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Gulf of Mexico Regional Collaborative Final Report

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1.1   GoMRC Overview and Objectives

The Gulf of Mexico is a vital international ecosystem that plays a critical role in the economic health of both the U.S. and Mexico. Activities such as coastal development, agriculture, fisheries, oil and gas exploration and production, and others that drive the economic health of the region are also placing the Gulf ecosystem under tremendous stress. Broader ecosystem stressors, including coastal wetlands destruction, harmful algal blooms (HABs), sea level change, and hurricane damage, are among the regional challenges that need to be better understood at appropriate temporal and spatial scales if effective resource management guidance is to be enacted.

An impressive amount of earth science work is being carried out in the Gulf of Mexico, which is contributing to a strong understanding of individual ecosystem parameters in focused geographic regions. Yet our ability to exploit this work to enrich our understanding of the complex relationships with this regional ecosystem is limited. Existing datasets and tools are diverse, disparate and variable in terms of quality and scope. A myriad of entities hold the data, systems and expertise necessary to examine the Gulf as regional ecosystem. End user access to available tools is often hindered by resource constraints, particularly at the state and local levels. Therefore, there is no single easy working environment that enables resource managers to look at their local resources within the context of the broader Gulf region.

The Gulf of Mexico Regional Collaborative (GoMRC) was established to help demonstrate a practical way to address ecosystem-scale integration and sustainable management challenges in the Gulf of Mexico. It is a first-of-its-kind effort aimed at providing resource managers and policymakers in the U.S. and Mexico with a flexible toolset that enables:

- An improved understanding of the Gulf's marine and coastal environment across a <u>wide range</u> of resource management issues and spatial-temporal scales
- Improved decision support by enabling users to <u>identify and test options</u> for natural resources planning and management

GoMRC has taken important steps toward these long-term objectives in its inaugural year by developing an extensible prototype system that incorporates an interactive set of ecosystem science, data management, modeling, and decision-support tools and demonstrates their use addressing important natural resource challenges in the Gulf.

The work, accomplished with seed funding from NASA, provides direct benefits to resource managers in the demonstration region, along with promising indications that these longer-term objectives can yield additional societal benefits by extending the GoMRC platform to a broader set of geographic areas and topics. These include:

- Providing an effective basis for bi-national science and technology cooperation;
- Providing local, regional and national decision-makers with a set of tools for understanding coastal and marine resources status and trends at a macro-scale and a basis for making decisions at a local scale; and,
- Leveraging and integrating multiple existing technologies, software tools, and data projects upon a framework guided by Gulf of Mexico ecosystem science.

GoMRC was initiated through a partnership of Pacific Northwest National Laboratory (a U.S. Department of Energy Laboratory managed by Battelle), the University of Alabama in Huntsville (UAH), the NASA Marshall Space Flight Center (MSFC), and Oregon State University (OSU), and has involved a broad set of state, federal, and academic end users. The GoMRC project has also leveraged work conducted by OSU under a separate contract funded by USRA. The USRA project has supported the transfer and integration of the IT methods and ecosystem modeling capabilities developed under the Pacific Northwest Regional Collaboratory (PNWRC) – a project in its fifth year of funding from NASA – to the GoMRC project.

1.2 Summary of Outcomes

The GoMRC project was organized around end user outreach activities, a science applications team, and a team for information technology (IT) development. Key outcomes from the first year of the GoMRC project are summarized below for each of these areas.

End User Outreach
- Successfully engaged federal and state end users in project planning and feedback
- With end user input, defined needs and system functional requirements
- Conducted demonstration to End User Advisory Committee on July 9, 2007 and presented at Gulf of Mexico Alliance (GOMA) meeting of Habitat Identification committee
- Conducted significant engagement of other end user groups, such as the National Estuary Programs (NEP), in the Fall of 2007
- Established partnership with SERVIR and Harmful Algal Blooms Observing System (HABSOS) programs and initiated plan to extend HABs monitoring and prediction capabilities to the southern Gulf.
- Established a science and technology working group with Mexican institutions centered in the State of Veracruz. Key team members include the Federal Commission for the Protection Against Sanitary Risks (COFEPRIS), the Ecological Institute (INECOL) a unit of the National Council for science and technology (CONACYT), the Veracruz Aquarium (NOAA's first international Coastal Ecology Learning Center) and the State of Veracruz. The Mexican Navy

(critical to coastal studies in the Southern Gulf) and other national and regional entities have also been engaged.
- Training on use of SERVIR portal planned for Fall 2007 in Veracruz, Mexico

Science Applications
- Worked with regional scientists to develop conceptual models of submerged aquatic vegetation (SAV) ecosystems
- Built a logical framework and tool for ontological modeling of SAV and HABs
- Created online guidance for SAV restoration planning
- Created model runs which link potential future land use trends, runoff and SAV viability
- Analyzed SAV cover change at five other bays in the Gulf of Mexico to demonstrate extensibility of the analytical tools
- Initiated development of a conceptual model for understanding the causes and effects of HABs in the Gulf of Mexico

IT Tool Development
- Established a website with the GoMRC web-based tools at www.gomrc.org
- Completed development of an ArcGIS-based decision support tool for SAV restoration prioritization decisions, and demonstrated its use in Mobile Bay
- Developed a web-based application, called Conceptual Model Explorer (CME), that enables non-GIS users to employ the prioritization model for SAV restoration
- Created CME tool enabling scientists to view existing, and create new, ecosystem conceptual models which can be used to document cause-effect relationships within coastal ecosystems, and offer guidance on management solutions.
- Adapted the science-driven advanced web search engine, Noesis, to focus on an initial set of coastal and marine resource issues, including SAV and HABs
- Incorporated map visualization tools with initial data layers related to coastal wetlands and SAVs
- Supported development of a SERVIR portal for data management and visualization in the southern Gulf of Mexico, as well as training of end users in Mexican Gulf States

1.3 Overview of Technical Approach

The overall technical approach for GoMRC involved using a science-based, user-driven method to develop a flexible and extensible IT infrastructure that could support decision makers addressing a broad set of coastal and marine environmental challenges. The architecture was designed to enable an end-to-end, data-to-decisions approach to analysis, using NASA satellite imagery integrated with data from other sources (Figure 1).

Prioritization of SAV restoration sites was the pilot application selected to demonstrate how the system could be used by a resource manager to make a more informed resource management decision. GoMRC scientists decided prioritizing SAV restoration was a tractable problem, which could be analyzed at a fairly localized scale, but would be of

regional importance. Targeted end user communities of the decision support system were engaged throughout the process to ensure alignment with priority information needs.

The following sections summarize the results of the end user outreach activities, science application development, and IT architecture development.
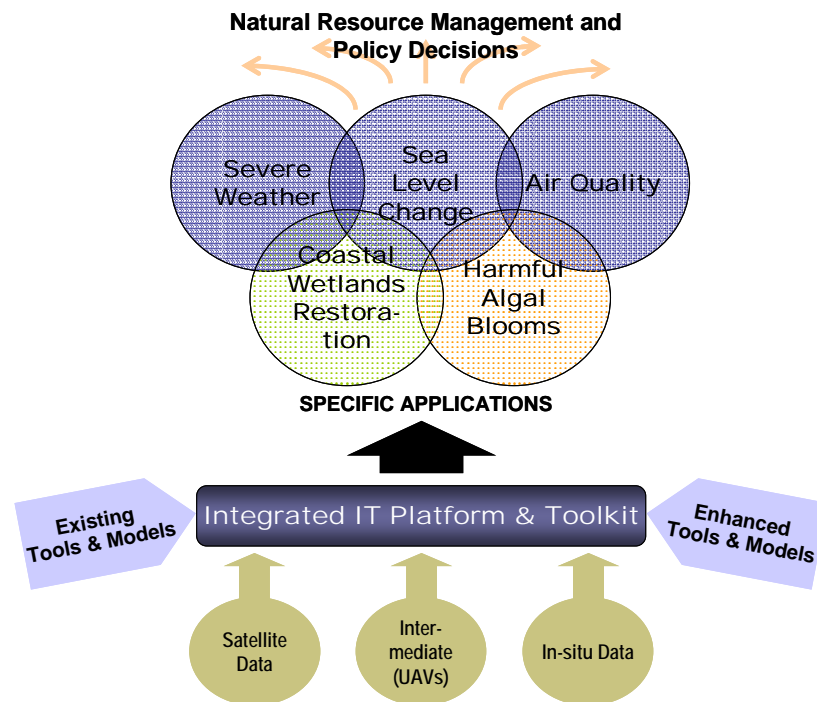
Figure 1. GoMRC system concept

2.0   End User Outreach Outcomes

2.1   Federal Steering Committee

Members of the GOMA Federal Working Group (i.e., NASA, EPA, and NOAA) were engaged at the outset of this project and at several intermediate points to help steer GoMRC's vision, activities and its approach. GoMRC engaged GOMA leadership during a visit to NASA Stennis in December 2006, and delivered a presentation at the GOMA Federal Working Group Meeting in Silver Spring, MD in March 2007. The Federal Working Group representatives provided direction in selecting members of an end user advisory committee and identifying initial environmental topics that GoMRC would focus on. GOMA federal representatives were also consulted through one-on-one interactions throughout the project.

2.2   End User Engagement

A 16-member End User Advisory Committee with Gulf-wide representation was established within the first month of start-up. (See Appendix A for committee list). The role of the End User Advisory Committee was to provide input into natural resource management needs and feedback on interim project outputs, ensuring that the GoMRC system is strongly aligned with user needs.

During spring 2007, GoMRC held three end user teleconferences in order to coordinate information collection on requirements and early progress of the project. Appendix B is a summary of the requirements input received from the committee.

On July 9, 2007, GoMRC conducted a full-day, in-person demonstration to the End User Advisory Committee and other invitees in order to share progress and solicit feedback at the three-quarters completion point of the project. The demonstration was held in conjunction with the GOMA 3rd Annual All-Hands Meeting in St. Petersburg, FL. Appendix C is a summary of the presentation and input received from the committee at the demonstration and in a follow-up questionnaire.

GOMA working group members were engaged extensively both as members of the End User Advisory Committee and independently. In particular, GoMRC actively coordinated with the GOMA Habitat Identification priority issue team in order to share datasets, and coordinate systems functionality in conjunction with the Priority Habitat Information System (PHINS) and related projects, such as the Geospatial Assessment of Marine Ecosystems (GAME) project and development of the Coastal and Marine Ecological Classification Standard (CMECS). Engagements included participating joint in PHINS/GAME/GoMRC teleconferences, an in-person planning meeting in Biloxi, and three PHINS state government user needs meetings. Follow-up propositions are planned wherein GoMRC, PHINS, GAME can CMECS can offer streamlined IT assistance to the other three GOMA priority issue teams. The federal sponsors of PHINS and GAME have determined that future proposals by these systems ought to include interoperability. Data exchange and software compatibility discussions began during Fall 2007.

A final demonstration of the GoMRC system and presentation of the first year's work products was conducted in November 2007 with the Mobile Bay NEP and selected staff from the Alabama state government. A subsequent teleconference will also be held with all the Gulf-region NEP managers to present an overview of GoMRC and discuss possible extension of the tools to their programs.

2.3   Conferences, Technical Meetings, Publications

GoMRC participated and provided visibility for GoMRC and NASA in several conferences and technical meetings throughout the year, including: Estuarine Research Federation 2007 conference; ESIP federation meetings; international SERVIR Summit (December 2006); two GOMA Federal Working Group meetings; the GOMA Annual

Governor's Action Plan All-Hands meeting; and two bi-national HABs meetings at NASA Stennis and Campeche, Mexico.

GoMRC scientists have submitted a journal article entitled, "From Satellites to Seagrasses, Wetland Restoration through Spatial Data Integration" to the journal, *Ecological Applications*. Other opportunities for publication on the novel work conducted under GoMRC are being sought.

3.0   Science Applications Development Outcomes

3.1   Introduction

The long-term goal of the GoMRC program is to develop a suite of applications that can facilitate decision-making related to major environmental issues for resource managers and scientists. The GoMRC science team has approached this goal by focusing its year one activities on a high-priority problem that illustrates a suite of GoMRC toolset functions.

Coastal ecosystem restoration, specifically SAV habitat, was selected as the primary demonstration application. With the growing population and pressure to develop coastal areas as well as coastal watersheds, conservation and restoration of coastal ecosystems is a high priority for the nation. Major programs in the Florida Everglades, Chesapeake Bay, San Francisco Bay, and Puget Sound are grappling with how best to design and implement ecosystem-based restoration projects on a massive scale. In addition, public entities, such as the National Estuary Program, and private entities, such as land trusts, have conservation and restoration missions, and thus need to plan and implement restoration in a way that maximizes results for the money invested.

Among the most often sought after tool by managers is one that prioritizes restoration projects. A prioritization decision tool provides one of the bases for making investments in restoration projects. Ideally the prioritization tool operates within a context that first establishes a clear view of the ecosystem, enables discovery and display of pertinent information, and employs defensible scientific underpinnings to facilitate the decision making process by providing an effective, interactive mechanism. The prioritization tool must also be embedded in a system that allows an array of end users to make real decisions – even end users with minimal resources and technical sophistication.

Resource managers must make decisions on complex problems every day, and having a credible scientific basis for these decisions is critical. Shared conceptual models of the ecosystem often serve as the foundation for technical deliberations. Many prospective end users advised GoMRC that it would fill a valuable gap in service if the system could build and illustrate linkages along the full lifecycle, from ecosystem vision, to data about coastal and land uses, as well as to simulation models to forecast interactions.

The primary objective of the Science Applications task was to develop an effective interactive computer-based system that could be used by decision makers, coastal zone

planners, regulators, and scientists to better plan and prioritize coastal ecosystem restoration projects.

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User scenario: Prioritizing Sites for Restoration

A resource manager responsible for SAV restoration off the coast of Alabama sees a number of potential sites that could benefit from replanting SAV. But she has a limited budget and wants to ensure that the sites she selects have the best chance at success. She has decent data on the area and good local knowledge. She wants to make her decision based on credible science, but does not have the budget to hire someone to do a rigorous analysis.

The GoMRC website provides her with several important resources to get started. A conceptual model of SAV helps her identify the factors that are most likely influencing SAV distribution in her region. She uses the conceptual model to discuss her ideas with her colleagues and interested stakeholders in her community who want to understand SAV loss and why it matters. She also uses the conceptual model and the Noesis search tool to start identifying relevant datasets. Since she has limited experience with ArcGIS she will use the web-based version of SAV Restoration Prioritization Toolset, called the Conceptual Model Explorer.

The resource manager uploads her datasets into the Restoration Prioritization Toolset, and changes the weighting on factors that stress SAV, since she knows that dredging is more problematic for SAV than seawalls in her region. She runs the model over the Internet, and comes up with the following results: a set of maps that shows her what sites have suitable conditions for SAV, where SAV conditions have changed over the last 20 years, and what management strategies (e.g. protect vs. restore) are most appropriate in light of these conditions.
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The approach to developing this system is based on previous efforts in the Columbia River estuary, and in Puget Sound. Through our experience in these other systems, the project team has developed a systematic approach to restoration project prioritization. The frameworks developed for specific ecosystems are presently used by coastal zone managers to make decisions on the use of a specific parcel of coastal property. The general approach provided by GoMRC can be used anywhere in the Gulf of Mexico.

To demonstrate conceptual model-oriented data integration and forecasts, the team has conducted an in-depth analysis in Mobile Bay. This effort examines the effect of land-use on the distribution, conservation and restoration potential of seagrasses and SAV in the bay. Focusing on seagrasses/SAV presented a tractable effort in this first phase. Further, this habitat type is often considered an excellent indicator of the general environmental condition of coastal aquatic systems. Our approach relied upon the collective components of restoration theory, hydrological and hydrodynamic modeling, GIS modeling, and was implemented within a computer-based platform.

3.2   Coastal Restoration Prioritization Approach

The fundamental model used to guide the development of the prioritization framework is as follows:

$$\text{Score for site} = \Delta\text{function x area x probability}$$

Where, the priority score for the site is related to the amount of change in the ecological function expected, the size of the site, and the probability that the restoration action will be successful in achieving its goals. The probability of achieving success is a function of the level of disturbance or stress of the site, the level of disturbance of the landscape within which the site resides, and the restoration strategy employed. A restoration strategy may indeed be site restoration, but often includes activities such as site preservation or conservation, enhancement of existing site or creation of a new habitat (Anderson 2007). Further details on restoration strategies, management and goals have been outlined on http://www.gomrc.org/restoration_overview.html.

3.3   Conceptual Model for SAV Habitat

Conceptual models are an increasingly popular method that resource managers use to document their understanding of system dynamics, and can be used as a basis for ecosystem restoration. In this application, the science team created a conceptual model for SAV habitat. (See http://www.gomrc.org/conceptual_model.html for an overview of conceptual model components). The model provides a scientific-based overview of relationships and processes that transpire within coastal SAV habitats, and offers guidance for future restoration efforts.

The fundamental concept is that there are certain environmental parameters (i.e., controlling factors) such as sufficient light, correct temperature, and correct substrate for growth, which a species needs to flourish. Areas with these characteristics at least have the basic requirements for restoration of the species of interest. However, stressors such as increased wave energy, contamination, or even disease may make an area with adequate ranges of controlling factors unsuitable for restoration. Suitable conditions lead to suitable habitat structure (e.g., SAVs) and the wide range of processes, functions, and values that the structure supports. The main elements of the conceptual model are illustrated in Figure 2 below.

Figure 2. Main elements of conceptual model

      Stressors- Ecosystem stressors are "out of the ordinary" natural and unnatural inputs to the system that disturb the controlling factors, structure, and processes in the ecosystem. Stressors produce potentially large-scale effects on the natural spatial and temporal dynamics of the system. Examples include storm events, dredging, filling, and changes in stormwater source runoff.

      Controlling Factors- Controlling factors are the basic physical and chemical conditions that construct, influence or limit the structure of the ecosystem. Examples include light, salinity, and temperature.

      Structure – Ecosystem structures are the major habitat units in the system. Fully developed and functioning structures are self-maintaining, resilient, and

sustainable. There are many possible structures that constitute a coastal habitat ecosystem such as barrier islands, coral reefs, and salt marshes. This model focuses on SAV as the primary structure of interest within an estuary.

Processes – Ecosystem processes are a series of biological, chemical, or physical steps or operations that have a given result or product in the ecosystem. Processes form the fundamental conditions and outputs of the ecosystem. Examples include filtration, wave dampening, and carbon sequestration.

Functions – Ecosystem functions are the primary "products" generated by the ecosystem in addition to providing basic ecosystem sustainability. Examples include storm surge protection, and water quality maintenance.

Values – Ecosystem values are the services provided by the system specifically in support of human needs. Examples: clean water, recreation, shoreline protection.

The conceptual model (Figure 3) provides the underlying foundation for other tools developed through GoMRC, including the Conceptual Model Explorer, geospatial models, and semantic ontologies.
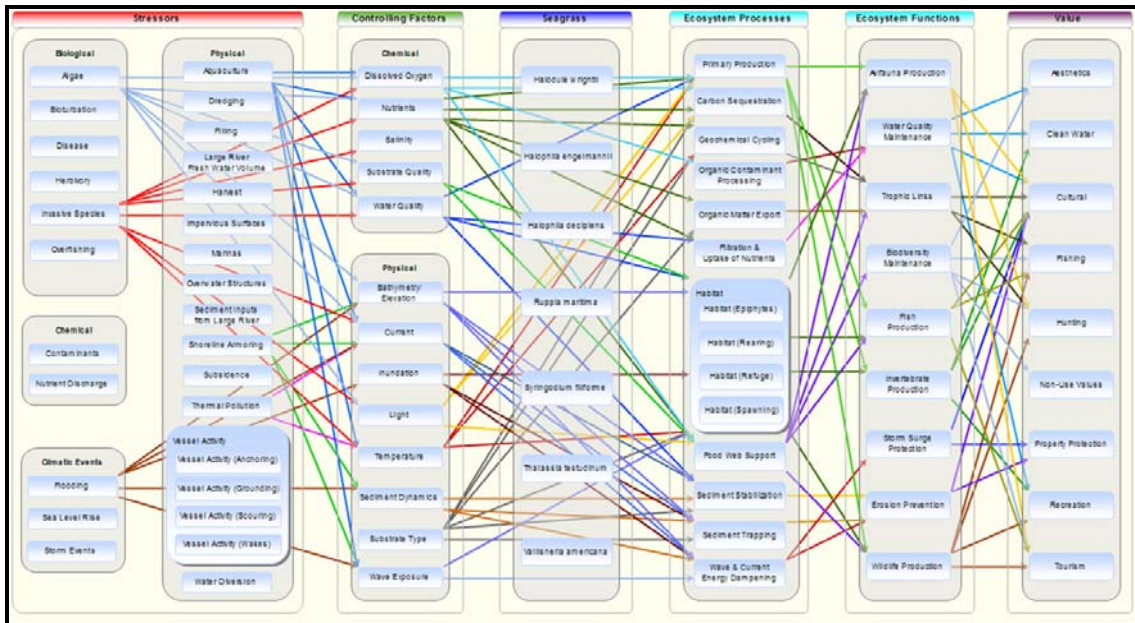
Figure 3. The prototype SAV conceptual model showing interconnections among various components

3.4 Mobile Bay Demonstration Project

3.4.1 Site Selection

Mobile Bay was selected to demonstrate the use of the prioritization tool for several reasons. First, there has been a decrease in SAV in recent decades as a result of urbanization and increased development. Like many regions, there is pressure on coastal

systems of Alabama as well as heavy reliance on coastal resources. Pressures affecting the quality of the regional ecosystem, and thereby could potentially impact SAV include, urban and rural development, point and nonpoint source runoff, shoreline modification, and commercial and recreational fishing. Furthermore, stakeholders were interested in SAV restoration trying to determine cause-effect relationships between observed conditions and SAV success. There was excellent support by the Mobile Bay NEP in conducting this analysis. The Mobile Bay ecosystem has a range of habitat types at a scale that has been measured *in situ* and remotely via satellites. Finally, the ecosystem stressors that impact the health of SAV in Mobile Bay are thought to be representative of stressors seen throughout the Gulf coast. Thus, using Mobile Bay provided an opportunity to demonstrate the extensibility of the model and methodology to areas Gulf wide. Of course, additional stressors can be incorporated depending on data availability.

3.4.2   Technical Approach

The Mobile Bay demonstration project was designed to help end users with decisions relating to current restoration management activities as well as future land use planning of activities that could influence the Mobile Bay ecosystem. Accordingly the technical approach included two basic components:

1. Development of the Restoration Prioritization Toolset to help resource managers identify viable restoration sites based on current environmental conditions, and;
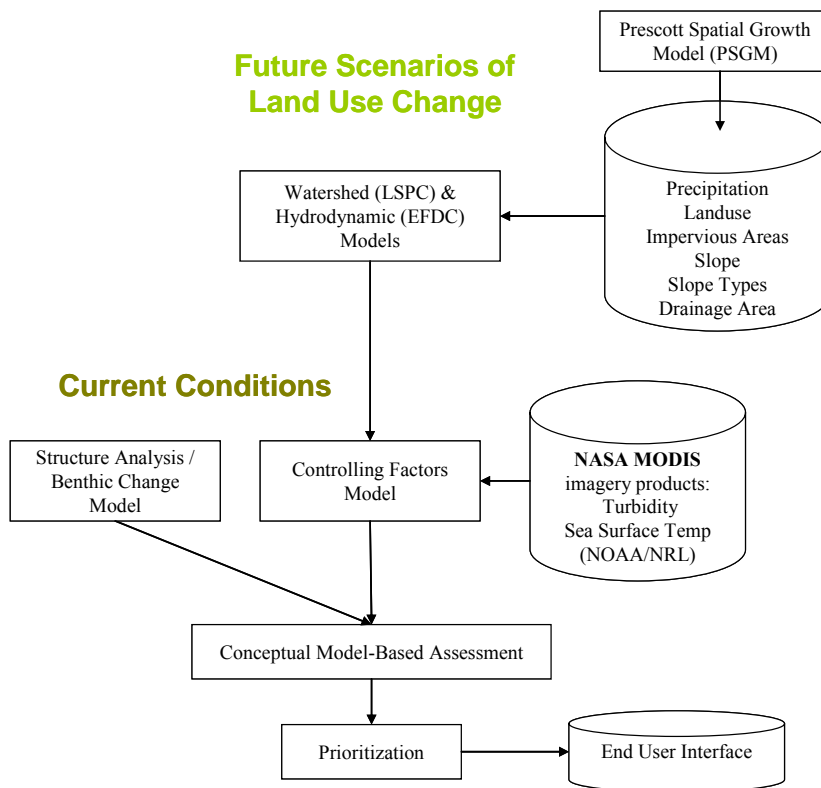
Figure 4. General flow of modeling used for the Mobile Bay demonstration project

2. Development of futuring scenarios to evaluate the potential impact of population growth and changes in stormwater runoff into the nearshore ecosystem.

Current conditions are examined using a suite of tools that include NASA MODIS imagery products and ancillary GIS datasets. Outputs from futuring scenarios feed as inputs into the prioritization toolset. The general flow of the models is shown in Figure 4, and additional details on model components are described in the following section.

3.4.3   Current SAV Conditions Analysis

Based on the conceptual model, the Restoration Prioritization Toolset uses local GIS datasets, bathymetric information, and datasets derived from NASA products to represent and evaluate elements of the conceptual model. This can assist the user in evaluating stressors and controlling factors, and recommend a restoration management strategy based on current and past structure distribution. These GIS modeling techniques use known growth ranges and distribution statistics derived from the model itself to score pre-defined ecological zones based on their suitability for restoration.

The Restoration Prioritization Toolset is comprised of three separate elements:
1. Controlling Factors Model – Uses NASA derived datasets with local datasets to predict areas which are suitable for species' growth.
2. Benthic Change Analysis Tool (or Structure Analysis) – Examines species structure and distribution.
3. Prioritization – Summarizes and weighs importance of stressors to produce final recommended management actions.

Controlling Factors Model

Model Description
The Controlling Factors Model (CF Model) is a spatially explicit GIS model developed as part of GOMRC. Based on the scientific conceptual model for SAV in the Gulf of Mexico, the CF Model evaluates three of the most universally important factors – desiccation, temperature, and available light – that control distribution of seagrasses and other types of SAVs.

Input datasets that represent these factors may be either image products (MODIS) or Environmental Fluid Dynamics Code (EFDC) model outputs. The output of the CF model is a scored grid with values of 0-9, corresponding with the suitability of habitat for SAV. This tool can be run either with a desktop ArcInfo license with Spatial Analyst or through the Web-based CME application.

The CF model is comprised of three sub-models that: 1) calculate light at the depth of SAVs and recodes the imagery in ranges of sufficient light; 2) recode the grid in ranges based on sea surface temperature and known limitations for the species, and; 3) evaluates distribution and recodes the grid based on desiccation potential. These three grids are combined in a weighting subroutine to determine best, suitable, poor, and not suitable habitat for SAV growth based on the model inputs.
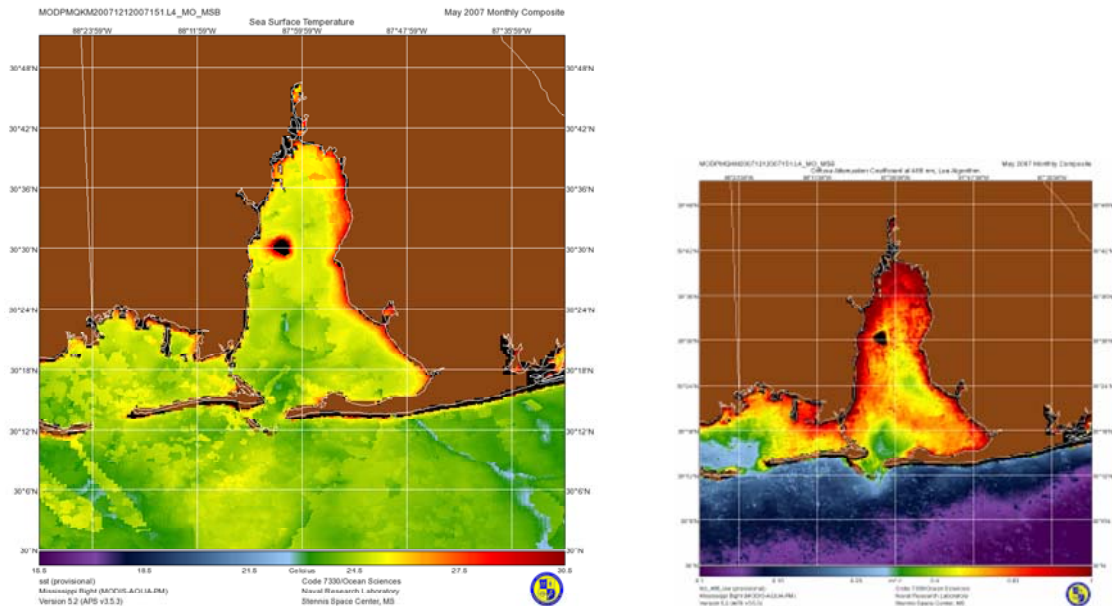
Figure 5. MODIS 250 m resolution imagery for sea surface temperature (SST, left) and light attenuation (right)

Application in Mobile Bay

NASA satellite imagery products developed through the Naval Research Laboratory (NRL) at Stennis under a NASA REASoN project were used as data inputs. These products include MODIS 250 meter resolution products for sea surface temperature and turbidity (K490) for the Mobile Bay region, composited for May 2007. May was chosen as it is a month critical to growth of SAVs (Figure 5). A high spatial resolution salinity product was also provided by NRL and tested as an input the model; however, it was determined that the algorithms required further refinement. As a result, the GoMRC science team relied on static GIS data layers for salinity data. In the future, however, the high resolution salinity data product would be of value to understand the impact of changes in salinity on SAVs, once problems with the algorithms are resolved. Identification of such gaps and needs and illumination of specific data requirements arising from decision needs (including utility as a function of scale, distribution, and data product format) is a key functionality of the scalable model system.

Current distribution of SAV is documented in a GIS layer (Vittor & Associates 2004) and a bathymetric layer from sonar (NOS, 1962) was used and corrected to Mean Sea Level. Results for Mobile Bay for the month of May 2007 are shown in Figure 6.
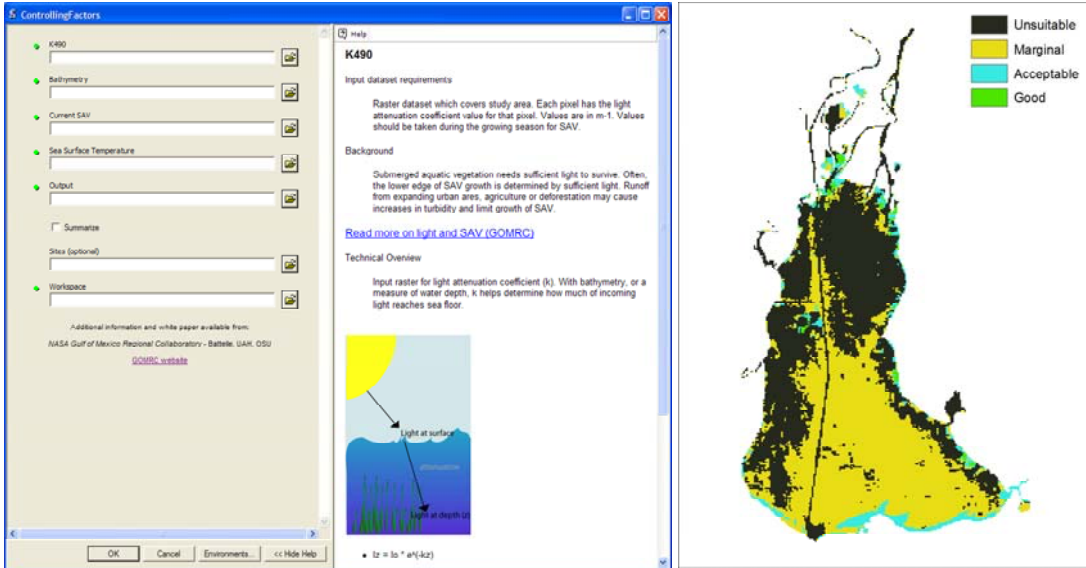
Figure 6. Desktop interface for Controlling Factors Model allows a user to either use pre-distributed data or their own data (left) and sample model output for Mobile Bay for May 2007 (right).

Benthic Change Analysis Tool

Tool Description
The Benthic Change Analysis Tool enables a user to quickly spatially evaluate presence/absence change for SAVs between two time steps. The output of the Benthic Change Tool is a coded grid with four values (Table 1).

Table 1. Benthic change output values. Area per code is summarized per site and a potential management strategy is recommended.

Code	Meaning	Potential Management Strategy
0	Currently present, historically absent	Protect
2	Currently absent, historically absent	Enhance / Create
4	Currently present, historically present	Protect
6	Currently absent, historically present	Restore

Area classified in each category is summarized by site, and evaluated along with the results from the CF Model to determine the best potential management strategy per site. As with the CF Model, this tool may either be run with a desktop ArcInfo license with Spatial Analyst or through the Web-based CME.

Application in Mobile Bay
In ArcGIS, spatial datasets for all past SAV distribution (National Wetlands Inventory (1992), Aerial photo interpretation 1950s -1970s)) were joined together for a consolidated coverage of areas where SAVs have historically occurred. This was used as the data input for historical distribution. Shapefiles for current distribution was acquired from Mobile Bay's NEP (Vittor and Associates 2004). Results were summarized based on sites, helping identify the management strategy appropriate for the site (Figure 7).

Figure 7. Appropriate SAV management strategies by site

Prioritization

Description
In this final step, the level of anthropogenic stress (local GIS dataset input) and the salinity (NOS –Biogeography Program, 2000) per site are evaluated. The level of stress is calculated based on the extent to which a stressor is present at a site, and given a rank (1-5) based on the level of stressor relative to other sites (Table 2). A user may weight stressors according to their relative level importance. These weights are multiplied by their rank, and all scores are added together for a final stressor score per site. This final element, prioritization, is only available through the CME.

Table 2. Stressor datasets (summarized based on geometry)

Input Stressor Dataset Type	Function	Output	Example
Line	For each polygon % total shoreline covered by linear feature will be recorded.	New attribute in Sites shapefile with calculations. Additional attribute will be added with ranking (1-5) or 0 if not present, in relation to other sites.	A user wants to know how much of a unit's shoreline is covered by armoring.
Point	For each polygon in Sites dataset, tool will calculate: Number of data points present standardized to number of points per 1000 ft / m.		A user summarizes how many boat launches there are per unit of interest and standardizes that number so that they may compare between units.
Polygon	For each polygon in Sites dataset, % of total area in unit covered by new polygon feature is recorded.		A user has a units shapefile and uses another shapefile of landslide occurrences to record for each unit the area of landslide.

From prior studies, it is known that the SAV species that occur in Mobile Bay have similar requirements and limitations for light, temperature, and desiccation. However, this is not the case for salinity. A salinity level that stresses one type of SAV is ideal for another. For example, the freshwater SAV, *Vallisneria americana*, does not do well in brackish waters, but *Ruppia maritima* does. Salinity values per site are compared with a species' known growth range. The site will be classified in one of the four following categories based on the highest and lowest values present in the dataset:

Salinity Category	High value (psu)	Low value (psu)
Seagrass	>24	>14
Freshwater SAV	< 6	—
Oligiohaline Ruppia	6-15	—
Ruppia & Halodule possible, outside optimal range	16-24	< 14

Application in Mobile Bay
In Mobile Bay, the project team chose to evaluate several stressors present in the system, including shoreline armoring, presence of aquatic invasive species, dredge disposal sites, dredge channels, and overwater structures. GIS datasets were acquired or developed to represent these stressors, and stressors were equally weighted.

Results can be seen in Figure 8. A resource manager can evaluate the best action for each site, as well as identify an appropriate species based on the salinity regime. For example, on the western side of Mobile Bay, many sites may have had SAV presence in the past, but currently have low controlling factors (i.e., desiccation, temperature, and available light). This area probably would not be appropriate to restore SAVs without first evaluating how the factors controlling distribution could be made more suitable for SAVs. On the other hand, near the Mobile-Tensaw delta, some sites with current SAV population have high stress. A resource manager would want to see how they could reduce stress in those sites, before additional loss is seen. If restoration of SAVs is the goal, a resource manager might be interested in sites with high controlling factors and low stress, with a salinity regime appropriate for the species of interest.
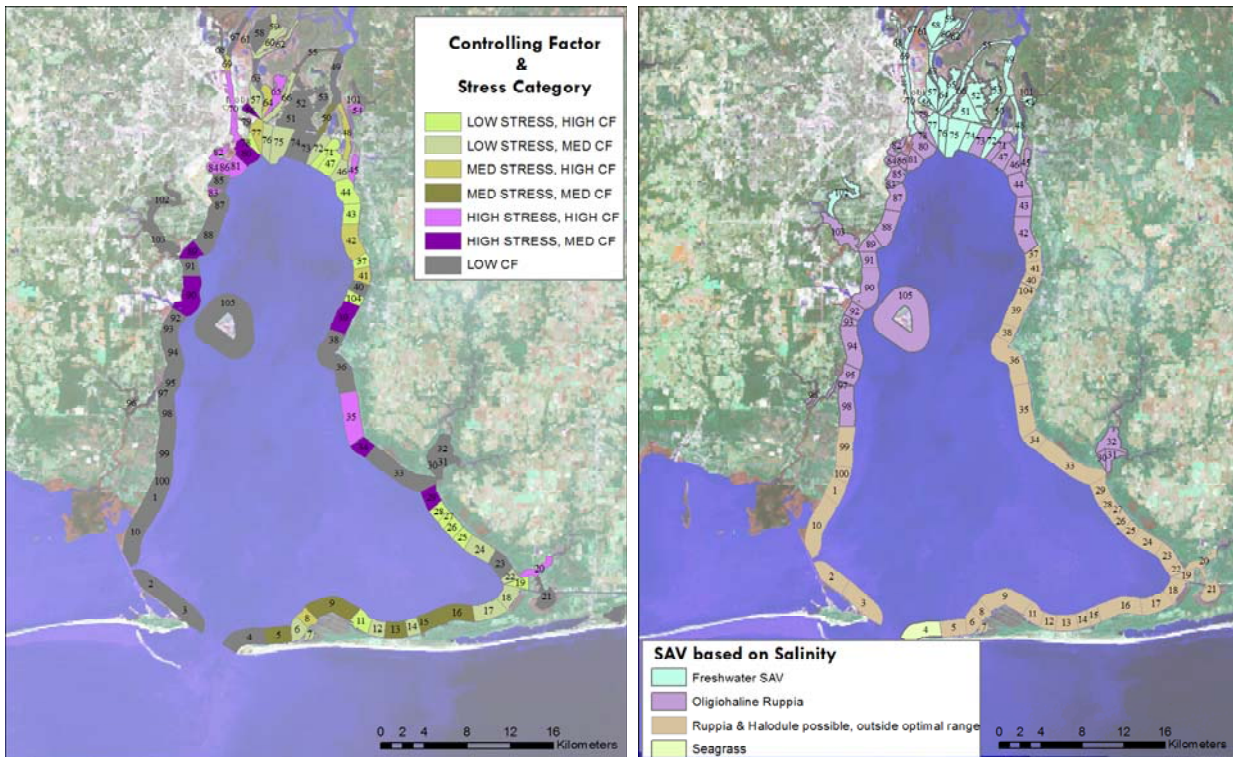
Figure 8. Results for prioritization in Mobile Bay. Controlling factors and stress level shown on left, and appropriate SAV species based on salinity shown on right.

Areas to the north often are suitable for freshwater SAV and have SAV present currently. High and medium levels of stress could threaten the current SAV population. Areas towards the middle of the bay may have high controlling factors and low stress, but the salinity level is not ideal for SAV habitat.

3.4.4   Historic and Future Land Use/Land Cover Change Analysis

Changes in land use and development within coastal watersheds are recognized by the scientific community as having a significant impact on SAV health, but have not been well studied. One of the major concerns is how changes in runoff quantity and quality may affect nearshore habitats, such as SAV. Urban development, runoff from agricultural

fields, and timber harvest have been identified as major contributing factors to increases in turbidity (Baynyat et al. 1999, Duarte 2002).

Spatial growth, watershed and hydrodynamic models were used to analyze the impacts of land use change around Mobile Bay on the factors controlling SAV distribution within the bay. Three specific models were used to examine conditions in four timesteps: 1943, 1992, 2001 and 2030.

1. <u>Prescott Spatial Growth Model</u> – Used to predict land use, population, and land cover change for future and past scenarios.
2. <u>LSPC Hydrologic Model</u> – Used the newly predicted land cover and predicted growth-related runoff and flow in stream systems entering Mobile Bay.
3. <u>EFDC Hydrodynamic Model</u> – Used the newly predicted runoff and flow as inputs to a hydrodynamic model to evaluate changes in temperature and salinity throughout Mobile Bay.

The newly derived outputs for temperature and salinity were used as inputs to the CF Model to evaluate potential changes in habitat for each timestep.

<u>Spatial Growth Modeling</u>

Model Description
The Prescott Spatial Growth Model (PSGM), developed at Prescott College (Arizona) in collaboration with NASA, allows users to build a variety of future growth scenarios based on current policy and development decisions. The PSGM is a dynamic process model that may be constructed as a set of "nested" models, applied to a variety of geographic scales and run at multiple grid scales depending on output requirements. The development of a set of growth rules provides the basis for allocating new types of development and to specify land not to be developed. Each rule is assigned a priority weight in relation to the other rules to reflect the assumptions of the scenario being developed. The model reflects the complex aggregation of these rules. These rules can be developed as a separate set for each type of land use being assessed in the model. The various rule sets are then run consecutively in a comprehensive model simulation, letting each rule set allocate land based on available area and priority. In the scenario, once land is used up by one type of development, it becomes unavailable to any other land use type (Estes et al. 2006).

Application in Mobile Bay
Landsat derived National Land Cover Data (NLCD) for Mobile and Baldwin Counties in 1992 and 2001 was used to determine recent historical trends and to serve as baseline land use input data and rate of growth for the spatial growth model. These rates of growth were applied to future scenarios. In addition, historical records from the U.S. Census Bureau and U.S. Department of Agriculture (USDA) Forest Service were used to determine past land use.

The 1948 land use classification was developed from a historical map, which included four classes that match the NLCD classification developed for this project. The classes

are timber, crop, pasture, and urban. Since no wetland classes were present even though wetland classes were know to exist in 1948, the modeling runs were normalized for wetlands by assuming that 1992 wetland classes and extent existed in 1948.

The output from the PSGM is a land use scenario for the 16 classes in the 2001 NLCD baseline for the Mobile Bay watershed study area. The modeling predicts growth in both Mobile and Baldwin Counties with conversion and fragmentation of forest land near Mobile and heavy development along the eastern and southern coastlines (Figure 9). In addition to changes in runoff and water quality, nearshore development is also associated with a suite of coastal stressors, like boating, overwater structures, and shoreline armoring. Predicted land cover for each of the four timesteps served as an input to the watershed modeling to evaluate exactly how runoff and would change.

1992   2030
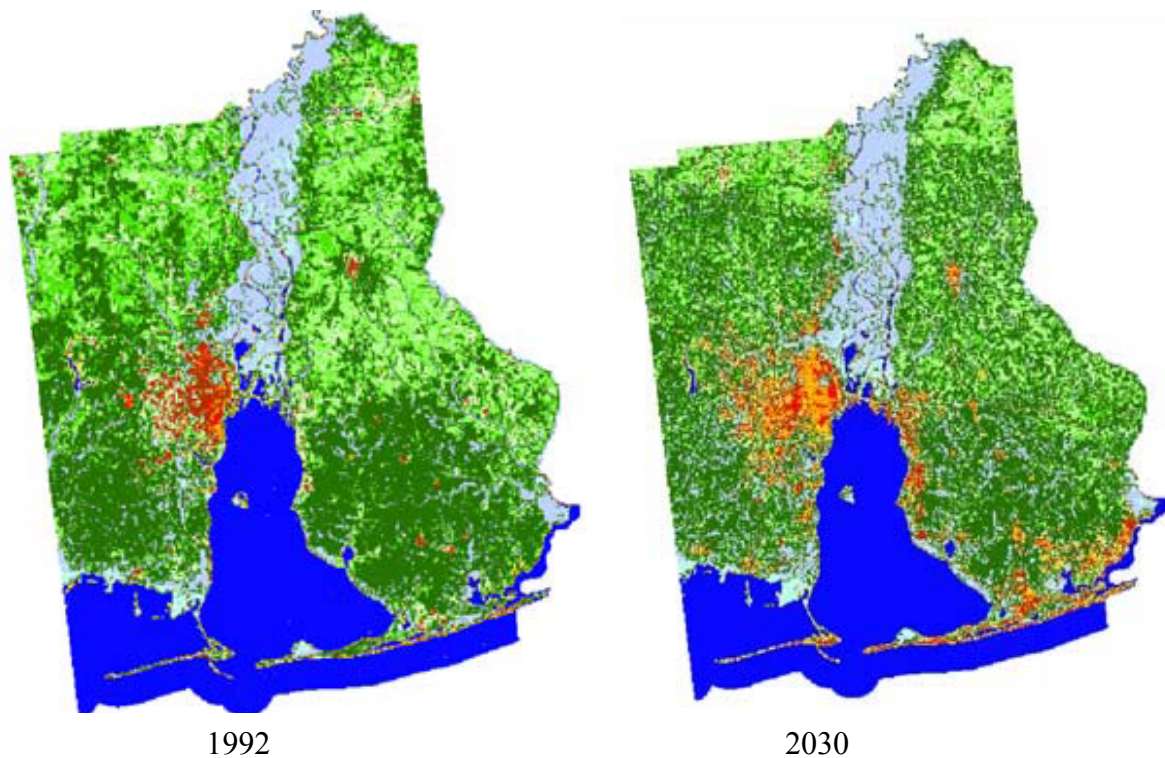
Figure 9. Land use for 1992 and 2030 in Mobile and Baldwin Counties, Alabama

It should also be noted that the 1992 and 2001 NLCD products had similar but not exact land use categories. A remapping of the 1992 and 2001 NLCD classes to a common classification scheme was necessary for comparison of the 1992 to 2001 periods and future or historical land use projections. The 1992 NLCD classification did not include a land use class for shrub/scrub as did the 2001 NLCD classes. The 2001 NLCD classification did not include Quarries/Strip Mine/Gravel Pit and Urban Recreational Grass classes that are part of the 1992 NLCD classification. Definitions for residential and commercial classes also did not match as well as desired. The following remapping was done to resolve these issues:

1992 Urban Recreational and Low Intensity Residential	=	2001 Developed Open Space
1992 High Density Residential	=	2001 Developed Low Intensity
1992 Commercial / Industrial / Transportation	=	2001 Developed Medium and Developed High Intensity
1992 Quarries / Strip Mine / Gravel Pit, Urban Recreational Grass, and Bare Rock	=	2001 Barren Land
1992 Mixed Forest	=	2001 Mixed Forest and Shrub/Scrub

Watershed Hydrologic Modeling

Model Description

The Loading Simulation Program in C++ (LSPC) is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream transport model. The model uses a Microsoft Access database to manage model data including land use scenarios and weather text files for driving the simulation. LSPC has been widely used for mining applications and to compute Total Maximum Daily Loads (TMDLs). LSPC was designed to handle very large-scale watershed modeling applications. For each model run, it automatically generates comprehensive text-file output by sub-watershed for all land-layers, reaches, and simulated modules, which can be expressed on hourly or daily intervals. Output from LSPC has been linked to other model applications, including the EFDC hydrodynamic model proposed for this project (ERD, 2007).

Application in Mobile Bay

The land use scenarios were developed in 1992, 2001, and 2030 using the PSGM for input into the LSPC to evaluate impacts of flows into Mobile Bay. The State of Alabama map archive provided data on land use coverage from 1948. Weather conditions for four years (2003-2006) were applied to each of the land use / land cover (LULC) scenarios. Model results showed an increase in flows at five key discharge points (Figure 10) with the greatest changes at Dog River and D'Olive Bay of about 7 cubic meters per second

Figure 10. Hydrodynamic discharge points in Mobile Bay

(CMS). Overall results to date indicate that LULC change to a more urban environment, with greater impervious surface cover, increases freshwater flows into Mobile Bay, as shown in the example from Dog River (Figure 11).
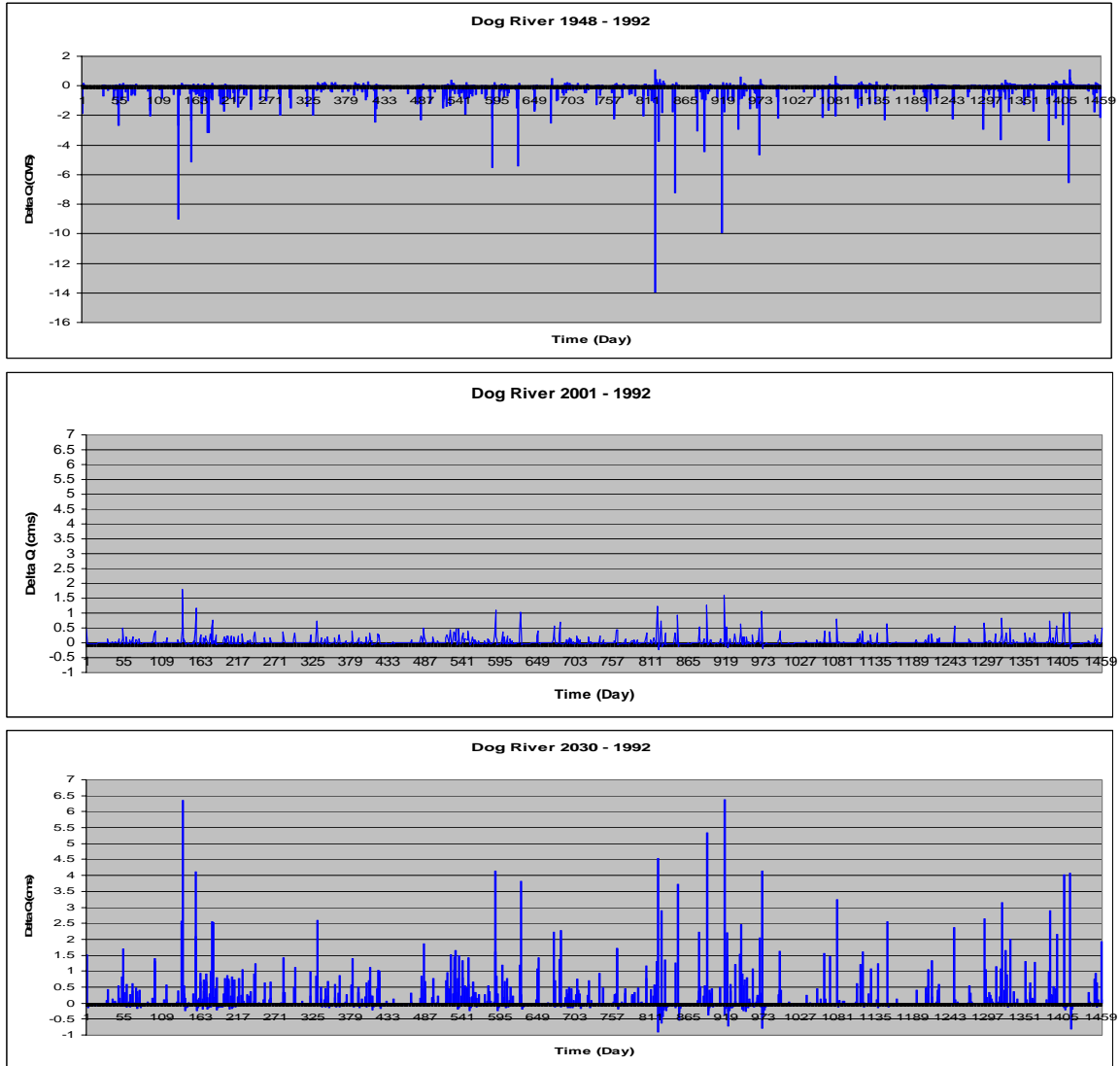
Figure 11. Comparison of flow changes at Dog River discharge point for three time periods. Results show discharge rates were lower on most days for 1948 land use conditions compared to 1992 conditions (top). Higher flow rates were seen on nearly every day with 2001 land use conditions compared to 1992 (middle) and even greater flow rates are projected with 2030 land use conditions compared to 1992 (bottom).

