Integrating Science into Coastal and Ocean Policy and Management: Barriers and Solutions

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Executive Summary

Expert knowledge, research, and monitoring data and information are critical inputs for the design of solutions to major coastal and ocean issues. International agencies and intergovernmental organizations, as well as national and state governments in the United States and around the world, recognize that they have underinvested time and resources toward better understanding and managing the coastal and ocean's vast resources. Leaders of these diverse entities generally agree that actions to change governance structures and improve coastal and ocean management must be science-based. Informed and effective decisions are those based on the best scientific principles and knowledge.[1] Using findings from research and drawing on brief case studies, this white paper will suggest ways to integrate expert knowledge, research, and monitoring data more effectively into coastal and ocean policy and management. This paper will also provide high-level ideas, insights, and recommendations for institutional leaders and key policy-makers and managers supporting and collaborating with institutions producing or promoting the integration of expert knowledge.

The first section, "Integrating Expert Knowledge into Coastal and Ocean Policy and Management," identifies barriers to the successful integration of expert knowledge into coastal and ocean policy and management. It also presents an overview of how institutions share information and prioritize their resources and efforts, as well as identifies some opportunities and gaps in this process. The second section, "Restructuring & Repositioning," recommends ways that producers and users of knowledge can internally restructure and externally reposition themselves to more effectively collaborate with each other and ultimately inform coastal and ocean policy-makers and managers more effectively.

There are currently many challenges in bridging the gaps between the producers and users of information. With these challenges come significant opportunities to improve the integration of science into policy and decision-making processes. Many of these opportunities are based on improving understanding, communication, and collaboration between producers and users of knowledge. These collaborations need to happen at multiple levels between: institutions, scientists and decision-makers, natural scientists and social scientists, and scientists and the media. Recommendations in this white paper for improving the integration of science into coastal and ocean policy and management address cultural attitudes, the tailoring of data and analysis, temporal coordination, communication around resource-constraints, and funding mechanisms that encourage collaborative work.

[1] US Commission on Ocean Policy. 2004. *An Ocean Blueprint for the 21st Century*. Final Report. Washington, D.C.; Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change*. Washington, D.C.; California Ocean Protection Council. 2006. *A Vision for Our Ocean and Coast: Five Year Strategic Plan 2006*. Sacramento.; and, Millennium Ecosystem Assessment. 2005. *Our Human Planet: Summary for Decision-makers*, Island Press, Washington, D.C.

1. Integrating Expert Knowledge into Coastal and Ocean Policy and Management

1A. Introduction

Resolving complex ocean and coastal issues related to economic stability, environmental health, and national security will require a strong understanding of oceanography, biology, and many other disciplines such as economics, policy, and sociology.[2] Decision-makers and managers will need to be able to integrate science concepts, engineering methods, and sociopolitical considerations to address and provide solutions to the growing number of serious, grand challenges the ocean faces. These include overfishing and ecosystem destruction and decline; coastal development; invasive species; climate change and the associated rise in sea levels; and nutrient runoff, which creates toxic algal blooms and degrades kelp forests and coral reefs.[3]

Many influential reports have discussed the need to integrate expert knowledge, research, and monitoring data more effectively into coastal and ocean policy and management.[4] The U.S. Ocean Commission on Ocean Policy and the Pew Oceans Commission call for a sea change in the organizational and structural mechanisms that manage coastal and ocean resources. Recommendations include: 1) integrating scientific information and improving understanding of coastal and ocean systems; 2) building knowledge and capacity in socio-economic data and analyses; 3) educating key decision-makers, stakeholders, and the public, as well as future ocean leaders, in cross disciplinary approaches; 4) collaborating and coordinating across sectors. The reports specifically highlight a need for expert knowledge, research, and monitoring data to be integrated into the policy and management sectors. In order to successfully integrate these three elements into coastal and ocean policy and management, there will need to be close collaboration and partnership among government agencies, private companies, NGOs, academic institutions, and international bodies at all levels between institutions and individuals. This white paper presents approaches and makes recommendations for institutions and individuals to more effectively collaborate, communicate, and integrate expert knowledge, research, and monitoring data into coastal and ocean policy and management.

1B.The Method

Thirty-five different institutions and programs were reviewed in the preparation of this paper (Table 1). Some of the institutions have multiple programs, and almost all focus on the intersection of science and policy. A total of 65 institutional-leaders and decision-makers were interviewed to ascertain best practices and lessons learned in developing and implementing activities focused on coastal and ocean problem solving. In addition, a

[2] US Commission on Ocean Policy. 2004. *An Ocean Blueprint for the 21st Century*. Final Report. Washington, D.C.
[3] Ibid.
[4] Ibid.; Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change*. Washington, D.C.; California Ocean Protection Council. 2006. *A Vision for Our Ocean and Coast: Five Year Strategic Plan 2006*. Sacramento.; and, Millennium Ecosystem Assessment. 2005. *Our Human Planet: Summary for Decision-makers*, Island Press, Washington, D.C.

few institutions in different sectors, such as public health and traffic safety, were examined in order to distill and apply lessons to the coastal and ocean context. Interviewees were questioned about barriers and solutions to the integration of expert knowledge into decision-making, both within their own organization and in their interactions with partner agencies and organizations. They were asked how it might be possible to more effectively influence processes that affect coastal and ocean issues through, for example, improved communications or collaborative efforts.

Table 1: List of Institutions

Name of Institution	Type
Center for Collaborative Policy, California State University Sacramento	Academic
Communication Partnership for Science and the Sea (COMPASS)	NGO
Conservation International, Center for Applied Biodiversity Science	NGO
Conservation International, Center for Environmental Leadership in Business (CELB)	NGO
Cooperative Research Centre (CRC) Reef Research, Australia	NGO
Duke University, Nicholas Institute for Environmental Policy Solutions	Academic
Duke University, Nicholas School of the Environment	Academic
East West Center	NGO
East West Center, Pacific Regional Integrated Sciences and Assessments (RISA)	Academic
Environmental Defense, Oceans Alive	NGO
Meridian Institute	NGO
Oceana, Pacific Program	NGO
Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)	Academic
Resolve	NGO
Resources For the Future	NGO
Scripps Institute of Oceanography	Academic
Scripps Institute of Oceanography, Center for Marine Biodiversity and Conservation	Academic
Seaweb	NGO
The Nature Conservancy, Global Marine Initiative	NGO
University of Rhode Island, Graduate School of Oceanography	Academic
University of California Santa Barbara, Bren School of the Environment	Academic
University of California Santa Barbara, Marine Science Institute (MSI)	Academic
University of California Santa Barbara, National Center for Ecological Analysis and Synthesis (NCEAS)	Academic
University of Miami, Center for Oceans and Human Health	Academic
University of Miami, Pew Institute for Ocean Science	Academic
University of Miami, Rosenstiel School of Marine and Atmospheric Science	Academic
University of British Columbia, Fisheries Centre	Academic
University of British Columbia, Project Seahorse	Academic
Wildlife Conservation Society, Marine Program	NGO
Woods Hole Oceanographic Institution (WHOI)	Academic
Woods Hole Oceanographic Institution, Center for Oceans and Human Health	Academic
Woods Hole Oceanographic Institution, Marine Policy Center	Academic
Woods Hole Oceanographic Institution, Ocean and Climate Change Institute	Academic

World Fish Center	NGO
WWF, Marine Programs	NGO

Questions were separated into two distinct categories. The first set focused on research institutions, think tanks, and applied research centers and the ways in which they interact internally and externally to prioritize efforts, measure success, collaborate, and ensure products are developed to solve coastal and ocean problems. A second set of questions was posed to a broader, external non-expert community, including facilitation and mediation institutions, government agency leaders, and policymakers. These questions concerned the integration of expert knowledge, research, and monitoring data and information into the decision-making process. This broader set of questions required interviewees to identify barriers to integrating expert knowledge into policy and management. They were asked to "think outside the box" in providing suggestions for ways in which institutions that use and produce expert knowledge could change internally and ultimately effect external change.

