

Technology and Information Needs of the Coastal and Estuarine Management Community

Executive Summary

Background

In January 1999, the Office of Ocean and Coastal Resource Management (OCRM/NOAA) contracted with Coastal States Organization (CSO) to identify coastal and estuarine management priorities and information needs in the National Estuarine Research Reserve System (NERRS) and Coastal Zone Management Programs (CZMP). The project's main goal is to provide information on coastal and estuarine management issues that the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) can use as a guide for its strategic planning and project selection. In addition, the project identifies organizations with missions and activities comparable to CICEET in order to provide information to CICEET on the extent to which relevant issues are currently being addressed by other organizations.

CICEET was established in 1997 as a national center for collaboration among academia, government, and the private sector to understand, reduce, and reverse the impacts of coastal and estuarine contamination and other anthropogenic causes of environmental degradation. The Institute is a partnership between the University of New Hampshire (UNH) and the National Oceanic and Atmospheric Administration (NOAA).

CSO project staff reviewed the existing literature relating to state, regional and national coastal management priority issues, research and technology needs. Based on the reviewed materials, a survey document for each state was prepared that incorporated references to state management issues and information needs identified from the literature. The survey was distributed to state coastal program (CP) managers, NERR managers, and National Estuary Program (NEP) directors. These coastal state managers were each asked to identify, prioritize (high, medium, low), and to add missing management issues that are relevant to the CICEET Strategic Mission and Goals. In addition, they were asked to specify technology and information needs that would increase their effectiveness and efficiency in addressing the key coastal management issues identified in their survey.

Coastal Management Issues

1. Literature Review Results

Based on a review of the relevant literature common key coastal and estuarine management issues were identified in the four most relevant national studies (NRC, EPA, NOAA, and CWAP Task Force²). The key issues, outlined in the following chart, were not prioritized in these studies. (Issues, which appear to be directly relevant to the CICEET Mission, are presented in bold italics.)

² Clean Water Action Plan (CWAP) Task Force is preparing a National Coastal Research & Monitoring Strategy, 1999.

NRC (1994) (National Research Council)	EPA/NEP (1997) (Environmental Protection Agency)	NOAA (1998)	CWAP Task Force (1999)
<i>Eutrophication</i>	<i>Nutrient overloading</i>	<i>Water-quality degradation</i>	<i>Eutrophication and its implications (HAB)</i>
<i>Toxic effects</i>	<i>Pathogen contamination</i>	<i>Harmful algal blooms (HAB)</i>	<i>Toxic substances, pathogens, aquatic toxins</i>
<i>Pathogens & toxins affecting human health</i>	<i>Toxic chemicals</i>	<i>Habitat loss & fragmentation</i>	<i>Physical habitat destruction and hydrologic changes</i>
<i>Habitat modification</i>	<i>Habitat loss/degradation</i>	Biodiversity loss	Institutional issues
Hydrologic & hydrodynamic disruption	Alteration of natural flow regimes	Coastal hazards	
Exploitation of resources	Declines in fish and wildlife population	Fishery collapse	
Invasive species	Introduced species	Aquatic nuisance species invasion	
Shoreline erosion & hazardous storms			
Global climate change			

As shown in the table above, these studies identified three common key national coastal management issues, also relevant to CICEET Mission: 1) nutrient overload, 2) pathogens and toxic contamination, and 3) habitat modification and loss. These issues were also frequently addressed in other studies that were reviewed and discussed in this report (see Appendix A).

2. Survey Results

In their response to the CSO Survey, coastal state resource managers generally confirmed the key national management issues identified in the above referenced studies. The individual responses (53), representing 35 coastal states and territories, are compiled in a companion document³ to this report. For the purpose of this report, the coastal states and territories have been grouped in seven regions. The top three management issues, identified most frequently as “high” priority in the survey results for each region, are presented in the following table:

³ “Responses to CSO Survey of Coastal State Resources Priority Management Issues & Information/Technology Needs”. CSO, Washington, D.C., 1999.

COASTAL REGIONS (35 states & territories)	PRIORITY MANAGEMENT ISSUES		
	#1	#2	#3
<i>Great Lakes (7)*</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Northeast (6)</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Mid-Atlantic (4)</i>	Nutrient enrichment (HAB)	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination
<i>Southeast (4)</i>	Nutrient enrichment	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination
<i>Gulf (4)</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Pacific (4)</i>	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination	Erosion and sedimentation
<i>Islands (6)</i>	Nutrient enrichment	Habitat degradation/loss	Pathogens & toxic chemicals contamination

(* The number of states and territories in each region.)

Nutrient enrichment and habitat degradation/loss and restoration were identified most often as high priority issues in all regions except the Pacific Region where pathogens and toxic contamination was one of the issues identified most frequently. The ranking of identified issues was based on the number of high choices for each state and for each region. Other issues frequently identified by the managers, that are not included in this summary table, were: habitat fragmentation, invasive species, dredging, hydrologic modifications (groundwater overdraft, freshwater inflow), and negative impacts of recreational uses. (See “Responses to the CSO Survey...” for data on regional and state individual responses). It is to CICEET to decide if they will focus their efforts on national priority coastal management issues, or address issues that are more relevant and specific to regions and states.

Coastal States Management Technology/Information Needs

Coastal state resource managers survey responses, and literature review (NRC, 1994; NRC, 1995; NOAA, 1995; CSC, 1995; NEP, 1997; EPA, 1998) frequently identified three generic areas of information and technology needs that apply to all management issues:

- need for comprehensive base line data;
- need for timely, accurate and cost-effective monitoring, and modeling technology; and
- need for improved ways to access and evaluate information gathered through monitoring programs.

Particular concern was expressed, in both the literature and the surveys, about the need to address the effects of complex interactions among multiple stressors in coastal/estuarine ecosystems (i.e. low oxygen concentration, habitat degradation, and toxic chemicals), and to develop modeling techniques to understand and forecast impacts of stressors. Several articles indicated that a number of technologies for measuring biological, chemical, and physical

parameters have not been routinely applied to coastal management issues (EPA, 1998; NIST, 1998; NRC, 1994). There is a need to expand the application of existing technologies to coastal management issues, as well as identify new technologies.

Based on the literature review and the survey responses, the information and technology needs that correspond to the three most common key management issues are outlined in the following table:

Management Issues	Information/Technology Needs
<i>Nutrient enrichment</i>	Identify sources, estimate wet and dry inputs of nutrients; Factors which trigger HAB; Storm drain and out-fall alternative treatment; Bio-indicators of nutrient enrichment; Improve modeling and assimilation techniques; Hydrodynamic modeling and atmospheric deposition data; Nutrient reduction tools; Alternative septic tank treatments; Models for predicting nutrient loading from easily measurable parameters;
<i>Habitat degradation/loss and restoration</i>	Evaluation techniques; Restoration success criteria; Long-term monitoring; Development of biological indicators for coastal habitats to indicate stressors; Measuring cumulative impacts of wetland drainage and loss; Cost effective technologies for restoration; User friendly GIS, remote sensing methodology for assessment analysis of land-use changes and wetlands loss; Unknown buffer distance adjacent to upland development projects to protect tidal, riparian, and estuarine habitats;
<i>Pathogens and toxic contamination</i>	Methods and technologies to treat and identify fecal coliform sources (human vs. natural); Additional indicators for pathogen contamination; (Bio)remediation of contaminated sediments; Vegetative tissue analysis and bioassay numeric guidelines; In situ technology for monitoring transport of contaminants; Cost effective testing of sediment contamination, and long term monitoring programs; Selection and validation of estuarine biomarkers for chemical contamination; Cumulative effects of multiple toxic substances on biota;

Coastal managers also frequently noted that they plan to expand the use of Geographic Information System (GIS) and remote sensing in the decision-making process, but there is a need for user-friendly techniques and tools. For example, GIS framework and models for integrated coastal zone management applications. In addition, coastal state resource managers frequently noted the problem of the scale of regional and national coastal assessments. They prefer information usable on local and state levels (NOAA/CSC, 1996; NOAA, 1995). Coastal resource managers indicated a desire for development of a consistent spatial and temporal framework for coastal environmental assessment on the local and state levels, which can be aggregated to address regional and national concerns. In addition, they indicated a need for mechanisms that can increase data accessibility. Identified research, technology and methodology gaps may be filled by potential CICEET projects that would also provide links between relevant research

activities and management decision-making process, and at the same time enhance cooperation between existing federal, state, educational and private organizations.

Organizations Similar or Comparable to CICEET Mission and Goals

Jurisdiction of coastal resources and habitats is shared among many states and Federal agencies. All agencies (Federal, state and private) that deal with natural resources appear to have programs for coastal and estuarine issues, some with activities that overlap CICEET’s Mission. The EPA’s Office of Research and Development (ORD) supports research on a variety of activities directed primarily to water quality and human health issues. However, EPA/ORD does not emphasize specific coastal management issues, and does not focus in activities that link management need with research priorities or have direct interaction with state CPs or NERRs. Several organizations and programs that have mission and goals, and activities relevant to CICEET, are outlined in the following table⁴:

Agency/Program	Goals/Issues Addressed
EPA/ORD (Office of Research & Development)	Goal is to develop new, field applicable biological indicators, and multi-scale monitoring designs for status and trends; Air modeling system; Multiple stressors assessments and methods; Techniques for decontamination and bioremediation of sediments and water; Techniques and methodologies to restore and rehabilitate coastal ecosystems; Toxic algal blooms;
NOAA/CSC (Coastal Services Center)	Mission is to identify, develop and facilitate use of technologies and information that support sustainable use & management of coastal resources (GIS, remote sensing, info library, internet activities);
NOAA/C-CAP (Coastal Change Analysis Program)	Program is designed to monitor change in terrestrial land cover and near shore benthic resources within coastal environments. It classifies types of land cover, analyzes changes in coastal submerged habitats, wetlands, and adjacent uplands using remote sensing techniques, and GIS in integration and interpretation of data.
EPA/OST (Office of Science & Technology)	Identified pathogen contamination issue as one of the major priorities for their research; Developed membrane filter test method for Enterococci in water;
USGS/BEST (Bio-monitoring of Environmental Status & Trends)	National water quality assessment; Surface water quality modeling (SPARROW); Hydroqual – water quality 3-D model for transport of nutrients, sediment, contaminants; National atmospheric deposition;
USDOE/NABIR (Natural & Accelerated Bioremediation Research Program)	Use in situ processes to develop new methods/technologies for bioremediation of heavy metals, radionuclides;
U.S. Fish & Wildlife Service/ Environmental Contaminants Program	Activities are directed towards the evaluation, protection and restoration of fish and wildlife, with emphasis on contamination prevention, investigation and restoration, and providing support to EPA on natural resource issues. This is the only Federal agency with fish and wildlife specific contaminants program.
NOAA/Sea Grant (29 National Sea Grant College Programs)	Encourages wise stewardship of marine resources through research, education, outreach and technology transfer. Issues: oyster disease, aquatic nuisance species, aquaculture, techniques for detecting pathogens in shellfish;
Battelle (Science & Technology Institute)	Provides the latest technologies, and develops new technologies, required for effective management, and utilization of natural resources.

⁴ Based on the reviewed literature, Appendix C provides the information on existing programs and organizations similar to CICEET Mission and Goals. In addition, Appendix D provides a compendium of environmental technology and information transfer sites that relate to coastal management issues and are relevant to “technology and information transfer” as one of the CICEET Strategic Goals.

Although several agencies and organizations, in the above table and cited in this report, have activities and goals similar to CICEET, there is no single agency addressing both coastal management issues, caused by anthropogenic contamination, and developing relevant technology/information on the local and state scale. CICEET is unique because its mission requires it to focus on projects and activities that link directly to management issues. In addition, other organizations and programs are often driven by single purpose objectives (e.g. water quality) or media specific goals (e.g. fisheries), rather than the ecosystem focus (coastal and estuarine) of CICEET. Because scientific solutions to ecological issues can no longer be isolated to one stress, one scale, or one medium, the cures will require more holistic ecosystem management approach, which will include scientists, managers, policymakers and the public.

Specific projects can address the effects of complex interactions among multiple stressors in coastal and estuarine ecosystems, such as low oxygen concentration or hypoxia, habitat degradation or loss, and toxic chemicals or pathogens. Potential CICEET projects can also address a development of modeling techniques to understand and forecast impacts of stressors on a smaller scale. In addition, projects can test existing tools and protocols for habitat restoration and its evaluation, as well as developing the new ones. Data collection and analysis (i.e. estuarine circulation models, fine temporal and scale resolution of toxics load estimates) can then be provided to specific management plans and most cost-effective management strategies. CICEET's specific focus on applying science and technology to develop new, or use existing, effective techniques and methods in monitoring, modeling, restoration and information transfer does fill a unique niche in the area of coastal resource management.

Through CICEET projects, the NERR sites are identified as unique laboratories, pilot areas, where experiments could be conducted by applying existing and develop new technologies and methods to monitor and address negative anthropogenic impacts on specific coastal ecosystems and habitats. However, in many cases the identified key coastal management issues are caused by anthropogenic negative impacts on the environment (i.e. pathogens, toxics, nutrient enrichment) and NERR sites might not the best examples where those individual issues and multiple stressors affects can be addressed. Therefore, while focus on NERRS sites has the advantage of utilizing a national system on which to focus its projects, CICEET should recognize the limitations where the sites may not represent the state, regional, or national issues.

I. Introduction

A. Background

The Cooperative Institute for Coastal/Estuarine Environmental Technology (CICEET) was established in 1997 as a national center for the development and application of innovative and effective technologies for monitoring, management, and prevention of anthropogenic contamination in estuaries and coastal waters. The Institute is a partnership between the University of New Hampshire (UNH) and the National Oceanic and Atmospheric Administration (NOAA). The stated Mission of CICEET is: *“To be a national center for collaboration among academia, government, and the private sector to understand, reduce, and reverse the impacts of coastal and estuarine contamination and other anthropogenic causes of environmental degradation.”*

CICEET seeks to achieve its Mission by:

- effectively using the National Estuarine Research Reserve System (NERRS) as living laboratories;
- fostering interdisciplinary work among biological and physical scientists, engineers, resource managers, and policymakers;
- being problem-driven and solution-oriented;
- ensuring the distribution of innovative environmental technology and techniques to user groups; and
- enhancing the current capabilities of estuarine science and management programs.