Hydrodynamic Modeling

Model Description

Output from the LSPC model – specifically flow changes – are used as input to the EFDC, a state-of-the-art hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions. It has evolved over the past two decades to become one of the most widely used and technically defensible hydrodynamic models in the world (Ecosystems Research Division, 2007).

Application in Mobile Bay

The EFDC was used to generate salinity and temperature outputs on a 1-2 km grid throughout Mobile Bay for different LULC change scenarios. The EFDC water flow

inputs at discharge points around the bay come from the LSPC watershed model outputs, which depend primarily on weather (i.e. precipitation and temperature) and LULC data. The salinity and temperature data were outputted from the EFDC for four vertical layers for each 1-2 km grid cell throughout the bay.

The results from the demonstration project, which has focused only on the LULC change in Mobile Bay neighboring watersheds in Mobile and Baldwin Counties, Alabama, have shown that the changes in LULC between 1948 and 1992, between 1992 and 2001, and between 1992 and 2030, for a fixed weather dataset, caused statistically significant changes in temperature (see Table 3) and salinity (see Figure 12) throughout the Mobile Bay grid. The changes in salinity and temperature between 1948 and 1992 were the highest among the three land cover simulations, and the changes in salinity and temperature between 1992 and 2030 were higher than those between 1992 and 2001.

Table 3. Comparison of surface temperature differences in Mobile Bay for different timesteps	
Timestep	**Temperature Differences**
2030 – 1992	0 – 4 C
2001 – 1992	0 – 1 C
1948 – 1992	+/- 0 – 7 C

2030 - 1992
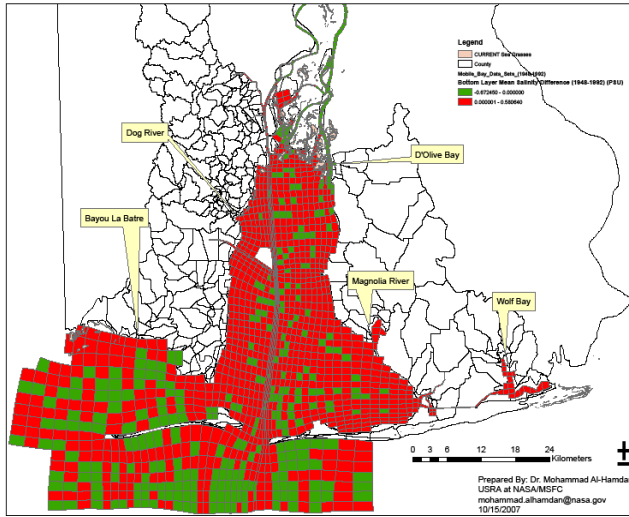
2001 - 1992
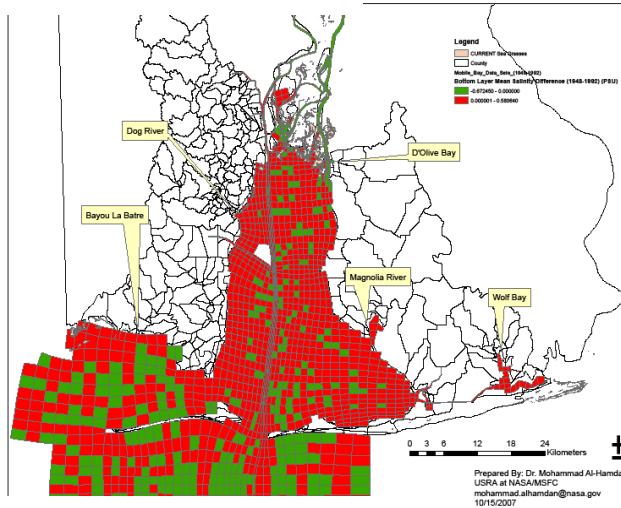
1948 – 1992
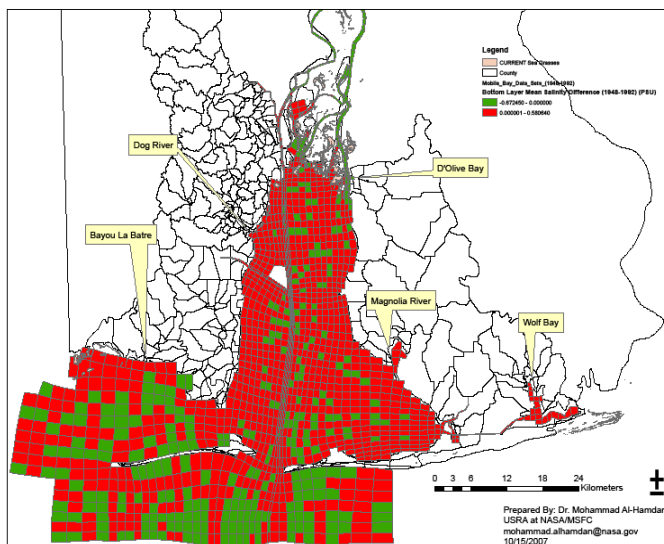
Figure 12. Salinity difference between 1992 and 2030 (top) 1992 and 2001 (middle) and 1948 and 1992 (bottom) in Mobile Bay. Green grids show a reduction in salinity, as observed at key discharge points, whereas other changes are static or show very small increases in salinity as indicated by red grids.

3.4.5 Potential Impact of LULC Change on SAV Habitat

Potential change in SAV habitat for each time step
Known species growth and habitat ranges (Table 4) were used to map potential species distribution for each of the four model time steps. Monthly averages and extremes for May of each year were used for input (1948, 1992, 2001, and 2030). Light was held constant, using the MODIS K490 product, within the CF Model. The newly created habitat was evaluated for each species and compared with current SAV distribution.

Model results suggest that changes in land use cause small, but statistically significant changes in salinity and temperature, but changes seen at this scale of analysis would not directly affect most SAVs (Figure 13). However, some areas would be affected. Dog River on the western shore and Little Point Clear on the southern shore show loss of potential SAV habitat from 1948 to 1992. This is consistent with the historical loss of SAV in theses areas. While larger potential changes are seen, they are often limited to the dredge channel, smaller inlets, and entrance to the bay, areas where SAVs are not currently present.

Table 4. Physical and chemical properties used to identify habitat suitable for individual species					
Species	**Temperature Maximum(°C)**	**Temperature Average (°C)**	**Salinity Max (psu)**	**Salinity Average (psu)**	**Salinity Minimum (psu)**
Metric used	Maximum temperature for 1st subsurface layer	Mean temperature for 1st subsurface layer from 3-5 PM	Maximum of all layer maximums	Average of all layers	Average – 2 standard deviations of mean
Halodule wrightii	< = 35	20 -30	<44	>= 20 & <= 35	> 5
Vallisneria americana			< 10	<5	0
Ruppia maritima			<32	<15	>5
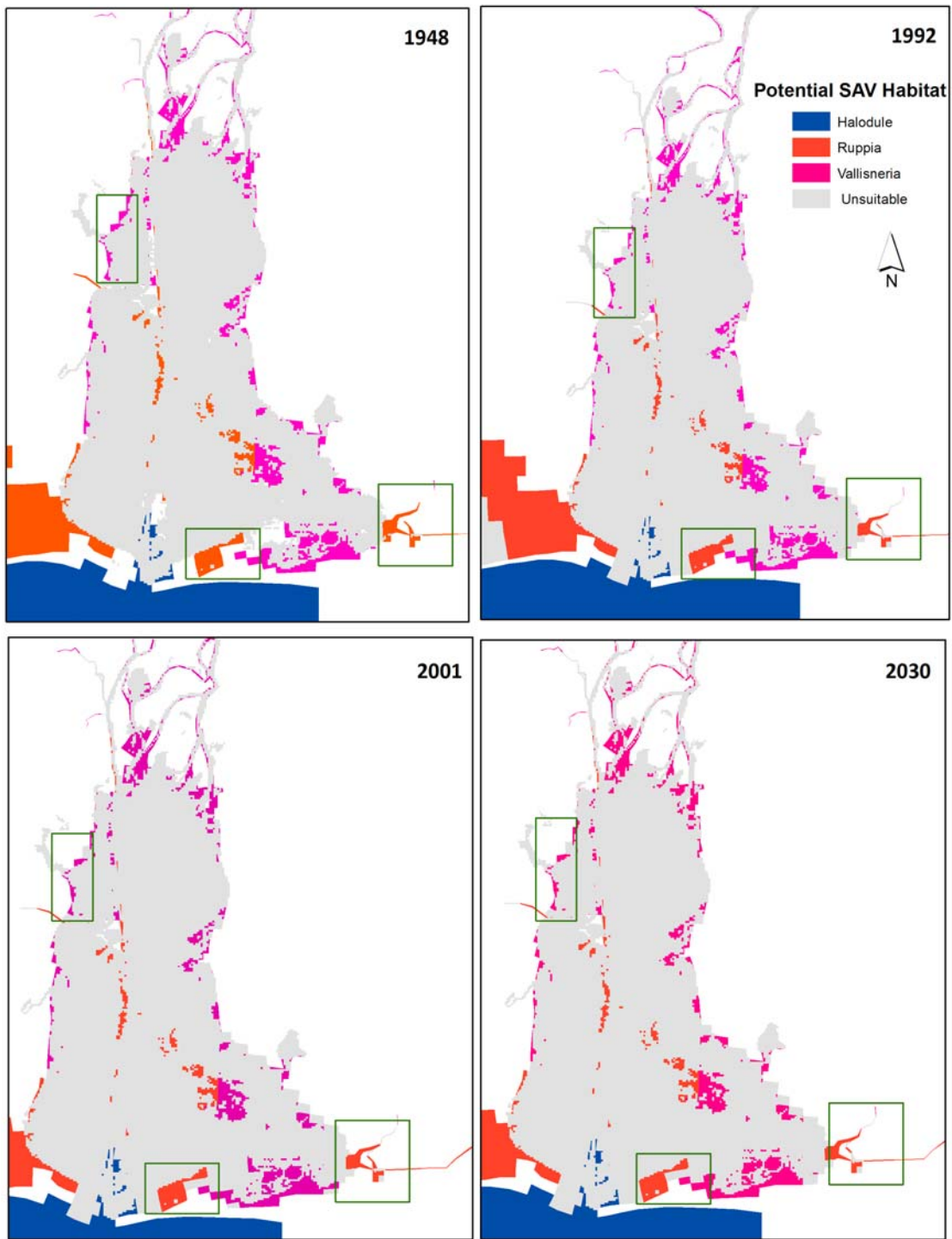
Figure 13. Potential SAV habitat based on different land use scenarios. Minor changes in habitat are observed, primarily between 1948 and 1992, however most areas exhibit little change.

Examining edge areas
Using the Benthic Change Analysis Tool in ArcInfo 9.2 (Judd et al. 2007), GIS shapefiles representing current and past SAV cover (Vittor and Associates 2004, 2005) were spatially analyzed to identify areas with actual SAV bed loss. The slope of the bottom layer of salinity was calculated to highlight areas of rapid change over a short spatial distance. Slope values were extracted for those areas with stable SAV populations and those with change to evaluate how horizontal salinity gradients may spatially co-occur with loss (Figure 14). While missing SAVs tended to occur in areas with a higher salinity slope (mean = 3.6%, SD = 5)
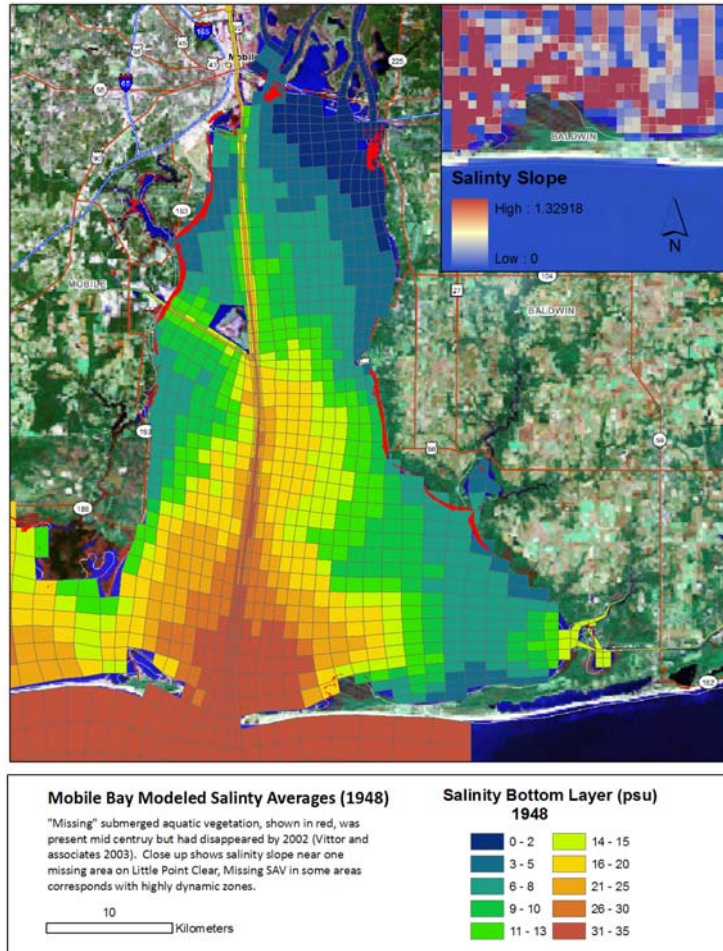
Figure 14. Modeled Salinity, May 1948
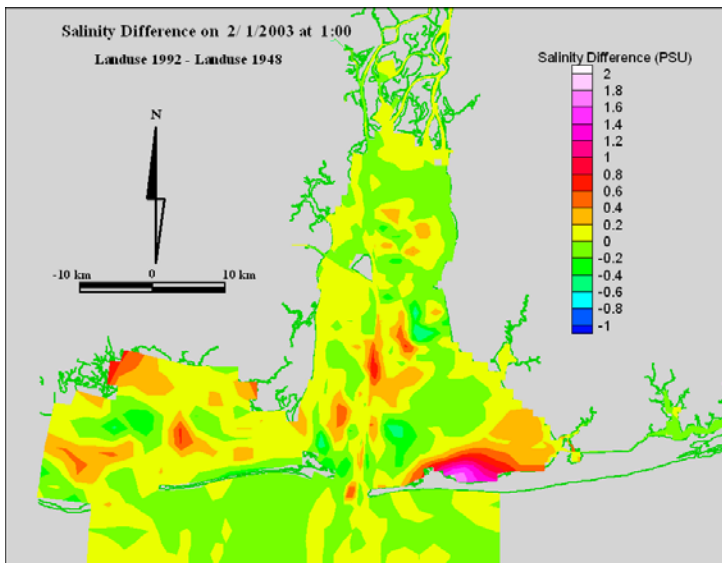
Figure 15. Salinity, February 1948. Examination of other time periods showed higher differences in areas of SAV loss. In this timestep, for example, high salinity differences are evident near Little Point Clear.

than did stable populations (mean = 2.7%, SD =4.9), statistically there is little difference between the two. Examination of data in non-peak growth times showed greater variance (Figure 15). It is likely that loss of edge areas or conversion of one habitat type to another is only one reason among many for SAV loss. It is possible that the greatest impact of land use change could potentially be on these highly dynamic edge areas though further research would be necessary to evaluate this theory.

3.4.6 Planning for the Future: Integration of Future with Current Scenarios

Land use changes are increasing freshwater flows into Mobile Bay, and these increasing freshwater flows are causing statistically significant increases in temperature and salinity fluctuations. While further research needs to be done to project the exact effect that land use change will have on the factors controlling SAV distribution in Mobile Bay, results from this preliminary analysis suggest that using cascading models to link upland activities with off-shore ecosystem conditions can provide useful insights to local and regional planners and resource managers.

In many ecological systems, change often affects edge areas first. This analysis of projected changes in land use in Mobile Bay did show changes in the conditions that influence SAV distribution in these edge areas. The implications for coastal managers are that they may want to select a more stable site for restoration over one located on the edge of the potential habitat range.

Future research should focus on expanding the modeling to include the entire Mobile Bay watershed and system dynamics, such as the causeway, will create a more robust analysis. Also, as turbidity is one of the foremost driving factors in SAV distribution in many areas, future work should be expanded to include turbidity as an element of analysis. Finally, in this preliminary analysis, precipitation and sea level were held constant throughout the years, using precipitation records from 2001. As elements such as light are analyzed, it is also necessary to evaluate how these elements may change in the future, whether from precipitation events or rising sea level.

Future work should also consider how such changes in salinity, temperature and other controlling factors will impact other components of the aquatic habitat of the bay. Hypoxic events in Mobile Bay, for example, are directly linked with vertical salinity gradients (May 1973, Park et al. 2007). These events, caused by low oxygen levels, can cause fish and shellfish loss. Model results show changes in vertical salinity gradients associated with land use change, but further research at a finer timescale and would be necessary to evaluate potential effects on other systems.

3.5   Meta-analysis

3.5.1   Background & Purpose

As discussed in the previous section, the GoMRC science team developed a Restoration Prioritization Toolset based on a conceptual model for SAV habitat, and applied it in Mobile Bay, Alabama. In addition, modeling was used to examine what impact future development in Mobile Bay may have on two factors considered important factors to SAV health: salinity and temperature. The purpose of the meta-analysis is to demonstrate how aspects of the SAV analysis methodology could be applied to other areas in the Gulf of Mexico, as there are common threads of anthropogenic and natural stresses and decline in habitat quality for seagrasses throughout the Gulf. It examines the relationship between

coastal land use trends and seagrass extent over the last decade in several Gulf of Mexico estuaries, using both spatial datasets and non-spatial historical records.

3.5.2 Technical Approach

Five estuaries and bays were selected (Figure 16) for the analysis based on presence of SAV at least historically along with information on LULC. The five sites included:

- Mobile Bay, AL
- Tampa Bay, FL
- Charlotte Harbor, FL
- Perdido Bay, AL & FL
- Galveston Bay, TX

SAV datasets from the NWI and various local agencies were compared with Landsat-derived NLCD from 1992 and 2001. Land use change was calculated by Hydrologic Unit Code (HUC) boundaries to quantify area and percent change for primary land use

Figure 16. Five bays selected for meta-analysis

classes and impervious surface change. Seagrass change and land cover change were correlated both on the individual Level 6 HUCs and for the overall watershed. For a long-term picture, county-level data for each watershed were collected from the U.S. Census Bureau and the USDA Forest Service documenting changes in farmland, urban, and forest acreages since the early 1900s. These figures were then compared to trends in seagrass coverage, taken from existing spatial datasets, prior studies, and historical navigation charts.

3.5.3 Results of Meta-Analysis

Recent Trends
County level data was acquired for counties which fell into watersheds adjacent to the study areas. Several consistent trends were seen historically throughout all of the coastal watersheds examined.

- All watersheds had extensive forest harvest and loss of overall forested land between the late 1930s and 1970s
- Farming increased with a peak during the 1950s, which slowly decreased throughout the 1980s and 90s (Figure 17).
- There was an increase in population and housing units, with higher rates of increase from the 1970s to present (Figure 18).

Farmland in Gulf Coast Watersheds
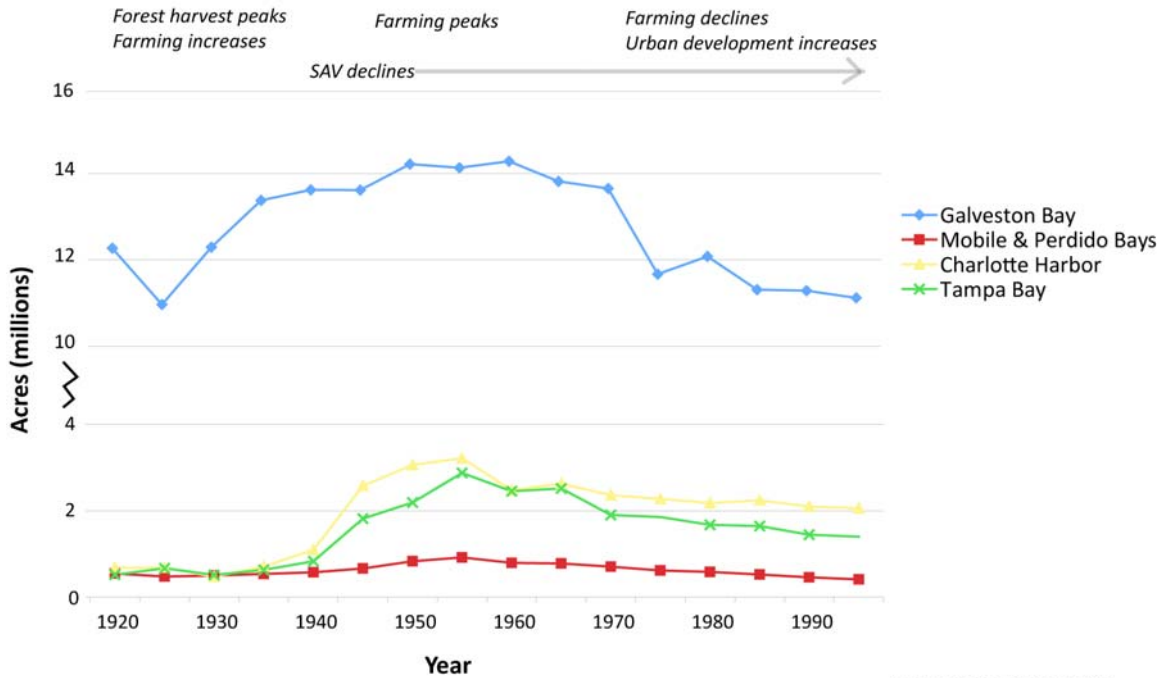
Figure 17. Change in farmland area along Gulf coast watersheds. Farmland increased as SAV populations declined.

Each bay showed clear declines in seagrass coverage throughout the 1900s, with the exception of Tampa Bay, which gained some acreage in the early 1990s. The most dramatic loss of seagrass coverage in many of the bays and estuaries within the Gulf occurred between 1940 and the early 1980s. This was accompanied by a loss of forest and wetlands to agriculture and urbanization.

Figure 18. Total housing units per watershed

Though correlations between development and loss of aquatic habitat can be examined through qualitative relationships, with recent aerial and satellite imagery products the relationship between development and habitat loss could be quantitatively evaluated.

Impervious surface increased in all watersheds from 1992 to 2001, with increases ranging from .3% to 7.2% over the ten-year period. At the same time, SAV decreased in distribution in most sub-basins, the exception being Tampa Bay and some areas of Charlotte Harbor. Dataset consistency was an issue in Galveston Bay with different mapping methodologies in the two years analyzed therefore it was left out of the analysis. Documented areas of SAV loss often occurred either within tributaries to the main bay (Figure 19).
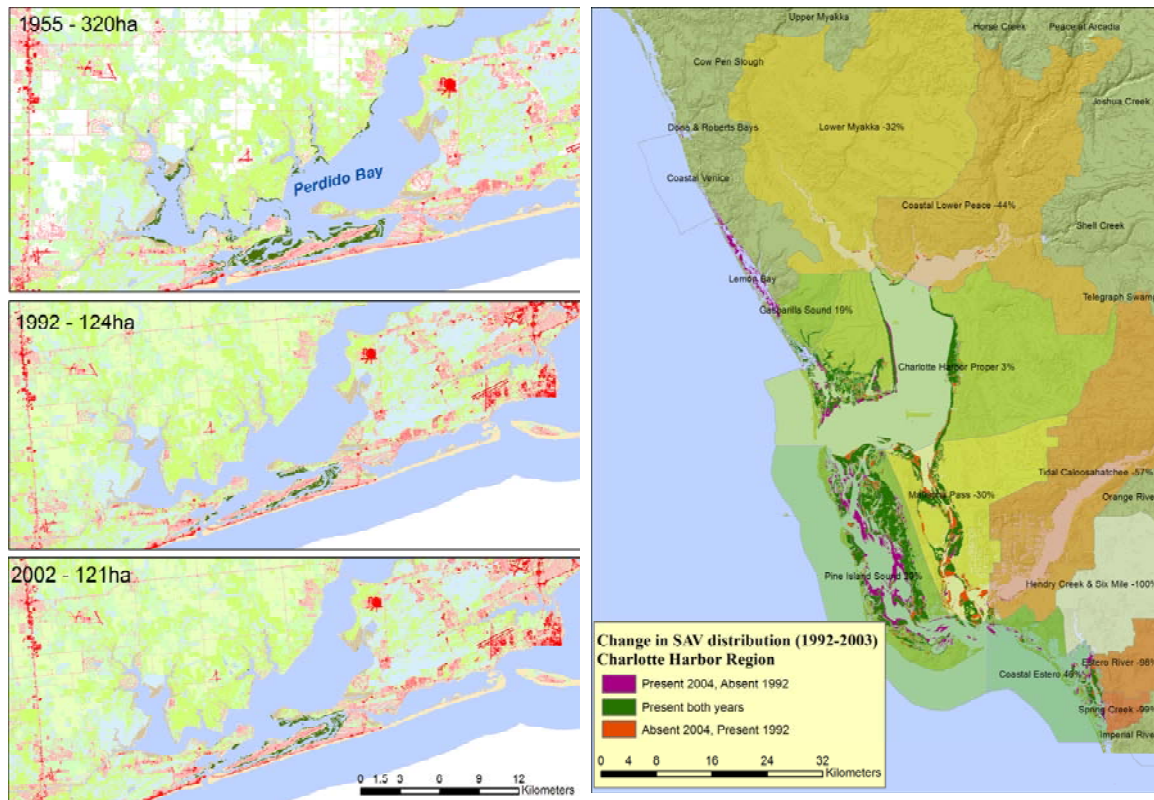
Figure 19. Perdido Bay (left) and Charlotte Harbor (right). SAV mapped from historical airphotos shows a decline in SAV from 1955 to 1992 along many of the tributaries which lead into Perdido Bay. From 1992 to 2003, Charlotte Harbor showed a similar loss trend. The highest rate of loss includes the Lower Myakka and Coastal Lower Peace, two tributaries which enter Charlotte Harbor. Though Hendry Creek & Six Mile show a higher percentage, this was originally a small population and could be due to differences in mapping methods rather than a true loss in SAV beds.

Increases in impervious surface are negatively correlated with SAVs, though the strength of relationship differs in different estuaries as does the relationship itself (Figure 20).

Results
It is likely that the major source of stress for SAVs from land use shifted from runoff in locations subject to timber harvest, to runoff from agricultural lands (and the associated, nutrient-rich runoff), to heavy development (with increased impervious surfaces and urban runoff) in the mid 1900s. These land use changes likely resulted in increased

turbidity in estuarine waters, which may have contributed to the dramatic losses witnessed throughout the Gulf of Mexico between 1940 and the early 1980s.

However, land use change was not the only source of stress within the 1900s. Dredging of the Gulf Intracoastal Waterway (1940-1960) is also recorded as a major cause of seagrass loss (Handley et al. 2007). The waterway is a good example of how land conversions can create sources of direct seagrass disturbance. Coastal development often results in more recreational boating (propeller-scarring), an increase in the construction of docks and armoring, as well as the need for structures like bridges and causeways; all of which harm seagrasses.

Change in SAV vs Impervious Surface (1992-2001)
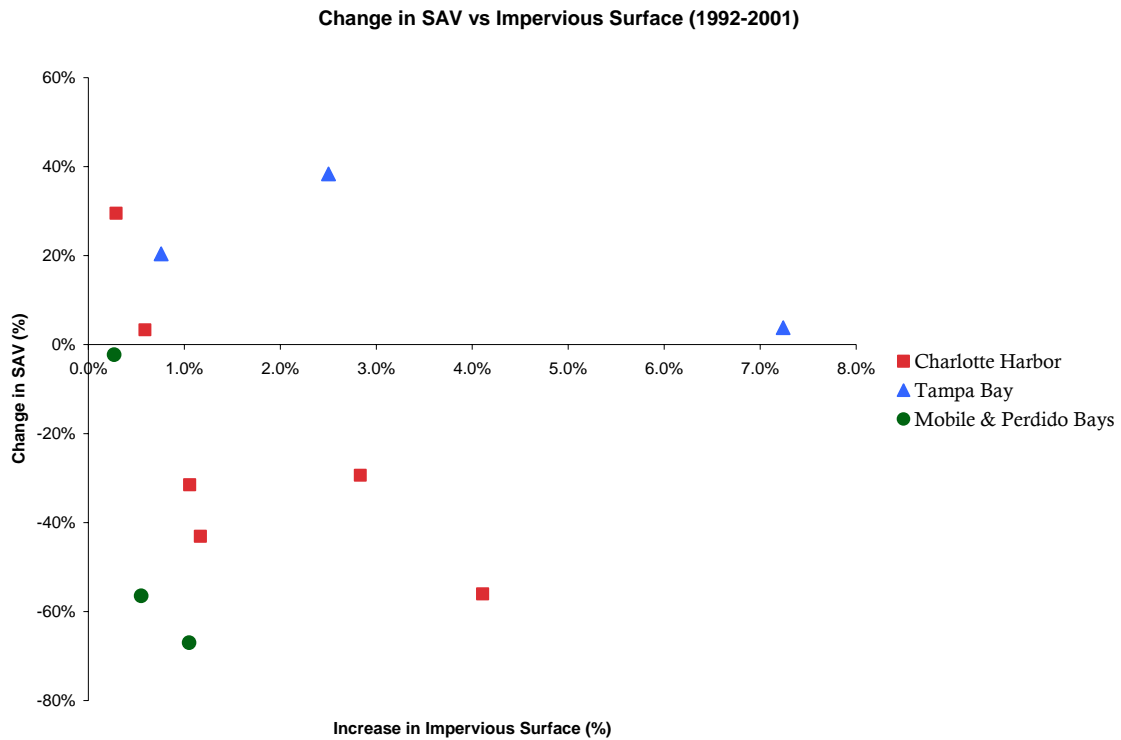
Figure 20. Increase in impervious surface and change in SAV. Though relationships are different in each bay or water body, there is a negative correlation between increase in impervious surface and change in SAV.

Overall, possible factors contributing to seagrass loss overlap greatly. However, there is a correlation between high levels of land use change and seagrass declines historically. Whether it is the immediate effects of these land conversions or the associated human activities that cause the most damage, land use changes must be managed to avoid future destruction of seagrass habitats.

These potential associations between general SAV loss and impervious surface change suggest that GoMRC's method of cascading models of growth, hydrology and SAV ecosystem stressors may be useful to identify viable sub-regions where marginal improvements to water quality may enable SAV restoration.

3.6   Harmful Algal Blooms

While the focus of GoMRC in year one was on the development of an SAV restoration application, preliminary activities were initiated on a second application, *harmful algal blooms (HABs)*. In recent decades there has been an increasing trend of HAB outbreaks in the Gulf of Mexico affecting both the United States and Mexico that could be better addressed through an integrated bi-national approach. A number of stakeholders are engaged in a number of ongoing activities related to HABs in the Gulf of Mexico. Like SAV restoration, HABs were identified as a priority management issue by the GOMA Federal Working Group. The principals (EPA and NOAA) of the Gulf of Mexico Component of the Presidents Ocean Action Plan have selected bi-national engagement with the HABs problem as the initial target for initializing a long term bi-national GoM sustainable management program. NOAA operates the HABs Forecasting System in the Gulf of Mexico. In addition, significant work to integrate field observations and remote sensing has been conducted through the HABSOS at the National Coastal Data Development Center with a primary demonstration activity in Florida and immediate plans for extension to Texas. GoMRC's outreach to Mexican collaborators in the Southern Gulf created an opportunity to concomitantly support expansion of the HABs program.

GoMRC focused on areas identified as value-added to these existing activities: 1) supporting the establishment of a bi-national HABs monitoring by providing a Gulf-wide decision support platform and, 2) developing a semantic search tool based on a ecological conceptual model for Gulf of Mexico HABs.

In support of a bi-national monitoring capability, GOMA is in the process of deploying a set of HAB sensor stations/buoys off the coast of Veracruz. GoMRC has provided organizational support to this effort by working with the bi-national red tide working group to establish a Veracruz-based center where data from these in situ platforms will be integrated with HABs data products and methods developed in the Northern Gulf. Specifically, GoMRC is working with this group to set up a SERVIR-GoMRC operating center at a local institution, which will provide the IT platform for the sensor data and opportunities to integrate the data with the broader HABSOS decision support system. (Please see further discussion of SERVIR in Section 4.7 below.) NASA seed funding provided through this project is being used to conduct an initial training session on user of the SERVIR-GoMRC platform. This initial training will operationalize the Veracruz bi-national node, bringing together a team to master the SERVIR toolset and understand the relationship of the SERVIR data and toolsets to HABs and other problems. Training will introduce the Veracruz team to the GoMRC collaborative environment and its analytical and decision support features and begin developing the capacity of the Veracruz team to define and collaborate on addressing other problems, such as coastal wetlands restoration and management, in an operating environment that is specifically designed to support resource assessment and management up to sub-regional and regional Gulf of Mexico scales.

The second focus has been on the development of a semantic search function for Gulf of Mexico HAB-related topics using an ontology-driven search engine (NOESIS, see Section 4.2 for a description), which allows users to query resources such as web pages, data, and publications. The search engine is based on based on a preliminary conceptual model that is focused on HAB events in the Gulf of Mexico, and understanding ways to manage and mitigate for blooms. This activity begins to address how the ecology of HABs are linked to larger ecosystem processes and allows exploration of hypotheses regarding triggers, mitigation and management of these blooms. Using the preliminary conceptual model, the components included in the search capabilities include: stressors and triggers of blooms, controlling factors, bloom species (current focus on *Karenia brevis* red tide and *Aureoumbra lagunensis* brown tide), conditions regulating longevity, bloom by-products, impacted resources, and management strategies of blooms. These are further defined below:

> ***Stressors/Triggers***- Ecosystem stressors are "out of the ordinary" natural and unnatural inputs to the system that disturb the controlling factors and structure. Stressors produce potentially large-scale effects on the natural spatial and temporal dynamics of the system. Examples include, ballast water introduction, nutrient discharge, and urban development.

> ***Controlling Factors***- Controlling factors are the basic physical and chemical conditions that construct and influence the structure of the ecosystem, such as light, salinity, temperature.

> *Structure* – Structures are generally considered the major habitat units in the ecosystem. In this model the major focus is on HAB species found in the Gulf of Mexico and as such, is considered the primary structure of interest.

> ***Conditions Regulating Longevity***- Conditions regulating longevity are characteristics of the bloom that contribute to its development, persistence, and termination, such as upwelling, water column turnover, and biomass decay.

> ***Bloom By-Products***- Bloom by-products are products made during or after bloom development, such as chlorophyll, toxins, aerosols, high biomass accumulation.

> ***Impacted Resources***- Impacted resources are resources (human and non-human) that are impacted directly or indirectly by bloom-by-products such as human health, shellfish, and water quality.

> ***Management***- Management of HABs relates to the tools that allow managers to detect, forecast, predict, prevent, and mitigate for blooms. It also includes educating the public.

A more comprehensive semantic database and metadata catalog search capability has been developed for submerged aquatic vegetation (SAV) that utilizes Noesis, and terms common to both configurations (SAV and HABs) have been linked to provide integration between the two topics. As additional citations are added to the metadata catalog and the

conceptual model more fully developed, the HAB meta-search capability will broaden in extent and usability.

3.7   Opportunities for Further Development

The approach developed using the conceptual model and prioritization framework and tools is intended to be generally applicable to the Gulf of Mexico coastal ecosystems. While the restoration toolset was developed for application to SAVs in Mobile Bay, the analytical toolset can be extended to support: 1) analysis of a broad set of SAV restoration sites in the Gulf of Mexico, and 2) analysis of ecosystem structures other than SAV throughout the Gulf.

The GIS models in the SAV restoration prioritization toolset can be relatively easily applied to other sites in the Gulf if the datasets represented in the GIS models are available. However, it is recommended that the resource manager create or adapt the conceptual model to their specific area of interest in order to effectively identify and evaluate the system stressors of concern. The CME allows users to establish a conceptual model for systems that they are interested in. Further, additional ontologies can be developed or incorporated into the GoMRC catalog to enable Noesis to search on a broader set of ecosystem structures (e.g. mangroves) or topics. From this information end users can develop the prioritization framework for evaluating the effects of stressor and environmental conditions on the present or future conditions in the coastal area that are relevant to the focal ecosystem or species. Using estimates of change in the system users can predict the ability of the ecosystem or species to thrive in various locations within the coastal area. Because restoration often means that stressors must be reduced, the user of the system can identify the key stressors that would make the biggest difference in improving the conditions.

The meta-analysis is intended to show that degradation and changes in land use in the watersheds proximate to several Gulf Bays correlated with the amount of SAV in the bays. Although intuitive, this simple analysis suggests that improvement in watersheds may alter the stressors and controlling factors to improve the likelihood of successful restoration or recovery of SAV. Based on this relationship it appears that extending the type of analysis conducted in Mobile Bay would provide a useful tool for evaluating the effects of various management options intended to improve conditions in Gulf bays. The system developed here appears to be a tool with wide potential for application in the Gulf.

Finally, MODIS high resolution (250 m) imagery products developed by NRL on a REASoN project GoMRC were a key input to the assessment of suitable sites for SAV restoration. While this high spatial resolution imagery was an important input to the GoMRC models, it is worth exploring under what conditions the more widely accessible 1 km products would suffice. A modest effort under a future project to compare the 250 m imagery with the 1 km imagery could provide valuable information to coastal resource managers about data requirements and to NOAA/NRL as they endeavor to determine

which "research" products developed under the REASoN project should be transitioned into "operational" products.

4.0 IT Infrastructure Development Outcomes

4.1 System Architecture Overview

The GoMRC information technology architecture was designed to facilitate searching, visualization, and analysis of data and data products that are available through interoperable standards (e.g., Open Geospatial Consortium (OGC) and other web services, FGDC/ISO metadata standards, and semantic knowledge representation standards). It is intended to be flexible and extensible to a broad set of domains or application areas.
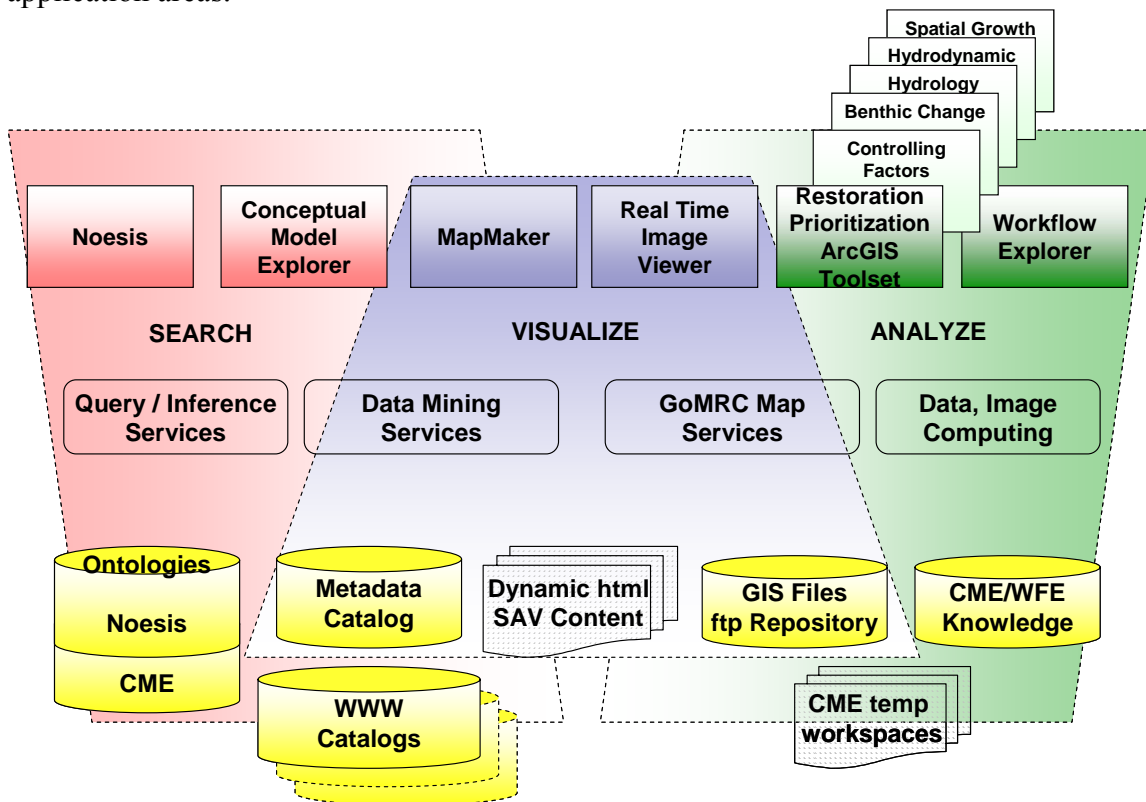
Figure 21. GoMRC system architecture

Figure 21 illustrates key features of the architecture, including user application tools (top), custom interoperability services (middle), and databases (bottom) that enable searching, visualization, and analysis. This support of interoperability allows compliant decision support tools to access and manipulate the information referenced and tracked by the GoMRC metadata catalog and other web registries. Interactions with the infrastructure are supported through a common web service interface layer including standard interfaces, where available, and public interfaces for GoMRC specific functionality. Semantic-assistance and metadata search/discovery of GoMRC data resources are supported through development of domain-specific ontologies that assist

users in navigating through available terms and conditions. An ontology is a data model that represents a set of concepts within a domain and the relationships between those concepts. The GoMRC ontology was developed and maintained in current industry standards such as OWL-based knowledge representations. The use of knowledge representation standards allows for the ontologies developed for GoMRC to be re-used by other systems and likewise for GoMRC to interoperate with knowledge bases developed elsewhere. Most of the GoMRC application software builds upon the consistent logical framework established by the SAV and HABs domain conceptual model terms and principles. In addition to databases, GoMRC contains a portfolio of dynamic webpage content and workflows pertinent to SAV. GoMRC IT architecture also employs workstation GIS tools (i.e. Restoration Prioritization Toolset) for local processing and manipulation.

4.2 Noesis

4.2.1 Purpose of Tool

Noesis is an ontology-driven metadata search engine which helps GoMRC users by aggregating science resources, such as web pages, data and publications. It uses ontologies to enable users to find the most appropriate terms to query for resources at concept level rather than at database schema level. The related terms provided by Noesis guide users to refine their search query, thereby reducing the user's burden to experiment with different search strings to producing better search results.

4.2.2 Approach

Noesis is an existing tool that is being used by several projects funded by NSF and NASA. An SAV-specific ontology was developed for GoMRC to demonstrate how a semantic database can assist metadata searches by GoMRC users. Additional support for GoMRC Data Catalog metadata that tags different data access resources, such as OGC Web Map Services (WMS) or directories of images, was added to provide more direct utilization of that information from the Noesis user interface.

4.2.3 Tool Development Results

Responding to direction from the GoMRC science team, IT team members developed an SAV ontology suited for the SAV decision support domain to demonstrate the utility of the GoMRC IT infrastructure. The domain-specific ontology helps guide users toward the most useful keyword terms to use when searching for data and information references across the many catalogs and registries searched by Noesis. Specialized enhancements to Noesis were implemented in support of the GoMRC Data Catalog, allowing users to directly access data visualization tools based on data access URLs available in the catalog for returned data sources (Figure 22). In addition to the GoMRC Data Catalog, Noesis also searches other scientific data catalogs (e.g., NASA's Global Change Master Directory (GCMD)), scientific publication registries, and general web search engines.

noesis

Home | About | FAQS | Contacts | ITSC | Disclaimer

Search   Stop

Number of Results:
59

Definition:

Salinity is a measure of the concentration of salts in water. Salinity is important for the physiology of plants and animals as well as chemical processes.

Source: GoMRC Catalog

Query:
salinity

Refine Search

+Mass Concentration
+salinity

Related Terms

+Stressor
- ☐ Salt Production
- ☐ Subsidence
- ☐ Fresh Water Volume
- ☐ Marinas
- ☐ Wake Diversion
- ☐ Flooding
- ☐ Sea Level Rise
- ☐ Impervious Surfaces
- ☐ Storm Events
+Structure
- ☐ Ecological Structur...

Add Additional Terms

Add

Search Results

NRL-Salinity
GoMRC
Salinity model
http://www.7320.nrlssc.navy.mil/global_ncom/

Keywords:
Chemical, Salinity

Salinity-Quasi static
GoMRC
No Description
http://www.ncddc.noaa.gov/website/CHP/viewer.htm

Keywords:
Physical, Controlling Factor, Salinity

Simulation Model of Seagrass Communities in Florida Bay (SIS# 4490)
GoMRC
Beginning in the fall of 1987 seagrasses, primarily Thalassia testudinum in dense seagrass beds, began dying. Die-off on the scale and in the manner observed in Florida Bay was unprecedented and is still poorly understood. Seagrass die-off and the subsequent extensive and persistent algal and turbidity blooms threatened the ecological function of Florida Bay and were thought to pose a threat regionally. Seagrasses are central to the ecology of Florida Bay. Understanding seagrass die-off is a critical need of the Florida Bay Research Program, an element of the state and federal Greater Everglades Ecosystem Restoration Program. Understanding its long-term and short-term origins, its relationship to turbidity and algal blooms, and its relationship to salinity and upstream water management are all central questions for the Florida Bay Research Program. A simulation model is needed in order to evaluate long- and short-term origins to seagrass die-off, to capture seagrass dynamics across the seascape of Florida Bay, to link seagrass dynamics in Florida Bay to upland hydrology, and to evaluate and or predict the response of the seagrass community to water management alternatives.
http://cars.er.usgs.gov/basis/Greater_Everglades/4490/4490.html

Keywords:
Submerged Aquatic Vegetation, Seagrass, gomex_habitat, sav, seagrass ecology, Thalassia testudinum, turtle grass, seagrass dieoff, Halodule wrightii, simulation model, salinity, water flow landscape model, Florida, FL, Gulf of

Filter by Engine

+ ☐ All
  + ☑ Data
    - ☑ GoMRC - 5
    - ☑ NCDC - 4
    - ☑ NASA GCMD - 50
  + ☐ Web
    - ☐ Google - 10
    - ☐ Yahoo -10
  + ☐ Publications
    - ☐ Ecol. & Systematics - 25
    - ☐ J. Ecol. Apps - 25
    - ☐ Ecol. Mono. - 25
    - ☐ Ecology - 25
    - ☐ J. Animal Ecol. - 25
    - ☐ J. Ecol. - 2
    - ☐ Rem. Sens. Env - 1
    - ☐ AMS - 0
  + ☐ Education
    - ☐ DLESE - 15

Figure 22. Noesis screen shot showing definition, related terms, search results, and filter options for "Salinity

4.2.4   Issues

There are no unresolved issues with the keyword functionality of the current instantiation of Noesis for GoMRC. The Noesis tool is focused on the SAV and HABs-related terms incorporated into the prototype ontological model. Additions or revisions to the ontology currently require direct assistance from IT specialists. Evaluation of the ability to add new terms occurred as a subset of pertinent terms and logic was added from the Coastal and Marine Ecological Classification Standard (CMECS). In its current mode of operation, the search results produced by Noesis can be arranged by source catalogs, but are not necessarily presented in order of relevance to the overall query terms. Search results are returned based on literal matches to combinations of keyword terms selected.

4.2.5   Opportunities for Further Development

The development of domain-specific ontologies is labor intensive and requires close collaboration between domain and IT experts. While input from domain-specific science is a critical ingredient to the ontologies, the development of tools that would facilitate the construction of domain ontologies could reduce resource requirements and the speed of deployment for new decision support topics.

The SAV and HABs intelligence built into the ontology could be used to strengthen catalog and registry search effectiveness. Searches could be expanded to identify and employ synonyms and or terms closely associated with the keywords provided by the user. This semantic search assistance would be valuable given the desire to find applicable knowledge about SAV or HABs amidst the variety of concepts, vocabularies and disciplines which might pertain. The intelligence imbedded in the ontology could also be used to process and reorder search results based on closeness of fit or relevance. Semantic search capabilities will require extensive interaction with users to determine preferences, as well as to refine the ontology and potential ambiguities.

Another enhancement to Noesis involves the ability to specify geographic boundaries as another search criterion when searching geographically-enabled registries and catalogs (e.g., GCMD and GoMRC). Noesis could be extended to allow input of geographic information system search parameters as well as using gazetteer services to enable users to provide names for geographic areas.

4.3   Conceptual Model Explorer (CME)[1]

4.3.1   Purpose of Tool

The Conceptual Model Explorer (CME) is a decision support tool for resource managers with two major functions:
- It provides users with a Web-based visual representation of ecological conceptual models, which enable users to share perspectives on the cause and effect and other relationships influencing different types of coastal habitat.
- It provides users with a spatial modeling environment for running established models and performing common geospatial calculations (e.g. computing road density for a specified watershed) for a geographic area of interest.

As outlined in Section 3, conceptual models have become an increasingly popular tool used by resource managers to document their understanding of system dynamics and support ecosystem restoration efforts. The CME is designed to support the development and sharing of conceptual models in a Web-based environment. The architectural building blocks of the CME are the ecosystem components, such as ecosystem stressors,

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[1] Note: Oregon State University was funded both through the USRA Infomart project and through GoMRC. The purpose of the USRA funding was to enable OSU to leverage work conducted for the Pacific Northwest Regional Collaboratory (PNWRC) Infomart and extend it to the Gulf region. Results reported here reflect work performed under both projects.

controlling factors, structures and processes. These relationships are depicted in an easy to understand conceptual modeling design-environment. Furthermore, CME includes search, hyper-linking (i.e. bookmarking), and annotations to Internet resources. To demonstrate its functionality, the SAV conceptual model has been setup as a template in the CME, offering GoMRC users a visual representation of the ecological factors that influence SAV habitat and the ecosystem processes and services that SAV structures impact.