1C. Barriers to Integrating Expert Knowledge into Coastal and Ocean Policy and Management

Leaders around the world increasingly recognize that a critical factor in achieving long-term success coastal and ocean health is the integration of science into coastal and ocean policy and management. However, efforts to enhance the capacity and processes of institutions that produce knowledge, as well as the users of such knowledge, need to focus on the integration between the two groups. The first step in addressing how scientists, including both natural and social scientists, and policy and decision-makers can collaborate more effectively is to identify existing barriers to success.

Findings from interviews conducted for this paper show that numerous barriers must be addressed in order to effectively integrate expert knowledge, research, and monitoring data into coastal and ocean policy and management.

Findings: Past Barriers to Success

(i.) Low Levels of Literacy and Respect Between Natural Scientists and Social Scientists

Decision-makers need expert information to be analyzed so that they can better understand the implications, tradeoffs, etc. of the information. In order to achieve a higher level of efficacy, decision-makers, natural scientists, and social scientists must work together to fully understand the connection between the functions and changes in natural systems and socioeconomic and political concerns. However, teamwork between natural and social scientists rarely occurs because neither group has significant incentives to work outside of their discipline. Fewer than half of the organizations interviewed perform multi-disciplinary research, and if they do, it is most often the physical and biological scientists, and occasionally economists, who collaborate.

To exacerbate matters, the groups often lack respect for one another. Natural scientists, for example, often say that social scientists lack knowledge about "hard" science. Social scientists may state that their natural science colleagues are biased and have a conservation agenda. Even within a discipline, teamwork may not occur; disputes among scientists about the best methodology, for example, pose a big problem. Although qualitative information and non-scientific, local expert knowledge is starting to be valued more, it remains frequently disregarded.

(ii.) Temporal Barriers

Temporal barriers affect the timely incorporation of scientific information into decision-making processes. The obstacles are manifold. Managers must often meet annual budget and election cycles, and they want answers to key issues and questions as soon as they are identified. Science, however, rarely adheres to this schedule, and a majority of the organizations surveyed do not produce results in a timely enough manner for policy and management use. Translating and synthesizing existing data into information or trends also takes time, and key decision-makers often lack the human or financial resources to develop meaningful expert-based policy or management recommendations and/or decisions. Similarly, the information may not have been peer reviewed within the required timeframe.

(iii.) Cultural Divides Between Key Decision-makers and Scientists

Just as a cultural divide between natural scientists and social scientists exists, so, too does a cultural divide separate decision-makers and scientists. Each group has different perspectives and values. Policy-makers generally prioritize the public implications of issues, while scientists read the data. The questions and hypotheses each group develops—and the answers they want—differ, as do their priorities (e.g. funding). As a result, many scientists do not wish to engage in the political process, yet they still believe that their recommendations should be adopted 100% of the time. Unfortunately, much of the time scientists do not put their recommendations into an appropriate and realistic context for decision-makers (e.g. incorporating considerations of budget constraints, etc.).

Academic and research institutions propagate much of this divide. Institutional culture rarely fosters teamwork or collaboration, much less face-to-face communication between scientists and decision-makers that could build trust, and it often discourages experts from thinking independently.

Furthermore, decision-makers and scientists have different educational backgrounds and experiences. Few decision-makers have formal training in the scientific method, while many scientists may not understand the political or regulatory process. Linguistic barriers between experts and key decision-makers also hinder the integration of expert knowledge into management and policy. Many government agencies have limited staff who are literate in both of these worlds. Scientists often use technical jargon to explain

their concepts; decision-makers, however, need expert information presented in layman's terms in order to understand its implications. However, expert information is not always easily accessible (rarely is it centrally located), presented in standard formats, or clear to decision-makers and/or the public. Monitoring programs and data, for example, often lack transparency. Conversely, scientists may also view decision-makers' speech as vague or inaccurate. These challenges often hinder communication between the two groups.

(iv.) Lack of Scientists' Political Influence vs. Politicization of Science

A recent editorial in *Science*[5] suggested that scientists should start actively lobbying for research funds; another article in *Nature*[6] explained that some science societies are successfully starting to lobby for research funds. Despite this trend, however, the scientific community as a whole currently lacks powerful lobbies to advocate its needs and goals.

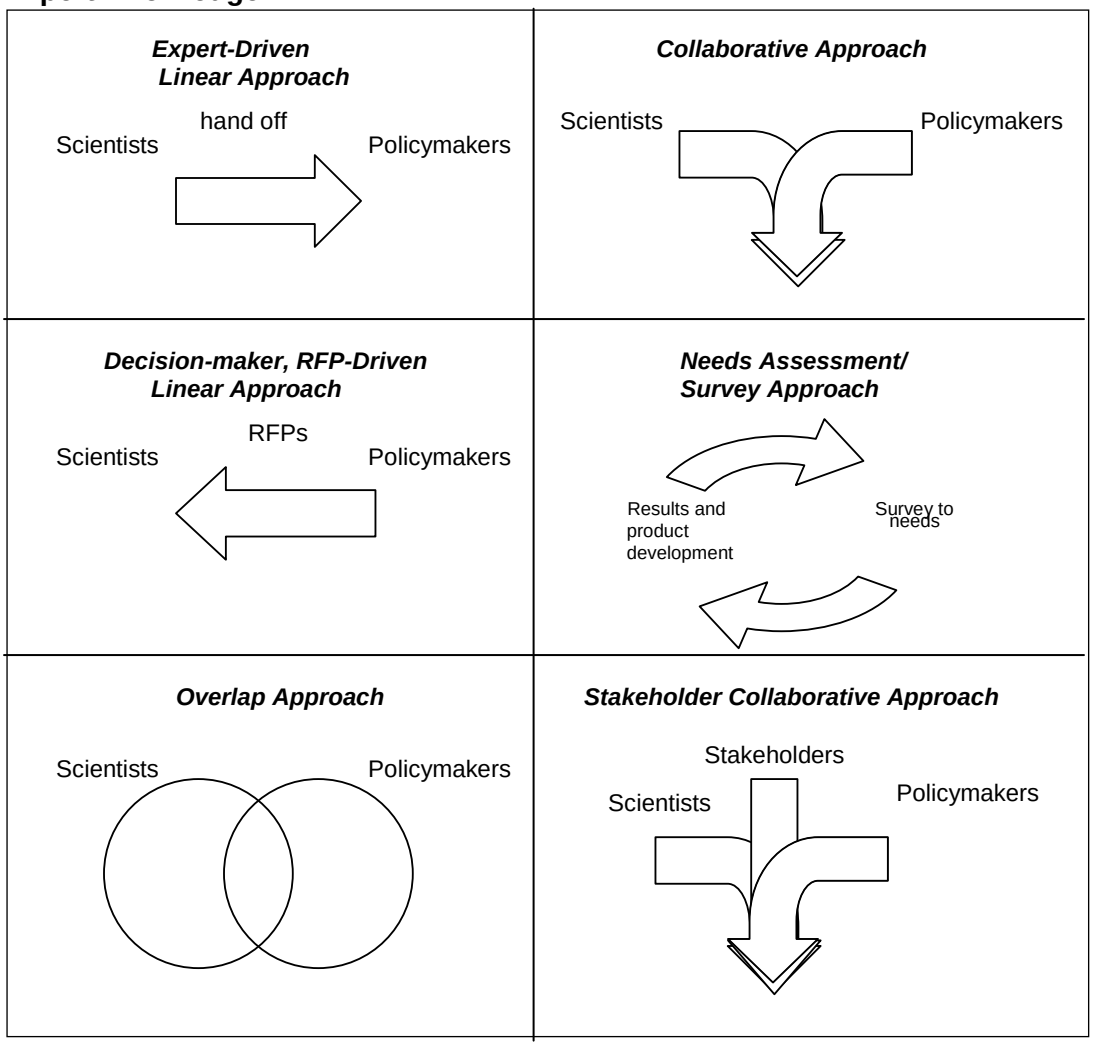
An inverse obstacle is the potential politicization of science. Some studies are published, marketed, and supported by industry and NGOs, even though the science is debatable, because the studies support a certain agenda. This creates distrust among stakeholders, key decision-makers, and the scientific community. Furthermore, as science becomes more integrated into policy and decision-making, clear and transparent processes must be established to address conflicts of interest, especially regarding science funding or monitoring and research programs.