CICEET’s Strategic Plan established four goals that represent functional areas in which CICEET focuses and the means by which technologies and techniques are transferred¹. The four goals are:

1. Monitoring - To improve technologies and techniques to improve collection and analysis of estuarine environmental data, and to enhance the NERR Systems wide Monitoring Program.
2. Modeling – To develop, test, and apply novel predictive models to understand and forecast impacts of pollution and contamination on estuarine systems.
3. Mitigation – To develop, test, and apply innovative methods or technologies to prevent, reduce or treat pollution, or restore coastal habitat.
4. Technology and Information Transfer – To transfer state-of-the-art environmental methodologies, technologies, and information to coastal resource managers, scientists, educators, and the public.

¹ CICEET web site provides more information on the past and current projects, as well as mission and goals.
<http://ciceet.unh.edu/index2.html>

In order to explain the meaning of “technology” in the context of both this report and CICEET Strategic Mission, the following is a technology definition and description from the “Technology for a Sustainable Future”, a report prepared by the National Science & Technology Council (NSTC, 1995). The term “technology” means an “environmental technology”, which is “*a technology that advances sustainable development by reducing risk, enhancing cost effectiveness, improving process efficiency, and creating products and processes that are environmentally beneficial or benign*” (NSTC, 1995). In the same report, the NSTC identified and described four categories of environmental technologies:

- *Avoidance technologies* that avoid the production of environmentally hazardous substances or alter human activities in ways that minimize damage to the environment;
- *Monitoring and Assessment technologies* are used to establish and monitor the condition of the environment, including releases of pollutants and other natural or anthropogenic materials of harmful nature;
- *Control technologies* that render hazardous substances harmless before they enter the environment; and
- *Remediation and restoration technologies* that render harmful or hazardous substances harmless after they enter the environment. Restoration technologies embody methods designed to improve ecosystems that have declined due to naturally induced or anthropogenic effects (NSTC, 1995).

Coastal and estuarine management within states is primarily performed by state and local agencies, and supported by federal agencies. The major state-federal partnership programs include Coastal Zone Management programs in 34 of 35 coastal states and 25 NERR sites based on the Coastal Zone Management Act (CZMA) of 1972, which is administered by NOAA. The CZMA is the only federal statute that sets forth a federal-state partnership to achieve goal of maximizing sustainable economic and environmental objectives. It provides a flexible framework for states to develop programs to address a broad range of development, economic, and natural resource issues.

In addition, the CZMA establishes and authorizes funding for the NERRS, a network of estuarine areas preserved for research and environmental education. The System currently consists of 25 coastal Reserve sites in 20 states and one territory with approximately 1,000,000 acres of estuarine waters, wetlands and upland habitat. NERRS primary objective is to study the causes and effects of natural and anthropogenically-induced changes in the ecology of estuarine and estuarine-like ecosystems (NERRS Draft Action Plan, 1999). Each Reserve provides a platform to monitor changes in the health of the coastal ecosystems in a nationally coordinated network of sites suitable for long-term research and monitoring. System-Wide Monitoring Program established by NERRS will “identify and track short-term variability and long-term changes in the integrity and biodiversity of the Reserves’ ecosystems and coastal watersheds for the purpose of contributing to effective national, regional, and site-specific coastal zone management.”² NERRS Reserves have also committed to contribute to a system-wide research in the areas of:

² <http://www.nos.noaa.gov/ocrm/nerr>

- Non-point source pollution (NPS)
- Estuarine ecosystem restoration
- Biodiversity and the effects of invasive species
- Ecological mechanisms for sustaining healthy coasts
- Socio-economic research applicable to estuarine ecosystem management.

Congress established the National Estuary Program (NEP) in 1987 to address the complex problems associated with estuary management. EPA administers 28 NEPs and provides financial support for development and implementation of a Comprehensive Conservation and Management Plan (CCMP) for the estuary. In addition, EPA coordinates the Chesapeake Bay Program and the Great Lakes Program that were separately established under the Clean Water Act of 1983.

B. Project Procedure

In January 1999, the Coastal States Organization (CSO) received a grant from NOAA/OCRM for the Coastal/Estuarine Environmental Management and Technology Project. The Coastal States Organization (CSO) is a non-profit association that represents the Governors of the coastal states on legislative and policy issues relating to sound coastal, Great Lakes and ocean resource management, protection, and development. The purpose of the Project is to describe the information and technology needs relevant to the coastal states and territories, and NERR management issues, and to support the efforts of CICEET.

The project staff conducted a review of existing literature and information on coastal and estuarine management issues and technology/information needs (see Appendix A and B). CSO, in consultation with NOAA and CICEET, established a Peer Review Panel³ of coastal and estuarine managers and scientists. Working with the Panel, a Survey was developed for the states, in order to identify specific priority management issues, and information/technology needs in each coastal state that relate to CICEET's Mission and Goals. In order to accomplish this task, the Survey was sent to all state CP managers (35), NERR managers (23) and NEP directors (28). The 53 individual responses, from 35 coastal states and territories, are compiled in a companion document⁴ to this report.

In addition, the CSO project staff conducted a review of other environment and technology service agencies and organizations to assess their relation to CICEET Strategic Mission and Goals. (A summary of identified organizations is attached as Appendix C) From this review, the project staff developed a compendium of environmental technology and information transfer sites that relate to coastal management issues and are relevant to "technology and information transfer" as one of the CICEET Strategic Goals (Appendix D).

³ Dr. Maurice Lynch, CBNERR Manager, VA; Debra Hernandez, Assistant Director, Coastal Resource Management, SC; Dr. Anne Giblin, WHOI, ERF President; Eldon Hout, Coastal Ocean Program Manager, OR; Dr. Geno Olmi, NOAA/CSC; Chuck Nieder, Research Coordinator, HRNERR, NY.

⁴ "Responses to CSO Survey of Coastal State Resources Priority Management Issues & Information/Technology Needs". CSO, Washington, D.C., 1999.

The project staff met with CP and NERR managers at the CICEET Workshop, Coastal Managers Meeting (March 1999) and discussed national key coastal management issues, in particular coastal states issues and needs relevant to CICEET. At the Coastal Zone '99, Conference in San Diego, July 1999, the project staff met with the Peer Review Panel, and participated in the CSO Meeting to review and discuss the Project findings and status. In addition, the project staff participated at the ERF (Estuarine Research Federation)/RAE (Restore American Estuaries) Habitat Restoration Workshop in Stamford, Connecticut, that was one of the three regional workshops (See Appendix A; ERF/RAE, 1999). Throughout the course of this project, the project staff had numerous personal communications with state CP managers, research coordinators and/or managers of each NERR, NEP directors or designees, and other relevant organizations (USGS, NASA, NRC, UNH, Battelle, VIMS, RAE, ERF, ESA, CMC, IRF, Heinz Center).

II. Project Findings

A. Literature Review on National and Regional Coastal Management Priority Issues and Information/Technology Needs

1. National Coastal Management Issues

Although each of the U.S. estuaries and coastal ecosystems are unique, many of them face similar environmental problems. In recent years, there have been four major national studies, which attempted to identify key national coastal management issues. The most thorough study was done by the Ocean Studies Board of the National Research Council (NRC), and summarized in the “Priorities for Coastal Ecosystem Science” report (NRC, 1994). In this report, the NRC Committee identified nine major coastal environmental issues, as a basis for determining scientific priorities to meet national coastal needs. In addition, the NRC Committee provided an integrated assessment of research priorities based on previous NRC studies, using “Setting a New Course for U.S. Coastal Ocean Science” as a framework (SUSCOS, 1993).

Another relevant study is the National Estuary Program Report, which summarized findings and conclusions from the EPA and Association of National Estuary Program (ANEP) Workshop in San Francisco in 1996. This report identified seven general problem areas as national key management issues, and identified scientific information and management approaches relevant to identified issues (EPA/NEP, 1997). For each of the key management issues, sources and impacts were described using NEP examples, and discussing the national standards and criteria for each issue. Based on the Workshop’s findings and conclusions, the Association for National Estuarine Program (ANEP) has proposed a development of a “Technology Transfer Document” that will present a means to disseminate technical information produced by NEPs, and relevant to identified management issues. The goal is to produce a document that will provide guidance on water quality and living resources issues in terms of translating and using technologies to develop and attain management objectives. (The Battelle organization has been developing the “Technology Transfer Document”.)

NOAA, in its “State of the Coast Report”, identified eight national coastal management problems, based primarily on the CZMA Effectiveness Studies draft reports (NOAA, 1998; Effectiveness Studies, 1999). Currently, the Clean Water Action Plan (CWAP) Task Force (representatives from Federal agencies, scientists, NGOs and state programs) is preparing the National Coastal Research and Monitoring Strategy (NCRMS). In its draft report, the Task Force identified four critical coastal and estuarine national management issues (NCRMS, 1999). These studies did not prioritize among the identified coastal management issues. The key national coastal management issues identified in these reports are outlined in the following table. Issues that are relevant to the CICEET Mission are presented in bold italics.

NRC (1994)	EPA/NEP (1997)	NOAA (1998)	CWAP Task Force (1999)
<i>Eutrophication</i>	<i>Nutrient overloading</i>	<i>Water-quality degradation</i>	<i>Eutrophication and its implications (HAB)</i>
<i>Toxic effects</i>	<i>Pathogen contamination</i>	<i>Harmful algal blooms (HAB)</i>	<i>Toxic substances, pathogens, aquatic toxins</i>
<i>Pathogens & toxins affecting human health</i>	<i>Toxic chemicals</i>	<i>Habitat loss & fragmentation</i>	<i>Physical habitat destruction and hydrologic changes</i>
<i>Habitat modification</i>	<i>Habitat loss/degradation</i>	Biodiversity loss	Institutional issues
Hydrologic & hydrodynamic disruption	Alteration of natural flow regimes	Coastal hazards	
Exploitation of resources	Declines in fish and wildlife population	Fishery collapse	
Invasive species	Introduced species	Aquatic nuisance species invasion	
Shoreline erosion & hazardous storms			
Global climate change			

As shown in the chart above, these studies identified three common, key national coastal management issues which are also relevant to the CICEET Mission: 1) nutrient overload, 2) habitat modification and loss, and 3) pathogens and toxic contamination. Other studies and surveys, discussed below, generally support the three priority areas but also identify other specific management issues and relevant research needs, on the regional and national levels⁵.

The EPA’s Office of Research and Development (ORD) in their report, the “Ecological Research Strategy”, identified more a detailed list of environmental management issues of national concern (ORD, 1998). The purpose of this report was to identify environmental issues of national concern, including coastal and estuarine areas, and to identify research needs to address them. The following is a list of environmental issues identified in the EPA report, which will be addressed through the ORD’s future efforts. Issues that are relevant to the CICEET Mission and Goals are in bold italics.

- ***Mercury contamination; nutrient over-enrichment; contaminated sediments; pesticides and toxics; wet weather flow (WWF) (untreated discharges during storm events); toxic algal blooms; eco-criteria; Total Maximum Daily Load (TMDL); acid deposition; ozone depletion; endocrine disrupters; UV-B radiation; and land-cover change.***

NOAA’s Coastal Services Center (CSC) conducted a Coastal Information Management Customer Survey, in the summer of 1996. The main purpose of their survey was to help identify products and services that CSC clients need or want, their computing capabilities and the analytical tools they use. Customers provided information about current coastal information

⁵ Appendix A contains an annotated list of additional documents and information sources reviewed for the purpose of this Report.

management problems and opportunities; GIS and remote sensing capabilities; and their current and planned activities and products. This list was based on 84 responses to specific questions whether the respondents' offices managed data or information related to a predetermined list of examples, selecting as many problems as were relevant to their offices. Findings on respondents information and technology needs were not specifically related to identified management problems (CSC, 1996).

Regarding coastal management problems, CSC survey results not only identified, but also prioritized twelve management issues and needs of coastal state management agencies, NERRs, National Marine Sanctuaries, Sea Grant programs, and other agencies dealing with coastal issues (CSC, 1996)⁶. Management problems that were identified and prioritized are listed below:

1. Habitat degradation/loss
2. Coastal development pressures and impacts
3. Water quality degradation
4. Wetland impairment or conversion to other uses
5. Coastal hazards/catastrophic events
6. Coastal erosion
7. Fisheries decline
8. Shellfish stock health
9. Seafood/drinking water contamination
10. Groundwater degradation
11. Rare & protected species
12. Resource management & restoration

2. Regional Coastal Management Issues

The most relevant studies that addressed the regional research needs and coastal and estuarine issues were done through the Regional Marine Research Programs (RMRP) of the U.S. coastal areas. NOAA and EPA established RMRP under the South Carolina Fish Hatchery Act of 1990, Title IV (PL 101-593). The legislation directs the program to set priorities for regional marine and coastal research support of efforts to safeguard the water quality and ecosystem health of the region and carry out such research through grants and improved coordination.

These Programs were performed in nine regions, and were designed to identify regional research needs, set priorities among them, carry out needed research and better coordinate existing research (See Appendix B; RMRP, 1992-1997). The Programs Reports stated that the research must have a regional or large-scale impact; the research must contribute in solving more than one issue of regional concern; it also has to address priority research questions and further scientific progress; and the research has to build upon and not duplicate existing efforts (RMPR, 1992-1997). These programs did not address how to integrate *in situ*, local scientific projects with

⁶ Coastal Services Center (CSC) prepared the Coastal Resource Management Customer Survey asking for information about primary management issues and their technology needs. CSC is currently surveying CP managers on their technology and information needs. <http://www.csc.noaa.gov/survey>

regional ones, and what type of methodologies should be implemented to identify gaps between research needs and management issues.

Although the RMRP programs identified several common coastal management issues in some of the regions, it was not their primary objective. In a summary, the following issues were frequently identified in RMRPs: Ecosystems degradation, alteration and loss; nutrient enrichment, eutrophication and HAB; habitat restoration; anthropogenic contamination and toxic materials; erosion; invasive species; and freshwater input.

