National Oceanic and Atmospheric Administration
National Centers for Coastal Ocean Science

Human Dimensions Strategic Plan

FY 2008 – FY 2013

Message from the Director

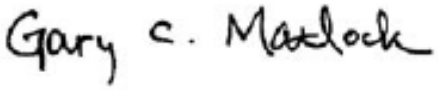
The National Centers for Coastal Ocean Science (NCCOS) provides coastal resource managers, other decision makers, and stakeholders with the highest quality ecosystem information and tools needed to balance society's environmental, social, and economic goals in mitigating and adapting to stressors such as climate change, extreme natural events, pollution, invasive species, and resource use.

Humans are integral to ecosystems, and the human dimensions of ecosystems are an integral focus of the science NCCOS conducts and conveys. This Human Dimensions Strategic Plan expands a "Societal Stressors" Objective in NCCOS's Strategic Plan. It will guide NCCOS in developing its ecosystem science agenda, workforce, organization, partnerships, and other capabilities to complement existing programs by integrating human dimensions research. A follow-up implementation plan will identify specific strategies to ensure that planning, programming, budgeting, and execution of NCCOS activities, conducted both as an organization and by our component research centers and cooperative laboratories, reflect the objectives of this plan through FY 2013.

This plan is intended not only as a strategic guide for NCCOS, but also as an educational tool and programmatic resource for the broader coastal and ocean science and management community. In addition to general goals and objectives, the plan provides detailed explanation and justification bolstered by references and Appendices providing critical human dimensions background and mission drivers.

As with all of its products, NCCOS is interested in determining the value of this Human Dimensions Strategic Plan, particularly in the context of coastal and ocean resource science and governance. We encourage you to provide feedback via email or telephone using the contact information below, and assure you that we will appreciate and consider all comments in directing our future efforts.

I am pleased to provide this Human Dimensions Strategic Plan to NCCOS employees, customers, and partners, and eagerly anticipate its implementation.



Gary C. Matlock, Ph.D.
Director, NOAA National Centers for Coastal Ocean Science

NOAA National Centers for Coastal Ocean Science
1305 East-West Highway, Room 8110, Silver Spring, Maryland 20910
Phone: (301) 713-3020, Fax: (301) 713-4353
Email: nccos.webmaster@noaa.gov
Internet: http://coastalscience.noaa.gov

Table of Contents

I. Summary **1**

II. Overview **5**

A. National Centers for Coastal Ocean Science (NCCOS) 5
B. Human Dimensions Defined 8
C. NCCOS Human Dimensions Accomplishments 10
D. Purpose of this Plan 13
E. Future Directions 14

III. Strategic Goals and Objectives **15**

Goal 1 Provide Human Dimensions Information Essential to Support an Ecosystem Approach to Management 15

Goal 2 Provide Integrative Ecosystem Information Essential to Support an Ecosystem Approach to Management 27

Goal 3 Promote Resilient Ecosystems 32

Goal 4 Provide Organizational Support 38

Appendix 1. Human Dimensions Background **40**

A Understanding Human Dimensions of Ecosystems 40
B. Balancing Societal Objectives 43
C. Promoting Ecosystem Resilience 45

Appendix 2. Mission Drivers **48**

Appendix 3. References **62**

1. Summary

The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Coastal Ocean Science (NCCOS) is pleased to present this Human Dimensions Strategic Plan. The plan will guide NCCOS's science agenda, workforce, organization, partnerships, and other capabilities from FY 2008 – FY 2013 to achieve the missions of NOAA and NCCOS.

NOAA's Mission
To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs (NOAA, 2005a, p. 1).

NOAA's Definition of an Ecosystem
An ecosystem is a geographically specified system of organisms, the environment, and the processes that control its dynamics. Humans are an integral part of an ecosystem (NOAA, 2005a, p. 3).

NOAA's Definition of the Environment
The environment is the biological, chemical, physical, and social conditions that surround organisms (NOAA, 2005a, p. 3).

NOAA's Ecosystem Mission Goal
To protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management (NOAA, 2005a, p. 2).

NOAA's Definition of an Ecosystem Approach to Management
An ecosystem approach to management is adaptive, specified geographically, takes into account ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives (NOAA, 2005a, p. 3; Sissenwine and Murawski, 2004).

NCCOS's Mission
To provide coastal managers with scientific information and tools needed to balance society's environmental, social, and economic goals (NOAA, 2004a, p. 5).

A review by an external **Social Science Review Panel to NOAA's Science Advisory Board** found that "the capacity of NOAA to meet its mandates and mission is diminished by the under-representation and under-utilization of social science" (NOAA Science Advisory Board, Social Science Review Panel, 2003, p. 1). Among its recommendations to the Science Advisory Board, the Panel advised integrating social science goals, plans, and outcomes into strategic plans; reprogramming new initiatives in mission-critical social science; developing social science capacity, including senior-level social science representation; and identifying specific strategies for increasing social science literacy throughout NOAA.

The findings and recommendations of the Social Science Review Panel prompted NCCOS to develop a "Societal Stressors" goal and associated objectives in the **NCCOS Strategic Plan** for FY 2005 - FY 2009. Specifically, NCCOS adopted a policy directive to provide scientific

information and tools critical to inform coastal management and other decisions aiming to influence human activities affecting coastal ecosystems (NOAA, 2004a). This Human Dimensions Strategic Plan expands NCCOS's strategic focus on Societal Stressors to develop more comprehensive guidance in providing human dimensions research critical to support an ecosystem approach to coastal and ocean resource management.

The **human dimensions of ecosystems** can be described in terms of three points of interaction between environmental and human systems: human causes, consequences, and responses to environmental change (National Research Council, 1992) (see Appendix 1, Human Dimensions Background) (Figure 5, p. 9). Encompassing a broad array of disciplines across the social and behavioral sciences, humanities, communication sciences, and related interdisciplinary studies, **human dimensions research** aims to understand these human-environmental interactions and facilitate use of this understanding to assist decisions affecting environmental processes and their societal outcomes (Figure 6, p. 10).

NCCOS's commitment to a comprehensive ecosystem science enterprise introduces scientific, organizational, and individual challenges. From a scientific standpoint, ecosystem science requires new approaches for linking the concepts, methods, and results of environmental and human dimensions research to inform decision making. From an organizational standpoint, critical needs include greater capacity in human dimensions expertise; leadership with interdisciplinary understanding and team-building skills across disciplines; organizational practices that identify, encourage, require, and reward mission-critical human dimensions research; integrated research prioritization and planning; adequate funding for human dimensions and interdisciplinary research; and leadership and workforce training to facilitate awareness and appreciation of the mission value of human dimensions research. Fundamentally, envisioning and implementing such scientific and organizational transformations requires fostering a workforce with the knowledge, skills, and dispositions to engage in and be transformed by learning, communication, and collaboration across disciplines.

The **purpose** of this Human Dimensions Strategic Plan is to articulate, justify, and explain goals and objectives that provide strategic guidance to NCCOS in overcoming these challenges to integrate mission critical human dimensions research into its science program. Three appendices support these strategic elements. Appendix 1, Human Dimensions Background, explains concepts critical to understand the goals and objectives. Appendix 2, Drivers, offers a robust, but non-exhaustive list of mandatory authorities, authorizations, statutes of general applicability, and significant reports that require or substantially inform NCCOS's commitment to human dimensions research. Appendix 3, References, cites extensive human dimensions literature to promote further learning. In addition to providing strategic guidance to NCCOS, the plan is intended as an educational tool and programmatic resource for the broader coastal and ocean science and management community.

In FY 2008, NCCOS will develop an **implementation plan** specifying program- and project-level strategies, fiscal and human resources needs, potential partnerships, and other programmatic and administrative strategies for achieving the goals and objectives of this Human Dimensions Strategic Plan.

GOAL 1 Provide Human Dimensions Information Essential to Support an Ecosystem Approach to Management

Objective 1.1 Characterize Stakeholders and their Values

NCCOS will characterize stakeholders of coastal and ocean ecosystems and their values.

Objective 1.2 Monitor Human Dimensions

NCCOS will monitor sociocultural and economic attributes that influence and are influenced by coastal and ocean systems and resource management.

Objective 1.3 Monitor Human Causes and Social Drivers of Ecosystem Stress

NCCOS will assess and monitor the status of and trends in the individual and interactive significance of human proximate causes and social drivers of ecosystem stress.

Objective 1.4 Document Traditional and Local Ecological Knowledge

NCCOS will conduct community-based research documenting traditional and local ecological knowledge, facilitate its application to enhance coastal and ocean science and resource management, and ensure equitable sharing of benefits arising from documentation.

Objective 1.5 Address Value and Ethical Dimensions

NCCOS will address value and ethical dimensions of coastal and ocean science and management to support decisions articulating a management vision and ensure socially responsible science.

Objective 1.6 Analyze and Develop Institutions

NCCOS will examine existing institutional arrangements, and the prospects for (re)designing institutions, to support an ecosystem approach to the management of coastal and ocean resources.

Goal 2 Provide Integrative Ecosystem Information Essential to Support an Ecosystem Approach to Management

Objective 2.1 Provide Integrative Information Products and Tools

NCCOS will develop and operationalize information products and decision support tools that link environmental and social information as appropriate to support an ecosystem approach to management.

Objective 2.2 Define and Implement Integrated Ecosystem Assessments

NCCOS will provide leadership within NOAA, and in collaborating with partners and stakeholders across sectors, to define, produce, and facilitate the use of integrated ecosystem assessments.

Goal 3 Promote Resilient Ecosystems

Objective 3.1 Assess Cumulative Impacts

NCCOS will comprehensively assess the cumulative impacts of hazards on coastal communities and the environmental systems upon which they depend.

Objective 3.2 Assess Risk and Vulnerability

NCCOS will conduct hazard risk and vulnerability assessments that assess exposure of environmental and human dimensions, and are informed by and responsive to the needs and concerns of decision makers and stakeholders.

Objective 3.3. Develop Risk Communication Strategies

NCCOS will conduct risk communication research critical to ensure that ecosystem forecasts, early warning systems, and other products promote risk-wise behavior to reduce vulnerability and promote resilience.

Objective 3.4 Evaluate Forecasting and Other Capabilities

NCCOS will evaluate the efficacy of its hazard forecasts and other products for reducing cumulative impacts on valued environmental, sociocultural, and economic attributes.

Goal 4 Provide Critical Support

Objective 4.1 Build Organizational Capabilities

NCCOS will build organizational capabilities critical to achieve the goals and objectives of this plan.

Objective 4.2 Provide Communications, Outreach, and Education Support

NCCOS will identify and implement communications, outreach, and education strategies promoting the goals and objectives of this plan.

II. Overview

A. National Centers for Coastal Ocean Science (NCCOS)

Ecosystem Approach to Management

- Adaptive
- Geographically specified
- Considers ecosystem knowledge
- Considers scientific uncertainty
- Considers multiple external influences
- Balances diverse societal objectives

The National Centers for Coastal Ocean Science (NCCOS) is the focal point of ecosystem science in NOAA's National Ocean Service and Ecosystem Goal Team. The Ecosystem Goal Team coordinates efforts within NOAA's line offices, including the National Ocean Service, to achieve NOAA's Ecosystems Mission Goal. As defined in NOAA's Strategic Plan, *New Priorities for the 21st Century FY 2006 – FY 2011*, **NOAA's Ecosystems Mission Goal** is to "protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management" (NOAA, 2005a, p. 2). NOAA defines an **ecosystem approach to management** as "management that is adaptive, specified geographically, takes into account ecosystem knowledge and uncertainties, considers multiple influences, and strives to balance diverse societal objectives" (NOAA, 2005a, p. 3). **NCCOS's mission** is to "provide coastal managers and other decision makers with scientific information and tools needed to balance society's environmental, social, and economic goals" (NOAA, 2004a, p. 5).

Organization

NCCOS is comprised of science centers and laboratories that cooperatively identify and implement ecosystem science essential to achieve NOAA's Ecosystems Mission Goal (Figure 1).

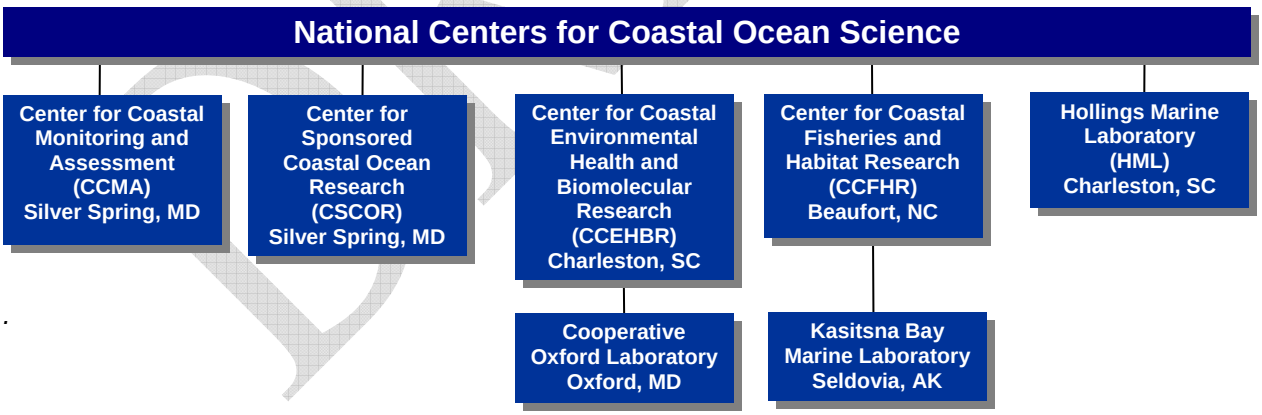


Figure 1. NCCOS cooperative centers and laboratories.

Ecosystem Science Focus

NCCOS's ecosystem science focuses on the individual and interactive significance of five categories of stressors affecting ecosystems of concern to NOAA (Figure 2).

Ecosystems of Concern	Ecosystem Stressors
National Marine Sanctuaries **Coral Reefs** **Coastal Oceans** **Estuaries (Including National Estuarine Research Reserves)**	**Climate Change** **Extreme Natural Events** **Pollution** **Invasive Species** **Resource Use (Terrestrial and Aquatic)**

Figure 2. NCCOS ecosystem science focal areas and stressors.

Integrative Role in Coastal and Ocean Science and Management

NCCOS's primary role in the coastal and ocean science and management community is to integrate ecosystem understanding critical to support coastal and ocean resource decision making. This integrative function has three components.

Integration of partners: NCCOS is a leader in coordinating research activities and linking research results across diverse partners within "one-NOAA" and in other federal and state agencies, tribes, communities, and universities.

Integration of ecosystem components: NCCOS is a pioneer in coordinating research activities and linking research results at the interface of environmental and human dimensions of ecosystems.

Integration of science and decision making: NCCOS is a model in producing and delivering scientific information and tools to decision- and policy-makers, the scientific community, and the public.

Integrated Ecosystem Assessments

NCCOS's fundamental mission strategy is the Integrated Ecosystem Assessment (Figure 3). Integrated ecosystem assessments support decision making by synthesizing available information about the environmental and human dimensions of focal ecosystems as a basis for assessing and forecasting the status, sustainability, and tradeoffs among diverse societal objectives under alternative management scenarios. Integrated ecosystem assessments provide a scientifically credible, collaborative focus for decision making across sectors, agencies, and stakeholder groups. They facilitate cooperation among diverse constituencies to clarify societal goals; evaluate tradeoffs; establish priorities; and select, implement, and evaluate strategies.

Figure 3. Schematic reflecting synthesis of information in integrated ecosystem assessments. (Adapted from Michigan Sea Grant, 2005)

Customers

Natural resource management decisions are "among the most challenging facing humanity because of the conjunction of several decision attributes, such as complexity, uncertain and conflicting values, incomplete and uncertain knowledge, long time horizons, high stakes, multi-scale management, linkages among decisions, and time pressure" (National Research Council, 2005, p. 23). Recognizing these challenges, NCCOS informs coastal and ocean resource decision making across spatial scales extending from the local to the global and social scales extending from individuals to intergovernmental, inter-sectoral networks. Specifically, NCCOS provides scientific information and tools to assist state and local coastal resource managers; tribes; local, state, and Federal governmental agencies; non-governmental organizations; private industry; resource user groups; and other parties whose decisions influence coastal and ocean ecosystems and their linkages to society.

Ecosystem Regions

Coastal and ocean resource management is fragmented across national, state, and local political boundaries, yet regional ecosystem processes such as coastal currents and cumulative human impacts straddle these lines. "The mismatches between the functional size and complexity of marine ecosystems and the fragmented authority for coastal research and resource management among state and federal agencies have resulted in largely uncoordinated, sector-by-sector management (e.g., fisheries vs. coastal zone management), multiple levels of governance, and geographically and topically constrained research" (National Research Council, 2000, p. 2).

The U.S. Commission on Ocean Policy recommends a regional approach to coastal and ocean research and management to enable "decision makers at all levels to coordinate their activities, reduce duplication of efforts, minimize conflicts, and maximize limited resources" (U.S. Commission on Ocean Policy, 2004, p. 87). Following this recommendation and its endorsement in the President's *U.S. Ocean Action Plan* (2004), NOAA delineated eight regional ecosystems, based on Large Marine Ecosystem (LME) boundaries adopted by the World Bank and Global Environment Facility, as a focus for internal and external coordination, ecosystem observation, ecosystem modeling, and stewardship and management. NOAA's regional foci are the Northeast Shelf, Southeast Shelf, Caribbean, Great Lakes, Gulf of Mexico, California Current, Alaskan Ecosystem Complex, and Pacific Island Ecosystem Complex (Figure 4).

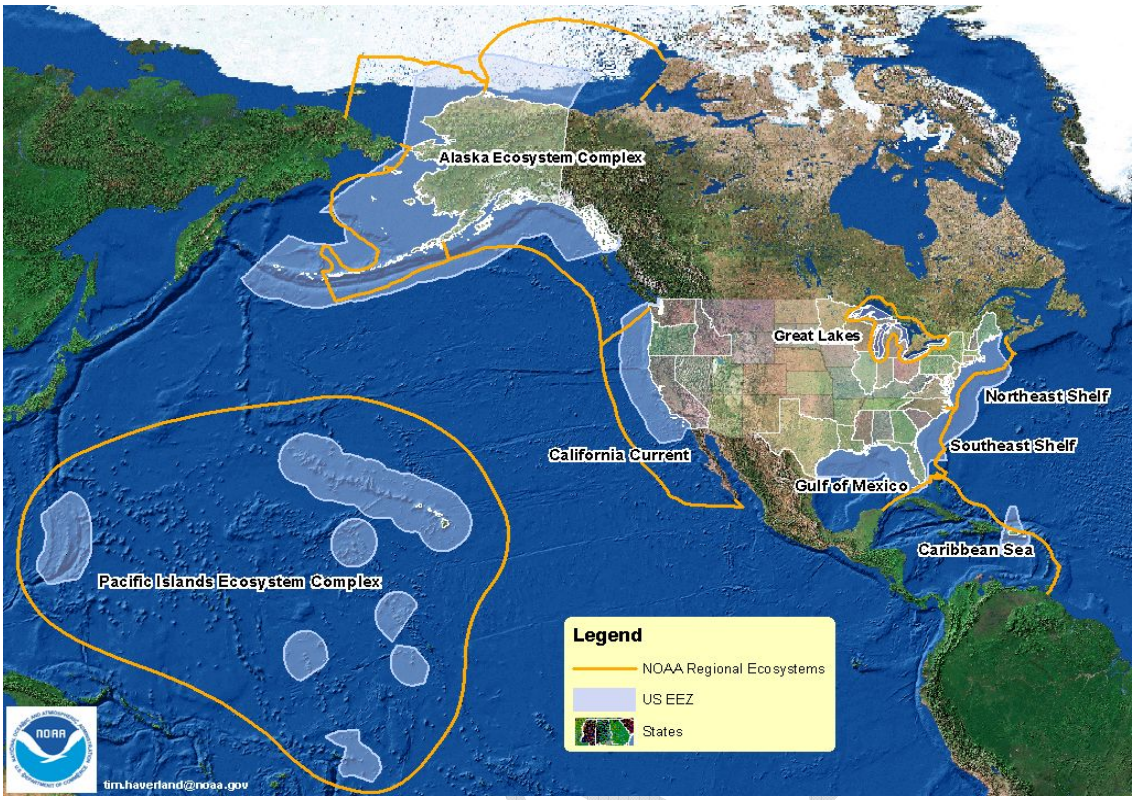


Figure 4. U.S. regional ecosystems based on Large Marine Ecosystems.

B. Human Dimensions Defined

Definition

The human dimensions of ecosystems can be described in terms of three points of interaction between environmental and human systems: human causes, consequences, and responses to environmental change (National Research Council, 1992) (see Appendix 1, Human Dimensions Background) (Figure 5).

Encompassing a broad array of interrelated disciplines across the social and behavioral sciences, humanities, communication sciences, and related interdisciplinary studies (Figure 6), **human dimensions research** aims to understand these human-environmental interactions and facilitate use of this understanding to support decisions affecting environmental processes and their societal outcomes.