1D. Different Approaches in the Science-to-Policy & Management Process

Figure 1 illustrates the six main ways in which producers and users of coastal and ocean expert knowledge, research, and monitoring data typically engage with each other.

[5] Robert D. Wells and Peter Farnham. Nov. 2006. "Why Aren't There More Scientists Advocating for Funding?" *Science* 314: 1081(in Letters).
[6] Editorial. Feb. 2007. "Steady Progress." *Nature* 445: 568 – 568.

Figure 1: Overview of Interactive Processes Between Producers and Users of Expert Knowledge



(i.) The Players: Producers, Users, and Stakeholders

The first group of participants in the science-to-management process includes the producers of expert knowledge. For the purposes of this white paper, this group includes people at academic and research institutes who tend to work on issues of personal interest. While their work furthers the academic and scientific communities' knowledge, it is not often put into context for decision-makers. Rather than being rewarded for collaboration with those who do "applied work," the success of these producers of knowledge is often measured by their publications in a highly specific discipline. Interdisciplinary work is rarely encouraged until after tenure is granted, and teamwork is often penalized if a person is not a first author on a paper. Nevertheless, when these academics were asked if they work on issues relevant to public and private decision-makers, most responded that grant funding and RFPs determined the priorities of their

work. The also receive little, if any, top-down coordination from the administrators of institutions who determine the priorities for the institutions.

The second group, users of expert knowledge, includes policymakers, government agency program managers and resource managers. This group tends to focus on the political process and public support for decisions, and their decisions are often bounded by a timeline or budgetary constraints. Policy-makers may have access to relevant scientific information and data, but they rarely base their decisions solely upon science. Some interviewees for this paper expressed the opinion that many policy-makers do not actively seek out scientific information and therefore will not need to think about the implications of their decisions. Resource managers have limited time and resources and are faced with pressing decisions daily. They may not have sufficient statutory authority to address the sources of major problems occurring in the area they manage, and the regulators often lack the resources or political will to implement existing laws. Efforts to improve monitoring, evaluation, and research do not always seek scientific input for development of the most effective design or stakeholder input into the important questions based upon their values. Political resistance often thwarts the development of measurable goals and targets, because these goals require resources and commitment and the results may ultimately reflect poorly on political performance.

The third group, stakeholders, is comprised of entities and individuals who have a legitimate interest in the process and effects of coastal resource management. For the purposes of this white paper, this group includes businesses, NGOs, and individual members of the public. In California, many stakeholders are well informed on the science and may have more knowledge on certain species distribution than the scientists. Stakeholders are active partners and can serve as stewards of the resources and translators to decision-makers. In a public process like the South Bay Salt Restoration Project, stakeholders play the important role of voicing various groups' concerns, interests, and values. Projects that include stakeholders in the process of designing monitoring programs have been shown to be more successful than those that do not.[7] The authors of the 2001 National Research Council Report, *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*, demonstrated that millions of dollars spent on monitoring activities was generally ineffective partly because the monitoring questions were framed by scientists operating apart from the users of the information.

(ii.) Characterization of Interactions Between the Players

There are six main ways in which producers and users of knowledge and stakeholders interact to share and manage information:

- *Expert-Driven Linear Approach*: Producers of expert knowledge create a paper or report of findings and hand results, untranslated, to a key decision-maker. The expert may testify or share information at a meeting. Organizations that are driven by individual researcher interests most often take this approach.[8]

[7] National Research Council Report. 2001. *Marine Protected Areas: tools for sustaining ocean ecosystems*. National Academy Press, Washington, D.C. .
[8] Roger A. Pielke Jr., Personal Communications.

- *Decision-Maker, Request for Proposals (RFP)-Driven Linear Approach*: Government agency managers identify a need for certain information and make requests for proposals and contracts to producers of knowledge; request staff to synthesize information; or coordinate a panel discussion on an issue (e.g. California Department of Fish and Game). This could also include the creation of a larger center, such as the existing Center for Oceans and Human Health at the Woods Hole Oceanographic Institute, that is devoted to the study of particular issues overlapping oceans and human health. Organizations with mission-driven work and product development often follow this approach.

- *Overlap Approach*: Scientists or staff of an organization identify specialists or managers who may be working on the same issues and give relevant information or papers to decision-maker (e.g. Nicholas Institute for Environmental Policy Solutions).[9]

- *Needs Assessment/Survey Approach*: Producers or funders of expert knowledge, research, and monitoring data assess the needs of users of data and information to determine information gaps undermining effective policy-making and management (e.g. NOAA's Regional Integrated Sciences and Assessments [RISA] program). Environmental non-governmental organizations (ENGOs) also may fit into this category, as they determine how to improve outcomes via capacity building, outreach, or education for individual public stakeholders and/or decision-makers.[10]

- *Collaborative Approach and Stakeholder Collaborative Approach*: Key decision-makers, possibly stakeholders and practitioners, and experts together determine the role of scientists in answering questions and fulfilling needs. This approach may incorporate all parties' knowledge and expertise. As presently designed, the California MPA Monitoring Enterprise fits into this category.

The first category of interaction, the expert-driven linear approach, is the most common way in which researchers and academics engage in policy and management. The second category is problematic because the users of expert knowledge often require that information be translated or interpreted as it applies to specific issues or questions, but this information is most often not presented in such a format. Once the information need is determined by the decision-maker, users may organize an expert panel to assist them in answering questions, hire a consultant or expert to write a synthesis document, or put together an RFP on a particular question. Decision-makers often request answers to a certain question or set of issues, but the expert information-producers have trouble presenting the results within a policy and management context. Furthermore, decision-makers may or may not recognize that experts are constrained in sharing their data before results are satisfactorily vetted.

[9] Ibid.
[10] Ibid.

In the past few years some new programs have attempted to integrate science and decision-making more effectively by using the Overlap Approach, Survey Approach, and more recently, Collaborative Approach, described above. The RISA program is an interesting model of the Survey Approach (discussed below), and the former Australian CRC Coral Reef (discussed on p. 10) is an intriguing model for the Collaborative Approach.

The last four categories listed above are usually coordinated by some sort of bridging institution such as intergovernmental organizations or the ENGO community. The bridging institutions, while generally focused on advocacy, tend to collaborate actively with key decision-makers and work across disciplines. For example, World Wildlife Fund's Marine Conservation Science Group serves WWF field program staff to inform and improve management decisions in the natural and social sciences. These institutions tend not to use the traditional metrics of success (e.g. published articles), but may have a hybrid mix of publications and application metrics focused on outcome-oriented goals that fit into a larger organizational mission-driven strategy and survey-oriented approach.

Text Box: RISA and Needs Assessment/Survey Approach

NOAA's Regional Integrated Sciences and Assessments (RISA) program addresses climate-related issues of importance to regional policy-makers and managers with jurisdiction over the impact of climate on water availability, wildfires, fisheries, agriculture, and public health. The eight RISAs currently funded are autonomous and have independent authority to determine the appropriate mix of original research, information synthesis, and outreach to policymakers to best achieve the program's goals.

Pacific RISA, which is housed at the East-West Center in Honolulu, HI with collaborators at the University of Hawaii at Manoa, focuses on reducing Pacific Island vulnerability to extreme climate-related events. The structure of the Pacific RISA program is based on a conceptual framework developed from the Pacific Assessment Report on the Consequences of Climate Variability and Change. This framework envisions a cycle of continuous feedback between climate researchers and the users of climate information to support decision-making (Shea, 2001). In this model of participatory research, sustained dialogue with users provides insights into regional and sectoral vulnerability and helps inform product design and evaluation. In addition to advancing scientific understanding, the Pacific RISA team explicitly focuses on interpreting their findings for users, developing useful products, and making the user community aware of available resources through outreach and education.

