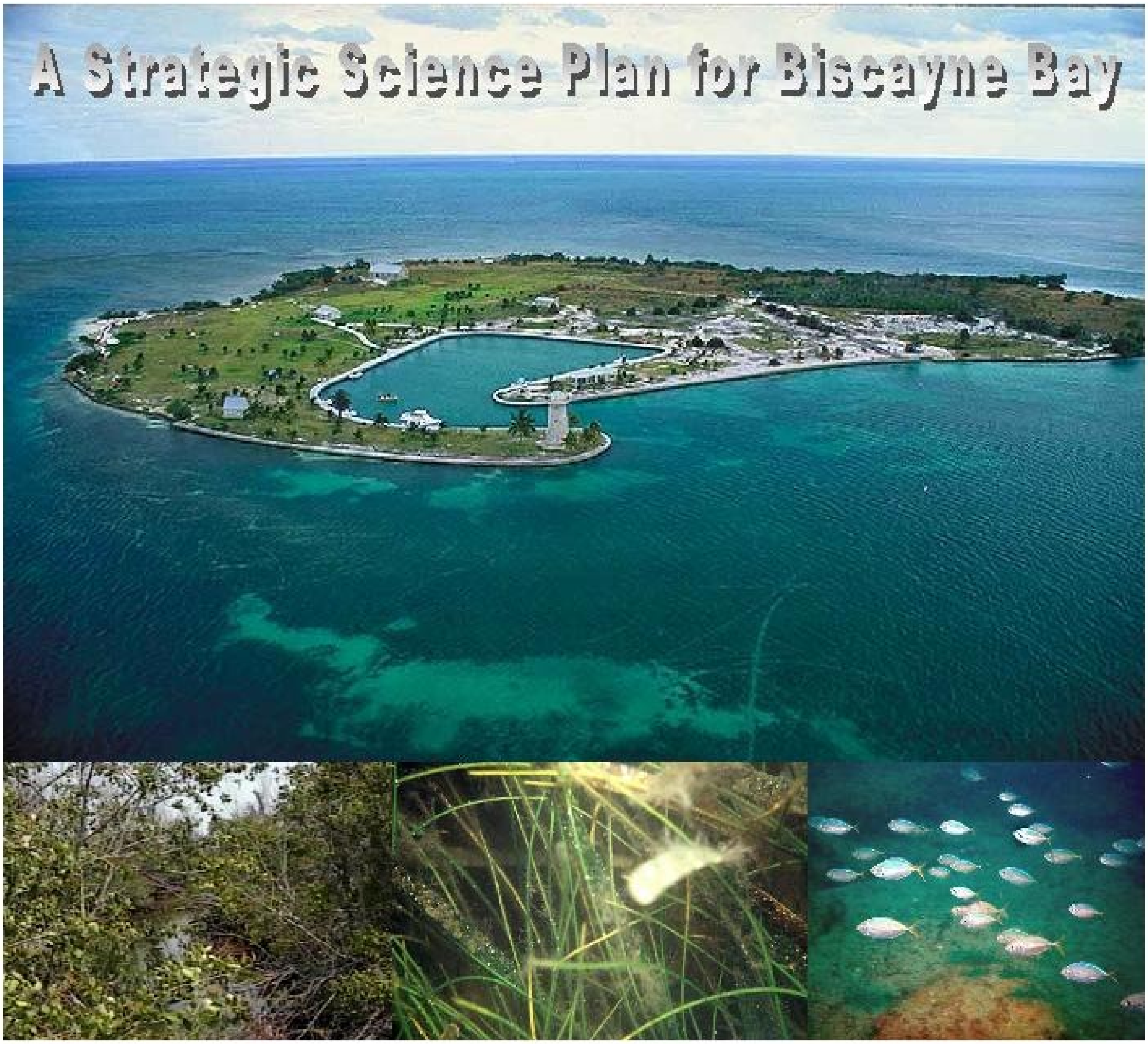

January 2002

A Strategic Science Plan for *Biscayne Bay*

Florida Bay and Adjacent Marine Systems Program Management Committee
January 2002

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January 2002

Prepared by the Biscayne Bay Subcommittee of the Florida Bay and Adjacent Marine Systems Program Management Committee

Introduction

The Florida Bay Program Management Committee (PMC) was appointed by the South Florida Ecosystem Restoration (SFER) Working Group (www.sfrestore.org) in 1994 to identify scientific information needs, and implement and coordinate scientific programs supporting resource management and ecosystem restoration actions affecting Florida Bay. Over time, the PMC developed a series of interagency strategic science plans, and a formal organization consisting of topical research teams, annual science conferences, a standing scientific oversight panel, topical workshops, an education/outreach effort, designated representation on relevant SFER and Comprehensive Everglades Restoration Plan (CERP) committees, and an Executive Director. For further detail, consult the PMC website at www.aoml.noaa.gov/flbay/.

In 1998, at the specific behest of the Working Group, responsibilities of the PMC were expanded to include connected marine ecosystems in adjoining waters, including Biscayne Bay. The PMC assumed responsibility for producing a strategic science plan for Biscayne Bay. A science survey team assembled under a separate process called the Biscayne Bay Partnership Initiative (BBPI) made substantial progress in that direction, therefore, this document takes advantage of information developed during the BBPI process.