To complement the conceptual model representations, a second tool embedded in CME, called Workflow Explorer (WFE), enables users to create models that depict how ecosystem data can be manipulated in a series of tasks, or "workflows", to produce forecasts or correlations. WFE will enable users to run established models and perform common geospatial calculations for a geographic area of interest. It provides natural resources managers with: 1) the ability to run models on the Internet that were developed for the ArcGIS desktop, and 2) access to the most commonly used building blocks for model-making or spatial analysis. In its current state of development, WFE users are able to import spatial data from the Internet. With a modest level of further development it will also enable users to subset, recode, and resample that data, and do multi-dataset analyses. Examples of such commonly used analyses that could help resource managers design appropriate restoration strategies include, computing road link density at various watersheds of interest, computing the proportion of a watershed with market value of land greater than a threshold value, or computing the proportion of pristine vegetation for sampling in a given decision unit.

To demonstrate the functionality of WFE, an SAV restoration site prioritization workflow has been setup in a WFE depiction. The SAV restoration site prioritization model in WFE mimics the ArcGIS Restoration Toolset built by the GoMRC science team. However, a key benefit of the WFE as a Web-based tool is that users do not need ArcGIS software to perform spatial coastal habitat restoration analysis.

While the initial CME/WFE toolset focuses on an SAV conceptual model and an SAV restoration prioritization workflow in Mobile Bay, the structure developed under GoMRC provides the basis for a common toolset with the ability to import spatial data and do common geospatial calculations that provide ecological status summary statistics for any geographic area in the Gulf of Mexico.

4.3.2   Approach

The CME was designed using W3C standards to deliver highly interactive, graphical conceptual models and workflows to modern web browsers without requiring the use of third party browser plug-ins. To achieve this goal, client-side JavaScript, XML, and AJAX were used along with server-side C#.

CME conceptual models embrace the concepts of Organizing Principles and System Components as a mechanism to present ecosystem relationships. CME workflows extend this approach utilizing specialized components, such as Datasets and Adapters, to model

and potentially execute workflows. An Adapter is a process that converts data from a given format to a desired format that is useable for subsequent processing.

The CME interface consists of two major components: the CME Editor for creating and editing conceptual models and workflows, and the CME Viewer for displaying the conceptual models and workflows. Execution of workflows is enabled in the Viewer.

The CME Geoprocessor Workflow (GPW) framework includes distributed decision support tools, composed of spatial data and geoprocessing functions, which interface with distributed datasets to provide site prioritization and other analyses via the Internet. The architecture of the GPW component can be scaled to a distributed multi-server configuration to serve a growing user community. Much of the GPW framework is built upon ESRI distributed GIS products. An advantage of using ESRI derives from the capabilities of its products and also the large user base. A disadvantage derives from difficulties developing using the core ESRI libraries.

Personalization code developed for the Pacific Northwest Regional Collaboratory (PNWRC) Northwest Explorer was incorporated into the CME to control access to the editor, model and workflow sharing, and to allow users to save search results as bookmarks, with user defined ratings and comments.

CME conceptual model system components link to GoMRC web services via AJAX requests so that contextual searches for component definitions and related assets can be easily queried within the CME Viewer.

4.3.3   Tool Development Results

The CME Editor allows authenticated users to create, edit, share and publish conceptual models and workflows. Conceptual models and workflows, as well as individual components, can be shared and reused in multiple models and workflows.

The CME Viewer displays conceptual models and workflows developed interactively by users of the Editor. The initial conceptual model for demonstration purposes is the SAV conceptual model. The Viewer provides tools allowing the user to zoom and pan the model, isolate component relationships, and search the GoMRC Catalog and Noesis for relevant datasets and assets (Figure 23).

CME personalization allows registered users to easily bookmark GoMRC Catalog search results by clicking on the icon to the right of the asset. The user can rate and add notes to the bookmark. The bookmarks are associated with the searched component and can be retrieved later by right-clicking the component. Bookmarks to Noesis search results and other external sites can also be added to components.

Spatial and temporal restraints as well as additional keywords can be added to CME Viewer search requests using the Query Filters window, which includes an interactive map to set the spatial extents.
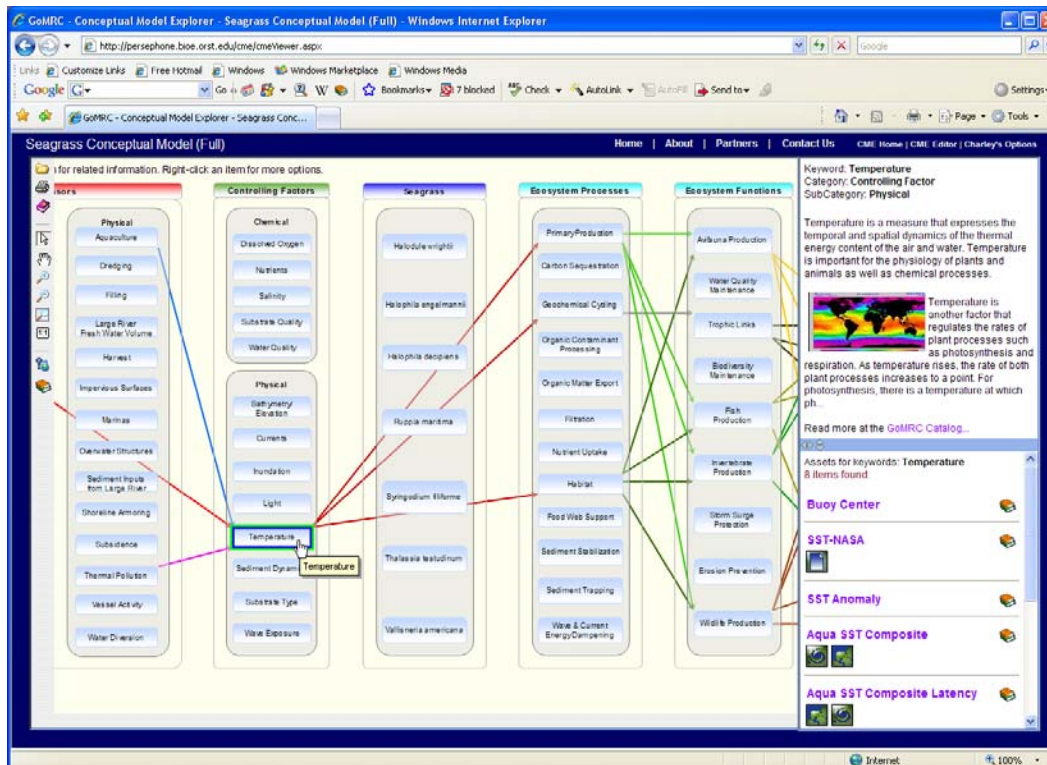
Figure 23. CME Screenshot showing SAV conceptual model

Workflows can be configured in the CME Editor to be executable by linking components to actual web services and data repositories. The CME Viewer permits the execution of these configured workflows allowing users to adjust parameters and perform analyses. The workflow for restoration prioritization of Gulf of Mexico SAV, discussed in the science applications section of this report (section 0) was integrated into the CME. Consequently a broader user base has access to the site prioritization toolset through the CME web-based interface. Users can use the workflow in decision support even if they do not own ESRI products and extensions that underpin execution of the models. Also, users can proceed with a mix of their local and GoMRC repository spatial data in the analysis.

Other GoMRC tools, such as Noesis and MapMaker can be queried and contextually launched through the CME Viewer.

4.3.4   Issues

The Conceptual Model Explorer is a graphics-intensive web application built to run in browsers without requiring a third party plug-in. As such, a modern browser with native, standards-compliant vector graphics (SVG or VML) support is required to satisfactorily use the CME.

The CME currently draws on a customized, local database of SAV terms and relationships which enable CME depictions and dynamic editing. The SAV conceptual

model represented in the CME database may be considered an ontology. As such, it is imperative that the CME ontology maintain equivalency with the Noesis search engine. Currently, these two ontologies have been built in parallel and have been reconciled to equivalence although stored via different database methods. Extensions of GoMRC will require vigilance to maintain currency between these tools and warrant automation attempts in the future.

There is currently a notable lack of publicly available web feature services (WFS) and FTP data available for real-time consumption in CME /WFE Geoprocessor Workflows. It is expected that there will be more of these automated services available enabling users to define a spatial extent and request the data needed. Until more are available, however, a significant effort is required to pre-process large datasets for consumption in WFE.

Finally, complicated workflows expressed in ESRI scripts and models must be deployed in the context of a distributed computational and database implementation on web servers. Likely contributors of workflows to WFE rarely consider the details of access control and workflow design because they develop their workflows in a desktop PC environment, where interactions with networked and server components are simpler. Thus some re-engineering of such workflows usually will be required before they can be available through CME to the wide user base on the Internet.

4.3.5 Opportunities for Further Development

Opportunities for further development include technical enhancements to the existing toolset and expansion of the conceptual models characterized in CME to other applications areas. Potential activities include:
- Decision support through ArcGIS custom Toolboxes on distributed servers. Users would be able to publish spatially explicit models on the Internet providing greater access and opportunities for review. A user with a PC with ArcGIS and an Internet connection could run the models from their PC as if on their own server.
- Integration of conceptual models and workflows in the CME for HABs and other priority Gulf issues (e.g. nutrient dynamics).
- Permanent GoMRC Catalog entries from workflow automation results. This would allow registered users to permanently store datasets relevant to customized WFE models if the user would like them to persist for future review/use.
- Develop execution environment for workflow and geoprocessing applications by extending the current Area of Interest tool to specify additional characteristics. These include raster cell-size, projection, and resampling method. This development would facilitate deployment of existing tools to other sites by automating data ingestion by the existing GoMRC tools.
- The addition of other relationship types to the underlying CME database schema would enhance the decision support (and ontological) functionality of the CME/WFE editor/viewer/workflow product. These relationship types would include those from standard ontology languages, and also those that would support quantitative analysis, such as correlation.
- Development of adapters to retrieve and prepare data for analysis using geographic specification set by user. These adapters include middleware to fill in

the gaps where WFS and WCS are unavailable, and also include geoprocessing adapters to facilitate the use of decision support tools with diverse data format requirements.

4.4   MapMaker

4.4.1   Purpose of Tool

The MapMaker application provides visualization of web-accessible geographic data through normal web browsers. MapMaker is able to overlay multiple data sources in a single view for comparison and reference. It should be noted that MapMaker is not intended to be used as a primary search tool.

4.4.2   Approach

The MapMaker application is a GIS data viewer compatible with OGC web service specifications, such as WMS, WFS, and WCS. The OGC services facilitate common interfaces for display of disparate geospatial information. Information on these service specifications is available at http://www.opengeospatial.org/. MapMaker is built on the open source Chameleon Web Mapping Framework. Chameleon was developed by the DM Solutions Group of Ottawa Canada and is widely used within the OGC community.

4.4.3   Tool Development Results

The MapMaker application (Figure 24) allows users to select from a list of available geographic data layers. Multiple data sources may be overlaid, including geographic and political boundaries. Users may zoom in and out from the base map location to view data sets that are local to a small region such as Mobile Bay. The context of the user's current display may be saved to be recalled later for continued work. The

Figure 24. Map Maker main window

viewer may be initiated from other applications by use of an HTTP parameter appended to the URL (see user documentation in Appendix J for details). More information on MapMaker functionality can be found in the MapMaker User's Manual (see Appendix K).
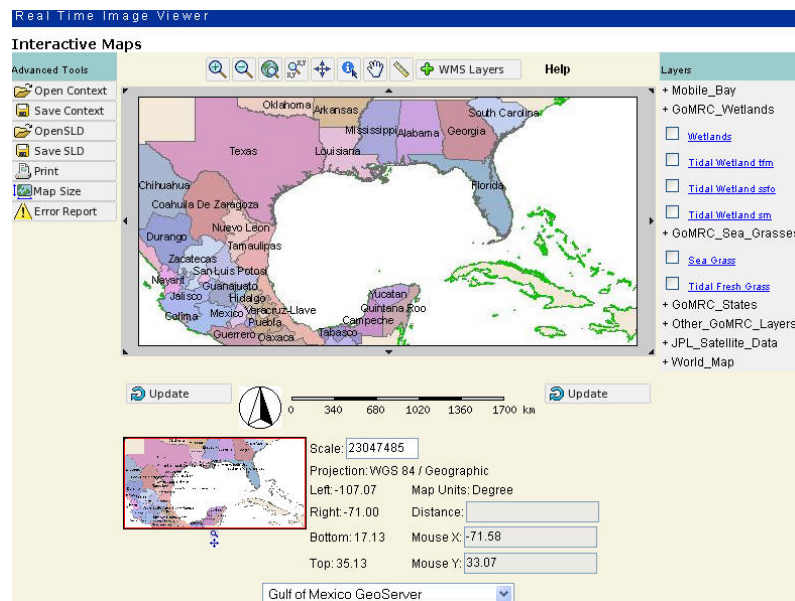
4.4.4   Issues

In some domains the availability of OGC-compliant data servers appears to be limited, so effort is needed to either assist in providing interoperability support for necessary datasets, or discovering existing compatible data providers. As built, MapMaker is a powerful tool to display geographic information discovered via GoMRC. MapMaker's reliance on WMS focuses the display capability on geospatial assets that can be offered as images from WMS sources. Importing WMS assets for display constrains the display to whatever fixed image contents are made available.

MapMaker's primary function is to display predetermined or recently discovered geospatial images. Some GoMRC users had expectations that the mapping tool would offer geographic search capabilities. While the current version does not have this capability, MapMaker does offer the ability to scroll through known WMS servers to see names of coverages they offer.

4.4.5   Opportunities for Further Development

The MapMaker viewer could be enhanced to enable geospatial discovery of OGC-compatible data from other geographic data registries and catalogs. This would facilitate the incorporation of this tool with other decision support applications. Improvements to the legend development function should also be pursued to facilitate user analysis. Acquisition of additional metadata may also enhance the understanding of imported images being displayed.

4.5   Real Time Image Viewer

4.5.1   Purpose of Tool

The Real Time Image Viewer (RTIV) provides the capability to access, display, and animate web-accessible images through a web browser interface. The application organizes images sequentially by time. Users may select individual images for static display or multiple images to create an animation. The RTIV also generates KML files for each image for display with Google Earth.

4.5.2   Approach

The RTIV was developed as a web-based application. It is accessible through any common web browser. The application is configurable to support domain-specific image collections for decision support needs, as is demonstrated in the SAV domain for GoMRC. The RTIV can display and animate images in any common format. For more information see the RTIV User's Manual (Appendix K).

4.5.3   Tool Development Results

Figure 25. Search results for Aqua SST imagery

The RTIV user interface was customized to match the GoMRC theme. Imagery collections relevant to the GoMRC application areas (e.g. chlorophyll concentration, sea surface temperature-SST) were encoded into the user interface menus. Users may select products from the list of imagery collections and bound the list of images by specifying starting and ending dates (Figure 25).

4.5.4   Issues

The RTIV currently uses a script to construct a path to the desired imagery products. This script, while robust and thoroughly tested, does not possess the flexibility of a database query approach. If the images were to be relocated to another file structure the scripts that access them would need to be changed.

4.5.5   Opportunities for Further Development

To address the issue above the RTIV should be restructured to use a service oriented approach. An inventory database should be developed and populated with a listing of image collections and their location. Services should be developed that allow the RTIV to search for information via the database. As with MapMaker above, the ability to search for assets based on geographic criteria would expand the utility of this visualization tool. This would be more efficient and flexible. The geographic extent of the RTIV display might be enhanced with zoom and pan capabilities.

4.6   Catalog and Services Infrastructure

4.6.1   Purpose of Infrastructure

The metadata catalog infrastructure was developed to provide a repository of information about available science data resources, as well as definitions and other background information about concepts in the GoMRC ontology. The intention was to be able to catalog all data resources regardless of the physical location of the data, thereby providing a more complete, focused domain knowledge base of available data products. SOAP (Simple Object Access Protocol) web service interfaces have been developed to make the catalog resource publicly available to applications, such as GoMRC and other decision support systems. An emphasis was placed on the support of standards for the IT infrastructure to facilitate interoperability for search, discovery and access.

4.6.2   Approach

The metadata schema definition started with the FGDC metadata standard in order to insure ultimate compliance with that standard for geographic metadata. Extensions to that schema were adopted to provide expanded support for data access and visualization metadata and support for semantic keyword tagging. Web service standards were adopted for the catalog services to insure the best interoperability with GoMRC and other decision support applications. The data catalog is situated to be available as national or international data registry as a result of supporting metadata standards and best practices during design and implementation phases of the infrastructure.

An initial ontology was developed for SAV as a demonstration of the usefulness of semantic interoperability for data search and discovery. The knowledge representation used for SAV ontology is a current industry standard and is interoperable with other recognized semantic systems and approaches. The actual definition of the SAV ontology was the collaboration between the GoMRC science team's SAV experts and the IT team. Definitions and other information about each of the terms in the GoMRC ontology are available via web service from the GoMRC Catalog.

4.6.3   Infrastructure Development Results

The Web Service Description Language (WSDL) documents for all catalog and related services are publicly available. These interfaces were utilized for the implementation of GoMRC tools and applications and are also available for use by other applications.

4.6.4   Issues

Construction of ontological knowledge bases is a time consuming effort and require significant resource allocation from both the science and IT experts. Catalog service interfaces should be standardized as accepted standards are resolved.

The breadth of metadata fields available to populate the GoMRC catalog varied greatly across data sources. The lack of information was found to limit the utility of some catalog

entries. GoMRC was dependent on external sources for this information and did not attempt to obtain missing information or search for additional information.

Lessons learned include:
- For a wider data search, both the Catalog and search clients should use the simplest form of a keyword term (e.g., singular instead of plural).
- For a more accurate data search, clients should not break keywords containing multiple terms into multiple keywords (e.g., search on "Water Quality" instead of "Water" and "Quality").
- All parties need to agree on how to handle keyword specialization (e.g., "Vessel Activity (Scouring)" and "Vessel Activity (Wakes)", vs. "Vessel Activity").
- All parties need to agree on how to handle compound keywords (e.g. "Filtration & Uptake of Nutrients", "Bathymetry/Elevation").

4.6.5   Opportunities for Further Development

Better tools are necessary to simplify the development and maintenance of ontological knowledge bases. OGC catalog services for the web (CSW) should be investigated as possible interoperability standard for this data catalog.

Numerous catalogs have been, or are still being, developed for Gulf of Mexico natural resources. During this first year GoMRC created a prototype catalog dedicated to SAV. The GoMRC team also identified two major catalog initiatives (PHINS and GAME) which offer promising activities that could extend GoMRC utilities well beyond the prototype catalog. NOAA's MERMAID tool for systematic metadata capture also offers an opportunity to consolidate further the diverse sources of metadata.

4.7   SERVIR-Gulf of México Data Portal

4.7.1   Purpose of Tool

SERVIR is a regional visualization and monitoring system for Mesoamerica that integrates satellite and other geospatial data for improved scientific knowledge and decision making by managers, researchers, students, and the general public. SERVIR headquarters are located at the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) in the Republic of Panama. A test bed and rapid prototyping SERVIR facility is managed by the NASA MSFC in Huntsville, Alabama.

SERVIR and GoMRC have established a collaboration through this project to expand the SERVIR toolset to the Gulf of Mexico. The main function of the SERVIR-Gulf of Mexico portal is to allow institutions to share data online through the publication of metadata. The expansion of SERVIR into the Gulf of Mexico will allow institutions in Mexico with significant data holdings to make their data and information more accessible to broader national, regional and international audiences.

4.7.2   Approach

Given the U.S. HABs program's intent to reach out to Mexico for a bi-national programmatic effort in the Gulf, the SERVIR-GoMRC partnership created the opportunity to embrace a specific priority program, HABs, as the pilot application, thus leveraging three activities with shared objectives of making common methodologies and tools for natural resource decision support available throughout the Gulf. (See discussion in Section 3.6 above.) The approach integrates these three complementary activities into a single "model" capacity development node in the Southern Gulf.

The primary activities in support of the SERVIR-GoMRC activities in the southern Gulf included:
- Participation in the two bi-national red tide meetings sponsored by EPA, NOAA, COFAPRIS, and the Gulf States of Mexico at New Orleans and Campeche to establish program objectives and strategy
- Consultations with national and Veracruz state institutions in Mexico to introduce the project and identify available data sets
- Development of the SERVIR Data Portal for the Gulf of Mexico
- Establishment of a physical center in Veracruz, with a server and computer workstation, to support an integrated set of SERVIR-GoMRC-HABSOS activities
- Training of end users in Mexico on use of the SERVIR Data Portal and SERVIR Viz tools

Initial training on the SERVIR platform maintained a focus on use of SERVIR data and tools to support coastal and marine applications. In the future, the SERVIR-GoMRC team plans to work with those responsible for HABs detection sensor stations deployment and use to determine how the data extracted from this region can be integrated into the SERVIR platform to provide required decision support. The growth model for this partnership includes geographical extension to other Southern Gulf States and topical expansion to other Gulf ecosystem problems, starting with Mexican companion projects to the Mobile Bay SAV demonstration.

4.7.3   Tool Development Results

This component of GoMRC is directed toward user outreach, data portal development, and capacity building. GoMRC established the Veracruz Science and Technology Working Group in Veracruz, including identification of a physical center for training and collaboration linking the SERVIR, GoMRC and HABSOS programs. The SERVIR Data Portal has been developed and provides access to data in Mexico available through WMS as well as satellite datasets for the Southern Gulf of Mexico. This platform is intended to serve as a central access point for data users in Mexico. Training on use of the SERVIR tools was completed in Veracruz, Mexico in December 2007 and involved over 20 attendees from state government, federal government, and universities in Mexico.

Subsequent to the initial SERVIR Data Portal training, the Veracruz team is expected to be trained in HABs identification and data entry into the HABSOS system.

4.7.4   Issues

GoMRC has supported the development of the SERVIR portal and introduction to the GoMRC toolset, but has not yet identified a programmatic basis for integrating the HABS data into the GoMRC/SERVIR platform, once the data from the buoys is available, nor extension to the other Mexican Gulf States.

4.7.5   Opportunities for Further Development

Key opportunities for ramping up this bi-national, science-based management program include:
- Further definition of capabilities and requirements for the integration of the combined features of SERVIR, GoMRC and HABSOS in both the U.S. and Mexico
- Extension of coastal wetlands restoration toolset (starting with seagrass/SAVs) developed for Mobile Bay, Alabama to areas in the southern Gulf

5.0   GoMRC Sustainability / Continuity Plan

In less than a year's time, the GoMRC team has established an extensible system architecture and preliminary toolset to help resource managers make improved decisions around priority management issues in the Gulf of Mexico. GoMRC's recent outreach efforts have focused on demonstrating the utility of this toolset to target end user groups.

As previously noted, GoMRC's long-term objective is *to develop an integrated platform that addresses a broad set of environmental issues and geographic areas within the Gulf of Mexico in support of regional sustainable development*. The mission of GoMRC directly assists the strategies developed by United States Group on Earth Observations (USGEO) for the U.S. Integrated Earth Observation System (IEOS) as well as the goals outlined by the GOMA in the Governor's Action Plan. There is currently no integrating framework that provides Gulf-wide operational decision support across various topic areas. Taking GoMRC to the next level, to provide this integrating framework, will require management support and funding from a number of stakeholder agencies.

The GoMRC team has identified a number of high-priority near-term activities that would make the GoMRC platform a more robust operational tool. These include:
- Extending the full SAV prioritization analysis to at least two other sites in the Gulf, including one in Mexico (potentially La Mancha Bay, Veracruz). Based on preliminary interest from the NEPs, GoMRC may extend the model to some or all of the other Gulf-coast NEPs.
- Continuing work with HABs participants in both the US and Mexico and set the stage for establishing SERVIR/GoMRC as the integrating platform for a Gulf-wide HABs decision support system linking established analytical capabilities and operating systems in the northern Gulf of Mexico with the southern Gulf.
- Finalizing development of a Gulf of Mexico HABS conceptual model by working with state resource managers in the U.S. and Mexico to validate and further develop the preliminary model. Integrate the model into the CME and Noesis to

enhance their decision support resources and work with HABSOS program to integrate the conceptual model with existing decision support tools.

- Expand GoMRC to focus on at least one new application area that responds to the Gulf of Mexico Alliance's Priority Issue Team goals, possibly a restoration prioritization decision support system for a different type of coastal wetlands structure, such as mangroves, or a Gulf-wide severe weather application.

In the two-year time frame GoMRC could serve as a central component in a GOMA systems integration project, providing the IT platform, data, models and decision support tools required to support the various GOMA end user needs. Additional support and direct collaboration with other key regional efforts (i.e., the GOMA PHINS catalog development effort, the Florida GAME data discovery effort, the CMECS standard) will be a necessary precursor to building such a technical integration framework for GOMA data and decision support. Once developed, the GoMRC toolset may be adopted as an operational capability to be maintained by an individual agency (e.g., NOAA) and the support of system architects and domain-specific application developers would be enlisted as necessary.

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Appendices

Appendix A. End User Advisor Committee Members

Organization	Committee Participant
Alabama Department of Conservation & Natural Resources, Coastal Section, State Lands Division	Carl Ferraro, Natural Resource Planner ADCNR-State Lands Division-Coastal Section
Charlotte Harbor National Estuary Program	Catherine Corbett, Senior Scientist
Coastal Environments, Inc.	Sherwood M. Gagliano, President
Florida Department of Environmental Protection, Office of Coastal and Aquatic Managed Areas (CAMA)	Stephanie Bailenson, Director Alternate: Steve Wolfe
Houston Advanced Research Center (HARC)	Jim Lester, Vice President and Chief Operating Officer (VP/COO)
Louisiana Department of Natural Resources, Office of Coastal Restoration and Management	Karim Belhadjali, Coastal Resources Scientist Manager, Restoration Technology Section
Mississippi Department of Marine Resources	Jeff Clark, Coastal Ecology Office
Mississippi State University /GeoResources Institute /Northern Gulf Institute	Michael Carron, Chief Scientist
Mobile Bay National Estuary Program	Roberta Swann
National Ecology Institute (INE)	Margarita Caso Chávez, Coordinator of Marine and Coastal Ecosystem Projects
NOAA National Coastal Data Development Center	Rost Parsons
Shell Oil	Ian Voparil, Environmental Ecology and Response group of Shell Global Solutions, Houston
State of Veracruz	Juan Manuel Irigoyen
Texas Parks and Wildlife Department	Jarrett (Woody) Woodrow, Director of Coastal Conservation Programs and Coastal Fisheries
The Nature Conservancy	Rafael Calderon, Director, TNC Gulf of Mexico Initiative
US EPA Gulf of Mexico Program	Diane Altsman, USEPA Region4

Appendix B. User Requirements Summary

Gulf of Mexico Regional Collaborative User Requirements
Summary of End User Committee Responses
April 19, 2007

This document provides an overall summary of responses received from the Gulf of Mexico Regional Collaborative (GoMRC) end user committee on the User Requirements Questionnaire. All input is still welcome, so please feel free to provide additional thoughts, suggestions, or comments.

Audience for the System
Several of the questions on the End-User Requirements questionnaire (Questions 1 and 2) were aimed at acquiring input on the audience for the proposed system. The majority of respondents felt that resource managers and scientists in federal, state, local, as well as private agencies would benefit from this type of system, particularly if tools were made available to support decisions. The agencies identified included: State Fish and Wildlife Departments (TX, LA, MS, AL, FL), U.S. Fish and Wildlife Service, EPA's Gulf of Mexico Program, NOAA's National Estuarine Research Reserves, Land Trusts, NGOs (The Nature Conservancy, Coalition to Restore Coastal Louisiana), Secretary of States and Universities.

It was suggested that the scientists within these organizations would most often be the staff using the system and providing the necessary information to the decision makers in their respective organizations. Scientists involved in research may also find a system helpful to provide access to information they do not currently have, particularly since knowledge pertaining to the structure and function of many Gulf coast ecosystems is continually being updated. Additionally, this type of system may help scientists identify gaps in knowledge and ultimately drive new lines of research.

The respondents were mixed on whether this system should include a focus on the interested public. Several respondents stated that if the interested public was to be included, the information would have to be presented in an easy to use, understandable, and appealing format. The public is not likely to understand the intricacies of the data and models and any information would have to be explained at a very general level.

The definition of the interested public also varied and included any citizen, taxpayers, educators, students, industry and commerce which would encompass fisherman, aquaculture, urban developers, tourism and eco-tourism operators, developers and NGOs. For some of these interested public groups, respondents felt the landowners and developers may benefit from this system. Approximately 80% of Louisiana coastal wetlands are privately owned and a large amount of this is under active management. Developers need information for permitting purposes and this type of information could be accessible through this type of system.

Questions and Issues Resource Managers Must Address
Several key questions asked on the end user questionnaire pertained to the types of questions and issues resource managers in the Gulf of Mexico States must address. To best identify the services the system can provide, the Science Group and IT group developing the system need this type of information for issues pertaining to HABs and coastal restoration.

Responses from end users indicated that there are several key issues they need to address with respect to HABs. These include:
- Where is the HAB occurring and what data exists to describe the bloom?
- Forecasting of HABs including location, aerial extent, severity, how long it will remain, where will it move next given winds and tides
- Forecasting when and for how long to:
  o close beaches in response to HABs
  o close shellfish beds in response to HABs
  o issue public health advisories for HABs
- What is the economic impact of the bloom on fishery resources?
- What are the reasons for the bloom event and when conditions are likely for an event (i.e., upwelling episodes, biological and chemical factors) ?

In response to coastal restoration, end users cited a variety of questions and issues that need to be addressed before they can even begin a coastal restoration project. These include:
- How to determine what to restore and the specific goals of the restoration effort.
- How to ensure that restoration goals are based on ecological targets and are not simply made up based on lack of historical information
- Prioritization of restoration efforts. Where to put efforts for the most ecological impact and how to identify those critical need areas
- Siting of restoration efforts. Can the restoration project be constructed given the nature of the surrounding area (i.e., soils), where are the adequate borrow areas for marshes, sand sources for barrier islands, sediment sources for other efforts?
- What are the current causes of habitat loss?
- Are the habitat losses, natural, man-made, cyclical or permanent and given these causes, does it make sense to restore?
- The extent of the area for restoration (how much habitat lost, how much should be restored)?
- How to secure land rights for wetland areas that are privately owned?
- What environmental impacts may result from the restoration project (i.e., impacts associated with freshwater diversion restoration projects)?
- What are the engineering designs for the restoration?
- What methods and techniques are necessary for the restoration as well as how to identify most effective methods and strategies to use for the project?
- What economic impacts are associated with the restoration effort?
- What is the timeframe of the restoration effort?

Data Needs to Address Resource Manager Issues
Based on the information received from resource managers and scientists, there are many
data and information needs that would assist in addressing the questions and issues
summarized above. This appears to be a fairly comprehensive list and some of this
information may not currently exist, or if it does, it may not be in a format that is readily
usable. These data needs (available or unavailable) include:
- Maps and GIS data showing historical and current seagrass/submerged aquatic
  vegetation (SAV) coverage
- Life cycle of seagrasses/SAV
- Impacts of fragmentation on seagrasses and SAV
- Impacts of stormwater runoff, boats and boat traffic, dock construction and other
  underwater construction on seagrasses and SAV
- Maps and GIS data showing
    - historical and current land use and land cover
    - historical and current locations of barrier islands
    - historical and current benthic habitat coverage and composition
    - sediment types and amounts
    - past and present invasive/exotic species coverage
    - current restoration efforts, location of dredging projects, location of beach
      renourishment projects
    - historical and current bathymetry
- Current habitat classifications
- Subsidence information
- Elevation data (LIDAR)
- Sea level rise, tropical storm surge and flood zone projections
- Water and sediment parameters (depth, color, DOM, chlorophyll, turbidity, grain
  size, flow, sediment load, sediment type, etc.)
- Sediment sources and dynamics (i.e., how does it behave in the system)
- Tide and current information (direction, speed, etc.)
- Freshwater inflow (and groundwater input) into coastal systems
- Historical and current land use/land cover change in coastal communities
- HAB forecast models and input parameters
- Spatial and temporal dynamics of phytoplankton, periphyton, macroalgae species
  composition and densities
- Coastal circulation, hydrodynamic, and water quality models
- Forecast models and the input parameters
- Modeling of future/prospective impacts of coastal land use/land cover change on
  seagrasses, other benthic habitats, wetlands etc.
- Models of coastal urban growth that forecast economic impacts
- Models/programs that calculate loss of seagrass/SAV, input parameters
- Status and trends of various systems (i.e. seagrasses) reported in a summarized
  version with locations, rates of change already calculated and interpreted.

NASA Data Products
From the responses to the question pertaining to NASA earth science remote sensing data, it appears that many of the members of the end-user committee do not feel they know enough about the types of information NASA collects with the various satellites. Some respondents were familiar with multispectral and hyperspectral data from AVHRR, ASTER, MODIS, and Landsat, and felt they may be able to provide some useful environmental data. Another respondent pointed out, that the end-users would likely benefit from processed data products produced from these satellites and not the raw data streams themselves.

Spatial and Temporal Coverage
Most respondents mentioned that the spatial and temporal resolution of this information will depend on the objectives of the study and what questions are being addressed. With development and growth occurring in many Gulf coast communities, annual land use/land cover changes should be considered. Wetland mapping in some areas is conducted on a 5-10 year basis and SAV mapping in some locations is conducted annually and annual or semi-annual loss estimates for seagrass would be preferred. Annual erosion rates are important for coastal marsh restoration. A general "rule of thumb" could be that restoration efforts need data and information on an annual or semi-annual basis. One respondent suggested that bathymetric information should be updated every 5 years. For HABs, respondents suggested that frequent data would be necessary, either weekly or bi-weekly. Water quality data needed for modeling and forecasting should be collected daily along with phytoplankton densities and species.

Spatial coverage also varied depending on the specific goals and objectives of the issue. Most respondents felt that there are 3 basic spatial resolutions: local, regional and national. Local or site specific data needs to be at the highest (finest) resolution of 1 meter or better. Regional scale would require approximately 15-30 meter resolution and with national scale being the most broad at over 30 meter resolution. For site-specific seagrass restoration efforts, one respondent suggested that annual loss estimates be available on a 0.5 acre scale.

Tools
Many of the respondents specified that they would welcome web-based tools that would help them address the issues summarized above and avoid the necessity of browsing the web looking for particular information resources. Along with a conceptual model or tool that organizes information and provides a portal to additional data and information, several committee members suggested that a spatial database or tool summarizing the major factors stressing the ecosystem for specific areas would be beneficial. Others mentioned that tools that would allow for prioritization of sites for restoration as well as those that would allow managers to assess the outcomes of various restoration scenarios would be useful. Finally, one respondent suggested that the system include a database that showcases restoration projects and provides sufficient detailed information to understand how the projects were designed, implemented and why they did or did not succeed.

Along with the tools for the system, the end user committee members also provided information on functionality requirements for the system. All respondents stated that the system needs to be equipped with routine search mechanisms, downloading tools combined with an interactive GIS component. Many respondents stated that the ability to query information, download information (both raw data and GIS layers) and generate maps would be critical for the system. The ability to overlay different data sets on aerial photography would also be useful. Additionally, one respondent suggested that the ability to upload data or run a model and view graphical or other output would be a nice feature, as well as the ability to zoom in and out and select only those data to download that are appropriate for the specific need. The ability to view data prior to downloading was also viewed as a critical function. For programs that would require a substantial amount of time, the interface could alert the user of the estimated time required to process the request.

In addition to tools and functionality, many respondents provided some insight into ensuring the system would not be too cumbersome. They also mentioned that it may be necessary to provide different interfaces for the large and varied group of users. Essentially, all agreed that the system should be easy to navigate without too many steps for locating and downloading data. Several respondents mentioned using an easy to understand data catalog and common data dictionary that provides associated vocabularies to translate between the different naming and referencing conventions used by the various data providers. The metadata should be compliant with FGDC standards, but because this can be cumbersome, even the use of descriptions of data sources and how they were created, analyses conducted and data processing methods would be beneficial. The interface should be standardized with no need to download extra plug-ins, special viewers or browsers. Respondents also suggested that the system should be available in Spanish, but they could not address what issues may arise in the translation from English to Spanish.

Data Quality and Metadata
Most respondents agreed that some type of metadata that gives the potential user some idea of the data quality should be included. Although most agreed that FGDC standards should be preferred, one respondent stated that making datasets FGDC compliant is very labor intensive. Others pointed out that there may be other useful information that is not FGDC compliant and these data should still be considered and disclaimers posted when data quality is unknown or metadata is unavailable. At minimum, all datasets should include information on methods of data collection, problems that may have been encountered during the collection and any assumptions associated with the dataset. As for fusion of disparate data sets, respondents stated that this is always a challenge and some level of preprocessing will be needed to properly adapt the data for its most effective use.

GoMRC Demonstration Meeting Summary
July 9, 2007
St. Petersburg, FL

A meeting was held on July 9, 2007 in St. Petersburg, FL to demonstrate the Gulf of Mexico Regional Collaborative (GoMRC) system to the End User Advisory Committee. The goal of this meeting was to share the progress of GoMRC mid-way through the project and to receive feedback from the end user committee on current direction of GoMRC for specific use in coastal restoration decision-making. The GoMRC team also hoped to solicit end user input on near-term improvements to the system components, content and functionality, as well as long-term improvements and expansion of the system.

1.0 Welcome, Goals and Overview

The meeting was facilitated by Dr. Jill Engel-Cox of Battelle. Dr. Engel-Cox began the meeting with a welcome and introductions of all GoMRC team members, End-User committee members, and other State and Federal agency staff present. A list of participants is included as Attachment 1.

Following introductions, Dr. Engel-Cox briefly reviewed the agenda for the day's meeting (see Attachment 2 for a copy of the Agenda). She emphasized that the GoMRC team was hoping for a great deal of feedback, and that the agenda was designed with several "Discussion" periods to allow for all end-users to provide verbal input. A hard-copy questionnaire was also handed out to each meeting participant to acquire written input.

The welcome and introduction continued with comments from Mr. Terry McPherson, the NASA Program Manager for the GoMRC project. Following a brief introduction of NASA's role in the GoMRC effort, Mr. Steve Gajewski, the Battelle Project Manager, provided an overview of GoMRC. Mr. Gajewski presented the GoMRC mission and approach, the key features of the GoMRC system, and the intersection and collaboration of the GoMRC effort with those of the Gulf of Mexico Alliance (GOMA). He also summarized progress to date. Dr. Engel-Cox presented a synopsis of the end-user input the GoMRC team received earlier in the project, which provided the initial direction for the GoMRC system.

Goals and Overview Discussion
The first open discussion followed the overview presentation on GoMRC. The end user committee and other participants were asked to provide input on whether the GoMRC

goals were clear and whether the team captured the earlier input provided by the end user committee members.

The Director of the EPA Gulf of Mexico Program, Mr. Bryon Griffith, offered several points. Mr. Griffith reinforced the importance of the end user. He stated that the key client for the federal investment in the Gulf of Mexico Alliance (i.e., the Alliance) is the state end user. There was some concern by members of the end user committee regarding how to engage state resource managers to use the GoMRC system. For example, committee members questioned whether there would be the impetus at a high enough level within the state to have committed state members participating in the GoMRC process or ultimately using the GoMRC platform.

Mr. Griffith stated that, in the Governor's Action Plan, Harmful Algal Blooms (HABs) are an important issue and the governors have committed to address this issue. There is also a push within federal agencies and university researchers to address HABs. Next week the Gulf Coast Ocean Observing System (GCOOS) is meeting to look into developing a HABs system through the Integrated Ocean Observing System (IOOS) program to support the advancement of HABs tracking, forecasting, etc. Mr. Griffith mentioned that the GCOOS does not have an end user community and he sees the GoMRC end user group as fulfilling that role. He reiterated the opportunity the GoMRC end user group has to influence the direction the HABs issues take, and mentioned the language of President Bush's cable to the Mexican President that committed to supporting HABs observing systems in the Gulf. Mr. Griffith also mentioned that given the prominence of HABs issues, he was surprised by the lack of end users from the state Department of Health agencies that are often called upon to address HABs issues in terms of beach closures, safety of shellfish, and human respiratory concerns resulting from HABs.

Mr. Griffith also pointed out that, post-Katrina, seagrasses have not been a major focus. He does not anticipate seeing any major policy changes in seagrass issues within the next year. The key focus will be on global climate change initiatives and how these are impacting the hypersensitive coast of the Gulf communities. Issues will involve human survival and maintenance of property. He stated that one application area for GoMRC to possibly focus on would be the combination of ecological issues with economic impacts.

One end user was surprised to see that the focus of part of the GOMRC project thus far has been on submerged aquatic vegetation (SAV) and on Mobile Bay. The end user emphasized that one cannot think of restoration without first thinking about conservation, and that the GoMRC effort needs to prioritize issues in terms of both short- and long-term needs. For example, the potential long-term impacts of climate change should be considered. The end user suggested that the group should remember the big picture and look at many issues collectively, not just SAVs and HABs. Also, he suggested that GoMRC should focus on a broad set of other areas, not just Mobile Bay.

Another end user noted that a great conference on seagrasses was held recently in Florida; many participants at that conference were of the opinion that the focus should be

on not losing habitat in the first place. The end user similarly suggested that maybe the focus of GoMRC should not be on prioritizing restoration sites, but rather pre-emptive conservation. As for addressing HABs, perhaps using macroalgae to cross between seagrasses and HABs would be useful. Florida has problems with macroalgae blooms on many coastal areas.

The group discussed the fact that many things the states do are done through partnerships. Many of these "partners" are not federal agencies, academics, or other institutions that have the scientific expertise to fully use systems such as GoMRC. Acknowledging that the GoMRC development team stated that they will not focus on designing a system for the public at this time, one end-user cautioned that the "public" has many faces and that there are other important users beyond those state agency partners. Designing a system that will be useful to many will be critical.

Along with identifying the ultimate end users of a future GoMRC system, one end-user questioned where the GoMRC project would be and who would inherit this type of system if the current funding were to stop. Many felt that something like this would logically be transitioned to NOAA, but that many of the other agencies would also need to be involved. NASA stated they were not in the business of operation, but that this project represents seed money to begin development of a framework to integrate data from all agencies. Battelle provided some information on on-going discussions related to long-term funding.

Members of the GoMRC development team noted that many of the end user committee members seemed to be thinking of GoMRC only as a piece of software (i.e., that if not used will be shelved). Ultimately the "owners" of the system will be those who are actively updating models, functionality, etc. The development team envisions, ultimately, that there will be many "owners," but that it will be important to integrate useful tools and provide outreach and training to the user community in the next several months to ensure the tool is fully used.

2.0 Coastal Restoration Prioritization Framework

Following the discussion period, Dr. Ron Thom presented the model for coastal restoration. Dr. Thom discussed the framework that should be used to prioritize coastal restoration projects. This framework includes a statement of the goal (i.e., either to conserve or restore), a definition of the ecosystem, development of a conceptual model presenting the forcing functions, stressors and ecosystem attributes/biotic components, an evaluation of stressors, an application of appropriate strategies, an assessment of the type, magnitude and probability of change, implementation, monitoring, and adaptive feedback.

Dr. Thom continued by presenting a Basic Prioritization Model which can be used to estimate a "score" for each site. This score can be represented as a simple mathematical equation: **Score = (Δfunction) (area) (probability).** The change in function can be

estimated by comparing the potential quality with restoration to the existing quality. When evaluating probability, Dr. Thom reminded the group that the probability of success of a project is dependent on the level of disturbance on the site and landscape scales, stating that the best strategies will vary depending on the level of disturbance. Management strategies may include creation, enhancement, restoration, conservation or protection.

For the GoMRC project, Dr. Thom stated that based on past discussions with NASA and other Gulf agencies, the team chose to first focus on seagrass and SAV. Reasons for doing so included the importance of this habitat, the priorities in the Governor's Action Plan, and the facts that data exist to support the relationships and processes within Gulf SAV habitats and therefore it is somewhat tractable as an initial example of an approach. The GoMRC development team also chose Mobile Bay as the site for a demonstration project. The goal of this demonstration project is to link watershed/landscape conditions and site conditions to changes in seagrass/SAV, and to assess restoration strategies. This effort will involve assessment of current conditions, including local stressors and environmental controlling factors, analysis for effects of land-use changes and other stressors over time (years 1992, 2001), assessing effects of projected future scenarios incorporating conservation and restoration strategies (year 2030). Ultimately, it is planned that this concept be extended to other bays in Gulf of Mexico. Following the introduction of the Mobile Bay demonstration project, Ms. Chaeli Judd provided a live online demonstration of how the tools on the GoMRC website can be used to identify priority sites within Mobile Bay for restoration.

Coastal Restoration Prioritization Framework Discussion
Following the presentations on the Coastal Restoration Prioritization Framework by Dr. Thom and the demonstration of the restoration site modeling example by Ms. Judd, the GoMRC development team asked for input on whether the end users thought the model presented here would be able to meet their needs.

Several end user committee members wanted to know how much time and effort would be needed for using the restoration models for an application area. For example, it was asked if a user could simply input their dataset, and if datasets representing both the stressor(s) and how to weight those stressors would be required user input.

Several users were very pleased with the tool. End users familiar with Mobile Bay thought the demo of the SAV in Mobile Bay demo was great, but that salinity would definitely need to be incorporated. The users liked having all data layers in one place. They would like to use this type of tool to look at general habitat preservation throughout the estuary, including wetlands, mangroves, long-leaf pines, etc., to better identify where to do restoration. In the past, the Mobile Bay National Estuary Program (NEP) worked with the Nature Conservancy to do some priority planning for restoration and conservation efforts. In the end, they still weren't comfortable with identified locations for restoration and conservation. In that case, one of the key factors in identifying sites was related to what parcels were available and which were good candidates for conservation. This discussion emphasized that another key parameter needed in site

prioritization is knowledge of whether the land is publicly or privately owned, and by whom.

Another end user committee member thought that a tool needs to be incorporated in GoMRC planning that would allow evaluation of end results. For example, if the tool provides base maps to reflect priority habitat, those same maps could be used throughout the restoration to check progress. Essentially, tools need to be developed for checking progress of all restoration/conservation activities, as well as the planning and implementation of those activities.

A participant from NatureServe mentioned that they have developed a dataset that presents categories of wetland areas throughout the Gulf. The dataset contains specific environmental variables for the different wetland categories, as well as ranked measures of condition (e.g., from poor to good). The dataset should be ready for release in the fall and would fit very nicely in the GoMRC system.

Another end user asked how the GoMRC system would address the valuation piece of site ranking (i.e., how do end users decide which habitat type should be preferred?). Also, it was noted that with projected sea level rise, there are some habitats that may not be wise choices for future investment. There are so many things changing so quickly in the Gulf, it will be important to understand how it is changing and which direction habitats are moving.

A concern among many of the end users was how long the tool will last and continue to be used. In many state agencies, people change positions and/or move on and there would be loss of continuity and training. Somebody at the agency would need to take ownership and provide training. Some potential users wondered if the goal for GoMRC was the ability to run as a separate piece of software on an individual computer, or to be an online resource. Some of these GoMRC tools may require user sophistication such that training will be necessary. Several end users questioned whether the models were standard type models that would need to be tweaked for particular regions, or whether the tools represented proprietary state of the art models that would not fit all scenarios.

It was also mentioned that the assumptions that go into the models need to be well thought out and getting scientists to agree on these assumptions will be difficult. For example, in Florida, the light attenuation piece is difficult and the algorithms don't work due to issues with color. Although end users thought it was a great idea to incorporate all of the appropriate datasets, models and assumptions into GoMRC, there was concern over who would do it. Most agencies don't have the scientists or technical support staff to process this data and get it into this type of model.

End users also thought that availability of data may be a limiting factor. For example, there may be additional data needs that cannot be acquired from remote sensing. One advantage of working closely with the Gulf of Mexico Alliance is that some of the focus groups are in the process of identifying available data. Another concern of the end users

was the potential costs for data. The GoMRC development team anticipates that the data and data products produced would be free, particularly from current satellites.

One end user observed that while the current GoMRC tool is successful in focusing on a very small piece of the Gulf of Mexico region, the Gulf area encompasses thousands of kilometers and the same levels or types of data streams will not necessarily be available from all areas. Therefore, it was suggested that the GoMRC development group consider providing different levels (scales) of products. The general "big picture" is also needed, because decision makers need to understand what is going on at the larger scales before they look at the smaller scales. Gulf-wide products may be needed along with the smaller scale tools for specific areas. It doesn't appear that the tools developed for the smaller localized areas could be applied to the more general/broader Gulf-wide picture.

At the larger scale, data limitation may again be a problem. It was mentioned that although it might appear there are 100 datasets that cover the entire Gulf region, as those datasets are further evaluated, maybe only a small number of those truly encompass the whole region. End users noted that caution must be used when using remote data because verification/validation of algorithms is needed before trusting the data.

On the small scale, many of the end-users like the tool and thought it could be useful. It was suggested that the algorithms be tweaked to see if the tools could work at the different scales. As the basic research continues the algorithms will continue to get better.

One potential danger many end users voiced was that these GoMRC tools have to have "life" to be successful – momentum to keep them going. They need folks to use them and promote them. They need to be part of a toolkit. One end user suggested that coordination with the website EBMtools.org, which is an ecosystem-based network designed to get data tools out to the public and it might allow GoMRC tools to "get their legs."

Other end users suggested other models that should be considered for incorporation into the GoMRC toolset, including economic models to evaluate costs associated with coastal issues, particularly those that assist with hazards planning. It was mentioned that NOAA is funding several projects looking at datasets that have economic aspects. These are still research efforts, but the pressure is there from Congress to show what the economic impacts are. Some participants stated it would be interesting to identify the economic costs of having to rebuild versus having left the natural environment there in the first place. The Nature Conservancy is seeing hazard planning combined with biodiversity planning. Mississippi is evaluating many different models associated with storms to determine where to have people move, and which areas to build levees in order to limit loss of life and property.

3.0 User Requirements and System Functions

The next presentations of the GoMRC system focused on the Conceptual Model Explorer, the advanced search capabilities using Noesis (a metadata search engine and resource aggregator), MapMaker and Real-time image viewer. Mr. Tom Gulbransen

began the presentation stating that the challenge to the GoMRC team is to find valued assets via useful services. The team chose to create a tool to convey a conceptual model to organize information and display the relationship between concepts. Additionally, restoration planning will need to rely on group awareness and a tool will enable a central clipboard for disparate findings. The conceptual model tool will also promote issue-oriented investigation across multiple disciplines that are transparent and can adapt to varying lines of evidence and perspectives.

Dr. Michael Guzy then presented the Conceptual Model Explorer tool and an online demonstration of the seagrass model. Following the demonstration by Dr. Guzy, Mr. Danny Hardin presented the rationale for creating a new data mining tool with display options. Mr. Hardin then gave a demo of the Noesis search and the MapMaker and image viewer functions.

User Requirements and System Functions Discussion
After the presentations, one end user pointed out that in Real-time Image viewer, a good part of Mexico is missing. This needs to be fixed to include all of the Mexican states as well as the US states.

