appropriate indicators and set goals. Discussions among scientists, managers, stakeholders and the general public are required to identify the issues of concern, and to refine

issue-oriented assessment questions. EPA regional representatives (PIs in our project) already experienced in this process, rather than our professional staff facilitator, will facilitate the public meetings we will use to identify additional issues and to refine issue- oriented assessment questions. This too will be an iterative process repeated as required at various stages of product development.

The issues of concern will be used to refine, modify, and select among the suite of indicators initially developed by the technical experts. The output of this suite of activities will be (1) a document identifying the natural resource goals, issues, and indicators that are critical for managers and policy makers; and (2) a recommendation on how these issues can be incorporated into the ecosystem goals (i.e. desired future conditions). Together with the technical information discussed above, this will constitute the Final Indicator Report for each geographical domain. The process described (first a CEM Workshop and Report, then an Indicator Workshop, then targeted briefings and public meetings, and ultimately a Final Indicator Report) would be repeated for each of the three "missing" geographical domains and, lastly, for the integrated South Florida Total Marine Ecosystem (SFTME) CEM domain. As stated earlier, it is our expectation (and one supported to date by interactions with management bodies) that the indicators we develop will be incorporated into

D. White Papers and Topical Reports

As technical questions emerge, and they undoubtedly will, smaller (non-facilitated) meetings will be held to produce supplementary white papers and topical reports with respect to what we termed the "touchstone" issues. These will be developed on-line in a virtual environment and we do not expect them to mature until near the end of the project after both the presently available and the "missing" CEMs have been integrated through the SFTME workshops, briefings and public meetings. **These products will be delivered to and incorporated into RECOVER scientific analyses and other state and federally mandated regular reports**.

E. Report Card for Decision/Policy Makers

The last step in the goal setting process will be the development of a science-based "Report Card" encapsulating for policy-makers and the public the current health of South Florida's coastal ecosystems. The report card will be developed using the quantitative goals developed for the integrated SFTME, though it may not include all of them. The report card will emphasize the goals, issues and indicators that have been identified as critical for managers and policy makers. The first of these report cards will be emitted as a final output of the current project. The form of the output will be modeled upon the SCG's system-wide South Florida Ecosystem Restoration Report Card that is being developed by a subset of the project's PIs. In contrast to the present draft SCG report card, not only natural resource but also human dimensions goals would be included in this project's Report Card. **It is our expectation that our report card will then be folded into the overall interagency SFER Report Card and repeated by the interagency group on the same bi-annual basis. Again, the conclusion of MARES will represent not an endpoint or handoff but the beginning of an improved interagency process.**

F. Real-Time Information Availability and Dissemination

We intend to maintain a high level of public outreach during this proposed project. This will be achieved via timed press releases, frequent web postings, and invitations for members of the press to attend decision-maker briefings and public meetings. **Our NGO PIs and the project staff have the greatest expertise in this area, and will take the lead with regard to effectively disseminating this information.**

VI. Some Lessons Learned

The implementation of this project is intended to build upon the Florida Bay and Adjacent Marine Systems (FBAMS) and RECOVER models in a number of more mundane but practical and therefore important respects. First, a major factor in FBAMS success was the collaborative interagency leadership provided by its Program Management Committee (PMC). The PMC was an example of a "community of practice," a recognized mode of self-maintaining group behavior. "Community of practice" is a term referring to a group of people bound by shared expertise and interest in a topic or an enterprise. Communities of practice are by nature informal, self-selecting and self-directed. This project will be lead by a similar PMC. Second, the FBAMS science program and its PMC were most effective when they employed a paid staff rather than relying entirely upon agency scientists and managers and volunteer academic scientists.