Biscayne Bay has been the site of significant research, monitoring, and active science-based management for more than two decades, and consequently, extensive descriptive data on Biscayne Bay history, bottom communities, water quality, and fisheries resources exist. Authorization of the CERP (U.S. Army Corps of Engineers) and related regional water management plans like the Lower East Coast Regional Water Supply Plan (South Florida Water Management District), require additional data and more quantitative scientific tools to effectively guide decisions that could affect Biscayne Bay. To measure success of these plans science-based hydrologic and ecological restoration targets and performance measures need to be developed to evaluate the effectiveness not only of specific CERP projects but also of other management, regulatory, and land use decisions within the Biscayne Bay watershed. CERP and related resource management programs recognize the enormous potential influence of upstream restoration actions upon Biscayne Bay, and have, therefore, included interim objectives and measures to assure protection and enhancement of its natural values. Success, however, will require considerably more specific and quantitative performance measures. The need is immediate because critical decision-making and funding allocations have already begun.

Management and restoration of Biscayne Bay must be based on sound scientific information. While some restoration strategies like stormwater system retrofitting and wetland re-creation have been widely used, and have proven effective in limited contexts, the success of the large-scale CERP projects now contemplated is far more uncertain. In fact, as presently described, it is not clear to scientists that CERP, as a whole, will benefit the Bay. Some proposed regional actions could fundamentally change the Biscayne Bay ecosystem. Even projects specifically designed to restore Biscayne Bay's coastal wetlands and nearshore estuarine areas will require more scientific information to ensure effectiveness. To successfully restore and preserve Biscayne Bay, it is essential that critical information gaps be identified and filled within the next few years to effectively guide redesign and re-engineering of local and regional water delivery and water treatment systems, and the policies or regulations that affect their operation.

Management plans that relate to Biscayne Bay, in whole or in part, include the Biscayne Bay Management Plan (Miami-Dade County), the Biscayne Bay Surface Water Improvement and Management Plan (South Florida Water Management District; (http://www.sfwmd.gov/org/wrp/wrp_ce/projects/bb/index.html), and the Biscayne National Park Management Plan (National Park Service). These plans have some common basic goals:

- Restore or enhance some of the Bay's estuarine character. This includes reconnecting and restoring wetland systems adjacent to the Bay.
- Eliminate or minimize pollutant inputs that adversely affect human health or the Bay ecosystem.
- Ensure the sustainability of the Bay's commercial and recreational fisheries.

A coherent interagency program for Biscayne Bay is essential to ensure that these goals are achieved, and the CERP process is aligned. Timely scientific information must be available to support management decisions. Although Biscayne Bay is inherently different from Florida Bay, the Florida Bay program can be used as a model for a Biscayne Bay program to increase management success. A formal interagency science program and organization will provide a more effective voice and coordination of requisite resources for focused research and monitoring. The program should include the same core elements: an interagency strategic science plan, multi-agency PMC consisting of local federal and state research managers, topical research teams, annual science conferences, topical workshops, a standing oversight panel, a designated representative on relevant SFER and CERP committees, and dedicated support staff.

As a first step, the PMC sponsored a Biscayne Bay science workshop on February 13, 2001 to summarize current and prior research and monitoring activities and identify the most urgent scientific information priorities. The workshop addressed four central questions. Addressing these questions will provide the information most critical to resource managers now, and over the next decade. Participants were asked to highlight those specific issues for which better information is needed in the very near future, during the next two to five years (Figure 1). These represent the highest priority research activities in Biscayne Bay.

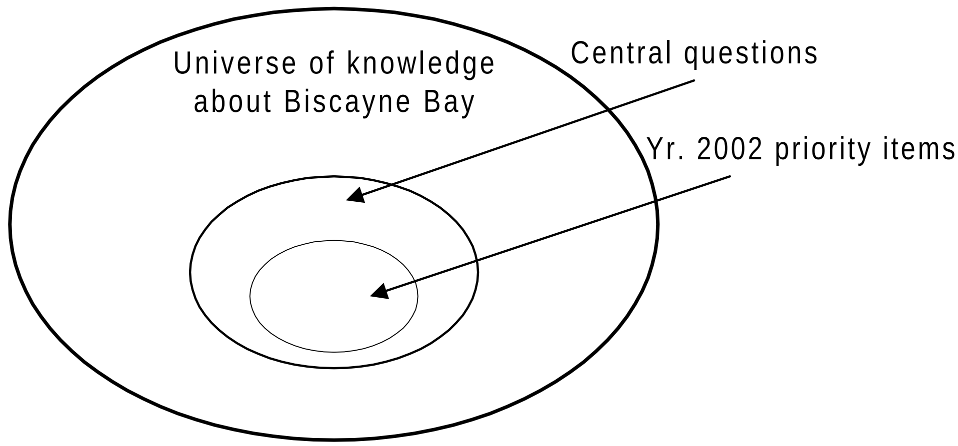

Figure 1. Relationship of central questions and highest priority items.

Background

Biscayne Bay is a naturally clear-water bay with a tropically enriched flora and fauna. The Bay was historically bounded by mangrove and herbaceous wetlands, and was hydrologically connected to the greater Everglades ecosystem through tributaries, sloughs, and groundwater flow. Because of the Bay's shallow depths and clear waters, its productivity is largely benthic-based. The benthic communities both filter particulates and stabilize sediments, thereby maintaining water clarity. Bottom cover in the central and southern part of the Bay consists of several species of seagrass, hardbottom communities including corals (hard and soft) and sponges, macroalgae, and coral-algal fringe. While seagrasses cover significant portions of the northern Bay, where the bottom and shoreline have been disturbed by past dredge-and-fill and bulkheading operations, and upland areas are impervious with limited treatment of stormwater runoff, much of the seagrasses and adjacent wetlands have been destroyed. Consequently, some areas experience chronic turbidity due to the resuspension of unconsolidated sediments. Beach restoration, dredging for port improvements and heavy vessel traffic also contribute to turbidity and physical impacts to benthic communities. Nevertheless, nutrient concentrations and turbidity remain relatively low in the open central and southern bay areas. All portions of the Bay support commercial and recreational fisheries resources, and provide habitat for a number of threatened and endangered marine species. In recognition of its exceptional value, the State of Florida has designated the Bay and its natural tributaries as Outstanding Florida Waters, and as such, they receive the highest level of protection from degradation. Moreover, most of the Bay is within either a State aquatic preserve, national park, or national marine sanctuary.

