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More than Information, What California's Coastal Managers Need to Plan for Climate Change

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MORE THAN INFORMATION: WHAT CALIFORNIA'S COASTAL MANAGERS NEED TO PLAN FOR CLIMATE CHANGE

PIER PROJECT REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California's electricity and natural gas ratepayers. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's Public Interest Energy Research (PIER) Program established the **California Climate Change Center** to document climate change research relevant to the states. This Center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts and the efforts designed to reduce emissions.

The California Climate Change Center Report Series details ongoing Center-sponsored research. As interim project results, the information contained in these reports may change; authors should be contacted for the most recent project results. By providing ready access to this timely research, the Center seeks to inform the public and expand dissemination of climate change information; thereby leveraging collaborative efforts and increasing the benefits of this research to California's citizens, environment, and economy.

More than Information: What California's Coastal Mangers Need to Plan for Climate Change is the first of three reports for the Assessing Potential Impacts of Climate Change on California project (project number 500-99-013, work authorization number BOA-119) conducted by the National Center for Atmospheric Research's Institute for the Study of Society and Environment.

For more information on the PIER Program, please visit the Energy Commission's website www.energy.ca.gov/pier/ or contract the Energy Commission at (916) 654-5164.

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Abstract

California's coastlines are vulnerable to the consequences of climate change and sea-level rise. Coastal managers at local, regional, state, and federal levels will need to plan and implement adaptation measures to cope with these consequences. This study explored the information needs of California's coastal managers, who confront the growing risks from climate change. It examined the challenges managers face presently, what information they use to perform their responsibilities, and what additional information and other knowledge resources they may need to begin planning for climate change. This study was conducted in the broader context of how science can best support policy makers and resource managers. Based on extensive interview and survey research in the state, researchers found that managers prefer certain types of information and information sources and would benefit from various learning opportunities (in addition to that information) to better use the available climate change information. Coastal managers are highly concerned about climate change and willing to address it in their work, but they require financial and technical assistance from other agencies at the state and federal level to do so. This study revealed a strong need for individuals or organizations to play an intermediary role between science and practice.

Keywords: Climate change, sea-level rise, coastal impacts, preparedness, coastal zone management, information needs, California

Executive Summary

Introduction

California, with its 1100 miles of open ocean coastline and another 1000 miles of San Francisco bay shoreline, is a major attraction for residential and commercial development, economic activity, tourism, and recreation. These highly developed coastal areas are vulnerable to the effects of sea-level rise and other climatic changes. Federal, state, and local managers and decision-makers in coastal states and communities around the country are beginning to consider how to adapt to the impacts of a rapidly changing climate and accelerating sea-level rise.

There is a still-prevailing assumption, especially among physical scientists, that "better science" can lead to "better decisions." A disconnect remains, however, at the intersection between the information and knowledge produced by scientists and the information and knowledge applied by decision-makers. While decision-makers are often preoccupied with the responsibilities of their jobs and tend not to have the time or inclination to search for information from scientific sources (even if it may be relevant to their work), researchers are typically driven to publish results in scientific and professional journals that often have a limited audience, and they have little incentive to deliver such information directly to non-scientists.

Purpose

The purpose of this project was to better understand what specific information and knowledge resources California coastal managers need to address adaptation to climate change in their day-to-day management responsibilities. To understand managers' information needs, this study also tried to determine how coastal managers perceive present and future changes caused by climate variability and change and sea-level rise.

Objectives

The research team sought to examine information needs of California's coastal managers to determine what information could best support them in confronting the growing risks from climate change and to evaluate this information in the broader context of how science can best support policy-making and resource management.

Specifically, this paper investigates the role that information and knowledge resources play in decision-makers' awareness of and attention to climate change impacts on their communities and attempts to gain a better understanding of:

- What coastal managers in California already know about climate change;
- What type(s) of information they draw upon to assess the risks they already face or may face in the future;

- What additional information coastal managers would need to incorporate climate change into their management decisions.

Methodology

This study proceeded in two stages. In the first phase, the research team interviewed government staff from the federal state and regional levels involved in California coastal management, to determine their awareness and understanding of climate change impacts, their information use and needs, and barriers to action. Building on the insights gained from the interviews, the study's second phase explored parallel questions with nearly 300 local (municipal and county-level) coastal managers using a comprehensive survey. The research explored the following questions:

- What are coastal managers' current management challenges and responsibilities?
- What is the level of awareness and understanding of climate change impacts on coastal zones?
- What information is currently being used in coastal management and what are managers' information and knowledge needs? What are the information needs related to climate change impacts?
- Besides lack of information, what other constraints affect coastal decision-making today?
- What actions have coastal managers taken in the past to cope with adverse coastal conditions, and do they perceive any changes in the state's coping capacity?

The interviews and survey also inquired about community/county characteristics, including the degree of development, vulnerable infrastructure, installations or coastal resources in the immediate coastal areas, and basic demographic information about the study participants (e.g., age, employment position, level of education attained).

The overall response rate to the survey was considered adequate, based on common survey experience. In total, 89 percent of coastal cities along the open ocean and bay shorelines and 89 percent of coastal counties are represented by respondents.

Key Findings

1. California coastal managers identified 15 major management challenges. Of these, the eight identified as the current greatest challenges (coastal/nearshore water quality, inland water quality, inland flooding, coastal flooding, salt water intrusion, coastal erosion, beach loss, species/habitat protection, and public access) can directly or indirectly be related to climate variability and sea-level rise, and can be expected to be further aggravated as climate change proceeds over this century.
2. To manage these coastal management challenges, coastal managers draw upon information that pertains directly to their job and management responsibilities.

The most frequently used type of information is about environmental conditions; the next most frequently used category of information is weather, climate, or hydrology-related. With only one or two exceptions, none of the interviewees currently use projections of *future* climate variability and change, or projections of sea-level rise under different climate scenarios in their planning and management decisions today.