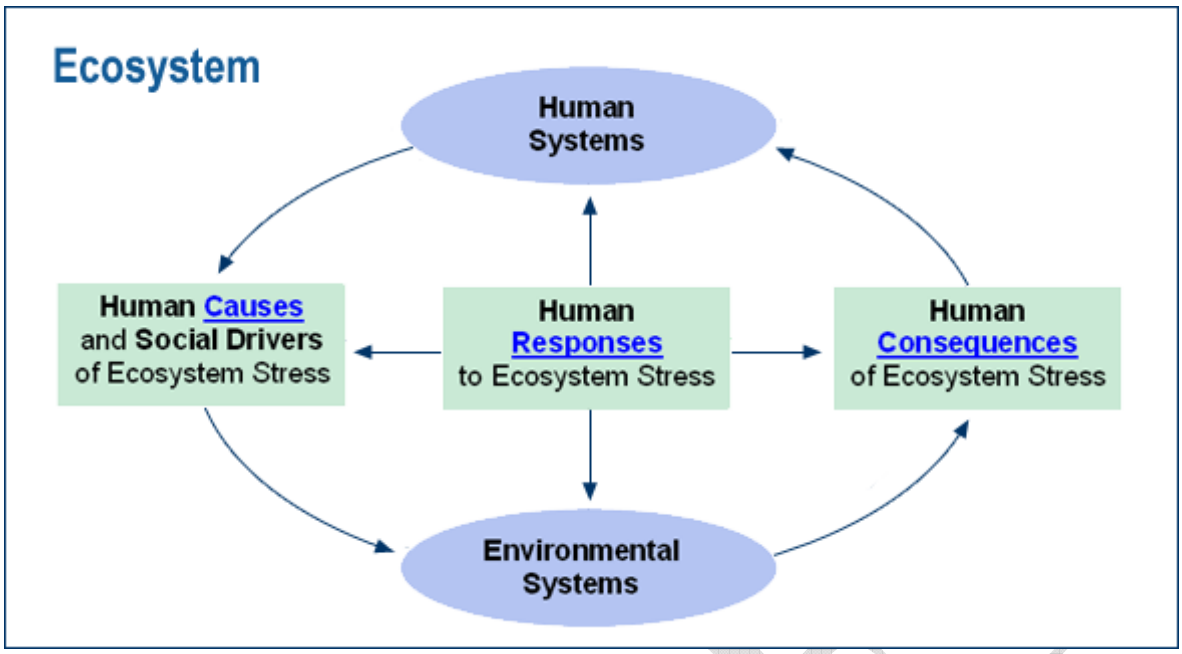


Figure 5. Human-environment interactions integral to ecosystems.

Drivers for Integrating Human Dimensions Research

NCCOS is governed by legal authorities (Federal laws and regulations, executive orders, and case law) and guided by significant internal and external scientific reports that mandate and guide consideration of human dimensions in coastal and ocean management and science informing it (see Appendix 2).

In addition, a review by an external **Social Science Review Panel to NOAA's Science Advisory Board** found that "the capacity of NOAA to meet its mandates and mission is diminished by the under-representation and under-utilization of social science" (NOAA Science Advisory Board, Social Science Review Panel, 2003, p. 1). Yet the Panel also found that developing adequate capacity is challenged by "a lack of formal understanding of what social science is and what its contributions can be, leading to an organizational culture that is not conducive to social science research" (NOAA Science Advisory Board, Social Science Review Panel, 2003, p. 2). Among its recommendations to the Science Advisory Board, the Panel advised integrating social science goals, plans, and outcomes into strategic plans; reprogramming new initiatives in mission-critical social science; developing social science capacity, including senior-level social science representation; and identifying specific strategies for increasing social science literacy throughout NOAA.

A review of NOAA's ecosystem science enterprise by an **External Ecosystem Task Team** entitled *Evolving an Ecosystem Approach to Science and Management throughout NOAA and its Partners* echoes the Social Science Review Panel recommendations. The Task Team affirms that "both natural and social science, including communication of science, are critical elements at whatever scale and for whatever purpose ecosystem approaches are being developed" (NOAA External Ecosystem Task Team, 2006, p. 26). As a guiding consideration, the Team emphasizes

that "transitioning from the current set of programs and mandates to an integrated ecosystem science enterprise [requires] understanding how humans take benefits from marine ecosystems and their components, and how those uses alter the ecosystems" (NOAA External Ecosystem Task Team, 2006, p. 8).

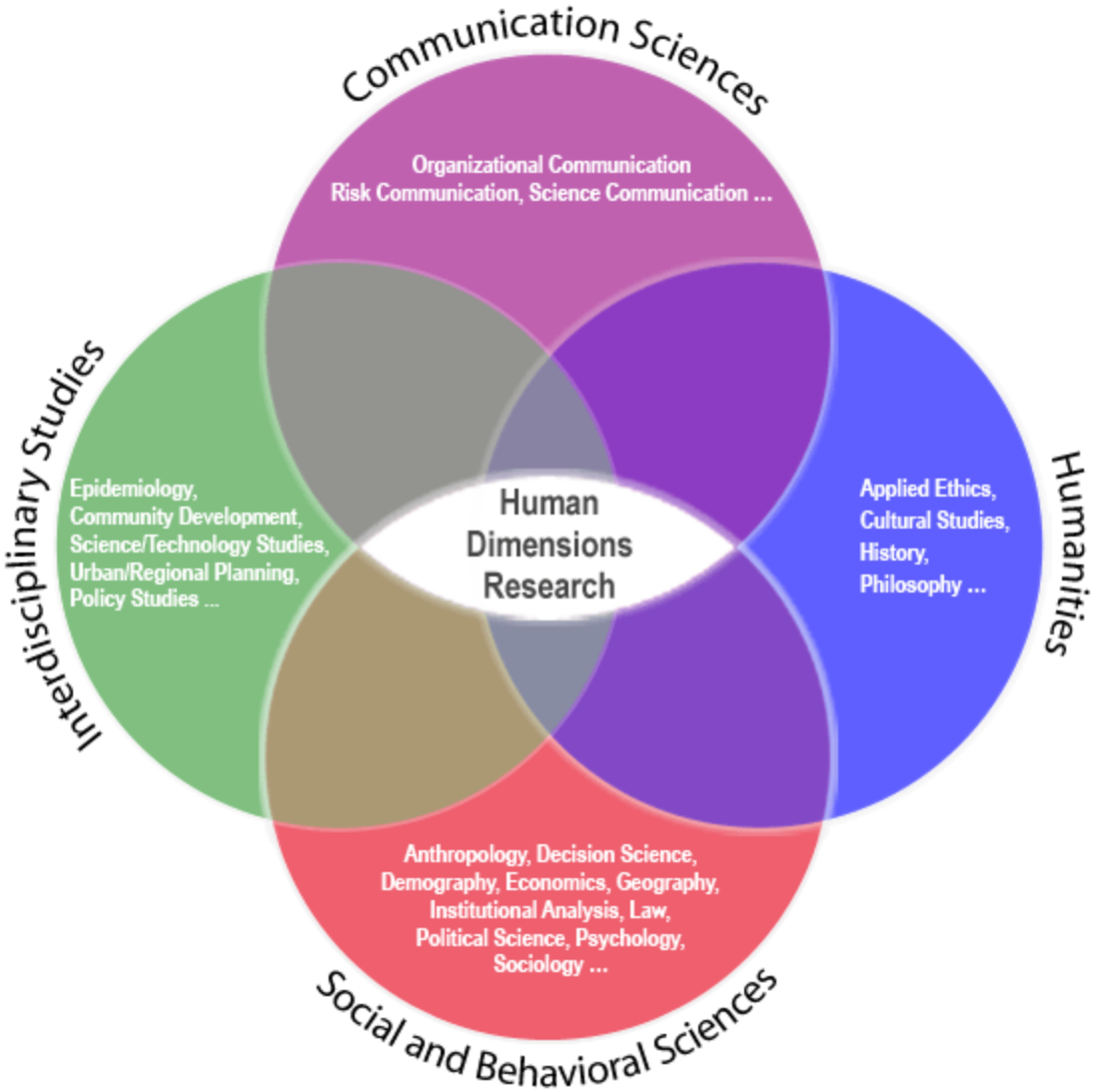


Figure 6. Diverse disciplines integral to mission-critical human dimensions research.

C. NCCOS Human Dimensions Accomplishments

The findings and recommendations of the Social Science Review Panel reflected a need for NCCOS to develop the following "Societal Stressors" goal and objectives in its Strategic Plan for FY 2005 - FY 2009 (NOAA, 2004a, pp. 16-17).

NCCOS's Strategic Plan – Goal 2: Societal Stressors: Coastal managers rely upon science to influence human activities affecting coastal ecosystems.

Objective 2.1: NCCOS will determine the social and economic costs and benefits to humans of human activities

Objective 2.2: NCCOS will determine the social, economic, and biological effects of human activities on specific ecosystems.

Objective 2.3: Coastal managers' capacities will be strengthened with the transfer of knowledge and tools from NCCOS research projects.

Objective 2.4: NCCOS will investigate the effectiveness of changing human activities in preserving ecosystems.

To implement this goal, NCCOS hired a Human Dimensions Research Coordinator, established a memorandum of agreement with two premiere human dimensions-related academic departments, and is funding graduate research assistantships in human dimensions research. In addition, NCCOS serves as the technical representative for the Environmental Cooperative Science Center (ECSC), a cooperative research and training center sponsored by NOAA and Florida A&M University (http://www.ecsc.famu.edu/). The ECSC's research themes include conceptual modeling of coupled human-environmental systems (see Reiter, 2004; Reiter et al., 2006), social and economic analyses, and environmental justice. Through capabilities such as these, NCCOS is providing human dimensions and integrated ecosystem information essential to support coastal and ocean decision making. Highlights include the following selected publications, ongoing projects, and completed projects.

Selected Publications

The following NCCOS publications provide analytical guidance in conducting critical human dimensions research to inform coastal management. Additional relevant publications can be found by searching the NCCOS project database (http://www8.nos.noaa.gov/nccos/cscor/publications.aspx).

Title	Description	Citation
Harmful Algal Research and Response: A Human Dimensions Strategy	A multi-agency plan for human dimensions research critical to reduce impacts of harmful algal blooms. Informs implementation of the Harmful Algal Bloom and Hypoxia Research Control Act (HABHRCA), National Plan for Algal Toxins and Harmful Algal Blooms (HARRNESS), and Oceans and Human Health Act.	Bauer, 2006

Human Dimensions of Coastal Restoration	Provides technical assistance for development and implementation of sound scientific monitoring of coastal restoration – including how to select measurable objectives that allow for the appropriate assessment of the benefits of coastal restoration projects to human communities and economies.	Salz and Loomis, 2006
Visual Impact Assessment of Small Docks and Piers: Theory and Practice	Summarizes legal bases for developing visual impact standards and analysis techniques, local and state capabilities to develop and implement visual impact standards, and mitigation.	Bliven and Kelty, 2005
Evaluation of the Economic Costs and Benefits of Methods for Reducing Nutrient Loads to the Gulf of Mexico	Evaluates the social and economic costs and benefits of alternative methods for reducing nutrient loads in the Gulf of Mexico. Part of a hypoxia science assessment documenting the state of knowledge of the extent, characteristics, causes, and effects (both ecological and economic) of hypoxia in the northern Gulf of Mexico.	Doering et al., 2000
Integrating Biology and Economics in Seagrass Restoration: How Much is Enough and Why?	Discusses integration of field data and economic methods (a technique called Habitat Equivalency Analysis) to determine the amount of habitat that must be restored to compensate for loss of services to the public resulting from environmental damage.	Fonseca et al., 2000
Socioeconomic Causes and Consequences of Coastal Ecosystem Change	Describes methods to understand linkages between: 1) social and economic causes and consequences, both direct and indirect, of coastal ecosystem changes; and 2) human response to ecosystem change.	Huppert et al., 1998
The Effects of Urbanization on Human and Ecosystem Health	Discusses the impact of environmental change on water quality and, ultimately, human health.	Vernberg et al., 1996
Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policymakers	Explains and illustrates basic economic concepts and tools used in environmental decision making such as willingness-to-pay cost effectiveness analysis, economic impact analysis, and sustainable development.	Lipton et al, 1995

1

Ongoing Projects

NCCOS is conducting an integrated assessment of the biogeographic and socioeconomic effects of a no-take area established in the Tortugas Ecological Reserve in the Florida Keys National Marine Sanctuary in 2001.

NCCOS is assessing community vulnerability to tidal creek flooding and the effects of water quality on property values and other aspects of quality of life in the Mid-Atlantic and Gulf Coast states. Environmental and socioeconomic data will be integrated through a GIS.

NCCOS is incorporating traditional and local ecological knowledge into resource management programs in Alaska.

Other Highlights

The NCCOS-sponsored project *Coral Reef Ecosystems Study: Integrating Science and Management in the Caribbean* documented local and traditional ecological knowledge and perceptions of marine resources and their use, management systems, and coral reef health to inform strategies for the establishment and co-management of marine protected areas (MPAs) in Puerto Rico.

As part of the NCCOS-sponsored project *Coral Reef Ecosystems Study: Integrating Science and Management in the Tropical Pacific Islands*, the Palau International Coral Reef Center used community surveys to focus outreach efforts informing Palauan traditional leaders and communities about the impacts of erosion on coral reefs. These outreach efforts led to community engagement and a moratorium on mangrove clearing, ultimately facilitating conservation of the reefs and sustainability of the vital services they provide to Palauan communities.

A chapter of the *National Coastal Condition Report II*, "Health of Galveston Bay for Human Use" assesses the health of Galveston Bay relative to its capacity to provide for human uses such as marine transportation; commercial and recreational fishing; receiving waters for industrial, municipal, and thermal wastes; recreational activities; habitat; oil and gas production sites; and residential housing. This approach complements other chapters focusing on environmental impacts of human activities (Environmental Protection Agency 2004).

D. Purpose of this Plan

NCCOS's commitment to a comprehensive ecosystem science enterprise introduces scientific, organizational, and individual challenges. From a scientific standpoint, ecosystem science requires new approaches for linking the concepts, methods, and results of environmental and human dimensions research to inform decision making. From an organizational standpoint, critical needs include greater capacity in human dimensions expertise; leadership with interdisciplinary understanding and team-building skills across disciplines; organizational practices that identify, encourage, require, and reward mission-critical human dimensions research; integrated research prioritization and planning; adequate funding for human dimensions

and interdisciplinary research; and leadership and workforce training to facilitate awareness and appreciation of the mission value of human dimensions research. Fundamentally, envisioning and implementing such scientific and organizational transformations requires fostering a workforce with the knowledge, skills, and dispositions to engage in and be transformed by learning, communication, and collaboration across disciplines.

What this plan is … The purpose of this Human Dimensions Strategic Plan is to articulate, justify, and explain goals and objectives that provide strategic guidance to NCCOS in overcoming these challenges to integrate mission critical human dimensions research. Three appendices support these strategic elements. Appendix 1, Human Dimensions Background, explains terminology and concepts critical to understand the goals and objectives. Appendix 2, Drivers, offers a robust, but non-exhaustive list of mandatory authorities, authorizations, statutes of general applicability, and significant reports that require or substantially inform NCCOS's commitment to human dimensions research. Appendix 3, References, cites extensive human dimensions literature. In addition to providing strategic guidance to NCCOS, the plan is intended as an educational tool and programmatic resource for the broader coastal and ocean science and management community.

What this plan is not … This plan intentionally does not propose program- or project- level strategies to achieve the goals and objectives put forth; outline fiscal or human resources needs; review related NOAA, interagency, and non-governmental research; or propose specific partnerships. Development of such programmatic and administrative strategies is challenged by a lack of understanding, appreciation, and formal investment in the mission contributions of human dimensions research (NOAA Science Advisory Board, Social Science Review Panel, 2003). This plan aims to promote an awareness and culture within NCCOS that is conducive to identifying and integrating mission critical human dimensions research – a prerequisite to developing a more detailed implementation plan.

F. Future Directions

In FY 2008, NCCOS will develop an **implementation plan** specifying program- and project-level strategies, fiscal and human resources needs, potential partnerships, and other programmatic and administrative strategies to achieve the goals and objectives of this Human Dimensions Strategic Plan. While it is beyond the scope of this plan to review related research or propose partnerships, it is important to acknowledge that NOAA, interagency, tribal, and non-governmental partnerships are a cornerstone of NCCOS's operations. The implementation plan will provide more detailed guidance toward cultivating NCCOS's partnerships in a "one-NOAA" and multi-sectoral society.

IV. Strategic Goals and Objectives

The following strategic goals and objectives will guide NCCOS's science agenda, workforce, organization, partnerships, and other capabilities from FY 2008 – FY 2013. Supporting concepts are elaborated in Appendix 1, Human Dimensions Background.

Goal 1 Provide Human Dimensions Information Essential to Support an Ecosystem Approach to Management

Objective 1.1

Characterize Stakeholders and their Values

NCCOS will characterize stakeholders of coastal and ocean ecosystems and their values.

The identification, articulation, and prioritization of values as drivers of coastal and ocean science, policy, and resource management has profound environmental, sociocultural, and economic implications. Balancing societal objectives, a criterion of NOAA's Ecosystems Mission Goal, requires establishing management priorities among the broadest spectrum of potentially affected stakeholder values. The term "value" encompasses the variety of opportunities, experiences, and conditions (environmental, social, and personal) that matter to people and, through individual and coordinated efforts to realize them, guide human action. The term "stakeholder" refers to individuals and groups whose values are affected (i.e., made more or less achievable or sustainable) by the condition of coastal and ocean systems and resource management. The term "societal objective" refers to values predominantly shared by some social group such as a geographic, cultural, or resource user group.

It is important to emphasize that societal objectives are not necessarily captured by statutory authorities, management plans, and other regulatory guidance. First, stakeholder groups can be marginalized or excluded from decision processes (e.g., in the Channel Islands, Bergen and Carr, 2003). Access to participation in decision making is mediated by diverse social factors, including sociocultural (e.g., managers' perceptions of stakeholders), epistemic (e.g., stakeholders' technical expertise), organizational (e.g., formation and perceived legitimacy of stakeholder organizations), and structural (e.g., balance of power inherent to decision structures) (Hollup, 2000). Consequently, regulatory guidance does not necessarily represent the full ensemble of societal objectives affected by (and affecting) the condition of coastal and ocean systems and resource management. In effect, management processes, policy deliberations, and scientific programs relying strictly on regulatory guidance to construct a vision of "what society wants" risk inaccurate, undemocratic outcomes.

Second, statutory authorities commonly express societal objectives in highly general terms that require specification to be operational. For example, the Endangered Species Act affirms that species provide aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people (16 U.S.C. §§ 1531-1543). However, defining site-specific protected

species management goals, and balancing them with other societal goals in the context of an ecosystem approach, requires a deeper understanding of the sociocultural and economic significance derived from various species by geographic, cultural, user, and other groups – including spatio-temporal patterns, gear types, and cultural beliefs characterizing practices for harvesting and using species.

Finally, relying on regulatory guidance to select societal objectives disregards the potential of participatory research, management, and evaluation to improve the substance, perceived legitimacy, and effectiveness of coastal and ocean resource management strategies (Mascia, 2003; Sutinen and Kuperan, 1999). Participants learn from each other and often create a shared understanding of issues, barriers, and opportunities that can lead to more creative problem solving and support for management practices. NOAA's External Ecosystem Task Team acknowledges this potential, urging that "NOAA has a unique role as leader in formulating and implementing a collaborative approach because of the diversity of its mandates, and can lead by example through establishment of effective collaboration within its own sub-agencies and with its stakeholders" (NOAA External Ecosystem Task Team, 2006, p. 26).

For these reasons, stakeholder assessment is needed to adequately characterize societal objectives as a basis for management decisions and ecosystem assessments informing them. Stakeholder assessment refers to the use of social scientific methods such as focus groups, surveys, and ethnographic research to identify and characterize individuals and groups whose values may be influenced (i.e., made more or less achievable or sustainable) by changes in the condition of coastal and ocean resources and resource management. In addition to values and value priorities, stakeholder assessments document stakeholder characteristics such as relevant perceptions (e.g., of resource user conflict), attitudes (e.g., level of trust in resource management agencies), management preferences (e.g., spatial boundaries for fishery closure), and resource use patterns.

The rich description of stakeholder characteristics and values provided by stakeholder assessments constructs a relatively comprehensive and democratic picture of "what society wants" – an essential component of Integrated Ecosystem Assessments (see Objective 2.2). Such a picture enables representation of a diverse constituency, providing basic social information needed to select criteria for ecosystem assessment, establish programmatic goals and performance metrics for ecosystem science programs, understand tradeoffs associated with management alternatives, critically establish priorities through processes combining deliberation and scientific analysis, and evaluate impacts of management decisions.