Water management actions related to drainage and water supply for the development of urban and agricultural areas have substantially changed freshwater inflow to Biscayne Bay. Historically, Biscayne Bay provided both estuarine and marine habitats, but the Bay's estuarine habitats have been eliminated or seriously degraded by changes that were made in the quantity, timing, and distribution of freshwater inflow associated with the construction and operation of the Central and Southern Florida Flood Control Project. Freshwater inputs that once entered the Bay through wetland systems in more distributed and steady flows were diverted to canals. This resulted in unnatural salinity gradients in remaining coastal wetlands and tidal creeks that provided critical estuarine habitat for Bay species requiring low to moderate salinity waters. Delivery of fresh water into the Bay as a pulsed, point-source discharge has caused further loss of estuarine habitat near canal mouths, both by direct physical disturbance and because of the biological stress induced by rapid salinity fluctuations. Unnatural variability of salinity can affect physiological processes central to the growth, survival, reproduction, and general well being of estuarine plants and animals. Moreover, the general lowering of the water table on the east-coast ridge and diversion of both surface and ground water into canals has degraded not only estuarine habitat of the Bay, but also adjacent coastal wetland communities, including freshwater wetlands formerly connected to the mangrove wetlands and intertidal zone.

Urban and agriculture development of the watershed has also directly and indirectly impacted Biscayne Bay. Extensive loss of wetland quality and coverage has affected the hydrology and ecosystem functions of Biscayne Bay. Dissolved nutrients, trace metals, organic chemicals, and particulates are introduced through stormwater runoff, sewage system overflows and leaks, canal discharge, industrial facilities, and vessels. In general, canal waters have lower dissolved oxygen, greater turbidity, and higher concentrations of anthropogenic contaminants than the receiving waters in the Bay. While Biscayne Bay's water quality has improved substantially in the past 30 years, and generally meets or exceeds federal, state, and local standards for recreational uses and propagation of fish and wildlife, pollutant loads are considered too great for maintaining a healthy ecosystem.

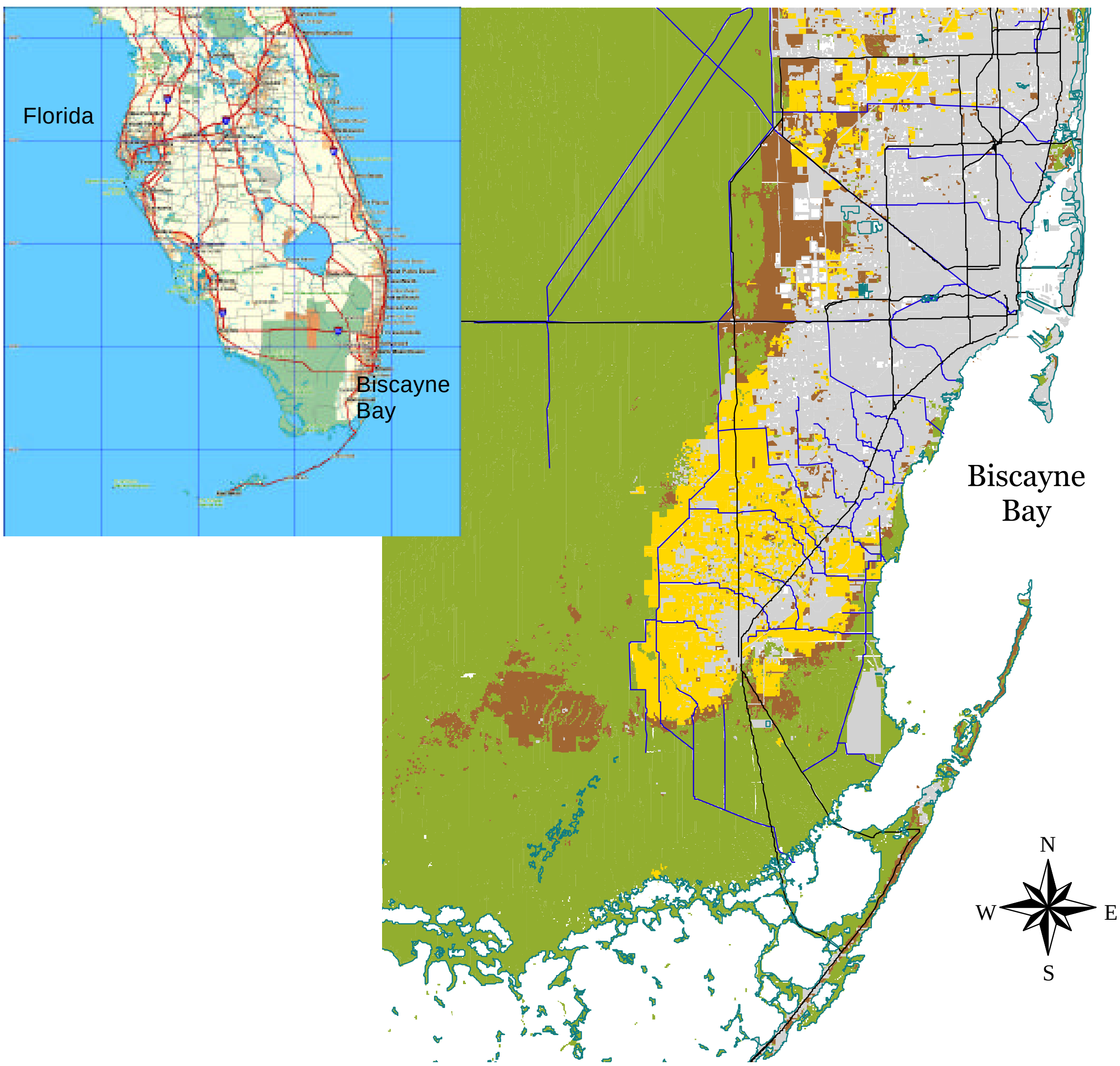

Figure 2. The watershed of Biscayne Bay contains extensive urban (gray) and agricultural (yellow) areas transected by water management canals. Wetlands border the southern portion.