3. Interviewees pointed to difficulties in accessing available information, rather than the complete lack of information, as the biggest problem.
4. Coastal managers typically consult in-house colleagues, the Internet, and professional or trade journals for the majority of their information needs. By contrast, more than 70 percent of survey respondents said that they either never or only rarely use the typical outlets for scientific information (primarily peer-reviewed scientific journals).
5. The tools managers commonly use in their management duties to display, analyze, and/or transform available technical information into useful management-relevant information are maps and geographic information systems (GIS). Limited capacity exists to use more sophisticated analytical, modeling, or forecasting tools. Capacity would need to be built if interpretation and use of climate change-related information required this type of information processing.
6. The most useful knowledge resource desired by managers is help with determining what elements of their community are most vulnerable to the impacts of climate change impacts.
7. Interviewees and survey respondents expressed a desire for more than just information. With concerns about global warming high, and a considerable readiness to act, California coastal managers wish for interactive forms of learning, forums for discussing this information, and action-oriented case examples to explore and learn about management options for adaptation.

Conclusions and Recommendations

Against a backdrop of already pressing management challenges, coastal managers have their hands full with dealing with current and ongoing problems. Lack of staff, financial, and technical resources, as well as lack of time and a legal mandate to address climate change are the primary obstacles to preparing for climate change to California coastal managers. Aside from these primary needs for assistance, coastal managers have very specific information needs, most of which are not about future problems but about the current conditions—many of which are already not addressed to managers' satisfaction. Interviewees and survey respondents suggested that education about and discussion of global warming issues related to coastal management could be facilitated through a variety of efforts not commonly undertaken by academic experts, including training workshops, learning in inter- and intra-agency working groups, improvements to and integration of existing information and knowledge resources, provision of web-based

clearinghouses of information, and so on. Assuming scientists do not typically offer such services, and managers are busy dealing with their day to day responsibilities, this study highlights the existing science-practice disconnect between climate change research and coastal managers. In an effort to alleviate the extent of this disconnect, formal boundary organizations (institutions or individuals translating and mediating between scientists and non-scientists) or informal communication and exchange channels between scientists and managers could provide precisely these convening, translating, and facilitating services, and thereby help improve coastal managers' efficacy in preparing for climate change.

Preparing, planning for, and effectively adapting to, climate change-related impacts on coastal areas requires getting ahead of the problems. Based on this study's findings, California's coastal managers may be better able to deal with the potentially severe impacts from climate change and sea-level rise if they begin preparing for them now. Improving the transfer of relevant scientific information and knowledge resources from scientists to decision-makers, where necessary with the help of intermediary boundary organizations, will help managers to prepare in advance of these emerging and worsening problems. While information alone will not suffice to help communities adequately prepare for climate change, California has a number of excellent resources available to draw on, including:

- World-renown expertise on climate change, impacts, and coastal hazards based in the state's universities and research laboratories.
- A considerable number of highly concerned and willing-to-act coastal managers (not everyone has to be on board from the start, but model communities ready to act can lead the way).
- Several institutions that could play boundary spanning roles, such as the state's Sea Grant programs, the Regional Integrated Sciences and Assessment center based at Scripps Institution of Oceanography, and others.
- A strong political leadership at the state level on global warming.

These resources should be brought together on the question of adaptation to climate change impacts in the coastal zone to maintain that vital economic, environmental, and cultural resource for Californians and visitors to the state.

1.0 Motivation and Overview

Governor Arnold Schwarzenegger's Executive Order S-3-05 of June 1, 2005, called for specific emission reductions and a periodic update on the state of climate change science and the emerging understanding of potential impacts on climate-sensitive sectors such as the state's water supply, public health, agriculture, coastal areas, and forestry. In addition, the executive order requested that future impact assessments include a "report on mitigation and adaptation plans to combat these impacts." This report responds to this request. It examines California coastal managers' information needs regarding climate change impacts on the coastal zone. A complementary report on managers' preparedness and capacity to deal with the existing climate variability and assesses opportunities and constraints in preparing for potential future impacts of climate change was prepared previously (see Luers and Moser 2006). An additional report on the preparedness of coastal managers in particular is forthcoming.

The request for plans to cope with and adapt to the unfolding impacts of climate change opens up a critical opportunity to expand the much-needed discussion on how society should manage the changes ahead. The growing focus on adaptation is thus welcome and timely.

This report explores how the state could support state and local coastal managers in their efforts to approach adaptation and take necessary preparatory measures. Section 2 places this challenge into the larger context of improving the interaction between science and practitioners such as coastal managers and policy-makers. Section 3 describes this study's research methods and data sources. Section 4 presents the findings, and Section 5 explores the implications of these findings for current and future science and decision-making related to the risks of climate change and sea-level rise, and discusses the transferability of these findings beyond California. Section 6 offers several preliminary recommendations on how scientists and practitioners can improve their interaction and communication to increase the nation's preparedness for the impacts of climate change in coastal areas.

2.0 Introduction

City managers and planners, public works officials, local and state elected officials, and community development specialists are at the forefront of making decisions that impact the social, political, and economic well-being of their local communities. Specific information and knowledge about the social, economic, and environmental conditions of a community are needed to make decisions that enhance the community's development and well-being while minimizing potentially adverse social and environmental impacts. This holds particularly true now as decision-makers in coastal states and communities of the United States must begin managing their jurisdictions to adapt to a rapidly changing climate and accelerating sea-level rise (Church et al. 2001; McLean et al. 2001; Nicholls et al. 2007) .

What information could best support coastal managers in confronting the growing risks from climate change? This report addresses this question by examining information needs of California's coastal managers. This study is placed into the broader context of how science can best support practitioners as they prepare for climate change[1] in their daily decisions. In particular, the research team investigated the role that information and knowledge resources play in decision-makers' awareness of (and attention to) climate change impacts on their communities. Researchers also attempted to gain a better understanding of what coastal managers in California already know about climate change, what type(s) of information they draw upon to assess the risks, and what additional information they would need in order to incorporate climate change into their management decisions.