Methodologically, it is crucial that stakeholder assessments be compatible in scale with coastal and ocean resource decision making. "Highly aggregated information may ignore or average out local information that is important in identifying future problems and developing solutions" (Dietz et al., 2003, p. 1908). Management decisions, and scientific assessments informing them, should take into consideration differences in values and priorities across local, regional, and national scales.

Objective 1.2

Monitor Human Dimensions

NCCOS will monitor sociocultural and economic attributes that influence and are influenced by coastal and ocean systems and resource management.

The U.S. Commission on Ocean Policy calls for a national monitoring network to "move toward an ecosystem-based management approach that considers human activities, their benefits, and their potential impacts within the context of the broader biological and physical environment. While current monitoring helps track specific substances, it has been less effective in helping understand how various ecosystem components interact and change over the long term" (U.S. Commission on Ocean Policy, 2004, p. 226). The Commission further urges that a long-term, comprehensive monitoring network is necessary to establish a baseline to facilitate the analysis of ecosystem change and "create an information base to allow managers to understand whether their strategies were effective in meeting their goals" (U.S. Commission on Ocean Policy, 2004, p. 231). Similarly, NOAA's External Ecosystem Task Team advises that core competence and capacity in sociocultural and economic monitoring is critical to producing Integrated Ecosystem Assessments (see Objective 2.2) (NOAA External Ecosystem Task Team, 2006).

One severe limitation in the Nation's monitoring capacity is a lack of time-series data describing the human dimensions of coastal and ocean ecosystems. Supporting an ecosystem approach to management requires synthesizing and generating new time-series data on sociocultural and economic parameters that enable:

- Understanding and tracking proximate human causes and underlying social drivers of ecosystem stress – i.e., linkages between (a) the status of, and trends in, human activities and underlying social drivers and (b) related changes in coastal and ocean systems;

- Tracking human consequences of ecosystem stress – i.e., linkages between (a) the status of, and trends in, coastal and ocean systems and (b) changes in the achievability, sustainability, and tradeoffs among societal objectives;

- Predicting human consequences of alternative governance approaches – i.e., linkages between (a) alternative governance approaches, including specific policy and management options, and (b) sociocultural and economic costs and benefits; and

- Evaluating scientific tools and governance approaches – i.e., linkages between (a) ecosystem services protected and restored and (b) the market and non-market value of human benefits.

In order to develop the comprehensive and coordinated national monitoring network managers need, it is imperative that NOAA, interagency, and non-governmental initiatives coordinate collection, storage, and sharing of sociocultural and economic data. Through NOAA's National Ocean Service, Ecosystem Goal Team, and other agency and interagency mechanisms, NCCOS should play a lead role in developing consistent parameters and shared resources for sociocultural and economic monitoring. An important building block is the National Ocean

Economics Program's (NOEP) meta study of data describing the national ocean and coastal economy (www.oceaneconomics.org). In addition, Sutinen et al. (2005, pp. 31-52) provide a valuable starting point toward developing a framework to monitor the human dimensions of large marine ecosystems (LMEs), suggesting the following steps:

1. Identify principle uses of LME resources;
2. Identify LME resource users and their activities;
3. Identify governance mechanisms influencing LME use;
4. Assess the level of LME-related activities;
5. Assess interactions between LME-related activities and LME resources;
6. Assess impacts of LME activities on other users;
7. Assess the interactions between governance mechanisms and resource use;
8. Assess the socioeconomic importance of LME-related activities and the economic and sociocultural value of key uses and LME resources;
9. Identify the public's priorities and willingness to make tradeoffs to protect and restore key natural resources;
10. Assess the cost of options to protect or restore key resources;
11. Compare the benefits with the costs of protection and restoration options; and
12. Identify financing alternatives for the preferred options to protect and restore key LME resources.

Objective 1.3

Monitor Human Causes and Social Drivers of Ecosystem Stress

NCCOS will assess and monitor the status of and trends in the individual and interactive significance of human proximate causes and social drivers of ecosystem stress.

Coastal and ocean resource management is fundamentally an enterprise in developing and implementing strategies that encourage change in human behavioral patterns, such as land and aquatic resource uses, to reduce or eliminate the threat they pose to valued environmental attributes. Understanding the status of and trends in proximate human causes and underlying drivers of ecosystem stress is critical to help resource managers and other decision makers focus mitigation and adaptation strategies. (Appendix 1, Human Dimensions Background, describes the distinction between proximate human causes and underlying social drivers of ecosystem stress, and types of mitigation and adaptation strategies.)

Huppert et al. illustrate this research imperative in the context of estuarine management: "Residential housing development, agriculture, commercial fisheries, dredging for shipping channels, and upland logging affect the functions and processes of estuaries. … Changes in estuaries are largely driven by human uses of the ecosystems, and these uses are driven by values that, along with perceptions of ecosystem conditions and human effects, shape the rules for using and conserving estuarine ecosystems. … Estuary managers attempt to shape and modify the interactions between the social system and [other components of] the ecosystem by regulating economic development, establishing a variety of laws and informal rules for using estuarine resources, informing the public of problems and opportunities, and modifying incentives for

conservation. … Understanding the status and trends in the human communities may be as crucial to successful estuary management as understanding the estuary ecosystem" (2003, p. 994).

For example, research on proximate causes may focus on assessing and monitoring behavioral patterns such as location, timing, seasonality, techniques, gear types, and social networks characterizing resource uses. Research on social drivers may focus on explaining proximate causes in terms of attributes such as cultural beliefs, perceptions, and attitudes; demographic changes; market incentives; organizational structures; equity issues; political pressures; regulatory mechanisms; and technological constraints. From a cultural perspective, "examining how different social groups and communities interpret and form attachments to particular places or natural features can provide invaluable information about how and why certain resource uses occur and persist, as well as how shifts in resource conditions can influence human adaptation and response (Endter-Wada et al., 1998, p. 898).

Objective 1.4

Document Traditional and Local Ecological Knowledge

NCCOS will conduct community-based research documenting traditional and local ecological knowledge, facilitate its application to enhance coastal and ocean science and resource management, and ensure equitable sharing of benefits arising from documentation.

Traditional ecological knowledge (TEK) is "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment … Traditional knowledge [is] gathered over generations by observers whose lives depended on this information and its use" (Berkes et al., 2000, p. 1252). "Traditional knowledge systems are based on the shared experiences, customs, values, traditions, subsistence lifestyles, social interactions, ideological orientations, and spiritual beliefs unique to aboriginal communities. Together, [traditional and nontraditional] foundations of knowledge articulate to form a worldview … that provides meaning and value to the lives of contemporary aboriginal peoples" (Stevenson, 1996, p. 281).

Like TEK, local ecological knowledge (LEK) "is tied to place (e.g., specific hunting or fishing grounds) and is acquired through experience and observation. It can be acquired over a single lifetime or over many generations. LEK differs from TEK in that it does not require an ancient or even a multi-generational accumulation of knowledge, it does not require that the population be indigenous, and it does not require embedding in a broader shared culture" (NOAA National Marine Fisheries Service Local Fisheries Knowledge Project, http://www.st.nmfs.gov/lfkproject/02_c.definitions.htm).

TEK and LEK encompass knowledge addressing taxonomic, population, and ecological levels (Drew, 2005) including human dimensions such as resource use patterns, community attitudes, and management practices. For example:

- Practices found both in conventional resource management and in some local and traditional societies – e.g., monitoring resource abundance, protection of vulnerable life history stages, protection of habitats, temporal restrictions of harvest, and species protection;

- Practices largely abandoned by conventional resource management but still found in some local and traditional societies – e.g., multiple species management, resource rotation, and succession management; and

- Practices related to the dynamics of complex systems, seldom found in conventional resource management but found in some traditional societies – e.g., management of landscape patches, watershed-based management, managing ecological processes at multiple scales, and responding to and managing pulses and surprises (Berkes et al., 2000; Folke et al., 1998).

TEK and LEK can enhance coastal and ocean science and resource management by supporting or augmenting scientific observations, suggesting testable hypotheses, contributing explanatory and predictive models, and expressing novel ways of understanding the relation of humans to the rest of nature (Huntington, 2000; Drew, 2005). TEK and LEK have not been widely integrated into coastal and ocean science or resource management in part due to the unfamiliarity of environmental researchers and managers with social scientific methods required for documentation (Huntington, 2000). The purpose of this objective is to build on and extend NCCOS's success documenting and utilizing TEK and LEK to enhance coastal and ocean science, including integrated ecosystem assessments (see Objective 2.2) and other tools for resource management. Following international law and policy regarding the rights of indigenous peoples (Convention on Biological Diversity, 1992; Mauro and Hardison, 2000), research should incorporate community participation at all stages and demonstrate respect for community self-determination and cultural heritage – for example, by equitably sharing any benefits arising from documentation.

Objective 1.5

Address Value and Ethical Dimensions

NCCOS will address value and ethical dimensions of coastal and ocean science and management to support decisions articulating a management vision and ensure socially responsible science.

NCCOS's mission is to provide coastal managers and other decision makers with scientific information and tools needed to balance society's environmental, social, and economic goals (NOAA, 2004a). Two aspects of this mission situate NCCOS at the interface of science and society. First, defining a reasonable "balance" is a societal decision process intermingling scientific understanding (and uncertainty) with consideration of diverse and oftentimes divergent value judgments establishing management goals and their relative priority. NOAA, the Coastal States Organization, and the U.S. Commission on Ocean Policy have all called for guidance in grappling with this intermingling of science and values in articulating a management vision (NOAA and Coastal States Organization, 2006; U.S. Commission on Ocean Policy, 2004). NCCOS will provide this guidance.

Second, scientific information and tools are developed and used in social context. On the one hand, science is itself a social activity shaped by political, cultural, organizational, and other societal dimensions. On the other hand, uses of scientific knowledge and tools have (sometimes unintended and unforeseen) desirable and undesirable consequences for environmental components and systems, human health, and society. NCCOS will ensure socially responsible science by anticipating and addressing ethical questions raised by the implementation and use of its science in hazard response, ecological restoration, regional planning, and other activities integral to NOAA's mission.

The examples below illustrate these value and ethical dimensions of coastal and ocean science and management. They may suggest, but do not exhaust NCCOS's research directions in this area. In general, understanding and addressing these kinds of questions requires the integration of perspectives across diverse disciplines including Applied Ethics, Sociology of Science, Philosophy of Science, Science and Technology Studies, Decision Science, Institutional Analysis, and Organizational Behavior. Related research is currently sponsored by the National Science Foundation's Science and Society Program through a component in Ethics and Values in Engineering, Science, and Technology (National Science Foundation, 2005).

1. Value Dimensions of Articulating a Management Vision

Resource management is guided by goals. Management goals establish a vision of success – i.e., a definition of a well-managed ecosystem or, more generally, a picture of what sort of world is worth pursuing. Environmental and social scientists can inform managers about the actual and predicted structure and function of an ecosystem, and the ecological consequences of alternative courses of action. But the question of what sort of ecosystem is worth pursuing is beyond the reach of science. Science generates information *describing* ecosystem conditions (the way ecosystems *are* or will be). In contrast, articulating a management vision is an endeavor in *prescribing* ecosystem conditions (the way ecosystems *should* be) by identifying, articulating, and prioritizing human values as management ends. (The technical term for prescriptive judgments concerning what matters, or the way things ought to be, is *normative*). Stakeholders who agree on all the relevant scientific facts may nonetheless rationally disagree about what matters, or what matters most – the ends of resource management.

In a recent discussion paper, NOAA and the Coastal States Organization cited "articulating a management vision" as a key challenge facing coastal and ocean management. The paper raises vexing questions such as: "Can the multiple, and often competing, goals of coastal management be reconciled or accommodated within a unified vision for success? Who determines the vision if there are competing local, state, and national interests? How is the "balance" among competing issues determined?" (NOAA and Coastal States Organization, 2006, p. 2).

These questions point to the crux of the "values" challenge in articulating a management vision – establishing priorities among conflicting values. When the way in which one value is pursued threatens the realization of another, articulating a management vision requires either (a) reducing or eliminating conflict to make values mutually achievable in so far as possible across social groups, places, and generations; or (b) when conflict is intractable, rationally establishing priorities. As Juda explains, "all societies are faced with mutually exclusive choices

regarding the use of resources. In line with the concept of opportunity costs, the use of a limited resource obviates its alternative uses. Accordingly, some values must be given a higher, and others a lower, priority" (Juda, 1999, p. 96).

In the face of intractable conflict, articulating a management vision requires not only understanding what matters to stakeholders (e.g., through stakeholder assessment as discussed in Objective 1.1), but also engaging stakeholders to rationally decide what matters most. Yet the National Research Council found that "in most cases, the weighing or balancing of conflicting objectives … is either ignored or only partially addressed" by environmental decision making (National Research Council, 2005, p. 188). Recognizing this shortfall, the U.S. Commission on Ocean Policy calls for new approaches to help coastal and ocean resource managers engage diverse stakeholders to articulate a management vision (U.S. Commission on Ocean Policy, 2004, p. 66).

The National Research Council (1996) recommends decision making that combines analysis and deliberation. Well-structured decision processes may be defined in terms of characteristics such as identifying stakeholder objectives; summarizing areas of agreement and disagreement among stakeholders, and their underlying rationales; determining priorities through rational and democratic debate; defining alternative courses of action to achieve a vision of success; describing consequences of alternatives in terms of the achievability, sustainability, and tradeoffs among objectives; examining how alternatives will affect future decisions; and considering uncertainty (e.g., Hammond et al., 1999; Gregory et al., 2001). The design and implementation of such decision procedures is an inherently interdisciplinary enterprise, requiring perspectives from the environmental and social sciences, and applied ethics. Applied ethicists should play a key role by providing theoretical and deliberative guidance for, and playing a mediating role in, discussions articulating and weighing values to establish management visions.

Responding to the Commission's call, NCCOS will provide both analytical and deliberative assistance to resource management and other decision arenas (such as urban planning and hazard response) engaged in articulating a vision for coastal and ocean ecosystems. Analysis refers to the logical and conceptual structure of a decision. Deliberation refers to the "formal or informal process for communication and collective consideration" (National Research Council, 1996). To illustrate, analytical assistance could take the form of a background paper or innovative decision tool helping resource managers and stakeholders (a) develop a deeper, common understanding of values at stake and (b) draw on ecosystem science to understand the points of convergence and divergence across various values under alternative management scenarios. Deliberative assistance could take the form of approaches to democratic stakeholder participation, integration of scientific information into value-based discussion, rational establishment of priorities, consideration of scientific uncertainty in decision making, or reconciliation of differences in stakeholder values across geographical scales when managing large marine ecosystems.

2. Ethical Questions Raised by the Implementation and Use of Science

The following examples illustrate types of ethical questions arising from the conduct and implications of scientific research, hazard response, ecological restoration, and other activities integral to NOAA's mission. NCCOS will engage applied ethicists and other human dimensions

researchers (e.g., through formal projects, research prioritization workshops, trainings, and seminars) to anticipate and address these and other ethical questions.

Role of Stakeholders in Establishing a Research Agenda

A recent public forum exploring Florida red tide research and research needs, sponsored by NCCOS's Center for Sponsored Coastal Ocean Research, raised vexing ethical questions concerning public participation in governmental research prioritization: What is the appropriate role of public preferences in determining governmental research priorities? Conversely, when representing governmental science at public forums and other outreach events, what is the appropriate role of scientists in informing or shaping public preferences concerning research priorities? (A description of the forum can be found at: http://www.cop.noaa.gov/stressors /extremeevents/hab/features/rt_mtg_mtg_0706.html).

Professional and Personal Responsibility

At a recent workshop sponsored by the Coastal Research and Response Center, oil spill researchers, responders, regulators, and affected parties identified two priority research themes related to ethics: Personal and Professional Responsibility, and Defining Success in Restoration. (The Center is a partnership between NOAA, through the Office of Response and Restoration, and the University of New Hampshire. A report summarizing workshop results is forthcoming. http://www.crrc.unh.edu/).

In the area of Personal and Professional Responsibility, workshop participants recalled numerous ethical quandaries with which they have grappled in the context of spill response and restoration. These decisions arise where legal guidance leaves off and personal-professional decision making is required: Does it make sense to spend thousands of public dollars to rehabilitate an individual bird that has a low likelihood of surviving and is otherwise biologically insignificant? Would euthanasia be a more appropriate option? Are the expected benefits of response actions associated with protecting a resource, cleaning a shoreline, or salvaging a leaky tanker worth the risk of worker injury or fatality? Are the benefits of response actions such as burning oil worth the risk of damage otherwise uncontaminated resources? Is it morally permissible to harvest or intentionally dose healthy animals to study contaminants? How can remediation of chronic waste sites best address environmental justice issues? Under what criteria is in-situ burning an appropriate containment and cleanup method – considering the risk of harm to proximate human populations, air quality degradation, and injury to response personnel?

Defining Success in Restoration

Participants at the Coastal Response Research Center workshop also raised the question of how to define success in the context of oil spill restoration. On the one hand, this is a legal question. The Natural Resource Damage Assessment regulations promulgated under the Oil Pollution Act of 1990 establish "baseline conditions" as the legal standard of success. Baseline refers to the "condition of natural resources and services that would have existed had the incident not occurred" – encompassing land, fish, wildlife, biota, air, water, ground water, drinking water supplies, other such resources, and functions performed by them.

However, this legal standard invokes ethical questions with serious practical import. Do spill responders, regulators, and other parties integral to restoration have a responsibility to restore public health, sociocultural, and economic conditions degraded by an incident, including natural resource services not traded in markets? Such a responsibility would necessitate broadening restoration practice to conduct injury assessment and restoration planning explicitly with respect to social values such as cultural identity (e.g., maintaining cultural subsistence practices), family relationships (e.g., care of children), and community well-being (e.g., cooperative relations among neighbors and co-workers).

On the other hand, even if the legal standard is understood to encompass community development values, the acceptability of "baseline" as the legal endpoint for restoration is itself questionable. On what grounds should *historical* conditions (i.e., those characterizing a community and its natural environment at the time of an oil spill) receive favored status? Is there good reason to think that the standard for restoration ought to demand engagement, coordination, and enhancement of community capacities to *improve* sociocultural, public health, economic, and environmental conditions from baseline in so far as practicable? An affirmative answer to this question would demand a standard of community engagement and development rather than restoration of the status quo.

Workshop participants concluded that research is critically needed to:

- Assess the extent to which, and mechanisms by which, restoration practice promotes community development and other ethical criteria such as environmental justice and democratic decision making;

- Develop a guidebook for trustee councils (specifically) and researchers, responders, regulators, responsible parties, and impacted parties (broadly) that describes best practices for promoting community development and other ethical criteria in restoration practice, and highlights points for improvement;

- Identify policy, organizational, communication, community-based and other strategies for implementing best practices for promoting community development and other ethical criteria in restoration practice; and

- Identify economic, moral, legal, and other incentives inducing responsible parties to play an integral role in implementing best practices for promoting community development and other ethical criteria in restoration practice.

Environmental and Societal Implications – a Nanotechnology Example

Nanotechnology is the "understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications" (National Science and Technology Council, 2004, 11). Research and development at the nanoscale promise diverse societal benefits through breakthroughs in "materials and manufacturing, medicine and healthcare, environment and energy, biotechnology and agriculture, electronics and information technology, and national security" (Roco and Bainbridge, 2001, 2). Of particular interest to

NCCOS are previously unimagined possibilities for the prevention, treatment, and remediation of environmental pollutants (Masciangioli and Zhang, 2003).

Yet there is "danger of derailing nanotechnology if serious study of [its] ethical, environmental, economic, legal, and social implications … does not reach the speed of progress in the science (Mnyusiwalla, 2003, 9). The nature, manufacturing, and use of nanotechnologies may have unintended and unforeseen deleterious consequences for environmental systems, human health, and society. Socially responsible nanotechnological development requires analytic frameworks and institutions that promote scientifically-informed, rational public deliberation weighing benefits and risks (National Nanotechnology Initiative 2003). In addition, as new applications emerge, it will be necessary to define the responsibility of scientists and the government in ensuring equitable transfer of nanotechnologies to developing countries and less advantaged populations in the developing world.

Objective 1.6

Analyze and Develop Institutions

NCCOS will examine existing institutional arrangements, and the prospects for (re)designing institutions, to support an ecosystem approach to the management of coastal and ocean resources.

The International Human Dimensions Programme of Global Environmental Change (IHDP) project on Institutional Dimensions offers a helpful characterization of institutions and their role in determining the course of environment-human interactions. Institutions are "systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles. Institutions arise in all areas of human endeavor. Where they arise to deal explicitly with matters involving human/environment relations, it is normal to speak of institutions as environmental or resource regimes. For instance, both local arrangements dealing with the operation of smallscale irrigation systems and international arrangements pertaining to human activities involving shared lakes or river basins are regimes that are rather narrowly focused in spatial and functional terms. Other arrangements, such as systems of commonfield agriculture in traditional societies or the modern arrangements that comprise the law of the sea in international society, are cast in broader terms" (IHDP, 2005, p. 27).