Cross-Cutting Science Themes

Similar overarching ecological themes or issues apply to Biscayne Bay and all South Florida coastal sub-systems: the fundamental role of freshwater inputs; the importance of functional coastal wetlands; the ecological significance of stable mesohaline regions within each larger subsystem; and the geographical context of the natural subsystem proximity to and integration with local agricultural, suburban or urban watershed development. The first three science themes are very similar to those being explored in the Florida Bay Interagency Science Program. Biscayne Bay differs significantly in its close proximity to an intensely developed urban landscape. Detailed quantitative information on specific urban impacts is essential to effectively guide decisions related to future growth, development and consumptive uses in and around Biscayne Bay. Major water resource issues are posed in the near term not only by CERP but also by many pre-existing activities and obligations.

A series of CERP projects could directly affect Biscayne Bay water supply and water quality. These include inter alia: the Biscayne Coastal Wetlands Project, the C-111N Spreader Canal Project, the Levee-31 North Seepage Management Project, the Lake Belt Project, and the West and South Miami-Dade Water Reuse Project. Other CERP projects could indirectly affect Biscayne Bay water supply, including the Water Conservation Area Decompartmentalization Project. Ongoing planning associated with Lower East Coast Regional Water Supply Plan, Minimum Flows and Level specification, and the Flooding Task Force's charge to enhance flood protection for Miami-Dade County all could affect Biscayne Bay. The Adaptive Assessment Team, a CERP committee, has promulgated a risk assessment conceptual model specifically for Biscayne Bay, and has been tasked with specifying performance measures, and requisite monitoring needs for the Bay related to CERP implementation. All of these activities have significant scientific information needs. To be successful the participants need to be informed by the best available science. Their needs (and timetables) explicitly and implicitly suggest prioritization in the scientific areas discussed below.

Figures 3 through 5 indicate the relationships of the science items or strategies (rectangles) to each of the three goals (hexagons) listed above with additional detail given as objectives (ellipses). To effectively achieve management goals and objectives including those of CERP, certain information gaps must be filled. The diagram is intended to provide guidance to managers and scientists about relationships and critical gaps. The information needs themselves fall within one of three general categories: characterizing the existing Bay, predicting how the Bay will respond to anticipated changes, and defining appropriate goals or metrics of a healthy sustainable Bay. The first category listed, adequate understanding of the existing system is the most basic. If scientists and managers do not have a good understanding of the existing ecosystem, little progress can be made in regard to the remaining information needs. Unfortunately, baseline data are still lacking about several key aspects of the Biscayne Bay ecosystem. Many of the high priority research needs are in this category. At the same time, however, work must proceed in better defining the relationships between freshwater flow, salinity and water quality, because of the major changes planned. Science has a role in helping select the most ecologically satisfactory from among the various alternatives proposed, if only to provide a benchmark against which management options can be evaluated.