2.1. Why California? Why State and Local Decision-makers?

California, with its 1100 miles of open ocean coastline, is a major attraction for residential and commercial development, economic activity, tourism, and recreation. These highly developed coastal areas are vulnerable to the effects of climate variability and change and sea-level rise (Griggs et al. 2005; Bromirski et al. 2002; duVair et al. 2002; Storlazzi and Griggs 2000; Ryan et al. 1999; Flick 1998). "Today's climate variability and weather extremes already pose significant risks to California's citizens, economy, and environment. They reveal the state's vulnerability and existing challenges in dealing with the vagaries of climate. Continued climate changes and the risk of abrupt or surprising shifts in climate will likely further challenge the state's ability to cope with climate-related stresses in the future" (Luers and Moser 2006). Indeed, the most recent

[1] The phrases "climate change" and "global warming" are used interchangeably throughout this paper. The term "global warming" is the more popular, if scientifically less accurate term, and it generally refers to changes in global temperature, whereas "climate change" encompasses temperature changes and other changes in climatic variables, including seasonal patterns, patterns of extremes, and so on. Researchers used and defined both terms in the survey and interviews, as lay people are frequently more familiar with the common phrase "global warming" but may think more broadly about impacts if prompted with "climate change."

climate change projections for the state project accelerated sea-level rise (SLR), greater potential for storm damage, and expensive economic impacts of a possible levee system failure (Cayan et al. 2006; Vicuña et al. 2006).

Under the federal Coastal Zone Management Act of 1972, as amended, and other relevant national laws, federal agencies have important roles to play in dealing with such coastal hazards. However, coastal managers at the state and local level will be at the front lines of preparing for the impacts of climate change, planning ahead, and adapting to the impacts as they unfold. Generally speaking, state and local coastal managers balance the needs and desires of a multiplicity of stakeholders and resource users, which greatly complicates their preparations for addressing climate change impacts.

State and local coastal managers already have their hands full with current problems related to protection of habitat and species; public safety in the face of natural hazards; access to coastal areas; provision of recreational areas; and supply and protection of water, energy, and other infrastructure—as well as the siting and appropriate construction of development (Luers and Moser 2006). These challenges leave them with little extra capacity to become knowledgeable about climate change or begin developing long-term adaptation strategies. Additional obstacles to addressing climate change include economic constraints, insufficient expertise and personnel to address pertinent issues, and lack of information (Moser and Tribbia 2006/2007).

This report explores coastal managers' information use and needs to begin to address climate change in their management decisions; in part to address a larger effort to provide California policy-makers with a scientific assessment of the state's preparedness for climate change (pursuant to Executive Order S-3-05 issued by Governor Arnold Schwarzenegger in June 2005). This report also examines how science–coastal management interactions could be improved to increase the likelihood that global change-related information effectively informs state and local decision-making.

2.2. The Science-Practice Disconnect

Researchers vie to construct as precise an understanding of coastal and climatic processes as possible to characterize the physical risks that may threaten coastal areas. Indeed, most research now confirms that climate change is occurring and that coastal impacts such as SLR, changing coastal storms, changing rainfall and runoff patterns into the coastal ocean, increases in coastal water temperature, species and habitat shifts, higher air and water temperatures, increasing flooding, coastal erosion, and cliff retreat are expected to continue and exacerbate in the future (Rahmstorf 2007; Meehl et al. 2005; Wigley 2005; Church et al. 2001; McLean et al. 2001). To ensure that coastal states and communities are beginning to prepare, mitigate, and adapt to the physical effects of climate change, the particulars of this information and knowledge should (ideally) percolate from scientists directly to community officials who need it most. All too often, however, decision-makers rely on "the expectation that [environmental] science can help

inform human decisions about societal change" while many management decisions continue to be made without scientific input (Sarewitz and Pielke, Jr. 2007).

A disconnect remains, however, at the intersection between science and decision-making—that is, between the information and knowledge produced by scientists and the information and knowledge applied by decision-makers. There are number of reasons why scientific information and knowledge is not always used in environmental policy and management. Scientists and researchers are driven to publish results in scientific and professional journals that often have a limited audience base. In addition, scientists have little incentive to deliver information to non-scientists. Many do not engage in research with the underlying purpose to communicate findings to anyone outside their area of expertise. Scientists also frequently simply assume that their information and knowledge is useful without necessarily checking this assumption against what decision-makers actually require (e.g., Sarewitz and Pielke Jr. 2007; Morss et al. 2005; Jacobs et al. 2005). On the other hand, decision-makers are preoccupied with the responsibilities of their jobs and tend not to have the time or inclination to search for information from scientific sources, even if it may be relevant to their work. Besides time constraints, the non-familiar, technical jargon common in many scientific reports can form tremendous hurdles for non-experts to overcome (e.g., Dabelko 2005). As McNie (2007, p. 17) summarizes the situation in her extensive review of the pertinent literature, "scientists… may simply be producing too much of the wrong kind of information [while] users may have specific information needs that go unmet."

2.3. Information Needs

The described science–practice disconnect persists in the face of the near-ubiquitous argument that to improve decision-making managers need "more and better" information, for example to take climate change and its impacts into account in planning and management decisions. Some suggest that improving science will, in turn, improve decisions about science issues (Myatt et al. 2003; Gregory and McDaniels 2005; Sarewitz and Pielke, Jr. 2007). Myatt et al. (2003), for example, believe that information shortages contribute to fallacies in decision-making when they argue that, "in general, people do not have enough information or knowledge to make informed decisions on many aspects concerning [coastal] flooding and defence" (p. 284). Other analysts state that decision-making requires "input from technical experts … to help anticipate how actions might affect the natural and the human environment and to develop approaches for mitigating potentially adverse [environmental] impacts" (Gregory and McDaniel 2005, p. 186). Consistent with these statements, the National Research Council concluded that the highest-priority questions for social science in support of environmental decision-making should now be to research *what type* of information decision-makers need from technical and scientific experts, how that information is used, and how it can best fit into the decision-making process (Wilbanks and Stern 2002, pp. 345–347).