There was also a question about a formerly supported mapping tool called WorldWind. UAH team members believe it is possible to use it, but that Google Earth had different aspects that were applicable to the tasks for this project.

One user commented that it also appears the map viewer itself is relying on users to document their map. It was suggested that maybe some sort of quality check (i.e., the minimum requirements) should be implemented. Very few people create metadata documentation for maps, but that documentation describes what the map is and provides defensibility for use.

Several users also wondered whether you could actually get the data from the map. For example, they asked if you could physically download the "bits", and if the files calibrated so that the end user could get some sort of grid for the images. The numbers would be more useful than just the picture. If the tool could be made to do this it would be very useful. For example, if the map provides what you are looking for, end users noted that it would be helpful to be able to link to the data that created it.

Similarly, for the Noesis search, if a metadata file is found, the end users thought it would be useful if it could link directly to the data. It might also be useful to create a login screen so that when a former user logs into the system, it brings that user's previous searches back up. Users commented that a search that resulted in a list that was prioritized by quality of the results may be helpful as well. For example, those files having the most attributes could go to the top of the list.

Several participants were still concerned about the practical implementation of many of these tools by staff in the field due to time investments needed to learn how to use them. The staff simply may not have sufficient time to "fiddle around with" the tools. It won't

matter how nice they are if they aren't used. The end users thought that a key question the GoMRC team needs to address is how can those people who need to make the decisions to do this work be brought in. This can be incredibly difficult because many times the state resource folks often cannot define their needs. Something needs to be created that will pull it all together and allows the user to quickly and easily see all the information and make a decision.

Other end-users reiterated the concern that many staff at resource agencies have limited time. Most do not have time to do any type of literature searches. Therefore, having the literature search capability may be helpful. If the experts could design work flows and sufficiently annotate them, the user could drill down and get associated documents and data. However, turning documents into data that can be visualized is difficult to do. It is also important to remember that when pulling data from other sources, the information may have already been processed several times. If metadata are not available, there is no direction on how to apply the data. Some participants wondered if the GoMRC team could pre-create the documents that organize results of search, while the sustained expertise of the user community would be responsible for continually updating the information.

An end user committee member suggested that teams of experts who are capable of identifying whether models are realistic or not could work with ecologists within the state agencies and train them how to use various tools. Some committee members thought it would be more effective to work from bottom up and not top down. If the programs and tools are perceived as too "canned" they won't address the unique concerns of Gulf. Within the NEPs and National Estuarine Research Reserve System (NERRS), the staff may be more open to using a program like the demos presented. Perhaps a strategy would be to target the first release on NEPs and NERRS and train them to use the tools. Then NEP and NERRS staff could be relied on to get the information out to others. Training will be critical and maybe just a few could be trained initially, 1-2 people in each area, focusing on those who have the ability to tweak the models when necessary.

A participant from Mexico thought the tool would definitely be useful and that staff conducting the National Wetland Inventory and evaluating sea level rise on mangroves, as well as those evaluating ecological land use planning, might find this tool helpful. It was suggested that the tools developed for this project be reviewed by scientists in the academic institutions and agencies in Mexico, but it was noted that people are very protective of their information and there may be some difficulties in establishing relationships.

Another Mexican participant suggested that the framework to work within in the United States would be the Gulf of Mexico Alliance, but that to work with Mexico, the Gulf of Mexico States Accord (GoMSA) might provide a better framework. GoMSA has existed for several years and has a successful model that is driven by the individual states needs (i.e., otherwise it would not build the capacities in those Gulf States). Veracruz has been working through the Accord to develop the Red Tide Monitoring capabilities for the state. In addition to monitoring via remote sensing, the state of Veracruz has built its first

offshore ground-truthing station and within the next 3 months is scheduled to implement three additional stations. In Mexico, there needs to be Gulf wide organization between the federal government and the state agencies, as well as the universities.

4.0 Next Steps and Opportunities

The final item on the agenda for the meeting was a short presentation on the next steps and opportunities for GoMRC. Mr. Steve Gajewski discussed the long-term GoMRC development applications, which included applications development to enhance Gulf-wide capability for SAV site prioritization, further development of the coastal habitat restoration model to include habitat structures beyond SAVs, and a Harmful Algal Bloom application. In terms of analyses, long-term aspirations include additional input and output flexibility with simulation models, user ability to adapt prioritization schema, and user contributions to contextual information, definitions, conceptual models and regional goals. The GoMRC team would also like to develop a suite of tools to assist in conducting baseline analyses, trend analyses, goal setting, additional prioritization, and forecasting. The search capability of the site would also include more catalogs, wider conceptual models, vocabulary and ontologies, geospatial mining, degree of relevance of results, and additional Web Map Service (WMS) or Web Feature Service (WFS) sources. Finally, the team would like to enhance access and manipulation by providing more adapters to access priority distributed assets, direct web services to and with archive centers and dynamic offering of Open Geospatial Consortium (OGC) coverage.

Next Steps and Opportunities Discussion
After the final presentation on "Next Steps," the end user group was asked what other priority decisions or questions would they like to see GoMRC address and what other subject areas the GoMRC team should focus on. Additionally, the team was interested in any additional input the end-user group had on how to keep this project moving forward.

In order to keep things moving forward, many in the group felt it would be important that the Gulf States commit to it. The states do not necessarily have to drive it, but they have to be committed to using and promoting it. Additionally, the NEPs and NERRS credibility with the states should be leveraged to reach out to and educate the states and other end users. Because Mexico does not have something like the NEPs, in that region the Gulf of Mexico States Accord should be used to help build the regional capabilities of the Mexican Gulf states into GoMRC.

As for issues, meeting participants mentioned a meeting in New Orleans that occurred several years ago. During this meeting, participants decided that red tide was the guiding issue that was going to be the theme for both the U.S. and Mexico to focus on. This theme would not politically affect anyone since algal blooms know no boundaries and flow from state to state, giving all parties a vested interest. This meeting set the stage for building an infrastructure that would serve the marine community. The status of the international HABs effort was questioned one of the end users. There was a question of

whether the effort requires funding from the federal agencies to keep the states coming to the table. A participant from Mexico stated that it is still being discussed within GoMSA.

NOAA is also supporting the U.S. – Mexico Binational HABs plan. A binational website is being developed. Brevebusters (optical detectors for *Karenia brevis* blooms) are being deployed, the NOAA HAB Bulletin is being expanded from FL to TX and the other Mexican states, and there is emphasis to include other species of HABs. If GoMRC goes further with HABs, it will be important to look and see what else is going on and what other, if any, new capabilities this GoMRC system would bring. There are still many unanswered questions regarding HABs, particularly in forecasting and socioeconomic impacts.

There was a suggestion from the end user committee to also begin looking at freshwater HABs and macroalgae. Local governments in FL are investing money in this issue. A starting point might be to put a conceptual model together to see where the gaps are and where the research needs to go. There was also a suggestion to go beyond SAV in the habitat realm and look at the classes of the Coastal and Marine Ecological Classification Standard (CMECS) system. There are 8-10 of these CMEC classes, and this would help clarify habitat issues for all states. Also, the GoMRC development team may want to look more broadly than independent stressors in the future. For example, it was suggested that GoMRC consider others factors like land use, suitability of habitat, and natural landscape connectivity.

Several end user participants felt that given the timeframe of the project, the development team will not be far enough along in 5 months to walk away from the original SAV and HABs focus. They suggested that it may be more beneficial for GoMRC to stick with these initial issues and get to a product that makes sense, demonstrating the utility of the current tools, and waiting to take on new capabilities until the initial capabilities are fully developed. The decision criteria for these issues within the states needs to be brought in and goes along with economic piece.

Participants felt that developing decision support tools was a good focus. It was pointed out that making a decision means choosing, something many politicians don't like to do. Perhaps it would be beneficial to present a case study where a choice must be made. For example, it was suggested that using the tools, the GoMRC team demonstrate how it would change something (e.g., some habit) or help make a decision in a given scenario. Presenting the "what would happen if……" case studies (e.g., in face-to-face workshops) for several different scenarios was viewed by the end users as being a useful way to educate the future end users of GoMRC tools and show how it can help them answer specific questions.

ATTACHMENT 1: List of Participants

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ATTACHMENT 2: Agenda

11:00 – 11:15	**Welcome, Introductions, and Goals** Welcome and introductions Review of agenda Goal and expected outcomes of demonstration NASA support of GoMRC	Jill Engel-Cox, Facilitator Terry McPherson, NASA Program Manager
11:15 – 11:45	**Overview of GoMRC** GoMRC project overview and progress to date GoMRC-GOMA collaboration Synopsis of user committee input	Steve Gajewski, Project Manager Jill Engel-Cox
11:45 - Noon	*Discussion:* *Are the goals of GoMRC clear?* *Did we capture your input effectively?*	
Noon – 12:30	**Coastal Restoration Prioritization Framework** ▪ Prioritization model ▪ Conceptual model for SAV habitat	Ron Thom
12:30 -1:00	**Working Lunch and Break (box lunch provided)** Laptops available to individually interact with GoMRC website	
1:00 – 1:30	**Restoration Sites Example** Restoration site prioritization for SAV in Mobile Bay	Chaeli Judd

1:30 – 2:00	*Discussion:* *How does this model for decision-making as presented here meet your program decision needs?* *What similar decision processes have you gone through recently where this type of investigation was warranted?*	
2:00 – 3:15	**GoMRC User Requirements and System Functions** Introduction ▪ Conceptual Model Explorer Overview of GoMRC search and discovery functions ▪ Advanced search with Noesis ▪ MapMaker, Real-time Image Viewer ▪ Keywords and Ontology ▪ GoMRC-SERVIR Mexico channel Work Flow Explorer ▪ Work Flow ▪ Personalization	Tom Gulbransen Danny Hardin Michael Guzy
3:15 - 3:45	*Discussion:* *What other functionality is important?* *What other datasets should GoMRC include?* *What other models should GoMRC be compatible with?*	
3:45 – 4:00	**Break**	
4:00 – 4:30	**Next Steps and Opportunities** ▪ Aspirations for long-term development of GoMRC ▪ Priority applications / management or policy decisions that would benefit from GoMRC platform ▪ Prospective Involvement in HABS, Sea Level Change, others	Steve Gajewski
4:30-5:00	*Discussion:* *What other priority decisions or questions would you like to see GoMRC address?* *How could the system be developed to support these?* *What other subject areas should GoMRC focus on?* *Should the focus be on more topics or deeper into few topics?* *How can we most effectively get end users to test and use this system?* *What is the best method to reach out to other users?* *Any other input?*	
5:00-6:00	**Final Input and Interactive Session** ▪ Laptops available to individually interact with GoMRC website ▪ Complete written questionnaire ▪ One-on-one questions and answers	Jill Engel-Cox
	Thank you!	

ATTACHMENT 3: GoMRC End User Questionnaire and Compilation of Results

Overview of GoMRC

If asked to describe the Gulf of Mexico Regional Collaborative in your own words what would you say?

MC: GIS-based coastal restoration decision making tool designed for use primarily by natural resource scientists generally working for state agencies and NGOs.

RP: Both a technical as well as collaborative capability demonstration

JI: To use GIS and remote sensing tools to better understand the geography and natural resources and atmospheric conditions of the Gulf area in order to preserve and restore habitats and ecosystems. The tools should contribute to better decision making for managers.

JC: GoMRC is an effort to provide Gulf of Mexico resource managers with web-based data, models and tools that will help them make better, more informed management decisions.

Are there areas where you see complementary or redundancy between GoMRC and other Gulf of Mexico resources/initiatives?

RP: EPA/NOAA HABSOS (Binational HABSOS Project). Corps of Engineers PHINS Map Viewer. GAME new EPA project from FWCC (Gap Analysis)

JI: No real redundancy. We need to study appropriate links. However, we should "merge" in some way the HABSOS Bulletin since politically that has been/will still be the driving theme.

JC: Gulf of Mexico Alliance, Gulf of Mexico States Accord, Gulf States Marine Fisheries Council, EPA Gulf of Mexico Program, TNC's Gulf of Mexico Initiative and probably many other similar efforts aimed at doing a better job of managing the gulf's resources exist and are complementary or redundant. I'm not familiar enough with these to say what parts may be redundant or complementary.

Does the organization of the website interface make sense? What additions would improve the interface?

RP: Good and getting better. Linkage – Noesis – MAP – Conceptual model

JI: It was very professional but we might be able to add a few things without making it too heavy, such as other tools and links with related pages.

JC: Currently, it looks fairly reasonable. Though if it grows to include more than SAVs and HABs, it could quickly get confusing.

Is additional "how to" information or user guidance needed? If so, what areas need more help documentation?

RP: How to .mpg movie? We did something similar through MS Public Broadcasting

JI: We need a handbook for "dummies" such as myself and the interested public. The result should be improved capacity for education.

JC: Yes, I think you should assume that even if this site is used mostly by scientists, not all of them will be comfortable with how to manipulate web-based models and GIS -type data. A tutorial or training workshop might be helpful.

Coastal Restoration Prioritization Framework

The restoration prioritization framework for SAV is based on an ecological conceptual model and includes tools for three model elements (ecosystem controlling factors, ecosystem stressors and habitat change). What are the benefits and drawbacks of this framework? Are there additional elements that should be incorporated?

RS: Recommend following Roberta's recommendations.

JI: We have to figure out how to better represent socio-economic stressors and source type of modeling and simulation capacities. By the way, the tool in place is very useful with the problem that it requires a very sturdy data stream.

JC: I'll leave this question to those who are more familiar with seagrasses.

GoMRC User Requirements and System Functions

Tools for Visualization, Animation, Display, and Information Search

Rate the utility of the following GoMRC tools for you/your program on a scale of 1 (not useful) to 5 (very useful).	Not Useful at all	Only slightly useful	Neutral	Useful	Very useful
	Number of people rating tool at each level of utility				
Ecosystem Conceptual Model Explorer			1	2	1
Restoration Prioritization Tool			1	3	
Interactive Maps (map viewer)		1	1	2	
Real Time Image Viewer (animator)		1	1	2	
Noesis search engine				3	1
Data, Tools, and Map Resources Links for the Gulf of Mexico				2	1
GoMRC Website Overall			1	3	

MC: All would be useful. The Interactive Maps and Real Time Image Viewer functionality exists elsewhere

RP: Ecosystem conceptual model explorer, restoration prioritization tool, Noesis search, GoMRC overall website useful. Interactive maps and Real Time Image Viewer only slightly useful – are not unique – go Google.

JI: Ecosystem Conceptual Model Explorer, Noesis search engine and Data tools, map resource links all very useful. Restoration prioritization tool, interactive maps and Real Time Image Viewer and overall website are useful

JC: I have not had much time to devote to looking at the website and have had some problems with displaying maps and data so these ratings are very preliminary. Ranked the ecosystem conceptual model explorer, restoration prioritization tool, interactive maps, real-time image viewer and overall website neutral. Noesis search engine and data, tools and map links useful

MapViewer / Animator

Are there additional mapping features you would find useful?

MC: would like to experiment with this more

RP: UMS limited by providing documentation of the data (how well is the data documented) – Filter to minimum standards – descriptive column by metadata

JI: Please talk to Bill Teague about his tool for tracking and simulation of ocean currents. We have to consider the inclusion of that tool.

JC: Not sure.

Noesis

Are there additional features you would find useful regarding the Noesis search capabilities (keyword options, ontology, information archiving, etc.)?

MC: would like to experiment with this more

RP: Great! Data to Map Viewer – needs some explanation on capability & limitations

JI: Once it was explained to us how to use it, it was easy to see its high value

JC: Archiving relevant sites would be useful.

Conceptual Model Explorer

Are there additional features you would find useful regarding the Conceptual Model Explorer?

MC: This looks very interesting. Would like to experiment with this more.

JI: I am not the person to answer this. I am sure it is very useful, but I find it complicated.

JC: Not sure.

Functionality / Areas for Improvement

What functionality that you saw demonstrated today will be most useful to you?

MC: Map Viewer

RP: Data quality in search

JI: The merging of maps with the GoogleEarth viewer. Visual tools are very powerful for making a point.

JC: Didn't see a lot of functionality at the meeting, but the Mobile Bay demo was interesting.

What other functionalities not already included in the GoMRC system are important for your program needs? (i.e., where is GoMRC lacking?)

RP: Data quality in search

JI: As a NASA funded project, we should explore how to better integrate other satellite sensors to this effort, specifically for higher resolution imagery capacity. The seagrass example brought forward was case in point. The involved sensors will miss a lot of it.

JC: Synthesis papers would be very useful, e.g., publications talking about positive and negative impacts of hardened shoreline or offshore breakwaters.

Other Input

Please include any additional comments you have.

MC: Thanks for letting me serve on your end user committee. I think that your program adds merit. I will spend more time working with your web page and will have more comments later.

RP: Transition Plan – Research to Ops – USGS, NOAA, EPA, State

Two audiences: Folks who will develop the "product" (e.g., authors the model) and managers who will analyze or use the output (final product)

JI: 1) Include in some way, socioeconomic parameters
2) Add main species habitats, specifically for protected species or for migratory birds
3) Merge the viewing tools in some evident way with GoogleEarth since it is the main viewing tool worldwide today, to the point perhaps to even include a specific tool.
4) We have to figure out how to better merge the different tools
5) More user-friendliness please!
6) Let's meet in Veracruz soon.
Good Job! Stay the Course.

JI (additional):

1.- In addition to the coastal data, we really need to do the land use characterization of the Gulf areas.- This has to be done on a general basis, not in a detailed fashion. We need to be able to identify land cover: wetlands, secondary tropical forest, jungle, mangrove forest; and land use: urban areas, crop lands; and even be able to identify crop differentiation: citrus trees, sugarcane, bananas and plantains, other...

This will allow both better conservation and planning. Both NOAA and NASA have tools that can do this without much difficulty and on a broad-based scale. By the way, I did take the chance to talk about it to both NOAA and NASA officials present and they agreed.

2.- Regarding the use of higher-resolution imagery, we should simply contact the GOOGLE-EARTH people in order to seamlessly incorporate their viewer.
Today, that is the Planet's open source platform, with over 250 million users. The real issue here is simply to guarantee that the whole region portrays Ikonos or Quickbird satellite imagery, so as to be able to provide users with both a very friendly and precision tool that can accommodate both the larger public and policy makers. It would also be great for educational purposes.

Also, GOOGLE-EARTH will provide a far more professional service for a reasonable fee, something that has to be explored.

Another alternative is NASA's own EARTH WIND viewer, which they can adapt without third parties.

JC: Providing this kind of product to a broad spectrum of users and issues has to be very challenging. Several folks at the meeting suggested focusing on HABs. If that's the issue that's most easily integrated into the GoMRC system, then you should focus in on that issue and show how GoMRC can improve the way resource managers currently deal with HABs.

RESTORATION PRIORITIZATION TOOLSET

Documentation and User's Guides 2007

Gulf of Mexico Regional Collabratory (GoMRC)

Pacific Northwest National Laboratory - Marine Science Operations

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Ron Thom

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October 2007

RESTORATION PRIORITIZATION TOOLSET

Documentation and User's Guides 2007

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1. Overview

1.1 Background

With the growing population and pressure to develop coastal areas as well as coastal watersheds, conservation and restoration of coastal ecosystems is a high priority for the nation. Managers must make decisions on complex problems every day, and having a credible scientific basis for these decisions is critical. In addition, they need to plan and implement restoration in a cost effective manner in order to maximize results for the money spent.

Among the most often sought after tool by managers is one that prioritizes restoration projects. A prioritization decision tool provides a basis for making investments in restoration projects. Ideally the tool contains the relevant scientific underpinnings, and facilitates the decision making process by providing an effective interactive mechanism.

The Restoration Prioritization Toolset forms part of an integrated system within the Gulf of Mexico Regional Collaborative (GoMRC) framework to facilitate decisions related coastal ecosystem restoration, specifically the management of submerged aquatic vegetation. The tool will examine environmental factors, and provide recommendations based on potential restoration success.

1.2 Development of a conceptual model

Conceptual models are an increasingly popular method resource managers use to document their understanding of system dynamics, and can be used as a basis for ecosystem restoration. In this application, we created a conceptual model for seagrasses/SAV (http://www.gomrc.org/conceptual_model.html). The fundamental concept is that there are certain environmental parameters (controlling factors) such as sufficient light, correct temperature, correct substrate for growth, etc… that a species needs to flourish. Areas with

these characteristics at least have the basic requirements for restoration of the species of interest. However, stressors (such as increased wave energy, contamination, or even disease) may make an area with adequate ranges of controlling factors unsuitable for restoration. Suitable conditions lead to suitable structure (SAVs) and the wide range of processes, functions and values that the structure supports.

The main elements are below.

Stressors → Controlling Factors → Structure → Process → Function → Values

- **Controlling Factors** are those elements such as light, temperature, sediment type and desiccation which limit and determine habitat suitable for species growth.
- **Stressors** are elements which act on controlling factors (or directly on seagrasses) and may make an otherwise suitable site unsuitable. Examples of stressors include dredging, filling, boating activities, storm events, and shoreline armoring.
- **Structure** is the species itself. In this case, it is SAVs or seagrasses
- **Processes** are environmental processes such as food web support or carbon sequestration which are a result of the structure
- **Functions** such as fish production result from the processes
- **Values** are social and economic values such as fishing, property protection or aesthetics which are a direct result from the functions.

1.3 Integration into GIS models

Based on the conceptual model, the Restoration Prioritization Toolset uses local GIS datasets, bathymetric information, and datasets derived from NASA products to represent elements of the conceptual model. This can assist the user in evaluating stressors, controlling factors and recommend a restoration management strategy based on current and past structure distribution. These GIS modeling techniques have involved weighting of system controlling factors and system stressors to score pre-defined ecological zones based on their suitability for restoration.

1.4 Restoration Toolset Elements

The Restoration toolset is comprised of three fundamental elements (Figure 1-1):

1. <u>Model for Controlling Factors</u> which uses NASA derived datasets with local datasets to predict areas which are suitable for a species growth.
2. <u>Benthic Change Tool</u> examines species structure and distribution
3. <u>Prioritization</u> are scripts which summarize and weight stress and produce final recommended management actions.

While each can be executed by itself, together they can be used for prioritization of restoration activities.
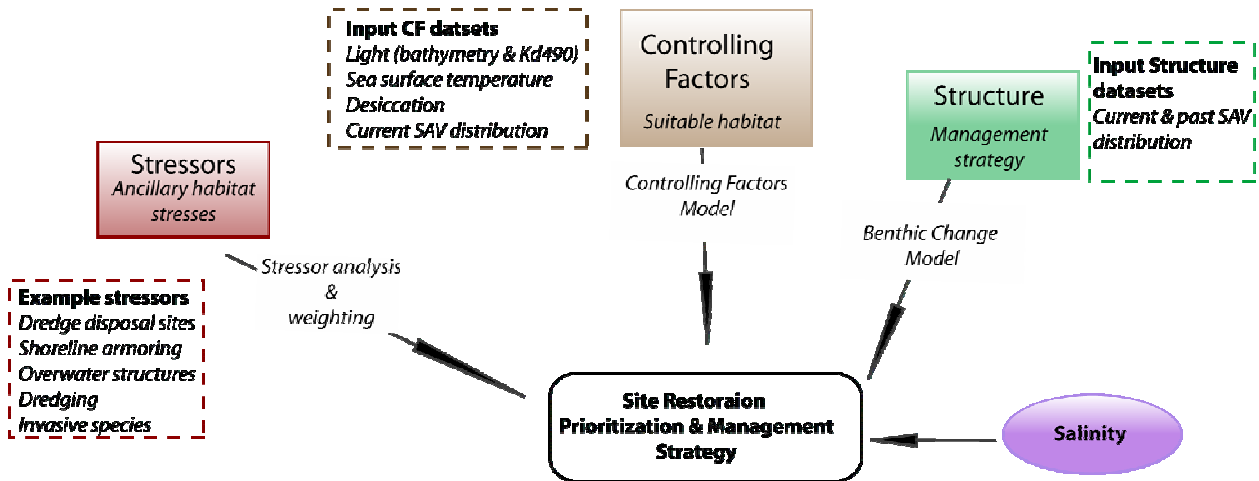
Figure 1-1. Restoration Toolset Elements. Restoration Toolset Models can be executed by themselves or sequentially for site prioritization and management. Each element analyzes one of the components of the conceptual model and provides feedback to the user based on that component. Finally, salinity for each site is examined to recommend a species appropriate for the site.

2. Controlling Factors Model

2.1 Background & Tool Overview

Predicting sites suitable for SAV habitat through models has been explored by several researches and applied in a variety of local bays and estuaries (Kelly et al. 2001, Lathrop et al. 2001, Short et al. 2002, Callahan et al. 2003), however all analyses have relied on previously collected in-situ data. New products derived from NASA's MODIS satellite provide a more cohesive spatial and temporal coverage in the Northern Gulf of Mexico on a 1km and a 250m scale for sea surface temperature and the light attenuation coefficient Kd488. These new products can provide a potentially better input into a GIS model, capturing spatial and temporal variability.

The Controlling Factors Model (CF Model) is a spatially explicit GIS model based on the scientific conceptual model for seagrass/SAV in the Gulf of Mexico (http://www.gomrc.org/conceptual_model.html) which evaluates three of the most universally important factors (desiccation, temperature, and available light) that control distribution of seagrasses and other types of submerged aquatic vegetation (SAVs). The output of the CF model is a scored grid with values of 0-9, corresponding with the suitability of habitat for SAV. This output can also be summarized based on sites of interest, or what we refer to as spatial decision units.

2.2 Scientific Basis for Scoring

Desiccation

Submerged aquatic vegetation found in the intertidal zone becomes stressed if it is exposed for extended periods of time to the elements, and desiccation may well be the major limiting factor for upper intertidal eelgrass (Boese et al. 2005). By examining current SAV distribution and bathymetry values, areas which are too high are excluded from further analysis, areas which are somewhat high are given a lower score and areas which are deep are given the highest score.

Sea Surface Temperature

Water temperature also affects submerged aquatic vegetation distribution. While different species have adapted to different water temperature ranges, the ones looked at in the gulf: *Halodule wrightii, Ruppia maritima and Vallisneria americana* (Fonseca 1998, McFarland

2006) have similar optimal temperature requirements.

Available Light

Submerged aquatic vegetation must have sufficient light to carry out photosynthesis. The deeper the plant is, the less light is available, and in fact, the lower edge of vertical distribution is often determined by the amount of light available to plants. This can be described by the following adaptation of Lambert –Beer's Law where, for any given wavelength:

$$I_{\lambda,z} = I_{\lambda,0} \ e^{\ (-kz)} \qquad (1)$$

> z is depth
> Io is irradiance for the wavelength λ at depth 0.
> K is an attenuation coefficient
> Iz is irradiance at depth z for wavelength λ.

Using the Kd488 (or the attenuation coefficient at 488nm) product and a separate bathymetry dataset, we can calculate the percent of light at the surface which exists at depth (z). The raster model then extracts values for % surface irradiance (SI) for areas where SAVs are currently present and scores areas with suitable light more than those without.

Assumptions:

This light product assumes that the incoming radiance at the surface of the water is the same throughout the study area. The amount of light present at the water's surface varies day to day and hour to hour. Weather, time of day, season of year, and solar flares are among the variables that alter the amount of radiance hitting the water's surface. We assume that the variance of these factors over any particular bay/estuary is negligible for the purposes of this analysis.

2.3 Scoring

Description of the scoring can be found in Table 2-1. Figure 2-1 provides an illustration of how scores are obtained from distribution characteristics for desiccation and light attenuation.

Table 2-1. Scoring regime for Controlling Factors Model. Results for each element are added together, for potential scores ranging from 0-9 for each pixel. Scores 0-6 should be interpreted as unacceptable, 7 marginal, 8 & 9 acceptable for SAV growth

Controlling Factor	Score	Score Range
Desiccation	2	Lowest elevation in bay to $+1\sigma$ for distribution
	1	$+1\sigma$ to maximum elevation for distribution of SAV
	Excluded	Areas above maximum elevation for SAV
Sea Surface Temperature	0	Below 20°C; Above 37°C
	1	20-28°C; 32-37°C
	2	28-32°C
Light Attenuation	0	Lowest (Iz/Io) in bay to min (Iz/Io) for distribution
	1	Minimum (Iz/Io) for distribution to - 1σ for distribution
	2	- 1σ for distribution to $-1/2\ \sigma$ for distribution
	4	$-1/2\ \sigma$ for distribution to $+1/2\ \sigma$ for distribution
	5	$+1/2\ \sigma$ for distribution to Mean Sea Level
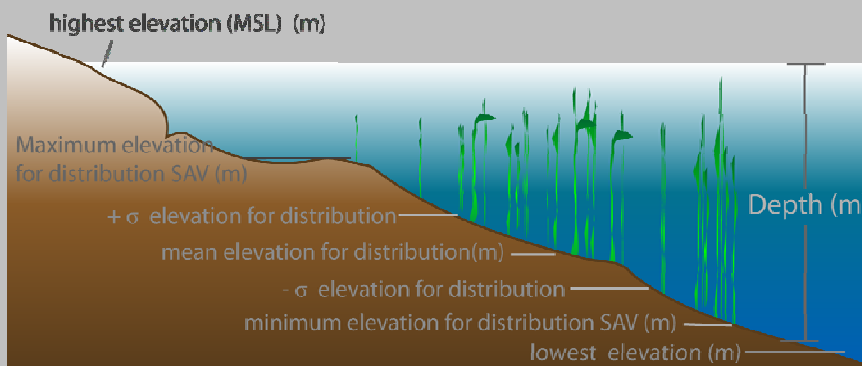
Figure 2-1. Scoring for desiccation. Based on current SAV distribution and bathymetry, we can derive the upper growth limit for SAV. We can then apply that limit to score the entire study area to score areas that are more like the current habitat higher than those that are not.

2.4 Technical requirements

Technical details for input datasets can be found in Table 2-2.

Table 2-2. Input dataset requirements

Input Dataset	Type	Description
Spatial Decision Unit (Potential Sites) *Optional*	Shapefile	Projected shapefile with a unique numeric code for each site. Includes attributes « AREA », which is the area of the site, and « LENGTH », which corresponds to the length of shoreline present in each site.
Bathymetry	Raster	Should be at a resolution sufficient to capture nearshore features. The vertical datum should be adjusted to Mean Sea Level and be in meters. Apply a mask to eliminate any values above sea level. Areas below sea level are positive.
Light Attenuation Coefficient	Raster	Current input is MODIS K490 composite for a month, units should be m-1.
Temperature	Raster	Current input is MODIS SST composite over a month. Units should be in degrees C.
Current SAV Distribution	Shapefile	Projected shapefile which only represents species of interest. Mapping project should be complete for the area of interest

Output

The output of the CF model is a scored grid with values of 0-9, corresponding with the suitability of habitat for SAV. A user may also specify that results be summarized based on the spatial decision unit. In this case, the original shapefile is copied and two new attributes area added: GDAREA which is the total area per decision unit rated as good, and AVGSCR which is the average of scores 7-9 per decision area.

3. Benthic Change Analysis Tool

3.1 Background & Tool Overview

Over the last century, seagrasses have undergone a dramatic decrease in extent throughout the Gulf of Mexico (Handley et al. 2006). Though in recent years, the rate of decline has decreased, and even reversed at some sites, monitoring how and where the extent of SAV changes is important for resource managers.

The Benthic Change Analysis Tool enables a user to quickly spatially evaluate presence/absence change for SAVs and seagrasses between two time steps. The output of the Benthic Change Tool is a coded grid with four values.

If the evaluation is carried out as part of the Restoration prioritization assessment the user also has the option to summarize output raster based on an input shapefile, where each record is considered a separate 'Site' or spatial decision unit. Through this option, three new attributes are added to the input shapefile: RESTORE, ENHANCE, PRESERVE. The area in each site coded for each potential management strategy is recorded (see Table 3-1). At this point, these are just potential management strategies, to be evaluated with other factors.

Table 3-1. Codes for Benthic Change Analysis. Analysis helps select management strategy appropriate to site.

Code	Meaning	Potential Management Strategy
0	Currently present, historically absent	Preserve / Conserve
2	Currently absent, historically absent	Creation / Enhancement
4	Currently present, historically present	Preserve / Conserve
6	Currently absent, historically present	Restore

3.2 Technical Requirements

Required inputs are summarized in Table 3-2. Both SAV datasets should be projected in the same coordinate system and in a vector format and representative of only features which are submerged aquatic vegetation. This analysis only examines change in presence, not changes in density or biomass. Because this tool evaluates change in a raster format, some error will be introduced in translating vector features to raster features. A cell size should be selected which will capture the vector data nuances, this is particularly important to ensure that linear fringy SAV is captured. Though this tool was developed for SAV change analysis, it can be used to evaluate change with any feature between two time steps.

Table 3-2. Input datasets for Benthic Change Tool. A user may choose to summarize data based on a spatial decision unit, or may choose just to view the coded raster output.

Input Dataset	Type	Description
Spatial Decision Unit (Potential Sites) *Optional*	Shapefile	Projected shapefile with a unique numeric code for each site. Includes attributes « AREA », which is the area of the site, and « LENGTH », which corresponds to the length of shoreline present in each site.
Current SAV Distribution	Shapefile	Projected shapefile which only represents species of interest. Mapping project should be complete for the area of interest
Historical SAV Distribution	Shapefile	Projected shapefile which only depicts species of interest.

4. Prioritization Tool

4.1 Background & Tool Overview

The prioritization tool is comprised of 2 scripts which (1) Summarize and standardize stressor datasets, and (2) Weight and score these datasets and summarizes outputs from prior steps.

The decision unit shapefile is copied and new attributes are added. Final attributes of interest are: « Salinity », « R_PRIORITY », and « R_ACTION ».

- **R_Action** lists a potential management strategy per site: Restoration, Conservation, Enhancement or a combination of the above.

- **R_Priority**, lists the amount of stress and site suitability.

- **Salinity** suggests the types of species which would be more suited for the site based on the salinity level

What is a spatial decision unit?

A spatial decision unit is the minimum unit at which a decision is made. It is at this level that the data is evaluated and summarized for the user. In this case, a spatial decision unit represents a potential restoration site (see figure to right), and is represented as polygons within a shapefile. Each unit has a unique code, and represents an area with contiguous benthic habitat and geomorphology. The goal is to define units so that a restoration action in the site will affect the function of the entire site.
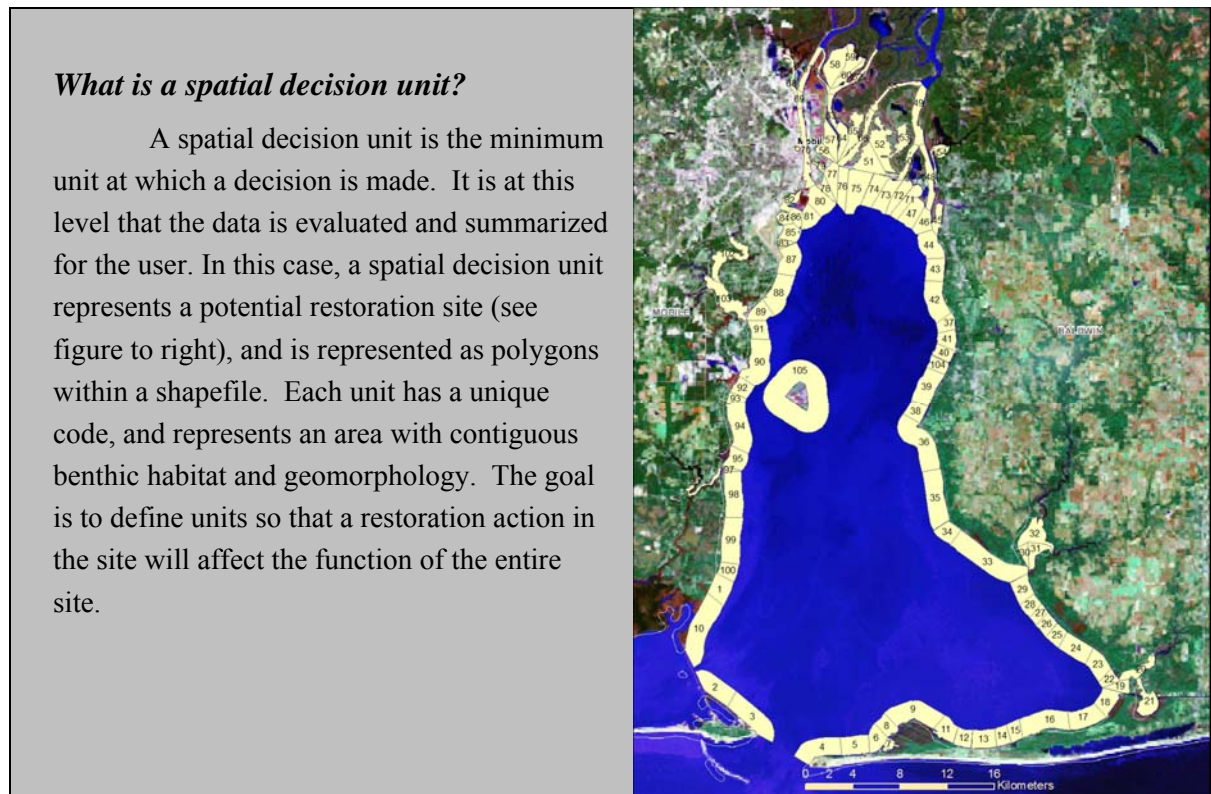
(1) Summarize and standardize stressor datasets

Through the process of summarizing stressor datasets, a user can identify any shapefile which can be considered stressful to SAVs. These stressors are standardized based on the length and area of the site and recorded in new fields in a Site polygon dataset (Table 4 -1). A summary will also be logged for the user's records.

Table 4-1. Summarizing stressor datasets per spatial decision unit. Datasets must have line, point, or polygon geometries to be used.

Input Stressor Dataset Type	Function	Output	Example of stressor
Line	For each decision unit polygon, % total shoreline covered by linear feature will be recorded	New attribute in decision unit shapefile with calculations. Attribute name will be the first seven characters of the file name with an extension of sd for a point dataset, and pc for a line or polygon dataset.	Shoreline armoring
Point	For each decision unit polygon, tool will record: • Number of data points present • Standardized to number of points per 1000 ft / m		Boat launches Piers Marinas Outfalls
Polygon	• For each decision unit polygon, % of total area in unit covered by new polygon feature is recorded		Invasive species Landslides

Weight and score datasets

At this stage, the user identifies and selects a relative weighting for each stressor. First, each factor is scored between 1-5 based on the severity of the standardized stressor in the polygon. Scoring is by quintile and relative to other scores in the area. Decision units with no stressor present receive a score of zero. This relative ranking is then multiplied by the user defined weight. After calculating the relative stress, the stressor scores are totaled for each spatial decision unit.

Finally, each site with some type of stress is ranked 1-3 based on the amount of relative stress based on their scores. 1 - Low, 2 - Medium, and 3 - High.

Salinity

High and low seasonal averages for salinity are extracted for each site and compared

against the salinity ranges for each species. The species which is most adequate for the site is recorded as in Table 4-2.

Table 4-2. SAV species category by salinity. Salinity category is recorded under new attribute "Salinity" for each potential site within decision unit shapefile.

Potential Restoration Action	Attributes within decision unit shapefile		
	RESTORE	PROTECT	GD_AREA
Restore	> 5 ha	<1 ha	> 5ha
Protect & Restore	> 5ha	>1ha	> 5ha
Protect	<5 ha	>1ha	> 1ha
Enhance	<5ha	<1ha	—

Restoration Management Strategy

The restoration management strategy uses results from the benthic change tool to evaluate what structure is present now and how it has changed over time to recommend a potential management strategy, under the new attribute **R_Action**. In addition, the tool evaluates the total area per site with suitable habitat to discern whether the conditions are adequate for restoration. Table 4-3 provides a summary.

Table 4-3. Potential Management Action. Management actions are based on the results of prior analysis and the attributes that they recorded in the decision unit file. RESTORE is the total area per site where SAVs were present historically, but absent present day. PROTECT is the total area per site where SAVs are currently present. GD_AREA is the total area per site with adequate controlling factors.

Salinity Category	High value (psu)	Low value (psu)
Seagrass	>24	>14
Freshwater SAV	< 6	—
Oligohaline Ruppia	6-15	—
Ruppia & Halodule possible, outside optimal range	16-24	< 14

Restoration Category

At this stage, the controlling factor scores are also ranked 1,2, or 3 depending on the average of acceptable scores (7-9) per site. Equal numbers of sites are placed in each group. Sites with no acceptable scores are ranked 0. These rankings are combined with the stressor score, for the final restoration category **R_Priority**. Table 4-4 summarizes how categories are defined.

Table 4-4. Restoration Priority Definitions. Restoration priorities summarizes the scores from the Controlling Factors and Stressors Analysis.

R_Priority Category	Controlling Factor Score	Stressor Score
Low Controlling Factors (CF)	0—1	Any
High Stress, Medium CF	2	3
Med Stress, Medium CF	2	2
Low Stress, Medium CF	2	1
High Stress, High CF	3	3
Med Stress, High CF	3	2
Low Stress, High CF	3	1

4.2 Interpreting Results

The three attributes: Salinity, R_Priority, and R_Action must be viewed together to evaluate potential management actions. A site with low controlling factors, for example, probably would not make a good site for restoration of SAVs. Managers might be interested in changing the controlling factors, and in many cases this would be related to characteristics of the watershed. On the other hand, a site with High Controlling Factors and Low or Medium Stress with a restoration action of RESTORE, might be an ideal site to replant SAVs. In a site with High Stress, High CF and a Protect action, managers may want to try to reduce stress to protect the current SAV population.

It is also important to keep in mind that the quality of results depend on the integrity and quality of the input datasets. If there are errors in the input datasets, there will be errors in the results as well.

This analysis should be viewed as a preliminary step in selecting a restoration management

action appropriate for an area. It is equally important to visit the site in person for a better understanding of the ecological characteristics.

4.3 Technical Requirements

Spatial decision unit dataset:

- **Unique ID**   The site dataset must be made up of polygons, with everything that is considered a site having a unique ID to identify it
- **LENGTH**   The site dataset must have an attribute LENGTH which represents the length of shoreline present
- **AREA** The site dataset must also have an attribute AREA which represents the total area of each site
- **Projection**—The dataset should be projected with a linear unit of meters. The projection should be the same for all input stressor datasets

Stressor datasets:

- Only feature of interest should exit in dataset
- Dataset should be projected in the same projection as the site dataset
- Datasets should be shapefiles with only points, lines or polygons represented

5. Case Study - Mobile Bay, AL

5.1 Background on Mobile Bay

Mobile Bay is one of the many estuaries and bays located within the Gulf of Mexico, and it has a very dynamic system (Figure 5 –1). On the north end of the bay, freshwater influx is high, and in the south, high salinity from the ocean dominates. The metropolitan area of Mobile, AL is located on the northwest edge, and smaller towns and community dot the shoreline.

Conversion of forest to farmland and development of rural and coastal areas are common development activities. Armoring and shoreline structures put additional stress on

Figure 5-1. Mobile Bay

the nearshore habitat. Hurricanes and tropical storms add stress as well. Recently, invasive aquatic vegetation has been found in Mobile Bay.

Where have all the seagrasses gone?
       Interpretation of early aerial photos from 1940-1966 allowed for SAVs to be mapped in portions of Mobile Bay. Recent aerial photos show a diminished distribution of SAVs. The figure to the right shows where the most recent mapping effort identified SAVs compared with mapping from historical photos.
       There are many suggested theories why this loss is seen. Some scientists point to altered salinity regimes within the bay, others to development and nearshore stresses, and others still to increased turbidity.

For further details about this study, please see:
Vittor & Associates. 2005. *Historical SAV Distribution in the Mobile Bay National Estuary Program Area and Ranking Analysis of Potential SAV Restoration Sites*. Prepared for Mobile Bay
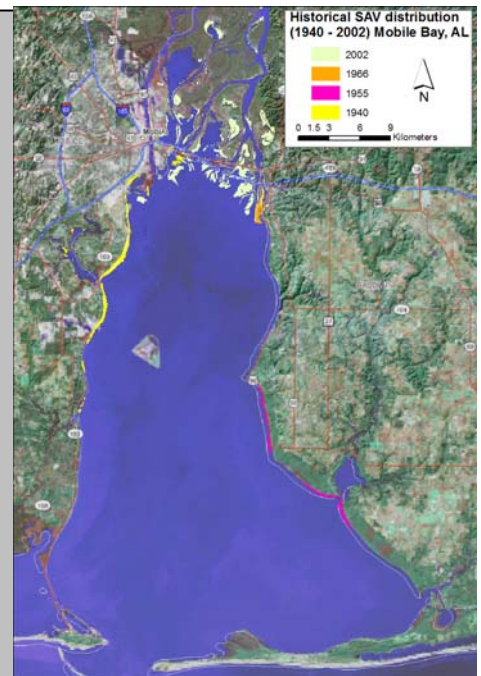
Defining the spatial decision unit

The spatial decision unit was defined by applying a buffer of 500m to the shoreline on the waterside and 200m on the land side. This buffer was extended in shallow areas near the Mobile—Tensaw Delta, to cover the entire zone where SAVs are found currently or were found in the past. The newly formed polygon was divided into sites identified by changes in benthic type and geomorphology class. An attribute "CODE" was added and set equal to the FID +1, for a unique CODE for each site. This new shapefile was intersected with a shoreline polyline, and the length of the polyline recorded under a new attribute LENGTH. Total area for each unit was recorded under an attribute "AREA".

Controlling Factors Model

NASA satellite imagery products developed through the Naval Research Lab at Stennis under a NASA REASON project were used as data inputs for sea surface temperature and turbidity (K490). Datasets were a composite for May 2007. May was chosen as it is a month critical to growth of SAVs, and a temporally significant scale. Current distribution of SAV is documented in a GIS layer (Vittor & Associates 2004) and a bathymetric layer from sonar (NOS, 1962) was used and corrected to Mean Sea Level.

Benthic Change

Spatial datasets for all past SAV distribution (National Wetlands Inventory (1992), Aerial photo interpretation 1950s -1970s)) were joined together for a consolidated coverage of areas where SAVs have historically occurred. This was used as the data input for historical distribution. Shapefiles for current distribution was acquired from Mobile Bay's NEP (Vittor and Associates 2004).

Prioritization

In Mobile Bay, we chose to evaluate several stressors present in the system, including: shoreline armoring, presence of aquatic invasive species, dredge disposal sites, dredge channels, and overwater structures. GIS datasets were acquired or developed to represent these stressors, and stressors were equally weighted.

Results

Results are summarized by decision unit (Figure 5-1). Together these results can help describe potential restoration sites, and provide user's with needed information, such as potential

management strategy (A), level of stress and suitable level of controlling factors (B), and appropriate species (C).
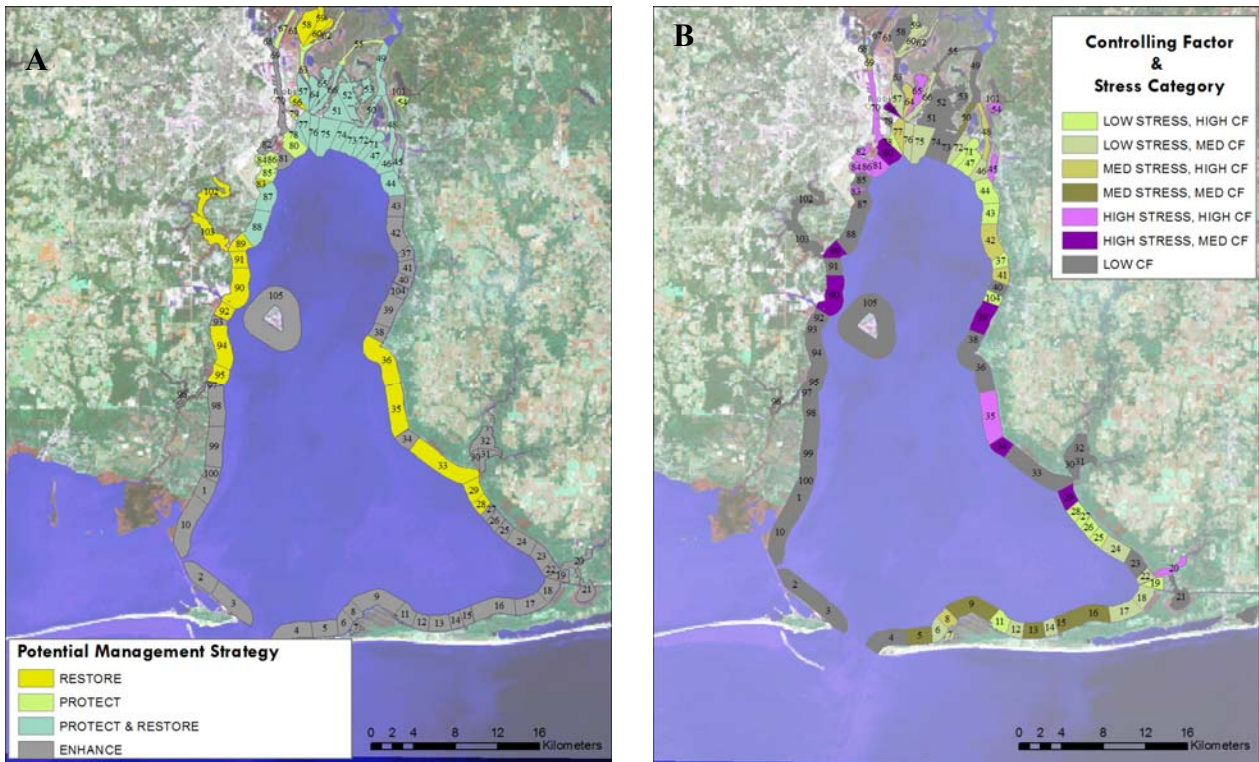
Figure 5-1. Results for prioritization in Mobile Bay. Areas to the north often are suitable for freshwater SAV and have SAV present currently. High and medium levels of stress could threaten the current SAV population. Areas towards the middle of the bay may have high controlling factors and low stress, but the salinity level is not ideal for SAV habitat.
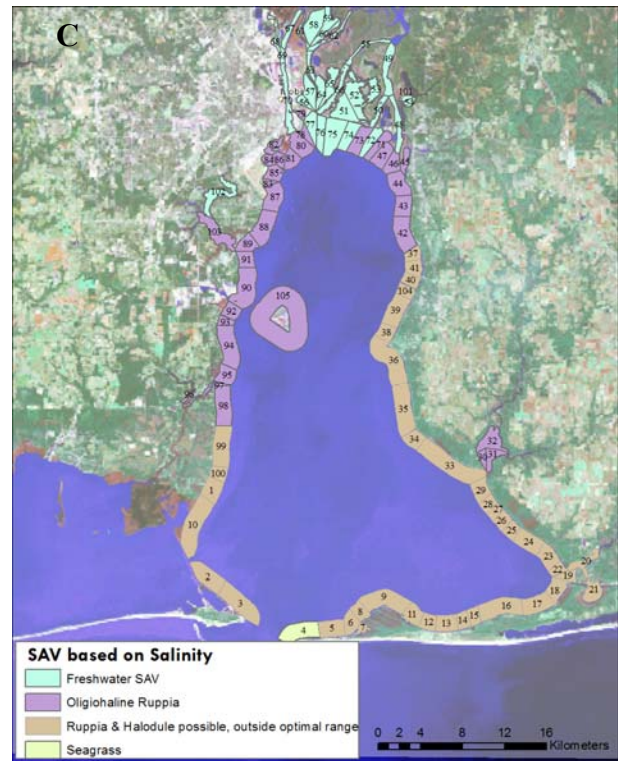
6. References

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Vittor & Associates. 2005. Historical SAV Distribution in the Mobile Bay National Estuary Program Area and Ranking Analysis of Potential SAV Restoration Sites. Prepared for Mobile Bay National Estuary Program, Mobile. AL. p 17.