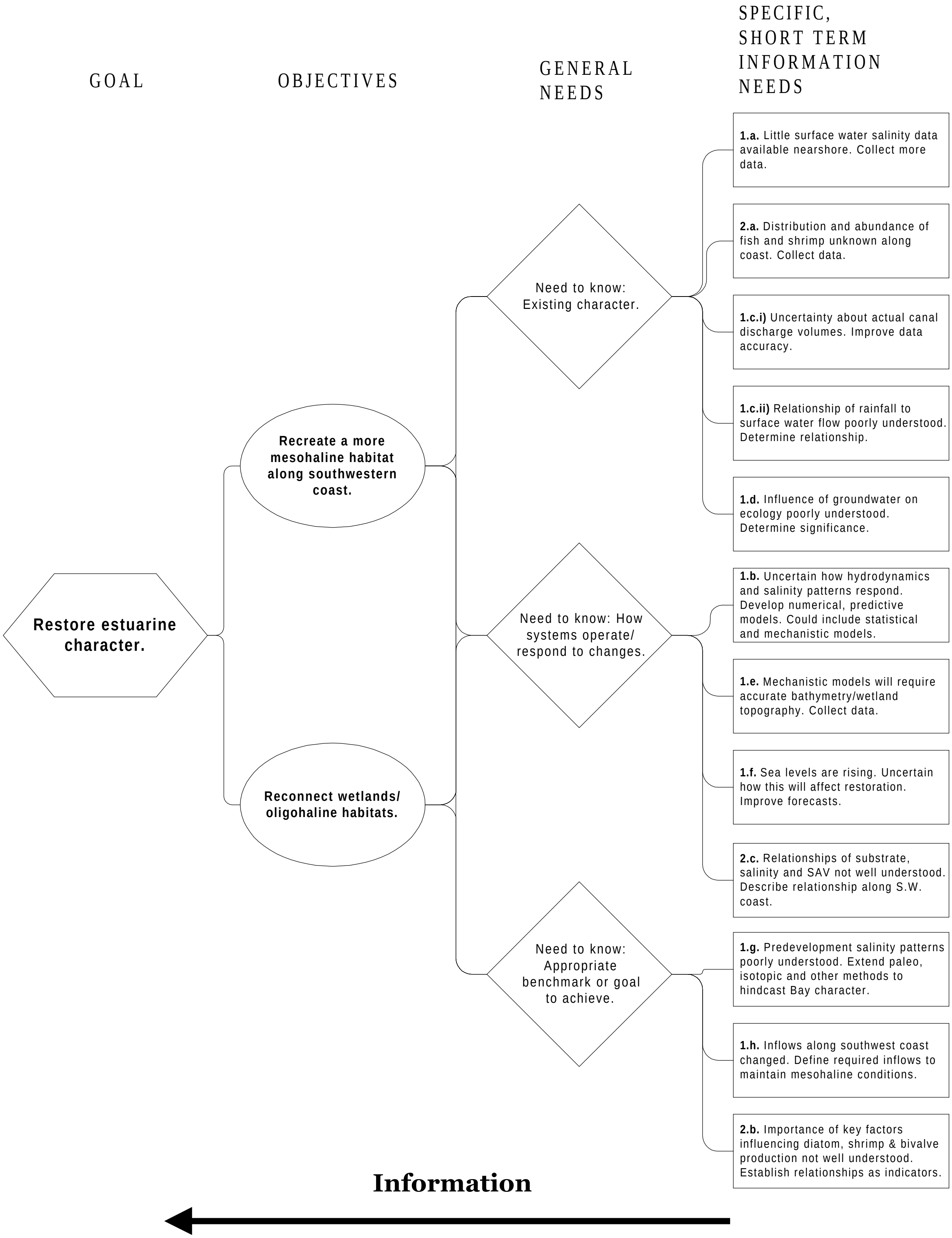

Figure 3. Research and monitoring needs related to the management goal to restore the estuarine character of Biscayne Bay. Information flows from data collection tasks to answer critical questions about how to achieve strategic objectives, and ensure effectiveness.

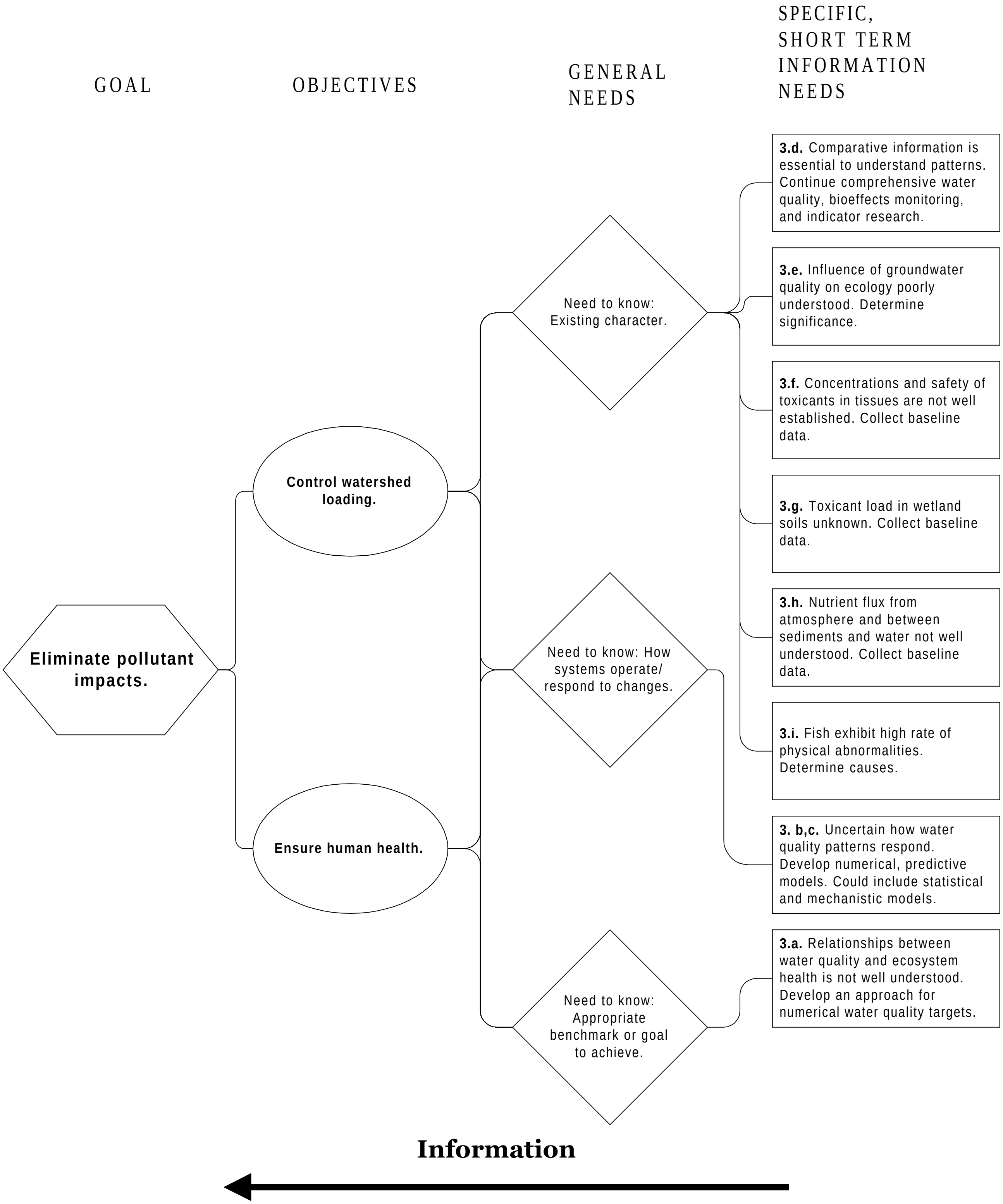

Figure 4. Research and monitoring needs related to the management goal to eliminate pollution impacts in Biscayne Bay. Information flows from data collection tasks to answer critical questions about how to achieve strategic objectives, and ensure effectiveness.