The characterization continues by distinguishing between institutions and organizations. "Although casual discussions sometimes use the terms interchangeably, institutions as understood in the IDGEC project are not to be confused with organizations treated as material entities possessing offices, personnel, equipment, budgets, and legal personality [sic] (Young, 1994). The U.S. Department of the Interior, for example, is an organization; the regime for hardrock mining articulated in the Mining Act of 1872 is an institution. Corporations, such as British Petroleum and DuPont, are organizations. But the world trade regime embodied in the provisions of the General Agreement on Trade and Tariffs (GATT) (and associated agreements) is an institution now administered by an organization called the World Trade Organization (WTO). Similarly, the International Tropical Timber Organization (ITTO) is an organization whose function is to administer the institutional arrangements set forth formally in the International Tropical Timber Agreement (ITTA). As a rough approximation, we can say that

organizations are players, while institutions constitute the rules of the game that structure their roles and guide their interactions with one another" (IHDP, 2005, p. 28-29).

From an institutional perspective, an ecosystem approach to management is an endeavor in designing, managing, and maintaining interactions among science, policy, management and other organizations (public, private, and non-profit); stakeholder groups; businesses; and other social groups to promote desirable outcomes. Desirable outcomes include a balance of societal objectives, efficiency, public accountability, and equity (e.g., Imperial, 1999a, 1999b). The social scientific field of Institutional Analysis focuses on the role that institutions play in resource management, including mechanisms for stakeholder participation, strategies for handling scientific uncertainty in decision making, conflict resolution measures, and translation of scientific information into policy change (Ostrom, 1990). For example, Leschine and Chadsey (in prep.) applied an institutional analysis framework to analyze Washington State's management of recreational shellfish harvests utilizing scientific information related to domoic acid contamination. Research objectives for institutional analysis in the context of harmful algal bloom research and response are recommended in Bauer (2006).

The United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection recognizes that "Institutional Analysis provides a systematic way of obtaining an understanding of the nature, strengths, and weaknesses of institutions within the context in which they are operating or in which it is proposed they may operate in the future. It is, therefore, a key element in moving away from sectoral-based management of natural resources to an holistic approach that is likely to require modifications in the roles of different institutions" (United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, 2001, p. 97). In general, "for a new resource management paradigm based on the principles of ecosystem-based management" … to flourish, researchers and practitioners must pay closer attention to the important institutional and interorganizational management questions" (Imperial, 1999b, 451). The Subcommittee on Integrated Management of Ocean Resources echoes this point by identifying several institutional research objectives as priority focal areas, including (1) "identify[ing] opportunities for improvements in the application of science in collaborative efforts;" (2) "analyz[ing] ways to improve efficiency and effectiveness of interagency ocean, coastal, and Great Lakes resource management activities;" and (3) "identify[ing] next steps to enhance interagency coordination on use and conservation of marine resources (e.g., energy, fisheries, recreation, and transportation)" (SIMOR, 2006, pp. 1-2).

Informed by the IHDP Science Plan for its Institutional Dimensions project (IHDP, 2005), NCCOS will examine existing institutional arrangements, and the prospects for (re)designing institutions, to balance societal objectives in mitigating and adapting to stressors such as climate change, extreme natural events, pollution, invasive species, and resource use.

Goal 2 Provide Integrative Ecosystem Information Essential to Support an Ecosystem Approach to Management

Objective 2.1

Provide Integrative Information Products and Tools

NCCOS will develop and operationalize information products and decision support tools that link environmental and social information as appropriate to support an ecosystem approach to management.

Ecosystem-based management requires ecosystem-based understanding, including analysis and monitoring of the integral roles of humans as stressors and beneficiaries of environmental systems. Identifying tradeoffs, establishing priorities, and developing strategies to achieve a democratically constructed vision requires a picture of the achievability and sustainability of diverse societal objectives as they are influenced by human-environment interactions. Environmental observation and forecasting (such as biogeographic assessment, predictions of aquatic nuisance species distributions, and remote sensing of harmful algal blooms and other extreme natural events) are necessary, but not sufficient to provide this picture.

The picture essential to inform decisions aiming to "balance diverse objectives" links changes in environmental conditions to:

- Social drivers of environmental degradation, information essential to focus mitigation strategies on underlying causes (see Objective 1.3);

- Consequences of environmental degradation for the achievability and sustainability of diverse societal objectives (see Objectives 1.1 and 1.2), information required to focus and adjust adaptive strategies to promote human welfare;

- Impacts of environmental changes and societal consequences on underlying drivers of stress; and

- Understanding of governance arrangements, communication strategies (see Objective 3.4), public willingness to support management strategies (see Objective 1.2), decision processes, and financing alternatives to support the development and adaptive implementation of mitigative measures and adaptive responses.

NOAA's External Ecosystem Task Team (2006, p. 8) emphasizes this point, recognizing the need for core competence and capacity in monitoring, analysis, and integration to "analyze, forecast and interpret relationships and interactions among ecosystem components and between human activities and natural ecosystem components." The purpose of this objective is to stimulate NCCOS to utilize existing methods and develop new methods, quantitative and qualitative, for linking environmental and human dimensions information to provide decision makers with the comprehensive ecosystem picture necessary to inform an ecosystem approach. Approaches to "linking" information may include, but should not be limited to:

- Geographic information systems (GIS) and participatory geographic information systems integrating environmental and socioeconomic data;

- Ecosystem forecasts and conceptual models following a four-component approach. Four component models link societal activities as drivers of environmental change, system stressors, effects of environmental change on valued ecosystem components, and resulting alternations to flows of goods and services valued by humans (e.g., food from fisheries) (Reiter, 2004; Reiter et al., 2006).

- Combining "people and pixels" through the use of remote sensing data in social science research – and use of social science research such as risk communication and perception studies to develop ecological forecasts that effectively reduce vulnerability and promote societal benefits (National Research Council, 1998); and

- Integrated Ecosystem Assessments (see Objective 2.2).

These approaches require active, persistent, and adaptive interdisciplinary learning and collaboration throughout the process of research design, implementation, application, and evaluation, emphasizing the need for increased human dimensions literacy and organizational incentives for integrated research in NCCOS and NOAA.

Objective 2.2

Define and Implement Integrated Ecosystem Assessments

NCCOS will provide leadership within NOAA, and in collaborating with partners and stakeholders across sectors, to define, produce, and facilitate the use of integrated ecosystem assessments.

NOAA's External Ecosystem Task Team concludes that regionally-based Integrated Ecosystem Assessments are "key components of NOAA's ecosystem science enterprise. Their production should be priority for NOAA and its science and management partners" (NOAA External Ecosystem Task Team, 2006, p. 32). This recommendation echoes NCCOS's Strategic Plan, which identifies the Integrated Assessment as NCCOS's fundamental approach (NOAA, 2004a).

NEPA Environmental Impact Assessment

- Integrates social and natural science
- Considers non-market values
- Assesses social impacts
- Recommends actions to resolve value conflicts

An integrated ecosystem assessment is similar to an Environmental Impact Assessment conducted pursuant to the National Environmental Policy Act (NEPA), less the selection of a preferred alternative. NEPA and its implementing regulations require an interdisciplinary approach to Environmental Impact Assessment that assesses social impacts, considers non-market values, and describes alternative courses of action addressing conflicts among resource uses. The Council of Environmental Quality promulgated Regulations for Implementing the

Procedural Provisions of NEPA that define the "human environment" to include "the natural and physical environment and the relationship of people with that environment." These regulations require Federal agencies to assess "aesthetic, historic, cultural, economic, social, or health" effects "whether direct, indirect, or cumulative" (40 C.F.R. 1500-1508). The Interorganizational Committee on Principles and Guidelines for Social Impact Assessment under NEPA define "social impacts" to mean "the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society" (Interorganizational Committee on Principles and Guidelines for Social Impact Assessment under NEPA, 2003, p. 231).

The overarching purpose of Integrated Ecosystem Assessments is to synthesize and deliver available, credible environmental and human dimensions information in a framework that informs and facilitates an ecosystem approach to coastal and ocean resource management. While focal ecosystems will vary in important respects (such as predominant stressors, and local concerns and politics), the overarching purpose of integrated ecosystem assessments dictates their definitive features such as multi-disciplinary information needs, analytic structure, methods, and outcomes. In terms of analytic structure, the purpose of integrated ecosystem assessments requires the following components:

Guiding Question: Integrated ecosystem assessments should be organized around a guiding question that serves as a basis for collaborative decision making across stakeholder groups, jurisdictions, and sectors toward the common goal of considering ecosystem understanding and uncertainty to identify, evaluate, select, and adaptively implement strategies for balancing diverse societal objectives.

Ecosystem Definition: Integrated ecosystem assessments should include a basic definition of the focal ecosystem, including characteristics such as geographic boundaries, predominant stressors, external influences, and institutional arrangements.

Stakeholder Objectives: Stakeholder objectives are the raison d'etre and starting point for integrated ecosystem assessments. This is because values motivate human actions that stress ecosystems and supply a complex system of goals for managing them. Integrated ecosystem assessments should characterize a broad spectrum of values that are or may be influenced (i.e., made more or less achievable or sustainable) by the condition and management of the focal ecosystem. It is important to represent the values of stakeholders across multiple spatial scales – e.g., local values (such as cultural or subsistence uses), outcomes that have significance to visitors (such as recreational opportunities), and values shared on a regional or global scale (such as genetic resources provided by biodiversity). Similarly, it is important to characterize values that specify outcomes for multiple temporal scales – e.g., relatively short-term concerns (such as providing recreational fishing opportunities during a single season) and longer-term outcomes (such as preserving stocks for future generations). Stakeholder assessment (Objective 1.1) is necessary to adequately characterize stakeholder objectives as a basis for Integrated Ecosystem Assessments.

Causes of Ecosystem Stress: Integrated ecosystem assessments should include an explanatory discussion of the status of and trends in anthropogenic and non-anthropogenic causes of ecosystem stress, and underlying social drivers.

Consequences of Ecosystem Stress: Integrated ecosystem assessments should include an explanatory assessment of the achievability, sustainability, and tradeoffs among diverse societal objectives (characterized in #3) in view of current ecosystem conditions and trends (characterized in #4).

Implications for Decision Making: Integrated ecosystem assessments should predict the achievability, sustainability, and tradeoffs among societal objectives under alternative policy and management scenarios defined by different priorities and governance approaches, including a "no action" alternative.

Research Needs: Integrated ecosystem assessments should identify gaps in environmental and human dimensions understanding necessary to inform and facilitate an ecosystem approach to management, and recommendations for research to fill these gaps.

As a first step toward implementing integrated ecosystem assessments, a cornerstone of NOAA's ecosystem science enterprise, NCCOS will develop a NEPA-inspired process model. Model development will be informed by NOAA partners, coastal resource managers, other relevant decision makers such as regional planners and water utility managers, interdisciplinary environmental and social scientists (including non-economic social scientists), and other stakeholders. NCCOS will adaptively refine the model through a pilot integrated ecosystem assessment.

Considerations specific to human dimensions include:

Human dimensions information needs: The process model should comprehensively outline essential human dimensions information needs for integrated ecosystem assessments. For example, they require characterization of stakeholder objectives tied to the focal ecosystem, as well as other relevant stakeholder attributes. Second, they must assess and forecast the influence of human activities and underlying social drivers on ecosystem properties. Data priorities for such an assessment may include description of the status and trends in spatial and temporal patterns of resource use; social drivers of resource use; intensity of use; and geospatial, sociocultural, and economic context of use (NOAA, 2006). Finally, integrated ecosystem assessments should describe the influence of changes in ecosystem properties on the achievability, sustainability, and tradeoffs among multiple sociocultural, economic, and environmental values of a broad spectrum of stakeholders. Local and traditional ecological knowledge are important sources of these human dimensions information needs.

Accessibility and management of human dimensions data: A mechanism (such as a devoted NOAA program) is needed to standardize, synthesize, manage, and disseminate consistent coastal and marine economic, demographic, and social data sets across NOAA and other agencies for integrated ecosystem assessment, regional ecosystem management, and other purposes. Through collaboration with NOAA's Social Science Working Group and other

partners, NCCOS should play a role in stimulating and guiding the development of such a mechanism.

Identification and articulation of societal objectives: For reasons discussed in Objective 1.1, societal objectives should be identified and framed using social scientific methods such as stakeholder analysis and/or stakeholder participation in development of integrated ecosystem assessments.

Analytic framework: The model should establish an analytic framework for integrated ecosystem assessments (i.e., a format for synthesizing and organizing information into an information product or tool). The analytic framework should be designed to assess and forecast the achievability, sustainability, and tradeoffs among societal objectives under alternative policy and management options. It should be appropriate to serve as a basis for collaborative decision making across stakeholder groups, jurisdictions, and sectors.

NOAA's External Ecosystem Task Team describes the following core social science capabilities needed to integrate human dimensions into integrated ecosystem assessments:

- "Social science capacity to analyze the spatial and temporal variations in the uses of the principal ecosystem resources (e.g., land use, extraction of living marine resources, recreation and tourism) in each region;

- Social science capacity to assess the market and non-market value of human uses of, and the natural services of ecosystems in each region;

- Social science capacity to assess the benefits and costs of protecting and/or restoring ecosystem resources (e.g., habitat, marine mammals) in each region; and

- Social science capacity to assess the sociocultural values of the uses of ecosystem resources and services in each region" (NOAA External Ecosystem Task Team, 2006, p. 28).

Goal 3 Promote Resilient Ecosystems

Resilience is a national and international priority (e.g., Disaster Mitigation Act of 2000; International Strategy for Disaster Reduction, 2005). As defined by the United Nations International Strategy for Disaster Reduction, resilience is the capacity of a "system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures" (United Nations International Strategy for Disaster Reduction, 2004, p.4). (See Appendix 1, Human Dimensions Background.)

Definition of Resilience

The capacity of a coupled social-environmental system potentially exposed to hazards to adapt, by resisting or changing, in order to reach an acceptable level of functioning and structure. This is determined in part by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (United Nations International Strategy for Disaster Reduction, 2005, p. 4).

Objective 3.1

Comprehensively Assess Impacts

NCCOS will comprehensively assess the cumulative impacts of hazards on coastal communities and the environmental systems upon which they depend.

Hurricanes, aquatic nuisance species, oil spills, chemical contaminants, and other coastal hazards, as well as institutional and other societal changes, influence the abundance, distribution, and ecology of living marine resources throughout the Nation's estuarine, coastal, and marine environments. Monitoring, analyzing, and forecasting environmental impacts of coastal hazards is critical to help policy makers, coastal managers, stakeholders, and other decision makers identify, evaluate, and adaptively implement strategies for vulnerability reduction and disaster prevention, preparedness, and response.

However, information on environmental impacts, while necessary, is not sufficient to promote resilience. In addition to environmental impacts, coastal hazards can impact the built environment, business communities, and sociocultural dimensions, including public health and safety (Heinz Center, 2000). Some "human impacts" are indirectly caused by environmental impacts – e.g., human illness caused by drinking water contamination due to storm-surge flooding. Analysis of differential distributional impacts on vulnerable populations is critical.

Human Impacts of Coastal Hazards

Built Environment: e.g., damage and loss to transportation, utility and power, residential, economic, governmental, transportation, and other infrastructure.

Business Community: e.g., inability to produce and provide retail services, employee absenteeism, loss of customers, and closure and loss of businesses.

Sociocultural: e.g., overburdened social support networks; threats to subsistence; loss of recreational opportunities; increased desertion and divorce; community conflict; and public health and safety impacts such as injury, illness, and death.

Comprehensive assessment of the environmental and human impacts of coastal hazards promotes "wise investment of limited mitigation dollars" (Heinz Center, 2000, p. 99) to develop effective hazard mitigation strategies – a "Grand Challenge for Disaster Reduction" identified in the National Science and Technology Council report, *Grand Challenges for Disaster Reduction* (National Science and Technology Council, 2005). "Ideally, everything that matters to society with respect to coastal hazards would be measured in terms of true costs, and these costs would serve as the basis for actions to reduce societal and environmental risk and vulnerability. … To the extent that assessments of impacts do not incorporate [the full range of valued environmental, sociocultural, and economic attributes], decision making in advance of future events could be less than optimal" (Heinz Center, 2000, p. 105).

Objective 3.2

Assess Risk and Vulnerability

NCCOS will conduct hazard risk and vulnerability assessments that assess exposure of environmental and human dimensions, and are informed by and responsive to the needs and concerns of decision makers and stakeholders.

Risk and vulnerability assessments are a "systematic approach to organizing and analyzing scientific information" to inform hazard planning, emergency response, and disaster recovery (National Research Council, 1996, p. 4). Common elements of risk and vulnerability assessments include:

- Hazard Identification: Identification of one or more hazards to which a coupled social-environmental system may be exposed;
- Risk Assessment: Estimation of the likelihood that the hazards will occur;
- Vulnerability Assessment: Assessment of the susceptibility of a coupled social-environmental system to potential impacts of the hazards; and
- Characterization of Risks and Vulnerabilities: A synthesis of results that responds to the needs and concerns of decision makers and stakeholders, and addresses uncertainties.

Human Dimensions Influencing Vulnerability to Coastal Hazards

Built Environment: e.g., concentration of population and development relative to hazard, proportion of property insured, quality of construction, and design of critical infrastructure systems.

Business Community: e.g., development and updating of disaster plans, building code compliance, and programs such as interest-free loans for employees.

Sociocultural: e.g., poverty, livelihoods tied to vulnerable resources such as fishing or tourism, physical ability, relevant skills and experience, health condition, and family and community networks.

The National Science and Technology Council report, *Grand Challenges for Disaster Reduction*, recommends assessing and reducing the vulnerability of critical infrastructure such as communications, electricity, financial, gas, sewage, transportation, and water services. In addition to critical infrastructure, vulnerability is mediated by social, economic, and environmental systems and their linkages. For example, global coastal vulnerability is increasing due to multiple, compounding factors such as changing demographic, technological, and socioeconomic conditions; unplanned urbanization; development within high-risk zones; environmental degradation; climate variability; climate change; geological hazards; competition for scarce resources; and the impact of epidemics (United Nations International Strategy for Disaster Reduction, 2005). More generally, vulnerability is influenced by characteristics of and linkages among the natural, built, and sociocultural environments (Heinz Center, 2000).

"The starting point for reducing disaster risk and for promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic, and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in the short and long term" (United Nations International Strategy for Disaster Reduction, 2005, p. 7). Risk and vulnerability assessments provide a basis for collaboration across sectors, agencies, and communities-at-risk to evaluate existing disaster preparedness and response strategies, and focus on critical needs and opportunities for enhancing resilience.

Objective 3.3

Develop Risk Communication Strategies

NCCOS will conduct risk communication research critical to ensure that ecosystem forecasts, early warning systems, and other products promote risk-wise behavior to reduce vulnerability and promote resilience.

In a report entitled *Grand Challenges for Disaster Reduction*, the National Science and Technology Council establishes "promoting risk-wise behavior" as a priority for sustained Federal investment in science and technology to improve America's capacity to prevent and recover from disasters. Individual behaviors and social practices are "risk-wise" so long as they incur reasonable risks to reduce vulnerability and achieve desired outcomes. For example, risk-wise behaviors in relation to harmful algal bloom response include participating in volunteer

phytoplankton monitoring efforts, complying with beach closures, and heeding seafood consumption advisories.

It is important to distinguish between risk-wise behavior and behavior that is absolutely risk-averse. It would be risk-wise to avoid ciguatera fish poisoning by restricting seafood consumption to unaffected species and areas. It would be absolutely risk averse to refrain from consuming seafood to eliminate the risk of mercury poisoning. The recommendation of *Grand Challenges* is to promote behavior that reduces vulnerability to unacceptable outcomes and promotes desired outcomes – though such behavior may involve reasonable risk-taking. (Whether a particular risk is reasonable is an ethical question.)

NCCOS provides a wide range of products that communicate hazard information to various audiences, including forecasts related to climate change, hurricanes, harmful algal blooms, and the hypoxic zone in the Gulf of Mexico; assessments of coastal and ocean water quality and contaminants; and studies related to the detection and risk of aquatic invasive species introduction. As *Grand Challenges* explains, "to be effective, hazard information (e.g., forecasts and warnings) must be communicated to a population that understands and trusts the messages. The at-risk population must then respond appropriately to the information" to avoid and respond to undesirable environmental, sociocultural, and economic consequences (National Science and Technology Council, 2005, 11). The report concludes that "this is a challenge that can only be met by effectively leveraging the findings from social science research" (National Science and Technology Council, 2005, p. 11).

One area of social science critical to develop effective hazard products is risk communication. Risk communication specialists can help NCCOS scientists and program managers identify, understand, and collaborate with user groups (i.e., audiences receiving hazard messages) to develop, test, operationalize, and evaluate products. Ultimately, risk communication research can promote development and transition of products to: (1) ensure that various user groups understand the messages they receive, (2) persuade users to change their attitudes or behavior as appropriate to reduce risk and recover from impacts, (3) create the conditions for effective stakeholder participation in planning and decision making, and (4) achieve other goals of risk management agencies, other decision makers, and interested and affected parties (Renn, 1998).