The following is a list of research priorities identified in nine regions:

1. *Alaska Region* - Research priorities: develop and test models broadly applicable to identify gaps in understanding of ecosystem change; role of physical transport of nutrients, larvae or other waterborne constituents on biological resources.
2. *California Region* - Research priorities: variability of coastal and estuarine ecosystems; cumulative impacts and effects of stress on ecosystem function; protection and restoration of coastal and estuarine habitats.
3. *Greater New York Bight Region* - Research priorities: integrated coastal management and application of GIS; waste disposal, nutrient enrichment and eutrophication; fisheries management and habitat restoration.
4. *Gulf of Maine Region* - Research priorities: patterns and transport mechanisms of contaminants, including nutrients and effects of living marine resources; physical, chemical and biological controls on noxious phytoplankton phenomena.
5. *Gulf of Mexico Region* - Research priorities: nutrient enrichment, freshwater input, toxic materials, coastal erosion, saltwater intrusion, nuisance species, trophic dynamics, and ecosystem modifiers.
6. *Insular Pacific Region* - Research priorities: assessment and monitoring of water quality, species and habitat; contaminant sources, transport and effects; application of research results.
7. *Mid-Atlantic Region* - Research priorities: synthesis of historical and contemporary data to guide further research relevant to management issues; development of analytical models of the region.
8. *Pacific Northwest Region* - Research priorities: alteration of marine and estuarine habitats due to anthropogenic activities; transport and effects of contaminants.
9. *South Atlantic and Caribbean Region* - Research priorities: four habitats are of greatest concern and highest priority - marine wetlands (mangroves/salt marshes), reefs, sandy beaches, and lagoons.

Many regional studies have targeted one or two specific coastal and estuarine issues, such as hypoxia, eutrophication or HAB (for example: Tampa Bay Program, Gulf of Mexico Program, Chesapeake Bay Program).

NOAA's Office of Ocean Resources Conservation and Assessment (ORCA) undertook a nine-year study to assess the nutrient enrichment conditions in estuaries in South Atlantic Region (1996), Mid-Atlantic Region (1997), North Atlantic Region (1997), Gulf of Mexico Region

(1997), and Pacific Coast Region (1998), except Alaska, the State of Hawaii, and U.S. Territories. This multi-year study sought to improve the understanding of nutrient enrichment and associated eutrophication events, and to support the development of an effective regional and national response strategy (See Appendix A). One of ORCA's fundamental objectives was to make maximum use of existing knowledge about the characteristic features of coastal areas and the processes that drive them as natural systems, and apply this information to resource management issues. Despite the nine years of study it is not clear how this regional and national assessment contributes to the management and solving the nutrient over-enrichment (eutrophication, HAB) and its negative impacts on estuarine and coastal ecosystems on the local, and state levels.

The U.S. Geological Survey's Patuxent Wildlife Research Center prepared and hosted a "Symposium on Coastal Issues and Information Needs", Annual Science Meeting (USGS, 1999). Unlike the studies above which focus primarily on the research and scientific community, the Symposium brought together Center scientists and Federal, state and local partners to encourage dialogue about information gaps and long-term data needs relevant to coastal resource management. The area of interest and primary focus of discussions was eastern coast of the U.S. (Northeast and Mid-East Regions). The coastal issues addressed were: nutrient enrichment – sources and ecosystem responses; physical alterations of coastal habitats; shoreline change processes; and long-term monitoring and research⁷. They addressed a population growth issue in the coastal zone and concomitant urban, industrial, and agricultural development that are threatening natural resources with a host of anthropogenic stressors. One of the statements was that the problem in the coastal zone stem from complex process interactions across a variety of temporal and spatial scales that require integrated and interdisciplinary responses. Symposium participants concluded that the need for a coordinated approach to research and management of coastal ecosystems has never been greater.

In reviewing the literature, it was difficult to find studies that identified links between key coastal management issues and relevant research, information and technology needs. Main reason for this is that scientific findings have been rarely directly applied to management decisions and without the early and substantive involvement of managers in the planning process from its inception. In order to address this issue, it is necessary to recognize the language and institutional barriers between scientists and managers, as well as differences in perspective among federal, state and local managers who each address a different set of management issues (CGOOS Workshop, 1999). In order for CICEET to fulfill its mission to be "problem driven" it will need to assure more interaction among scientists and managers overcome these barriers.

3. Information and Technology Needs

Several years ago, NOAA's Integrated Coastal Management Committee, based on a survey, issued a report on general principles and information and technology needs of 34 Coastal Zone Program managers (NOAA, 1995). The coastal program managers identified the products and

⁷ List of specific research and information needs identified in this study, which are relevant to resource management, is presented in the Appendix B.

services they needed but did not perceive as available. The following is a list of their identified needs:

- scientifically supported methodologies for addressing development impacts;
- an information clearinghouse;
- correlation between land-use practices, implementation of nonpoint source coastal zone management strategies, and changes in water quality parameters;
- information on what technical assistance or data is available, and direct mechanism to get information when it is needed;
- information generated on the scale that is not useful for coastal managers (need for site specific, local data, not site-averaged, regional/national aggregates);
- input into the design of research, monitoring, and assessment projects to ensure that coastal management problems are addressed;
- information on available cost-effective technologies that relate to management issues, and
- a focus on issues and generation of data that are irrelevant to tropical island needs.

This list reflects a mix of specific information and technology needs to address coastal management issues, as well as general needs to increase accessibility, applicability and cost-effective availability of existing and new information.

National surveys and studies frequently cited the importance of information integration, access, dissemination, and data application (NOAA/CSC, 1996; NSTC, 1995). Coastal managers of all levels require reliable, useful, timely, and accurate information about the actual state of an ecosystem and its resources at a variety of temporal and spatial scales. Coastal state resource managers have indicated that a scaling issue exists and their preference is for information usable on local and state levels, which can be aggregated to address regional and national concerns (NOAA, 1995; NOAA/CSC, 1996). CICEET should be cognizant of the general needs, as well as supportive of specific project addressing information and technology needs.

For example, below is a list of several Federal agencies programs that conduct monitoring and environmental assessment with their performance scales (resolutions):

- NOAA/C-CAP (Coastal Change Analysis Program) perform land cover change measurements in 16 coastal states every one to five years using remote sensing (satellite images have resolution of approximately 30 meters);
- EPA/EMAP (Environmental Monitoring & Assessment Program) perform measurements of multi-resource ecological indicators on the regional level at 12, 600 sites in the U.S. with the resolution of 635 km₂ (systematic grid), and on the smaller grid scale of 40km₂;
- NOAA/National Status & Trends conduct measurements of chemical contamination in mussels and oysters, annually, at 260 sites in the U.S., with estimated resolution of 70 km between sites along the continental coast not including Alaska; (for island states and territories the resolution was not estimated);
- USGA/NAWQA perform measurement and assessment of water quality in the U.S. watersheds on the regional and national level, with established 59 study units from which 24 are in coastal areas, with an average site unit of 40, 000 km₂.

Very often those scales and gathered data are not appropriate for addressing specific, smaller scales coastal states management issues, or in the case of remote sensing and GIS applications, they are not cost-effective and accessible.

In order for state coastal resource managers to access and use collected data in the above monitoring programs, the existing information has to be organized and synthesized, providing a consistent spatial and temporal framework on the local and state levels, not only on the regional and national levels, and to provide mechanisms that can increase data accessibility.

The following sections specifically address technology, information, and research needs that were identified through the literature review, and which are relevant to nutrient enrichment, habitat degradation/ loss and restoration, pathogen and toxic contamination.

(I) *Nutrient enrichment* - Most often studies relevant to this issue indicated a need for improved monitoring, and upgrading of critically important data on nutrient loadings from all sources (NAS, 1990; ORCA, 1996; RMRP, 1992-1996). For example, in order to address eutrophication process there is a need to develop improved standards and protocols for collection methods and analytical comparable techniques (NEP, 1997). Another frequently identified need is development of better indicators of unacceptable coastal/estuarine ecosystem stress and better understanding of the key ecosystem processes/functions. Regarding HAB, tools and current methodology for bloom species identification and toxin detection are inadequate, as is the understanding of acute and chronic effects of toxins on biota. The literature also identified a need for indicators to predict HAB occurrence and hazards, and better techniques to mitigate their impacts on coastal resources (Turgeon *et al.*, 1998; ITF, 1999). Recently, researchers have become aware that nutrient enters the biosphere via wet and dry deposition. Therefore, there is a need for better research programs and effective technologies to monitor estimates of atmospheric deposition of nitrogen, and other contaminants (EAS, 1997; EPA, 1997; Ch. Bay Program, 1997; ORD, 1998). Very often, the literature refers to the need for increased attention and better monitoring to predict and prevent nutrient over-enrichment, eutrophication, and HAB rather than just focus on treatments of its ecological impacts (NCRMS, 1999).

(II) *Habitat degradation, loss and restoration* - Degradation and loss of ecosystems can result from coastal land management practices, hydrologic modification, erosion and sedimentation, over-enrichment of nutrients, and pollution. In general, there is a lack of data, tools, and demonstrated technologies to design and implement successful risk management programs for ecosystems at the local level. Development of protocols and methodologies are needed by coastal managers to evaluate ecosystems health risks and threats (e.g. biomarkers and ecosystem indicators, models, and GIS tools). Cost-effective stress reduction caused by anthropogenic sources might not always be practical and feasible. It is important to develop cost-effective restoration technologies, including protocols and indicators, to diagnose ecosystem restoration needs and evaluate the restoration progress within watersheds (ERF/RAE, 1999). Because, successful restoration has to be based on the knowledge of the baseline community that existed prior to degradation, a comprehensive base line data (environmental assessment) is needed to develop better restoration/mitigation techniques and methodologies. Relevant monitoring programs need to be incorporated into the restoration strategy to determine success rates relative

to the baseline (ERF/RAE, 1999). In general, there is a need to develop new, cost-effective prevention and control, remediation technologies/techniques to identify sources of stressors, and effective habitat restoration approaches and methods.

Several federal studies (ORD, 1998; NRC, 1995; NRC, 1994; NSTC, 1997) identified a need for research on ecosystem structure and function that would enhance management ability to assess habitat loss and alteration impacts, develop restoration methods, and evaluate their effectiveness. Although these studies indicated that some methodologies exist for habitat restoration (salt marshes, SAV, and for some coral reefs), they have not been tested in nature over wide geographic areas and different scales. One of the conclusions at the ERF/RAE Habitat Restoration Workshop was that there is a need to develop new methodologies to test the current effective techniques throughout different geographic regions and scales in order to provide appropriate guidelines and best management practices for restoring coastal and estuarine ecosystems (ERF/RAE, 1999).

(III) *Toxic and pathogen contamination* - Negative anthropogenic impacts that cause toxic and pathogen contamination are often associated with residential development, industrial wastes, and sewage contamination. Most of the research and work regarding contamination issues has been focused on monitoring toxic chemicals inputs at or near their sources, pathways into the coastal ecosystems, and on determining acute toxic effects of single compounds on organisms/species in laboratory experiments (NCRMS, 1999). Several programs, in their reports, indicated a need for better understanding of processes that move toxic substances to locations away from their sources, from one media to another (e.g. atmosphere-water-groundwater), and the effects of toxics on biota at very low concentrations (Chesapeake Bay Program, 1999; EPA, 1998; EPA, 1997; ORD, 1998). Integrated research and monitoring programs should focus on understanding the sources, kinetics, chemical combinations of toxics in aquatic environments, and on synergistic and antagonistic interactions among multiple toxics acting on aquatic organisms. The problem of cumulative effects of multiple toxic substances on biota of long-term exposure to low levels is barely being addressed (ORD, 1998; NEP, 1997). There is a need to address the effects of complex interactions among multiple stressors in coastal and estuarine ecosystems (i.e. low oxygen concentration, habitat change, and toxic chemicals).

Health risks from pathogens are associated with the improper treatment or disposal of human wastes and the subsequent closure of shellfish beds. Septic tank design and performance criteria are set by the states, and require cost-effective alternative technology to improve maintenance of the septic tanks and secondary wastewater treatment *in situ*. Nationally, the indicators for human sewage and animal waste are coliform bacteria because these bacteria are easily measured and may indicate the same sources as pathogens. Within the National Estuary Programs, states are using either total or fecal coliform or enterococcal organisms as indicators of pathogens (NEP, 1997). Several pathogens (*Clostridium perfringens*, *Cryptosporidium*, *Giardia*, etc.) have no published standards, and there are no national guidelines for sediment contamination or ecological effects of tissue (i.e. fish, shellfish) contamination. There is also an indicated need to develop additional indicators of pathogenic contamination and timely, cost-effective technology/technique in distinguishing sources of pathogens (e.g. human vs. natural) (ORD,

1998).

Most of the remediation research on environmental contamination has been directed to waste site cleanup and has been driven by human health risk concerns. Current remediation approaches for contaminated media within ecosystems are concentrating both on reducing the stressors and on sustaining ecosystem function. In order to do so, new cost-effective technologies for *in situ* treatment of contaminated sediments and other media should be developed and tested (ARCS, 1998). Bioremediation is a developing technology that exploits the power of naturally occurring microorganisms and plants to transform harmful environmental contaminants (in soils, groundwater and subsurface sediments, and marine and estuarine sediments) into relatively benign substances (Drell, et al, 1999; Biosolve, 1999). The U.S. Department of Energy (DOE) launched the Bioremediation Societal Implications and Concerns (BASIC) program in 1996, in order to help complex clean-up processes of DOE's waste sites (mixtures of metals, radioisotopes, and solvents). However, this effort does not address the specifics of coastal and estuarine contaminated areas.

In a summary, Federal agencies support research, monitoring, and assessments to predict impacts of nutrient enrichment, habitat degradation and loss, quantifying habitat status and trends, studies on ecosystem processes and species-specific information (NCRMS, 1999). New technologies and protocols for mapping habitat type, change, and loss are needed to generate a more accurate status and trends of habitats on local, regional, and national levels. Existing traditional measures and methodologies for physical and chemical parameters need development of biological indicators for coastal waters, as well as adequate monitoring technologies (instruments) for indicating natural and anthropogenic stressors. There is a need to develop a set of aquatic indicators that will be effective to interpret the cumulative stress in local and regional communities (ORD, 1998).