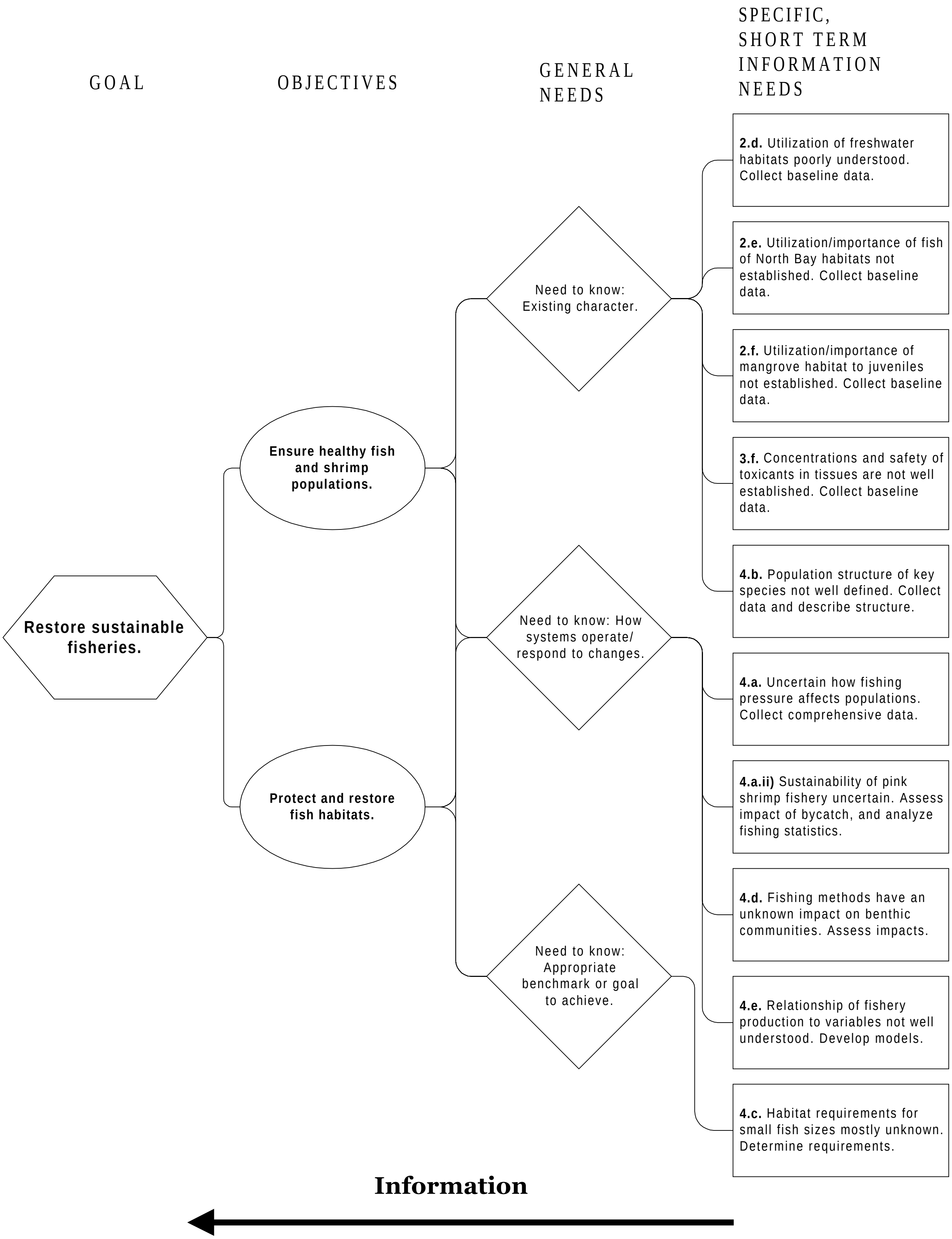

Figure 5. Research and monitoring needs related to the management goal to restore sustainable fisheries in Biscayne Bay. Information flows from data collection tasks to answer critical questions about how to achieve strategic objectives, and ensure effectiveness.

Strategic Science Plan Elements by Central Question

The Biscayne Bay Science Workshop was structured around four central questions to help organize the presentation and capture of information.

<u>Question One</u>

1. ***What volume, timing, and distribution of freshwater inflow are needed to protect, enhance, and, to the degree possible, restore Biscayne Bay?***

   a. **Additional monitoring of salinity patterns in the shallow nearshore waters of central and south Biscayne Bay.** This task is necessary to fill a gap in existing salinity data, which, although geographically and temporally extensive, do not include much information on very shallow areas nor upon event-scale variability.

   b. **Development of computerized numeric physical models (or interim short-term statistical models) to predict salinity patterns over time/space.** The model(s) must be able to project the effects on salinity patterns of changing freshwater quantity, timing, or delivery mode. A linkage between Biscayne Bay circulation and regional hydrological models (groundwater and surface water) is required to do this. Separate models are needed to address patterns on a *bay-wide scale* and to describe detailed processes occurring at the *interface across the nearshore estuarine zone and coastal wetlands*. The general characteristics of appropriate circulation models prescribed at PMC sponsored workshop concerning Florida Bay apply here as well. To see the Modeling Terms of Reference developed at that workshop see: www.aoml.noaa.gov/flbay/FB_models_mtg.html.

   c. Accurate measurements of surface water flow. Existing data on canal discharge volume are calculated based upon cross sections and differences in stages upstream and downstream of control structures. These estimates need to be revisited, and can be markedly improved and extended in applicable range. Beyond that, direct measurements of flow are needed to obtain greater accuracy, particularly under extreme conditions (positive or negative).