Risk communication research needs critical to develop hazard products that promote risk-wise behavior and otherwise inform hazard preparedness, emergency response, and disaster recovery efforts include:

Identifying Audiences: To be maximally effective, NCCOS products must respond to the needs and concerns of, and deliver understandable messages to, a wide variety of user groups. In general, these include not only natural resource managers, but also (depending on the hazard) affected communities, emergency responders, local and regional planners, public health professionals, private sector groups such as the tourism industry and flood insurance industry, marine resource user groups, and other parties. Audiences may be direct (receiving information directly from use of the product) or secondary (receiving information from direct users or other channels such as the mass media). NCCOS product development must consider the needs of,

and receive feedback from, both direct and secondary audiences – i.e., reaching beyond "traditional" audiences such as coastal resource managers.

Understanding Audiences: To communicate hazard information effectively, it is critical to understand intended audiences. Characteristics of audiences that can influence product effectiveness (by influencing access, interpretation, and response to hazard communication) include relevant concerns, perceptions of risks, attitudes, knowledge, level of credence and trust in authorities, cultural attributes, and primary information sources. A "mental models" approach to the design of risk communication uses formal analysis and empirical study to compare an ideal or "expert" understanding to an audience's "layperson" understanding of risks, impacts, and mitigation strategies related to a hazard. Comparison reveals gaps in audience knowledge and misconceptions that should be addressed in product development to promote understandability of messages and effectiveness in prompting risk-wise response (Atman et al., 1994).

Building Organizational Trust: The extent to which an audience believes risk information is closely related to its degree of trust and confidence in the communicating agency or other party (Kasperson, 1986). Trust and credibility are influenced by factors such as perceptions of communicators' knowledge, openness, honesty, and concern (Peters et al., 1997). Given the importance of trust and credibility in communicating hazard information, NCCOS will engage risk communications specialists to design products that help coastal managers and other direct users establish trust and credibility with their constituents and customers.

Developing Effective Messages and Strategies: The content and delivery of hazard information can influence an audience's interpretation and behavioral response. For example, the way in which hazard information is presented can significantly influence an audience's understanding, perception of the sending agency, disposition to consider the relevance of the information, and decision to seek additional supporting or contradicting information (Scherer et al., 1999). Similarly, strategic decisions such as communication objectives and channels must be based on audience analysis to be effective. NCCOS will utilize risk communication specialists to develop effective hazard products by studying and collaborating with audiences to develop prototypes, test prototypes using experimental methods, and ultimately apply risk communication science to develop effective hazard products.

Consistent with NOAA's Policy on Transition of Research to Application, which requires research programs to dedicate funds and personnel to operational production, and the *Grand Challenges* report, which establishes "promoting risk-wise behavior" as a Federal priority, all NCCOS research programs related to hazards will include a risk communication component addressing needs such as those discussed above.

Objective 3.4

Evaluate Forecasting and Other Capabilities

NCCOS will evaluate the efficacy of its hazard forecasts and other products for reducing cumulative impacts on valued environmental, sociocultural, and economic attributes.

The Government Performance and Results Act of 1993 requires Federal agencies to submit to the President and Congress an annual report evaluating the effectiveness of program activities in achieving strategic performance goals. Among other purposes, these strategic planning and program evaluation requirements are intended to: (1) "improve Federal program effectiveness and public accountability," (2) "help Federal managers improve service delivery by requiring that they plan for meeting program objectives and by providing them with information about program results and service quality," and (3) "improve congressional decision making by providing more objective information on achieving statutory objectives, and on the relative effectiveness and efficiency of Federal programs and spending" (31 U.S.C. § 2(b)(2-5)). In addition, pursuant to Executive Order 12862 for "Setting Customer Service Standards" (1993), customer satisfaction measurement is critical to evaluate program outputs against customer needs and standards.

Economic, risk communication, and customer satisfaction approaches are critical to systematically assess the manner and extent to which program outputs, such as synthesized data and forecast products, achieve program performance goals. For example, a "value of information" approach estimates the economic value of market and non-market benefits resulting from improved decision making enabled by information such as synthesized data or a forecast product (e.g., Centric Consulting Group, 2003; Kite-Powell et al., 2004). In addition, risk communication specialists use multiple methodologies to retrospectively evaluate the efficacy of communications for program goals such as audience understanding of messages, targeted changes in attitudes or behavior that reduce impacts, or facilitation of successful stakeholder participation (Bostrom et al., 1993).

Goal 4 Provide Organizational Support

Objective 4.1

Build Organizational Capabilities

NCCOS will build organizational capabilities critical to achieve the goals and objectives of this plan.

NCCOS's commitment to a comprehensive ecosystem science enterprise introduces scientific, organizational, and individual challenges. From a scientific standpoint, ecosystem science requires new approaches for linking the concepts, methods, and results of environmental and human dimensions research to inform decision making. From an organizational standpoint, critical needs include greater capacity in human dimensions expertise; leadership with interdisciplinary understanding and team-building skills across disciplines; organizational practices that identify, encourage, require, and reward mission-critical human dimensions research; integrated research prioritization and planning; adequate funding for human dimensions and interdisciplinary research; and leadership and workforce training to facilitate awareness and appreciation of the mission value of human dimensions research. Fundamentally, envisioning and implementing such scientific and organizational transformations requires fostering a workforce with the knowledge, skills, and dispositions to engage in and be transformed by learning, communication, and collaboration across disciplines.

As part of a follow-up implementation plan, NCCOS will develop a strategy to build critical organizational capabilities, including:

Human Resources: Develop an exceptional, competitively hired human dimensions team with an organizational structure that fosters cooperation in identifying and implementing human dimensions research priorities across NOAA and NCCOS centers/laboratories and research programs;

Human Dimensions Literate Workforce: Foster a workforce that understands, appreciates, advocates, and incorporates the mission value of human dimensions research;

Financial Resources: Harness appropriate budgetary processes to seek and dedicate adequate funding for actions critical to implement this plan.

Integrated Research Prioritization and Planning: Ensure integrated environmental and human dimensions research prioritization and planning in NCCOS, PPBES (Planning, Programming, Budgeting, and Execution System), and other planning processes.

Partnerships: Identify and collaborate with NOAA and external partners for human dimensions research priorities.

Objective 4.2

Provide Communications, Outreach, and Education Support

NCCOS will identify and implement communications, outreach, and education strategies promoting the goals and objectives of this plan.

The purpose of this objective is to ensure that NCCOS communications outreach, and education efforts provide critical support to achieve the goals and objectives of this plan. Critical functions include reaching out to diverse audiences (e.g., NCCOS employees, partners, Congress, the public, students, coastal managers and other decision makers) to:

Promote Ecosystem Literacy: NOAA has adopted a cross-cutting priority and strategic plan to promote environmental literacy defined as "understanding of the earth around us" (NOAA 2004c) or "understanding of our planet's dynamic air and water systems and the effect those systems have on all aspects of people's lives" (NOAA 2005a, 2004c). NCCOS recognizes that environmental literacy is necessary, but not sufficient to support NOAA's vision of "a better world through environmental and ecological knowledge and stewardship" (NOAA 2005a). Ecosystem literacy – defined as integrated understanding of interactions across all ecosystem components (including human causes, consequences, and responses to environmental change) – is critical to inform decision making by individuals, businesses, governments, the NOAA workforce, and other actors. NCCOS will promote ecosystem literacy by integrating human dimensions information to reflect a comprehensive ecosystem approach in all internal and external communications, outreach, and educational activities.

Promote Human Dimensions Research Priorities: NCCOS will identify human dimensions research priorities and promote them through leadership in NOAA's Ecosystem Research Program, Ecosystem Goal Team, PPBES (Planning, Programming, Budgeting, and Execution System), strategic and research planning, and other venues.

Promote Visibility of NCCOS Human Dimensions Research: Communications, outreach, and education venues also provide opportunities to promote the visibility of NCCOS human dimensions research activities and products, which can serve to enhance national recognition, foster partnerships, and increase the trust and assistance of constituents.

Develop a Human Dimensions Workforce: A strategic goal of the Education Plan for NOAA is to increase the number of people, particularly in underrepresented groups, who choose education and careers supporting NOAA's mission. NOAA's Educational Partnership Program accomplishes this by providing financial assistance through competitive processes to minority serving institutions. Consistent with the findings of the Social Science Review Panel to NOAA's Science Advisory Board (NOAA Science Advisory Board, Social Science Review Panel, 2003), NCCOS recognizes a special need to develop and attract employees with critical human dimensions expertise. Through collaborations with NOAA's Educational Partnership Program (particularly the Environmental Cooperative Science Center), sponsorship of Knauss Marine Policy Fellows, and other opportunities, NCCOS will promote development of a human dimensions workforce supporting NOAA's mission.

Appendix 1. Human Dimensions Background

A. Understanding Human Dimensions of Ecosystems

"Environmental governance depends on good, trustworthy information about stocks, flows, and processes within the resource systems being governed, as well as about the human-environment interactions affecting [and affected by] those systems" (Dietz et al., 2003, p. 1908). Consequently, integration of the social and environmental sciences is an "increasingly important element of emerging research and development programs in the federal agencies" (National Research Council, 2005, p. 21).

The human dimensions of ecosystems can be described in terms of three points of interaction between environmental and human systems: (1) human causes of environmental change; (2) consequences of environmental change for the achievability, sustainability, and tradeoffs among societal objectives; and (3) human mitigative and adaptive responses to environmental change (National Research Council, 1992) (Figure 5, p. 9). Encompassing a broad array of interrelated disciplines across the social and behavioral sciences, humanities, communication sciences, and related interdisciplinary studies (Figure 6, p. 10), **human dimensions research** aims to understand these human-environmental interactions and facilitate use of this understanding to support decisions affecting environmental processes and their societal outcomes.

Ecosystem

As defined by NOAA, an **ecosystem** is a "geographically specified system of organisms [including humans], the environment, and the processes that control its dynamics. Humans are an integral part of an ecosystem" (NOAA, 2005a, p. 3). Recognizing the linkages between environmental systems, resource management science has predominantly adopted a systems approach focusing on **coupled environmental-human systems** referred to as "social-ecological systems" (e.g., in theory and as applied to fisheries management, Berkes and Folke, 2000; Gunderson and Holling, 2002; Hanna, 1998; Lee, 1994; Young, 2002) (Figure 7).

NOAA's Definition of an Ecosystem

A "geographically specified system of organisms [including humans], the environment, and the processes that control its dynamics. Humans are an integral part of an ecosystem" (NOAA, 2005a, p.3).

Ecosystem Stress

Any degradation to the structure or function of an ecosystem, including the well-being of current and future generations of humans, is a form of **ecosystem stress**. The U.S. Commission on Ocean Policy (2004) suggests that prevalent causes of ecosystem stress are water quality degradation (from excess nutrients, other contaminants, harmful algal blooms and sediment contamination), compromised resources (related to fishery declines, coastal habitat loss, and invasive species), and climate change. Such forms of environmental degradation are called "ecosystem" stressors rather than "environmental" stressors because they can be influenced by, and have profound sociocultural and economic consequences for, human and social welfare.

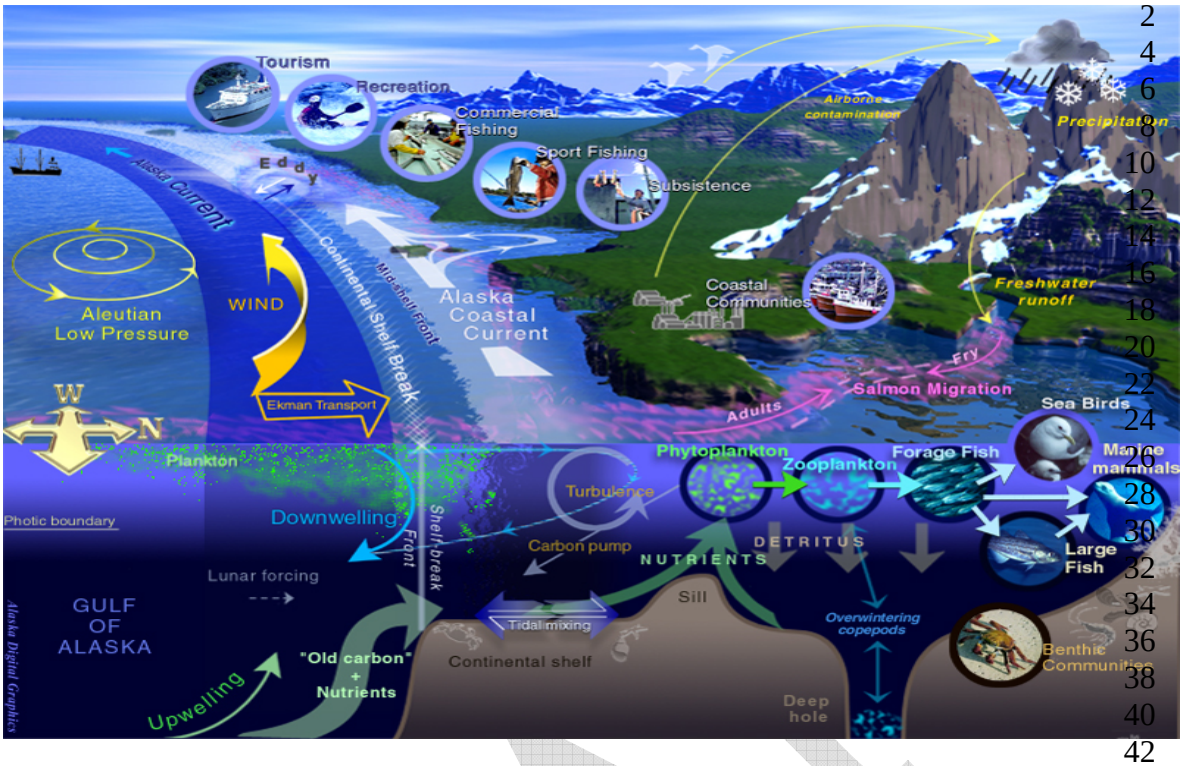


Figure 7. Coupled human-environmental systems.

Human Causes of Ecosystem Stress

Ecosystem stress can have anthropogenic and/or non-anthropogenic causes. Human activities that significantly contribute to ecosystem stress are called **proximate human causes**. For example, agricultural practices significantly contribute to nitrogen over-enrichment in the Gulf of Mexico, which fuels hypoxic conditions that threaten the suitability of waters for swimming and drinking, cause fishery declines, and precipitate clogged pipes and loss of recreational opportunities (Committee on Environment and Natural Resources, 2000). Human activities that act as proximate causes of ecosystem stress are driven by a complex of social variables referred to as **social drivers**. Social drivers include values, attitudes, and beliefs that motivate human behavior; demographic changes; market dynamics; organizational structures; equity issues; political dynamics; regulatory mechanisms; and technological innovations.

Consequences of Ecosystem Stress for the Achievability and Sustainability of Human Values

Natural capital and functions integral to environmental systems provide **ecosystem goods and services** essential to the well-being of current and future generations. Ecosystem goods and services can be categorized as supporting (e.g., nutrient cycling and soil formation), provisioning (e.g., timber and food), regulating (e.g., water purification and flood control), or cultural (e.g., spiritual opportunities and aesthetic experiences). Such goods and services are essential to support **human well-being** in that they directly or indirectly provide for human values such as:

- Security - e.g., secure resource access and protection from natural disasters;

- Basic material for a good life - e.g., sufficient nutritious food, shelter, and access to goods;
- Health - e.g., feeling well and access to clean air and water;
- Good social relations - e.g., social cohesion, mutual respect, and ability to help others; and
- Freedom of choice and action - e.g., provision of opportunities to achieve personal values and foster personal identity (Millennium Ecosystem Assessment, 2005).

Ecosystem stress threatens the well-being of current and future generations by degrading the quantity, quality, or intergenerational sustainability of ecosystem services. For example, coral reef disease and mortality (environmental degradation) result in a decline in the quantity and diversity of available reef products such as fish, seaweed, crabs, sea cucumbers, and lime (impact on a provisioning service). Reduced flow of these valued ecological components can threaten the food security and livelihood stability of reef-dependent communities and increase conflict among reef stakeholders (a significant threat to human well-being) (Whittingham et al., 2003).

Human Response: Mitigation and Adaptation

Ecosystem stress is mediated by human intervention aiming to sustain diverse human values. Human intervention can be directed at the human causes or consequences of ecosystem stress. **Mitigation measures** aim to prevent, limit, delay, or slow the rate of undesired *impacts* on environmental systems. They include direct modification of environmental systems (e.g., installing artificial coral reefs to provide essential fish habitat); reducing proximate human causes of ecosystem stress (e.g., regulating a fishery to prevent depletion of stocks); and intervening with social drivers (e.g., providing education and financial assistance to promote agricultural practices that reduce nitrogen inputs). **Adaptive responses** aim to reduce or eliminate deleterious *consequences* of environmental degradation for human well-being. They include blocking impacts of environmental degradation on human values (e.g., improving diagnosis and treatment of illness caused by harmful algal blooms); adjusting to experienced impacts (e.g., evacuating a flooded area); and modifying human systems to reduce anticipated impacts (e.g., establishing early warning systems for hazards) (National Research Council, 1992).

In the context of ecosystem-based resource management, **governance** includes the design and implementation of mitigation and adaptation strategies to promote and sustain societal objectives. Such strategies encompass "the formal and informal arrangements, institutions, and mores which determine how resources or an environment is utilized; how problems and opportunities are evaluated and analyzed; what behavior is deemed acceptable or forbidden; and what rules and sanctions are applied to affect the pattern of resource use. As suggested by this definition, the concept of governance is not equivalent to government but rather incorporates other mechanisms and institutions" that direct humans to satisfy their needs and fulfill their wants" (Juda, 1999, pp. 90-91). For example, resource governance encompasses the roles of non-governmental organizations, economic instruments, cultural worldviews and practices, technological innovation, and social arrangements in shaping human behavior and social interaction in relation to environmental systems.

In the most general terms, "governance arises as a social or societal concern whenever members of a group find that they are interdependent in the sense that the actions of each impinge on the

welfare of others" (Young, 1994, p.15). For example, when multiple users have access to a common pool resource such as a fishery, the harvesting practices of each influence the resource availability for the others. "Interdependence is likely to become a source of conflict when the efforts of individual members of the group to achieve their own goals interfere with or impede the efforts of other to pursue their own ends. It will be seen as a basis for cooperation, on the other hand, when opportunities arise to enhance social welfare by taking steps to coordinate the actions of the individual members of the group" (Young, 1994, p.15).

B. Balancing Societal Objectives

NOAA defines an **ecosystem approach to management** as "management that is adaptive, specified geographically, takes into account ecosystem knowledge and uncertainties, considers multiple influences, and strives to balance diverse societal objectives" (NOAA, 2005a, p. 3).

Societal Objectives

The term "**value**" encompasses the variety of opportunities, experiences, and conditions (environmental, social, and personal) that matter to people and, through individual and coordinated efforts to realize them, guide human action. The term "s**ocietal objective**" refers to values predominantly shared by some social group such as a geographic, cultural, or resource user group. Societal objectives embody the full depth and dimensionality of the human experience, including personal and cultural attachment of significance to actual and potential resource uses, the experience and existence of natural environments, social relations, economic conditions, health and security, and opportunities for future generations.

Articulating a Management Vision

Values as Management Ends

Management goals establish a vision of success – i.e., a definition of a well-managed ecosystem or, more generally, a picture of what sort of world is worth pursuing. Environmental and social scientists can inform resource managers about the actual and predicted structure and function of an ecosystem, and the natural and human ecological consequences of alternative courses of action. But the question of what sort of ecosystem is worth pursuing is beyond the reach of science. Science generates information *describing* ecosystem conditions (the way ecosystems *are* or will be). In contrast, articulating a management vision is an endeavor in *prescribing* ecosystem conditions (the way ecosystems *should* be) by identifying, articulating, and prioritizing values as management ends. (The technical term for prescriptive judgments concerning what matters or the way things ought to be is *normative*). Stakeholders who agree on all the relevant scientific facts may nonetheless rationally disagree about what matters, or what matters most – the ends of resource management.

Conflict

"Sharp differences in power and in values across interested parties make conflict inherent in [resource management]. Indeed, conflict resolution may be as important a motivation for

designing resource institutions as is concern with the resources themselves" (Dietz et al., 2003, p. 1909). When the way in which one value is pursued threatens or prevents the realization of another, articulating a management vision requires either (a) reducing or eliminating conflict to make values mutually achievable in so far as possible across social groups, places, and generations or (b) when conflict is intractable, rationally establishing priorities. As Juda explains, "all societies are faced with mutually exclusive choices regarding the use of resources. In line with the concept of opportunity costs, the use of a limited resource obviates its alternative uses. Accordingly, some values must be given a higher, and others a lower, priority" (Juda, 1999, p. 96).