The Pacific RISA collaborates with other regional climate programs, such as NOAA's Pacific ENSO Applications Center (PEAC), (ENSO is the El Niño Southern Oscillation climate cycle in the U.S.-Affiliated Pacific Islands). As described by Hamnett et al. (2000)[11], scientists and government officials throughout the Pacific agree that forecast information provided by PEAC in advance of the 1997-1998 El Niño event, coupled with a sustained program of education and outreach, helped mitigate the negative impacts of that event. PEAC outreach efforts enabled many communities to plan and take appropriate action. For example, communities improved the state of their water storage and distribution systems to help mitigate the effects of the severe drought conditions caused by the 1997-1998 El Niño in many Pacific jurisdictions. The Pacific RISA program was built on the individual and institutional relationships that emerged as a result of the work and experience of PEAC in its first decade of operations.

In 2006, Pacific RISA and PEAC together hosted a series of workshops in five Pacific Island jurisdictions entitled "Climate Variability and Change in the U.S.-Affiliated Pacific Islands: Challenges and Opportunities." These hybrid workshops included representatives from academic institutions, business, government, and non-governmental organizations. The programs provided information on the contemporary understanding of climate variability and change and its effect on U.S.-Affiliated Pacific Islands;

[11] Hamnett, M.P., C.L. Anderson, C. Guard and T.A. Schroeder. 2000. "Pacific ENSO Applications Center: Lessons Learned for Regional Climate Forecasting." Pacific ENSO Applications Center, University of Hawaii, Honolulu. *See also,* http://www.climate.noaa.gov/cpo_pa/risa/; http://research.eastwestcenter.org/climate/risa/ ; and http://www.soest.hawaii.edu/MET/Enso/index2.htm.

discussed opportunities to enhance the resilience of these jurisdictions to climate vulnerability and change; and identified information needs and priorities for information-users in those jurisdictions.

Future planning for the Pacific ENSO Applications Center and the Pacific RISA program and related climate activities in the American Flag and U.S.-Affiliated Pacific Islands is now being organized in the context of a Pacific Climate Information System (PaCIS). PaCIS provides a programmatic framework to integrate ongoing and future climate observations, forecasting, research, assessment, data management and education activities designed to advance a vision of "resilient and sustainable communities using climate information to manage risks and support practical decision-making in the context of climate variability and change" (Shea, personal communication). Representatives of user-communities in key sectors and government agencies serve on the PaCIS Steering Committee, which provides overall policy and strategic guidance. Those same user-communities will be full and active partners in the efforts of the PaCIS working groups responsible for implementing the program (Education, Outreach and User Engagement; Operational Climate Observations, Products and Services; and Research and Assessment).

1E. Summary of Findings

Improving the ways in which producers and users of expert knowledge interact is essential for successful science-based decision-making. The Collaborative and Needs Assessments/Survey approaches are critical to the implementation of effective solutions to coastal and ocean challenges. Some key findings from interview data include:

- As shown in red in Table 2 on page 11, a number of gaps and opportunities were identified in the interview process. Specifically, opportunities exist in developing more strategic partnerships, bridging functions, and using more needs-based and collaborative approaches. Most research is primarily driven by the interests of the experts themselves or produced in response to RFPs. Alternatively, new centers have been formed in direct response to RFPs. Few organizations actively look for synergies between their research strengths and the needs of decision-makers.
- Mission-driven ENGOs with clear objectives and indicators of success may follow the RFP-driven Approach in the prioritization of their efforts, but generally use the Collaborative Approach in their engagement with expert knowledge, research, and monitoring data.
- The least popular approach is the Overlap Approach, possibly due to researchers' or organizations' fears of being perceived as biased. The Nicholas Institute for Environmental Policy Solutions is a model of this approach. Its coordinators have begun to identify the needs of key decision-makers and relay science results to them in a clear usable format.
- Organizations rarely use the Collaborative Approach to determine the purpose or direction of research and monitoring. Some, including the California Interagency Ecological Program, are testing this approach, with increasingly positive results.
- Few organizations that use the Expert-Driven, Linear Approach succeeded at informing or influencing outcomes, which suggests that these types of activities do not arise organically.
- Only two organizations (COMPASS and Seaweb) make strategic communications a major focus.
- Stakeholder engagement and consensus building occur as isolated activities distinct from advocacy work or strategic communications. It is clearly necessary to generate opportunities for meaningful dialogue and partnership-building.

Table 2: Summary of Organizations by Approach and Activity

	RFT-Driven Linear Approach	Expert-Driven Linear Approach	Overlap Approach	Needs-Assessment/ Survey Approach	Collaborative Approach	Stakeholder Collaborative Approach
Research	5	11	2	1		
Strategic Partnerships			2	1	3	1
Advocacy		1		4		
Strategic Communications		1		1		
Stakeholder Engagement					3	1

(Note: Some organizations conduct activities under a variety of approaches; however, categorization is based on the methodology of their core or exemplary activities.)
Red = Opportunities
Grey = Not Applicable

Text Box: CRC and Collaborative Approach

The Cooperative Research Centres (CRC) Programme is an initiative of the Australian government designed to bring together researchers and research-users. CRCs are established through a competitive selection process that focuses on whether the proposed center will benefit Australia's economy or environment. The program also emphasizes the training of graduate students who will then pursue careers in industry. CRC Reef Research Centre (CRC Reef) was established in 1993 to provide research solutions designed to mitigate threats to the world's coral reefs, with a particular focus on the Great Barrier Reef World Heritage Area. After the second round of funding expired in 2006, the center merged with the Rainforest CRC to form the Marine and Tropical Sciences Research Facility, located at James Cook University in Cairns and Townsville.

CRC Reef's work was structured to ensure that research products were useful to industry partners. CRC Reef's strategic direction, although not the specific research agenda, was determined by the board of directors, which was composed of representatives from partner organizations who had contributed matching funds. Participants included representatives from industry as well as academic and public institutions. A Scientific Advisory Committee was also established to provide the board with technical advice.

The CRC Reef's research focused on six different areas:

- Conserving World Heritage Values
- Sustainable Industries
- Maintaining Ecosystem Quality
- Healthy Country Health Reef
- Reef Futures
- Torres Strait

Each of these research programs was divided into projects, which were then divided further into research tasks. Each program, project, and task was led by a scientist from one of the participating institutions. Each task was also assigned a "task associate," an industry or management partner who assisted in developing research objectives, in maintaining research focus, and in communicating research results and recommendations to industry and management agencies. To ensure effective collaboration, funds were released to researchers only after the task associate signed off on the research and progress reports.

CRC Reef provided an effective mechanism to generate monitoring data that was collected consistently over the center's entire lifespan. The Australian Institute for Marine Science, a CRC partner, hosted a centralized data center for research findings, making it easy to study long-term trends. To ensure that CRC-funded research was readily available to users, CRC Reef retained ownership of all intellectual property that was produced; however, researchers were actively encouraged to publish their findings. In addition, one of the outcomes for most projects was the production of a technical report that summarized research findings at a level appropriate for industry and management partners.