      i) Define relationship of salinity to surface water inflow. Pending development of a comprehensive hydrographic model, statistical approaches could be evaluated for assessing effects of projected changes in canal discharge, such as those proposed in CERP preferred alternatives. However, doing so requires reasonably accurate canal discharge data.

      ii) Relationship of surface water inflow to rainfall and water management operations. Reasonably accurate canal discharge data are required.

d. **Define the extent of present groundwater inflow** and its influence, if any, on local salinity patterns.

e. **Develop detailed topographic data for nearshore and coastal wetland/tidal creek area of South Biscayne Bay.**

f. **Determine how the coastal, wetland, estuarine and marine environments and their patterns of distribution in Biscayne Bay will change in response to anticipated global-warming-induced increase in the rate of sea level rise over the coming century.**
   - i) Use guidance from late Holocene shoreline and sediment body response and environmental shifts to project new configurations of coastal and marine environments for Biscayne Bay in 50 and 100 years using a sea level rise scenario compatible with south Florida's subsidence and sea level rise history and an agreed upon forecast sea level rise from the most recent UN-IPCC projection.
   - ii) Produce maps of anticipated 50 and 100-year reconfigurations of Biscayne Bay's shorelines, sediment distribution and bathymetry for use in restoration scenario forecast assessment.

g. **To further refine restoration objectives, determine historical salinity patterns:**
   - i) Extend the geographical scope of paleoecological studies to determine historical salinity patterns in the nearshore south and central Bay.
   - ii) Explore isotopic and other chemical methods of determining historical salinity patterns.

h. **Define the freshwater inflows (surface and ground) required to establish a persistent mesohaline zone in the western nearshore Bay.**

Question Two

2. ***Biscayne Bay is a mosaic of interconnected habitats and natural systems. What are the geographic and temporal patterns in the plant and animal communities, and how are these linked to each other and to ambient water quality? Particularly, what is the role of coastal wetlands in Biscayne Bay water quality, freshwater inflow and distribution, and productivity?***

   a. **Describe the distribution and abundance of fauna and flora in the nearshore and coastal wetland interface in south and central Biscayne Bay.** Of particular importance is acquiring additional information on the abundance of pink shrimp and fish within the relatively narrow (< 2 km wide) strip centered along the mangrove shoreline. This information will fill a geographic "gap" in the existing fisheries data.

   b. **Develop short and long-term biological indicators of system response to freshwater inflow, including habitat changes and direct salinity effects.** Promising work has already been done on the relationship between salinity and diatom distribution in Biscayne Bay's coastal wetlands. Additional biological indicators should be identified and additional data are needed to refine models based on the presently defined relationships. The structure of the benthic community can serve as an indicator of surface and groundwater inflows, as can the presence/absence or density change of organisms sensitive to the physiological stress of rapid acute salinity change.

   c. **Describe the relationships between sediment/substrate type, salinity, and the distributions of seagrasses and distinct biological community types. Seagrass distributions in the nearshore western zone of South Biscayne Bay, where extensive freshwater inflow redistribution will occur, are particularly critical.**

   d. **Develop baseline data on fish utilization of freshwater habitats adjacent to the Bay (canals and wetlands).** Determine interactions and relationships between estuarine and oligohaline fish communities.

   e. **Develop baseline data on fish utilization of North Biscayne Bay shoreline areas, including both artificial and natural habitats.**

   f. **Determine the degree to which mangrove habitats and other South Biscayne Bay shoreline features are used by various fish species as juvenile habitat.**

Question Three

3. ***What are the geographic and temporal patterns in Biscayne Bay water and sediment quality in relation to upstream land uses and other possible sources? In this context, the contaminants of interest include nutrients, pathogens, and toxicants such as metals and organic chemicals.***

   a. **Define numerical targets or performance measures for nutrients and water clarity.** This information is needed to refine CERP-related performance measures and determine the level of treatment required for stormwater, wastewater, or other potential sources of freshwater.

   b. **Develop a water quality model(s) to assess pollutant loading associated with freshwater (surface and groundwater) and atmospheric inputs.** A model could be used to quantitatively evaluate the effects of different water management and watershed development scenarios. Research is needed to define mathematical relationships within the model.

   c. **Develop a water quality model(s) coupled to, or initialized by, hydrographic and hydrological models to predict water quality patterns in the Bay.** A water quality model could help to quantitatively evaluate the expected effects of different water management and watershed development scenarios where pollutant loading is a concern.

   d. **Given extensive urban and agriculture land uses and infrastructure in the watershed, and vessel facilities and operations, maintain long-term monitoring of sewage indicators and potential toxicants in addition to water clarity and nutrient concentrations.**
      i) Monitoring of metals and organic chemicals should include chemical and biological effects testing (e.g. toxicity, reproductive effects, bioaccumulation) of sediments, particularly in urban tributaries or industrial areas, and the development and use of biomarkers in the local native fauna.
      ii) Baseline data and epidemiological studies on alternative indicators of sewage pollution are required. Existing water quality standards are based upon coliform bacteria, but other bacterial or viral indicators may be more appropriate for tropical marine waters.

   e. **Develop additional data on groundwater quality and effects.** These data are very limited at present.

   f. **Develop baseline data on the concentrations of potential toxicants (metals and synthetic organic chemicals) in organism tissues.** Data are needed on levels of contaminants in fisheries species, to evaluate human health effects of consumption of fish/crustaceans. Tissue concentrations of contaminants from some species may be used as an indicator of pollution or may have ecological significance in its own right (e.g. body burden in higher-trophic level species).

g. **Develop site-specific baseline data on toxicant concentrations**in wetland sediments, stormwater retention areas, or upland soils in any area identified for use in redistribution of freshwater inflow.

h. **Develop baseline data on atmospheric nutrient loading and sediment-water nutrient flux**. Pay particular attention to wetland sediments or stormwater retention areas where identified for use in freshwater inflow redistribution projects.

i. **Evaluate/determine factors influencing the prevalence of abnormalities** in Biscayne Bay fishes.