However, this traditional approach to providing scientific information to decision-making (that is, getting the science right and only then giving it to decision makers) has

been found to not always be effective (Cash et al. 2006). Many environmental policy initiatives fall short of expectations because experts simply believe that "better science will lead to better decisions" without fully understanding the decision situation, the institutional context within which scientific information could be used (e.g., French and Geldermann 2005; Rayner et al. 2005), or what a decision-maker could really use. In the typical "loading dock" approach (Cash et al. 2006), the primary emphasis of information production is "on the opinions of scientists and other technically trained participants" rather than the potential users framing science-related policies (Gregory and McDaniels 2005, p. 189). Sarewitz and Pielke, Jr. (2007, p. 9) similarly suggest that, "more information may not lead to better decisions" because "the information is not relevant to the user needs; it is not appropriate for the decision context; it is not sufficiently reliable or trusted; it conflicts with users' values or interests; it is unavailable at the time it would be useful; it is poorly communicated."

2.4. Boundary Organizations

If "better information" or "more information" is not sufficient, and maybe not even as significant to decision-making as previously thought, but information—well integrated into the decision process—appears necessary, then what process can help create or ensure a better match between science and practice? Researchers suggest that certain intermediary organizations can help improve the process of knowledge production and application by enabling scientists and decision-makers to increase mutual understanding of capacities and needs while remaining within their respective professional boundaries. Such an intermediary organization—also known as a *boundary organization*—would be responsible for communicating the information scientists have available (or could provide) to decision-makers and communicating information needs from decision-makers back to scientists.

Within the science policy literature, boundary organizations are defined as institutions or individuals mediating between scientists and non-scientists (e.g., Cash et al. 2006; Cash et al. 2003; Cash 2001; Guston 2001; Gieryn 1999). The purpose of these organizations is to solve the problems associated with information exchange between scientists and practitioners. "They involve the participation of actors from both sides of the boundary, as well as professionals who serve a mediating role to co-produce knowledge that can be used by multiple audiences" (Guston 2001, p. 401). For example, the National Sea Grant College Program could be viewed as a boundary organization spanning between coastal research and management. It comprises a network of 30 university-based programs "dedicated to enhancing the understanding, conservation, and sustainable use of the nation's coastal and marine resources" supported by efforts from scientists and engineers at public and private universities (California Sea Grant, no date). The California Sea Grant College Program is the largest of these 30 programs and is one of the institutions in California that could potentially play such a boundary spanning role between researchers and coastal managers. Its program description states:

> "California Sea Grant contributes to the growing body of knowledge about coastal and marine resources and helps solve contemporary marine-related problems through its sponsored research. It supports graduate education by funding trainees who work with marine scientists and engineers on a diversity of subject areas. Through its outreach and communications components, developments in information and technology are transferred to stakeholders. Our Extension personnel play a major role in the link between university, industry, and the public." (California Sea Grant, no date)

Boundary organizations like California Sea Grant help identify the information needs of decision-makers and facilitate a co-production of knowledge by "managing the boundaries between science and policy, across disciplines, across scale, and across knowledges to create information that is salient, credible, and legitimate to multiple audiences" (Cash et al. 2006, p. 465; see also Clark et al. 2002; Mitchell et al. 2006). As such, boundary organizations perform four critical functions: convening, translation, collaboration, and mediation. These functions help manage and maintain the relationship between information producers and users (Cash et al. 2003). Each is discussed in turn below.

The first is a *convening* function: bringing stakeholder parties together for face-to-face contact. As a result, relationships of mutual trust and respect can be fostered while mutual understanding grows. Trustful partnerships between information users and suppliers are the foundation of effective information production, transfer, and ultimate use (Wilbanks and Stern 2002). The National Research Council's Panel on Social and Behavioral Science Research Priorities (Brewer and Stern 2005, p. 26) agrees that forums are needed in which participants "integrate analysis with broadly based deliberative processes involving the range of parties interested in or affected by the decisions." Convening relevant stakeholders then provides the foundation for the other three functions of boundary organizations.

The second function—*translation*—assures that information and resources are comprehensible for cooperating individuals and organizations. Translation can be crucial for coastal managers attempting to communicate what type(s) of information or resources they need, and for scientists to provide the needed information or resources to coastal managers. Translation addresses the problem identified by Sarewitz and Pielke, Jr. (2007) and many others that scientists speak in disciplinary jargon hard to understand by managers who, in turn, have their own professional shorthand and perspectives, which are unfamiliar to academics.

The third function is to facilitate *collaboration.* Boundary organizations can bring cooperating groups together to effectively work together and co-produce relevant and scientifically credible applied knowledge. Active and collaborative participation of information providers and users in the actual production of knowledge can thrive when participants have equal status, share mutual respect, and hold transparent, frank

discussions. Collaboration also enhances buy-in from both sides and facilitates further trust building, and thus increases the chances that information is actually being used in decision-making.

The final function that boundary organizations sometimes play is mediation. Scientific information rarely, if ever, compels a particular course of action. More often, many other considerations besides science come into play. To the extent science supports a particular course of action that produces or unearths values conflicts among stakeholders, boundary organizations can play a critical mediating role. The goal of such mediation is to assure fairness in representing various interests of stakeholders, information producers, and users (e.g., O'Riordan and Cameron 1994).

The foregoing discussion establishes three key arguments underlying this report:

- Scientific information can, and some would argue should, inform decision-making, especially for long-term problems such as global change.
- Information per se often does not adequately inform decision-making because of a persistent science-practice disconnect.
- Intermediary or boundary organizations (or less formal arrangements of science-practice interactions) can play important roles in bridging that disconnect and facilitate the production of useful information as well as foster the actual use of such information in decision-making.