B. Survey of Coastal States Priority Management Issues and Technology/Information Needs

1. Methodology

The primary goal of this Project is to identify priority coastal and estuarine management issues in coastal states and territories that can be addressed by environmental monitoring, modeling, restoration/mitigation, technology/technique and information transfer consistent with the CICEET Mission. CSO project staff reviewed existing literature relating to state, regional and national priority coastal management issues, and to research and technology needs. Based on the materials reviewed, a Survey tailored to each state was prepared with identified management issues and information needs, from the relevant literature. The Survey was distributed (May and November 1999) to state coastal program (CP) managers, NERR managers, and National Estuary Program (NEP) directors. The coastal and estuarine managers were asked to confirm and correct issues identified, and to prioritize and add missing issues that are relevant to the CICEET's Strategic Mission and Goals (see Memorandum "I"). Survey respondents were also asked to specify technology/information needs that would increase the effectiveness and efficiency in

solving the key coastal states management issues identified. Respondents were also asked to provide any comments relevant to the Survey, and to add relevant documents, reports to the reference list. For the purpose of this Project, the 35 coastal states and territories were grouped into seven regions: Great Lakes Region, Northeast Region, Mid-Atlantic Region, Southeast Region, Gulf Region, Pacific Region, and Islands⁸.

Responses to the May Survey were received from 53 individual coastal and estuarine programs representing 35 coastal states and territories. The May Survey results were summarized for each state based on responses from CPs (29), NERRs (15), and NEPs (9), and are presented in the Regional Tables 1-7. The responses were ranked in the regional summary results based on a number of prioritizations “high, medium, and low” for each issue from the state’s individual respondents. Each state provided additions to the survey document based on management issues of particular concern. If the columns for some issues were left unmarked for some states, it does not necessarily mean that the issue is not of concern. Because some states responses only represent the NERR site, those state responses do not fully represent management issues that might be relevant to other parts of the state (especially regarding pathogens and toxic contamination issues, because NERR sites are rarely affected).

In addition, comments and conversations with coastal program managers indicated that they have prioritized issues that are currently their highest priority and area of interest. As noted by Maryland CP and Chesapeake Bay NERR, “prioritization of the indicated activities reflects current Coastal Zone Management Programs focus, but not necessarily overall state priorities. Some activities are ranked lower because other programs within the state are handling the issue.”

In order for CICEET to improve its strategic planning and future project selections, it is necessary to ensure that CICEET is addressing the appropriate coastal management issues. The coastal managers inputs will be used in RFP development and in CICEET strategic planning. Because each coastal state has not had an opportunity to see all issues and needs identified by other coastal states in their responses, the May Survey summary results with additional list of management issues and information needs identified in other states and regions were sent to the same 54 respondents (CPs, NERRs, and NEPs) for revision and, if relevant, reprioritization (November 1999). In addition, the respondents were also given an opportunity to provide recommendations for CICEET’s further interactions with states coastal and estuarine programs by answering five questions (see Memorandum “II”). Responses to the November Survey were received from 23 coastal management programs (13 CPs, five NERRs, and five NEPs) representing 20 coastal states. The summary results are also presented in Regional Tables 1-7. Individual responses are published in the separate document “Responses to the CSO Survey of Coastal States Priority Management Issues and Information/Technology Needs”.

⁸ Individual Coastal States Survey Responses are presented as a separate document that includes all responses from state CP managers, NERR managers, NEP directors; each survey includes a list of references used in its preparation.

2. Survey Results

Responses received from both May and November Survey are combined and summarized bellow. All the regions identified three general areas of management concern:

- Nutrient enrichment (eutrophication, HAB);
- Habitat degradation/loss and restoration; and
- Pathogens and toxic contamination.

Another high priority issue identified in the Pacific and Island regions was erosion and sedimentation. Although the erosion and sedimentation was not indicated as one of the potential issues in the current CICEET Strategic Mission and Goals, it may in some areas be indirectly related to the habitat degradation and loss. Other issues, frequently identified by the survey, included invasive species, dredging, negative impacts of recreational uses, and hydrologic modifications.

The following chart is presenting the survey summary results of the top three priority issues identified in seven regions.

COASTAL REGIONS (35 states & territories)	PRIORITY MANAGEMENT ISSUES		
	#1	#2	#3
<i>Great Lakes (7)*</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Northeast (6)</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Mid-Atlantic (4)</i>	Nutrient enrichment (HAB)	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination
<i>Southeast (4)</i>	Nutrient enrichment	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination
<i>Gulf (4)</i>	Habitat degradation, loss and restoration	Nutrient enrichment	Pathogens & toxic chemicals contamination
<i>Pacific (4)</i>	Habitat degradation, loss and restoration	Pathogens & toxic chemicals contamination	Erosion and sedimentation
<i>Islands (6)</i>	Nutrient enrichment	Habitat degradation/loss	Pathogens & toxic chemicals contamination

(* The number of states and territories in each region.)

Survey responses also indicated three general areas of information and technology needs that apply to coastal and estuarine management concerns:

- comprehensive base line data;
- timely, accurate, and cost-effective monitoring, and modeling technology; and
- improved ways to access and evaluate information gathered through monitoring programs.

Both, the priority management issues and relevant information and technology needs are consistent with issues and needs frequently identified in the literature.

<p><i>Nutrient enrichment</i></p>	<p>Identify sources, estimate wet and dry inputs of nutrients; Factors which trigger HAB; Storm drain out-fall alternative treatment; Bio-indicators of nutrient enrichment; Improve modeling and assimilation techniques; Hydrodynamic modeling and atmospheric deposition data; Nutrient reduction tools; Alternative septic tank treatments; Models for predicting nutrient loading from easily measurable parameters;</p>
<p><i>Habitat degradation/loss and restoration</i></p>	<p>Evaluation techniques; Restoration success criteria; Long-term monitoring; Development of biological indicators for coastal habitats to indicate stressors; Measuring cumulative impacts of wetland drainage and loss; Cost effective technologies for restoration; User friendly GIS, remote sensing methodology for assessment analysis of land-use changes and wetlands loss; Unknown buffer distance adjacent to upland development projects to protect tidal, riparian, and estuarine habitats;</p>
<p><i>Pathogens and toxic contamination</i></p>	<p>Methods and technologies to treat and identify fecal coliform sources (human vs. natural); Additional indicators for pathogen contamination; (Bio)remediation of contaminated sediments; Vegetative tissue analysis and bioassay numeric guidelines; In situ technology for monitoring transport of contaminants; Cost effective testing of sediment contamination, and long term monitoring programs; Selection and validation of estuarine biomarkers for chemical contamination; Cumulative effects of multiple toxic substances on biota;</p>

The specific information and technology needs identified in the survey are presented in the following table and are grouped in relation to the three, most frequently identified, national and regional management issues. These findings are based on the literature reviewed in preparation for the survey and the survey responses.

3. Regional Survey Results

The following paragraphs summarize the survey results from the seven regional tables: Great Lakes, Northeast, Mid-Atlantic, Southeast, Gulf, Pacific and Islands (Tables 1-7).

Table 1: GREAT LAKES REGION (WI, IN, MN, OH, MI, IL⁹, PA)

(Responses were received from five coastal program managers, one NERR manager, and the EPA office.)

Most of the states in this region identified habitat degradation/ loss and restoration as a high priority. Specific types of habitat degradation were identified in most of the states (i.e. wetlands, forested wetlands, and barrier beaches). Managers identified a need for information on land use changes and wetlands loss, and development of user-friendly GIS modeling tools for incorporating and analyzing monitoring data. Managers indicated a need for accessible tools and evaluation techniques for "...achieving sustainable restoration of highly, diverse native hardwood swamp forests" in Wisconsin, for sand dunes in Minnesota, and riparian vegetation in Pennsylvania.

Nutrient enrichment was frequently identified by all states as a high or medium priority issue, and urban runoff was identified, most often, as the primary cause of nutrient input. Coastal managers identified a need for alternative technologies for septic tank wastewater treatment. They specified a need for better technology to identify sources, and methods to distinguish between natural and manmade sources of nutrient inputs. Managers also identified a need for better measurement of nutrient flux for modeling that would also consider groundwater and atmospheric nutrient inputs.

Pathogens and toxic contamination in coastal waters and sediment, including pesticides, heavy metals, and pathogens, was another important issue. Managers expressed a need to improve methods for identification of human vs. natural coliform sources, and need for timely, cost-effective monitoring techniques for pathogens. They also identified a need for better remediation techniques, and effective bioassays and numeric guidelines regarding sediment contamination issue. Managers indicated a need to address identification of atmospheric sources of pollution.

Managers from all seven states identified intrusion of non-native species as a high priority issue. Minnesota indicated that "...invasion of exotic species as the most important and detrimental issue." In order to address this problem, managers identified needs for development of effective management strategies, prevention technologies, monitoring, and impact assessment methodologies. However, the current CICEET Strategic Mission and Goals does not consider the invasive species issue to be one of their goals. Another important issue identified as a high priority in four states was erosion and sedimentation. Although this issue was not specified as

⁹ In the case of Illinois, the response was received from the EPA's state office (see Survey Document), because other coastal programs (CZM, NERR, NEP) are not yet established.

one of the goals in the current CICEET Strategic Mission and Goals, it can be indirectly related to habitat degradation and loss.

In their responses, managers also recommended establishment of better communication between coastal managers *via* CICEET website which should promote the transfer of information on identified management issues and information needs. In addition, the website should be comprehensive providing links to wide range of resources and technology transfer. Response from MN suggested establishment of a brief newsletter by email on a regular bases. The responses were supportive of potential regional workshops as an appropriate way of discussing the identified issues, but they should be combined with existing meetings (e.g. the Great Lakes annual meetings first week in October).

Table 2: NORTHEAST REGION (ME, NY, MA, NH, CT, RI)

(Responses were received from four coastal program managers, three NERR managers, and two NEP directors.)

High priority management issues identified in the survey were habitat degradation/loss and restoration, referring to specific habitats such as SAV, shellfish areas, and salt marshes. Regarding specific habitats, there is a need for impact assessments analysis (i.e. dock/boat impacts), and evaluation techniques and methods for habitat restoration and its success. Rhode Island indicated that there only 90 acres of SAV remain in Narragansett Bay, and that they need to update location data and assessment. Managers expressed a need for affordable remote sensing and user-friendly GIS tools in order to assess data on land use changes, long term monitoring, and cumulative impact modeling. Coastal program management in NY specified as high priority degradation and loss of non-tidal wetlands, while response from the Narragansett Bay NEP identified barrier beaches and fishery habitats degradation as additional high priorities. Regarding habitat restoration, oyster reef restoration was identified as high priority in NH-NERR response, and seagrass habitat restoration was identified as high priority in RI-NEP response.

Another important issue was nutrient enrichment caused by runoff from septic tanks, urban developments, storm water, and atmospheric inputs. Managers indicated needs for better methodologies to identify sources of nutrient inputs, and effective automated monitoring technologies. In addition, coastal managers expressed a need for cost-effective removal methods for nitrogen/phosphorus, and modeling methods that will incorporate data from different nutrient inputs (atmospheric, and groundwater measurements). Very often, managers indicated a need for development and implementation of BMPs for storm water runoff, and evaluation methods for BMPs effectiveness.

Pathogens contamination was identified as a high priority issue in all states of this region except in Connecticut where it was medium. Other types of contamination included pesticides and fertilizers, sediment contamination and contaminated seafood. Regarding pathogen inputs to coastal waters, there is a need for alternative treatment and disposal of wastewater, disinfection technologies, and identification techniques for human vs. natural fecal coliform sources. Managers requested additional indicators for pathogenic contamination (not only coliforms), as well as effective technology to indicate presence and affects of non-traditional pathogens (i.e. *Pfisteria*, *Cryptosporidium*). Coastal managers also indicated a need for better monitoring technologies, specifically to monitor *in situ* transport of contaminants, and to identify bioaccumulation of contaminants in fish and wildlife. For sediment contamination identified needs included (bio)remediation and stabilization technologies, long-term monitoring and cost-effective testing for toxics.

New Hampshire indicated that data information and access is a key for managers and decision-making process, specially regarding geo-spatial data and simple models that can be used on PCs. Comments from the Waquoit Bay NERR indicated "...a need for comprehensive planning efforts to address all identified management issues (in a given environment) as cumulative impacts instead of looking at everything piecemeal, and use helpful tools like GIS. The question is how appropriate is it for CICEET to address this?"

Additional comment from New York indicated that very often "...for many issues of interest, the barriers to successful management are not always "scientific". Rather, they are attributable to the lack of an institutional framework (regulatory, incentive, educational) which would assure that the management steps will be taken."

All the responses support the idea of using the CICEET website to contribute addressing identified issues and enhancing communication between managers and researchers. The regional workshops in this region already exist (EPA-NEP, NOAA-OCRM) and should be used as "polygons" for CICEET to address specific regional issues and technology transfer and implementation.

Table 3: MID-ATLANTIC REGION (NJ, DE, MD, VA)

(Responses were received from three coastal program managers, and four NERR managers.)

One of the most important management issues identified in this region was nutrient enrichment, more specifically harmful algal blooms (HAB) and eutrophication. Regarding this issue, managers indicated a need for more information on factors that trigger HAB and better bio-assessment methodologies. They also expressed a need for identification of sources of nitrogen and phosphorus, and evaluation of best management practice (BMP) effectiveness. The survey also identified a need for better hydrodynamic modeling methods that incorporate atmospheric deposition data of nutrients.

Another priority coastal management issue identified was habitat degradation and loss, specifically SAV habitats and tidal salt marshes. Managers identified a need for information on and methodologies to determine the rate of habitat loss and its causes. Managers in VA and MD indicated the importance of oyster reef and riparian vegetation habitats restoration. Information needs included monitoring and evaluation techniques for determining habitat quality and success criteria, and a better understanding of recovery methods. Another identified issue was habitat fragmentation, and a need for establishing physical habitat characteristics (indicators) and habitat suitability modeling (HMS). Additional comment, provided by CBNERRVA manager regarding habitat degradation and need for restoration, but "...we have very few tools to use in assessing whether a habitat is in a less than optimal condition. We can tell when some habitats are completely degraded, but we cannot assess when a habitat is on the way up or down."