Question Four

4. ***What level of direct exploitation (e.g., fishing, recreational use) and other direct impacts (e.g. dredging and filling) can the Biscayne Bay system tolerate?***

   a. **Update data on commercial and recreational fishing pressure bay-wide.** The most recent bay-wide recreational fishing assessment was conducted in the early 1980s.
      i) Currently, creel surveys are conducted only at selected sites in Biscayne National Park. Enhanced surveys must include quantitative information on fishing activity, patterns, and trends, and determination of catch per unit effort for commercially and recreationally important fish and invertebrate species**.**
      ii) Determine the sustainability of the recreational and commercial pink shrimp fisheries. Specifically: Assess the impact of bycatch from the live bait-shrimp fishery, and provide separate analysis of fishing mortality, catch, and catch per unit effort for the trawl shrimp (both bait and food) and wing-net (food) fisheries.

   b. **Assess population structure, including abundance and size distribution of key fisheries species.**

   c. **Define the habitat requirements and distributions of the smaller size-classes of selected fisheries species and potential ecological indicator species.** A gap exists in data for juvenile fishes and macroinvertebrates, in part due to gear selection and limited access to shallow areas and coastal wetlands. This task is related to similar tasks in Question 2.

   d. **Assess the impacts of fishing and fishing methods, dredging and other vessel operations upon benthic community structure and function and water quality.**

   e. **Develop fisheries production models for key species** (such as pink shrimp) that incorporate habitat distribution modifications associated with changes in freshwater input regimes.

   f. **Develop biological success criteria to assess effectiveness of habitat restoration and resource protection strategies.**

Appendix

Biscayne Bay Science Workshop Agenda

National Marine Fisheries Service
Southeast Fisheries Center
Virginia Key, Miami

February 13, 2001

8:00 – 8:10, 10 min	Introduction Peter Ortner

Question One: What volume, timing, and distribution of freshwater inflow are needed to protect, enhance, and restore the natural values of Biscayne Bay

8:10 – 8:40, 30 min	Summary Joan Browder
8:40 – 10:00, 1 hr 20 min	Panel Discussion
10:00 – 10:15, 15 min	Break – Refreshments

Question Two: Biscayne Bay is a mosaic of interconnected habitats and natural systems. What are the geographic and temporal patterns in the plant and animal communities, and how are these linked to each other, water quality, and water quantity? Particularly, what is the role of coastal wetlands in Biscayne Bay water quality, freshwater inflow and distribution, and productivity?

10:30 – 11:00, 30 min	Summary Joe Serafy
11:00 – 12:20, 1 hr 20 min	Panel Discussion
12:20 – 1:20, 1 hr	Lunch – University Food Court

Question Three: What are the geographic and temporal patterns in Biscayne Bay water and sediment quality in relation to upstream land uses and other possible sources? In Biscayne Bay, contaminants of interest include nutrients, pathogens, toxics such as metals, and organic chemicals.

1:20 – 1:50, 30 min	Summary Susan Markley
1:50 – 3:10, 1 hr 20 min	Panel Discussion
3:10 – 3:25, 15 min	Break – Refreshments

Question Four: What level of direct exploitation (e.g. fishing, recreational use) and other direct impacts (e.g. dredging and filling) can the Biscayne Bay ecosystem tolerate?

3:25 – 3:55, 30 min	Summary Jim Bohnsack
3:55 – 5:15, 1 hr 20 min	Panel Discussion
5:15 – 5:30, 15 min	Wrap up Peter Ortner

Biscayne Bay Science Workshop Participants; February 13, 2001

Name	Organization
Rick Alleman	South Florida Water Management District
Jim Baker	U.S. Army Corps of Engineers
Sarah Bellmund	Biscayne National Park
Stephen Blair	Miami-Dade Department of Environmental Resources Management
Gwen Burzycki	Miami-Dade Department of Environmental Resources Management
Adriana Cantillo	National Oceanic and Atmospheric Administration
Laura Engleby	Florida Sea Grant
Mitch Granat	U.S. Army Corps of Engineers
Don Hansen	The Cooperative Institute for Marine and Atmospheric Studies
Doug Harper	National Marine Fisheries Service
Scott Ishman	Southern Illinois University
Mike Johnson	National Marine Fisheries Service
Brian Keller	Florida Keys National Marine Sanctuary
Brian Lockwood	Biscayne National Park
Susan Markley	Miami-Dade Department of Environmental Resources Management
David Mayer	Florida Department of Environmental Protection
Keven Mayo	Miami-Dade Department of Environmental Resources Management
David McClellan	National Marine Fisheries Service
Geoff Mester	University of Miami Rosenstiel School of Marine and Atmospheric Science
William Miller	U.S. Fish and Wildlife Service
Mary Munson	National Parks Conservation Association
Matt Patterson	Biscayne National Park
Mike Robblee	U.S. Geological Survey
Mike Ross	Florida International University
Michael Schmale	University of Miami Rosenstiel School of Marine and Atmospheric Science
Tom Schmidt	Everglades National Park
Gail Sloane	Florida Department of Environmental Protection
Steven Smith	University of Miami Rosenstiel School of Marine and Atmospheric Science
Trisha Stone	South Florida Water Management District
Steve Traxler	U.S. Army Corps of Engineers
John Wang	University of Miami Rosenstiel School of Marine and Atmospheric Science
Harold Wanless	University of Miami Rosenstiel School of Marine and Atmospheric Science
Cecelia Weaver	South Florida Water Management District