Therefore, this research explored the following questions: What are decision-makers' information needs regarding global climate change and related adaptation decisions? How well and by whom are they getting these information needs met already? What more do managers need? What other knowledge resources (besides *just* information) would help coastal managers in California prepare for and adapt to climate change?

3.0 Research Methods

This research proceeded in two stages. In the first phase, government staff from various levels involved in California coastal management were interviewed to determine their information use and needs. The research team elicited insights into how California is currently dealing with challenges in the coastal zone, how these issues may be affected by global warming in the future, and whether the state has begun to prepare for climate change impacts on coastal ocean and resources. The 18 semi-structured interviews with key informants typically lasted 60 to 90 minutes. Interviewees included regional, state, and federal coastal zone managers, including staff from regional institutions such as the San Diego Association of Governments (SANDAG) and the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON); state government staff from the San Francisco Bay Conservation and Development Commission (BCDC) and Coastal Commission, State Parks, Resource Agency, State Office of Emergency Services, Department of Boating and Waterways, Water Resources Control Board. Federal staff from the U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency (FEMA), and the National Parks Service were also interviewed. Interview questions explored the following themes:

- Current coastal management challenges and management responsibilities of interviewees.
- The level of awareness and understanding of climate change impacts on coastal zones.
- Information use and constraints that affect coastal decision-making.
- Historic actions taken by coastal managers to cope with adverse coastal conditions and perceived changes in the state's coping capacity.
- Information needs related to climate change impacts.
- Other perceived barriers to California's ability to adapt to climate change.

This report mainly covers the information uses and needs aspects of the interviews, while other papers (published and forthcoming) address other interview topics (see, e.g., Moser and Tribbia 2006/2007). Interviews were transcribed and qualitatively analyzed. The research team was particularly interested in commonalities and notable differences in information needs, pragmatic suggestions for improving information supply and use, and informational and other critical barriers to begin preparing for climate change at this time.

Building on the insights gained from the interviews, in this study's second phase researchers explored parallel questions with local coastal managers, using a survey to understand current coastal management challenges. Researchers elicited perceptions and attitudes about global warming and related impacts on coastal areas and information they need to manage current and future coastal challenges.

For this study, "coastal management" is defined as *all management occupations concerned with the safety, environmental protection, public infrastructure, and development of coastal areas, on land and in nearshore coastal waters* (see also Moser and Tribbia 2006/2007). Therefore, the research team contacted planners; permitting officers; public works engineers; community development coordinators; harbor, parks or beach managers; environmental specialists; water resources managers; emergency managers; and to a lesser extent, elected officials. Researchers surveyed 299 municipal and county government employees in these management resorts. Table 1 lists the number and types of respondents (Moser and Tribbia 2006/2007). The research team identified survey respondents through extensive web searches and with the help from the California Coastal Commission and Bay Conservation and Development Commission. The team attempted to obtain responses from at least two or three individuals from each coastal county or city, but was often able to identify six or more individuals from communities with larger government staff.

Table 1. Survey respondents (numbers in top row and percentage in bottom row, n=135)

Planner	Permitting Officer	Public Works Engineer	Environ. Specialist	Development Coordinator	Harbor etc. Manager	Water Res. Manager	Elected Official	Other*
50	13	24	5	9	3	3	1	24
37.9%	9.8%	18.2%	3.8%	6.8%	2.3%	2.3%	0.8%	18.2%

* Emergency service managers, natural resources managers, multiple/mixed responsibilities, or not otherwise specified by respondent

Source: Moser and Tribbia (2006/2007, p.6)

The 18-page, 40-question mail survey inquired about the following topics:

- Community/county characteristics including degree of development and types of current coastal management challenges and strategies.
- Attitudes about global warming and knowledge of possible consequences of global warming on coastal areas and management.
- Information currently used or needed to effectively carry out coastal management responsibilities.
- Basic demographic information (e.g., age, employment position, level of education attained).

Again, this report focuses primarily on responses to information uses, needs, and constraints vis-à-vis current and future coastal management challenges. Survey questions consist of open-ended and multiple-choice informational questions, attitudinal questions based on a Likert scale, and check-all and forced-choice questions. Out of the 299 mailed surveys, 14 were returned blank or due to inadequate address and eight

additional respondents considered their location non-coastal. The overall response rate was 46.1% with the 135 usable responses representing about 89% of coastal cities and about 89% of all the coastal counties approached. These statistics indicate a reasonably good response rate[2] and very good representation of coastal communities in California.

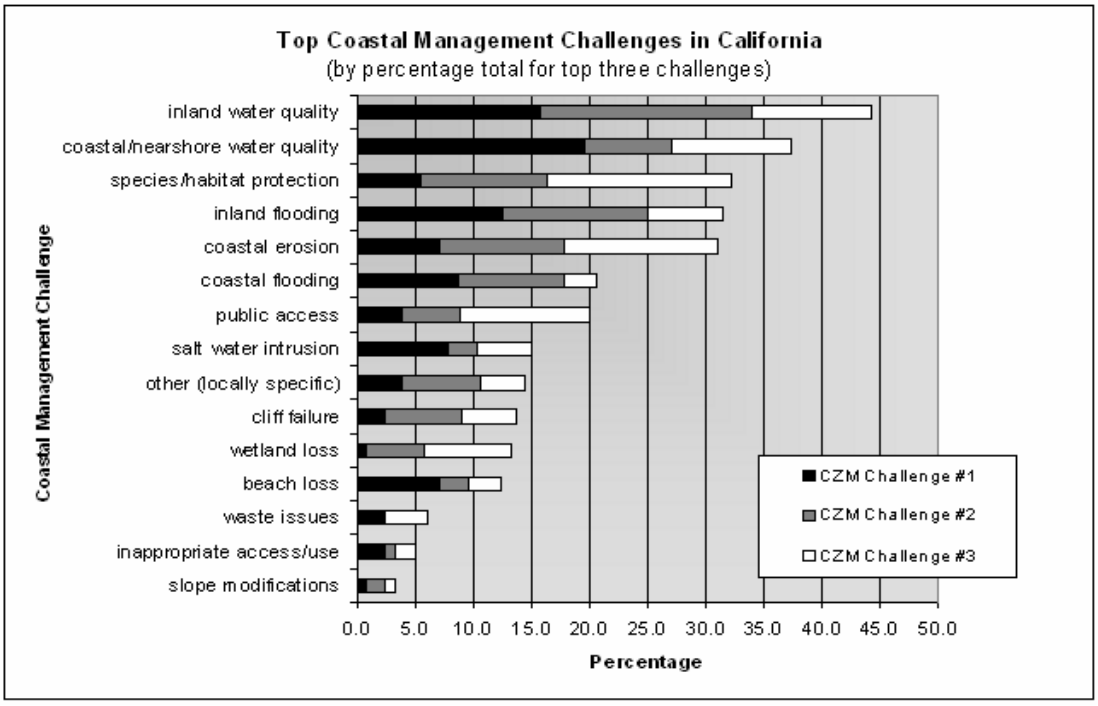
The data from the survey were analyzed using simple statistical analyses. In addition, the qualitative comparisons from both the survey and interview instruments offered interesting insight to managers' perceptions, information needs, and job functions. These findings are discussed in the section below.