Appendix A. Overview of User's Tools and Guide

Which version of the tools should I use?

The restoration toolsets are available in two forms:

- Conceptual Model Explorer (CME) on the web
- ArcGIS Toolboxes (Controlling Factors and Benthic Change only)

Conceptual Model Explorer

The tool within the CME has more parameters hardwired than the ArcGIS toolbox, but allows complete execution of the Restoration Toolset elements. This may be ideal for users with limited experience with GIS, or no access to ArcGIS, or those interested specifically in Mobile Bay.

ArcGIS Toolbox

The Restoration Toolbox should be used for those with access to ArcGIS 9.2, with Spatial Analyst. The toolbox does not contain the prioritization tool, but does allow users to examine habitat suitability for SAVs (Controlling Factors) and to evaluate change per polygon between two timesteps (Benthic Change). Complete instructions are housed within the tool itself.

How do I access and install these different versions?

Conceptual Model Explorer

This web based tool provides a simple user interface and requires no downloading of tools or data. However, at present time, it is configured for execution only for Mobile Bay, AL with limited substitution capability. To access the tool, go to (**http://persephone.bioe.orst.edu/cme/**) and follow user's guide.

Instructions for installation of Restoration Toolbox

Requirements:

Toolboxes are formatted to be executed in ArcInfo 9.2 with a current Spatial Analyst extension.

Instructions:

1. Download zipped toolbox folder to your computer and extract contents to a folder
2. Open ArcMap
3. Right click on the top level "ArcToolbox" within your ArcToolbox window, and select "Add Toolbox"
4. Navigate to the place on your computer where you saved the folder and select the toolbox.

5. The toolbox should now appear within the ArcToolbox window.

To execute, simply follow directions within tool.

Appendix B. User's Guide: Restoration Toolset within the Conceptual Model Explorer

Background

The Restoration Prioritization Toolset forms part of an integrated system within the Gulf of Mexico Regional Collaborative (GoMRC) framework to help decision makers from a variety of agencies in their environmental restoration planning process, focusing in this case on submerged aquatic vegetation.

GoMRC's approach to prioritizing sites for restoration is based on a science- based representation of how a system functions, known as an ecological conceptual model. A conceptual model was developed for SAV habitat to help users understand how ecosystem stressors and certain coastal habitat conditions, referred to as controlling factors, can influence SAV distribution and abundance.

Geospatial data can provide insights on various elements of the conceptual model for SAV habitat. Analysis of this data enables user's to predict where:
1. Controlling factor ranges are suitable for maintaining healthy SAV
2. SAV distribution has changed over time; and
3. Local stressors are influencing SAV habitat

GoMRC's Restoration Toolset provides a means of collectively evaluating controlling factors, SAV distribution and local stresses, and recommending sites for SAV restoration in Mobile Bay.

Conceptual Model Explorer (CME) provides a simple user interface to execute complex spatial analyses and provide results. For those familiar with ArcGIS products, the restoration toolset runs analyses on ESRI's ArcServer through the CME, and a user can execute with default datasets, provide new datasets, change weighting and choose to view or download results.

Restoration Toolset Elements

The Restoration toolset contains three fundamental models that will run sequentially:
1. Model for Controlling Factors which uses NASA derived datasets with local datasets to predict areas which are suitable for a species growth.
2. Benthic Change Tool examines species structure and distribution
3. Prioritization are scripts which summarize and weight stress and produce final recommended management actions.

Further details about each of these models is available online at www.gomrc.org.

Restoration Toolset Execution – Four steps

The restoration framework can be executed by following four simple steps:

1. **Log on to the conceptual model explorer**
2. **Select "Execute Workspace"**
3. **Configure set-up if desired**
4. **Download or map results**

1. Log on to the conceptual model explorer (http://persephone.bioe.orst.edu/cme/)

While a casual user may view conceptual models and tools without logging on, a log in is required to execute or change tools. Users can easily sign up for a free user account, by selecting **Create New User** from log in screen.

After logging on, the user will have a choice of different tools and models to view, edit or execute within the CME. In this case, we will **select the link "SAV Restoration Prioritization Tool".** The toolset workspace (as shown below) will appear. This is a visual representation of analysis elements. The toolset is comprised of three separate models that will run sequentially. Input datasets are grouped by the category of the scientific conceptual model they represent: Controlling Factors, Stressors or Structure.
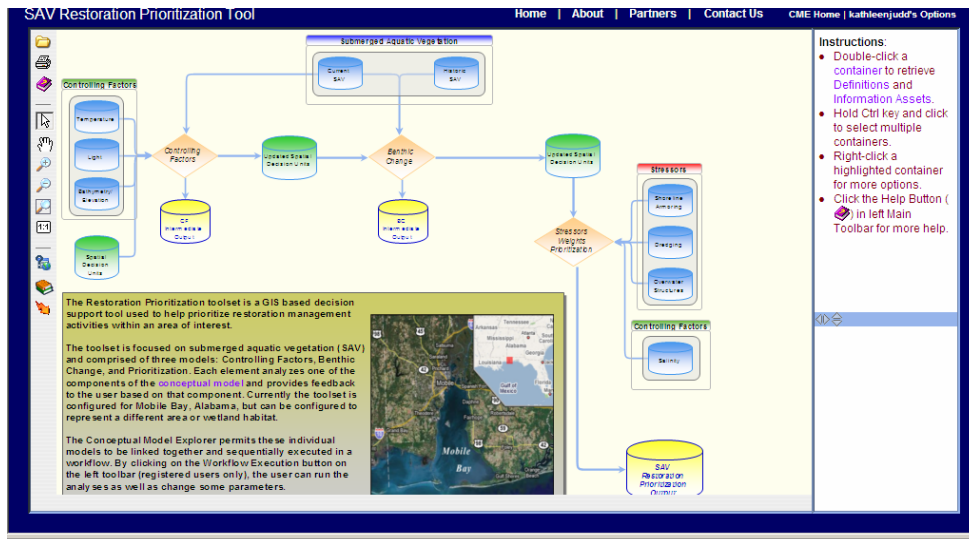
Models are visually represented by orange diamonds, and in this case are referred to as "Adapters".

Input **datasets** are shown in blue, and outputs in yellow. In this case the shapefile for restoration sites is shown in green. After execution, newly derived datasets may either be visualized in our interactive map, or downloaded.

Relationships are represented by blue arrows. They can represent inputs to a model and outputs from a model.

Further details on these components and the CME itself are available through the CME help

2. Select "Execute the Workspace"

To execute the spatial analysis, users should click on the **"Execute Workspace"** button on the left side toolbar. This will launch a user interface to change input datasets or weights. The window below will pop up.
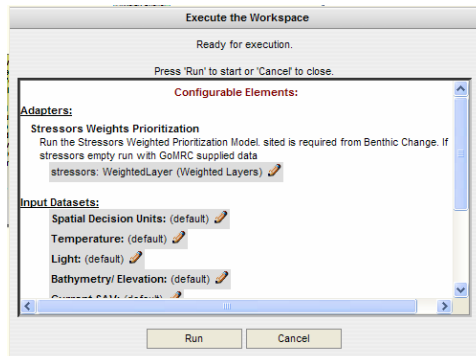
3. Configure set-up if desired

The window allows access to change default inputs for (a) Scoring of stressors or (b) Input datasets (Experimental).

(a) Scoring of Stressors

Click on the pencil. The "Edit Parameter" dialog box will appear. Users can change the relative importance of each unique stressor by entering a new number (integers) in the Weight box. After changes, user should select "Save".

(b) Input datasets (Experimental)

Input datasets can also be changed by clicking on the pencil. If access to the entire dataset is available online, the user can enter the URL. If the user has the dataset

locally on their computer, they can upload the file (as long as it is under 10MB). Please see entire documentation for requirements for each dataset.

Click **RUN** for models to execute.

Users can track the progress of the model, by viewing the icons next to the adapters. The green check box indicates successful execution, gears indicate that particular model is running, and an hour glass shows that the model is waiting to be run.
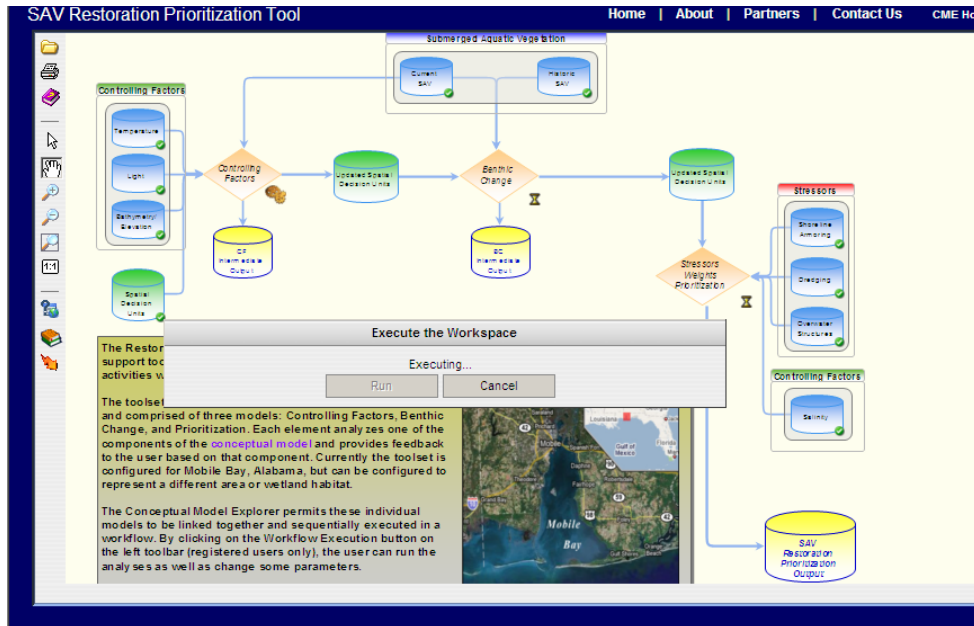
4. Download or Map Results

After successful execution, **right click** on any of the yellow output datasets to either download or map results in our interactive map. Results will be available in the form of a shapefile. For those interested in accessing the results in a spreadsheet, choose to download the .dbf file. This file can be opened in Excel.

Appendix C. Technical documentation of Restoration Prioritization Toolset

Background

   With the growing population and pressure to develop coastal areas as well as coastal watersheds, conservation and restoration of coastal ecosystems is a high priority for the nation. Managers must make decisions on complex problems every day, and having a credible scientific basis for these decisions is critical. In addition, they need to plan and implement restoration in cost effective ways in order to maximize results for the money spent.

   Among the most often sought after tool by managers is one that prioritizes restoration projects. A prioritization decision tool provides one of the bases for making investments in restoration projects. Ideally the tool contains the relevant scientific underpinnings, and facilitates the decision making process by providing an effective interactive mechanism.

   The Restoration Prioritization Toolset forms part of an integrated system within the Gulf of Mexico Regional Collaborative (GoMRC) framework to facilitate decisions related coastal ecosystem restoration, specifically the management of submerged aquatic vegetation. Based on the conceptual model, the Restoration Prioritization Toolset uses local GIS datasets, bathymetric information and datasets derived from NASA products to represent elements of the conceptual model. This can assist the user in evaluating stressors, controlling factors, and recommend a restoration management strategy based on current and past structure distribution. These GIS modeling techniques have involved weighting of system controlling factors and system stressors to score pre-defined ecological zones based on their suitability for restoration.

Application Description

The toolset is comprised of three elements:

1. <u>Model for Controlling Factors</u> which uses NASA derived datasets with local datasets to predict areas which are suitable for a species growth.
2. <u>Benthic Change Tool</u> examines species structure and distribution
3. <u>Prioritization</u> are scripts which summarize and weight stress and produce final recommended management actions.

The Controlling Factors and Benthic Change tools are available both within the Conceptual Model Explorer (CME) and as stand alone ArcGIS toolboxes. The prioritization scripts are only executable through the CME.

Each tool was originally written in Python for execution in ArcInfo 9.2 with Spatial Analyst license and accessed by an ArcGIS toolbox. Scripts were recoded for execution within ArcServer.

Expected inputs for each model and outputs can be summarized in the tables below:

Input Dataset	Type	Description
Spatial Decision Unit (Potential Sites)	Shapefile	Projected shapefile with a unique numeric code for each site. Includes attributes « AREA », which is the area of the site, and « LENGTH », which corresponds to the length of shoreline present in each site.
Bathymetry	Raster	Should be at a resolution sufficient to capture nearshore (30m pixels). The vertical datum should be adjusted to Mean Sea Level and be in meters. Apply a mask to eliminate any values above sea level. Areas below sea level are positive.
Light Attenuation Coefficient	Raster	Current input is MODIS K490 composite for a month, units should be m-1.
Temperature	Raster	Current input is MODIS SST composite over a month. Units should be in C
Current SAV Distribution	Shapefile	Projected shapefile which only represents species of interest. Mapping project should be complete for the area of interest
Historical SAV Distribution	Shapefile	Projected shapefile which only depicts species of interest.
Salinity	Shapefile	Projected shapefile with High and Low salinity values recorded.
Stressor Datasets	Shapefiles	Projected shapefiles which represent environmental stressors of interest which occur within the spatial decision unit.

Model	Output	Description
Controlling Factors	Raster & New Decision Unit Shapefile	The output of the CF model is a scored grid with values of 0-9, corresponding with the suitability of habitat for SAV. A user may also specify that results be summarized based on the spatial decision unit. In this case, the original shapefile is copied and two new attributes area added: GDAREA which is the total area per decision unit rated as good, and AVGSCR which is the average of scores 7-9 per decision area.
Benthic Change	Raster & New Decision Unit Shapefile	The output of the Benthic Change Tool is a coded grid with 4 values, representing the type of change seen per cell. **Code** — **Meaning** — **Potential Management Strategy** 0 — Currently present, historically absent — Preserve / Conserve 2 — Currently absent, historically absent — Creation / Enhancement 4 — Currently present, historically present — Preserve / Conserve 6 — Currently absent, historically present — Restore The user also has the option to summarize output raster based on the spatial decision unit. Through this option, three new attributes are added to the input shapefile: RESTORE, ENHANCE, PRESERVE. The amount of area in each site for each potential management strategy is recorded.
Prioritization	New Decision Unit Shapefile	Decision Unit shapefile is copied and new attributes are added. Final attributes of interest are: « Salinity », « R_PRIORITY », and « R_ACTION ». R_Action lists a potential management strategy per site: Restoration, Conservation, Enhancement or a combination of the above. R_Priority, lists the amount of stress and site suitability. Salinity suggests the types of species which would be more suited for the site based on the salinity level.

Processing

Detailed information on data processing and scoring is available Restoration Prioritization Toolset: Documentation and User's Guides 2007

QA, Validation and Testing

The desktop toolset went through a functional QA process as well as a critical scientific peer review of modeling and prioritization methods.

Relationship to other GoMRC Tools

The prioritization scheme is based on the Scientific Conceptual Model for SAV Restoration: http://www.gomrc.org/conceptual_model.html

The models are currently embedded in the Conceptual Model Explorer: http://persephone.bioe.orst.edu/cme/

Data inputs can be identified through the use of Noesis: http://dev.gomrc.org/GoMRC-Noesis/

Outputs will be able to be visualized on MapMaker: http://mapa.itsc.uah.edu/GulfofMexico/mapmaker/index.phtml

Appendix E. Conceptual Model Explorer Technical Documentation

Background

- Purpose
    - The CME was developed as a decision support tool allowing resource managers to understand ecological cause and effect relationships in coastal habitat restoration. Initially developed to present conceptual models, the ability to design and execute workflows was subsequently added so the CME is interchangeably referred to as the CME/WFE (Conceptual Model Explorer / Workflow Explorer) or sometimes the WFE (Workflow Explorer) when focusing on its workflow capabilities.
    - The Geoprocessor Workflow (GPW) component of the CME/WFE provides the means to deploy, via the GoMRC application, decision support tools composed of spatial data and geoprocessing functions. The tools are available to a wide user community using the Internet. The tools are rapidly developed by scientists using ESRI scripting and model building facilities; then ingested into the CME/WFE/GPW framework. Tools may also be developed using the CME Editor, but in the current version, the richness and variety of geoprocessing architectural building blocks is limited. Versioning and quality control of tools and data is managed by GoMRC scientists and simplified by the Internet deployment model. The architecture of the GPW component can be scaled to a distributed multi-server configuration to serve a growing user community.

- Functional Relationship to other GoMRC Tools
    - The CME interfaces with the GoMRC Catalog web services to retrieve system component's definitions and assets for display in the CME Viewer when users perform searches. Additionally, contextual searches based on system components can be sent to Noesis, and MapMaker and the Real Time Image Viewer sessions can be instantiated from search results as well.
    - The Geoprocessor Workflow (GPW) is integrated with the CME.

- Level of Development Achieved
    - The CME is at the draft level of development.
    - The GPW is at the alpha level of development.

CME Application Layer

- Code: Microsoft ASP.NET 2.0 C#, mxGraph 0.9.12.2, JavaScript and XML located at the Department of Biological and Ecological Engineering, Oregon State University.

- Developer and origin of code: The Department of Biological and Ecological Engineering, Oregon State University developed all code. The applications level code depends upon the mxGraph JavaScript library.

- Required input

- No inputs are required for the CME Viewer. The GoMRC Catalog is used for contextual searches so CME editors should ensure graph element labels are compatible GoMRC Catalog entries for optimal search results.
- CME Editor workflows may use the CME service layer for automation. That service layer is the host for externally contributed workflows based on the ESRI geoprocessing modeling framework. That service layer also hosts primitive geoprocessing features that depend upon OSU code that uses the ESRI engine.

- Brief synopsis of processing or manipulation
  - Conceptual models and workflows (graphs) are displayed in a web browser using the CME Viewer. The user can search for and navigate to links and data related to graph elements. Additionally, workflows created to leverage the WFE/GPW may be executed via the CME Viewer.
  - The CME Editor is a browser-based tool that allows authorized editors to create, edit, save and share CME conceptual models and workflows.

- Output produced
  - Personalized user bookmarks stored on CME server.
  - CME/WFE GPW dataset results (see CME Services Layer section 7.5.3.5) from executed workflow automations.

- QA/Testing: Testing was performed by OSU developers, GoMRC project partners and end users. The CME is stable but due to its intensive use of vector graphics, it works only in modern web browsers. CME performance varies among these browsers due to their different implementation levels of W3C standards. Optimal performance has been observed with Microsoft Internet Explorer 7.0 followed by Firefox 2.0 and later browsers on PCs. Testing on Macintosh and Unix platforms has been limited though the latest versions of Firefox for these platforms should yield satisfactory performance.

CME Services Layer
- Code: Microsoft C# code and ESRI geoprocessor Python Script codes. Located at OSU.
- Developer and origin of code: The Department of Biological and Ecological Engineering, Oregon State University developed all code. Battelle developed python scripts that functioned in a desktop environment as a decision support tool (SAV). These scripts from Battelle were re-engineered by OSU to meet the standards to be published as ESRI Web Services. These standards are published by ESRI and include consideration of Data Types, Distributed File Systems, OS Security, and also choice of API function calls—Battelle python script code met only the lesser standards for Desktop PC functionality.
- Required input
  - The Services Layer requires published web services of the ESRI type, including Map Services and Geoprocessing Services, and also ESRI system toolboxes. The former are derived from Python Scripts and from ESRI

Desktop Models. ESRI system toolboxes are available on Servers and accessed by OSU adapter codes.

- o Fully developed decision support tools, namely the SAV Controlling Factors/Prioritization model, are ingested as ESRI Map- and Geo-processing Services based on Python scripts. Quality assured data for input and drive of these fully developed tools is accommodated.
- o ESRI system geoprocessing tools are required for the CME/WFE/GPW spatial extent and projection and model execution environment, including project, subset, and resample. These tools and other systems tools (e.g. recode) are available as primitive adapters in the Application Layer.

- ▪ Brief synopsis of processing or manipulation
  - o Services layer is exposed as Web Service running at OSU. Depending on the how well contributed python scripts meet standards for publishing as ESRI Web Services, additional programming is required to assimilate contributions. Geoprocessing primitives have been (and more are planned to be) exposed by OSU libraries in the Server Layer of the CME and use ESRI geoprocessing engine.
  - o The CME application layer uses WSDL to discover the tools available.
  - o Each tool returns a standard return type that includes information for:
    - o http output location of spatial data results
    - o http log file location for detailed messages
    - o expiration—all outputs are temporary
    - o information for rendering by UAH MapMaker
  - o Input to each tool varies. At this version input is a number of strings identifying the location of input spatial data

- ▪ Output produced: Temporary TIFF and ESRI Shapefiles are produced and placed on an OSU and/or UAH server

- ▪ QA/Testing: Testing performed by OSU developers.

CME Server Layer
- ▪ Content archived
  - o Personalization data and CME conceptual models and workspaces created by users or stored in SQL Server 2005 databases. The following is the database schema used to archive the conceptual models and workspaces created in the CME Editor and viewed in the CME Viewer:

Conceptual Model Explorer Containers Database
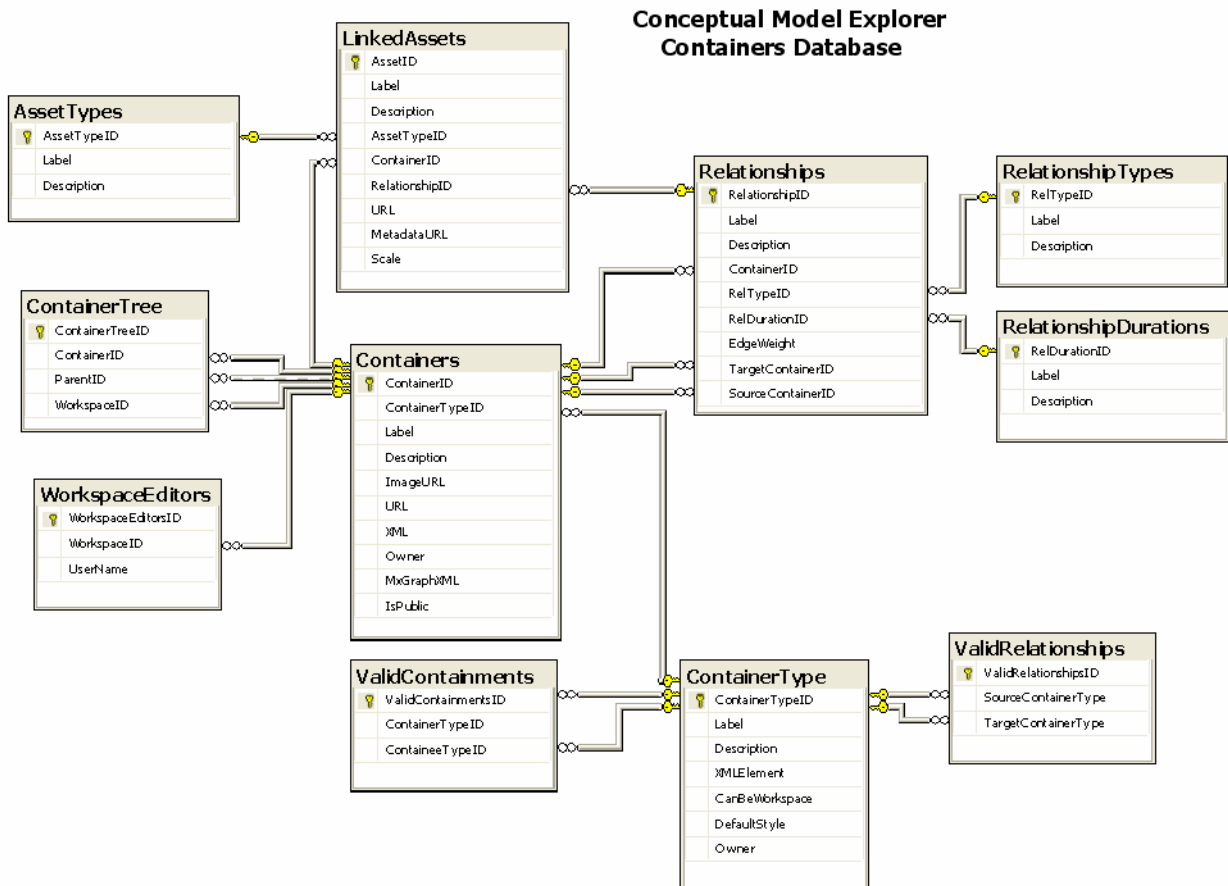
- o Input spatial data are archived for the WFE/GPW component.

- Developer and origin of code: The Department of Biological and Ecological Engineering, Oregon State University.

- Proprietary Software
  - o A library of codes has been developed that works with the COTS software to provide capabilities to the Services layer.
    - Distributed Resources. Various middleware to facilitate transport of spatial data in various formats. The transport is necessary because of a lack of WFS and WCS support from data providers and from ESRI.
  - o Adapters. Various codes called by the Services Layer.
    - A middle layer between the Service Layer and the COTS libraries.
    - A middle layer between the Service Layer and the fully developed decision support models supported by GoMRC. This layer ingests models and also mediates data type conversions between the COTS libraries and the Services Layer.
  - o Personalization data and CME conceptual models and workspaces created by users.
  - o Input spatial data are archived for the WFE/GPW component.

- COTS Software and Version: ESRI ArcGIS Server and Engine Version 9.2 SP2, and Microsoft SQL Server 2005, and Microsoft Server 2003, and IIS 6.0 are used to provide much functionality. For the test case S.A.V. model, datasets.

- Location and server administrator: The Department of Biological and Ecological Engineering, Oregon State University hosts and administers the server.

- External Connectivity: No direct external connectivity to source code.

- CME Security
  - User types and authorization mechanism: The CME has two basic types of users:
    - Anonymous User – The default CME user type. This user can use the CME Viewer, but can not leverage the CME bookmark or other personalization features.
    - Registered User – Registered users gain access to the CME bookmark features. A user registers with CME web site via a Registration page to become a registered user and uses a Login page to authenticate via a username and password combination.
  - Access levels: Registered users can have one of three access levels:
    - User – A CME User is the basic registered user type allowing access to the CME bookmark features.
    - Editor – CME Editors have the same privileges as the Registered User, but can additionally use the CME Editor. This user type is currently available to GoMRC project partners by request through the CME Feedback Form.
    - Administrator – CME Administrators can manage CME registered users permissions. This user type is reserved for CME developers.

- Implementation layer
  - The CME is accessible via the Internet using HTTP at http://persephone.bioe.orst.edu/cme/.
  - Industry standard use of encryption for connection strings.

- Redundancy: The CME and its components are currently hosted on one server with mirrored drives so service is not interrupted in case of a hard drive failure.

- Backup and Recovery: Nightly backups of all code and databases.

CME Online Help
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1. Overview
1.1. CME Description

Conceptual models can be used by coastal and marine scientists to help identify, assess, and communicate relationships between stressors on natural systems and ecological responses. The Conceptual Model Explorer (CME) is a decision support tool that enables scientists to view existing conceptual models and create new ones to support their resource planning and management activities.

The CME consists of two components:

- CME Editor
- CME Viewer

The CME Editor is used to create and edit conceptual models, workflows and adapters (collectively referred to as "workspaces" in the CME). The CME Viewer is used to display the workspaces created in the CME Editor. Most users will only use the CME Viewer as access to the CME Editor is only available by request.

1.2. CME Intended Uses
The CME is designed to accommodate a broad set of conceptual models and workflows. The initial conceptual model and workflow are intended to provide resource managers with decision support on submerged aquatic vegetation (SAV) habitat restoration. The CME SAV application is intended to provide:

- A visual representation of SAV habitat restoration, which shows ecological cause and effect relationships.
- The ability to set priorities for SAV restoration within the broader ecosystem.
- Definitions of ecosystem components, such as ecosystem stressors, structures and processes.
- Access to datasets and other information products that relate to the topic of interest.

1.3. CME Features
1.3.1. Conceptual Models and Workflows

The Conceptual Model Explorer was originally designed as a tool to create and publish ecological conceptual models via the Internet. The CME conceptual models embrace the concepts of Organizing Principles and System Components as a mechanism to represent ecosystem relationships. This representation serves two primary purposes:

1. help users understand what relationships are important in determining ecosystem response to a variety of possible stressors and controlling factors, and
2. provide an easy-to-use interface to facilitate user search for information relevant to those components and relationships.

In addition to representing Organizing Principles and System Components, the CME enables users to personalize the system by building their own "workflow" for a scientific problem of interest. The specialized components or "containers" to support workflows in the CME include Datasets, Geoprocesses, Adapters, Conceptual Models, and Workflows.

An advanced feature of the CME is that components, including entire conceptual models and workflows, can be shared among editors, copied, and reused and/or nested in multiple workspaces (conceptual models, workflows, and adapters). For more information on these features, see the Creating Workspaces and Sharing and Publishing Workspaces sections in the CME Editor chapter.

1.3.2. Searches

One of the key features of the CME is the ability to quickly perform contextual searches for the components depicted in a conceptual model or workflow. The CME Viewer has a Definitions Window and an Information Assets Window which display associated information, queried from GoMRC Catalog web services, when a component is double-clicked. The Definitions Window presents a brief description of the component and the Information Assets Window lists relevant links that may provide additional information and/or raw data relating to the clicked component. Contextual searches using the Noesis advanced search tool can also be executed in CME.

Additionally, the CME has a Query Filters Dialog window that allows the user to refine searches spatially, temporally, and with additional keywords.

For more information on searches, see Section 2.5 - Performing Searches

1.3.3. Bookmarks and Personalization

The CME allows for user personalization. Registered users have the ability to save and easily retrieve CME Bookmarks to the information assets obtained through their search results. CME Bookmarks not only store a link for quick navigation to the information asset, but they also allow

the user to rank the information asset and add personal notes about the information asset. CME Bookmarks are always associated with the component(s) that were selected when the bookmark was added so it is easy to find your favorite information assets for a particular model or workflow component.

CME personalization also permits users to become Editors who can create, edit, share and publish conceptual models and workflows. For more information on becoming an Editor, see the Editors section in the Personalization chapter.

1.3.4. Workflow Automation

Conceptual Model Explorer workflow automation is currently in the early stages of development and not all features are implemented. The goal of the workflow automation feature is to enable users with minimal expertise and training to publish and easily modify a series of related elements in a scientific process (a "workflow"). Editors can configure workflows so that their components link to actual data sources and web services with geoprocessing and other modeling capabilities. The user will be able to adjust parameters, change data sources, execute the workflow and view the output. Additionally, the user will be able to select the area-of-interest for which to run the workflow via the Query Filters Dialog window.

For more information, see the Advanced Workflow Automation chapter.

1.4. Getting Started
1.4.1. Browser Requirements

The Conceptual Model Explorer is a graphics-intensive web application built to be executable in browsers without requiring a 3rd party plug-in. As such, a modern browser with native, standards-compliant vector graphics support is required to effectively use the CME.

The **latest versions of Internet Explorer and Firefox are the recommended browsers** for best performance. For more information, please see the Browser Compatibility section in the CME Known Issues chapter.

1.4.2. Accessing Help
The CME Help system can be accessed in two ways:

- **Outside the Editor or Viewer** - Before entering the CME Viewer or Editor, the CME Help system can be accessed from all other CME web pages by clicking on the "CME Help" link in the upper right corner of the page. The browser will redirect to the CME Help system when the link is clicked.
- **Within the Editor or Viewer** - Within the CME Editor or CME Viewer, the CME Help system is accessed by clicking the CME Help button (🔧) in the Main Toolbar. Clicking the button displays the help system in a popup window within the Viewer or Editor, or if the help window is already displayed, it will close the help window.

1.4.3. Registration
Registering with the Conceptual Model Explorer provides a user with a personalized experience when using the Explorer. Benefits of registering include:

- Potential access to non-public models as editors may limit model accessibility to select users.

- Store and manage bookmarks associated with model components to more quickly find results from past queries.
- Ability to request editor privileges so that users can create and edit their own models.

To register, click on "Login" in the CME Top Toolbar and then select "Create New User..." on the Login page. Fill in the user information form and click the "Create User" button when finished.

For more help with login and registration, see Login and Registration (3.2.1) in the Personalization chapter.

1.4.4. CME Viewer Quick Start

To best take advantage of the CME Viewer capabilities, users should read the CME Viewer chapter to become familiar with all of the Viewer features and tools. However, the following list should provide enough guidance to get started using the CME Viewer:

- To use CME Bookmarking, users must register and login to the CME before starting the CME Viewer.
- Start the CME Viewer from the CME Home Page.
- The Open Workspace Dialog will be displayed with a list of available workspaces. If the workspace's editor has provided a description, the workspace's description will appear in a tooltip when you place the mouse cursor over a workspace name. If no tooltip appears, no description is available. Click a workspace to open it and the Open Workspace dialog will close. To open another workspace, the Open Workspace dialog can be displayed at any time by clicking the Open Workspace Dialog button (🗀) in the Main Toolbar.
- Use the Workspace Navigation Tools in the Main Toolbar to pan and zoom the workspace.
- Within the workspace, double-click an object to populate the Definitions Window and Information Assets Window with the container's definition and information assets. Multiple containers can be selected by holding the Ctrl key down while clicking containers.
- Right-clicking a selected container provides a list of additional options including the ability to display only the container and its relationships in the Viewer.

1.4.5. CME Editor Quick Start

To use the CME Editor, a user must be registered and submit a request to be an Editor (see the Editors section in the Personalization chapter).

Once a user obtains Editor status, it is highly recommended that they read the CME Editor chapter before creating workspaces (conceptual models or workflows). It is important that user's understand the full functionality of CME Editor because the user's actions can potentially affect other editor's workspaces that they have access to. Help sections 4.4 Creating Workspaces and 4.5 Sharing and Publishing Workspaces are most critical to read before beginning as they describe the optimal sequence of events for building workspaces, and the implications of editing shared workspaces. Knowing the details and required sequence of events for configuring workflows for automation is extremely important before beginning to configure workflows.

1.5. CME Example Scenarios
1.5.1. Exploring the GoMRC Submerged Aquatic Vegetation (SAV) Conceptual Model
1.5.1.1. SAV Conceptual Model Overview

The Submerged Aquatic Vegetation (SAV) Conceptual Model is a decision support tool for resource managers who are concerned with coastal habitat restoration. It provides the user with a visual representation of the ecological cause and effect relationships to SAVs. Additionally, the SAV Conceptual Model provides the user with definitions of ecosystem components, such as ecosystem stressors, structures and processes, and it provides access to datasets and other information products that relate to the components.

More information about the approach and development of the SAV Conceptual Model can be found on the GoMRC Coastal Habitat Restoration web page. The following sections demonstrate performing common tasks in the CME Viewer with the SAV Conceptual Model:

1.5.1.2. Navigating the SAV Conceptual Model

The user can open the SAV Conceptual Model in the CME Viewer by selecting the "Submerged Aquatic Vegetation (SAV) Conceptual Model" link on the CME Home Page. By default, the entire SAV Conceptual Model is displayed in the CME Viewer when loaded:

Given the complexity and large size of the SAV Conceptual Model, the user will need to adjust its display as they explore the model. The following display tools are available to the user in the Main Toolbar at the left of the model:

Pan Mode Button
   Puts the mouse left-click in Pan mode. The user can then move the model by holding the left mouse button down on the canvas (tan area), dragging the model to a new position, and then releasing the mouse button. (Note that the mouse left-click action should be put back into Select Mode by clicking the Select Button ( ) before selecting containers) Alternatively, the user can pan the workspace using the right mouse button without having to use the Pan Mode button. Note that in either pan method, the mouse pointer must be over the tan background and not over a container or relationship when panning is initiated.

Zoom In Button
   Clicking this button zooms-in one level on the SAV Conceptual Model.

Zoom Out Button

Clicking this button zooms-out one level on the SAV Conceptual Model.

Zoom to Extents Button
Clicking this button zooms the SAV Conceptual Model to its full extents so that the entire workspace is displayed. This is the default display (pictured above) when the model is initially loaded.

Zoom Actual Size (1:1) Button
Clicking this button zooms the SAV Conceptual Model to a one-to-one ratio (or its "actual size"). This zoom-level makes the text easy to read but limits the amount of the model displayed; therefore, the user must use the panning feature to change the displayed portion of the model when using this zoom-level.

Additionally, note that it is possible to resize the canvas displaying the model by dragging the move icon ( ) located between the Definitions and Information Assets Windows.

1.5.1.3. Altering Displayed Relationships

By default, all relationships are displayed in the SAV Conceptual Model. Since there are so many relationships depicted, the model becomes difficult to interpret in some areas. The user may adjust the display of relationships as needed using the context menus available when right-clicking on a container. For example:
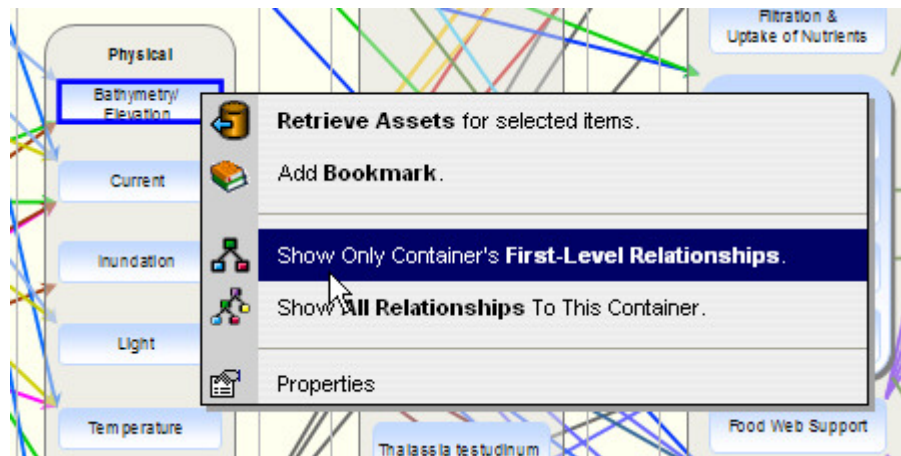
Selecting "Show Only Container's First-Level Relationships" from the "Bathymetry/Elevation" container's context menu (above) will hide all relationships except those directly connected to "Bathymetry/Elevation":
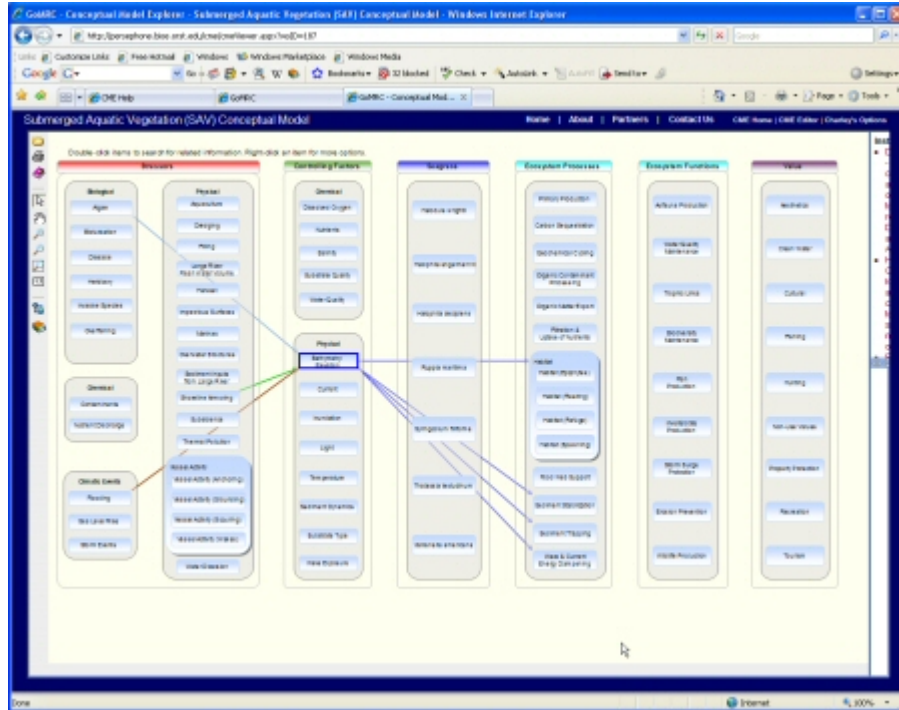
If the user wants to display all relationships that connect to the "Bathymetry/Elevation" container at all levels, they select "Show All Relationships With This Container" from the context menu:
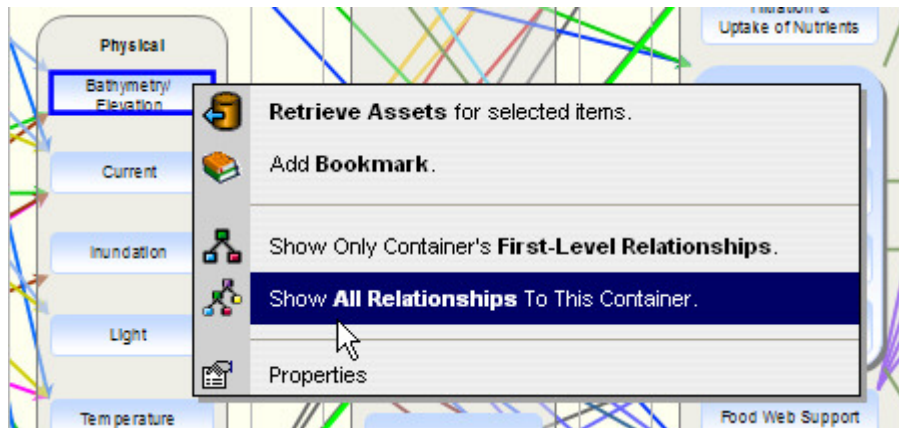
Which yields:
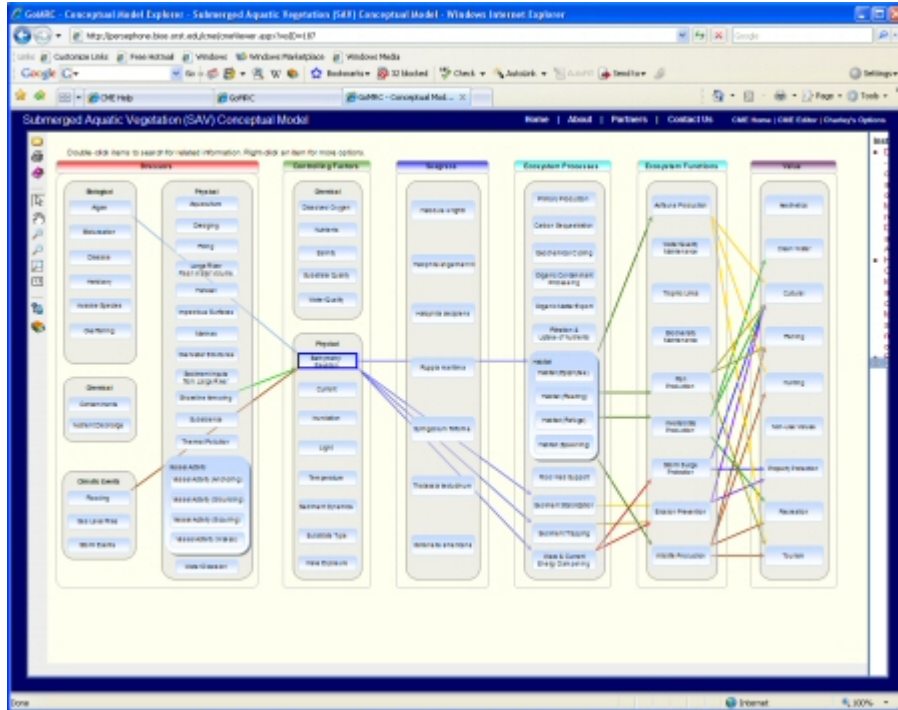
To hide all of the model's relationships, the user must right-click the mouse on the canvas where no containers or relationships are displayed. This will show the Workspace Context Menu from which the user selects the "Toggle All Relationships On/Off" option:
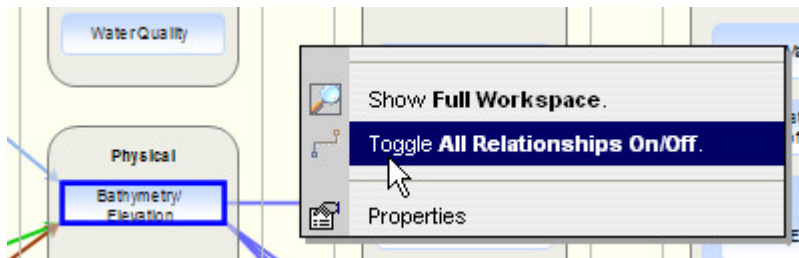
In this state, when no relationships are displayed, the user may dynamically display all relationships associated with a container by placing the mouse over the desired container (Note: the display may take a few seconds to update while the connected relationships are determined). This technique provides a useful means to quickly explore relationships associated with different containers:
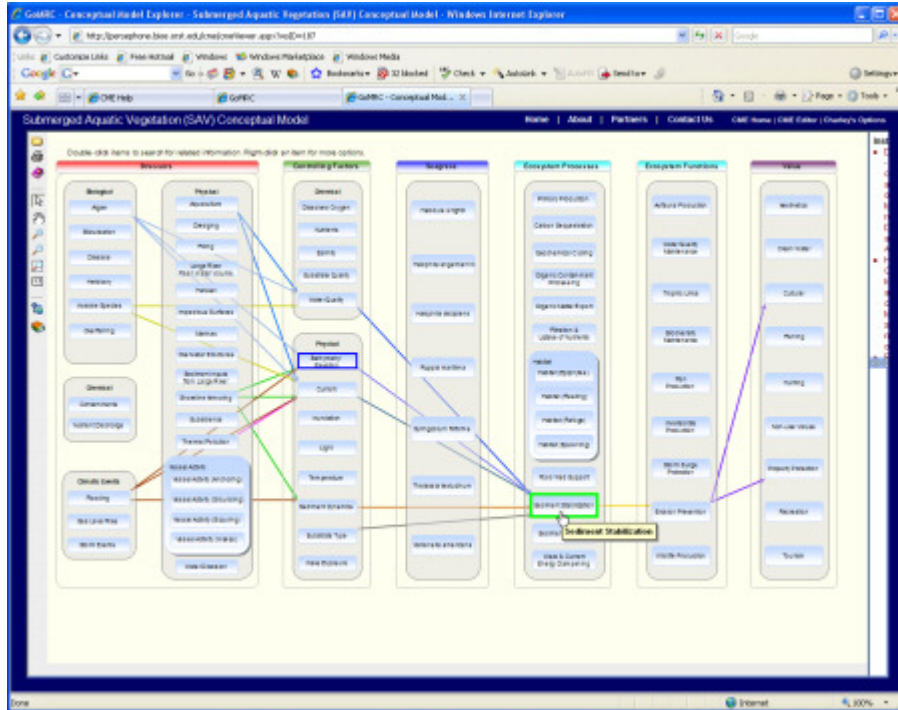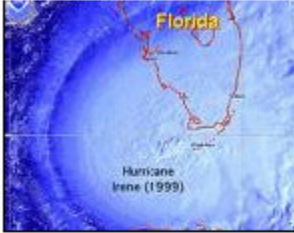
To reset the display to show all model relationships, select the "Toggle All Relationships On/Off" option in the Workspace Context Menu again.

1.5.1.4. Searching the SAV Conceptual Model

The containers in the SAV Conceptual Model can be used to search the GoMRC Catalog and Noesis. Double-clicking a container retrieves a definition and information assets for the container (from the GoMRC Catalog) that are displayed in the CME Viewer Definitions and Information Assets Windows, respectively. Information Assets are verified metadata entries in the GoMRC Catalog for available web sites, analysis tools, and data related to the container. The following image shows the results of double-clicking the "Storm Events" container within "Stressors":

Keyword: **Storm Events**
Category: **Stressor**
SubCategory: **Climatic Events**

Climatic events which cause severe wind, precipitation, storm surges and flooding.

Storm events are a natural and necessary part of coastal ecology in the Gulf of Mexico as evidenced by the fact that hurricanes typically do not result in sustained damage to unmodified coastal systems...

Read more at the GoMRC Catalog...

Assets for keywords: **Storm Events**
7 items found:

Buoy Center

http://www.ndbc.noaa.gov/
Wind speed, direction, air temp, water temp
+ more...

WIND

SST Anomaly

TOPEX/POSEIDON

JASON

NOAA Tidal Stations

NOAA-NOS Storm Events

Search NOESIS for more results.

The Definitions Window displays a concise definition followed by a detailed description (when available). Typically an image is provided to augment the definition. If a higher-resolution image is available, placing the mouse cursor over the image will direct the user to click it to enlarge the image. Often the GoMRC Catalog provides more information than can be optimally displayed in the CME Viewer. In these instances, a link is provided to display the full description directly from the GoMRC Catalog in a new window.

The Information Assets Window displays any verified metadata entries in the GoMRC Catalog. Placing the mouse cursor over an entry will display a brief description of the entry in a tooltip. Clicking the entry's title will expand the entry providing a hyperlink to the resource and any summary information available (see the Buoy Center entry in the example above). Clicking the entry's title a second time hides the details. Additional details are accessible by clicking the "+ more..." option on each entry and can then be hid by clicking "- hide...":
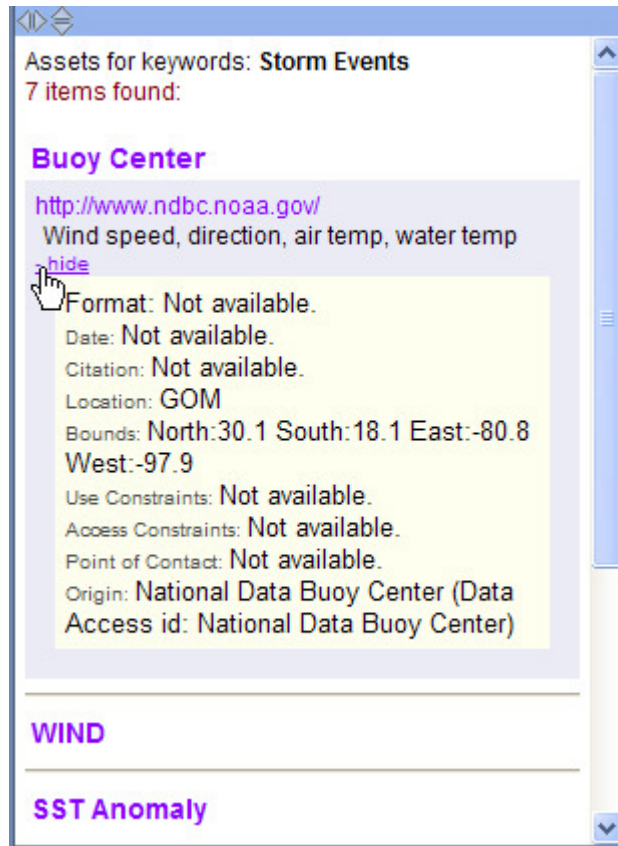
Every search provides a link in the Information Assets Window to launch (in a new browser window) a GoMRC Noesis search with the search terms previously sent to the GoMRC Catalog. Noesis performs a more extensive search using additional Internet catalogs and search engines which typically yields more search results.