Contamination, identified in this region as one of the high priorities, included toxic chemicals (specifically pesticides in NJ, MD, and DE) and pathogens in coastal waters and sediment. They also identified a need for selection and validation of estuarine biomarkers for chemical contamination, and a need for low cost monitoring tool for pesticides. Coastal managers also indicated a need for additional indicators of pathogen contamination and sources of coliform bacteria (human vs. natural). In addition, they indicated a need for a better selection and validation of estuarine biomarkers for chemical contaminants; cost effective monitoring tools for pesticide impact assessment and BMPs development.

Additional responses from VA-NERR and MD-CZM, recommended a website that would provide useful technical information on issues of concern and information exchange on how states are addressing some issues. In addition, it would be useful to update what CICEET has done to meet identified management needs. Regarding regional workshops they should include managers and scientist addressing specific issues within the region and potential solutions transfer from other regions.

Table 4: SOUTHEAST REGION (NC, SC, GA, FL)

(Responses were received from three CP managers, two NERR managers, and two NEP directors.)

Nutrient enrichment was identified as one of the priority coastal management issues in this region. Nutrient enrichment is mainly caused by stormwater runoff and urban NPS pollution. Information needs indicated by coastal managers included atmospheric and groundwater nutrients input data, and measurement of nutrient flux with algorithms for better modeling. Regarding a storm water runoff and BMP developments, North Carolina expressed a need for adequate models that would show effectiveness of buffers vs. reducing impervious surface areas and interaction between two methods. BMPs development was also indicated as a need for management and control of agricultural runoffs and animal farm operations in Florida and North Carolina. Nutrient enrichment often causes eutrophication, which coastal managers in Florida identified as one of their priority issues, and harmful algal blooms that seems to be less important issue in this region than in the Mid-Atlantic Region.

Habitat degradation/loss of salt marshes, forested wetlands, coral reefs, and restoration of wetlands, sea-grasses and marshes were another high priority issues identified in the survey. Managers indicated needs for the baseline data and land-use changes (using GIS tools); a need for models of mainstream-river flows; and a need for better methods for gathering water quality data in small tidal creeks. They also indicated a need for cost-effective methodologies and evaluation techniques of habitat restoration. In addition, coastal managers expressed a need for better monitoring programs based on biological indicators of environmental stress caused by anthropogenic changes.

Hydrologic modification and changes of freshwater inflows were identified as a high priority issue in Georgia and Florida. Regarding this issue, managers indicated needs for information on hydrologic modification effects on tidal rivers, estuarine habitats and fish nursery areas. In addition, indicated were needs for biological indicators of salinity changes, and modeling of groundwater flows.

Pathogens and toxic contamination was another high priority issue in this region. Managers indicated that the toxic contamination issue requires better techniques for vegetative tissues analysis and bioassay numeric guidelines. Managers also indicated a need for better technology/methods for monitoring of shellfish areas and swimming areas, and cost effective techniques for the identification of fecal coliforms, and their sources (human vs. natural).

In additional responses, managers suggested that the CICEET website would be useful for access to information and technology developed by CICEET and others, and to learn how other areas address similar problems. Most of the respondents think that regional workshops would be helpful in exchanging information and technologies, particularly if they would use existing meetings (NEPs, NERRs, DCA- Coastal Program or SWIM programs in Florida).

Table 5: GULF REGION (AL, MS, LA, TX)

(Responses were received from three CP managers, and one NEP director.)

The survey results in this region identified habitat degradation/loss and restoration as high priority management issues. Coastal program manager from Alabama indicated that the most important need is the baseline inventory and information assessment on current habitats using aerial photography and GIS tools. Mississippi indicated information needs on causes of SAV loss, and possible solutions, while other states also indicated a need for innovative habitat restoration techniques.

Nutrient enrichment was indicated as a high priority in Alabama, and more specifically as eutrophication in Louisiana, and HAB in Texas. Coastal resource managers identified a need for information on factors that trigger HAB and identification of sources of nutrient inputs.

Pathogen contamination was identified as a high management issue in three states, except Alabama where it was low. Identified needs included a development of methods to identify and treat fecal coliforms, and to identify sources of fecal coliforms (human vs. natural). Managers also identified information needs for sources of pesticides and their impacts on sediment quality and ecosystems health. Oil spill was identified as a high priority issue (in LA), with indicated needs for adequate models of dispersion and development of *in situ* remediation technologies.

Additional issues included dredging (MS, LA), erosion (AL), invasive species (LA), and hydrologic modifications (LA) that were identified as high priorities in individual state responses. Coastal resource managers expressed their need to identify areas where dredged materials can be used for wetland restoration. Regarding erosion they identified a need for better shoreline monitoring and use of GIS and remote sensing in modeling.

Table 6: PACIFIC REGION (AK, WA, OR, CA)

(Responses were received from four CP managers, two NERR managers, and three NEP directors.)

Coastal managers in this region identified habitat degradation/loss and restoration most frequently as high priorities in their states. They indicated a need for better monitoring based on ecological indicators, and coupling of *in situ* and remote sensing data to understand status and trends of lost habitats (tidal wetlands, marshes, eelgrass beds). Habitat restoration of riparian vegetation, salmonid habitats, and salt marshes require effective techniques and performance standards, and development of methods to evaluate the effectiveness and success of habitat restoration/mitigation practices.

Pathogen contamination was identified as another high priority management issue. Managers indicated that they require better technologies and biosensors for identification of pathogens and their sources. Regarding sediment contamination, California indicated needs for techniques to detoxify (degrade) DDT in nature, and to better quantify bioavailability of chemicals adsorbed to sediments in estuarine and marine systems as a potential source of pollutants. Alaska's response indicated a need to improve monitoring of sediment toxicity, and to select appropriate indicator species.

Nutrient enrichment caused by agricultural, urban and stormwater runoff was identified as a high priority issue in California and Washington. Their coastal managers indicated needs for BMPs development and implementation, and techniques for measurement of BMP effectiveness.

Erosion and sedimentation, was another important issue identified in this region, where managers indicated a need for better methods of tracking sediment plumes and erosion (using remote sensing and GIS tools). In addition, they indicated needs for bathymetry mapping and hydrodynamic models to better understand sedimentation problems in this region.

Additional issues, identified in this region as high priorities, include intrusion of non-native species (WA, CA, OR), freshwater inflow and groundwater overdraft in California. Coastal resource managers expressed a need for mapping, modeling and better eradication techniques for invasive species.

Two additional responses from Oregon (CZM and NEP) suggested that CICEET's efforts would become useful only if they are not duplicating existing ones such as NEP's Technology Transfer Project. Both respondents support productive regional workshops that would strictly gear information transfer, include representatives from appropriate regional agencies and require substantial preparation on selected workshop topics.

Table 7: ISLAND REGION (PR, VI, HI¹⁰, AS, GU, CNMI)

(Responses were received from seven CP managers, one NERR manager, and one MS manager.)

Nutrient enrichment caused by agriculture and stormwater runoff, and wastewater discharges, was identified as a high priority by most of the islands. Managers indicated a need for better monitoring, modeling, and BMPs application for landowners and small sites. They also indicated a need for better sewage treatment and stormwater drain out-fall technologies.

Managers indicated that habitat degradation and loss of coral reefs and mangrove habitats are high priority issues. They need baseline information on coastal habitats (environmental assessment) by using remote sensing and GIS, and better monitoring of habitat changes and use of ecological indicators. There is also a need for effective restoration techniques and performance standards. Some managers indicated a need for information on aquaculture possibilities.

Contamination issues were identified as another management priority, in PR pesticides were identified as high priority, in VI sediment contamination was identified as high, as well as in AS, where oil spill was also identified as a high priority issue.

Coastal erosion and sedimentation was identified as a high and medium management issue by all the islands. Managers indicated a need for remote sensing to track sediment plumes and erosion, and GIS techniques to model alternative treatments for erosion control and shoreline changes.

Additional comment from Guam indicated that they have been addressing all identified coastal management issues and that the problem is not as much technical as it is political. In the follow-up communications and conversations between Project staff and coastal managers and researchers, it was indicated that there are needs to establish long-term monitoring programs for contaminants and toxic pollutants in estuaries and coastal ecosystems. In this specific region, which includes Islands from different bioregions, managers also indicated that they do not have enough information about types of contamination (toxic chemicals), and regarding pathogens there is a need for appropriate indicators in subtropical marine waters, and identification of pathogens sources.

The respondents from island states and territories support the idea of using the CICEET website to exchange the information relevant to identified management issues and needs. The Island Region expressed the need for workshops that would address specific problems and related technologies and information transfer in order to help solving identified issues.

¹⁰ In addition to the CP manager responses, the state of Hawaii also provided a response from the Marine Sanctuary, however this survey was not targeting the National Marine Sanctuaries.

C. Findings on organizations with similar mission and goals to CICEET

This project did not identify an organization or agency whose mission and goals appeared to be fully overlapped with the CICEET Strategic Mission and Goals. Many organizations address one or two goals similar to CICEET, but their performance has been based on larger scales, targeting regional and national coastal issues (NOAA/CSC, DOC/NIST, EPA/EMAP, EPA/TIO, USGS/NAWQA, U.S. Fish & Wildlife/Environment Contaminants Program, DOE/NABIR), or in the case of Sea Grant, universities and institutes which are targeting site and research specific issues. The review of Federal, state, and private organizations' missions and goals were mainly done through Internet searches.

The most relevant organization identified in this report is the EPA's Office of Research and Development (ORD). EPA/ORD has established research programs to improve ecosystem risk assessment and risk management as highest priority research areas for investment over the next 10 years (ORD, 1998). The mission of the ORD's Ecological Research Program is to "...provide scientific understanding required to measure, model, maintain, and/or restore, at multiple scales, the integrity and sustainability of ecosystems now, and in the future." The Program objectives are:

- Monitoring research (develop new, field-applicable biological indicators and criteria for measuring and diagnosing effects and recovery; develop multi-scale monitoring designs for monitoring current conditions and trends);
- Modeling research (develop an air modeling system to handle multi-pollutant issues; modeling key transport processes for nutrients, industrial chemicals, pesticides, metals, and incorporating them into terrestrial and aquatic exposure models);
- Risk assessment research (develop new methods to conduct place-based, multiple-stressors assessments); and
- Risk management and restoration research (develop best management technologies to reduce the impact on the ecosystem conditions; develop techniques to improve decontamination and bioremediation of the coastal sediments and waters; develop techniques and methodologies to restore and rehabilitate coastal ecosystems and achieve local, regional and national goals).

Unlike CICEET, there is no mission to link activities with coastal management priorities or needs. Jurisdiction of coastal resources and habitats is shared among the states and several federal agencies. All agencies (Federal, state and private) dealing with natural resources have programs for coastal and estuarine issues, some with activities similar to the CICEET Strategic Mission and Goals. For example, the EPA/ORD supports research on a variety of activities directed primarily toward water quality and human health issues. However, it does not emphasize specific coastal management issues, and does not have direct interaction with state CPs or NERRs.

Agencies and programs identified in this report that have relevant goals to CICEET are presented in the following table¹¹:

Agency/Program	Mission/Goals or Issues Addressed
EPA/ORD (Office of Research & Development)	Goal is to develop new, field applicable biological indicators and multi-scale monitoring designs for status and trends; Air modeling system; Multiple stressors assessments and methods; Techniques for decontamination and bioremediation of sediments and water; Techniques and methodologies to restore and rehabilitate coastal ecosystems; Toxic algal blooms;
NOAA/CSC (Coastal Services Center)	Mission is to identify, develop and facilitate use of technologies and information that support sustainable use & management of coastal resources (GIS, remote sensing, info library, internet activities);
NOAA/C-CAP (Coastal Change Analysis Program)	Program is designed to monitor change in terrestrial land cover and near shore benthic resources within coastal environments. It classifies types of land cover, analyzes changes in coastal submerged habitats, wetlands, and adjacent uplands using remote sensing techniques, and GIS in integration and interpretation of data.
EPA/OST (Office of Science & Technology)	Identified pathogen contamination issue as one of the major priorities for their research; Developed membrane filter test method for Enterococci in water;
USGS/BEST (Bio-monitoring of environmental status & trends)	National water quality assessment; Surface water quality modeling (SPARROW); Hydroqual – water quality 3-D model for transport of nutrients, sediment, contaminants; National atmospheric deposition;
USDOE/NABIR (Natural & Accelerated Bioremediation Research Program)	Use <i>in situ</i> processes to develop new methods/technologies for bioremediation of heavy metals, and radionuclides;
U.S. Fish & Wildlife Service/ Environmental Contaminant Program	Activities are directed towards the evaluation, protection and restoration of fish and wildlife, with emphasis on contamination prevention, investigation and restoration, and providing support to EPA on natural resource issues. This is the only Federal agency with fish and wildlife specific contaminants program.
NOAA/Sea Grant (29 National Sea Grant College Programs)	Encourages wise stewardship of marine resources through research, education, outreach and technology transfer. Issues: oyster disease, aquatic nuisance species, aquaculture, techniques for detecting pathogens in shellfish;
Battelle (Science & Technology Institute)	Provides the latest technologies, and develops new technologies, required for effective management, and utilization of natural resources;

¹¹ Based on the reviewed literature, Appendix C provides the information on existing programs and organizations similar to CICEET Mission and Goals. In addition, Appendix D provides a compendium of environmental technology and information transfer sites that relate to coastal management issues and are relevant to “technology and information transfer” as one of the CICEET Strategic Goals.

III. Conclusions

As we enter the next century, when 70% of the U.S. population will reside within 50km of coastal areas, the anthropogenic stressors and effects on coastal environment will substantially increase (UNEP, 1998). As the cumulative effects of small-scale modifications and the impacts of development are considered, the urgency of coastal (environmental) management becomes obvious (Clark, 1996; Sorensen, 1997). Long-term environmental implications of the effects that these modifications may have on living resources, geomorphology, and climate are uncertain. As a result, regional, national and global scale problems, including habitat degradation and loss, land-use changes, and loss of biodiversity are currently considered greater risks to ecosystems than site-specific problems have been the subjects of most of the research and scientific studies (EPA, 1998; ORD, 1998; CGOOS, 1999). However, in order to assist coastal resource managers and contribute in solving large-scale environmental problems they have to be addressed on the local, *in situ* scales as well. In addition, rather than only treat negative ecological effects and impacts the literature and the survey results expressed a need for better prevention and prediction of anthropogenic stressors.