[2] Research in survey methods suggests typical response rates to mail surveys of 20%–40% (Nachmias and Nachmias 1987). A response rate of 50% is generally considered adequate for stringent quantitative analysis (Babbie 2007), above and beyond the simple statistical analyses conducted here. While respondents and non-respondents to a survey typically differ in attitudes, interests, and opinions, the response rate and regional representation obtained must thus be considered reasonably good to very good.

4.0 Findings

To provide some case-specific context to the discussion of coastal managers' information needs, they were asked what they considered the top three coastal management challenges. Figure 1 illustrates the current challenges identified by survey respondents. Interviewees qualitatively confirmed these views.

Figure 1. Top coastal management challenges in California as identified by survey respondents



Source: Adapted from Moser and Tribbia (2006/2007, p.7)

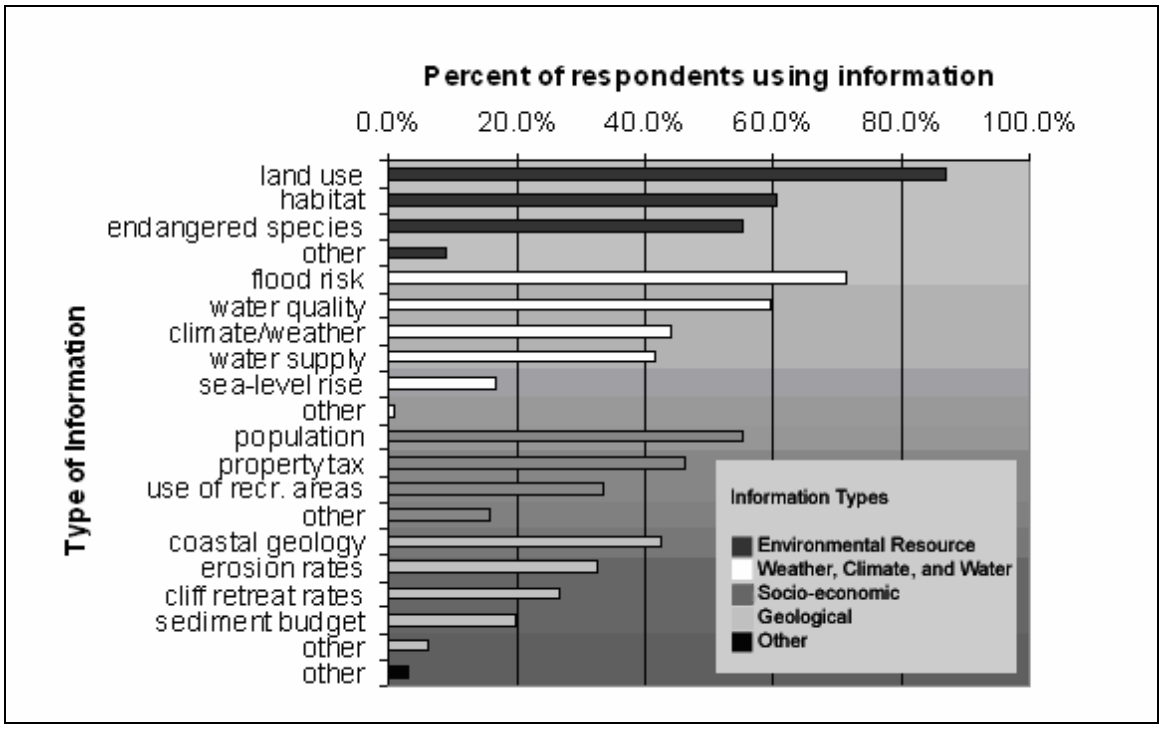
It is notable that eight of the top fifteen challenges (coastal/nearshore water quality, inland water quality, inland flooding, coastal flooding, salt water intrusion, coastal erosion, beach loss, species/habitat protection, and public access) can directly or indirectly be related to climate variability and sea-level rise. This suggests that coastal managers are already dealing with many of the problems expected to become aggravated as sea-level rise accelerates due to global warming.

4.1. Information Currently Used in Coastal Management

Managers were first asked what sources of information they generally use in their daily work. Figure 2 illustrates the sources coastal managers commonly draw on (by general category). Not surprisingly, given the types of management challenges faced, and the population of respondents, the most frequently used type of information is about environmental features: 87.1% use land-use information, 60.6% draw on some kind of

information about habitats, and 55.3% use information about endangered species. The next most frequently used category of information is weather, climate or hydrology-related, including issues such as flood risk (used by 71.2%), water quality (59.8%), and climate and weather (43.9%). Leading socioeconomic information include population data (used by 55.3% of respondents) and property tax information (46.2%). Additionally, managers use some types of geologic information, including about coastal geology (42.4%), erosion rates (32.6%) and cliff retreat rates (26.5%).