It is possible to query the GoMRC Catalog and Noesis for multiple containers at one time. This is achieved by selecting multiple containers before initiating the query. Multiple containers are selected by holding the Ctrl-key down and left-clicking multiple containers while in Select Mode (the default mode). Next, right click one of the selected containers to display the container's context menu. Select "**Retrieve Information Assets** for Selected Items" to initiate the query. The Definitions window will display the definition for the container that was right-clicked, but the Information Assets window will query for all selected containers using an "OR" operator:
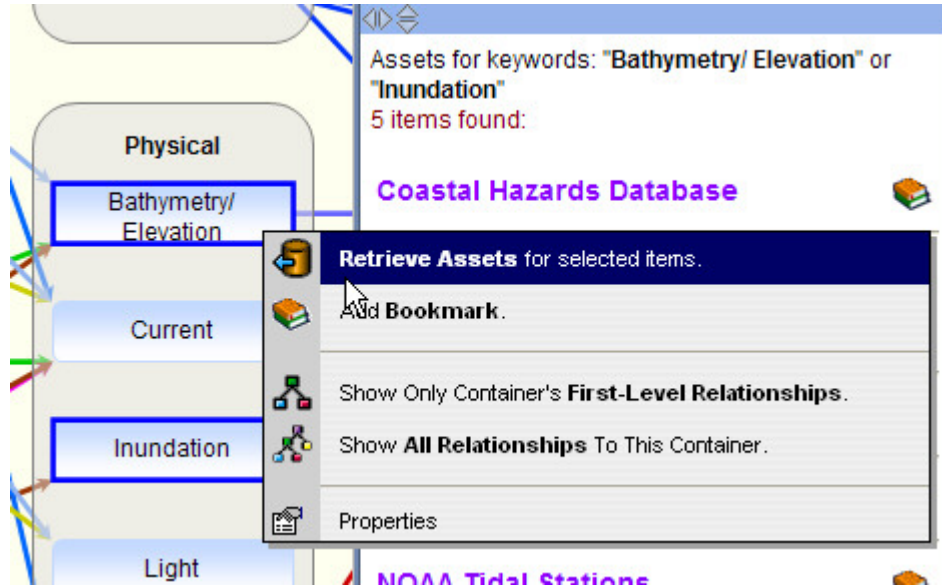
The Query Filters Dialog may be used to refine container initiated searches. The user may specify additional keywords, specify spatial extents via the interactive map, and/or select a time period to augment an information asset query. To apply these optional query parameters, one or more containers must be selected before pressing the "Submit Query" button. If the Query Filters Dialog is visible, the optional parameters set within the window (if any) will be applied to all subsequent searches (including those initiated directly from containers) until the parameters are reset or the dialog is closed.

Please note that a lot of information assets in the GoMRC Catalog do not currently have spatial or temporal attributes, so results may be limited. Also the additional keywords parameters are passed to Noesis when initiating a Noesis search from the Information Assets Window; however, the spatial and temporal constraints currently are not.

1.5.1.5. Bookmarking Search Results

Registered users have the ability to save and easily retrieve CME Bookmarks to the information assets obtained through their search results. CME Bookmarks are always associated with the container(s) selected when the information asset is bookmarked. They include not only a link for quick navigation to the information asset, but they also allow the user to rank the information asset and add personal notes.

If a user is registered and logged-on to the CME, and they perform a search as described in the previous section, each information asset returned in the Information Assets Windows will include a bookmark icon ( ). Clicking the button launches the Bookmarks Dialog which is then used to add the bookmark. The user may add custom notes and ratings for each bookmark added to their profile. The following images show a user adding a bookmark to the Temperature container from the Information Assets Window:
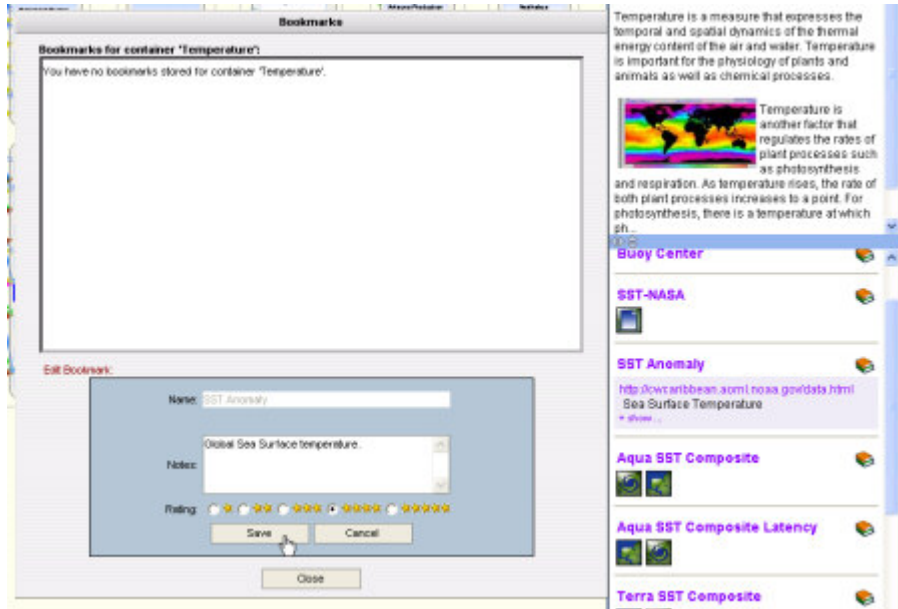
After clicking the bookmark icon next to the information asset, the Add Bookmark Dialog is displayed with a pre-populated title. The user then adds an optional comment, selects a rating and saves the bookmark. The bookmark is associated with the selected container(s) and added to the user's profile:
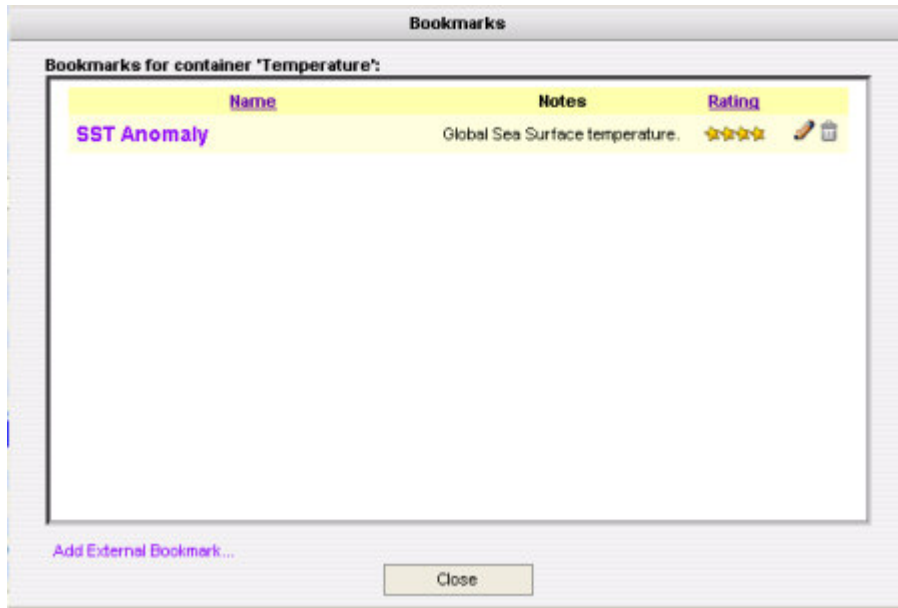
After closing the dialog, the user will be able to quickly view the bookmark at any time using the Temperature container's context menu by right-clicking the Temperature container:
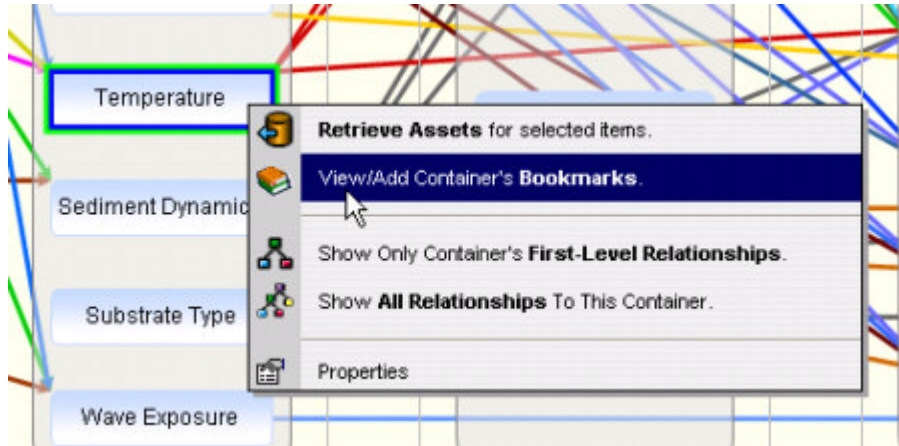
The method described is the most direct way to add a bookmark to a container. Bookmarks can also be added directly from external sites using the Google Toolbar or added manually by selecting "Add External Bookmark" from the Bookmarks Dialog (see External Bookmarks). In addition to displaying bookmarks by container as presented above, it is possible to see a user's bookmarks for all containers at once (see the Bookmarks Button in the Main Toolbar), and sort, edit, and delete bookmarks. For more information about using these features, please see the Bookmarks Dialog and Personalization/Bookmarks sections.

1.5.2. SAV Restoration Prioritization Tool - Mobile Bay (Workflow Automation)
1.5.2.1. SAV Restoration Prioritization Tool Overview

Background

The Restoration Prioritization Toolset forms part of an integrated system within the Gulf of Mexico Regional Collaborative (GoMRC) framework to help decision makers from a variety of agencies in their environmental restoration planning process, focusing in this case on submerged aquatic vegetation.

GoMRC's approach to prioritizing sites for restoration is based on a science-based representation of how the system functions, known as an ecological conceptual model. A conceptual model was developed for SAV habitat to help users understand how ecosystem stressors and certain coastal habitat conditions, referred to as controlling factors, can influence SAV distribution and abundance.

Geospatial data can provide insights on various elements of the conceptual model for SAV habitat. Analysis of this data enables the user to predict where:

- Controlling factor ranges are suitable for maintaining healthy SAV,
- SAV distribution has changed over time, and
- Local stressors are influencing SAV habitat.

GoMRC's Restoration Toolset provides a means of collectively evaluating controlling factors, SAV distribution and local stressors, and recommending sites for SAV restoration in Mobile Bay.

CME provides a simple user interface to execute complex spatial analyses and provide results. For those familiar with ArcGIS products, the restoration toolset runs analyses on ESRI's ArcGIS

Server through the CME, and a user can execute with default datasets, provide new datasets, change weighting and choose to view or download results.

Restoration Toolset Elements

The Restoration Toolset contains three fundamental models that will run sequentially:

- Model for Controlling Factors which uses NASA derived datasets with local datasets to predict areas which are suitable for a species growth.
- Benthic Change Tool examines species structure and distribution.
- Prioritization are scripts which summarize and weight stress and produce final recommended management actions.

Further details about each of these models are available on-line at www.gomrc.org.

1.5.2.2. Executing the SAV Restoration Prioritization Tool

The restoration framework can be executed by following four simple steps:

1. Log on to the Conceptual Model Explorer.
2. Select "Execute Workspace".
3. Configure set-up if desired.
4. Download or map results.

1.5.2.2.1. Login

While a casual user may view conceptual models and tools without logging on, a login is required to execute or change tools. Users can easily register for a free user account, by selecting "Create New User" from the CME Login page.

After logging on, the user will have a choice of different tools and models to view within the CME. In this case, we will select the "SAV Restoration Prioritization Tool" from the CME Home page. The CME Viewer will then open with the SAV Restoration Prioritization Tool workspace loaded:
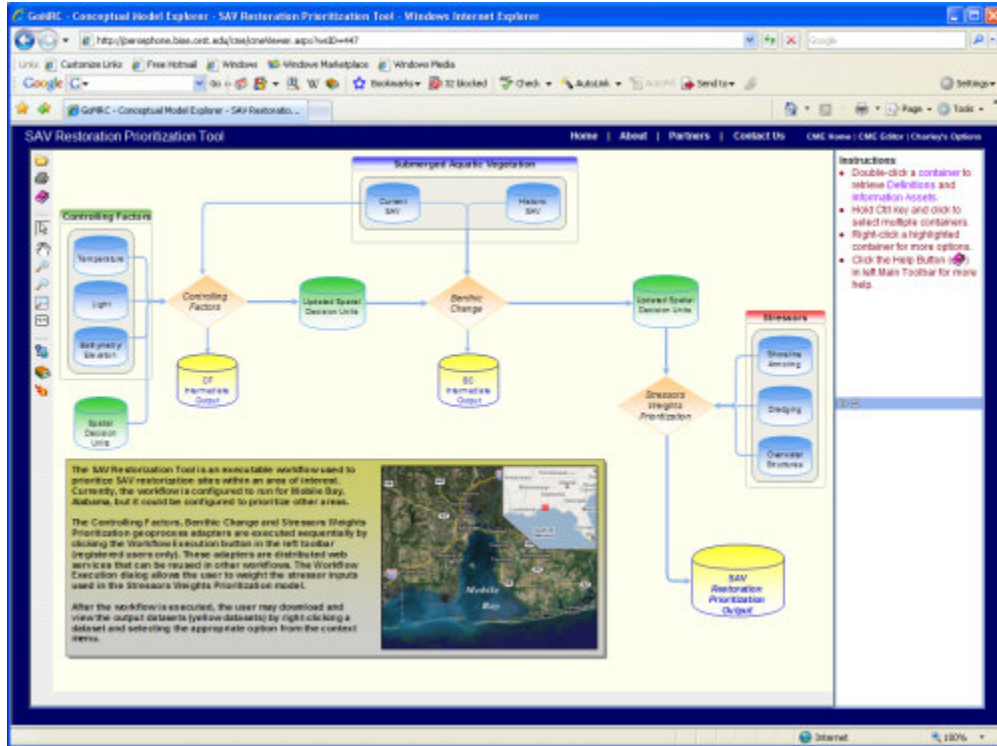
This is a visual representation of analysis elements. The toolset is comprised of three separate models that will run sequentially. Input datasets are grouped by the category of the scientific conceptual model they represent: Controlling Factors, Stressors or Structure (SAV).

Models are visually represented by orange diamonds ("Adapters").

Input datasets are shown in blue, and outputs in yellow. In this case the shapefile for restoration sites is shown in green. After execution, newly derived datasets may either be visualized in our interactive map, or downloaded.

Relationships are represented by blue arrows. They can represent inputs to a model and outputs from a model.

Further details on these components and the CME itself are available through the CME help which is always accessible from the Main Toolbar on the left of the CME Viewer.

1.5.2.2.2. Execute the Workspace

To execute the spatial analysis, users should click the Workspace Execution Button ( ) on the left side Main Toolbar. This will launch the Workspace Execution Dialog which will allow the user to run and optionally configure the SAV Restoration Prioritization Tool:
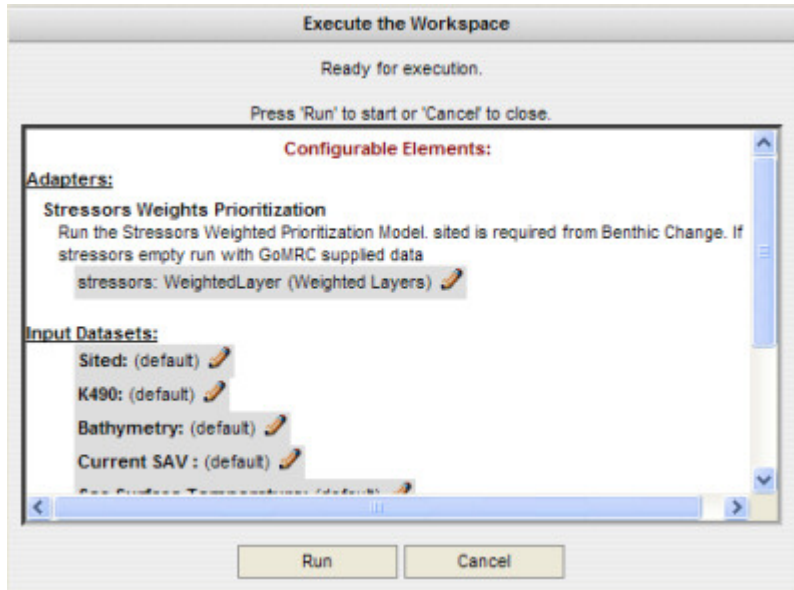
To run the SAV Restoration Prioritization Tool with its default settings, click the "Run" button. Icons will then appear on the workspace indicating the status of the containers during execution:

 Processing.

 Processing Complete.

 Terminal output dataset populated.

 Waiting to process.

 Processing Error.

The dialog will indicate when execution is finished or if an error occurs. The Cancel button closes the dialog window and stops execution of the workspace if it was started.

1.5.2.2.3. Optional Configuration

Using the Workspace Execution Dialog shown above, the SAV Restoration Prioritization Tool can optionally be configured by the user to better fit their specific needs before it is executed. Currently, the user may change the default input datasets and/or adjust the scoring weights of the input stressors.

Scoring of Stressors

The Configurable Elements section of the Workspace Execution Dialog indicates that the "Stressors" parameter of the Stressors Weights Prioritization Adapter (model) is configurable. The user can view and adjust the "Stressors" parameter by clicking the Edit button () to the right of the parameter which opens the "Edit Parameter" dialog:

Edit Parameter

Adapter: Stressors Weights Prioritization
Parameter Type: Weighted Layers
Parameter Name: WeightedLayer
Edit Values and then Save:

Layer	Weight
ShorelineArmoring	1
Dredging	1
OverwaterStructures	1

Save   Cancel

The user can change the relative importance of each unique stressor by entering a new number (integer) in the Weight box for each input stressor. The user should click "Save" to record their weight changes. The user is then retuned to the Workspace Execution dialog where the SAV Restoration Prioritization Tool can be run with the new stressor weights.

Input Datasets

Input datasets may also be changed prior to execution the SAV Restoration Prioritization Tool by clicking the Edit button ( ) to the right of the desired dataset. When the Edit button is clicked, the Edit Dataset URL dialog appears:

Edit Dataset URL

Dataset: Temperature
URL: (default)

Save   Cancel

The user must enter the URL of the dataset to be used. The complete dataset in the proper format must be available online. Please see the Coastal Habitat Restoration Model for Submerged Aquatic Vegetation documentation for each dataset requirement. (Note: User upload of datasets directly from their computer to the CME server is currently experimental and will be supported in future CME versions.) The user should click "Save" to record their dataset change. The user is then retuned to the Workspace Execution dialog where the SAV Restoration Prioritization Tool can now be executed with their data.

1.5.2.2.4. View and Download Results

The SAV Restoration Prioritization Tool may take several minutes to run. The Workspace Execution dialog will indicate when the entire SAV Restoration Prioritization Tool is finished, and then the dialog may be closed. Closing the Workspace Execution dialog during execution will cancel execution and reset all SAV Restoration Prioritization Tool parameters and datasets to their default settings.

The SAV Restoration Prioritization Tool execution progress may be monitored by watching the container status icons as mentioned above. As each adapter (model) finishes, their yellow output datasets will be populated with viewable and downloadable results. The user will know these

datasets are ready when they display the MapMaker icon (). The user can click the MapMaker icon to view the results with MapMaker in a new window. Additionally, the user may launch the results in MapMaker from the dataset's context menu (right-click dataset to view) where they may also download the dataset to their computer:
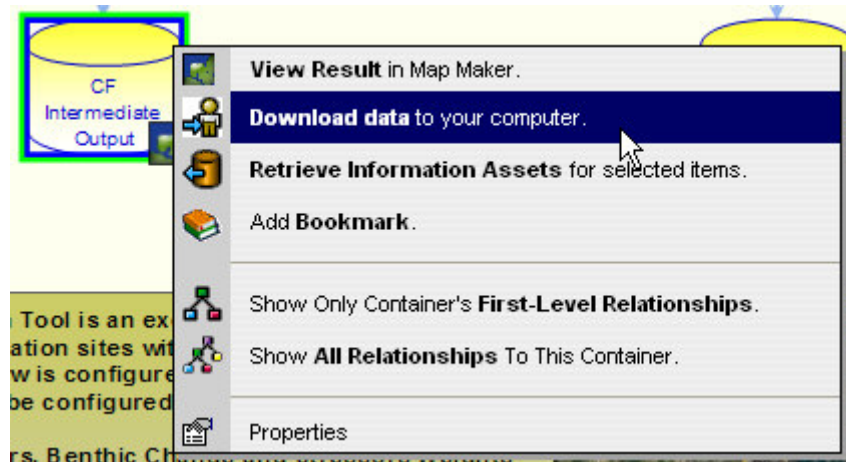
The final dataset will be available in the form of an ESRI shapefile. For those interested in accessing the results in a spreadsheet, choose to download the .dbf file. This file can be opened in Excel. Intermediate dataset outputs will be in GeoTIFF format.

For more information on CME workflow automation, please see the Workflow Automation and the Advanced Workflow Automation sections.

For more information about the SAV Restoration Prioritization Tool, please see the Coastal Habitat Restoration Model for Submerged Aquatic Vegetation documentation.

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2. CME Viewer
2.1. Overview

The CME Viewer is a web application providing the ability to explore conceptual models, workflows and adapters (collectively referred to as "workspaces" in the CME) developed by scientists and researchers. Detailed information about workspace components (referred to as "containers" and "relationships") can be easily obtained in the CME Viewer through built in tools that query a variety of remote web services and search tools. Additionally, some workflows allow users to modify component parameters, execute the workflow, and view the results through the CME Viewer.

To get started using the CME Viewer, users should familiarize themselves with the following:

- Viewer Desktop
- Viewer Dialogs
- Navigating Workspaces

Due to its extensive use of vector graphics, the CME Viewer will only work properly in modern web browsers with native support for SVG or VML graphics. Please see the Known Issues and Bugs section for supported browsers if you are having display problems.
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2.2. Viewer Desktop

The CME Viewer desktop (main window) is designed to have the look and feel of a desktop application. Most notably, the page flashing typically associated with web sites posting back to the server have been eliminated through extensive use of AJAX technologies which allow your browser to transparently communicate with the CME Server as you click elements in the Viewer. Additionally, the Viewer contents adjust to make the most efficient use of the entire browser area so that the user can achieve optimal graphics display. The main windows within the viewer are also size-adjustable to help maximize the viewing experience.
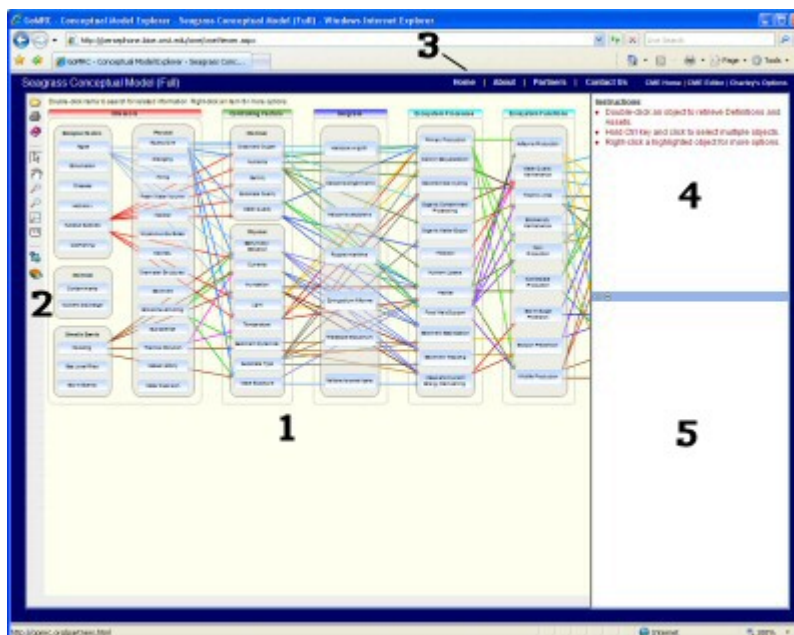
There are several areas of the CME Viewer that the user should be familiar with before using the tool:

- Canvas
- Main Toolbar
- Top Toolbar
- Definitions Window
- Information Assets Window

2.2.1. Canvas

The Canvas (#1 in image above) is the area where workspaces (conceptual models, workflows and adapters) are displayed. For more information on using the canvas area, see the Navigating Workspaces and Main Toolbar help sections.

2.2.2. Main Toolbar

The Main Toolbar (#2) located on the left side of the Viewer contains tools to control the display of models and workflows on the canvas. Additionally, several dialogs can be toggled on and off from the toolbar. Displayed toolbar options will vary depending on the type of workspace loaded into the canvas and whether the user is registered and logged-in.

Toolbar options include:

📁 Open Workspace Dialog Button
Shows/Hides the dialog to open a workspace. A workspace can be a conceptual model, workflow, or adapter.
Also see Open Workspace Dialog.

🖨 Print Workspace Button
Launches a new temporary window with only the currently loaded workspace (at the current zoom level) displayed and then automatically launches user's browser print dialog. After user confirms or cancels print job, the temporary window is closed and the user is returned to the CME Viewer.

📖 Help Dialog Button
Shows/Hides the CME help dialog.

Workspace Navigation Tools:

🔺 Select Mode Button
Puts the mouse left-click in Select mode so the user can select canvas objects by left-clicking. To select multiple objects, hold the "CTRL" key while clicking.

✋ Pan Mode Button
Puts the mouse left-click in Pan mode. The user can then move the workspace by holding the left mouse button down and dragging the workspace.

🔍 Zoom In Button
Clicking this button zooms-in one level on the workspace currently loaded in the canvas.

🔍 Zoom Out Button
Clicking this button zooms-out one level on the workspace currently loaded in the canvas.

🔍 Zoom to Extents Button
Clicking this button zooms the workspace currently loaded in the canvas out to its extents so that the entire workspace is displayed.

1:1 Zoom Actual Size (1:1) Button
Clicking this button zooms the workspace currently loaded in the canvas to a one-to-one ratio (or the "actual size").

Other Tools:

Query Filters Dialog Button
Shows/Hides the Query Filters dialog window. The Query Filters dialog window is displayed by default when the CME Viewer is launched. Constraints set in the dialog will only be used if the window is displayed when queries are sent.
Also see Query Filters Dialog.

Bookmarks Button
Launches dialog displaying all bookmarks the user has saved for all workspaces. The user can edit and delete bookmarks from this dialog, but can not add bookmarks since bookmarks are associated with workspace containers. To add a bookmark, the user must first select one or more containers and then use the right-click context menu to launch the dialog for adding bookmarks.
Also see Bookmarks Dialog.

Workspace Execution Button
Appears when a Workflow or Adapter is loaded. The Execution button launches the dialog that allows a user to run a Workflow or Adapter. Workflows and Adapters are potentially executable, but they must be configured for execution by their authors. Additionally, the user may be required to or have the option to change settings before execution. If the loaded Workflow or Adapter has not been properly configured to execute, the user will be notified when attempting to execute it.
Also see Workspace Execution Dialog.

2.2.3. Top Toolbar
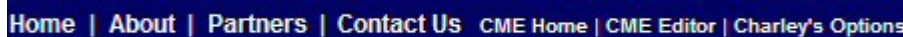
The Top Toolbar (#3) is comprised of two sections. The left side provides navigation back to the main GoMRC web site:

- Home - Gulf of Mexico Regional Collaborative (GoMRC) home page.
- About - Overview of the Gulf of Mexico Regional Collaborative.
- Partners - Gulf of Mexico Regional Collaborative partners.
- Contact Us - Launches default email program to send message to GoMRC.

The right side of the Top Toolbar provides:

- CME Home - Conceptual Model Explorer home page on the GoMRC web site.
- Login - Allows user to register and/or login to the CME to leverage advanced features.

Additionally, if a user is already logged-on to the CME, the right side of the Top Toolbar will appear slightly different:

A hyperlink to the CME Editor is added if the user has editor privileges and the Login link is replaced with a link to the logged-on user's options which include logging-out and updating the user's profile.

To the left of the Top Toolbar is an area that displays the name of the currently loaded workspace when a workspace is loaded.

2.2.4. Definitions Window

Keyword: **Light**
Category: **Controlling Factor**
SubCategory: **Controlling Factor**

Light refers to the solar energy utilized by plants in photosynthesis, termed "photosynthetically active radiation" (PAR).

Light from the sun is used by plants for photosynthesis. The wavelengths that drive photosynthesis are in the 400 to 700 nanometer range, and are referred to as photosynthetically active radiation (PAR). These wavelengths cover the range for vi...

Read more at the GoMRC Catalog...

The definitions window (#4) located in the top right of the CME viewer displays detailed information (when available) about a container when a container is double-clicked with the left mouse button. In addition to definitions, the window may display images, links and other relevant information.

If the mouse pointer changes to the hand icon when placed over an image, the image can be clicked to toggle it between its original and reduced size.

The size of the Definitions Window can be adjusted by dragging the move icon (◁▷⬍) located to the lower left of the window.

2.2.5. Information Assets Window

Assets for keywords: **Inundation**
5 items found:

Coastal Hazards Database

SRTM

NED

Natural Hazards

NOAA Tidal Stations

Search NOESIS for more results.

*If a user is logged-on, each information asset will have the Add Bookmark icon 📚which launches the Add Bookmark Dialog so the user can easily add an information asset bookmark to their
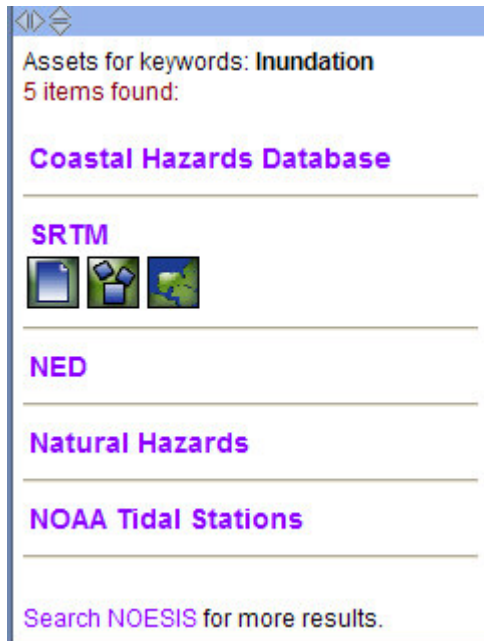
The Information Assets window (#5) located in the bottom right of the CME viewer displays information assets (when available) linked with a container when it is double-clicked with the left mouse button. An information asset is a search result that provides links to metadata, GIS data, imagery, web sites, and more.

Clicking on an information asset title will expand the item to provide additional asset details and access to hyperlinks. Sometimes icons are displayed which will launch external applications displaying the information asset or part of the information asset in a new window. These applications include animations, interactive maps, and others. The tooltips can help familiarize the user with navigation

personal bookmarks.

of the dialog and the icons.

The size of the Information Assets Window can be adjusted by dragging the move icon (◁▷⟺) located to the top left of the window.

2.3. Viewer Dialogs
The CME Viewer contains four main dialogs:

- Open Workspace Dialog
- Query Filters Dialog
- Bookmarks Dialog
- Workspace Execution Dialog

These dialog windows can be moved by left-click and dragging the title bars. Buttons to minimize and close the windows will be displayed in the title bar's right side when available. Additionally, these dialog windows have a button to toggle their display in the Main Toolbar.

2.3.1. Open Workspace Dialog
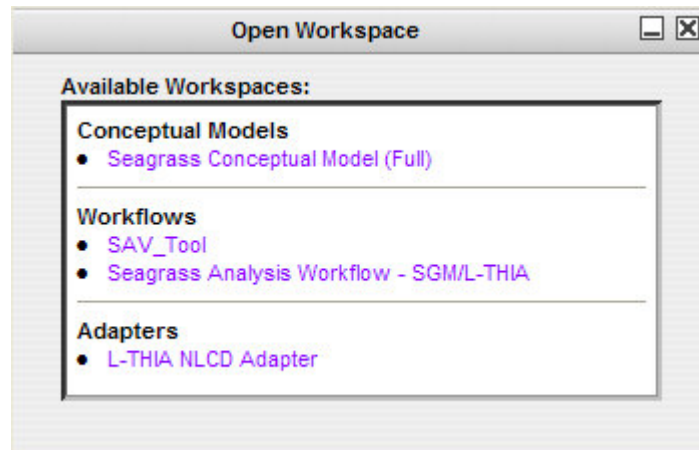
The Open Workspace dialog appears automatically when the CME Viewer is started. Click on the desired workspace to load the workspace into the canvas. The dialog will automatically close.

The Open Workspace dialog can be displayed or hidden at anytime using the Open Workspace Dialog Button. The dialog can be minimized or closed using the buttons in the upper-right of the window.

2.3.2. Query Filters Dialog

The Query Filters dialog allows a user to refine an information asset query. The user may specify additional keywords, specify spatial extents via the interactive map, and/or select a time period to augment an information asset query. To apply these optional query parameters, one or more containers must be selected before pressing the "Submit Query" button. If the Query Filters Dialog is visible, the optional parameters set within the window (if any) will be applied to all subsequent searches (including those initiated directly from containers) until the parameters are reset or the dialog is closed.

Please note that a lot of information assets in the GoMRC Catalog do not currently have spatial or temporal attributes, so results may be limited. Also the additional keywords parameters are passed to Noesis when initiating a Noesis search from the Information Assets Window; however, the spatial and temporal constraints currently are not.

The Query Filters dialog provides three options:

- Additional Keywords
- Spatial Filter
- Temporal Filter

2.3.2.1. Additional Keywords
Any words entered in the Keywords textbox will be sent in addition to the selected container's name. Currently, additional keywords are combined with the container's name implicitly using the "OR" boolean operator.

2.3.2.2. Spatial Filter

A Spatial Filter can be set using the interactive map. Use the mouse wheel or ZoomIn and ZoomOut icons to zoom the map. Left-click and drag to pan the map. To draw a spatial extent on the map, put the map into Draw mode by clicking the Draw Extents button. Then left click to add points defining your desired area. Add the last point with a right-click to finish and close the polygon. The polygon will appear in red and the spatial extent will be drawn as a green box around the polygon. The minimum and maximum latitude and longitudes from the green box will

be displayed in the textboxes below the map, and these are the spatial parameters that will be sent with queries. When defining a spatial extent, to quit without saving, click the Cancel button. To clear a spatial extent, click the Reset button, or if you wish to redefine the extent, just click the Draw Extents button again and the previous extents will automatically clear when the map goes into Draw mode.

2.3.2.3. Temporal Filter
The Temporal Filter allows the user to select a year or range of years from a drop-down list.

2.3.3. Bookmarks Dialog

Bookmarks are a personalization feature of the Conceptual Model Explorer. Registered users may save bookmarks created from search results in their profile. Bookmarks are always associated with one or more workspace containers.

The Bookmarks Dialog is presented to the user to add and/or manage bookmarks:
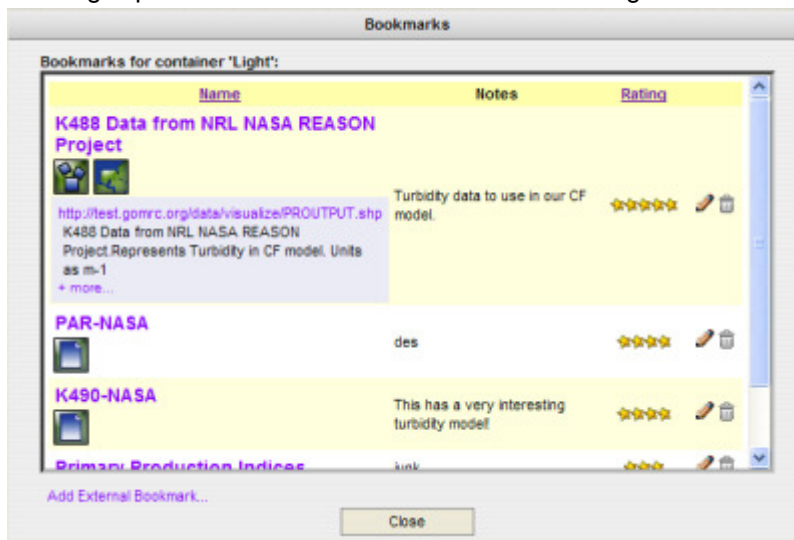
If the dialog is opened using the Bookmarks button in the main toolbar, all of the user's bookmarks from all workspaces and containers are displayed. Alternatively, a user can right click on a container and launch the dialog showing only bookmarks associated with the selected container. This method also allows a user to add external bookmarks that will be associated with the selected container.

The bookmarks dialog displays the bookmark name, user notes and user rating for each bookmark. The dialog listing can be sorted by name or rating by clicking on the desired heading. To the right of each bookmark listed are the edit ( ) and delete ( ) buttons. The edit button opens a dialog to allow the user to edit the name, URL, notes and rating for the bookmark. The delete button will remove the bookmark from the user's profile.

There are two potential type of bookmarks, GoMRC Catalog bookmarks and External bookmarks:
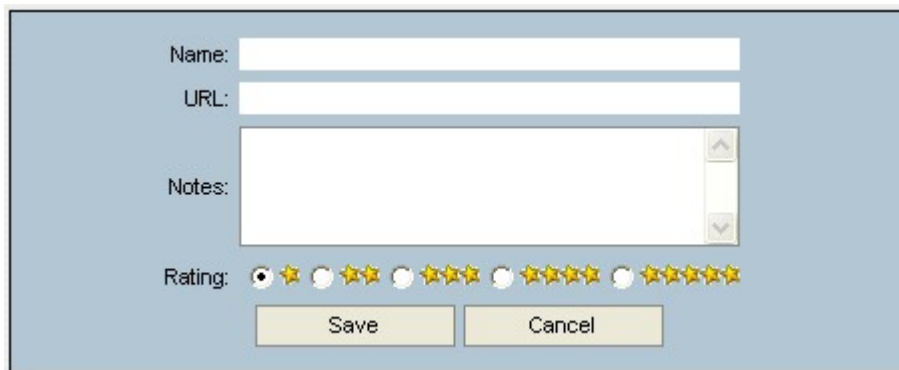
2.3.3.1. GoMRC Catalog Bookmarks

GoMRC Catalog bookmarks are added directly from search results appearing in the Viewer Information Assets Window. When clicking on a GoMRC Catalog bookmark name in the

Bookmarks Dialog, additional details about the information asset appears below the name. GoMRC catalog bookmarks may also display additional icon buttons which launch remote applications. When editing a GoMRC Catalog bookmark, the user will not have the option to edit the bookmark's name or URL.

2.3.3.2. External Bookmarks

External bookmarks are those that a user finds in sources other than the GoMRC Catalog, such as through Noesis. When an External Bookmark is displayed in the Bookmarks Dialog, clicking on its name loads the bookmark's URL in a new browser window. A user adds these bookmarks to their bookmarks after launching the Bookmarks dialog by right-clicking on the selected container. Then the user selects the "Add External Bookmark" option and a dialog appears:

The Add External Bookmark dialog and the Edit Bookmark dialogs are very similar. The user must type a name for the new bookmark and type or cut-and-paste a URL into the URL text box. Optionally, the user can add notes and select a rating. When finished, the user clicks the "Save" button and the new bookmark appears in the container's bookmark list as the Add External Bookmark dialog closes.

External bookmarks can also be added from a Google toolbar. Click the link below to add a CME Bookmarking button to your Google Toolbar. The user will be prompted to install the Google Toolbar if it is not already installed:

<p style="text-align:center;color:blue;">Add CME Bookmark Button to Google Toolbar</p>

Once installed, when the user navigates to a third party web site through a CME Search, they will have the option of clicking the CME Bookmark Icon (🔖) in the Google toolbar of that window. Clicking the icon will redirect the browser to a pre-populated CME form to add a CME bookmark from that site to the user's CME profile.

2.3.4. Workspace Execution Dialog

The Workspace Execution Dialog is still being developed and is subject to change. The dialog is launched from the main toolbar by clicking the Workspace Execution Button (🔥). The Workspace Execution Button only appears when a Workflow or Adapter is loaded as these are the only potentially executable workspace types.

If a workspace has been configured for execution and the Workspace Execution Button is clicked, the Workspace Execution Dialog appears with the "Run" and "Cancel" buttons displayed:
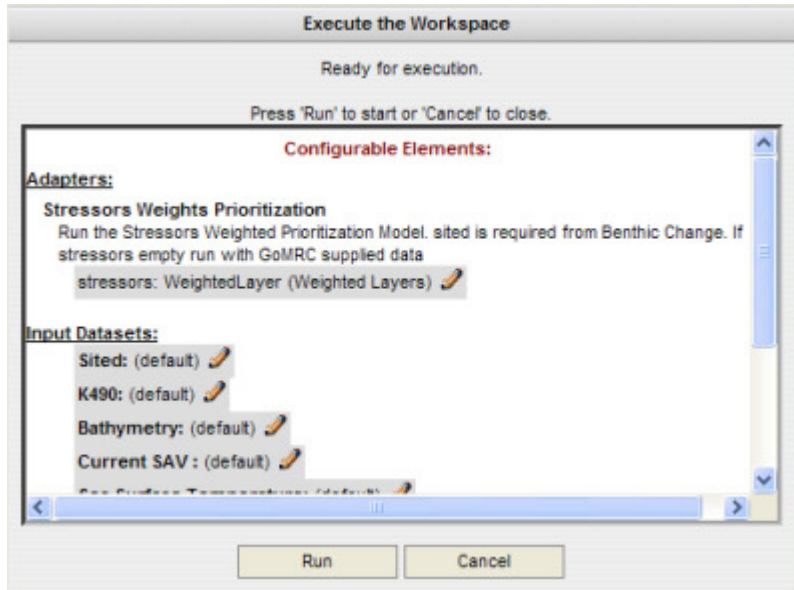
Clicking the Run button begins execution of the workspace. Icons will then appear on the workspace indicating the status of containers during execution. The dialog will indicate when execution is finished or if an error occurs. The Cancel button closes the dialog window and stops execution of the workspace if it was started.

If a workspace has not been configured for execution, or has been incorrectly configured, and the Workspace Execution Button is clicked, the Workspace Execution Dialog appears as follows:
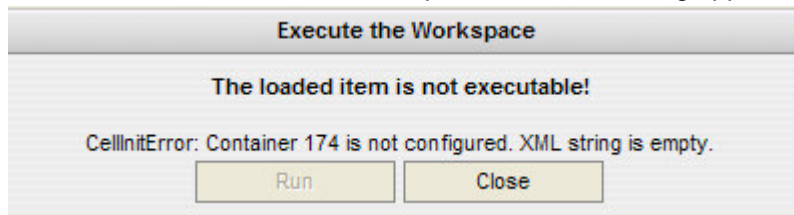
Notice the dialog indicates that the workspace is not executable and additionally lists the first error encountered when verifying workspace configuration. If the user knows the workspace is supposed to be executable, they can use the error message to help correct configuration problems.

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2.4. Navigating Workspaces

Workspaces (conceptual models, workflows, and adapters) are displayed in the CME Viewer Canvas. Buttons in the Workspace Navigation Tools portion of the Main Toolbar can be used to control selection, panning and zooming(scaling) the displayed workspace on the Canvas. This section describes the other tools available within the canvas which can change the workspace display.

2.4.1. Workspace Elements

There are three basic types of workspace elements the user should be familiar with to be able to navigate a workspace that is loaded in the Canvas:

- Containers
- Relationships
- Workspace
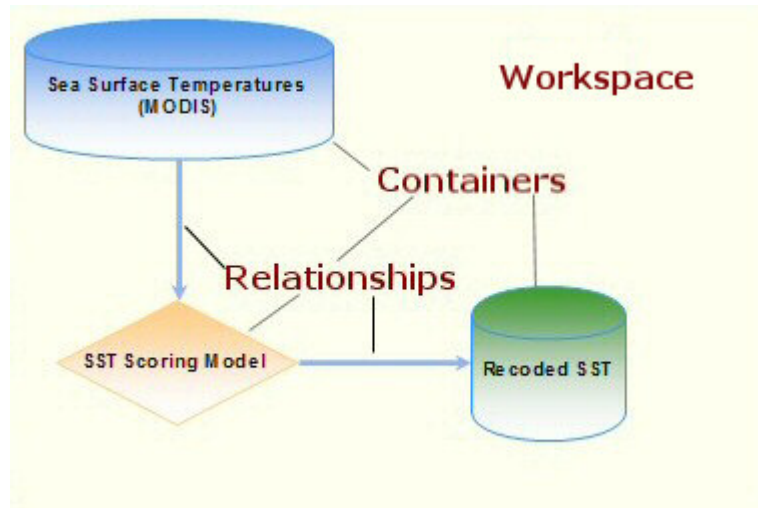
Additional workspace objects including plain text and images exist to help document a workspace. These objects are static, providing no user interaction capabilities, so they require no further explanation. The following sections briefly describe the major workspace elements.

2.4.1.1. Containers

Containers are objects on a workspace that represent Organizing Principles, System Components, Datasets, Geoprocesses, Adapters, Conceptual Models, and Workflows.

2.4.1.2. Relationships

Relationships are directional edges that connect containers and are represented as arrows on the canvas. Relationships may have a type and/or duration as well as other information which can be viewed through the Properties menu by right clicking a relationship.

2.4.1.3. Workspace

The Workspace is the entire workflow, conceptual model, or adapter represented in the canvas area. Workspace options can be accessed by right clicking anywhere on the canvas where there is no object displayed.

2.4.2. Context Menus

Once a workspace is loaded into the Canvas from the Open Workspace Dialog, the user is able to alter the display of containers and relationships through the use of context menus. Context menus are popup menus that list options available related to the object (container, relationship, or canvas) that the mouse cursor is currently over when the right mouse button is clicked. The context menu options vary depending on which type of object is hovered. The following sections

detail the context menu options for the three basic types of objects that may appear in the canvas:

- Container Context Menus
- Relationship Context Menus
- Workspace Context Menu

2.4.2.1. Container Context Menus

Container context menus are the menus that the user will use most often. The following briefly describes the container context menu options:
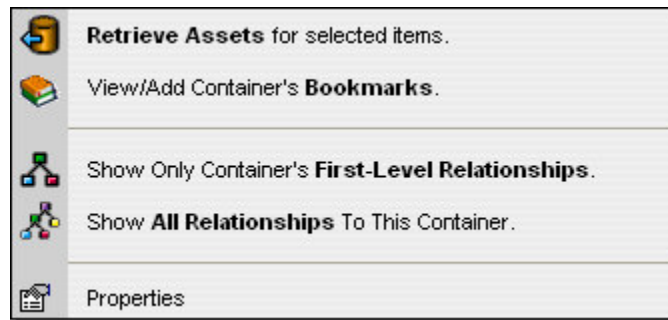
⬤ Retrieve Information Assets for Selected Items
Sends requests to remote web service catalogs using names of selected containers and options selected in the Query Filters Dialog. Results are displayed in the Definitions and Information Assets Windows. See Performing Searches for more information.

⬤ View/Add Container Bookmarks
Launches the Bookmarks Dialog to view or add bookmarks for the selected container. If the container currently has no bookmarks, this menu item will be displayed as "Add Container Bookmarks". See Bookmarking for more information.

⬤ Show Only Container's First-Level Relationships
Hides all relationships except those directly connected (first-level) to the selected container. This option is used to isolate the items of interest in complex workspaces. All relationships can be redisplayed using the Workspace Context Menu.

⬤ Show All Relationships With This Container
Shows only the relationships that occur in the paths to and from the selected container. All other relationships are hidden. This option is used to isolate the items of interest in complex workspaces. All relationships can be redisplayed using the Workspace Context Menu.

⬤ Properties
Launches a Properties Dialog displaying additional properties about the container if any have been defined by the workspace's editor. See Properties Dialogs for more information.

Optional menu items:

⬤ Download Data To Your Computer
If the container is of type Dataset and the Dataset has been configured with an FTP

or web site URL, this option will be displayed. Clicking this option will cause the URL to open in a new window so the data can be directly downloaded to your computer. Datasets with this option are typically found in Workflows or Adapters.

View Result in Map Maker
If the container is of type Dataset and the Dataset has a valid FTP or web site URL, this option will be displayed. Clicking this option will launches MapMaker to display the dataset. Datasets with this option are typically found in Workflows or Adapters.

2.4.2.2. Relationship Context Menus

Relationship context menus are not used very often at this point since most current workspaces have not been created to leverage relationships to their full extent. The following briefly describes the relationship context menu options:

Retrieve Information Assets for Selected Items
*Relationships are currently not supported by remote catalogs.
This option is for future implementation.
Sends requests to remote web service catalogs using names of selected relationship and options selected in the Query Filters Dialog. Results are displayed in the Definitions and Information Assets Windows. See Performing Searches for more information.

Properties
Launches a Properties Dialog displaying additional properties about the relationship, including type and duration, if any have been defined by the workspace's editor. See Properties Dialogs for more information.

2.4.2.3. Workspace Context Menu

The Workspace context menu is always available and provides tools that apply to the entire workspace that is displayed on the canvas. The following briefly describes the workspace context menu options:
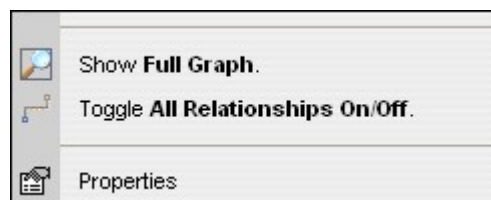
Show Full Workspace
Redraws the workspace with all containers and relationships at its full extent so everything is displayed. This option basically resets the workspace to the same view as when it is originally loaded.
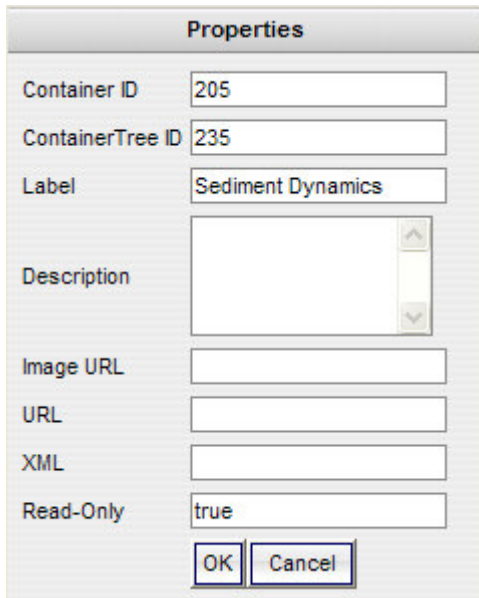
Toggle All Relationships On/Off

Toggles the display of all Relationships. If any or all relationships have previously been hidden, all relationships will be displayed. Otherwise, all relationships will be hidden which helps to simplify the display of complex workspaces to focus on containers.