The key coastal and estuarine management issues, identified most frequently by all regions of the coast as a high priority, include nutrient enrichment, toxic substances, pathogens, physical habitat destruction and loss. In general, there is also a need to improve accuracy, timeliness and cost-effectiveness for detection, analysis, monitoring, comprehensive modeling of nutrients, pathogens and toxic materials, and (bio)remediation of polluted/contaminated habitats and ecosystems.

Based on the studies and surveys reviewed for this report, one of the most significant challenges facing coastal managers today is how to move toward an integrated, ecosystem-based management that incorporates feedback from the natural environment. The Clean Water Action Plan states that: “effective enhancement of coastal ecosystems requires a comprehensive strategy that draws on the full range of tools and skills available from Federal agencies and programs, as well as active participation and support from state, tribal, and local governments, businesses, and the public (CWAP, 1998).” Because of the complexity of environmental problems and the ecosystems on which they act environmental problems are not as likely to be solved in a short time but, rather, must be managed iteratively through sustained interagency efforts. Long-term solutions depend upon an adequate understanding of the physical, chemical and biological ecosystem processes, which require interdisciplinary, long-term research programs (NSF, 1999). One of the recommendations from the NRC Report is that in order to develop the knowledge needed to address current and emerging environmental issues the research should not only be core research but, also problem-driven and solution-oriented research (NRC, 1997).

The White House Committee on Environment and Natural Resources (CENR) determined that current Federal environmental monitoring and related research programs do not provide integrated data across multiple natural resources at the various temporal and spatial scales needed to develop policies based on current scientific understanding of ecosystems processes

(NSTC, 1997). CICEET's problem driven mission and partnership with NERRS and state coastal resource managers can contribute significantly to improve current efforts.

The literature and coastal managers survey responses indicated that scientific findings are rarely applied to management decisions and without the early and substantive involvement of stakeholders and managers in the planning process from its inception. Number of examples show that successful research programs are those with clearly defined uses and users, which require early interaction between scientists responsible for designing the research program and decision-makers as the primary data users (for example: Tampa Bay Program, Delaware Inland Bays Program, or Chesapeake Bay program). To be successful, this interaction will require recognition of language barriers between scientists and managers, as well as differences in perspective among federal, state and local managers who each address a different set of management issues. Past experience indicates that a sustained effort by CICEET will be needed to bring scientists and researchers together with managers in the decision-making process. There is a need to provide links between relevant research activities and management decision-making, and improve ongoing communication and coordination among CICEET, NERRS, CZM managers, scientists, and researchers. This communication and networking will help identify links and gaps between coastal/estuarine issues and research, technology/methodology needs that can potentially be filled by projects sponsored by CICEET.

A substantial amount of monitoring is conducted throughout estuaries and coasts by different Federal, state, and local programs, and university/research institutions with no unifying scientific concept to integrate data (NAS, 1990; NCRMS, 1999). CENR has proposed a national environmental monitoring framework that will enable coordination and full range of integration between remote sensing, regional surveys and site-specific monitoring. Current development of a National Coastal Research and Monitoring Strategy (NCRMS) is intended to address the need for integrated coastal research and monitoring on all the levels, and identify areas that overlap in existing programs and recommend improvements (CWAP, 1998). This Strategy, and other national and regional efforts, can be supported on a smaller scale with better *in situ* environmental assessments and projects conducted through the CICEET efforts at the NERRS and other coastal and estuarine sites. Integrating monitoring data within a given system, such as the NERR sites, could present the system view (habitat, ecosystem), and become the model for that given system. However, CICEET should also recognize the limitation of NERRS sites as not always representatives of coastal or estuarine systems. Therefore, other coastal and estuarine sites should be considered for potential CICEET project applications that broader reflect ecosystem concerns and address coastal management issues.

Currently improved monitoring designs for environmental assessment are most often directed at narrowly defined problems, although integration of data provides regional and national assessments it does not provide a value for holistic ecosystem risk assessment (NSTC, 1997). Long-term monitoring programs (i.e. Chesapeake Bay Program) have not supported assessment of toxics conditions and loadings like it has been done for nutrients. Because monitoring of toxics is typically 10-100 times more expensive than nutrient monitoring, it has been difficult to get good spatial and temporal coverage of ambient toxics data and comprehensive loadings estimates from the watersheds. Therefore, support for comprehensive monitoring framework and

identification of target chemicals for monitoring management, might help guide states in developing their toxic monitoring programs so that data on a local, state, regional and national levels can be comparable.

In order to support restoration of coastal habitats, managers and researchers expressed a need for science and technology transfer initiatives to establish “pilot studies” that relate to habitat change and process-oriented research *in situ*. NERRS sites are potential pilot project-sites for testing new approaches, methods and technologies that can subsequently be applied to estuaries and coastal ecosystems and address regional and national concern. CICEET has an opportunity to develop and enhance effective environmental technologies relevant to specific coastal and estuarine habitats, which can best support the management decision-making. Data collection and analysis (e.g. estuarine circulation models and fine temporal resolution of toxics load estimates) can become available for development of specific habitat management plans and cost-effective management strategies.

Based on the coastal managers survey responses, future models should include multimedia, multipath sources, intermedia pollutant transfers, transport and transformations of pollutants, and receptor activity patterns resulting from anthropogenic causes. Although complex, this effort may lead to smaller scale, ecosystem, mechanistic models assessing effects, for example, of nutrient enrichment on hypoxia, loss of SAV habitats, or HAB (ORD, 1998). Particular concern was expressed, in both the literature and the survey responses, regarding the need for research projects to address the effects of complex interactions among multiple stressors in coastal/estuarine ecosystems (i.e. low oxygen concentration, habitat degradation, and toxic chemicals), and to develop modeling techniques to understand and forecast impacts of stressors. Studies and surveys also identified a need for ecosystem models development to help understand, predict, and assess the current and probable future exposure and response of coastal ecosystems to multiple stressors at multiple scales. Several articles indicated that a number of technological advances in measuring biological, chemical, and physical parameters have not been routinely applied to coastal management issues (ORD, 1998; NIST, 1998; NRC, 1994).

Another very important and complex key issue for managers is information integration, access, dissemination, and application (NSTC, 1995, NOAA/CSC, 1996). Managers on all levels require reliable, useful, timely, accurate information about the actual state of the ecosystem and its resources at a variety of temporal and spatial scales. Managers also emphasized that they are planning to use GIS and remote sensing in the decision-making process, but there is a need for user-friendly techniques and tools (i.e. Geographic Information System /GIS/ frameworks and models for integrated coastal zone management applications). In addition, coastal state resource managers indicated that a scaling issue exists and their preference is for information usable on local and state levels, which could be aggregated to address regional and national concerns (NOAA, 1995).

Identifying technology/technique needs and priorities “from the ground up” will provide opportunities to use existing, and to develop and enhance technologies that can best be applied to management’s decision-making process. In order to advance coastal environmental science and to manage our coastal resources more efficiently, it is necessary to develop an integrated, holistic

understanding of fundamental physical, chemical, and biological processes through site-specific comparative studies of coastal ecosystems. The *in situ* approach to environmental problems and problem-solution driven projects will enhance current capabilities of coastal science, technology, and management programs on local, state, regional, and national levels.

In general, there is a need for establishment of guidelines for planning and managing the uses of ocean and coastal resources on the state level, and development of Best Management Practices (BMPs) for activities and uses within the coastal areas. This requires improved attention to environmental conditions (resource assessment) in order to reduce negative impacts on coastal ecosystems (impact/risk assessment). Many coastal managers stressed a need for development of analytical framework and guidelines at local, regional, and national levels that will endorse and incorporate effective monitoring and modeling methods, as well as restoration and remediation technologies and techniques. Ultimately, development of an analytical framework will ensure that planning decisions will be based on environmental concerns of the area. Any activity must work within the environmental limits for sustainable development. Within these limits, however, many options for environmental and social development exist. Successful coastal resource management demands knowledge and understanding of the natural resources being used, the consequences of each particular use, and awareness that decisions ultimately reduce remaining options. In addition, the knowledge and awareness of these consequences can be used to mitigate “bad choice” decisions and minimize the need for restoration and remediation.

Although several agencies and organizations, indicated in this report, have similar efforts and goals to CICEET, there is not a single agency that is addressing specific state coastal management issues and their technology/information needs on the local and state scales. It is clear that scientific solutions to ecological issues can no longer be isolated to one stress, one scale, or one medium. The cures will require more holistic ecosystem management approach, including scientists, managers, policymakers and the public. Therefore, CICEET’s specific focus on applying science and technology to develop and use existing, effective techniques and methods in monitoring, modeling, restoration and information transfer can fill a unique niche in the area of coastal resource management.

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Appendix A

Documents/Reports on Coastal Management Priority Issues

National

➤ EPA's National Water Quality Assessment 305(b) Reports. Present details and information about common coastal water quality problems. According to the 305(b) Reports, nutrient loading is one of the top causes of degradation in estuaries and coastal areas. EPA has formed a national team of specialists that is leading an effort to develop measures of nutrient over-enrichment of surface waters. During the next two years this team will develop technical guidance for four sets of nutrient criteria: lakes and reservoirs, rivers and streams, coastal marine waters and estuaries, and wetlands. Development of reference conditions and eventual setting of nutrient criteria will be based on the STORET database for data on total nitrogen, total phosphorus, chlorophyll a, and Secchi depth in each of the four water-body types.

<http://www.epa.gov/305b/>

➤ Managing Coastal Resources Report. NOAA. July 1998. Identified key coastal management problems: water quality degradation, harmful algal blooms (HAB), coastal hazards, loss and fragmentation of habitat, loss of biodiversity, aquatic nuisance species invasion, and fishery collapse. Document also addresses needs for certain management technology development and uses of GIS and remote sensing for mapping, modeling and resource assessment.

http://state-of-coast.noaa.gov/bulletins/html/crm_13/intro.html

➤ Mussel Watch Project (1986-1996), and National Benthic Surveillance Project: Sediment Toxicity in U.S. Coastal Waters (1998). NOAA's National Status & Trends Program for marine environmental quality has been monitoring contaminants in the coastal waters by sampling mollusks (mussels, oysters) and sediment. The objectives are to determine concentrations of trace metals and six organic compounds (pesticides: DDT, PCBs, PAHs, BT, dieldrin, and chlordane), at 186 sites on all coasts, to identify increasing or decreasing trends. Contamination is decreasing for chemicals whose use has been banned (DDT, chlordane, and dieldrin) or severely curtailed (cadmium, tributyl tin). For other chemicals there is no evidence on a national scale for either increasing or decreasing trends.

<http://state-of-coast.noaa.gov/siteindex/html/siteindex.html>

http://state-of-coast.noaa.gov/bulletins/html/ccom_05/ccom.html

➤ National Assessment of Nutrient Enrichment Conditions in Estuaries. NOAA. Report. 1996-99. Office of Ocean Resources Conservation and Assessment (ORCA/NOAA) performed a nine-year study to assess the nutrient enrichment conditions in estuaries in South Atlantic Region (1996), Mid-Atlantic Region (1997), North Atlantic Region (1997), Gulf of Mexico Region (1997), and Pacific Coast Region (1998) except the State of Hawaii, and U.S. Territories. This multi-year programs intended to improve understanding of nutrient enrichment and associated eutrophication events and support the development of an effective national response strategy. One of the ORCA's fundamental objectives is to make maximum use of what we already know about the characteristic features of coastal areas and the processes that drive them as natural systems, and then to apply this information to resource management issues. The question is how

this regional and national assessment can solve nutrient enrichment (eutrophication, HAB) and its impacts on estuarine and coastal ecosystems on the local levels?

http://www-orca.nos.noaa.gov/organization/orca_org.html#sea

➤ National Plan for Marine Biotoxins and Harmful Algae Blooms (HAB). NOAA, NSF and Woods Hole Oceanographic Institution established a site that provides the information on national red tide efforts and HAB (i.e. *Pfiesteria*, *Gymnodinium breve*); it also provides information on existing projects and research; information and maps of appearance of the HAB nationwide; also provides information on the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) which is an interagency research program for implementing the Federal research strategy for *Pfiesteria* (NOAA, EPA, USDA, HSF, NASA).

<http://www.redtide.whoi.edu/hab/>

➤ Partnership for Marine, Estuarine and Freshwater Living Resources: Assessing Aquatic Resources – A National Workshop to Determine Information Needs. Aquatic Restoration & Conservation (ARC). Workshop Report. 1998. The objective of the Workshop was to obtain guidance for development of a national partnership that will assess and monitor aquatic resources for habitat quality and biological integrity. 91 people attended the workshop, representing 40 federal, state, private and professional organizations that work with aquatic resources (i.e. Ecological Society of America, NOAA/NMFS, USGS, The Nature Conservancy, US Fish & Wildlife, International Association of Fish and Wildlife Agencies, American Fishery Society). The major defined goal is to characterize and map (GIS) freshwater and marine species, communities, and their habitats on a landscape scale. With this information decision-makers and resource managers at local, state, regional, and national levels can evaluate their aquatic resources and base their decisions on this necessary environmental assessment.

<http://www.arcpartners.org>

➤ EPA's National Coastal Pollution Discharge Inventory provides a comprehensive data base and computational framework that contains pollutant loading estimates of all major categories of point, nonpoint and riverine sources located in coastal areas discharging to coastal waters of the contiguous U.S. It is the most comprehensive and consistent database of pollutant load estimates available for the Nation's coastal watersheds.

Regional

➤ Symposium on Coastal Issues and Information Needs, USGS. February 10-11, 1999. Hosted by the U.S. Geological Survey (USGS) Patuxent Wildlife Research Center. The goal was to bring scientists and practitioners together and encourage dialogues about information gaps and long-term data needs that are relevant within a coastal resource management framework. The area of interest and primary focus of discussions was the eastern coast of the United States (Northeast and Mid-east Regions). Research and information needs, relevant to resource management, that were identified:

- Hydrologic and water quality models; models for predicting nutrient loading from easily measurable parameters; atmospheric deposition data; chemical contaminants in living resources; remote sensing tools; nutrient reduction tools; post-mitigation habitat assessment; hydraulic

claming impacts on SAV; ecological consequences of increasing habitat fragmentation; standardized E. coli monitoring for NPS open water swimming beaches; impacts of personal watercrafts on water quality and biodiversity; impacts of hydrocarbon emissions from boats; effects of mosquito control chemicals on coastal flora and fauna; determination of standards and criteria for evaluating restoration success; methods for monitoring horseshoe crabs; unknown buffer distance adjacent to upland development projects to protect tidal, riparian, and estuarine habitats; identify cumulative effects of small-scale development (septic systems, docks, piers construction, localized NPS) on coastal watersheds and estuarine systems; need for information on the characteristics of an ecologically healthy watershed.