Figure 2. Information commonly used by coastal managers (by type)



Interviewees related similar information use, reflecting interviewee's agency affiliations and job responsibilities. With only one or two exceptions, none currently use projections of *future* climate variability and change, or projections of sea-level rise under different climate scenarios in their planning and management decisions today (the sea-level rise information typically used is simply an extension of past SLR trends into the foreseeable future). Beach loss or cliff retreat information is similarly based on historic rates and does not account for likely future acceleration.

4.2. Problems With and Suggested Improvements Regarding Currently Available Information

Notably, interviewees frequently complained about all the information they would like to use but do *not* have, or that is barely accessible (e.g., they accidentally found reports

on someone's dusty shelf or in a forgotten basement). Several mentioned the declining or general lack of funding for ongoing monitoring of current environmental conditions. For them, this problem loomed larger than the lack of information about future conditions (i.e., climate change and its impacts). Interviewees pointed to difficulties in accessing available information, rather than the complete lack of information, as a big problem. As one federal agency interviewee stated, "The more information and the better access we have to it, I think, that will help our decision-making process." In summary, interviewees identified various information management needs and specific ways to make available information more accessible and user-friendly, including:

- Better collaboration and exchange of relevant information among all agencies (at federal, state, and local levels) in coastal management in California.
- Inventory and integration of existing (and additionally developed) information into common formats; for example, geographic information systems (GIS).
- Development of an integrated database accessible by managers at different levels of governance; data ideally would be aggregated or disaggregated to various levels of spatial resolution (e.g., state, local, watershed/littoral cell levels) and for different temporal resolutions (e.g., calculation of erosion over a variety of specified time increments of 10, 20, and 50 years).
- Regular exchange of information among coastal states, and among coastal communities about their management responses to climate change-related impacts and risks (Luers and Moser 2006, pp. 21–23).

As one state official so aptly summarized it, "There are so many pieces; we need a basic structure to integrate the information that we do have. Then we can find out what else we need to know. I don't have enough information at my fingertips to even say what doesn't exist."

4.3. Information Sources Commonly Consulted by Coastal Managers

The research team also inquired about the sources of information managers typically consult. It is important to identify these sources so that climate change researchers can provide useful research results to decision-makers through the channels they commonly turn to and review. Using customary information channels can help improve manager's access to and use of the available information.

As Table 2 illustrates, the typical outlets for scientific information (primarily peer-reviewed scientific journals) are either never or only rarely used by more than 70% of respondents. By contrast, scientists write rarely in the professional or trade journals, which nearly 80% of the surveyed managers consult occasionally, frequently, or all the time. Interesting also is the relatively low use of local experts (38.9% never or rarely consult one), while another 37.2% draws on local expertise occasionally. In the interviews, this somewhat surprising finding was confirmed especially among the officials from regional institutions. While some potentially interesting information—at

least general background information about global warming—can be found via the Internet, and most managers use this source, quality assurance is hard to assess and local specificity may not be obtained from this source. Professional listserves, by contrast, where more specific management-relevant information could be exchanged, show an even spread across the spectrum of user frequency.

The other notable (albeit not surprising) finding is the high-frequency use of interpersonal communication channels: much information is obtained from colleagues in-house or in similar positions in other local communities, from state agencies, and at conferences and in meetings. Especially the latter two point to opportunities for information transfer that could be far better exploited than they are at present.

Table 2. Information sources consulted by California coastal managers (by frequency of use)*

	Scientific journals (%)	Prof. journals (%)	Colleague in-house (%)	Prof. listserve (%)	State agency staff (%)	Colleague in other community (%)	Conference or meetings (%)	Local experts (%)	Internet (%)	Other (%)
Do not use	35.1	7.0	4.4	24.1	5.1	2.6	2.5	11.6	2.5	94.1
Rarely	35.1	13.9	7.1	23.1	23.7	15.4	11.6	27.3	4.9	0.8
Occasionally	22.5	40.0	15.0	25.0	34.7	47.9	54.5	37.2	18.9	1.7
Frequently	7.2	28.7	39.8	22.2	26.3	23.9	24.0	14.9	41.8	2.5
All the time	0.0	10.4	33.6	5.6	10.2	10.3	7.4	9.1	32.0	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

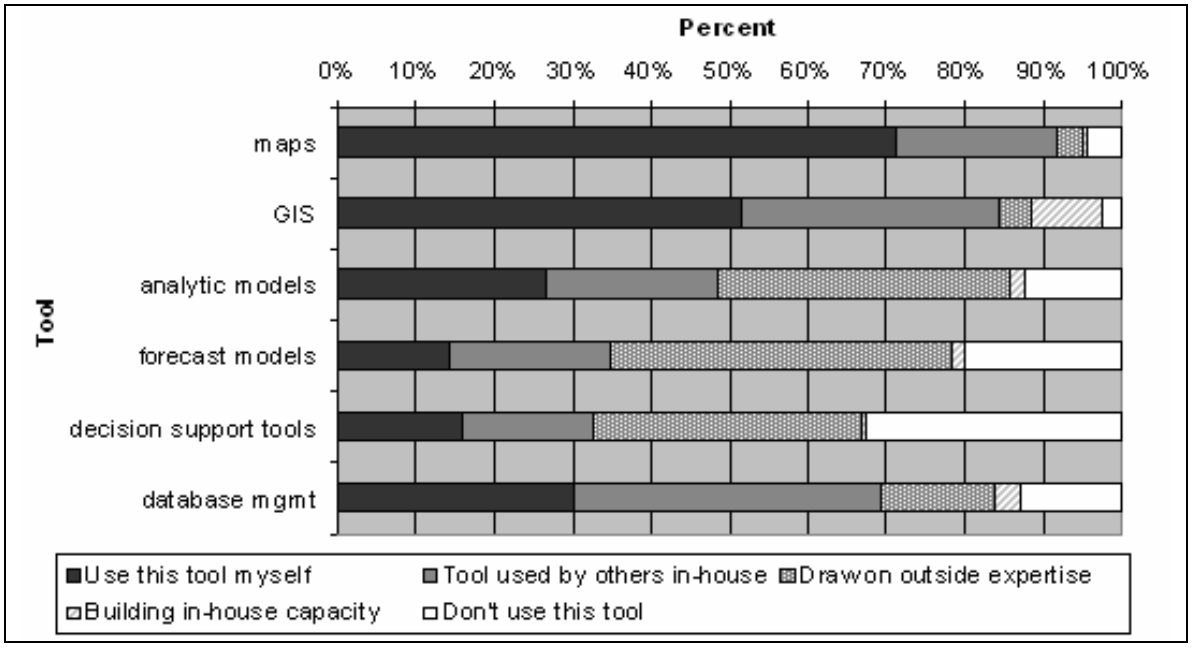
* N varies between 108 and 122 because not all survey respondents answered, and not all answered this question for all categories.