Properties
Launches a Properties Dialog displaying additional properties about the workspace, including description, if any have been defined by the workspace's editor. See Properties Dialogs for more information.

2.4.3. Properties Dialogs

Properties dialogs are available from the three previously discussed context menus though their content will vary depending on the element they describe. Currently, the properties dialogs are read-only and display information used mostly by workspace editors. The properties that most users would be interested in are "Label" and "Description". Relationships additionally have "Type", "Duration", and "Edge Weight" properties which will be utilized in future workspaces. Other properties are currently irrelevant to general users and will likely change or disappear in future revisions.

2.5. Performing Searches

One of the key features of the CME is the ability to quickly perform contextual searches for the components depicted in a conceptual model or workflow. The easiest way to perform a search is by double-clicking a container. Alternatively, a search may be instantiated from a container's context menu which is available by right-clicking on a container.

When a search is submitted, the words comprising the selected container's name are sent to Gulf of Mexico Regional Collaborative (GoMRC) ontological catalogs. The catalogs are searched for the keywords, and the results are displayed in the CME Viewer Definitions Window and Information Assets Window. The Definitions Window presents a brief description of the selected container and the Information Assets Window lists relevant links that may provide additional information and/or raw data relating to the selected container(s). If multiple containers are selected (by holding down the Ctrl key while selecting with left mouse button), all selected containers' names are queried to produce the Information Assets Window results while only the last selected container is used for the Definitions Window's content.

Finally, the Query Filters Dialog allows one to refine searches spatially, temporally, and with additional keywords. Whenever the Query Filters Dialog is displayed, any parameters set within the dialog will be applied to the Asset Window results when submitting searches. Using the Query

Filters Dialog with searches enhances the user's ability to refine searches, and consequently may substantially limit the number of returned results.

2.6. Bookmarking

When registered users execute searches, the results in the Information Assets Window will

display a button (🔖) which permits the user to initiate saving the result in their personal CME bookmarks collection. Clicking the button launches the Bookmarks Dialog which is then used to add the bookmark. The user may add custom notes and ratings for each bookmark added to their profile. Added bookmarks are always associated with the containers selected when the search query was submitted.

For more information on bookmarks, please see the Bookmarks Dialog and Personalization/Bookmarks sections.

2.7. Workflow Automation
2.7.1. Workflow Automation Overview

A CME workflow represents a process to achieve a task or series of related tasks. Typically a workflow consists of input and output datasets linked in series by relationships with one or more adapters and/or geoprocesses. Additionally, organizing principles are often included to help categorize the containers.

While CME Workflows are usually built initially to present the details of a process or analysis methodology, the more significant and interesting feature of CME Worklflows is that they can be made user executable. If a workflow has been made executable, registered users may use the CME Viewer to configure, run, and view the results of the workflow. The following sections introduce the user to using these automated workflows.

2.7.2. Configuring and Executing the Workflow

If the user is a registered user and the loaded workflow is executable, the Workflow Execution Button (🔧) will appear in the CME Viewer Main Toolbar. Clicking the button will launch the Workspace Execution Dialog and verify that the workflow is configured properly. If the workflow has user configurable properties, such as layer weighting or dataset specification, the dialog will provide the options for the user to configure these before running the workflow. Please see the Workspace Execution Dialog for more details.

The user begins workflow execution by clicking the Run button in the dialog. As the workflow runs, each container will display an icon indicating its execution status:

 Processing.

 Processing Complete.

 Terminal output dataset populated.

 Waiting to process.

 Processing Error.

The Workspace Execution Dialog will display the status of execution including if an error occurs and when the execution is successfully completed. If the user cancels execution, execution stops and all execution-related icons are removed from the workflow. The next section explains how the user may leverage the workflow execution results.

2.7.3. Workflow Results

When terminal output datasets (a dataset that does not pass to another container) have been populated with results, they will display the MapMaker icon ( ) which the user can click to view the results with MapMaker in a new window. Additionally, the user may launch the results in MapMaker from the dataset's context menu (right-click dataset to view) where they may also download the dataset to their computer:
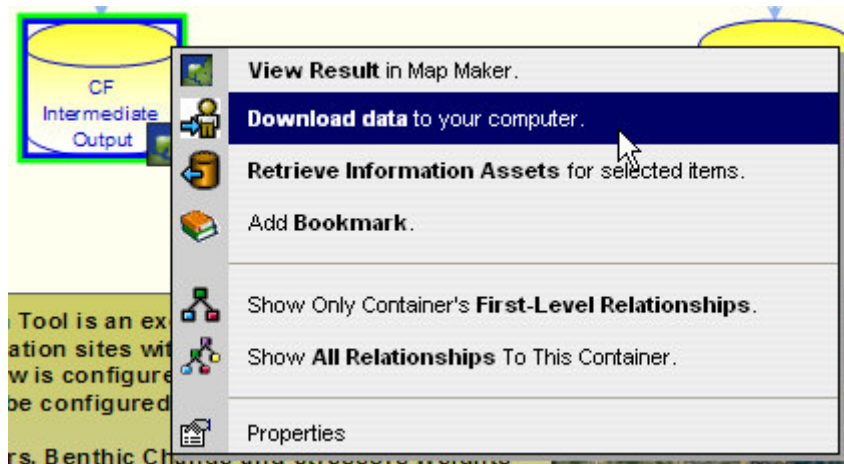
For more information on workflow automation, please see the SAV Restoration Prioritization Tool user scenario and the Advanced Workflow Automation sections.

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3. Personalization

The Conceptual Model Explorer supports two types of users, Anonymous (the default) and Registered. The following sections elaborate these two user types.

3.1. Anonymous Users

The Anonymous User type is the default. Anonymous users can access the CME Viewer only. They have access to all of the Viewer features except for CME Bookmarking. No login or registration is required for anonymous CME users.

3.2. Registered Users

Registering with the CME provides the user with the ability to store and use CME Bookmarks. Additionally, registered users can request Editor privileges to create and edit CME workspaces. Registering with the CME is free, and all private information is used only for the CME and is not shared.

3.2.1. Login and Registration

Registered users can access the Login page by clicking the "Login" item in the upper right menu on the Home page. New users can register by selecting the "Create New User..." option on the Login page which redirects them to the Registration page.

When logging-in to the CME, the checkbox for placing a cookie on the user's computer is selected by default. This option allows the user to be automatically logged-in on subsequent visits if they do not logout. If using a publicly accessible computer, the user may want to uncheck this box in case they forget to logout.

Once logged-in, the "Login" option in the Top Toolbar changes to *Username*'s Options. This new item will redirect the user to a page with multiple task options including logging out and updating their CME Profile (user information).
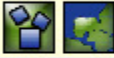
3.2.2. Bookmarks

Registered users have the ability to save and easily retrieve CME Bookmarks to the information assets obtained through their search results. CME Bookmarks not only store a link for quick navigation to the information asset, but they also allow the user to rank the information asset and add personal notes about the information asset. CME Bookmarks are always associated with the component(s) that were selected when the bookmark was added so it is easy to find favorite information assets for a particular model or workflow component. A user's CME bookmark collection is private and maintained on the CME server so it is available in subsequent CME sessions.

There are two basic types of CME bookmarks which are discussed in the following sections.

3.2.2.1. GoMRC Catalog Bookmarks

Search results displayed in the Viewer Information Assets Window are generated from queries to the GoMRC Catalog. These results may be saved to the user's personal bookmarks collection as GoMRC Catalog bookmarks. GoMRC Catalog bookmarks include additional descriptive information (generated by the GoMRC Catalog) about an information asset beyond a name and URL. They may also include additional icon buttons that launch remote applications. When editing a GoMRC Catalog bookmark, the user will not have the option to edit the bookmark's name or URL.

Example GoMRC Bookmark.

3.2.2.2. External Bookmarks

External bookmarks are those that a user finds in sources other than the GoMRC Catalog, such as through Noesis. They include the URL, a user specified name, a user rating, and optionally user notes.

The External Bookmarks subsection in the Bookmarks Dialog help section provides guidance for adding external bookmarks from within the CME Viewer. External Bookmarks may also be added from the target site itself with the aid of the Google Toolbar as explained in the next section.

3.2.2.2.1. Adding Bookmarks Via the Google Toolbar

External bookmarks can be more easily added directly from a browser window displaying the target site using the Google toolbar. Click the link below to add a CME Bookmarking button to your Google Toolbar. The user will be prompted to install a Google Toolbar if it not already installed:

<div align="center">Add CME Bookmark Button to Google Toolbar</div>

Once installed, , when the user navigates to a third party web site through a CME Search, they will have the option of clicking the CME Bookmark Icon () in the Google toolbar of that window. Clicking the icon will redirect the browser to a pre-populated CME form to add a CME bookmark from that site to the user's CME profile.

3.2.3. Editors

CME Registered users may request Editor permissions so that they may create, edit and share workspaces in the CME. Currently, CME Editor privileges are limited to GoMRC project partners involved with the development of GoMRC identified workspaces. To request CME Editor permissions, please register with the CME and then submit a request for Editor status via the CME Feedback Form. Be sure to include your CME Username when requesting Editor privileges.

3.2.4. Workspace Sharing and Publishing

Editors may share their workspaces with other editors for development and can publish them to the CME Viewer so all CME users can see them. For more information on how to do this, see the Workspace Sharing and Publication Dialog help in the CME Editor section.

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4. CME Editor
4.1. Editor Overview

The CME Editor is a web application providing the ability to create, edit and share conceptual models, workflows and adapters (collectively referred to as "workspaces"). Workspaces created with the CME Editor may be published to the CME Viewer for use by the general public. To use the CME Editor, a registered user must first request Editor privileges. The remainder of this chapter provides guidance for using the CME Editor. To obtain optimal results, new users should read the entire chapter, especially Section 4.4 Creating Workspaces, before using the editor.
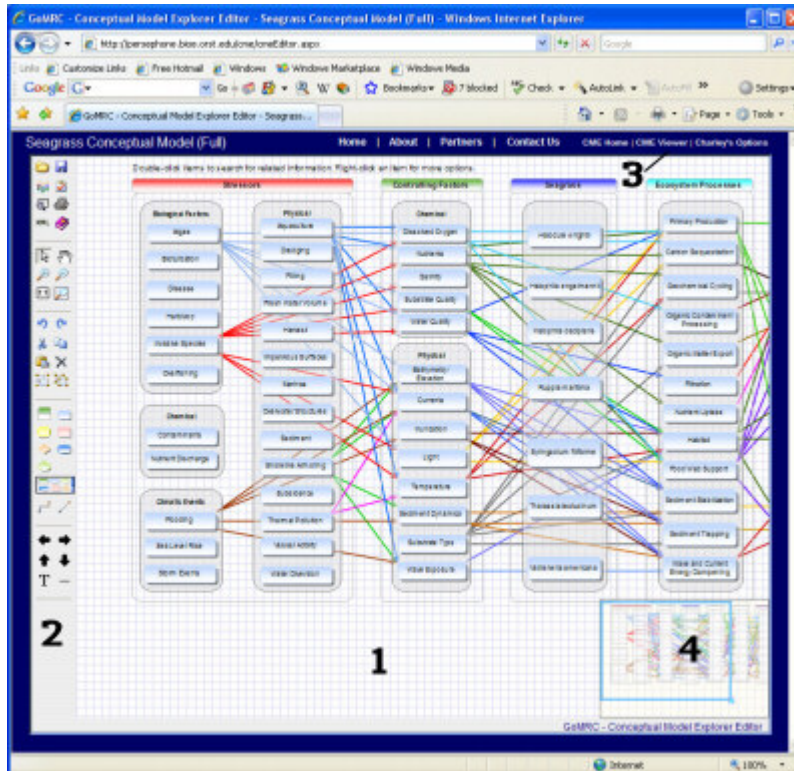
Like the CME Viewer, users should be familiar with several areas of the CME Editor before using the tool:

- Canvas
- Main Toolbar
- Top Toolbar
- Quick-Nav Window

4.2. Editor Desktop
4.2.1. Canvas

The Canvas (#1 in image above) is the area where workspaces (conceptual models, workflows and adapters) are displayed. Containers, relationships, and other graphic objects are added to the Canvas using the Editor's Main Toolbar.

4.2.2. Main Toolbar

The Main Toolbar (#2) located on the left side of the Editor contains tools to create, edit, and control the display of workspaces on the canvas. Additionally, several dialogs can be toggled on and off from the toolbar.

Toolbar options include:

Open Workspace Dialog Button
Shows/Hides the dialog to open a workspace. A workspace can be a conceptual model, workflow, or adapter.
Also see Open Workspace Dialog.

Save Workspace Button
Saves the current workspace to the CME database.

Workspace Sharing and Publishing Dialog Button
Shows/Hides the dialog to share the current workspace with other editors and to publish it to the CME Viewer.
Also see Workspace Sharing and Publishing Dialog.

Tasks Menu Button
Shows/Hides the Tasks Menu Dialog. The Tasks Menu is used to configure the properties of selected workspace elements.
Also see Tasks Menu Dialog.

Preview Workspace Button
Launches a new browser window displaying the current workspace at the current scale.

Print Workspace Button
Launches a new temporary window with only the currently loaded workspace (at the current zoom level) displayed and then automatically launches user's browser print dialog. After user confirms or cancels print job, the temporary window is closed and the user is returned to the CME Editor.

Display Workspace XML Button
Displays the workspace's underlying XML in a new browser window. This feature is currently used mostly by developers for debugging; however, it may be extended in future versions to allow saving and retrieving of models to a user's computer.

Help Dialog Button
Shows/Hides the CME help dialog.

Workspace Navigation Tools:

Select Mode Button
Puts the mouse left-click in Select mode so the user can select canvas objects by left-clicking. To select multiple objects, hold the "CTRL" key while clicking.

Pan Mode Button

Puts the mouse left-click in Pan mode. The user can then move the workspace by holding the left mouse button down and dragging the workspace.

Zoom In Button
Clicking this button zooms-in one level on the workspace currently loaded in the canvas.

Zoom Out Button
Clicking this button zooms-out one level on the workspace currently loaded in the canvas.

Zoom Actual Size (1:1) Button
Clicking this button zooms the workspace currently loaded in the canvas to a one-to-one ratio (or the "actual size").

Zoom to Extents Button
Clicking this button zooms the workspace currently loaded in the canvas out to its extents so that the entire workspace is displayed.

Edit Tools:

Undo Button
Undoes the last action in the user action history. The user may go back up to 50 actions or to the last save. Applies only to actions performed on workspace objects and not to navigation actions.

Redo Button
Moves forward through action history reapplying actions that have been undone using the Undo Button.

Cut Button
Cuts the selected element(s).

Copy Button
Copies the selected element(s).

Paste Button
Pastes the selected element(s).

Delete Button
Deletes the selected element(s).

Group Button
Creates a group containing the selected element(s).

Ungroup Button
Removes the selected group from its contained element(s).

Container & Relationship Tools:

Organizing Principle Button
Adds a new Organizing Principle container to the canvas. When button is pressed, clicking on the canvas will add an Organizing Principle.

Alternatively, the user may drag-and-drop the button to the canvas.

Component Button
Adds a new Component container to the canvas. When button is pressed, clicking on the canvas will add a Component. Alternatively, the user may drag-and-drop the button to the canvas.

Workflow Button
Adds a new Workflow container to the canvas. When button is pressed, clicking on the canvas will add a Workflow. Alternatively, the user may drag-and-drop the button to the canvas.

Conceptual Model Button
Adds a new Conceptual Model container to the canvas. When button is pressed, clicking on the canvas will add a Conceptual Model. Alternatively, the user may drag-and-drop the button to the canvas.

Adapter Button
Adds a new Adapter container to the canvas. When button is pressed, clicking on the canvas will add an Adapter. Alternatively, the user may drag-and-drop the button to the canvas.

Dataset Button
Adds a new Dataset container to the canvas. When button is pressed, clicking on the canvas will add a Dataset. Alternatively, the user may drag-and-drop the button to the canvas.

Geoprocess Button
Adds a new Geoprocess container to the canvas. When button is pressed, clicking on the canvas will add a Geoprocess. Alternatively, the user may drag-and-drop the button to the canvas.

Container Gallery Button
Hides/Shows the Container Gallery Dialog. The Container Gallery is used to add exiting containers, both the user's and those created and shared by other user's, to the canvas and therefore the workspace.

Segmented Relationship Button
Adds a new elbow Relationship to the canvas.

When the button is pressed, the user may connect two containers with a new, directional relationship. The user must place the mouse cursor over the desired source container until it is highlighted with a green box. The green box indicates that pressing the left mouse button will begin the relationship add. The user must press and hold the mouse button as they drag the cursor to the desired target container. When the target container highlights with a green box, the left mouse button can be released to complete the relationship add.

Straight Relationship Button
Adds a new straight Relationship to the canvas.

When the button is pressed, the user may connect two containers with a new, directional relationship. The user must place the mouse cursor over the desired source container until it is highlighted with a green box. The green box indicates that pressing the left mouse button will begin the relationship add. The user must press and hold the mouse button as they drag the cursor to the desired target container. When the target container highlights with a green box, the left mouse button can be released to complete the relationship add.

Other Graphics Tools:

- **Left Arrow Button**
  Adds a left arrow image to the canvas.

- **Right Arrow Button**
  Adds a right arrow image to the canvas.

- **Up Arrow Button**
  Adds an up arrow image to the canvas.

- **Down Arrow Button**
  Adds a down arrow image to the canvas.

- **T Text Button**
  Adds a text element to the canvas.

- **— Horizontal Line Button**
  Adds a horizontal line element to the canvas.

4.2.3. Top Toolbar

The Top Toolbar (#3) is the same as for the CME Viewer except that when the user has the CME Editor open, the CME Editor menu item is replaced by a CME Viewer item so the user can go directly to the Viewer when done editing.

Please see the CME Viewer Top Toolbar section for more information.

4.2.4. Quick-Nav Window

MRC - Conceptual Model Explorer Editor
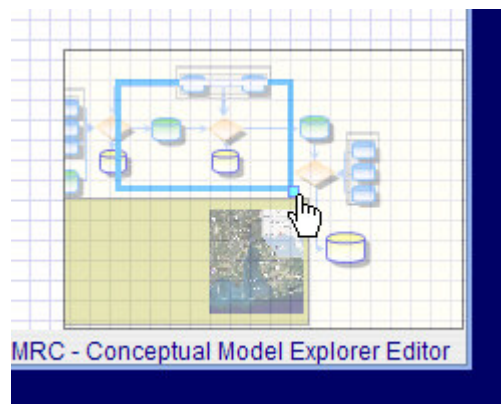
The Quick-Nav Window (#4) allows the user to quickly pan and zoom the displayed workspace. The blue rectangle within the Quick-Nav window represents the canvas extents. The user may left-click and drag the extents to quickly pan the canvas. The lower right corner may be left-clicked on the small brighter blue square and then dragged to alter the zoom level.

4.3. Editor Dialogs
The CME Editor contains six main dialogs:

- Open Workspace Dialog
- Tasks Menu Dialog
- Container Gallery Dialog
- Workspace Sharing and Publication Dialog
- Configure Containers Dialog
- Custom Object Dialog

These dialog windows can be moved by left-click and dragging the title bars. Buttons to minimize and close the windows will be displayed in the title bar's right side when available. Additionally, some dialog windows have a button to toggle their display in the Main Toolbar.

4.3.1. Open Workspace Dialog
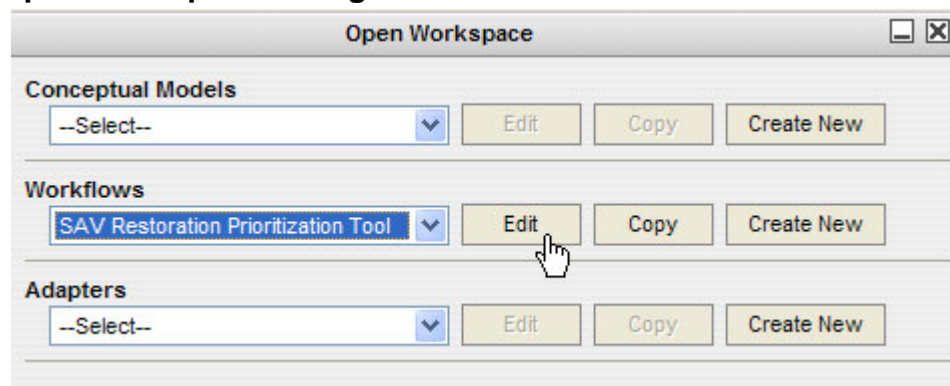
The Open Workspace dialog appears automatically when the CME Editor is started without a workspace. The Open Workspace dialog can be displayed or hidden at anytime using the Open Workspace Dialog Button. The dialog can be minimized or closed using the buttons in the upper-right of the window.

The user has the option to create a new Conceptual Model, Workflow, or Adapter by clicking the "Create New" button in the corresponding category. This option will prompt the user for a workspace name. After the user submits a new workspace name, the CME Editor will initialize a new workspace with that name, and the user may then begin building their workspace.

A user may alternatively select an existing workspace from one of the dropdown lists to edit or copy if any existing workspaces are available. When the user makes a selection from a dropdown list, the "Edit" and/or "Copy" buttons will enable depending on the existing workspace's permissions. If the user has edit permissions on the existing workspace, they can click the "Edit" button to view and update that workspace. Otherwise, clicking the "Copy" button will prompt the user for a new workspace name and save a copy of the workspace with the new name and the current user as its owner. Edits to copied workspaces have no impact on the original workspace that was copied.

4.3.2. Tasks Menu Dialog
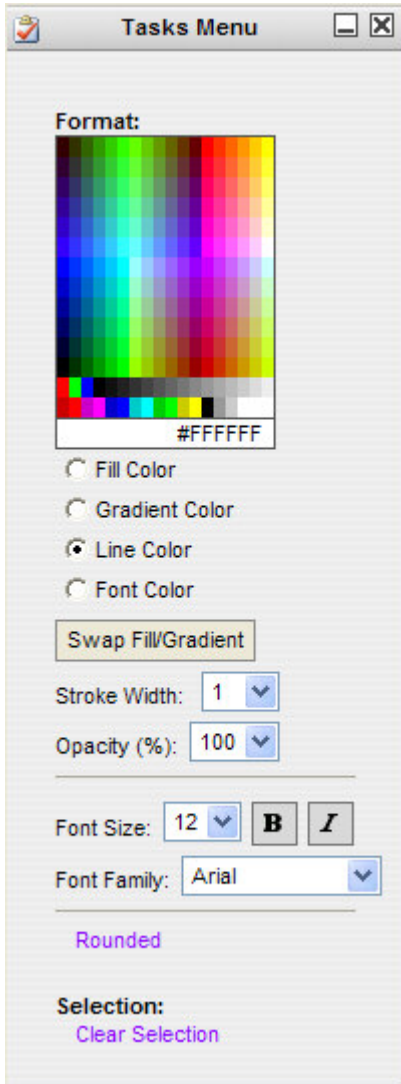
The Tasks Menu Dialog is dynamically generated and updated as workspace elements are selected and edited. The dialog will display different options depending on the type of element (container, relationship, image, etc.) selected.

Generally, the Tasks Menu is used to quickly change the style of an element. For example, a user can change the fill color, line color, font style, and font size of a selected container using the dialog.

After making such style changes, the user may view and manually edit the updated styles by right-clicking the selected container and selecting "Properties" from the context menu. The "Style" property in the Properties Dialog contains the style attributes which may be manually edited. However, this is an advanced, currently undocumented feature.

4.3.3. Container Gallery Dialog
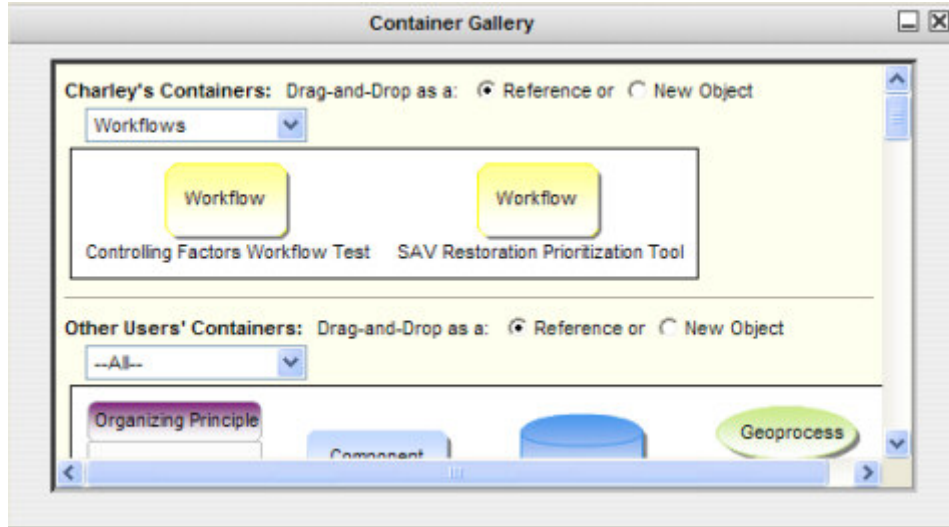
The Container Gallery Dialog allows the user to reuse their existing containers from other workspaces or containers created by other editors.

To view the Container Gallery, the user clicks the Container Gallery Button in the left-side Main Toolbar. The top section of the dialog window displays the user's existing containers from other workspaces, and the bottom section displays other user's containers from workspaces for which the current user has edit permissions. The user may select to display all available containers or select by container type using the dropdown lists.

If the user has "Reference" selected (default), the added container will be a reference to the existing container and a new container will not be created in the CME database. If "New Object" is selected, a new container is created in the CME database and all properties of the existing container are copied to it. The current user will own that new container.

To add a displayed container, the user left-clicks and drags the desired container onto the canvas. The dialog may be closed by clicking the Close button in the upper right of the dialog or by clicking the Container Gallery Button again.

4.3.4. Workspace Sharing and Publication Dialog
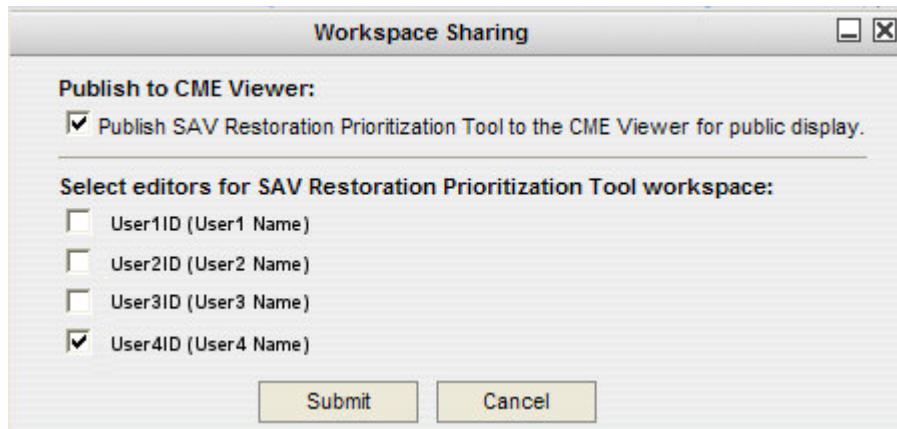
A workspace owner (the original creator) may decide to share their workspace with other editors or publish the workspace to the CME Viewer. The Workspace Sharing and Publication Dialog provides these functions for the currently loaded workspace, and is accessed by clicking the Workspace Sharing and Publishing Dialog Button in the left-side Main Toolbar. If the current user is not the owner of the loaded workspace, the dialog will indicate that they are not permitted to adjust these workspace permissions.

The top section of the dialog controls if the workspace will be displayed to all users in the CME Viewer. This option should only be checked for finalized and peer-reviewed workspaces.

The bottom section lists all currently registered CME editors. Checking any box will allow that user to edit the currently loaded workspace. Un-checking a box will remove editor privileges to the workspace for that user.

Click the "Submit" button to save changes to the CME Database or the "Cancel" button to cancel any changes made.

4.3.5. Configure Containers Dialog

The Configure Containers Dialog is the main dialog used to configure a Workflow or Adapter for execution. All Datasets, Adapters, and Geoprocess connected by Relationships as part of the execution process must be configured for a workspace to successfully execute. Access each of these containers' Configuration Dialog by right-clicking the container and selecting "Properties". From the Properties Dialog, click the "Configure Container" button.

To configure a dataset, the user should select "FTP":

Configure Container

URL: %ref442_Controlling_%

○ Web Service ◉ FTP

Available Inputs:

| Container	Reference Name	
Controlling Factors:	%ref442_Controlling_%	Add

Save   Cancel
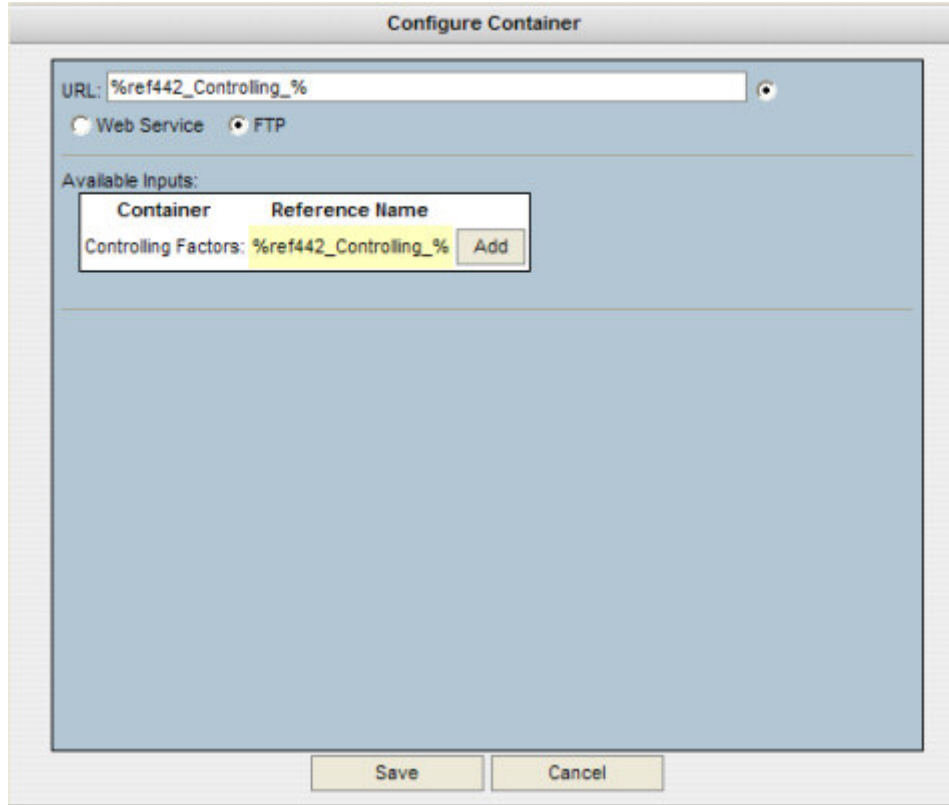
In the URL textbox, the user should enter a valid URL pointing to a dataset in the appropriate format. If the dataset represents an output from an Adapter or Geoprocess, the user should select the radio button to the right of the URL textbox and click the "Add" button next to the container that will produce the desired output dataset (see above).

To configure an adapter or a geoprocess, the user should select "Web Service", enter the location of the web service WSDL, and then click the "Query WSDL..." button to populate the dialog with the web service's available methods:
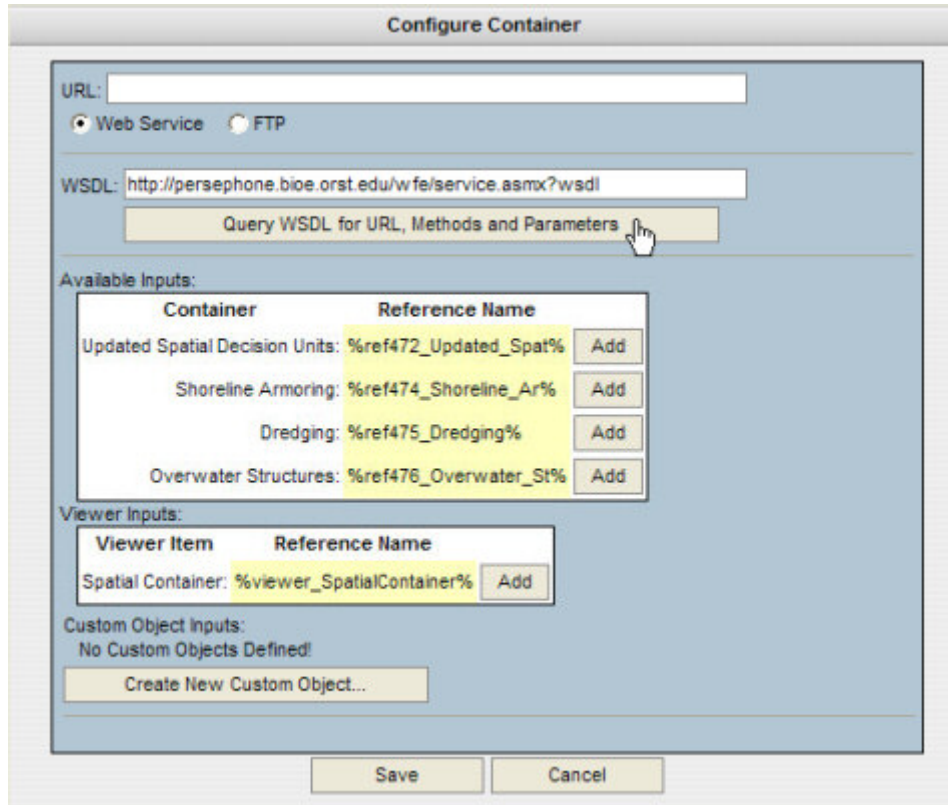
The URL textbox will be updated with the web service URL, and all available web methods from the service will be displayed in the "Select Method" dropdown list. A method description (if available) will display in a tooltip when the user puts the cursor over each method in the list. The user should select the desired web method. The required web method parameters will then be displayed.

The user must enter valid values for each parameter. Each required parameter will have the parameter type displayed in brackets to help the user enter a valid value. The user may pass the results from an input (usually a URL string) to a required parameter by selecting the radio button to the left of the desired parameter and then clicking the "Add" button next to the desired input container. Checking the checkbox to the right of a parameter will make that parameter user editable when the workflow or adapter is executed in the CME Viewer:
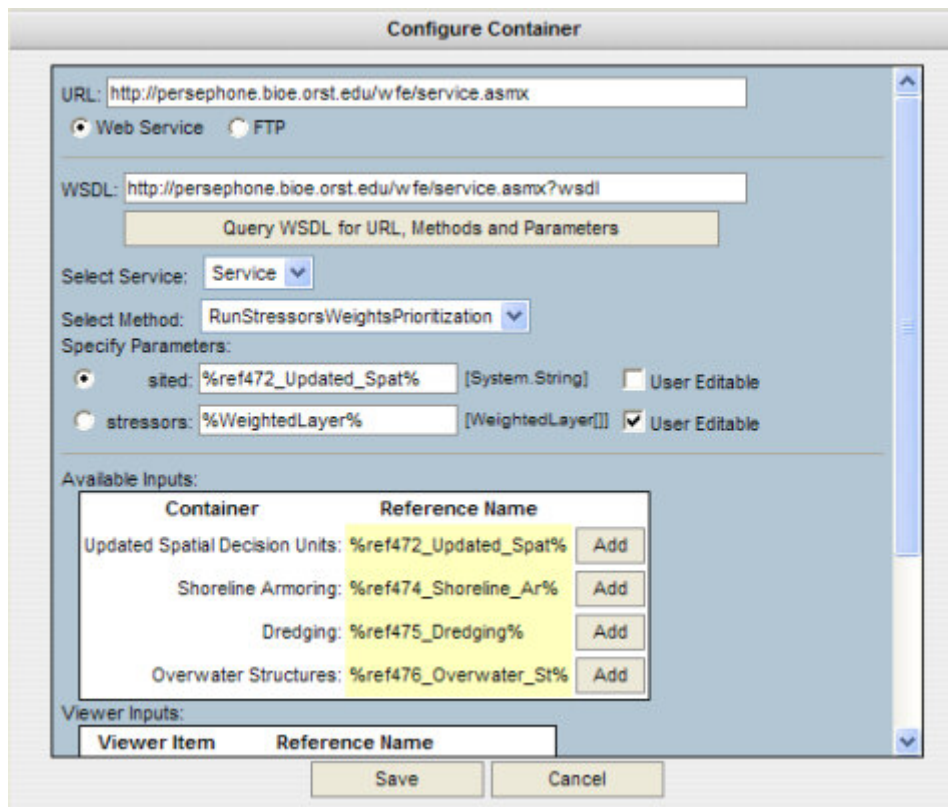
Most required web service parameters will be standard types such as string, integer, bool, and etc. However, the CME supports passing custom, complex object types as parameters. The custom parameter types must be known to both the CME and the web service being called. Currently, the CME supports two custom types:

- Recode Array - Recodes values in a geodataset to new values.
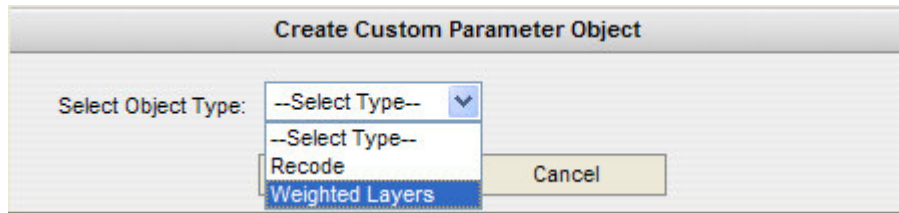- WeightedLayer Array - Allows user assigned weights to multiple inputs for analysis.

The Custom Object Dialog presented in the next section is used to create a supported custom object. Once created, a custom object can be passed to a parameter by selecting the radio button to the left of the desired parameter and then clicking the "Add" button next to the desired custom object.

After the user has configured the web service or dataset URL, they should click the "Save" button which saves the configuration to the container.

The user can modify the configuration at anytime and the dialog will be prepopulated with the saved settings when it is opened. Any changes to a specified web service or web method will be reflected in the dialog as the web service's WSDL is always queried to rebuild the dialog. If changes have occurred since the last configuration, the user may have to update the container's configuration. If a specified web service no longer exists, the user will receive an error message indicating the service can not be found.

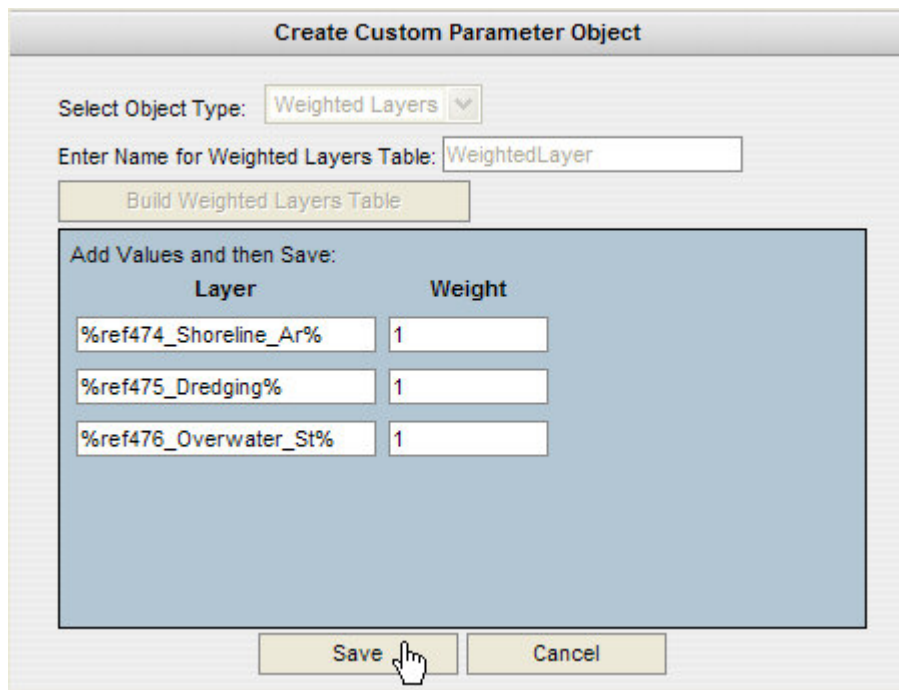## 4.3.6. Custom Object Dialog

The CME supports passing custom, complex object types as parameters to web services. The Custom Object Dialog is used to create a supported custom object. The dialog is accessed by clicking the "Create New Custom Object..." button in the Configure Containers Dialog.


The user must select one of the supported custom types:

- Recode Array - Recodes values in a geodataset to new values.
- WeightedLayer Array - Allows user assigned weights to multiple inputs for analysis.

Next the user must follow the dialog for the selected type. Typically a unique name is specified and a button is clicked to build the object. The Recode object dialog will also request the user to specify the number of values to be included in their recode. After the custom object is created, a table will be presented for the user to enter the default values. The format of the table will vary by object type. The following shows the table to populate a WeightedLayer Array object:

The user clicks the "Save" button to save the custom object. The Configure Containers Dialog will now have the new custom object displayed, and the object may be added to a web service parameter as described in the Configure Containers Dialog section:
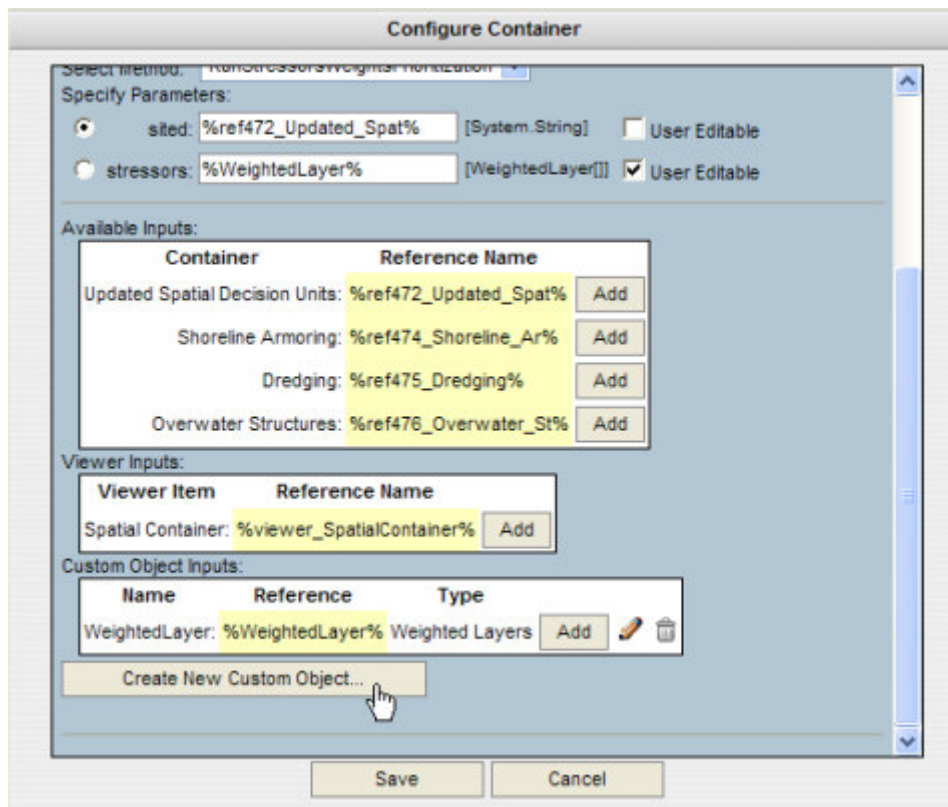
Additionally the user may delete or edit the custom object at anytime using the buttons to the left of the object. The user should note that a custom object is only available for use by the container it was created for - it is not a global object.

4.4. Creating Workspaces
4.4.1. Recommended Procedures

Creating workspaces in the CME Editor is fairly straightforward:

- The user uses the Open Workspace Dialog to initialize a workspace.
- Containers and graphics are added to the workspace using tools in the Main Toolbar and can be dragged around the canvas.
- Container labels are editable by double-clicking the label.
- Containers may be grouped or dropped into an Organizing Principle to create a hierarchical structure.
- Directional relationships may be added between containers using the Relationship Buttons in the Main Toolbar.
- The Tasks Menu Dialog may be used to quickly change the style of a container or relationship.
- Any element put on the canvas has user editable properties and edit tools available from the context menu displayed when right-clicking the element.
- Save the workspace before closing or navigating from the CME Editor if you want to keep it.

The easiest way to get started is to follow these few guidelines, familiarize oneself with the Editor Desktop and Editor Dialogs sections, and then begin creating a new workspace. The user will quickly learn the features of the CME Editor as they explore the tool.

It should be noted that the CME Editor is still in its early, evolving stages. Many obstacles to building the Editor in a web browser without a third party plug-in have been surmounted, but some still exist. Future versions will have more and refined features as well as extended documentation.

4.4.2. Configuring Workflows for Automation

Workflows and adapters may be configured for execution in the CME Viewer. This is typically done to allow users to perform some type of spatial, environmental analysis on an area of interest. Automation is achieved by configuring CME adapters and geoprocesses to call corresponding web services and to use Internet accessible datasets. The execution sequence is determined by the connections (relationships) between these elements.

The CME Workflow Automation feature is in its early stages and standards are still being established. However, an editor may experiment with this feature by following the guidelines presented in the Configure Containers Dialog, Custom Object Dialog, and Advanced Workflow Automation sections.

Important:
Please note that currently, all containers and relationships should be added and labeled, and the workspace saved before configuring a workflow for execution. This allows the CME database to give each container a unique ID and use the ID when passing container properties as parameters to web services. All containers in an execution sequence must be configured in the CME Editor for the CME Viewer to successfully execute a workflow. If a container is added after configuration, the new container must be configured and any connected (by a direct relationship) containers must be reconfigured after first re-saving the workspace. Likewise, if a container is deleted, any remaining containers that were previously connected to the deleted container may require reconfiguration. Future CME versions will refine this process.

4.5. Sharing and Publishing Workspaces

An editor may share their workspace with other CME editors and may publish their workspace to the CME Viewer for all CME users to view. Only the workspace owner (original creator) may share and publish a workspace. The main purpose of sharing a workspace with other editors is to collaboratively develop and review the workspace. The owner and all editors of a workspace will be able to view it in the CME Viewer as well as edit the workspace in the CME Editor. Therefore, a workspace should not be published to the CME Viewer for all users to view until it is complete and peer reviewed.

Please see the Workspace Sharing and Publication Dialog for detailed instructions on adding editors to and publishing workspaces.

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5. Containers and Workspaces
## 5.1. Containers and Workspaces Overview

The Conceptual Model Explorer is used to create and view workspaces via the Internet. The term workspace is a generic term used in the CME which can represent a Conceptual Model, a Workflow, or an Adapter.

Workspaces are comprised of Containers, Relationships (edges connecting containers) and ancillary text and images. Containers are the most important object type to understand as workspaces themselves are special containers which can be nested within other workspaces. The rest of this section focuses on detailing the different types of Containers and their use in CME workspaces.

5.2. Containers

A container is an object representing a system or workflow component or organizing principle within a CME workspace. The CME establishes a set of standard container types to represent systems and workflows. The standard container types are detailed below. The special container types, which may also be Workspaces, are subsequently detailed in Section 5.3.

5.2.1. Component
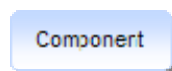
A Component is the most basic or generic type of container used in the CME and can represent any kind of system component. If the system component needed does not fit one of the other specific container types, then the Component type should be used. All other containers are derived from this basic container type.

5.2.2. Dataset

A Dataset container represents a data archive. Typically this would be an FTP or web site hosting data in a known format.

5.2.3. Geoprocess

A Geoprocess is a sequence of events that perform one or more spatial operations on data. When developing an automated workflow, a geoprocess typically represents a publicly available web service with the geoprocessing capabilities.
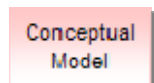
5.2.4. Organizing Principle
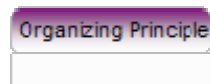
An Organizing Principle is a special container type used to group related containers.

5.3. Special Containers (Workspaces)

The containers in this section are special because they have the potential to be workspaces. When an editor creates a new workspace, it will be one of these three types, and it will be embeddable into other workspaces.

5.3.1. Conceptual Model

A Conceptual Model depicts a system through the use of system components, their relationships and organizing principles.

5.3.2. Workflow
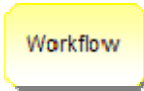
Workflow A Workflow represents a process to achieve a task or series of related tasks.

5.3.3. Adapter

Adapter An Adapter is a process that converts data from a given format to a desired format that is useable for subsequent processing. Adapters may modify not only the storage format but spatial extent, resolution and other properties as well. Adapters are usually used in workflows, and they will represent a web service with the desired functionality when automating a workflow.

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6. Advanced Workflow Automation

This chapter is being developed to support CME workflow editors in creating and configuring CME automated workflows. Additionally, it will eventually contain guidance on creating the underlying web services that are represented in workflows as adapters and geoprocesses. Information on hosting and uploading datasets consumed by the web services will be included as well.

Since workflow automation is still in the experimental stage, this chapter will only contain summary information until standards have been adopted for the underlying web services.

6.1. Dataset Sources

The datasets represented in CME workflows and adapters must correspond to real datasets available on the Internet and represented by a URI. These URIs should have a prefix of "ftp://" or "http://" as appropriate. Workflow datasets must be configured in the CME Editor to point to these URIs using the Configuration button on the dataset's context menu. When clicked, the configuration dialog will open. The "FTP" option should be selected and the URI entered. Click the Save button to update the dataset's configuration with the new URI.

There is an experimental option in the CME Viewer that allows users to upload their datasets to the CME server at runtime for workflow execution. This option is currently only available to select users, but look for this file upload feature to be available and expanded in future versions of the CME.

6.2. Building and Publishing Adapters and Geoprocesses

Adapters and geoprocesses in CME workflows can interface with web services that provide the represented functionality. The SAV Restoration Prioritization Tool - Mobile Bay is an example of an executable workflow with adapters that interface with such web services. That workflow was the first effort to prove the concept of creating and executing workflows within the CME. Future efforts will develop standards for web service developers to follow so that they may create web services that can be easily executed from within the CME.

6.3. Workflow Output

Adapters and geoprocesses embedded in workflows typically produce some type of spatial dataset such as a TIFF raster or an ESRI shapefile. These outputs may be final outputs or intermediate datasets to be passed to subsequent tasks. Currently, any terminal dataset (a dataset that does not pass to another container) can be downloaded or viewed in MapMaker after workflow execution using the dataset context menus. For more information, please see section 2.7.3 Workflow Results.