<http://www.pwrc.usgs.gov/research/coastal.htm>

➤ Estuaries Habitat Restoration Workshops. ERF/RAE.1999. Prepared by the Estuary Research Federation (ERF) and the Restore America's Estuaries (RAE), with the goals: to improve the practice of estuarine habitat restoration and promote collaboration between scientists, managers and practitioners; to identify issues and opportunities in estuarine habitat restoration; to explore restoration in an ecosystem context; and to identify opportunities for collaboration between ERF and RAE. One of the conclusions was that it is essential to seek out restoration approaches that are cost effective enough to have the potential to be employed widely as "Best Management Practices" (BMPs) in estuarine habitat restoration. A major challenge for restoration is the need to develop management approaches that restore ecosystems to functioning levels. Considerably more is known about seagrass habitat functioning and restoration than oyster habitat functioning and restoration. We can take what is known today and use this as a basis for combating additional habitat loss/degradation and designing restoration projects, incorporating new understandings as they emerge. Despite the investment of Federal funding in wetland restoration very little attention has been given to monitoring restoration projects. There is a need to identify hydrologic and vegetation indicators that should be monitored to determine if restored wetland is recreating the lost functions and values. The final Report will be presented at the ERF Conference in New Orleans in September 1999. <http://www.estuaries.org/>

State (See Coastal States Survey Responses Document)

Appendix B

Documents/Reports on Coastal Management Information/Technology Needs

National

- Integrating the Nation's Environmental Monitoring and Research Networks and Programs: A Proposed Framework. NSTC. March 1997. The National Science and Technology Council (NSTC), the Committee on Environment & Natural Resources (CENR), proposed in this report a national framework for integrating environmental monitoring and related research on the Nation's ecological systems and resources with predictive modeling and process research. The information will be useful to improving documentation of status and trends in the ecosystems and natural resources of the U.S., and to integrating our knowledge of environmental monitoring and research networks. There are three areas of emphasis: National Environmental Report Card by the year 2001; National Network of Index Sites (pilot projects); Regional Mid-Atlantic Pilot application. <http://www.epa.gov/cludvgxb/Pubs/framework.pdf>

- Ecological Research Strategy. EPA/ORD. 1998. Identifying specific national technology and information priority needs that EPA/ORD will address through its programs and projects:
 - new monitoring instruments; alternative restoration options; development of better indicators for nutrient over-enrichment; effective remediation technologies; development of diagnostic indicators for benthic ecosystems to identify toxicity to benthic community; control technology for drainage systems; more reliable test methods and indicators to detect pathogens and make better decisions about beach advisories, and shellfish beds; effective disinfection techniques; effective, low-cost, high-rate control/treatment technologies for removing toxics and other pollutants from WWF; methods to distinguish loadings between anthropogenic sources and other sources (sources of fecal contamination in watersheds). <http://www.epa.gov/ORD/WebPubs/final/eco.pdf>

- Relevant National Research Council (NRC) publications:
 - Managing Troubled Waters: The Role of Marine Environmental Monitoring. NRC. 1990. Addressed the need for integration, interpretation and dissemination of monitoring data among scientists and users.
 - Restoring and Protecting Marine Habitat: The Role of Engineering and Technology. NRC. 1994. Topics in this publication include: impacts of technology in the coastal zone; applying technology; alternative approaches and technologies for minimizing or avoiding impacts to marine habitats; implementation factors affecting use of technology; research needs relevant to marine habitat management; environmental technology needs; engineering technology needs; what research is need to advance the state of practice?
 - Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies. NRC. 1997. This Report identifies many current deficiencies in the cost-effective management of contaminated sediments, lack of comprehensive risk assessment and specifically lack of systematic performance data on engineered and in situ remediation technologies.

- Atmospheric Nitrogen Deposition to Coastal Watersheds. ESA. Report. 1997. The Ecological Society of America (ESA) Workshop addressed a technical assessment and research needs regarding nutrient enrichment in coastal/ estuarine waters and identified them at the Workshop. The following is a list of identified needs:
 - Improve estimates of ecological benefits and implementation costs of options for reducing atmospheric nitrogen deposition (on local, regional, and national levels).
 - Examine the effects of forest management and agricultural practices (animal operations and applications of fertilizer and animal wastes) on delivery of nitrogen to coastal waters.
 - Undertake rigorous technical assessments (research, monitoring, modeling) to set goals, define costs, and understand the multiple benefits of controlling atmospheric N inputs: connecting and applying airshed and watershed modeling efforts in management purposes, establish basic estimates of organic nitrogen deposition rates and loading.
 - Develop models for characterizing the vulnerability or susceptibility of coastal waters to atmospheric deposition of nitrogen.
 - Develop appropriately scaled models capable of coupling nitrogen sources with ecological effects of nitrogen on living marine resources.

Regional

- Coastal Change Analysis Program (NOAA/CSC/C-CAP) is developing a nationally standardized database of land cover and habitat change in the coastal regions and inventories of coastal submersed habitats, wetland habitats and adjacent uplands through analysis of satellite imagery (primarily Landsat Thematic Mapper), aerial photography, and field data. These are interpreted, categorized, and integrated with other spatial data in a geographic information system (GIS). This requires close cooperation with local, state, and regional resource agencies throughout the process in order to assure logical and meaningful results. The role of the NOAA's Coastal Services Center (CSC) is to bridge this gap between technology and the coastal managers. <http://www.csc.noaa.gov/ccap/>
- National Estuarine Inventory (NEI) developed by ORCA's Strategic Environmental Assessment Division maintains and updates information on 124 estuaries regarding estuarine freshwater inflow, sediments, salinity, pollution, and eutrophication potential. Data types include: population, wetlands, shellfish areas, fish kills, pollutant sources and loads, pesticide use, outdoor public recreation areas, fish and invertebrate distributions, bottom sediment types, salinity gradients, etc. http://www-orca.nos.noaa.gov/organization/orca_org.html#pecb
- Assessment and Remediation of Contaminated Sediments (ARCS) Program. EPA/ARCS. Final Report. 1998. The Report sets forth the major findings of the five-year study and demonstration projects relating to the control and removal of toxic pollutants in the Great Lakes, with emphasis on the removal of toxic pollutants from bottom sediments. This document provides technical guidance for subaqueous, in-situ capping as a potentially economic and effective approach/technique for remediation of contaminated sediments. It also provides description of the processes involved with identification of the design requirements of an in-situ capping project and sediment characterization, cap design, monitoring and management

consideration. The ARCS Program also evaluated treatment technologies, and one of them is bioremediation of PCB-contaminated sediment from the river, the question is remaining about proper development of engineered system. Major findings and recommendations for defining the magnitude and extent of sediment contamination at a site are:

- to use an integrated sediment assessment approach, incorporating chemical analyses, toxicity testing, and benthic community surveys;
- to develop modeling techniques and risk assessment to evaluate the potential impacts associated with contaminated sediments;
- to evaluate effectiveness of treatment technologies in removing or destroying sediment contaminants; sediment washing technologies were found to be promising in that they were both feasible and cost-efficient, although they are applicable for only certain types of sediments. <http://www.epa.gov/grtlakes/arcs/>

Appendix C

Organizations with Similar Mission and Goals to that of CICEET

Federal & National

➤ EPA's Technology Innovation Office (TIO). Mission is to advance the applications of innovative treatment technologies for characterization and remediation of contaminated waste sites, soils, and groundwater. Objective is to describe programs, organizations, publications, and other tools for federal and state personnel, consulting engineers, technology developers, researchers, remediation contractors, community groups, and individual citizens (<http://www.epa.gov/ttnrmrl/>). TIO provides most of the information on Hazardous Clean-Up Information Homepage at <http://clu-in.org>.

➤ EPA's Environmental Monitoring and Assessment Program (EMAP). EMAP is a research program to develop the tools necessary to monitor ecosystem health and assess the status and trends of natural resources at the regional scale (R-EMAPs). One of the goals is to translate environmental monitoring data from multiple spatial and temporal scales into assessments of ecological condition and forecast of the future risks and sustainability of our natural resources. The Program is researching methodologies to monitor and assess the status and trends of national ecological resources and to translate environmental monitoring data from multiple spatial and temporal scales into assessments of ecological condition and forecasts. The goal is to develop a demonstration of an intensive site network of monitoring and research locations throughout the U.S. utilizing the National Parks as "outdoor laboratories". The strategy is to, based on the knowledge of the science, build the national network from the bottom up starting with existing networks and add where gaps exist. The EMAP highest priority research areas are ecological indicators, monitoring design, and integration/synthesis of environmental data. Although existing since 1989, the Program' national demonstration or implementation was not achieved for any of the resource areas despite significant interagency cooperation. One of the problems is that EMAP sampling program operates at too coarse a scale in space and time to reflect information needs for management decisions. If national and regional assessments can be aggregated from the local level data then all scales are represented necessary to provide information for management decisions at multiple scales. Also, the retrospective and prospective monitoring approach has to match the environmental assessment needs and the needs of policy makers.

<http://www.epa.gov/emap/>

➤ Science To Achieve Results (STAR), (EMAP/EPA). The research program to develop more cost-effective ecological indicators and to design multiple-tier monitoring methods capable of detecting trends and associating ecological impacts with likely stressors. This approach will support state, regional, and national level environmental report cards encompassing multiple stressors. <http://www.epa.gov/emap/html/remap.html>

➤ EPA's Superfund Innovative Technology Evaluation Program (SITE). SITE encourages development and implementation of innovative treatment technologies for hazardous waste site remediation and monitoring and measurement. Innovative Technology Evaluation Report evaluates all available information on the technology and analyzes its overall applicability to

other site characteristics, waste types, and waste matrices. Testing procedures, performance and cost data, with quality assurance and quality standards are also presented. <http://www.epa.gov/ORD/SITE/>

➤ EPA/ECOTOX integrates Office of Research and Development (ORD), National Health and Environmental Effects Research Laboratory (NHEERL), and Mid-Continent Ecology Division (MED). ECOTOX provides the means to cost-effectively collect standardized and critically needed effect data for a wide variety of ecological risk assessments. It is a comprehensive computer based system that provides chemical specific toxicity values for aquatic life (AQUIRE), terrestrial plants (PHYTOTOX), and terrestrial wildlife (TERRETOX). Technical Support Document: http://www.epa.gov/ecotox/ecotox_download.htm.

➤ EPA's Office of Science and Technology (OST) developed a method 1600: Membrane Filter Test Method for Enterococci in Water, and identified pathogen contamination issue as one of the major priorities for EPA's research efforts. <http://www.epa.gov/OST/beaches/entero.html>

➤ Overview of Nano and MEMS (Micro-mechanical Engineered Systems) Technologies for Chemical Sensors and Biosensors, prepared by the National Institute of Standards and Technology (NIST) Program, describes the history of the sensors development and current needs for biosensors and chemical sensors technologies and commercialization. <http://www.atp.nist.gov/atp/focus/98wp-nan.htm>

➤ NOAA/National Sea Grant Program encourages the wise stewardship of our marine resources through research, education, outreach, and technology transfer. It is a partnership between the nation's universities and NOAA since 1966 (National Sea Grant College Program Act). Sea Grant supported research includes uses of marine organisms to provide models for new vaccines, detergents, agricultural fertilizers, genetically altered organisms for aquaculture and the seafood industry. Created the comprehensive database on Great Lakes contaminants and developed an input-output model of a toxic industrial chemicals in aquatic ecosystems. Sea Grant researchers have used biotechnology to develop fast and highly specific techniques for detecting pathogens in shellfish. <http://www.nsgo.seagrant.org/WhatisSeaGrant.html>

➤ National Association of Marine Laboratories (NAML) represents over 110 laboratories that provide access to the diversity of ecosystems that define the U.S. coastal zone, and to state agencies responsible for managing coastal environments and resources. NAML provide on-site resources for research, monitoring, education and public outreach, and has initiated LABNET to document and apply the collective assets of U.S. coastal laboratories to meet national needs for monitoring and research in the coastal areas. One of the goals is to identify current local and regional problems that would benefit from the integration and synthesis of databases and activities that address issues of environmental change in coastal areas.