A significant lesson learned through the CERP/RECOVER Leadership Group is the utility and effectiveness of facilitated meetings. We will therefore retain a professional facilitator who has worked effectively with the RECOVER Leadership Group. Another lesson we have learned is that one can only ask so much of volunteers. To assure document production based upon the CEM workshops you cannot and should not rely entirely upon volunteer efforts but rather competent individuals who receive sufficient staff support to compensate them for their contributions. Moreover a mechanism is needed to cover at a minimum the travel expenses of State and Federal participants who are expected to regularly attending multiple day meetings. Not being able to do so has restricted attendance at critical CERP and SCG meetings due to individual agency budgetary restrictions, and we can't afford to lose the participation of these knowledgeable individuals from the resource management, environmental, and restoration agencies. We will be able to cover the travel expenses of all the participants in the workshops we propose. Lastly, there are far too many meetings already on the calendar for South Florida. One need only consult the online calendars for CERP and SFER to see just how burdensome these have become. Wherever possible we will need to move forward without face-to-face all day meetings.

An online web portal will be developed to streamline the complex scientific collaborative process that has been proposed. The portal will be adapted for project needs from available Microsoft SharePoint software. SharePoint was initially developed to provide industry with a means to connect people and projects, but recent versions were modified to offer knowledge workers a way to organize, find, and share information. It is now being applied in fields beyond industry, and has proven to be an effective management and strategic tool (Millet et al., 2005).

These applications include the medical field, where it increased the overall quality of patient care through greater efficiency of healthcare providers by increasing the quality of documentation and providing the ability to work offsite (Hook and Bartley, 2007). The proposed web portal for this project will be based on the design concept implemented in the Integrated Information system for Social and Ecological Assessment (i^2SEA), a Microsoft SharePoint-based web portal already being used in a UM/RSMAS-lead multi-institutional project, to facilitate the integration of data from social, political, ecological, hydrodynamic and other ocean observing research into a set of coherent decision support tools for coastal and marine resource management. As such, the development model allows for efficient collaboration through the following functions:

- Document Exchange: Members can upload, download, check-out the document, open a discussion on a document posted, track changes and author a document simultaneously.
- Project Calendar: A common project calendar is most useful in posting project-related events and scheduling meetings. This feature can be synchronized with commonly used local calendar systems (e.g. Outlook, iCAL).
- Discussion Forum: A common workspace for members to discuss issues related to the project. It is a more efficient method to exchange ideas, resolve conflicts and build consensus than flooding email boxes and/or numerous phone calls.
- Announcements: A feature that allows members to post messages to the portal and has the option to cascade the message as an email to all members.

The portal will also have links for a common repository of digital images, URLs of interest to the project and list of contacts. Moreover, to facilitate web conferencing and internet-based meetings, the portal will also provide a link to Voice-over-IP functions using WebEx, Microsoft BizTalk or Adobe Connect.

Two further lessons must also be kept in mind. Neither the SCG nor CERP/RECOVER has sufficiently involved the NGOs. These organizations are invaluable partners that can provide crucial links to the stakeholder communities and can interact with the political process in ways impossible for state or federal agency employees. Lastly, it is widely recognized (see e.g. O'Neill, 2001) that people are today among the most significant components of our ecosystem, yet for a variety of reasons, neither the SCG nor CERP has devoted sufficient attention to human dimensions and the attendant non-natural science disciplines. In this project we will remedy that by including at all the workshops, specialists in economics and other social sciences, familiar with South Florida and capable of providing insights and information that have not been sufficiently integrated to date, such as quantification of the ecological services provided by a healthy sustainable South Florida coastal ecosystem.

Our over-arching research approach is rooted in the notion of "integrated assessment", a widely accepted way of approaching complex, multi-disciplinary problems. Traditionally, integrated assessments have been thought of as syntheses and critical appraisals of scientific information on topics such as coastal resource management or hurricane forecasting. More recently, a broader view has been offered that encompasses not only the analytical outputs but

also the social, dynamic, iterative processes that lead to and follow them (e.g., Miller and Jasanoff, 1997). As such, assessments serve many functions (Moser, 1999):

- Integrating disparate knowledge from many disciplines and research programs;
- Disseminating consensus research answers to policy officials and decision makers;
- Identifying gaps in scientific knowledge; and
- Re-evaluating the relevance of knowledge claims.