7. CME Known Issues
7.1. Browser Compatibility

The Conceptual Model Explorer is a graphics-intensive web application built to be executable in browsers without requiring a third party plug-in. As such, a modern browser with native, standards-compliant vector graphics support is required to effectively use the CME.

Compatible browsers in order of best performance include:

- Internet Explorer 5.5 and later
- Firefox 1.5 and later
- Netscape 8.1.3 or later using the Internet Explorer Engine mode
- Camino 1.2 and later (experimental)
- Opera 9.0 and later (experimental)

The **latest versions of Internet Explorer and Firefox are recommended** as the majority of testing has been done with these browsers.

Some additional browser notes:

7.1.1. Camino
Support for Camino 1.2+ is currently experimental only. Camino should render graphics properly, but no testing has been performed yet.

7.1.2. Firefox
Significant CME testing has been performed with Firefox 1.5+ and 2.0+ on Windows platforms. Workspaces are best displayed in Firefox using the "Normal" text size in the browser settings. Increasing or decreasing the default browser text size may cause container labels to not display optimally. Firefox is recommended for Macintosh users although testing is still in progress.

7.1.3. Internet Explorer
Extensive CME testing has been performed with Internet Explorer on Windows. Windows version 5.5 or later should work, but IE 7.0 or later is recommended for optimal results.

7.1.4. Opera
Support for Opera 9.0+ is currently experimental only. In Opera, container's context menus must be triggered by shift-left click instead of the usual right-click.

7.1.5. Safari
Safari is unsupported due to its insufficient support of the SVG standard. Mac users should use the latest Firefox browser for best results.

Appendix G. Noesis Technical Documentation

Background
- Purpose: Semantically assisted web search for data and information
- Functional Relationship to other GoMRC Tools: Noesis is functionally interoperable with the GoMRC Data Catalog as well as with other scientific data registries and catalogs through interoperable service layers.
- Level of Development Achieved (alpha, beta tested, draft, final): Noesis is a mature product that has been utilized by other projects and domains.

Application Layer
- Code: Noesis has been developed in Java. The GoMRC instantiation is hosted at UAH on the www.gomrc.org server.
- Required input: Domain ontology
- Brief synopsis of processing or manipulation: Noesis utilized domain-specific ontologies to assist users in refining search terms. The searches are then performed across a configurable list of scientific data registries, catalogs and indexes using web service layers and other mechanisms depending on the source.
- Output produced: list of resulting data and information sources
- QA/Testing: Noesis has been tested internally and externally to UAH by many users in different scientific domains.

Security
- GoMRC is a publicly available system. Web security is provided through normal web hosting security measures maintained for systems at UAH.

Noesis is a meta-search engine and resource aggregator that uses ontologies to help users produce intelligent searches of internet based resources. It suggests search terms by drawing information from its underlying domain ontologies. These ontologies encode domain specific knowledge of concepts, constraints and the relationships among them. Noesis helps users refine their search query and thereby achieve better precision and completeness in their results. The search results are aggregated according to filters selectable by the user. This section will illustrate how Noesis is used to search for information and how the user can organize the results.

Searching for Information
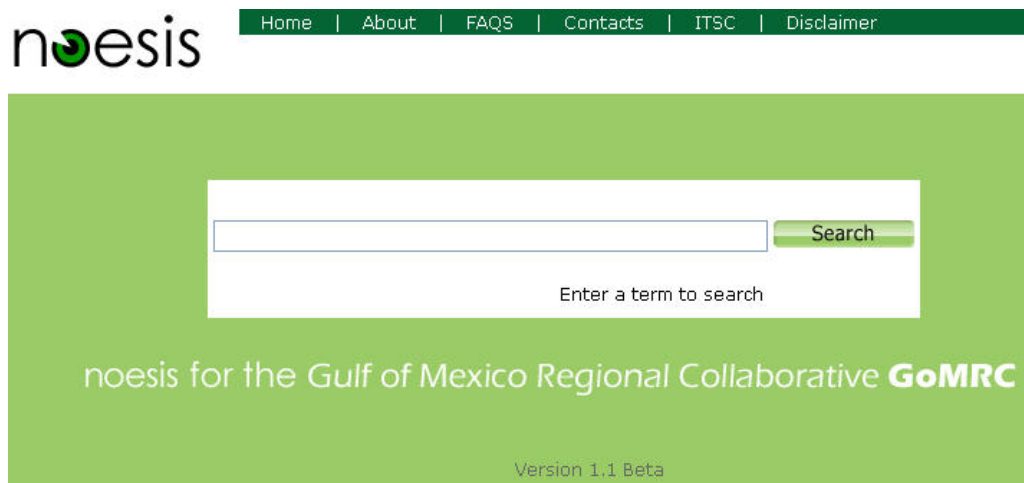
Figure H-1. Main Noesis search screen

Noesis presents a very simple search interface. As shown in Figure H-1 above, the user simply enters a search term in a text box. As the user types in their term Noesis will automatically show a list of terms that begin with the typed letters. For example, typing "Sed" as a start toward typing the word "sediment" will result in Noesis suggesting a list of terms beginning with "Sed." The user can continue typing or double click on one of the suggested terms.

Once the search term is entered a new page will appear containing four sections. At the top of the page is information about the search term including its definition. In the middle of the page below the definition are the search results. On the left side is a list of terms with check boxes for each term. On the right is a list of filters with check boxes next to each (see Figure H-2).

noesis

Home | About | FAQS | Contacts | ITSC | Disclaimer

Search

Stop

Number of Results:
76

Definition:

A methodology that obtains a representative discharge- weighted water–sediment sample over stream verticals, except in an unmeasured zone near the streambed, by continuously cumulatively collecting a portion of the water–sediment mixture as the sampler traverses the vertical at an approximately constant transit rate.

Source: http://amsglossary.allenpress.com/glossary

Query:
Sediment + Bathymetry + Mobile

Refine Search

+Sediment

Related Terms

+Structure
- Sea Grass
- Ecological Structur...
+ControllingFactor
- Bathymetry
- Substrate Quality
- Light
- Sediment Dynamics
- Substrate Type
- Inundation
- Water Quality
- Controlling Factor
+Others
- Natural
- High
- Medium
- Regional
- Type
- Spatial Scale
- Weight

Add Additional Terms

Mobile

Add

Current Additional Terms

Search Results

ERDC/RSM-TN-13, Lessons Learned in Regional Sediment Management ...
Google
relative to sediment transport over the region. The Mobile District then developed a program ..... stated, bathymetric data are limited over the RSM region. ...
http://www.wes.army.mil/rsm/pubs/pdfs/rsm-tn-13.pdf

SMF Europe - Multibeam bathymetry : Specialists in shallow water ...
Google
SURVEX is a multibeam bathymetry mobile vessel. ... A sediment sampling tool is used on board SURVEX vessel to collect sediment for analysis when required.
http://www.smf-europe.fr/?lang=en

MOBILE UNIT FOR SHALLOW WATER MULTIBEAM BATHYMETRY and SONAR IMAGERY
Google
profiles and sediment studies Waterways network mapping Periodic ... MULTIBEAM BATHYMETRY MOBILE UNIT the best powerfull tool for your surveys ...
http://www.dansurvey.com/Downloads/Survex1.pdf

Overthrusting and sediment accretion along Kilauea's mobile south ...
Google
Locations of line 2 (black, with annotated shot points) and nearby seismic lines (gray) are indicated. Illumination is from north. Bathymetry is from Smith ...
http://geology.geoscienceworld.org/cgi/content/full/28/7/667...

Overthrusting and sediment accretion along K - lauea?s mobile ...
Google
Overthrusting and sediment accretion along K. l. -. lauea?s mobile .... Shaded-relief bathymetric and topographic map of K ...
http://geology.geoscienceworld.org/cgi/reprint/28/7/667.pdf

Filter by Engine

+ All
+ Data
- GoMRC - 17
- NCDC - 0
- NASA GCMD - 0
+ Web
- Google - 10
- Yahoo -10
+ Publications
- Ecol. & Systematics - 1
- J. Ecol. Apps - 3
- Ecol. Mono. - 1
- Ecology - 2
- J. Animal Ecol. - 0
- J. Ecol. - 2
- Rem. Sens. Env - 0
- AMS - 0
+ Education
- DLESE - 47

Figure H-2. Noesis search results

Modifying the Search

As the search results are returned and listed in the center of the page, Noesis will present a list of terms on the left side of the page (Figure H-3). These terms are generated from the ontology and fall into three categories: Specializations, Synonyms and Related Terms. Users may add these terms to the current search query simply by clicking the text box next to the desired term. Noesis will immediately begin a refined search based on the combination of terms selected.

Specializations can be used to provide a more detailed search. For example a search for "Cyclone" would show specializations, "Hurricane" and "Typhoon".

Synonyms are different terms that have the same meaning. In ontological terms these are the equivalent concepts. For example a search for "Reflectance" shows synonym, "Albedo". Appending this term to the query expands the search, thus providing better search coverage.

Gulf of Mexico Regional Collaborative Year-end Report   H-2

Figure H-3. Terms related to sediment as suggested by Noesis

Every concept has a set of related properties that are neither in the same inheritance hierarchy nor equivalent. These are called Related Terms. They are captured in the ontology through the property relationships. The user can search for resources on a concept with respect to a particular property. For example a search for "Cyclone" shows "Rain" as a Related Term. Appending this term to the search narrows the search to resources that contain information about "Cyclone" within the context of "Rain."

In addition to the terms suggested by Noesis there is a text box at the bottom left where the user can type in a free text term. In Figure H-3 the user has typed in the term "Mobile". User added terms can be removed from the search just as easily by un-checking the associated checkbox.

Filtering the Results

On the right side is a list of filters (Figure H-4). The search results can be managed by selecting returns from a number of resources by checking the check boxes next to their

name. For example if the user only wants to see search results from Google they can check that check box only.
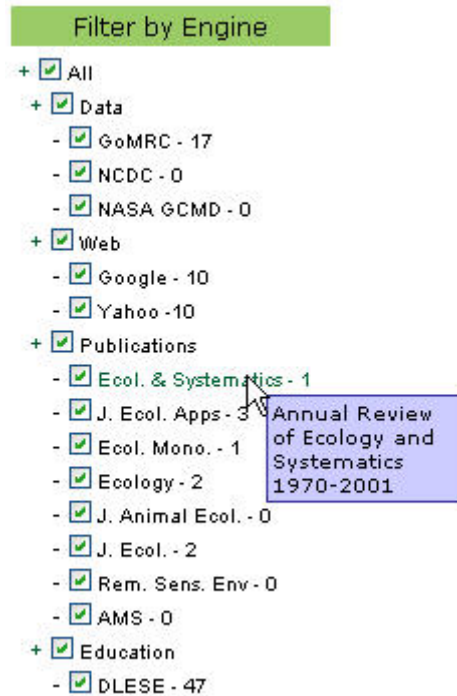
Figure H-4. Main Noesis search screen. List of filters provided by Noesis.

As shown by Figure H-4 search returns are available from several resources. The major web search engines Google and Yahoo are available as are a number of publications databases and data catalogs such as the Global Change Master Directory (GCMD). Figure H-5 shows selected search results from Google, Yahoo and a publications database.
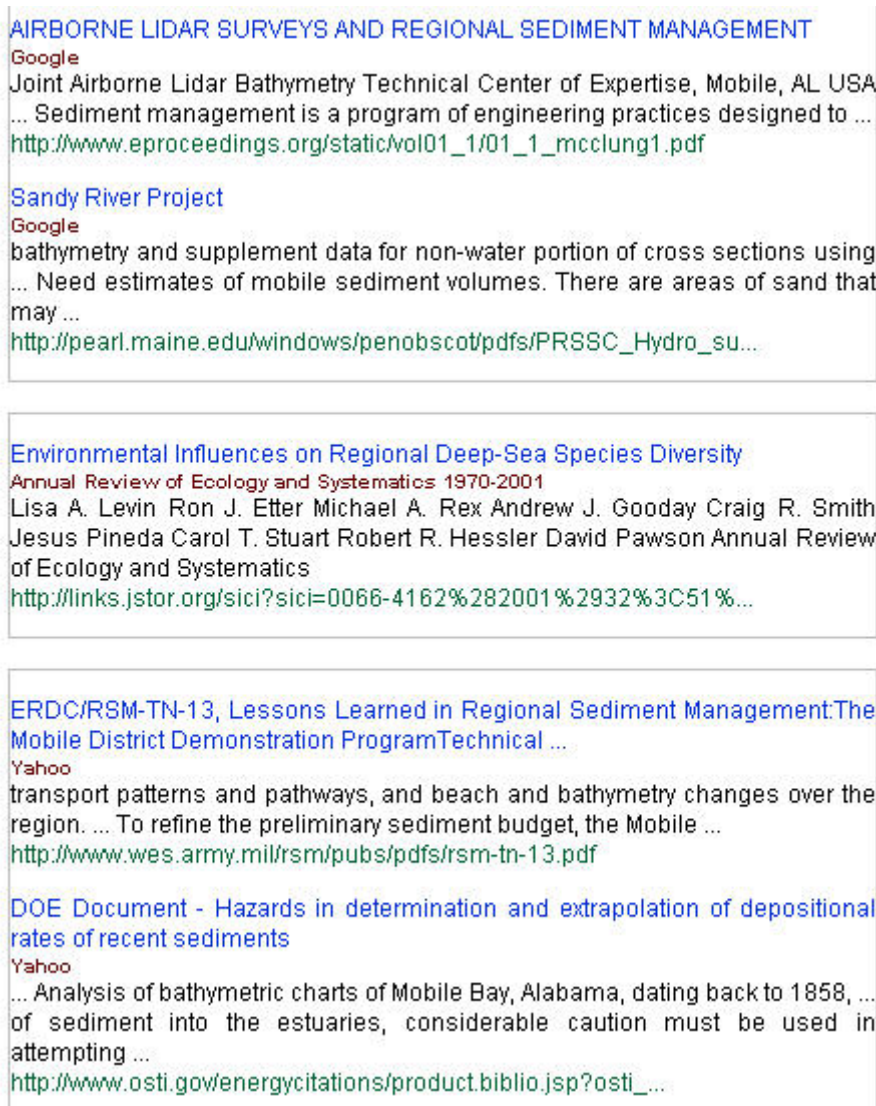
Figure H-5. Noesis search results organized by filter

Launching the RTIV and Map Maker

In many cases it is desirable to allow Noesis to search localized catalogs. Research projects may develop a specialized database of information that relates to a special topic, geographic region or research area. In cases such as these domain experts may have developed conceptual models, ontologies or databases that are very specific. If there exists sufficient information about a data product and there are well defined methods for importing that product into an application then Noesis can produce specialized search returns that allow the user to launch the application directly. This is the case with imagery and map products that are viewable with the RTIV and Map Maker. In the previous sections it was shown that both the RTIV and Map Maker can be launched through a URL with product information appended. When Noesis encounters a search result for such a product it drops in special icons that will launch the respective tool when clicked.

Figure H-6 shows search results from a query on SST with icons that will launch the RTIV and Map Maker.
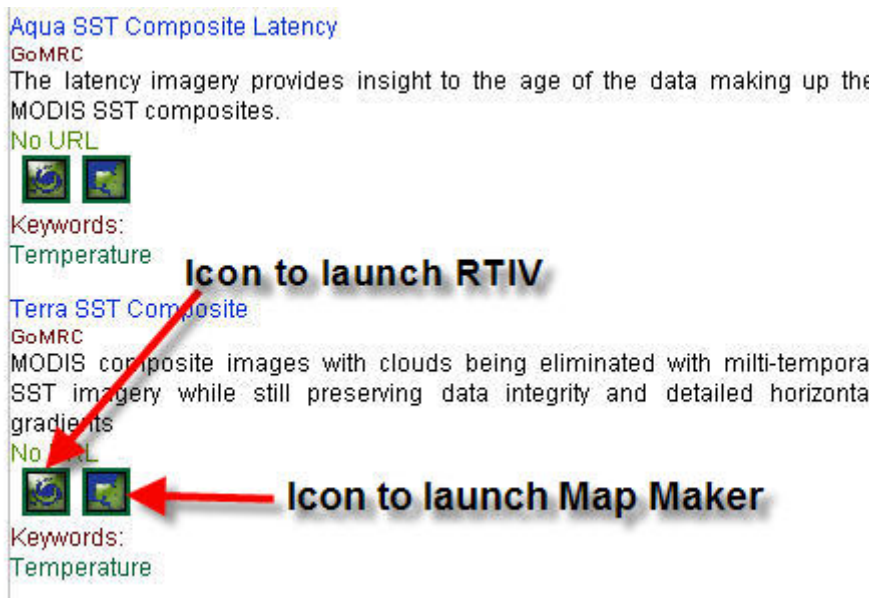
Figure H-6. Noesis search return with icons for RTIV and Map Maker

Noesis Search Architecture

Noesis uses a three step algorithm to search resources. The three steps are Query Analysis, Semantics Presentation and Resource Search. The algorithm architecture is depicted in Figure H-7.

A. Query Analysis
In this step, the user provided search query is broken down to identify concepts that are defined in the domain ontology. Once they are identified, they are annotated with the associated concepts from the ontology.

B. Semantics Presentation
The annotated concepts from the query string are used to search the Ontology Inference Service (OIS) for associated concepts (Specializations, Generalizations, Synonyms and Related Terms). The Specializations and Generalizations are shown in a tree structure to allow users to navigate through the hierarchy. Synonyms and Related Terms are shown in separate categories and a check box is provided to let the user select the term to append to the search. The user employs these terms to refine the search query.

C. Resource Search
The selected terms are then used for searching the resources. For open web resource searches the refined query is directly used to provide results since no semantic information is encoded (annotated) in these resources. For hidden web resources like data archives, an Application Ontology is added for every new vocabulary used. The concepts in the refined query are used to search the Ontology.
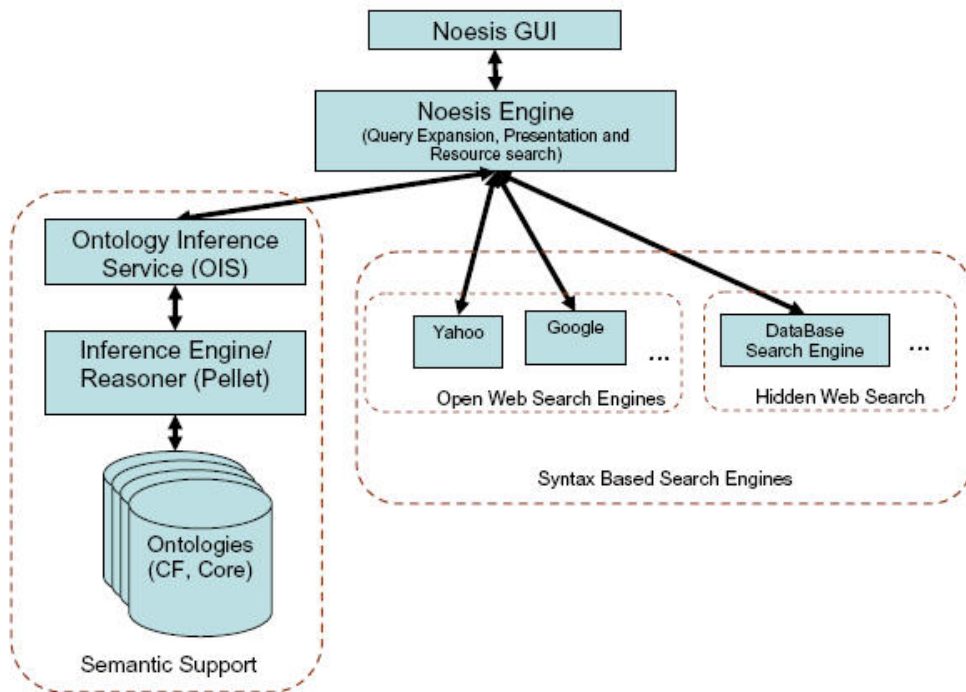
Figure H-7. Noesis search architecture

Appendix I. MapMaker Technical Documentation

Background
- Purpose: Display OGC-compatible GIS data resources
- Functional Relationship to other GoMRC Tools: The Map maker can be invoked from Noesis, the Conceptual Model Explorer, or independently via a URL to display GIS information
- Level of Development Achieved (alpha, beta tested, draft, final): GoMRC is a prototype system so its components are at a draft level. However, a version of the Map Maker has been operation for several years in the SERVIR project. The GoMRC Map Maker was derived from the SERVIR version.

Application Layer
- Code: based on the open source Chameleon software, hosted on servers at UAH
- Required input: OGC-compatible data web services (WMS, WFS, WCS)
- Brief synopsis of processing or manipulation: MapMaker is a data visualization application. It is used to display GIS information served in the form of web map services (WMS), web feature services (WFS) or web coverage services (WCS).
- Output produced: web based visualization
- MapMaker has been tested internally and externally to UAH by many users

Server/Repository Layer
- MapMaker is hosted on servers at UAH/ITSC
- MapMaker is HTTP accessible

Security
- GoMRC is a publicly available system. Web security is provided through normal web hosting security measures maintained for systems at UAH.

The Map Maker is used to display GIS information served in the form of web map services (WMS), web feature services (WFS) or web coverage services (WCS). Map Maker was implemented using the open source Chameleon Web Mapping Framework. Chameleon was developed by the DM Solutions Group of Ottawa Canada from a set of re-usable components for clients in the Government of Canada. It is widely used along with the open source Minnesota Map Server to provide web map services through a web based interface. This section describes how the Map maker is invoked and employed to display GIS information.

Invoking Map Maker

The Map Maker may be invoked by entering the following URL into a standard web browser:

http://mapa.itsc.uah.edu/GulfofMexico/mapmaker/index.phtml

A page will appear as shown by Figure J-1 below.

Map Maker Functionality

The Map Maker possesses functionality that is consistent with that of numerous commercial and open source web map viewers. The display is dominated by the map window that appears in the center of the display. The coordinates of the map are preset to the area of interest. In this case the Southeaster USA and Gulf of Mexico. A list of default layers appears on the right. This list is organized into categories. Each category may be expanded or collapsed by clicking on the "+" plus sign.

Beneath the map are several items. On the left is the reference map, a smaller version of the main map. Users map click and drag the mouse over this small map to change the coordinates of the main map. Form example one could draw a rectangle over the state of Florida to "Zoom" the main map to that region (Figure J-2).
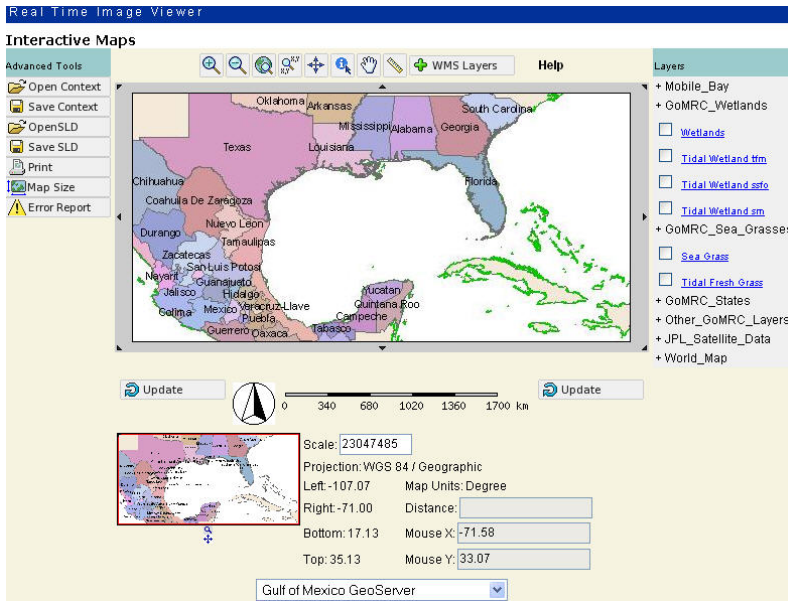
Figure J-1. Map Maker main window
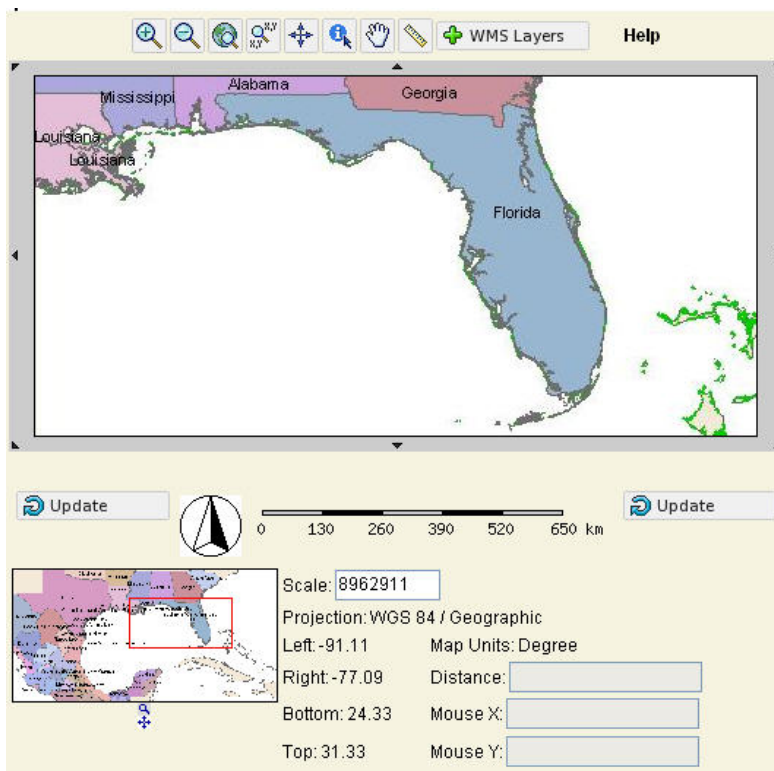
Figure J-2. Map zoomed to Florida using reference map

To the right of the reference map is geographic location information. There are four numbers representing the longitude of the left and right sides and the north latitude of the top and bottom of the main map coverage. The Map Units specifies the units, in this case degrees, employed for latitude and longitude. The Distance textbox displays the output

when using the ruler tool. When the mouse is over the main map its location is output to the Mouse X and Mouse Y text boxes.

Just below the main map on each side are two identical buttons called Update. These are used to update the map following a change in the layer selection. Layers do not automatically appear when their respective check boxes are checked. Users must click on the "Update" button to add or remove layers from the main map. Finally, there is a scale bar centered below the main map.

Several standard tools are located above the map. These are summarized below:

Zoom In: After clicking on the magnifying glass (containing a plus sign) to select it the user may click on the main map window to zoom in. The map is reloaded and centered at the click point.

Zoom Out: After clicking on the magnifying glass (containing a minus sign) to select it the user may click on the main map window to zoom out. The map is reloaded and centered at the click point.

Zoom to Full Extent: Clicking on this icon reloads the main map and restores it to its full extent.

Zoom to Bounding Box: Clicking on this icon causes a dialog box, Figure 8, to open where the user may specific latitude and longitude coordinates and then zoom the main map to those coordinates.

Center Map: Clicking on this icon activates map center mode. Afterwards the user may click on the map at any point. The map will reload with the selected point at the center.

Identify Feature: Clicking on this icon activates the query functionality. Afterwards the user may click on a layer visible within the main window to obtain information about the feature (Figure J-3). The layer must contain metadata about the feature for the query function to return meaningful information.

Pan: Clicking on this icon activates pan mode. Afterwards the user may place the mouse curser over the main map and "drag" the map to a new location. When the muse button is released the map will be reloaded at its new location.

Distance Tool: Clicking this icon activates the distance measure tool. Afterwards the user may click and drag the curser over the main map to get the distance between two points or the total distance of a number of connected straight-line paths. Figure J-4 shows the distance tool employed to measure the distance from New Orleans to Mobile. The distance is also shown in the Distance text box below the main map display. To terminate the distance measurement tool pres the ESC key.

WMS Layers Clicking this button opens the Layer Explorer allowing the user to load layers from remote web map servers. The Layer Explorer is explained in detail later in this document.

Bounding Box Coordinates

Please enter the coordinates of the bounding box (i.e. extents) of the area you wish to view.

Max Y
35.23

Min X
-107

Max X
-70

Min Y
16.77

🔍 Zoom

Point Coordinates

Please enter the coordinates of the location (i.e. point) you wish to view.

X: -88.5   Y: 26   🔍 Zoom

✖ Cancel

Figure J-3. Bounding box for entry of latitude and longitude coordinates

On the left are several "Advanced Tools" A summary of the function of these tools follows:

Open Context Load Context: Load a previously saved context. A map context is a XML document that describes the appearance of layers from one or more WMS servers, and can be transferred between clients while maintaining startup views, the state of the view (and its layers), and storing additional layer information.

Save Context Save Context: Save a map context. Please see above for Map Context.
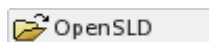
OpenSLD Open Styled Layer Descriptor (SLD): This tool allows users to get information about feature(s) within a layer. It is mainly used for Vector data layers and must be pre-defined in WMS servers.

Save SLD Save Styled Layer Descriptor (SLD): Allow user to save SLD information. SLD must be pre-defined in the WMS server.
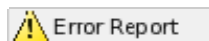
Error Report Error Report: Show any errors when displaying a map.
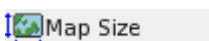
Map Size Map Size: Change the size of the main map display
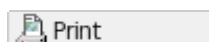
Print Print Map: Send a copy of the current map to the printer.

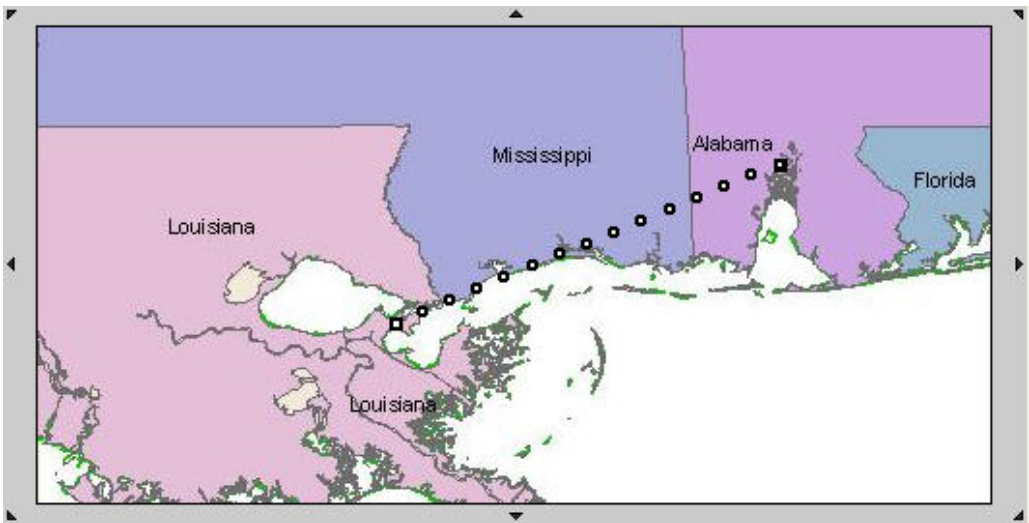**Figure J-4. Results of query**

Figure J-5. Results of using the distance tool

Loading and Removing Layers

To add layers to the map display the user simply selects the desired layers by checking the check boxes next to the layer name (Figure J-6). Once the layers are selected they are added to the map by clicking the "Update" button below the main map display.
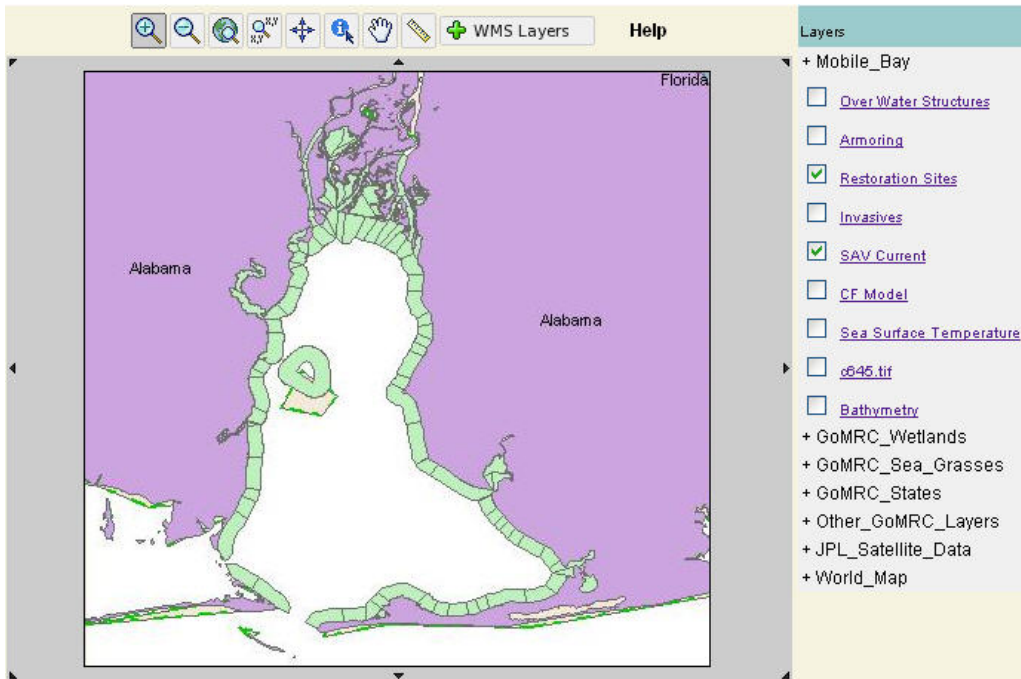
Figure J-6. Map reloaded with two new layers visible

The Layer Explorer

The default list of layers are all served by the local web map server located at the National Space Science and Technology Center (NSSTC) located in Huntsville Alabama. The Map Maker can also download and display layers hosed by remote web map servers. The tool for doing this is known as the layer Explorer. To open the layer Explorer the user clicks the "WMS Layers" button at the top right of the main map display. This opens the Layer Explorer in a separate window (Figure J-7).
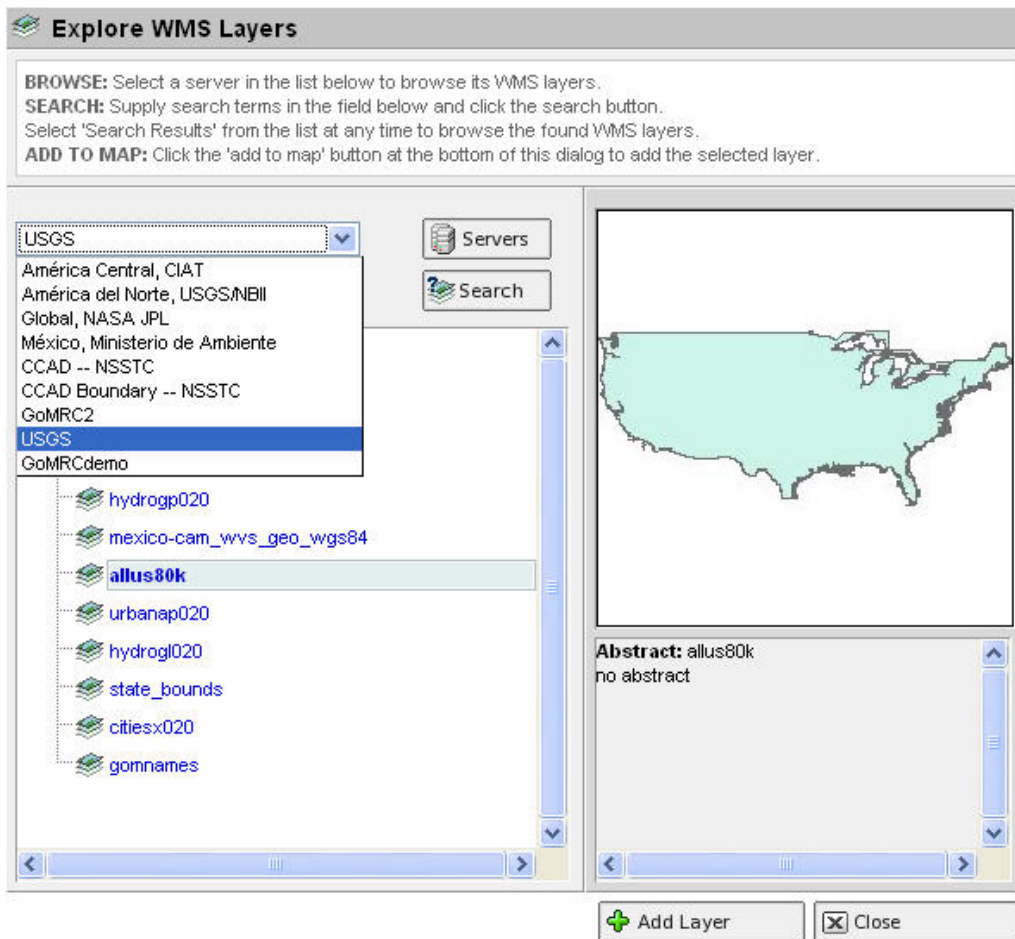
Figure J-7. Layer Explorer Window

Adding a Layer from a Remote Server

Adding a new layer is a simple process. With the layer Explorer window open the user can browse a list of available web map servers. By clicking on a server name the list of layers it serves can be viewed in the window directly below. In Figure 12 the USGS web map server was selected and the layers available are shown. The user may then preview a layer by clicking on its name. In Figure 12 a layer with the name "allus80k" is previewed. The user can add this layer to the current set of Map Maker layers by clicking the "Add layer" button. If this option is chosen the layer will be added to the current set of layers and its name will be inserted at the top of the list on the right of the main map window (Figure J-8). Once the layer is added it may be removed from the main map display in the same manner as all other layers. Its name will remain on the list of layers as long as the Map Maker session is running.
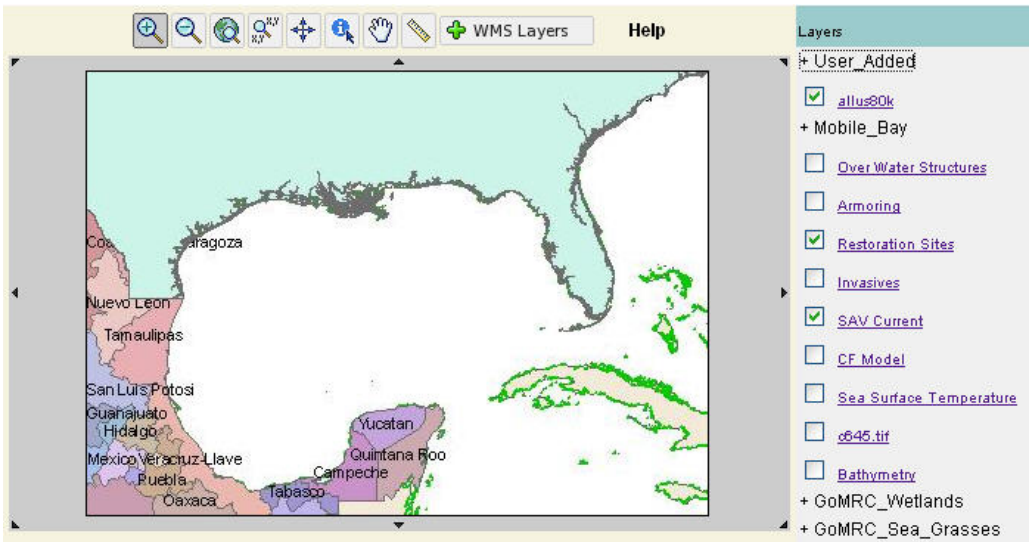
Figure J-8. Map with remote layer added

Invoking the Map Maker with a Specified Layer

The Map Maker may also be invoked with a specific layer in view by appending a reference to the desired layer to the URL. An example is shown by Figure J-9.

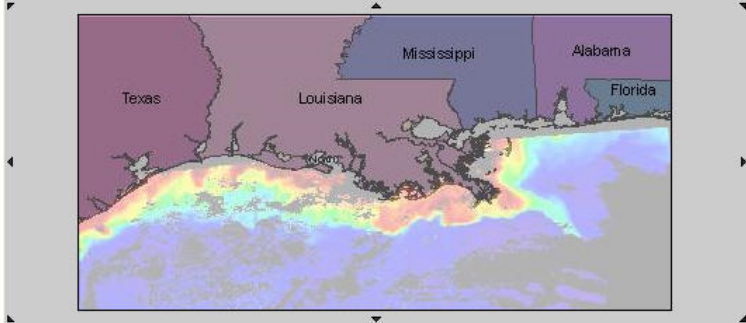http://mapa.itsc.uah.edu/GulfofMexico/mapmaker/index_gomrc.phtml?keyword=redtide

Figure J-9. Map Maker with Red Tide image loaded

Appendix K. Real Time Image Viewer Technical Documentation

Background
- Purpose: Display and animation of imagery
- Level of Development Achieved (alpha, beta tested, draft, final): GoMRC is a prototype system so its components are at a draft level. However, the RTIV has been operational in the SERVIR project for several years. The RTIV for GoMRC was adapted from that of the SERVIR project.

Application Layer
- Code: Java and JavaScript software, hosted on servers at UAH
- Required input: web-accessible files in common image formats
- Brief synopsis of processing or manipulation: RTIV is a image viewer and animation application
- Output produced: web based visualization and animations
- RTIV has been tested internally and externally to UAH by many users.

Server/Repository Layer
- RTIV is hosted on servers at UAH/ITSC
- RTIV is HTTP accessible

Security
- GoMRC is a publicly available system. Web security is provided through normal web hosting security measures maintained for systems at UAH.

Appendix L. Real Time Image Viewer User Guide

The Real Time Image Viewer (RTIV) is used to access, display and animate image files stored on an FTP server. It has a search interface that allows users to select the category, start and end dates, and start and end times. When the user goes to the RTIV web site at URL http://www.gomrc.org/visualizations/imageviewer.html the window shown by Figure L-1 below will appear.

Figure L-1 Main Window of the Real Time Image Viewer

Searching for Imagery

The user begins by selecting an image product from those listed on the drop down list to the left on the green bar entitled Image Products. Users can accept the default start and end dates and times or constrain the search results by choosing a beginning date and time and an ending date and time. This can be accomplished by typing the dates and times into the respective text boxes or by clicking on the calendar icons. After selecting the Image Product and setting the start an stop dates and times the user clicks on the "Go" button at the far right to generate a search request. This causes the RTIV to construct a search for the image products specified. The results are presented in a list as shown by Figure L-2.

Figure L-2. Search results or Aqua SST imagery

Viewing Specific Image Files

The list of image files that match the search criteria are presented as a list organized by date. Each file name is also a hyperlink. The image can be displayed in a separate window by clicking on the file name (Figure L-3). To the right of the file name is a button entitled "View in Google Earth". Choosing this button will launch Google Earth with the corresponding image visible in the 3D window. (Note: The user must have Google earth installed on the workstation.) Figure L-4 shows the Aqua SST image file for September 10, 2007 displayed with Google Earth.

EOS AQUA MODIS SST COMPOSITE(K) 20070910 DAY VER 3
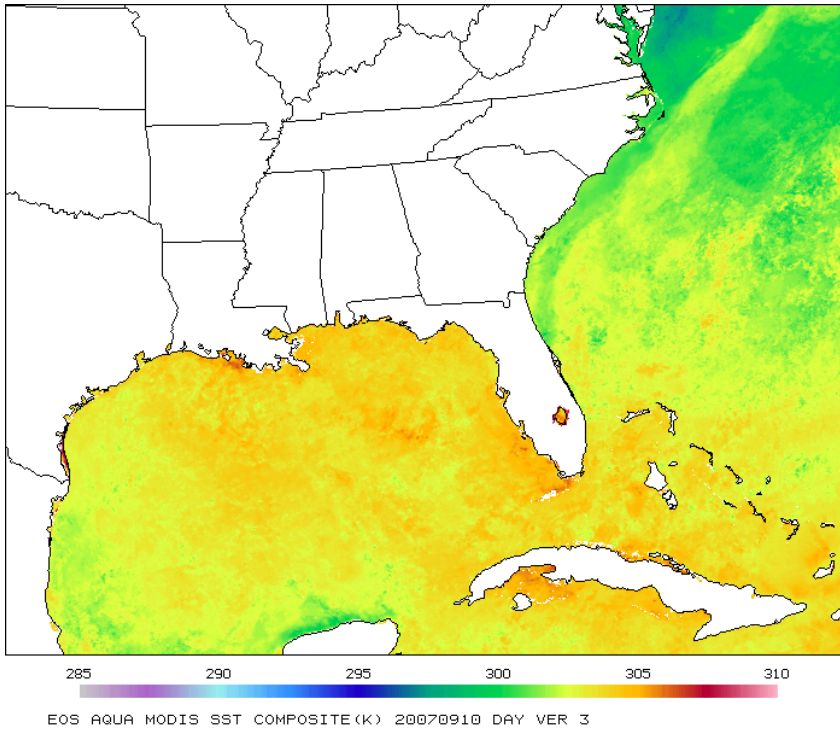
Figure L-3 Single image produced by clicking image file name
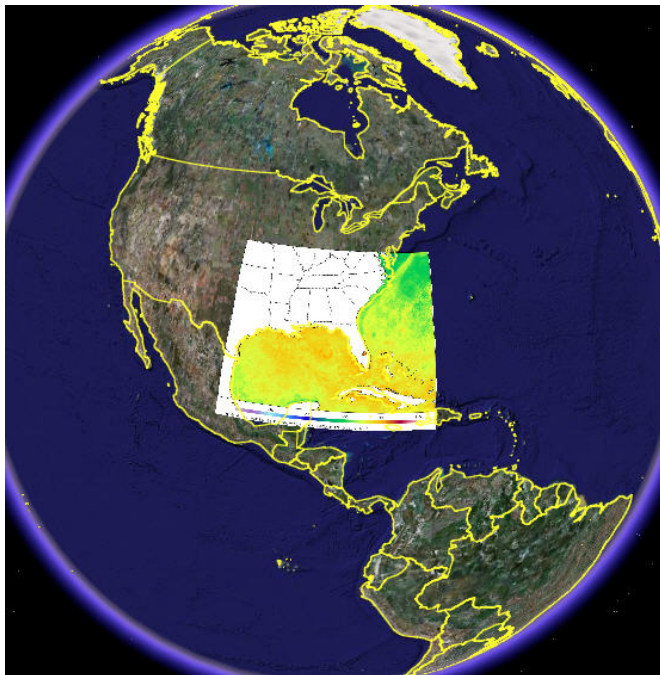
Figure L-4. Aqua SST image displayed with Google Earth

Creating Animations

As shown by Figure L-2 there is a check box located to the left of each image file name. In addition there is a check box to the left of the date just above the image file name. This is for convenience of selecting all images on a given date. In the example there is only one file per day. To create an animation the user checks the files of interest and then clicks the "Create Animation with Selected Files" button. It is not necessary to choose contiguous files. The RTIV will create an animation from the selected image files and display the animation in a new window (Figure L-5).
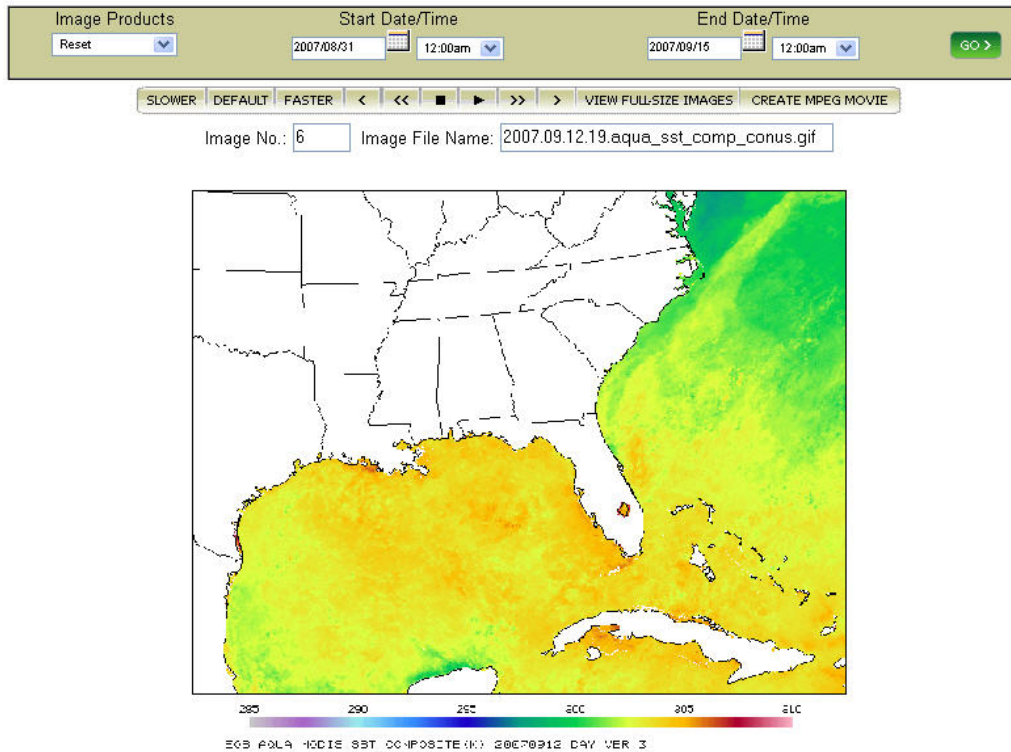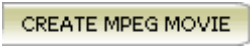

Figure L-5 Animation created from selected Aqua SST images

Controlling Animations

The RTIV animation window has a control bar that allows users to direct the playing of the animation. There are eleven buttons on the control bar. The function of each is described below:

- SLOWER Clicking this button slows the pace of the animation. It may be clicked repeatedly to slow the animation further.

- DEFAULT Clicking this button restores the animation speed to the default pace.

- FASTER Clicking this button increases the pace of the animation. It may be clicked repeatedly to speed up the animation

- Single frame mode, reverse: Clicking this icon displays the images frame by frame in the reverse

- Play in reverse: Clicking this button cause the animation to play in reverse.

- Stop: Clicking on the solid square icon stops the animation.

- Play: Clicking on the right arrow icon plays the animation.

- Play forward: Clicking this icon causes the animation to play in its normal forward mode.

- Single frame mode, forward: Clicking this icon causes the animation to proceed frame by frame in the forward direction.

- By default large images are scaled to fit within the browser window. To view the images at full resolution click on this button. A new window will open with animation of the full resolution images.

- Clicking this button will cause the RTIV to create an mpeg movie of the animation. When choosing this option the user should be aware that this operation may take a lot of time. The amount of time depends on the number of frames (image files) selected for the animation. The user will be presented with a message in a separate window when the movie is completed.

Invoking the RTIV

The RTIV may be invoked with a URL string specifying a path to the directory containing imagery files. If the user has a specific product they want to animate (such as SST to remain consistent with the examples shown above) then they may invoke the RTIV directly by appending the product name to the URL as shown below:

http://www.gomrc.org/cgi-bin/imageviewer/imageviewer.pl?prod=aquaSSTcomp

If the above URL is entered into a web browser then the RTIV animation window will appear with the animated sequence of Aqua SST images loaded. No search is necessary.