Empirical study of conflict is important to inform goal-setting, strategy development, and implementation in resource management. Social scientific methods include:

- *Mapping stakeholders, their interests, and their preferences for conflict management:* Stakeholders commonly involved in coastal conflicts include resource user groups such as fishermen or tourists, governmental agencies, and scientific institutions or researchers. Conflict can occur across economic sectors, cultural groups, geographic communities, nations, and generations;

- *Analyzing conflicts:* For example, conflict analysis can focus on the attendant social context, relationship to environmental status and trends, or underlying disagreement concerning values and value priorities;

- *Developing methods for conflict management:* For example, methods include direct engagement of stakeholders such as deliberative decision processes and development of institutions such as market-based systems (e.g., tradable environmental allowances); and

- *Integrating stakeholder analysis, conflict analysis, and conflict management into resource management:* This area of inquiry examines the ways in which conflict analysis and management can be integrated as components of resource management (Bruckmeier, 2005).

Establishing Priorities

Defining a reasonable "balance" by establishing priorities across conflicting objectives is a societal decision process intermingling scientific understanding (and uncertainty) with consideration of diverse and oftentimes divergent value judgments. NOAA, the Coastal States Organization, and the U.S. Commission on Ocean Policy have all highlighted the need for guidance in grappling with this intermingling of science and values in articulating a management vision (NOAA and Coastal States Organization, 2006; U.S. Commission on Ocean Policy, 2004).

In the face of intractable conflict, articulating a management vision requires not only understanding what matters to stakeholders (e.g., through stakeholder assessment as discussed in Objective 1.1), but also engaging stakeholders to rationally decide what matters most. Yet the National Research Council found that "in most cases, the weighing or balancing of conflicting objectives … is either ignored or only partially addressed" by environmental decision making

(National Research Council, 2005, p. 188). Recognizing this shortfall, the U.S. Commission on Ocean Policy calls for new approaches to help coastal and ocean resource managers engage diverse stakeholders to articulate a management vision (U.S. Commission on Ocean Policy, 2004, p. 66).

The National Research Council (1996) recommends decision making that combines analysis and deliberation. Well-structured decision processes may be defined in terms of characteristics such as identifying stakeholder objectives; summarizing areas of agreement and disagreement among stakeholders, and their underlying rationales; determining priorities through rational and democratic debate; defining alternative courses of action to achieve the vision of success; describing consequences of alternatives in terms of the achievability, sustainability, and tradeoffs among objectives; examining how alternatives will affect future decisions; and considering uncertainty (e.g., Hammond et al., 1999; Gregory et al., 2001). The design and implementation of such decision procedures is an inherently interdisciplinary enterprise, requiring perspectives from the environmental and social sciences, and applied ethics. Applied ethicists should play a key role by providing theoretical and deliberative guidance for, and playing a mediating role in, multi-stakeholder discussions articulating and weighing values.

C. Promoting Ecosystem Resilience

In 2003, coastal counties accounted for 53 percent of the nation's population, or 153 million people, although they make up only 17 percent of the total land area of the United States (not including Alaska) (NOAA, 2004b). These coastal populations are exposed to anthropogenic and non-anthropogenic hazards, both chronic and episodic, such as floods, harmful algal blooms, hurricanes, aquatic nuisance species, oil spills, erosion, and pollution. A **hazard** is "an act or phenomenon that has the potential to produce harm or other undesirable consequences to humans or what they value" (National Research Council, 1996, p. 215). Maintaining ecosystem function and social welfare in coastal areas – and, through linkages such as commerce and social networks, the Nation – requires building the necessary capacities at the community and national levels for vulnerability reduction and disaster prevention, mitigation, and preparedness (United Nations International Strategy for Disaster Reduction, 2005).

A National and International Priority

Resilience is a national and international priority (e.g., Disaster Mitigation Act of 2000; International Strategy for Disaster Reduction, 2005). For example, the ten-year strategy for disaster reduction developed by the National Science and Technology Council's Subcommittee on Disaster Reduction, *Grand Challenges for Disaster Reduction*, presents six grand challenges for disaster reduction and provides a framework for prioritizing Federal investments to achieve them.

Acknowledging this national and international priority, the National Research Council provides a framework for sustained national investment in social science critical to understand and promote hazard resilience. The Council concludes that "disaster research, which has focused historically on emergency response and recovery, is incomplete without the simultaneous study of the

societal hazards and risks of disasters, which includes data on the vulnerability of people living in hazard-prone areas" (National Research Council, 2006, p. 2).

The National Research Council recommends an integrative approach linking environmental and social science disciplines within a framework that appreciates linkages across hazards and disaster research. Specifically, the Committee notes that "hazards and disaster research have evolved in parallel, with the former focusing primarily on hazards vulnerability and mitigation and the latter primarily on disaster response and recovery, and the two veins intersecting most directly with common concerns about disaster preparedness. It is vital, however, that future social science research treat hazards and disaster research interchangeably and view the five core topics of hazards and disaster research [Figure 8] within a single overarching framework. Such integration also provides the foundation for increased collaborative work by social scientists with natural scientists and engineers" (National Research Council, 2006, p. 2).

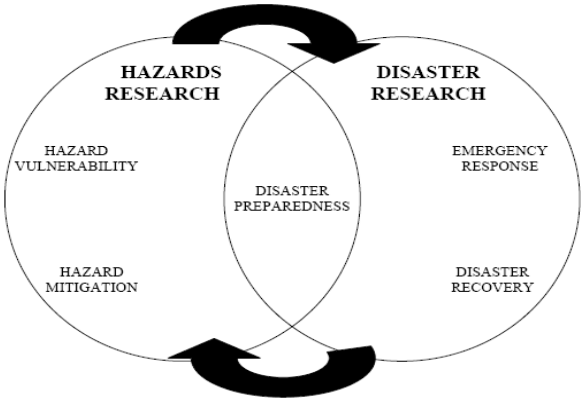


Figure 8. Core topics of hazards and disaster research (National Research Council, 2006).

Resilience and Vulnerability

As defined by the United Nations International Strategy for Disaster Reduction, **resilience** is the capacity of a "system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures" (United Nations International Strategy for Disaster Reduction, 2004, p.4).

Conversely, **vulnerability** refers to an erosion of resilience – i.e., the susceptibility of a coupled social-environmental system to incur impacts from hazards. Essential capacities or forms of "capital" enable individuals, households, communities, institutions, and nations to resist and recover from the impacts of hazards: *natural capital* (e.g., natural resources and ecological services), *social capital* (e.g., relationships of reciprocity and institutions that govern relationships within and between social groups and natural resources), *cultural capital* (e.g., means of production), *human capital* (e.g., knowledge and skills), *economic capital* (e.g., savings), and *physical capital* (e.g., lifeline infrastructure) (Berkes and Folke, 1998).

Resilience and vulnerability are properties of coupled social-environmental systems (as opposed to environmental or social systems considered independently). "Importantly, the social and biophysical responses or coping mechanisms influence and feed back to affect each other, so that a response in the human subsystem could make the biophysical subsystem more or less able to cope, and vise versa" (Turner et al., 2003, p. 8077). For example, "environmental degradation such as land clearing, coastal erosion, over fishing, and coral mining has reduced the potential

for economic recovery from the [2004] Asian tsunami because of the loss of traditional income sources related to coastal ecosystems rich in biodiversity and ecosystem functions" (Adger et al., 2005, p. 1038).

The "acceptable level of functioning" that sets the standard for resilience is fundamentally a value judgment. Alternate regimes of environmental and social systems (i.e., "configurations in which the kinds or strengths of feedbacks differ and in which there are different internal controls on function") can have "significantly different implications for society and thus call for societal decision as to which is most desirable" (Walker et al., 2006, p. 2). For example, society faces a decision between a hypoxic regime in the Gulf of Mexico (characterized by substantial declines in commercially important fisheries) and a regime characterized by acceptable water quality (but requiring changes to agricultural practices that come with economic, political, social, and other costs and benefits) (National Science and Technology Council, 2000). This is a decision about which state of affairs is best – a value judgment. Accordingly, risk reduction and disaster response are part of community development – research and practice aiming to build community capacities to define and sustain sociocultural, economic, and environmental goals.

Appendix 2. Mission Drivers

The following is a non-exhaustive list of mandatory authorities, authorizations, statutes of general applicability, and significant reports that require or substantially inform NCCOS's commitment to human dimensions research. Drivers are categorized as cross-cutting or applicable to specific stressors, regions, or managed areas.

Cross-Cutting

International

Title	Human Dimensions Relevance
Agenda 21 – Chapter 17: Oceans and Coasts United Nations Environment Programme (UNEP), 1992	Promotes sustainable development of the marine and coastal environment through measures such as: - Providing an integrated policy and decision-making process to promote a balance of uses; - Identifying existing and projected uses of coastal areas and their interactions; - Developing and applying methods, such as national resource and environmental accounting, that reflect changes in value resulting from uses of coastal and marine areas; - Developing socioeconomic and environmental indicators; - Developing economic incentives to avoid degradation of the marine environment; and - Taking into account traditional knowledge and interests of local communities, small-scale artisanal fisheries, and indigenous people in development and management programmes.
Convention on Biological Diversity UNEP, 1992	Establishes three main goals to be achieved through national monitoring and in-situ conservation measures: conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising from the use of genetic resources.
Convention on Biological Diversity Strategic Plan UNEP, 2002	Guides implementation of the Convention of Biological Diversity at the national, regional, and global levels. Discusses socioeconomic obstacles to implementation: poverty, population pressure, unsustainable consumption and production patterns, and lack of capacities for local communities.
Global Program of Action for the Protection of the Marine Environment from Land-Based Activities UNEP, 1995	Provides guidance for devising and implementing sustained action to prevent, reduce, control, and/or eliminate marine degradation from land-based activities. Affirms that action priorities should, among other human dimensions considerations: - Reflect the relative importance of impacts upon food security, public health, coastal and marine resources, ecosystem health, and socio-economic benefits, including cultural values; - Reflect the costs, benefits, and feasibility of options for action, including the long-term cost of no action; and - Involve stakeholders – specifically, local authorities and communities and relevant social and economic sectors, including nongovernmental organizations, women, indigenous people, and other major groups.

International Human Dimensions Program on Global Environmental Change (IHDP) Science Plans IHDP, 2006	The IHDP is an international, interdisciplinary, non-governmental science program dedicated to promoting, catalyzing, and coordinating research on the human dimensions of global environmental change. IHDP has seven core projects with science plans and implementation strategies: Global Environmental Change and Human Security; Institutional Dimensions of Global Environmental Change; Industrial Transformation; Land-Use and Land-Cover Change; Land-Ocean Interactions in the Coastal Zone; Urbanization and Global Environmental Change; and Global Land Project. (http://www.ihdp.uni-bonn.de/)
Millennium Ecosystem Assessment Island Press, 2005	"Focuses on ecosystem services (the benefits people obtain from ecosystems), how changes in ecosystem services have affected human well-being, how ecosystem changes may affect people in future decades, and response options that might be adopted at local, national, or global scales to improve ecosystem management and thereby contribute to human well-being and poverty alleviation. Synthesizes information from the scientific literature, datasets, and scientific models, and includes knowledge held by the private sector, practitioners, local communities and indigenous peoples" (from http://www.maweb.org/en/index.aspx)
Rio Declaration of Principles UNEP, 1992	Establishes principles guiding national conduct for sustainable development, including the need to reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies (Principle 8); the importance of public participation (Principle 10); use of the precautionary approach in the face of scientific uncertainty (Principle 15); the need for economic instruments to internalize environmental costs (Principle 16); and the vital role of indigenous and local communities in environmental decision making (Principle 22).

National

Title	Human Dimensions Relevance
America's Living Oceans: Charting a Course for Sea Change Pew Oceans Commission, 2003	Recommends reform in national policies and practices to combat major threats to oceans. Calls for increased national social science research capacity, including "monitoring of both human and natural systems" (p. 90) and documentation of traditional ecological knowledge. For example, the report affirms that ""we need to know as much about people and economics as we do about the biology and ecology of living marine resources and ecosystems. Complex interactions between human and environmental systems must be better understood. Cooperative research involving the fishing industry and native communities, that offer valuable experiential and traditional knowledge, should be a central element of a number of these new scientific programs" (p. 89). (http://www.pewoceans.org/)
Charting a Course for Ocean Science in the United States: Research Priorities for the Next Decade Joint Subcommittee on Ocean Science and Technology (JSOST), 2006	Establishes an Ocean Research Priorities Plan and Implementation Strategy designed to identify and realize national priorities for ocean science and technology. A draft dated August 30, 2006, lists the following priorities: - "Understand human-use patterns that may influence resource stability and sustainability" (p. 4); - "Understand how human use and valuation of ocean resources affect and can be affected by ocean impacts on human health" (p. 5); - "Apply understanding of socioeconomic activities involving marine ecosystems to maximize the ability of those ecosystems to provide essential goods and services" (p. 5); - "Understand human health risks associated with the ocean and the potential benefits of ocean resources to human health (p. 5); and - "Apply understanding of human behavior to develop information and tools necessary to carry out effective, safe, and secure marine operation" (p. 5). (http://ocean.ceq.gov/about/jsost.html)

Coastal Zone Management Act and Amendments 16 U.S.C. §§ 1451 et seq.	Provides Federal grants to states for the development and implementation of coastal zone management programs to "achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development." The Act provides flexibility to states in selecting management priorities that tradeoff objectives of resource use and conservation.
Coral Reef Conservation Act and Amendments 16 U.S.C. §§ 6401 et seq.	Authorizes NOAA to issue matching grants of financial assistance for broad-based coral reef conservation activities, consistent with the purposes of the Act. The 20006 reauthorization specifies criteria for project approval, including "promoting and assisting entities to work with local communities, and all appropriate governmental and nongovernmental organizations, to support community-based planning and management initiatives for the protection of coral reef systems." This Act provides NCCOS an opportunity to protect coral reefs by partnering with internal and external partners to conduct critical human dimensions research.
Executive Order 12866 – Regulatory Planning and Review	Requires regulatory agencies, in deciding whether and how to regulate, to assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits include both quantifiable measures and qualitative measures that are difficult to quantify, but nevertheless essential to consider.
Implementing the Work Priorities of the Subcommittee on Integrated Management of Ocean Resources (SIMOR) SIMOR, 2006	Identifies priority areas and related action items to improve coastal and ocean resource use and conservation. Proposes initiatives addressing human dimensions, including: - Conducting community workshops to "demonstrate new and innovative ways to integrate coastal and watershed management programs, funding sources, policies, and other tools" (p. 7); and - Expanding Ocean and Coastal Economics Data and Analysis to "support the needs of federal agencies and state and local governments for comprehensive economic data to address specific management problems such as ocean and coastal transportation and infrastructure issues, minerals management, and understanding of tourism and recreation at the state and local level" (p. 8). (http://ocean.ceq.gov/about/docs/SIMOR_WorkPlan_Final.pdf)
Interorganizational Committee on Principles and Guidelines for Social Impact Assessment Impact Assessment and Project Appraisal, 2003, 21(3): 231-250	Provides guidance for the conduct of social impact assessment in the context of the National Environmental Policy Act. Six principles focus on understanding of local and regional settings; dealing with the key elements of the human environment; using appropriate methods and assumptions; providing quality information for decision making; addressing environmental justice issues; and establishing mechanisms for monitoring and mitigation. (http://www.nmfs.noaa.gov/sfa/reg_svcs/social%20guidandpri.pdf)
National Action Plan to Conserve Coral Reefs U.S. Coral Reef Task Force, 2000	Provides a detailed, long-term strategy for implementing Coral Reef Protection Executive Order 13089, which charges the U.S. Coral Reef Task Force with developing and implementing, with the scientific community, research aimed at identifying the major causes and consequences of degradation of coral reef ecosystems. Adopts a core principle to "incorporate the human dimension into coral reef conservation strategies by ensuring that management measures reflect, and are sensitive to the local socioeconomic, political and cultural environment, and that they build an informed public engaged in choosing alternatives to activities that harm coral reefs." Specifies four major components of understanding coral reef ecosystems and their long-term conservation, including "socioeconomic studies of the human dimension of successful coral reef conservation." (http://www.coralreef.gov/taskforce/pdf/CRTFAxnPlan9.pdf)

National Environmental Policy Act 42 U.S.C. §§ 4321 et seq.	Requires Federal agencies to: - Utilize a systematic, interdisciplinary approach integrating the natural and social sciences, and the environmental design arts, in planning and in decision making which may have an impact on the environment; - Consider presently unquantified environmental amenities and values in decision making; and - Prepare an Environmental Impact Statement prior to approval of any major Federal action significantly affecting the quality of the human environment.
National Environmental Policy Act - Regulations for Implementing Procedural Provisions 40 C.F.R. 1508.14	Requires Federal agencies to interpret "human environment" comprehensively to "include the natural and physical environment and the relationship of people with that environment. … When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment."
Ocean Blueprint for the 21st Century U.S. Commission on Ocean Policy, 2004	Develops recommendations for a coordinated and comprehensive national ocean policy, as mandated by the Oceans Act of 2000, including consideration of human dimensions and explicit calls for social science research. For example, Recommendation 25-3 urges that a new "National Ocean Council (NOC) research strategy should include a national program for social science and economic research" that includes: - An operational socioeconomic research and assessment function within the National Oceanic and Atmospheric Administration (NOAA). - An interagency steering group, chaired by NOAA … to coordinate ocean-related socioeconomic research" (p. 384). (http://www.oceancommission.gov/documents/welcome.html)
Oceans and Human Health Act 33 U.S.C. §§ 3101-3104	Establishes a national research program to improve understanding of the role of the oceans in human health.

NOAA

Title	Human Dimensions Relevance
NOAA National Ocean Service Social Science Plan NOAA, 2003	Summarizes social science capacity in NOAA's National Ocean Service and establishes goals for social science as a basis for coordination to further NOAA's mission. (http://marineeconomics.noaa.gov/SSP/Plan_pub.html)
NCCOS Strategic Plan FY 2005 – FY 2009 NOAA, 2004	NCCOS's second strategic goal regarding societal stressors "focuses on the human activities that affect coastal ecosystems. Successfully managing those activities to reduce the stress they impose on ecosystems requires a sound scientific basis. It also requires a good understanding of what society desires of the services provided by the management of coastal ecosystems. By combining the social expectations, economic costs and benefits, and the natural sciences, NCCOS will be able to make predictions (with specified certainty) of the social and economic costs and benefits of alternative management actions that could be taken to achieve ecosystem conservation goals" (p. 16). (http://www.nccos.noaa.gov/documents/strategicplan.pdf)
Evolving an Ecosystem Approach to Science and Management Throughout NOAA and its Partners External Ecosystem Task Team Report	Identifies three guiding considerations that cut across its recommendations on how to improve NOAA's ecosystem science enterprise over the next decades. Two of these address human dimensions: (1) "NOAA science and management need to take account of how human activities affect the ecosystem properties for which NOAA is steward – and how those ecosystem properties affect the wellbeing of citizens socially, economically, and culturally; and (2)

to NOAA Science Advisory Board, 2006	NOAA science support for decision-making must be integrated across ecosystem components and across its management of different human activities" (p. 27). Recognizes social science as integral to core capabilities in monitoring, analysis, and integration needed in each region to develop Integrated Ecosystem Assessments as key components of NOAA's ecosystem science enterprise. Overall, affirms that "both natural and social sciences, including communication of science, are critical elements at whatever scale and for whatever purpose ecosystem approaches are being developed" (p. 26). (http://www.sab.noaa.gov/Reports/eETT_Final_1006.pdf)
New Priorities for the 21st Century – NOAA's Strategic Plan: Updated for FY 2006-FY 2011 NOAA, 2005	Recognizes that "humans are an integral part of an ecosystem" (p. 3). Adopts an ecosystem approach to managing coastal and ocean resources that strives to balance diverse societal objectives. Aims to improve resource management by "advancing our understanding of ecosystems by gathering information consistent with established social and economic indicators to support monitoring, assessing, and predicting national and regional ecosystem health" (p. 5). Affirms the need for "a strong economic and social science capability" to ensure sound, state of the art research by analyzing and understanding "evolving user requirements, priorities, and benefits of our information, services, and products" (p. 16). (http://www.ppi.noaa.gov/pdfs/STRATEGIC%20PLAN/Strategic_Plan_2006_FINAL_04282005.pdf)
Social Science Research Within NOAA: Review and Recommendations Final Report to the NOAA Science Advisory Board (SAB) by the Social Science Review Panel, 2003	Finds that "the capacity of NOAA to meet its mandates and mission is diminished by the under-representation and under-utilization of social science" (p. 1), yet developing adequate capacity is challenged by "a lack of formal understanding of what social science is and what its contributions can be, leading to an organizational culture that is not conducive to social science research" (p. 2). Among other recommendations, the Panel advises integrating social science goals, plans and outcomes into strategic plans; reprogramming and new initiatives in mission-critical social science; development of social science capacity, including senior-level social science representation; and specific strategies for increasing social science literacy throughout NOAA. Also identifies social science research needs for each of NOAA's line offices. (http://www.sab.noaa.gov/Reports/NOAA_SocialSciencePanelFinalReport.pdf)

Stressors

Climate Change

Title	Human Dimensions Relevance
Climate Change Science: An Analysis of Some Key Questions National Research Council, 2001	Concludes that "in order to address the consequences of climate change and better serve the Nation's decision makers, the research enterprise dealing with environmental change and environment-society interactions must be enhanced." Specific needs include "(a) support of interdisciplinary research that couples physical, chemical, biological, and human systems, (b) an improved capability of integrating scientific knowledge, including its uncertainty, into effective decision support systems, and (c) an ability to conduct research at the regional or sectoral level that promotes analysis of the response of human and natural systems to multiple stresses" (p. 5).
Global Environmental Change: Research Pathways for the Next Decade National Research Council, 1999	Outlines a research framework across multiple areas related to global environmental change, including human dimensions as an integrated and separate topic. "Human dimensions research addresses human activities that alter the Earth's environment, the driving forces of those activities, the consequences of environmental change for societies and economies, and human responses to the experience or expectation of global change. Such research is essential both to understand global change and to inform public policy" (p. 293).