In other words, integrated assessment is not just about synthesizing what is known but also about advancing that state of knowledge and ensuring its relevance. And because we have a lasting interest in the problems we study, the inter-disciplinary dialogue itself must be considered an important output since it is the infrastructure of problem solving. **A critical part of our research is the process of team formation and collaboration since it will enable us to move beyond isolated studies of parts of marine ecosystem problems to a more systemic view and to sustain the effort after MARES itself concludes.**

VII. Project Organization and Schedule

The Table in Appendix A delineates the respective roles of the network of more than fifty collaborators who have prepared this proposal and would participate as discussed above. **That is all fifty are actually PI's who have contributed to the proposal (and obtained the approval of their appropriate agency heads to do so and to contribute as described should the proposal be funded). However, we anticipate additional workshop participation based on the rollout briefings and upon input received from NOAA in particular NOS/CSCOR since if accepted the project would be implemented as a Cooperative Agreement. In particular we look to NOS/CSCOR for guidance as to necessary additional participation within NOAA.** A Project Management Committee (PMC) will be responsible for the overall management of the project and oversight of the staff personnel. The PMC will attend all of the eight facilitated workshops and will represent the project at the targeted briefings of management and planning groups. This group, modeled on the FBAMS PMC, will include Federal agency, academic, and NGO representatives, three of whom served on the FBAMS PMC, including the present and past Federal co-chair. There will be a paid staff fully compensated for their contribution that will consist of an Executive Officer, an Administrative Officer, a Facilitator, an Information Technology specialist, and two economists. The Executive Officer served the FBAMS in exactly the same capacity and the Administrative Officer has been working with CERP and the SFER for the past year or more through Florida Sea Grant Extension. The administrative support staff will be responsible for workshop preparation, organization, facilitation, post-workshop document production, targeted briefing arrangements, outreach (with NGO input and guidance) and website support. Each of the two staff economists will supplement and support the academic and government economists and human dimension specialists at four of the regional CEM and indicator workshops to assure these topics receive their appropriate emphasis.

The Workshop Leaders (WS Leaders) will work with the Administrative and Executive Officer to organize the workshops (and assure that appropriate additional individuals are invited), and with the Facilitator to lead the workshops. After each workshop, these individuals (who will be paid for their time) will be responsible for obtaining the necessary additional input from the larger group of unpaid (excepting travel costs) workshop participants and generating the workshop reports and summaries with the assistance of the staff. Unpaid Federal or State agency PIs named herein have agreed to participate in one or more workshops depending upon their geographic scope and, significantly, to serve whenever necessary as intermediaries in arranging briefings of responsible natural resource agency leadership, interagency committees, etc.

Based on previous experience, we have spaced the workshops at 3- 4-month intervals, allowing sufficient time for document production, briefings and public workshops, indicator refinement and topical white paper development. We will work downstream through the system, first with the Southwest Florida Shelf, then the Florida Keys and Dry Tortugas, and lastly the Southeast Florida Shelf. When these are completed, we will integrate these domains (and their indicators) with the pre-existing CEM's (and indicators) for the CERP/RECOVER estuarine systems into a South Florida Total Marine Ecosystem CEM with over-arching goals and indicators. Assuming funds are received in August 2008, the first of these workshops will be held in early October 2008 to permit time for the staff and support infrastructure to be brought on board and up to speed. The last workshop will be held in Spring 2010. The resulting Schedule of Milestones and Deliverables is provided in Appendix B.

Since touchstone issue white papers will be developed primarily through virtual meetings as required based upon workshop outcomes, it is impossible to schedule them in advance.

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IX. Appendices

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Appendix B – Milestone/Deliverable Schedule

Year One:

August/Sept Rollout Meetings
October CEM Workshop
December CEM Report
January Indicator Workshop
February/March Indicator Briefings/Public Meetings
April Indicator Report
May CEM Workshop

Year Two:

August CEM Report
September Indicator Workshop
November Indicator Briefings/Public Meetings
December Indicator Report
January CEM Workshop
May Indicator Workshop
July Indicator Briefings/Public Meetings

Year Three:

August Indicator Report
September CEM Workshop
December CEM Report
January Indicator Workshop
February/March/April Indicator Briefings/Public Meetings
May Indicator Report
June/July Final Recommendations/ 1st Bi-annual So.Fla. Coastal Ecosystem Report Card