➤ Coastal Long-Term Ecological Research Program (CLTER), funded by the National Science Foundation (NSF), is a continuing multi-disciplinary research effort that requires large-scale conceptual, analytical, and numerical models to guide the research and facilitate comparative

approaches in different ecosystems. The general mission of the CLTER Network is to understand ecological phenomena that occur over long temporal and broad spatial scales; create a legacy of well-designed and documented ecological experiments; conduct major synthesis and theoretical efforts; and provide information necessary for identification and solution of environmental problems. Critical issues addressed include:

- Loss of habitat; invasive species; industrial, agricultural and domestic contamination; and changes in the nutrient budgets of ecosystems. http://www.nsf.gov/geo/egch/gc_lmer.html

- Technology for a Sustainable Environment (TSE) is a research area funded by NSF and EPA through extramural grants competition, which awards approximately \$5 million with a project award range from \$50,00 to \$150,00 per award per year, with duration of 2 to 3 years. This competition is designed to address pollution avoidance, prevention processes, methodologies, and technology research, and advance development and use of innovative technologies and approaches directed at avoiding or minimizing the generation of pollutants at the source. Projects must employ fundamental new approaches, and address, or be relevant to, current national concerns for pollution avoidance/prevention at the source. Areas of interest are: chemistry for pollution avoidance or prevention; engineering for pollution avoidance or prevention; simulations, modeling, sensors, and feedback techniques for pollution avoidance or prevention; and industrial ecology. <http://www.nsf.gov/pubs/1999/nsf99108/nsf99108.htm>

- Advanced Technology Program (ATP) established by DOC's National Institute of Standards & Technology (NIST) to benefit U.S. economy by cost sharing research with industry, in order to foster new, innovative technologies. Research priorities for the ATP are set by industry not the government. <http://www.atp.nist.gov/>

- Science & Technology Institute – contributes in development and implementation of the National Environmental Technology Strategy and addressing other key interagency environmental science and technology issues, and providing support to OSTP ([White House Office of Science and Technology Policy](#)) and other government agencies. This site provides contacts for further information on Environmental Technology Transfer, General Technology Information, Grant Information, and Marketing Information. <http://www.rand.org/centers/centers.html>

- Center for Environmental Industry & Technology (CEIT) (EPA/New England) promotes awareness of innovative environmental technologies and provides inventory and access to technology developers and companies for issues like air pollution control, detection and monitoring, remediation, sludge treatment, wastewater treatment, stormwater. <http://www.epa.gov/region01/steward/ceit/invent.html>

- Environmental Contaminants Program (US Fish & Wildlife Service) has a mission to prevent, investigate, and mitigate the adverse impacts of environmental contaminants on fish and wildlife resources. Natural Resource Damage Assessment & Restoration is only a mechanism to restore natural resources injured by hazardous substance releases, while the Contaminant Information Management and Analysis System (CIMAS) is a new data management system with

purpose to track all contaminant related and to ancillary data from all methodologies associated with the Service funded investigations. <http://www.fws.gov/r9dec/ecprog.html>

➤ USGS's National Water Quality Assessment Program (NAWQA) is designed to describe the status and trends in the quality of the Nation's ground and surface-water resources and to provide a sound understanding of the natural and human factors that affect the quality of these resources. Bio-monitoring of Environmental Status & Trends (BEST); Spatially Referenced Regressions on Watershed Attributes (SPARROW); Surface Water-Quality Modeling; Endocrine Disruption in Aquatic Systems; R-UNSAT computer model for analysis of NPS and PS contamination, and atmospheric depositions; Hydroqual - water quality 3-D numerical model to determine how nutrients, sediment, contaminants and other water-born materials are transported (Massachusetts Bay); Columbia Environmental Research Center (national mission of expertise in environmental toxicology and chemistry); National map of pesticides use; National Atmospheric Deposition Program. <http://www.rvares.er.usgs.gov/nawqa/>

➤ USDOE's Natural & Accelerated Bioremediation Research Program (NABIR) with a mission to provide the scientific understanding needed to use natural in situ processes for developing new methods/technologies and accelerate those processes for bioremediation of heavy metals, radionuclides, in the subsurface zone; this hypothesis-driven and field-related research will provide understanding necessary to develop new bioremediation technologies for site cleanups. <http://www.er.doe.gov/nabir/>

➤ USDOE's Lawrence Berkeley National Laboratory (LBNL) patented the guidance, containment, treatment, and imaging of below ground substances using ferrofluids giving a new hope to subsurface environmental remediation. http://www.gnet.org/Coldfusion/News_Page2.cfm?NewsID=7527

➤ USDOE's TechCon Program connects site-specific environmental management needs (i.e. remediation) with private industry capabilities and public sector experience. <http://www.ead.anl.gov/techcon/>

➤ Pacific Northwest National Laboratory (PNNL) Technology Transfer - Site contains abstracts on innovative technologies available for commercialization and developed at the PNNL. Topics categorized in the following areas: in-situ bioremediation, in-situ microbial remediation of aquifers in-situ corona, in-situ nitrification, and remedial action assessment system (RAAS) software. <http://www.gwrtac.org/html/links.html#international>

➤ NOAA/CSC/Coastal Information Services has a goal to identify, develop, and facilitate use of technologies and information that support sustainable use and management of coastal resources (GIS, remote sensing, coastal information library, and internet access activities). <http://www.csc.noaa.gov/>

➤ NASA/Ecosystem Science & Technology Branch is focused on using NASA technology to

understand ecosystem processes and biosphere-atmosphere trace gas exchange on regional to global scales, and on the application of remote sensing and geographic information system technologies to public health and other ecological issues. <http://geo.arc.nasa.gov/sge.html>

State

- State Science & Technology Institute is a non-profit corporation designed to enhance government-industry programs at the state level and encourage the growth of business and industry through the application of science and technology; detailed description of states' cooperative technology programs. <http://www.ssti.org/states/>
- National Small Flows Clearinghouse (West Virginia University) offers free and low-cost technical assistance, products, and info services regarding small community and onsite wastewater treatment and pollution prevention issues. <http://www.estd.wvu.edu/>
- Center for Coastal Studies is a research division of Scripps Institution of Oceanography (University of California) engaged in studies of coastal physical oceanography (waves, currents, tides, sediment transport, fluid-sediment interactions), development of data acquisition systems and research instrumentation, and advising on coastal protection and sediment management. <http://www-ccs.ucsd.edu/>

Private and NGOs

- Battelle Memorial Institute is the world's largest, independent science and technology institute and technology based environmental consulting that assists global organizations to develop strategic environmental, health, and safety management systems providing the latest technologies required for the effective management and utilization of environmental resources. Battelle develops new environmental technologies, commercializes products and provides solutions for industries and government. <http://www.battelle.org/environment/>
- Global Network of Environment & Technology (GNET) is a non-profit organization dedicated to the promotion and use of technology to achieve environmentally sustainable development. Developed by Global Environment & Technology Foundation (GETF) and U.S. Department of Energy. It was created to assist government scientists and researchers to commercialize innovative environmental technologies, providing free interactive database (*techknow*). The GNET Website contains hundreds of profiles of environmental clean-up technologies that have been developed by the DOE, industry, and research institutions. <http://www.gnet.org/> and <http://www.gnet.org/filecomponent/newsfeed.cfm>
- Global Environment & Technology Foundation (GETF) is a non-profit organization dedicated to work with all institutions of society to build an infrastructure for sustainable development. They fill the gap between public and private institutions by building interconnected information and educational networks to facilitate and spread best practices, and

promoting new technologies and practices that enable improvements in the quality and environmental impact of what we produce and consume. <http://www.getf.org/>

➤ Applied Science Associates, Inc. (ASA) is a marine science consulting firm that has developed and applied sophisticated computer tools to investigate and model marine environment. ASA created a system that simplifies data input and graphically animates model results. Their mission is to create reliable and cost-effective solutions to environmental problems in surface waters. Modeling and analysis of oil spills, hydrodynamics, pollutant transport and water quality, natural resource damage assessment, erosion control, dredging and disposal impacts, field studies and GIS. <http://www.appsci.com/>

➤ Terrene Institute/National Geographic Society & Conservation Fund convened the National Forum on NPS Pollution to identify and demonstrate innovative, non-regulatory solutions for NPS pollution based on education, voluntary initiatives and economic incentives. <http://www.terrene.org/>

➤ Water Environment Federation (WEF) is an international non-profit educational and technical organization founded in Chicago in 1928. The Federation provides expertise and latest information on wastewater treatment and water quality protection. WEF's Website has a Technical Discussion Groups on issues like biological nutrient removal, biosolids and solids management, combined sewer overflows, remote monitoring, standard methods, disinfection, industrial treatment and hazardous waste, soil and groundwater remediation. <http://www.wef.org/forums/>

➤ Restore America's Estuaries (RAE) is a national coalition of 11 regional, coastal community based organizations with a combined membership of over 250,000 citizens. The coalition is working to preserve estuaries across America: the Chesapeake Bay Foundation, Coalition to Restore Coastal Louisiana, Galveston Bay Foundation, Conservation Law Foundation (Gulf of Maine), Hudson-Raritan Estuaries of NY and NJ, Save the Sound (Long Island Sound), Save the Bay (Narragansett Bay), North Carolina Coastal Federation, Puget Sound, San Francisco Bay association, and Tampa Baywatch. In 1995 they began to work together and committed to seeing 1,000,000 acres of estuary habitat restored by 2010. The mission is to work together to help save and restore America's estuaries and coastal heritage for our children before it disappears, through habitat restoration projects and education. RAE provided a Compendium of Current Federal Programs with Fiscal Year 1996-1998 Funding Levels, Funding for Habitat Restoration Projects, A Citizen's Guide. <http://www.estuaries.org/>

Appendix D

Sites with Technology/Information Transfer Relevant to CICEET Mission and Goals

- Technology Innovative News Survey (EPA) provides information about innovative treatment technologies to the hazardous waste remediation community. It describes programs, organizations, publications and other tools for federal and state personnel, consulting engineers, technology developers and vendors, remediation contractors, researchers, community groups, and individual citizens. <http://clu-in.org/>
- Environmental Technology Commercialization Center (ETC) works with industry to infuse federal environmental technology into products and processes; mission is to identify, analyze, and market EPA's expertise, resources, innovative technologies to private sector firms; provides information on innovative technologies in Chemical Processes, Measurement/Sensor Control, Pollution Control Technologies; and other Technology Transfer Sites. <http://www.etc2.org/>
- EPA's Environmental Technology Initiative (ETI) gather and assess information about innovative and alternative wastewater technology projects (for small and large communities), and collection of information about onsite technologies (UV disinfection, chlorine disinfection, ozone disinfection, bubble aeration, recirculating sand filters, etc). <http://www.estd.wvu.edu/nsfc/ETIfs.html>
- EPA/EnviroSense (common sense solution to environmental problems) is a free, public environmental information system that provides users with pollution prevention solutions, innovative technology and policy options. Also provides access to funding, grants and environmental research information. <http://es.epa.gov/describe.html>
- EPA/Envirofacts warehouse allows you to retrieve environmental information from EPA databases on [Air](#), [Chemicals](#), [Facility Information](#), [Grants/Funding](#), [Hazardous Waste](#), [Risk Management Plans](#), [Superfund](#), [Toxic Releases](#), and [Water Permits](#) and [Drinking Water](#). http://www.epa.gov/enviro/index_java.html
- Science Traveler International/Wastewater Worldwide provides national and international information on activated sludge (modeling, microbiology, nitrification, denitrification, phosphorus removal, sedimentation, sludge dewatering and waste disposal, waste management, organizations and research groups, publications and software).
- EPA and Agency for Toxic Substances and Disease Registry are sponsoring a nationwide effort to inform health professionals and their patients about dangers of eating fish and shellfish harvested from contaminated waters. <http://www.epa.gov/OST/fish>
- The Almanac of Enforceable State Laws to Control Nonpoint Source Water Pollution (Environmental Law Institute and EPA) is a report that provides detailed state-by state information on each state enforceable laws to control nonpoint source pollution.

<http://www.eli.org/bookstore/rralmanac98.html>

➤ Priority Toxic Chemicals (EPA) provides a strategy for reducing priority persistent bioaccumulative toxic (PBT) chemicals in the environment and the proposed rule to add new PBTs and lower the threshold of those chemicals currently on the Toxic Release Inventory.

<http://www.epa.gov/pbt/pbtstrat.html>

➤ Project Overview for Environmental Management Systems (EMS) of municipalities implementation to assess the use of ISO 14000. EPA's Office of Wastewater Management and Office of Compliance are sponsoring a Municipalities Initiative, designed to assist small and medium-sized government organizations in developing and implementing an ISO 14001 Environmental Management System (EMS). The most prominent environmental management systems standard, currently in place, is the ISO 14001 International Standard, completed in September 1996. Organizations around the world are beginning to implement EMS based on ISO 14001, certified by the third-part auditors. Germany, Japan, the Netherlands, and the United Kingdom continue to lead the world market in sheer numbers of ISO14001 EMS registration, and the United States industry is far behind other countries in registration activity (~100 registered companies). <http://www.iso14000.net/empire>

<http://www.epa.gov/owmitnet/wm046200.htm#guide>

➤ Five Star Restoration Challenge Grant Program is specifically designed to promote community-based wetland and riparian restoration projects in 500 watersheds in the next 5 years. Primarily, it provides challenge grants, facilitates technology/information transfer and partner collaboration, and supports peer-to-peer communication programs. EPA, the National Association of Counties (NACo), the National Association of Service and Conservation Corps (NASCC), the National Fish and Wildlife Foundation (NFWF), and the Wildlife Habitat Council (WHC) sponsor the Five-Star Restoration Challenge Grant Program. The Challenge Grant Program is designed to provide modest financial assistance to support community-based wetland and riparian restoration projects, to build diverse partnerships, and to foster local natural resource stewardship. Projects must include a strong on-the-ground habitat restoration component, and may also include education, outreach, and community stewardship.

<http://www.epa.gov/owow/wetlands/restore/5star/>

➤ USGS's National Coastal and Marine Geology Program provides information on coastal and near-shore erosion as well as the program goals and objectives. Lists current regional (South Carolina, West Central Florida, Southwest Washington, Hawaii) and future planned studies concerning erosion and shoreline changes. <http://marine.usgs.gov/natplan97.htm#hazards>

➤ Long-Term Hydrologic Impact Assessment (LTHIA) is a prototype tool that allows to evaluate the long-term hydrological impacts of land use changes, such as urban sprawl or agricultural transitions, for any location in the United States. The LTHIA was developed, as a

joint effort between Purdue University and U.S. EPA Region 5, is a simple technique for determining impacts of land use changes. Given a county and soil type, the software will calculate the effects of various land use decisions on water quality. Techniques traditionally used to assess the impacts of land use change on runoff typically focus on individual short-term "design" storm events of specific recurrence intervals, and are used to calculate peak discharge rates and hydrographs. Although single storm methods are suitable as engineering approaches in estimating flood intensities for stormwater facilities management, they do not address the long-term, cumulative hydrologic impacts of land use change.

<http://danpatch.ecn.purdue.edu/~napra/LTHIA>

➤ Sustainable Earth Electronic Library (SEEL) is a digital library devoted to the collection of publications that educate people on ways to preserve and restore our natural environment (Hazardous Waste, Health and the Environment, Water, Hydrosphere and Aquatic Environments). By providing access to this valuable information, it is their hope that participating organizations and individuals will share with one another the ways in which they are making the world ecologically secure. SEEL is a project of Sustainable Earth, Inc., a Virginia 501(c) 3 nonprofit organization created with the purpose of using the considerable leverage of technology for the benefit of the environment by creating Internet-based information resources and services. <http://www.enviroweb.org/publications/>