Intergovernmental Panel on Climate Change Assessment Reports	Aims to "assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation." (http://www.ipcc.ch/)
Making Climate Forecasts Matter National Research Council, 1999	Proposes a program of research to understand and increase the value of seasonal-to-interannual climate forecasts. Programmatic questions "fall into three broad categories: research on the potential benefits of climate forecast information, on improved dissemination of forecast information, and on estimating the consequences of climatic variations and of climate forecasts" (p. 129).
U.S. Climate Change Science Program Strategic Plan U.S. Climate Change Science Program, 2003	Describes critical research on human contributions and responses to climate variability and change, including "the potential effects of climate variability and change on human health and welfare; human influences on the climate system, land use, and other global environmental changes; analysis of societal vulnerability and resilience to global environmental change; decision making under conditions of significant complexity and uncertainty; and integrated assessment methods" (p. 6).

Harmful Algal Blooms

Title	Human Dimensions Relevance
Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) 16 U.S.C. §§ 1451 note	Requires local and regional assessments, a report on prediction and response capacity, and plans for a "comprehensive and coordinated national research program to develop and demonstrate prevention, control, and mitigation methods to reduce the impacts of harmful algal blooms on coastal ecosystems (including the Great Lakes), public health, and the economy."
Harmful Algal Research and Response: A Human Dimensions Strategy U.S. Harmful Algal Bloom Office, 2006	Provides a detailed implementation plan for human dimensions research critical to reduce public health, sociocultural, and economic impacts of harmful algal blooms. Research needs fall into six areas: socioeconomic impacts, public health impacts, recreational and drinking water impacts, risk communication, coordination in research and response, and education and outreach. The research strategy is critical to implement HARRNESS and HABHRCA (below). (http://www.nccos.noaa.gov/stressors/extremeevents/hab/HDstrategy.pdf)
Harmful Algal Research and Response: National Environmental Science Strategy (HARRNESS) 2005	"Reflects the views of the U.S. research and management community about the current state of the harmful algal bloom problem, needs and priorities, and approaches available to address these problems. Priorities and needs fall into four foci: bloom ecology and dynamics; toxins and their effects; food webs and fisheries; and public health and socioeconomic impacts. (http://www.esa.org/HARRNESS/)

Coastal Hazards

Title	Human Dimensions Relevance
Facing Hazards and Disasters: Understanding Human Dimensions National Research Council, 2006	Assesses the current state of social science research related to hazards and disasters, and recommends social science research and interdisciplinary collaboration to improve disaster preparedness and response. For example, Grand Challenge #6 - Promote Risk-Wise Behavior - affirms that "to be effective, hazard information (e.g., forecasts and warnings) must be communicated to a population that understands and trusts the messages. The at-risk population must then respond appropriately to the information. Significant progress is being made, but this is an ongoing challenge that can only be met by effectively leveraging the findings from social science research" (p. 11).

Grand Challenges for Disaster Reduction National Science and Technology Council, 2005	Establishes a framework for sustained Federal investment in science and technology, including social science research, to enhance the disaster resilience of communities. http://www.sdr.gov/SDRGrandChallengesforDisasterReduction.pdf)
Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center), 2000	Develops a risk and cost assessment framework for hazard preparedness and mitigation planning that takes into account a broad range of economic, business, social, and environmental costs associated with hazards.
Human Links to Coastal Disasters Heinz Center, 2002	Examines human factors influencing vulnerability to coastal hazards, including policies and practices that drive coastal development. Explores human impacts of hazards, including changes related to physical health, mental well-being, and social institutions. (http://www.heinzctr.org/NEW_WEB/PDF/Full_report_human_links.pdf)
Oil Pollution Act 33 U.S.C. §§ 2701 et seq.	Authorizes NOAA, as the primary Federal trustee for coastal resources, to recover natural resource damages resulting from oil spills and defines natural resource damages to include the cost of restoring, rehabilitating, replacing or acquiring the equivalent of the damaged resources; the reasonable cost of assessing those damages; and the diminution in values of those natural resources pending restoration. Damages encompass injury to and economic losses from destruction of real or personal property; loss of subsistence use; loss of profits and earning capacity; and costs associated with increased public services. NCCOS has a responsibility to conduct human dimensions research supporting NOAA's trustee role in assessing and restoring coastal and marine resources injured by oil spills, hazardous substance releases, and vessel groundings. Such research may include risk communication strategies, institutional analysis to improve coordination in response and restoration, or non-market valuation for damage assessment.

Invasive Species

Title	Human Dimensions Relevance
Non-indigenous Aquatic Nuisance Prevention and Control Act 33 U.S.C. §§ 1251 et seq.	Aims to "understand and minimize economic impacts of nonindigenous aquatic nuisance species." Establishes an Aquatic Nuisance Species Task Force required to "develop and implement a program for waters of the United States to prevent introduction and dispersal of aquatic nuisance species; to monitor, control and study such species; and to disseminate related information." The program is to include research on the "economic risks and impacts associated with the introduction of aquatic nuisance species into the waters of the United States; possible methods for the prevention, monitoring and control of aquatic nuisance species; and the assessment of the effectiveness of prevention, monitoring and control methods."
Ocean Blueprint for the 21st Century – Chapter 17: Preventing the Spread of Invasive Species U.S. Commission on Ocean Policy, 2004	Recommends research focusing on "understanding the human dimensions behind species introductions, including human behavior, decision making, and economics." (http://www.oceancommission.gov/documents/welcome.html)

Executive Order 13112 of February 3, 1999 - Invasive Species	Aims to "minimize the economic, ecological, and human health impacts that invasive species cause." Defines "invasive species" as a species that causes economic harm or harm to human health.

Pollution

Title	Human Dimensions Relevance
Chesapeake 2000 Chesapeake Bay Program, 2000	Aims to "identify specific actions to address the challenges of communities where historically poor water quality and environmental conditions have contributed to disproportional health, economic or social impacts" by 2005. Addressing such challenges requires research identifying, describing, and engaging communities suffering disproportional health, economic or social impacts. (see http://www.chesapeakebay.net/agreement.htm)
Marine Protection, Research, and Sanctuaries Act 16 U.S.C. §§ 1431 et seq.	Creates a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, over fishing, and man-induced changes of ocean ecosystems. Such research shall consider "economic considerations involved in both the protection and the use of the oceans, possible alternatives to existing programs, and ways in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind." Also requires Federal agencies to "assess the feasibility in coastal areas of regional management plans for the disposal of waste materials" addressing, among other things, "the environmental, economic, social, and human health factors (and the methods used to assess these factors) associated with disposal alternatives."

Resource Use

Title	Human Dimensions Relevance
Coastal Sprawl: The Effects of Urban Design on Aquatic Ecosystems in the United States Pew Oceans Commission, 2002	Reviews trends in coastal population growth and urban expansion in the U.S., describes the state of science related to affects of impervious surfaces on aquatic ecosystems, and discusses strategies and implementation measures for watershed planning. (http://www.pewtrusts.com/pdf/env_pew_oceans_sprawl.pdf)
Social and Cultural Impact Assessment of the Highly Migratory Species Management Plan Prepared for the Highly Migratory Species Office, National Marine Fisheries Service, NOAA, 1998	Assesses the social and cultural impacts of the Fisheries Management Plan (FMP) for Highly Migratory Species and the amendment to the FMP for Atlantic Billfish. Explains what is meant by social and cultural impacts, reviews the methods used, and discusses major impacts and possible mitigating measures across affected communities. (http://www.st.nmfs.gov/st1/econ/cia/hms.pdf)
Socioeconomic Perspectives on Marine Fisheries in the United States Pew Oceans Commission, 2003	Describes the social and economic status and health of U.S. marine fisheries. (http://www.pewtrusts.org/pdf/environment_pew_oceans_socioeconomic_perspectives.pdf)
Sustainable Fisheries Act 16 U.S.C. §§ 1801 et seq.	Includes National Standard 8 which requires that conservation and management measures "take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities."

Regions

Alaskan Ecosystem Complex

Title	Human Dimensions Relevance
North Pacific Research Board (NPRB) Science Plan NPRB, 2005	Recognizes the importance of understanding "how societies adapt to changing environments, ecosystems and management systems." Identifies and expresses intent to fund human dimensions research needs related to Fishery Management and Policy, Baseline Assessment, Human Health, Human Values and Resource Protection, and Climate Variability. (http://www.nprb.org/sciplan/index.htm)
People and the Arctic: A Prospectus for Research on the Human Dimensions of the Arctic System National Science Foundation, Arctic System Science Program, Human Dimensions of the Arctic System, 1997	Provides research principles, objectives, questions, and methods for the Human Dimensions of the Arctic System (HARC) program of the National Science Foundation's Arctic System Science Program. In general, HARC research "considers human activity, both within and outside the Arctic, as a link and vital driver among the terrestrial, marine, and climatic subsystems. Accordingly, the initiative provides a significant opportunity to integrate ecosystem and climate studies with a broad range of the social sciences." (http://www.arcus.org/harc/prospectus.html)

California Current

Title	Human Dimensions Relevance
California Marine Life Protection Act California Fish and Game Code, Chapter 10.5, Sections 2850 to 2863 Sections 2850-2863	Requires that the California Department of Fish and Game develop a master plan to improve the design and management of the state's marine protected area system. The master plan shall take into account socioeconomic and environmental impacts of various alternatives and "be prepared with the advice, assistance, and involvement of participants in the various fisheries and their representatives, marine conservationists, marine scientists, and other interested persons."
California's Ocean Economy National Ocean Economics Program, 2005	Measures the coastal and ocean economy of California, including sectors related to living resources, ocean minerals, marine transportation, marine construction, ship and boat building, and tourism and recreation. (http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf)
Regional Priorities for Social Science Research on Marine Protected Areas: Pacific Coast NOAA National Marine Protected Areas Center (MPAC), 2005	Identifies region-specific social science research needs in six priority areas for planning, management, and evaluation of marine protected areas: governance and institutions; use patterns; attitudes, perceptions, and beliefs; economics; communities; and cultural heritage and resources. (http://www.mpa.gov/pdf/helpful-resources/pacificcoast-ssrs-final.pdf)

Caribbean

Title	Human Dimensions Relevance
Managing Beach Resources in the Smaller Caribbean Islands	Contains papers presented at a workshop entitled "Integrated Framework for the Management of Beach Resources within the Smaller Caribbean Islands" at the University of Puerto Rico, Mayaguez Campus, 21-25 October 1996.

University of Puerto Rico Sea Grant College Program and United Nations Educational, Scientific, and Cultural Organization (UNESCO), 1997	Papers discuss human dimensions topics such as anthropogenic causes of beachfront erosion, traditional and sociocultural beach management issues, community-based approaches to beach management, social issues affecting beaches, and the management of beaches as a tourism resource. (http://www.unesco.org/csi/pub/papers/papers1.htm)
Regional Priorities for Social Science Research on Marine Protected Areas: U.S. Caribbean and South Florida MPAC, 2003	Identifies region-specific social science research needs in six priority areas for planning, management, and evaluation of marine protected areas: governance and institutions; use patterns; attitudes, perceptions, and beliefs; economics; communities; and cultural heritage and resources. (http://www.mpa.gov/pdf/helpful-resources/caribbean.pdf)
Small Islands Voice: Voices in a Changing World UNESCO, 2004 (Also Relevant to Pacific Region)	Describes UNESCO's Small Islands Voice, an inter-regional (Caribbean, Indian Ocean, and Pacific) and island-based initiative for visioning and capacity building to promote sustainable development. Based on a representative interview survey, describes and discusses issues that concern residents of small islands: economy, employment, health care, education, infrastructure, environment, tourism, decline in traditional values, increased crime, and governance. Discusses the importance of island heritage. (http://www.unesco.org/csi/pub/papers3/world.htm)

Great Lakes

Title	Human Dimensions Relevance
Great Lakes Sea Grant Programs – Strategic Plans NOAA Sea Grant Great Lakes Network	Provides specific goals and strategies addressing ten national priority research themes, including a focus on coastal communities designed to strengthen coastal planning, build community capacities, and stimulate sustainable economic development. (http://www.greatlakesseagrant.org/)
Human Dimensions of Great Lakes Fishery Management Great Lakes Fishery Commission, Fishery Research Program, 2003	Provides background information, a statement of research focus, and a list of key research questions to define and implement the Human Dimensions theme of the Great Lakes Fishery Commission's Fishery Research Program. The research focus is organized around "three main lines of inquiry: 1) decision-making and the role of human dimensions information, 2) research into organizational structure and behavior (formal and informal), and 3) research into stakeholder participation in management, including communications, collaborative decision-making, and processes that foster interaction among fishery managers." (http://www.glfc.org/research/humandimensions.pdf)

Gulf of Mexico

Title	Human Dimensions Relevance
Assessment of the U.S. Outer Continental Shelf Environmental Studies Program: III. Social and Economic Studies National Research Council, 1992	Recognizes that the Minerals Management Service (MMS) and other Federal agencies charged with natural resource management "are increasingly being required by their enabling legislation and by other laws to assess the social, economic, and cultural effects of development and regulation." Evaluates and provides guidance to the MMS socioeconomic research program.
Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature	Provides "a comprehensive search and integration of environmental and socioeconomic data for the deepwater Gulf of Mexico." The synthesis report (Volume I) summarizes available information by topic including socioeconomic activities in the area. The annotated bibliography (Volume II) incorporates "existing literature, relevant data, and

Synthesis U.S. Department of Interior, Minerals Management Service, 2000	ongoing research pertaining to geological, physical, chemical, and biological processes of the study area, social and economic data and literature, and deepwater technology." (from http://www.gomr.mms.gov/homepg/whatsnew/techann/000049.html)
Florida Coastal Environmental Resources: A Guide to Economic Valuation and Impact Analysis Florida Sea Grant, 2002	Discusses concepts and methodologies of environmental economics (e.g., tradeoffs, willingness to pay, cost-benefit analysis, and environmental valuation) important for natural resources management. Presents case studies of regional projects that demonstrate the nature and importance of coastal resource valuation and economic impact analysis. (http://nsgl.gso.uri.edu/flsgp/flsgph02002.pdf)

Northeast

Title	Human Dimensions Relevance
New England's Fishing Communities MIT Sea Grant College Program, 2001	Identifies fishing communities in the New England region and assesses their fishing dependency to lay the groundwork for measuring the social impacts of specific management regulations, as required by the Sustainable Fisheries Act. (http://web.mit.edu/seagrant/aqua/cmss/marfin/index.html)
Overview of the Social and Economic Survey Administered during Round II of the Northeast Multispecies Fishery Disaster Assistance Program NOAA Technical Memorandum, NMFS-NE-164, 2001	"Characterizes and summarizes responses to selected questions from the Social and Economic Survey administered in spring and summer 2000 to recipients of the second round (Round II) of financial assistance in the Northeast (Gulf of Maine) Multispecies Fishery Disaster Assistance Program." Describes "how these fishermen conduct their livelihood, the beliefs they have about fishing, and the social communities in which they live, and points to further research needs generated by the initial survey results." (from http://www.nefsc.noaa.gov/nefsc/publications/tm/tm164/)

Pacific Island Ecosystem Complex

Title	Human Dimensions Relevance
Hawaii Revised Statutes – Designation of Community-Based Subsistence Fishing Area HRS §188-22.6	Authorizes the Hawaii Department of Land and Natural Resources to "designate community based subsistence fishing areas and carry out fishery management strategies for such areas … for the purpose of reaffirming and protecting fishing practices customarily and traditionally exercised for purposes of native Hawaiian subsistence, culture, and religion."
Regional Priorities for Social Science Research on Marine Protected Areas: U.S. Pacific Islands MPAC, 2005	Identifies region-specific social science research needs in six priority areas for planning, management, and evaluation of marine protected areas: governance and institutions; use patterns; attitudes, perceptions, and beliefs; economics; communities; and cultural heritage and resources. (http://www.mpa.gov/pdf/helpful-resources/pacific_islands.pdf)

Southeast

Title	Human Dimensions Relevance
Florida Statutes – Environmental Regulation Commission 2006 Florida Statutes, Title XXIX,	Requires the Florida Environmental Regulation Commission to "consider scientific and technical validity, economic impacts, and relative risks and benefits to the public and the environment." Requires that the Commission conduct a study of "the economic and environmental impact which sets forth the benefits and costs to the public" of any proposed

Chapter 403.804	standard.
Florida Statutes – Saltwater Fisheries 2006 Florida Statutes, Title XXVIII, Chapter 370.025	Specifies that "conservation and management measures shall be based upon the best information available, including biological, sociological, economic, and other information deemed relevant."
Regional Priorities for Social Science Research on Marine Protected Areas: South Atlantic MPAC, 2003	Identifies region-specific social science research needs in six priority areas for planning, management, and evaluation of marine protected areas: governance and institutions; use patterns; attitudes, perceptions, and beliefs; economics; communities; and cultural heritage and resources. (http://www.mpa.gov/pdf/helpful-resources/south_atlantic.pdf)

Managed Areas

Estuaries

Title	Human Dimensions Relevance
Estuary Habitat Restoration Strategy Estuary Habitat Restoration Council, 2002	Specifies that "successful restoration of estuarine habitat will protect native flora and fauna in estuaries and their watersheds, while providing multiple additional benefits such as improved surface and ground water quality and quantity, nutrient cycling, flood control, outdoor recreation, and other services valued by local stakeholders." This specification, combined with NOAA's responsibility under the ERA to develop monitoring guidance for coastal restoration practitioners, creates the need for selecting human dimensions goals for restoration projects and developing measurable parameters that can be monitored to assess effectiveness in achieving them (see Salz et al., 2005). The Strategy was developed by the Estuary Habitat Restoration Council in accordance with the requirements of the Estuary Restoration Act of 2000 (ERA) (33 U.S.C. §§ 2901 et seq.), the strategy (http://era.noaa.gov/htmls/era/era_strategy.html)
National Estuarine Research Reserve System (NERRS) Research and Monitoring Plan, 2006-2011 NOAA's National Ocean Service, Office of Ocean and Coastal Resource Management, Estuarine Reserves Division, 2006	Includes "Social Science and Economics" as a NERRS research priority designed to address the following questions: - How are coastal population demographics changing and how does this/will this impact natural resource protection and management? - What are the economic tradeoffs/effects of increasing development and urbanization in the coastal zone on traditional commercial enterprises such as seafood harvesting, etc.? - How do human perceptions of health risks influence coastal decision making and natural resource protection? - What are the cumulative impacts of multiple human recreational and economic activities on the coastal environment? (p. 21) (http://nerrs.noaa.gov/pdf/Research_Monitoring.pdf)
National Strategy to Restore Coastal and Estuarine Habitat Restore America's Estuaries, 2002	Provides a framework for estuarine restoration that recommends broad public involvement and consideration of social and economic benefits in establishing priority regions, selecting goals, developing projects, and monitoring success. (http://www.estuaries.org/?id=7)

Marine Protected Areas

Title	Human Dimensions Relevance
How is Your MPA Doing? A Guidebook of Natural and Social Indicators IUCN, World Conservation Union, 2004	Provides socioeconomic and governance indicators for successful development, management, and performance of marine protected areas. (http://effectivempa.noaa.gov/guidebook/guidebook.html)
Mapping Human Activity in the Marine Environment: GIS Tools and Participatory Methods National Marine Protected Areas Center (MPAC), 2005	Develops general design criteria for GIS-based participatory methods for collecting spatial data on human resource use patterns to inform local and regional MPA planning processes. (http://www.mpa.gov/pdf/helpful-resources/hupi-workshopreport-fdraft.pdf)
Marine Protected Areas Needs Assessment NOAA Coastal Services Center with the MPAC, 2002	Emphasizes that social science regarding marine protected areas is "desperately needed" as a cross-cutting priority and "there is universal agreement across the MPA community that stakeholder/community involvement is critical to success" (p. 4). Specific social science needs include incorporating traditional knowledge into marine management, stakeholder assessment, monitoring resources with historical and cultural significance, and evaluating socioeconomic impacts. (http://www.mpa.gov/pdf/helpful-resources/mpanafinal.pdf)
Marine Reserves: A Tool for Ecosystem Management and Conservation Pew Oceans Commission, 2002	Argues that marine reserves are a fundamental tool in ecosystem-based management. Emphasizes need for research to understand the social impacts of reserves. (http://www.pewtrusts.org/pdf/pew_oceans_marine_reserves.pdf)
Social Science Research Strategy for Marine Protected Areas MPAC, 2003	Provides "a practical and compelling framework for incorporating social science in the planning, management, and evaluation of the nation's marine protected areas" (p. 5). Identifies priority social science research areas (governance; use patterns; attitudes, perceptions, and beliefs; economics; communities; and cultural heritage and resources) and specific topics. (http://www.mpa.gov/pdf/publications/ssr_strategy.pdf)

National Marine Sanctuaries

Title	Human Dimensions Relevance
National Marine Sanctuaries Act 16 U.S.C. §§ 1431-1445c-1	Authorizes the Secretary of Commerce to designate and manage marine areas of special national significance as the National Marine Sanctuary System. Requires that proposals for designating a national marine sanctuary include a resource assessment documenting "present and potential uses of the area, including commercial and recreational fishing, research and education, minerals and energy development, subsistence uses, and other commercial, governmental, or recreational uses." Requires reviews of sanctuary management plans that "include a prioritization of management objectives."