Policy and management outcomes resulting from CRC's efforts are documented in a recent report entitled *World Heritage Research: Making a Difference CRC Reef: Research, Education and Capacity Building 1999-2006.*[12] The CRC is a model for integrated end-user driven research. Dozens of policy and management changes and solutions result from each CRC focused research area. Taking one line of research as an example, the CRC Reef contributed to better understanding of the threatened dugong, including its life history, population estimates, and specialist habitat requirements. In turn, this knowledge led to a number of policy and management changes by both the Commonwealth and Queensland government including:

- Declaration of Dugong Protection Areas in both Commonwealth and State waters which include the removal of net fishing from some significant dugong habitat.
- Inclusion of key dugong habitat in 'no-take' and limited fishing zones of the Great Barrier Reef Marine Park Zoning Plan 2003.
- Introduction of voluntary vessel lanes and/or speed restrictions to protect dugongs from vessel strikes in prime dugong habitat (e.g. Hinchinbrook Island).
- Development of mutually acceptable legal agreements with traditional owners for the management of traditional hunting in local areas.
- Replacement of shark nets with drumlines at most locations where bather safety is an issue.
- A review of the use of herbicide, which has been detected in both dugong tissues and the sediments associated with seagrass beds.
- Organization of a collaborative marine wildlife carcass salvage program.
- Provision of evidence to the Natural Resource Management Ministerial Council about indigenous harvest of dugongs in the northern GBR and Torres Strait, that led to the establishment of the national partnership approach to the harvest of marine turtles and dugongs in Australia in 2005.

Core Participants:
Industry: Association of Marine Park Tourism Operators Limited; Queensland Seafood Industry Association; SUNFISH Queensland Inc.
University: James Cook University.
Commonwealth: Great Barrier Reef Marine Park Authority; Australian Institute of Marine Science.
State: Queensland Department of Primary Industries.
Other: Great Barrier Reef Research Foundation.

2. Restructuring & Repositioning

Institutions need to assess how they can improve and modify current activities, approaches, and processes in order to more successfully achieve science-based ocean policy and management solutions. This may require changing the way organizations traditionally conduct business both internally and externally. Internal restructuring may entail, for example, re-organizing or modifying internal culture and values, reconsidering staffing needs, retooling staff skills, changing performance evaluation measurements, and engaging in strategic planning. External repositioning, by contrast, focuses on the entities' external strategies, activities, and processes by which they may interact with users and producers of knowledge. Restructuring and repositioning present an opportunity for entities to assess their strengths and weaknesses as well as the needs and gaps in their activities. Restructuring and repositioning also present the opportunity to set organizational goals and to be more strategic in how such goals can best be achieved. The connection between the internal restructuring and external repositioning is critical for developing a consistent and cohesive strategy and activities that positively reinforce one another.

[12] See www.reef.crc.org.au/publications/finalsynthesis/Making-a-difference_72dpi.pdf; Great Barrier Reef Marine Park Zoning Plan 2003, available at www.gbrmpa.gov.au/__data/assets/pdf_file/0016/10591/Zoning_Plan.pdf.

For example, government agencies at the federal and state levels have realized the need to collaborate in a new way through repositioning. A strategy document prepared in January, 2007 by the National Science and Technology council (NSTC) Joint Subcommittee on Ocean Science and Technology[13] outlines the roles different sectors should play in decision-making processes.

Text Box: Roles of Entities

Federal Agencies: These agencies coordinate support and resources in order to make progress and encourage collaboration on ocean research priorities consistent with respective agency missions.

Local, Tribal, State, and Regional Governments: Agencies at these levels ensure that ocean research priorities are tailored to appropriate areas and groups. These agencies facilitate partnerships to address issues affecting multiple states (e.g. storm-surge and coastal-inundation forecasts), and effectively use results from nationally coordinated research efforts to mitigate impacts.

International Entities: These groups coordinate and implement international ocean research, management, and policy efforts. They also collaborate with the United States on oceanographic issues that cross national borders, as well as influence research on other ocean-related and Earth processes.

Research Institutions: These institutions initiate research as well as collaboration among disciplines, sectors, researchers, and stakeholders, while incorporating the latter's issues into the planning process. They also disseminate findings to appropriate user groups.

Educational Institutions: These groups, ranging from K-12 classrooms to universities to aquaria, communicate research results to the public. They provide platforms for discussion among researchers, managers, and decision-makers about the present marine environment and its future.

Private Sector: This sector provides expertise, resources, products, and services; uses research results to establish economic development opportunities; and facilitates the development of research infrastructure. The private sector has important resources to leverage.

Nongovernmental Organizations: NGOs link communities, distribute resources, represent/communicate needs, serve as stewards for the ocean ecosystem, and/or act as conduits for ocean research. Engagement of their knowledge, research, and outreach efforts is critical.

2A. Restructuring Recommendations for Entities Producing and Using Expert Knowledge to Create Internal Change

(i.) Cross-Training

Cross-training can enable institutions to reposition themselves in ways that facilitate internal change. Natural and social scientists, as well as scientists and decision-makers, should engage in open, interdisciplinary dialogue and trust-building activities.

Overall, institutions will benefit from restructuring themselves in ways that foster cross-training for present and future leaders. Many universities are challenging the

[13] NSTC Joint Subcommittee on Ocean Science and Technology. January 26, 2007. *Charting the Course for Ocean Science in the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy*. Washington, D.C. available at http://ocean.ceq.gov/about/jsost.html.

departmental system and replacing it with broadly based interdisciplinary centers with clear societal or commercial goals.[14] Because of the frequent disconnect in the interpretation of questions, research design, and results, it is important to encourage both the policy arena and the scientific community to develop a clear vocabulary and a willingness to communicate their questions and findings. Mechanisms that promote cross-training include financial compensation for time spent and fees incurred in training, as well as performance reviews that include rewards for participation in training.

Because few cross-training courses exist for mid-career decision-makers and researchers, there is an opportunity to fill such a gap.

(ii.) Communications Training

Communications and teaching training for natural and social scientists endows these groups with an important skill set that many scientists lack. There are an increasing number of training programs, such as the Aldo Leopold Fellows Program at Stanford University's Woods Institute for the Environment, that work with participants to improve their communication skills for the media and policy-makers. It is critical for experts to be able to communicate their ideas or results in a manner that the media and policy-makers will understand and remember. In addition, increased engagement and interaction with the media will lead to more public outreach and education. In turn, the public will help shape key decision-maker priorities.

(iii.) Cultural Shift

Institutions can also reposition themselves vis-à-vis their cultural and/or institutional values by embracing and communicating with people from other disciplines and sectors. Producers of knowledge should encourage teamwork, applied research, and collaboration with other disciplines and key decision-makers, as well as recognize the importance and value of communications with the media, stakeholders, and the public. By thinking of users of knowledge as clients and by working with other disciplines, experts can present their findings more holistically and, consequently, temper the arrogance that often comes from working in an academic setting.

Users of knowledge, on the other hand, should place greater value on the development of long-term, science-based decisions. The government agencies that are territorial over their areas of management will suffer in the long-run from their inability to work with other institutions. Cultural shifts may emerge slowly, but they will be effective if driven by institutional leadership. Fostering leadership that values science, politics, and the interaction between the two is critical to successful coastal and ocean management.

(iv.) Changing Performance Metrics and Incentives

[14] Editorial. April 2007. "The University of the Future." *Nature* 446: 7139; Macilwain, Colin. April 2007. "The Arizona Experiment." *Nature* 446: 7139.

Currently, many academic institutions evaluate scientists' and researchers' performance using specific metrics, such as the number of publications produced per year. However, a new set of success metrics for producers may more effectively encourage high performance, collaboration, applied work, community service, and the application of findings to policy and management. Rather than receiving rewards for working independently, knowledge producers should be given incentives to change their work culture and values.

Users of information should adopt performance metrics and incentives that reward science-based decision-making and collaboration with other agencies and scientists. This will ensure the most effective use of research and monitoring data and information. Developing new success metrics for both producers and users will result in the best integration of science into decision-making and the reduction of duplicate efforts. Granting agencies and donors can play a greater role in this effort by using their funds to leverage change and adherence to goals. Regular assessments of program effectiveness are also important to continually improve approaches and programs.