Socioeconomic Overviews of National Marine Sanctuaries NOAA, Coastal and Ocean Resource Economics, Spatial Trends in Coastal Socioeconomics (STICS)	Includes overviews for Channel Islands National Marine Sanctuary, Northern and Central California Sanctuaries, and Gray's Reef which provide the socioeconomic information needed for sanctuary management and lay the groundwork for analyzing the socioeconomic impacts of management decisions. (http://marineeconomics.noaa.gov/socioeconomics/assessment/cinms.html)

Appendix 3. References

Adger, W., Hughes, T., Folke, C., Carpenter, S., and Rockström, J. (2005, August 12). Social-ecological resilience to coastal disasters. *Science, 309,* 1036-1039.

Atman, C., Bostrom, A., Fischhoff, B., and Morgan, M. (1994). Designing risk communications: Completing and correcting mental models of hazardous processes, part 1. *Risk Analysis, 14*(5), 779-788.

Bauer, M. (2006). *Harmful algal research and response: A human dimensions strategy.* Woods Hole, MA: National Office for Marine Biotoxins and Harmful Algal Blooms, Woods Hole Oceanographic Institution.

Bergen, L., and Carr, M. (2003). Establishing marine reserves: How can science best inform policy? *Environment, 45*: 8-19.

Berkes, F., and Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. In F. Berkes and C. Folke (Eds.), *Linking social and ecological systems: Management practices and social mechanisms* (pp. 1-25). Cambridge: Cambridge University Press.

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications, 10*(5), 1251-1262.

Bliven, S., and Kelty, R. (2005, September). *Visual impact assessment of small docks and piers: Theory and practice.* Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Coastal Ocean Program Decision Analysis Series No. 25.

Bostrom, A., Atman, C., Fischhoff, B., and Granger, M. (1004). Evaluating risk communications: Completing and correcting mental models of hazardous processes, part I. *Risk Analysis 14*(5), 789-98.

Bruckmeier, K. (2005). Interdisciplinary conflict analysis and conflict mitigation in local resource management. *Ambio, 34*(2), 65-73.

Centric Consulting Group. (2003). *Investigating the economic value of selected NESDIS products.* A report to the National Environmental Satellite, Data, and Information Service. http://www.economics.noaa.gov/library/documents/benefits_of_observing_systems/centrec.pdf.

Colding, J., Berkes, F., and Folke, C. (2000). *Linking social and ecological systems: Management practices and social mechanisms for building resilience.* New York: Cambridge University Press.

Committee on Environment and Natural Resources. (2000). *Integrated assessment of hypoxia in the Northern Gulf of Mexico.* Washington, DC: National Science and Technology Council. http://www.nos.noaa.gov/products/pubs_hypox.html.

Deutsch, M. (1973). *The resolution of conflict: Constructive and destructive processes*. New Haven, CT: Yale University Press.

Dietz, T., Ostrom, E., and Stern, P. (2003, December 12). The struggle to govern the commons. *Science, 302,* 1907-1912.

Disaster Mitigation Act. 42 U.S.C. §§ 5121 et seq. (2000).

Doering, O., F. Diaz-Hermelo, C. Howard, R. Heimlich, F. Hitzhusen, R. Kazmierczak, J. Lee, L. Libby, W. Milon, T. Prato, and M. Ribaudo. (1999, September). Evaluation of the economic costs and benefits of methods for reducing nutrient loads to the Gulf of Mexico: Topic 6 report for the integrated assessment on hypoxia in the Gulf of Mexico. Silver Spring, MD: NOAA Coastal Ocean Program Decision Analysis Series No. 20. NOAA Coastal Ocean Program. http://oceanservice.noaa.gov /products/hypox_t6final.pdf

Drew, J. (2005). Use of traditional ecological knowledge in marine conservation. *Conservation Biology*, *19*(4), 1286-1293.

Endangered Species Act. 16 U.S.C. §§ 1531-1543. (1973).

Endter-Wada, J., Blahna, D., Krannich, R., and Brunson, M. (1998, August). A framework for understanding social science contributions to ecosystem management. *Ecological Applications, 8*(3), 891-904.

Environmental Protection Agency. (2004, December). Health of Galveston Bay for human use. In *National coastal condition report II.* EPA-620/R-03/002. Washington, DC. http://www.epa.gov/owow/oceans/nccr2/.

Executive Office of the President, Council on Environmental Quality. (2004). *U.S. ocean action plan: The Bush Administration's response to the U.S. Commission on Ocean Policy*. http://ocean.ceq.gov/actionplan.pdf.

Folke, C., Berkes, F., and Colding, J. (1998). Ecological practices and social mechanisms for building resilience and sustainability. In F. Berkes and C. Folke (Eds.), *Linking social and ecological systems: Management practices and social mechanisms for building resilience* (pp. 414-436). Cambridge: Cambridge University Press.

Fonseca, M., B. Julius, and W. J. Kenworthy. (2000). Integrating biology and economics in seagrass restoration: How much is enough and why? *Ecological Engineering 15*, 227-237.

Government Performance and Results Act. 31 U.S.C. §§ 1101 et seq. (1993).

Gregory, R., McDaniels, T., and Fields, D. (2001). Decision aiding, not dispute resolution: Creating insights through structured environmental decisions. *Journal of Policy Analysis and Management, 20*(3), 45-432.

Gunderson, L.H. and Holling, C. S. (2002). *Panarchy: Understanding transformations in human and natural systems.* Washington, DC: Island Press.

H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center). (2000). *The hidden costs of coastal hazards: Implications for risk assessment and mitigation.* Washington, DC: Island Press.

Hammond, X., Keeney, R., and Raiffa, H. (1999). Smart choices: A practical guide to making better decisions. Cambridge: Harvard Business School Press.

Hanna, S. (1998). Institutions for marine ecosystems: Economic incentives and fishery management. *Ecological Applications, suppl., 8*(1), S170-S174.

Hollup, O. (2000). Structural and sociocultural constraints for user-group participation in fisheries management in Mauritius. *Marine Policy 24*, 407-421.

Huntington, H. (2000, October). Using traditional ecological knowledge in science: Methods and applications. *Ecological Applications, 10*(5), 1270-1274.

Huppert, D. (2003, August). Interactions between human communities and estuaries in the Pacific Northwest: Trends and implications for management. *Estuaries 26*(4B), 994-1009.

Huppert, D., A. Olson, M. Hershman, K. Wing, and C. Sweeney. (1998, April). Socioeconomic causes and consequences of coastal ecosystem change. In G. McMurray, R. Gregory, and R. Bailey (Eds.), *Change in Pacific Northwest coastal ecosystems: Proceedings of the Pacific Northwest coastal ecosystems regional study workshop, August 13-14, 1996, Troutdale, Oregon. NOAA Coastal Ocean Program Decision Analysis Series No. 11* (pp. 39-90). Silver Spring, MD: NOAA Coastal Ocean Office.

Imperial, M. (1999a). Analyzing institutional arrangements for ecosystem-based management: Lessons from the Rhode Island Salt Ponds SAM Plan. *Coastal Management, 27*, 31-56.

Imperial, M. (1999b). Institutional analysis and ecosystem-based management: The institutional analysis and development framework. *Environmental Management, 24*(4), 449-465.

International Human Dimensions Programme on Global Environmental Change. (IHDP) (2005). *Science plan: Institutional dimensions of global environmental change.* (IHDP Report No. 16). http://www.ihdp.uni-bonn.de/html/publications/reports/IHDP-IDGECreport16.pdf.

Interorganizational Committee on Principles and Guidelines for Social Impact Assessment under NEPA. (2003). Principles and guidelines for social impact assessment in the USA. *Impact Assessment and Project Appraisal, 21*(3), 231-250.

Juda, L. (1999). Considerations in developing a functional approach to the governance of large marine ecosystems. *Ocean Development and International Law, 30*, 89-125.

Kasperson, R. (1986). Six propositions on public participation and their relevance for risk communication. *Risk Analysis, 6*(3), 275-281.

Kite-Powell, H., Colgan, C., Wellman, K., Pelsoci, T., Wieand, K., Pendleton, L., Kaiser, M., Pulsipher, A., and Luger, M. (2004). *Estimating the economic benefits of regional ocean observing systems.* A report prepared for the National Oceanographic Partnership Program, Marine Policy Center, Woods Hole Oceanographic Institution. http://www.economics.noaa.gov/library/documents/benefits_of_observing_systems/regional-obs-system-benefits-whoi-nov04.pdf.

Lee, K. (1993). *Compass and gyroscope: Integrating science and politics for the environment.* Washington, DC: Island Press.

Leschine, T., and M. Chadsey. In prep. Science and management for harmful algal blooms.

Lipton, D., K. Wellman, I. Sheifer, and R. Weiher. (1995). *Economic valuation of natural resources: A handbook for coastal resource policymakers. NOAA Coastal Ocean Program Decision Analysis Series No. 5.* Silver Spring, MD: NOAA Coastal Ocean Office.

Mascia, M. (2003). The human dimension of coral reef marine protected areas: Recent social science research and its policy implications. *Conservation Biology 17*(2), 630-632.

Masciangioli, T., and Wei-Xian, Z. (2003). Environmental technologies at the nanoscale. *Environmental Science and Technology, March 1*, 102-108.

Mauro, F., and Hardison, P. (2000, October). Traditional knowledge of indigenous and local communities: International debate and policy initiatives. *Ecological Applications, 10*(5), 1263-1269.

Michigan Sea Grant. (2006). Causes and consequences of environmental change: Integrated Assessments. http://www.miseagrant.umich.edu/downloads/about/IA-factsheet-2005.pdf.

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Synthesis.* Washington, DC: Island Press.

Minteer, B., and Collins, J. (2005). Ecological ethics: Building a new tool kit for ecologists and biodiversity managers. *Conservation Biology, 19*(6), 1803-1812.

Mnyusiwalla, A., Daar, A., and Singer, P. (2003). 'Mind the gap': Science and ethics in nanotechnology. *Nanotechnology 14:* R9-R13.

National Oceanic and Atmospheric Administration (NOAA) National Centers for Coastal Ocean Science (NOAA). (2004a). *NCCOS strategic plan FY 2005- FY 2009.* http://coastalscience.noaa.gov/documents/strategicplan.pdf.

National Oceanic and Atmospheric Administration (NOAA). (2004b). *Population trends along the coastal United States: 1980-2008.* http://www.oceanservice.noaa.gov/programs/mb/supp_cstl_population.html.

National Oceanic and Atmospheric Administration (NOAA) Office of Education and Sustainable Development (NOAA). (2004c). *An education plan for NOAA.* http://www.oesd.noaa.gov/NOAA_Ed_Plan.pdf.

National Oceanic and Atmospheric Administration (NOAA). (2005a). *New priorities for the 21st Century: NOAA's strategic plan – updated for FY 2006-FY 2011.* http://www.ppi.noaa.gov/pdfs/STRATEGIC%20PLAN/Strategic_Plan_2006_FINAL_04282005.pdf.

National Oceanic and Atmospheric Administration (NOAA). (2005b). *Policy on transition of research to application.* (NAO 216-105). http://www.corporateservices.noaa.gov/~ames/NAOs/Chap_216/naos_216_105.html.

National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service Local Fisheries Knowledge Project. (Website accessed November, 2006). http://www.st.nmfs.gov/lfkproject/02_c.definitions.htm.

National Oceanic and Atmospheric Administration (NOAA) National Marine Protected Areas Center . (2006). *Mapping human activity in the marine environment: GIS tools and participatory methods: Workshop summary.* http://www.mpa.gov/pdf/helpful-resources/hupi-workshopreport-fdraft.pdf.

National Oceanic and Atmospheric Administration (NOAA) and Coastal States Organization. (2006). *Discussion paper: Current and future challenges for coastal management.* http://coastalmanagement.noaa.gov/czm/discussion_paper.pdf.

National Oceanic and Atmospheric Administration, Science Advisory Board, External Ecosystem Task Team (NOAA External Ecosystem Task Team). (2006, July 15). *Evolving an ecosystem approach to science and management throughout NOAA and its partners.* http://www.sab.noaa.gov/Reports/eETT_Final_1006.pdf.

National Oceanic and Atmospheric Administration, Science Advisory Board, Social Science Review Panel (NOAA). (2003). *Social science research within NOAA: Review and Recommendations.* http://www.sab.noaa.gov/Reports/NOAA_SocialSciencePanelFinalReport.pdf.

National Nanotechnology Initiative. (2003). *Nanotechnology: Societal implications – maximizing benefits for humanity.* http://www.nano.gov/nni_societal_implications.pdf.

National Research Council. (2006). *Facing hazards and disasters: Understanding human dimensions.* Washington, DC: The National Academies Press.

National Research Council. (2005). *Decision making for the environment: Social and behavioral science research priorities.* Washington, DC: The National Academy Press.

National Research Council. (2000). *Bridging boundaries through regional marine research.* Washington, DC: The National Academy Press.

National Research Council. (1998). *People and pixels: Linking remote sensing and social science.* Washington, DC: The National Academy Press.

National Research Council. (1996). *Understanding risk: Informing decisions in a democratic society.* Washington, DC: The National Academy Press.

National Research Council, (1992). *Global environmental change: Understanding the human dimensions.* Washington, DC: The National Academy Press.

National Science Foundation. (1995). *Science and society: Program solicitation.* Arlington, VA: Directorate for Social, Behavioral, and Economic Sciences, Division of Social and Economic Sciences, NSF 05-588. http://www.nsf.gov/pubs/2005/nsf05588/nsf05588.pdf.

National Science and Technology Council. (2005). *Grand challenges for disaster reduction.* http://www.sdr.gov/SDRGrandChallengesforDisasterReduction.pdf.

National Science and Technology Council. (2004). *The National Nanotechnology Initiative Strategic Plan.* http://www.nano.gov/NNI_Strategic_Plan_2004.pdf.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action.* Cambridge: Cambridge University Press.

Peters, R., Covello, V., and McCallum, D. (1997). The determinants of trust and credibility in environmental risk communication: An empirical study. *Risk Analysis, 17*(1), 43-96.

Pfirman, S., and National Science Foundation Advisory Committee for Environmental Research and Education (AC-ERE). (2003, January). *Complex environmental systems: Synthesis for earth, life, and society in the 21st century. A 10-year outlook for the National Science Foundation.* http://www.nsf.gov/geo/ere/ereweb/ac-ere/acere_synthesis_rpt_full.pdf.

Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR 1500-1508). (2005).

Reiter, M. (2004). A simple fuzzy logic approach to analyze integrated interdisciplinary "four-component" conceptual resource management models. *Interdisciplinary Environmental Review, 6*(2): 1-13.

Reiter, M., Parsons, G., Scarborough, R., Fan, C., and Thur, S. (2006). An interdisciplinary conceptual metamodel for the St. Jones River Watershed, Delaware: Development, results, and implications. *Journal of Environmental Monitoring and Restoration, 2*, 38-50.

Renn, O. (1998). The role of risk communication and public dialogue for improving risk management. *Risk Decision and Policy, 3*(1), 5-30.

Roco, M. C., and Bainbridge, William S. (2001). *Societal implications of nanoscience and nanotechnology*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Salz, R., and Loomis, D. (2005). Human dimensions of coastal restoration. In Department of Commerce, National Oceanic and Atmospheric Administration, Coastal Ocean Program Decision Analysis Series 23(1), *Science-based restoration monitoring of coastal habitats. Volume 2: Tools for monitoring coastal habitats* (pp. 14.1-14.91). http://coastalscience.noaa.gov/documents/rmv2/Ch14Bundle.pdf.

Scherer, C., McComas, K., Juanillo, N., and Pelstring, L. (1999). Promoting information decision-making: The role of message structure. *Risk: Health, Safety, and Environment, 10*, 209-221.

Setting Customer Service Standards. Executive Order 12862. (1993).

Shaw, A. and Robinson, J. (2004). Relevant but not prescriptive? Science policy models within the IPCC. *Philosophy Today, suppl. 48*(5), 84-95.

Sissenwine, M. and Murawski, S. (2004). Moving beyond 'intelligent tinkering': Advancing an ecosystem approach to fisheries. *Marine Ecology Progress Series, 274*, 291-295.

Stevenson, M. (1996). Indigenous knowledge in environmental assessments. *Arctic, 49*(3), 278-291.

Subcommittee on Integrated Management of Ocean Resources. (2006). *Priorities for the Subcommittee on Integrated Management of Ocean Resources*. http://ocean.ceq.gov/about/docs/SIMOR_Priorities_050505.pdf.

Sutinen, J. (lead author) with Clay, P., Dyer, C., Edwards, S., Gates, J., Grigalunas, T., Hennessey, T., Juda, L., Kitts, A., Logan, P., Poggie, J., Rountree, B., Steinback, S., Thunberg, E., Upton, H., and Walden, J. A framework for monitoring and assessing socioeconomics and governance of large marine ecosystems. In T. Hennessey and J. Sutinen (Eds.), *Sustaining large marine ecosystems: The human dimension* (pp. 27-82). Amsterdam: Elsevier.

Sutinen, J. and Kuperan, K. (1999). A socio-economic theory of regulatory compliance. *International Journal of Social Economics, 26*(1/2/3), 174-193.

Turner, B., Kasperson, E., Matson, A., McCarthy, J., Corell, R., Christense, L., Eckley, N., Kasperson, J., Luers, A., Martello, M., Polsky, C., Pulsipher, A., and Schiller, A. (2003, July 8). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences, 100*(14), 8074-8079.

United Nations Environment Programme Convention on Biological Diversity. 31 ILM 818 (1992). http://www.biodiv.org/doc/legal/cbd-un-en.pdf.

United Nations International Strategy for Disaster Reduction. (2005). *Hyogo framework for action 2005-2015: Building the resilience of nations and communities to disasters.* (Extract from the final report of the World Conference on Disaster Reduction, A/CONF.206/6). http://www.unisdr.org/eng/hfa/docs/Hyogo-framework-for-action-english.pdf.

United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. (2001, January 15). *Protecting the oceans from land-based activities.* GESAMP Reports and Studies No. 71. http://gesamp.imo.org/no71/index.htm.

United States Commission on Ocean Policy. (2004). *An ocean blueprint for the 21st century* (Final Report). http://www.oceancommission.gov/documents /full_color_rpt/000_ocean_full_report.pdf.

Varner, G., Gilbertz, S., and Peterson, T. (1996). Teaching environmental ethics as a method of conflict management. In A. Light and E Katz (Eds.), *Environmental Pragmatism.* New York: Routledge.

Vernberg, W., G. Scott, S. Strozier, J. Bemiss, and J. Daugomah. (1996). The effects of urbanization on human and ecosystem health. In F. Vernberg, W. Vernberg, and T. Siewicki (Eds.), *Sustainable development in the Southeastern coastal zone: The Belle W. Baruch Library in Marine Science Number 20.* Columbia, SC: University of South Carolina Press.

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., and Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society 11*(1), article 13. http://www.ecologyandsociety.org/vol11/iss1/art13/.

Whittingham, E., Campbell, J., and Townsley, P. (2003). *Poverty and reefs* (DFID-IMM-IOC/UNESCO). Volume 1: http://ioc.unesco.org/gcrmn/ Poverty%20and%20Reefs/VOL_1_LOWRES_POVREEF.PDF. Volume 2 , Case Studies: http://ioc.unesco.org/gcrmn/ Poverty%20and%20Reefs/VOL_2_LOWRES_POVREEF.PDF.

Young, O. (1994). *International governance: Protecting the environment in a stateless society.* Ithaca: Cornell University Press.

Young, O. (2002). *The institutional dimensions of environmental change: Fit, interplay, and scale.* Cambridge: MIT Press.