(v.) Bridging Functions

Entities can also create internal change by adopting bridging functions. Bridging institutions connect science to policy and management. They have functions that assist with linking science into action through activities such as convening groups, assessing the needs of decision-makers, translating scientific findings, synthesizing data, and producing outreach and education materials. One way to create bridge functions is to hire more employees that have experience or training in communications, graphic design, new media (such as the web, podcasts, digital radio, etc.), policy and management, and science. Hires should include people with experience and/or education in both science and policy/management who will facilitate communication between different groups. Entities that embed bridge functions into their operations should be recognized, for example, by foundations in the creation of special fellowships for the fulfillment of "cross-over" activities or the award of grant money for exemplary programs. External support for bridging functions incentivizes their adoption by generating revenue and prestige for the institution. One model for such "bridging" may be the California Coastal Commission, which, unlike most other organizations, conducts both data-translation and decision-making in-house. If the appropriate experts are not available on staff, experts are invited to present to the Coastal Commission and coached about the decision-makers' needs prior to the presentation.

(vi.) Collaboration

Institutions can effect internal change by improving collaboration at many levels: with users and producers of expert knowledge, research, and monitoring data and information; and with multidisciplinary teams (as discussed in sections i and iv above). Collaboration takes time and resources. Therefore, institutions need to allocate staff time and resources to collaborative activities. Grant-making agencies and donors should encourage collaboration by allocating budgets and goals accordingly. Institutions should design projects and processes that serve this purpose (See CRC Text Box).

(vii.) Strategic Planning

Research institutions can develop collective long-term strategies and goals that extend beyond an individual's work effort or annual budget. Both producers and users of knowledge can create a strategic plan designed to bring together researchers and decision-makers and prioritize goals and work plans. (See Text Box on WorldFish, p. 16.) Policy-makers and managers should be more proactive, not reactive: institutions can effect internal change by planning for the future. With strategic planning, institutional managers can allocate future resources, e.g. funds for long-term monitoring, as well as design effective programs that take into account long-term goals and needs. Proactive planning will prevent the development of hastily constructed, ineffective programs.

Text Box: WorldFish Strategy and Teams

The WorldFish Center is a non-profit organization that focuses on alleviating poverty and hunger by improving fisheries and aquaculture. WorldFish is one of 15 international research centers supported by the Consultative Group on International Agricultural Research, a strategic alliance of countries, international and regional organizations, and private foundations.

The WorldFish Center is a mission-driven organization with measurable objectives. In 2005 it updated its strategy to better focus its efforts on identified needs and core competencies. WorldFish produces new syntheses and insights that integrate ecological, social, economic, and policy perspectives. These analyses are the basis for key policy advice and agenda-setting at the national and regional geopolitical levels. The Center also develops new information, tools, networks, and capacity building mechanisms in developing countries. WorldFish's core competencies include:

- Socioeconomic analysis of the fisheries sector
- Institutional analysis for governance of aquatic resources
- Global databases for managing aquatic resources
- Methods for developing improved fish strains
- Development and evaluation of smallholder focused aquaculture technologies
- Culture and restocking of coral reef invertebrates
- Management approaches for small scale fisheries
- Watershed approach to aquatic resources management

WorldFish research is managed through a discipline by region matrix structure to promote interdisciplinary research and synthesis. There are three core science disciplines in the organization: Policy, Economics, and Social Sciences; Aquaculture and Genetic Improvement; and Natural Resource Management. Each is led by a director who is responsible for science strategy, cross disciplinary integration, quality of research and attracting and retaining suitably skilled researchers. Beside work that is global in scope, the capacity within these disciplines supports work in six regions, each with its own director. The role of the Regional Directors is to develop and uphold relationships with key institutions (donor, government, research and others) to identify research needs, develop projects and gain funding. Research staff have their time directly allocated to specific projects.

Use of the matrix allows WorldFish to partner with governments and determine research priorities on a local/regional level, while benefiting from the cross-disciplinary teams, resources and knowledge of the entire organization.

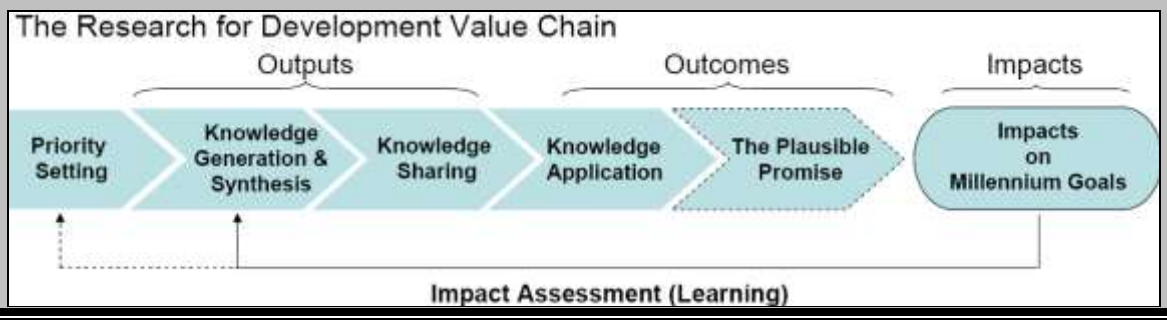
WorldFish prioritizes the needs of policymakers and managers in setting the Center's research agenda.

An example of WorldFish research feeding into the policy arena is the AsiaFish Model, developed in response to a request from the governments of Bangladesh, China, India, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand and Vietnam. This model, published in 2005 in the Journal of Aquaculture Economics and Management, predicts the future supply and demand for fish under various scenarios. Its predictions are informing policy dialogues in governments and helping them respond to challenges in the fisheries and aquaculture sector.

A second example of WorldFish's impact is the 'NEPAD FISH' initiative in Africa, which has induced a reorientation of fisheries-related development priorities and policy processes at regional and, in some cases, national levels in favor of poverty-reduction goals. The impetus for this initiative came from a series of technical and scientific assessments of the development potential of African fisheries and aquaculture,[15] led

[15] Neiland, A.E., Chimatiro, S., Khalifa, U., Ladu, B.M.B., and Nyeko, D. 2006. "Inland Fisheries in Africa: Key issues and future investment opportunities for sustainable development." *Technical Review Paper Series New Directions for African Fisheries and Aquaculture Vol 1*. The WorldFish Center, Cairo; Bâ, M., Berraho A., Bodiguel C., Cunningham S. and Mgaya Y. 2006. "Coastal and Marine Fisheries in Africa: Towards a new vision for the exploitation and sustainable management of Africa's fishery resources."

by the African Union's New Partnership for Africa's Development (NEPAD) and the WorldFish Center. The findings from these studies called for a refocusing of policy and development efforts towards supporting small-scale and inland fisheries and accelerating the growth of sustainable aquaculture because these activities have a high impact on poverty and hunger on the continent. In response, the African Union adjusted its main agriculture policy documents[16], and several sub-regional economic communities[17] and international partners[18] have adopted these new priorities. In some countries, including Malawi,[19] Ghana,[20] and Zambia,[21] NEPAD FISH has stimulated new policy aimed at increasing public and private investments in particular in aquaculture.



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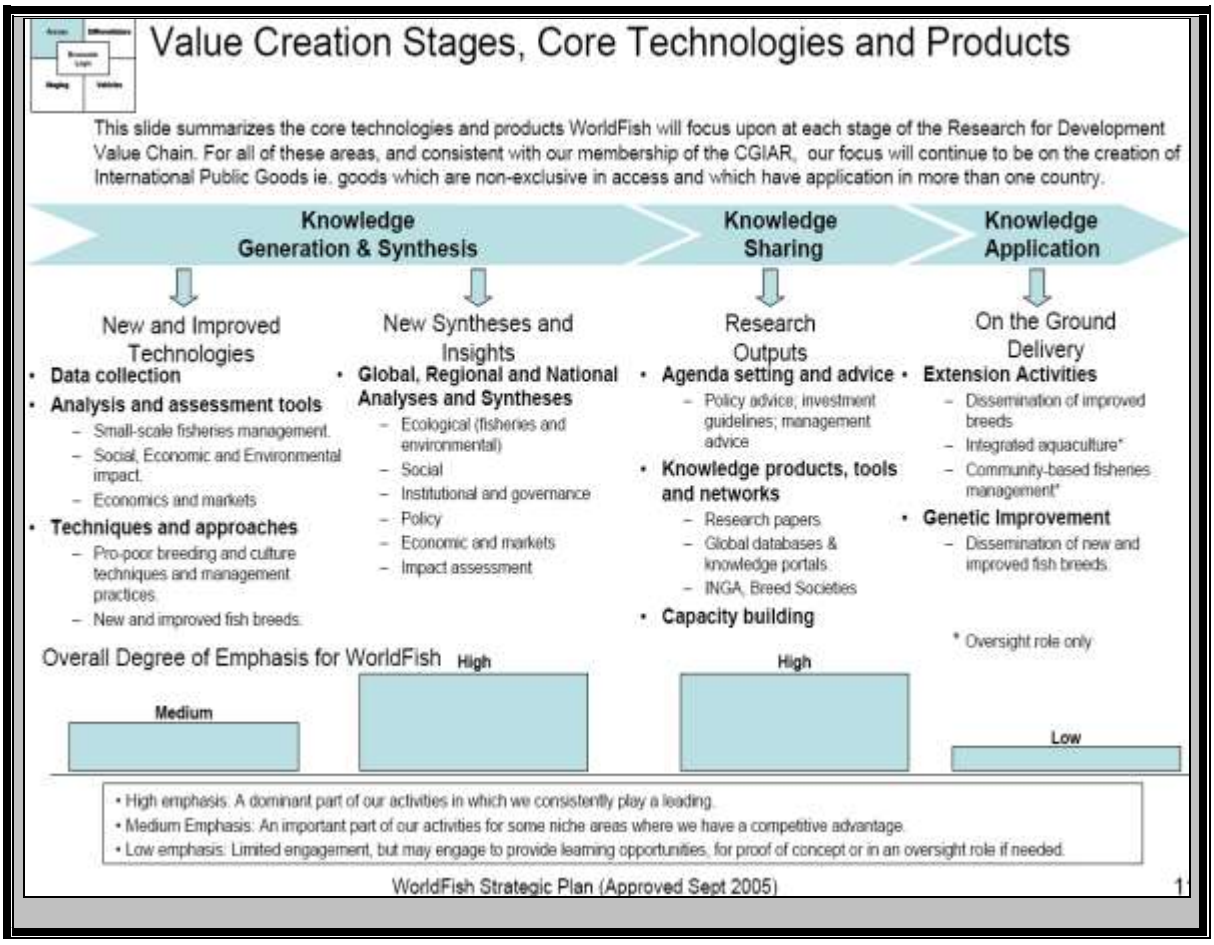

2B. Repositioning Recommendations for Producers and Users of Expert Knowledge to Effect External Change

(i.) Presentation of Research Implications for Policy and Decision-Making

Fewer than half of the research institutions examined present the policy implications of their findings to policy-makers, managers, and/or the public. Research institutions can effect external change by better presenting their research and its implications to these groups. Furthermore, an opportunity exists to work with scientists on ways to communicate scientific uncertainty by presenting an "initial read" on results, as well as explain how results will be evaluated in the future. Scientists can highlight their certainties; overall, the development of consensus statements is an effective way to share scientific information with decision-makers (i.e. COMPASS has developed these statements).

Requests for knowledge by decision-makers (i.e. RFPs, grants, and contracts) need to explicitly require that projects include relevant policy or decision-making analysis and communication deliverables. Producers of knowledge should work to determine the

needs of their users and fill gaps in communication where they are present. Users of knowledge should provide feedback to producers of knowledge on whether or not the implication analysis is relevant and useful. In filling the needs of the users, producers should collaborate or partner with others as necessary. Funders should consider the creation of a bridging institution(s) as an arm of an already existing entity that would provide technical support and inter-disciplinary communication assistance, including the facilitation of the analysis of findings for their policy implications, for scientists, and for other producers of knowledge. Interim reports should be utilized to more frequently update policy-makers periodically on the status of research and preliminary findings.

(ii.) Consistent Timeframes & Temporal Continuity

Both users and producers of knowledge need to coordinate their timelines so that the production of research, data, and information matches decision-making deadlines. Timing issues are best dealt with through communication between users, producers, and funders at the planning and contract negotiation stages of projects.

Users of knowledge should understand the importance of and work to support the establishment of long-term programs. Producers need to make a clear case for establishing continuous long-term analysis, forecasting/modeling, monitoring, etc., because it is essential to understanding ongoing data-relationships, changes, and trends. While many research institutions producing knowledge focus on synthesizing new data, few focus on synthesizing already existing monitoring data from agencies. Furthermore, the development of cross-disciplinary and interactive models and forecasts will enable producers of knowledge to better communicate tradeoffs and decisions to enact external change. Similarly, the continuity of financial and human resources is crucial to long-term monitoring and trend analysis.

(iii.) Strengthening Coastal and Ocean Social Science Research

Producers and users of knowledge should stress collaboration between the natural and social sciences (as mentioned in section 2A, i and iv). Academic institutions need to build the training programs to develop a cadre of specialized coastal and ocean social scientists in fields such as sociology, psychology, political science, education, and communications, etc.

Users should fund social science research that will help them make informed decisions by, for example, identifying social attitudes, values, and needs as well as socio-economic impacts. A significant investment needs to be made by granting agencies and donors to build coastal and ocean social science knowledge and train the next generation of social science and interdisciplinary leaders to solve complex coastal and ocean management issues.

(iv.) Communications & Translation

Forging strong communications and connections between producers of knowledge, users of knowledge, and stakeholders is crucial to effecting change. It is important to understand the ways in which the public and decision-makers process and use information. There is a need to understand what forms of communication are most effective to reach certain target audiences. While there are examples of the effective use of strategic communications—e.g., Seaweb's Seafood Choice Alliance, a sustainable seafood campaign targeting the seafood industry, from fishermen and fish farmers to distributors, wholesalers, retailers and restaurants, to create an environmentally and economically sustainable marketplace—fewer than half of the organizations examined for this paper have a convening function that brings together multi-stakeholder groups.

Engagement of the media in all formats is another important aspect of effective strategic communications. It is crucial that any communications and media strategy includes outreach with both the legislative branch and the public. Bridging functions are essential for effective translation and communications.

There is a tremendous need to improve the clear analysis and translation of research and monitoring data, the unbiased presentation of information, and the development of decision support tools for key decision-makers, stakeholders, the public, and the media. Public communication activities need to provide easy-to-read materials with graphics and should consider the use of an "ocean health report card," website, or podcasts. The California Department of Water Resources "Snow Report," for example, has been very successful at communicating snow water content and precipitation to the public.

Policy-makers, educators, and NGOs need to work together to improve science programs at all levels of education and encourage public access to science and participation in the management process. Strong interest and active participation around coastal and ocean management needs to be cultivated among public stakeholders through public information campaigns and interactive stakeholder participation throughout decision-making processes. One way to do this is by creating venues for public dialogue between local experts and non-scientists with decision-makers.

(v.) Promotion of Cross-Disciplinary Literacy

In order to effect external change, building literacy among natural scientists, social scientists, and policy-makers is critical. A number of programs already in place are creating opportunities for literacy capacity building. The Marine Life Protection Act Initiative Blue Ribbon Task Force, for example, received training from a Science Advisory Team on the marine environment and marine protected areas. The Aldo Leopold Fellowship at Stanford's Woods Institute for the Environment offers communications training to scientists. There is an opportunity to develop and implement more cross-training courses that provide communications or natural science training to social scientists, or science training for decision-makers. Other examples of program opportunities include short courses for professionals to build knowledge and capacity on a wide range of applied ocean topics, from designing monitoring, evaluation, and adaptive management programs to project management and strategic planning.

Besides formal training, program managers should make long-term investments in building the capacity of their experts over time. For example, if a science panel is asked to make recommendations to a government agency on a set of issues, it would be valuable to follow up with the panel to let them know which recommendations were used, which weren't, and why. This interactive process will help the panel become more literate about the decision-making process and should encourage them to stay engaged in the long-run.

(vii.) Collaborative Science-to-Policy & Management Processes

As findings in the first section of this paper demonstrate, the process of turning expert knowledge into coastal and ocean policy and management needs to include active collaboration between the participants in the entire process. Effective collaboration should be strategically designed to determine how scientists can best deliver data and results that are useful for the decision-making and legislative processes. Advocacy groups should participate in dialogue concerning research and monitoring, evaluation, and adaptive management.

Collaboration will work only if certain conditions are met. Partnerships must outline clear goals and benefits for all involved; funds must be coordinated and allocated for collaboration; and satellite and/or matrix teams should work on specific issues (see Text Box on UCB Traffic Safety Center, where the use of Advisory Boards is an effective mechanism for connecting expert knowledge to policy and management change). While a social science/natural science divide, compounded by a researcher/policy maker divide, can hinder effective change, ample opportunity exists for cross-disciplinary dialogue and the sharing of different perspectives on ocean problems and solutions. Collaboration is critical to creating networks, building trust, debating issues, and sharing information and lessons among diverse groups. Grant-making agencies and donors should consider prioritizing the funding of collaborative processes when funding activities require expert knowledge.

A common theme among decision-makers interviewed for this paper was that often recommendations from scientists were unrealistic because there was not enough funding to support the "best" program. When experts are asked to make recommendations, it would be beneficial for decision-makers to state 1) some key constraints to consider, and 2) request that experts make recommendations based upon more than one funding scenario. For example, if a decision-maker asks an expert panel to make recommendations for research and monitoring, the information-user may want to request that the experts develop three scenarios that prioritize efforts and explain tradeoffs based upon financial and human resources.

(viii.) Providing User-Friendly Data Management and Access

Producers and users of knowledge need to adopt user-friendly web-based applications, such as Geographic Information Systems, to facilitate place-based work. Standardized methods and formats are important to facilitating meaningful analysis and comparison. There is a recognized need in the State of California for the gathering of monitoring data

from multiple sources into a single framework that can be accessed by multiple audiences who need comprehensive access to the State's environmental data, especially the public and grant-funded projects. In reaction to this need, the Consolidated Grants Program has proposed incorporation into the California Environmental Data Exchange Network (CEDEN) and integration with data flows initiated under a previous 2004 EPA Challenge grant award to the Department of Water Resources. Related to CEDEN, the Central Coast Water Quality Control Board is pilot testing an online system for data management of its Surface Water Ambient Monitoring Program. This example provides one model to consider in organizing data management and access systems. This model, which self-checks and allows researchers to upload data, has improved the processes of cleaning the data and standardizing formats.

There is also an opportunity for producers of knowledge to develop clear data dictionaries. Data agreements between users and producers of knowledge should be negotiated to clarify success, intellectual property rights, quality control and assurance, responsibilities, and timeframe for delivery. If users of knowledge in the government offer grants or contracts to researchers for the data collection, they will own the intellectual property rights and it should be available to the public. However, the California Interagency Ecological Program gives scientists the right to publish from data within a certain timeframe before releasing it to the public. This may be an appropriate consideration for other agencies to offer to contracting scientists. Grant-making agencies and private donors should also consider investing resources into retrieving and standardizing historical and current data sets and developing a web-portal to the federal, regional, state, and local monitoring efforts underway.

(ix.) Transparent Link Between Science & Funders

Interactions between science and political decision-making are susceptible to two types of funding-related distortions. First, decision-makers may be negatively influenced by biased science that is funded by industry or private donors and their representatives. To mitigate this problem, government entities should prioritize funding for and distribution of non-partisan, non-commercially-motivated scientific work that directly informs decision-making. Additionally, funding sources of scientific work that is not government-funded should be fully disclosed before decision-makers incorporate the work into the decision-making process.

It is crucial that government agencies, if involved with research and monitoring decisions, clearly identify any potential advisory committee or board conflicts of interest, produce unbiased communications, avoid politicizing science, and, above all, remember that scientists are a stakeholder group.

(x.) Incorporating Variability into the Regulatory Framework

The needs of decision-makers are in some ways fundamentally at odds with the form and nature of scientific findings and the way in which coastal and ocean processes occur and change. Decision-makers require set findings so that they can make definitive laws and policies. Science and coastal and ocean systems, by contrast, constantly fluctuate.

Although difficult, it may be possible to develop a method of writing formulas of variability into policies and laws. If decision-makers and the regulated community came to view laws and policies not as fixed, but rather as "living" and constantly evolving, all participants in the regulatory system would develop a very different relationship with the regulatory scheme. For example, if a developer knows that the permissible actions he can take at any given time with regard to building a new house on the coast depend on the most up-to-date scientific consensus and resulting baseline law/policy (for example, on how clean the water is in any given monitoring period), he will actively engage in tracking the progress of cleaning up the water. He will also try to better understand how his impacts contribute to water quality as a whole, as well as pressure other polluters who may be hindering his ability to proceed with a project.

Text Box: UC Berkeley Traffic Safety Center

The Traffic Safety Center (TSC) at the University of California, Berkeley aims to reduce traffic fatalities and injuries through a combination of education, research, and outreach. The Center is multi-disciplinary and includes participants from Berkeley's Institute of Transportation Studies, Schools of Public Health and Optometry, Department of Civil Engineering, City and Regional Planning offices, other universities, and public and private agencies. The Center conducts applied research; provides technical assistance to governments and communities; and teaches courses in the Schools of Public Health and Civil Engineering. In addition, the Center manages the California Office of Traffic Safety's mini-grant programs for sobriety checkpoints and seat belt enforcement programs.

The Traffic Safety Center convenes project-specific advisory boards composed of a diverse group of California traffic safety stakeholders, including the state Office of Traffic Safety; county health departments; emergency room physicians; police departments; and experts from a variety of disciplines. The Center consults with the Advisory Board in determining research priorities and identifying funding opportunities and potential partners.

Sample projects include:

- Under contract with the State of California, TSC researchers are analyzing data from the statewide traffic collision data base to help the State conduct traffic safety planning as mandated for funding under the 2005-2008 federal transportation bill.
- Under contract with a Bay Area city, TSC researchers conducted an assessment of pedestrian and bicycle safety within the city. The TSC studied several intersections, and made recommendations for improving safety to the City. Several of the recommendations have been reviewed by an engineering firm as well as the City, and have been implemented.
- The TSC conducted an evaluation of the State's Safe Routes to Schools program, as mandated by the California Legislature. The report was presented to the Legislature in March 2007.

3. Conclusion

Improving the quality and efficacy of coastal and ocean policy and management requires the effective integration of expert knowledge, research, and monitoring data throughout the decision-making process. Effective integration is impeded by the perceptual, institutional, and operational gaps between the producers and users of knowledge. Key gaps between these groups include a cultural divide that undermines respect and openness in communication; disparate educational backgrounds, which includes a lack of a shared lexicon or literacy between issue-related disciplines; institutional barriers, especially battles for scarce funding resources and funding processes that award individual, rather than collaborative, successes; and operational challenges, such as the day-to-day difficulties of coordinating the work of scientists and decision-makers working for un-affiliated entities and in different locales.

While the gaps between producers and users are significant, there are a number of opportunities to directly address these issues and dramatically improve the integration of science into coastal and ocean policy and management. Many of these steps are based on collaborating at multiple levels and improving understanding and communication between producers and users of knowledge at the various points of their interaction. Key recommendations for improving the integration of science into coastal and ocean policy and management include encouraging changed cultural attitudes toward interdisciplinary research and expert and decision-maker coordination by demonstrating and institutionalizing the mutual benefits of doing so; tailoring analysis of data and other knowledge to directly meet the decision-based, temporal, and resource-constrained characteristics of the decision-making process; increasing communication and translation functions; and strongly encouraging funders and users of knowledge to prioritize funding for collaborative, interdisciplinary, integrated activities and institutions.

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