Next, the research team inquired about the tools managers commonly use in their management duties to display, analyze, and/or transform available technical information into useful management-relevant information. The team termed managers' ability to process information, transform it and use it in decision-making analytic capacity. Figure 3 illustrates coastal managers' analytic capacity and the types of tools they use in their daily work.

The findings suggest that managers most commonly use standard tools such as maps (71.3%) and, increasingly, geographic information systems (51.6%). If respondents do not use these tools themselves, typically a colleague nearby does. The capacity to use more sophisticated tools such as analytic or forecasting models and decision support tools (not specified in the survey, so up to respondents' interpretation) drops significantly, at the same time that communities have to draw more frequently on outside expertise if they want to use these tools. This generally indicates areas in which local communities would have to spend money to increase their capacity to make use of available information, and thus—in economically challenging times for municipal budgets—a rather vulnerable form of analytic capacities. Likewise, interviewees indicated using GIS, maps, analytic, database management, and modeling tools. Some use high-resolution, albeit expensive data, such as from Light Detection and Ranging

(LIDAR) technology. Finally, a sizable proportion of survey respondents replied that they do not need or use some of these more sophisticated tools in their work. If managers were to be expected to process complex information and use sophisticated tools, a significant amount of local capacity building would be necessary. Thus it is noteworthy to point out again that scientific information—if it is to be easily accessible and useful to state and local managers—should be presented in highly processed form, and/or in the formats (e.g., in graphic displays, or for use in commonly used GIS platforms or spreadsheet software) managers are well-versed using already.

Figure 3. Coastal managers' analytic capacity and use of information processing tools



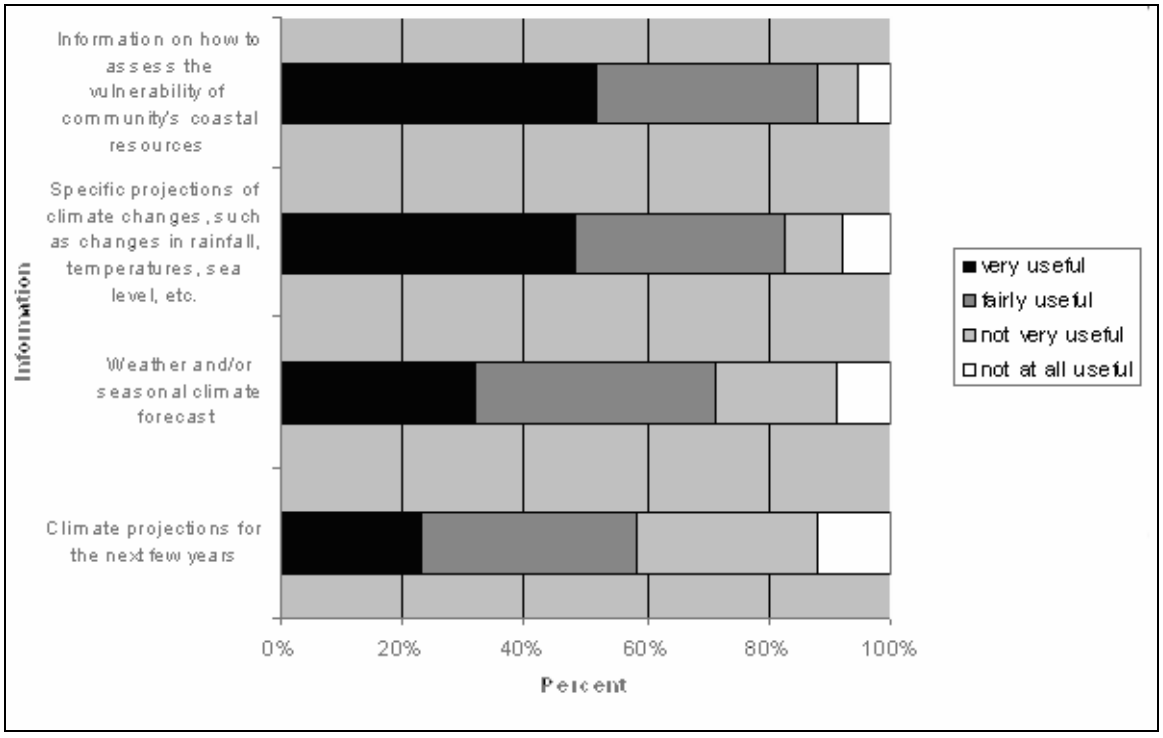
4.4. Information Gathered and Desired about Global Warming

Researchers next asked coastal managers what type of information their community had already gathered to date on the potential impacts from global warming and related climate changes. Fewer than 5% of the respondents had hired a consultant to gather climate change information and another 6% had contacted a local expert; less than 10% had convened a working group among their colleagues to pull together such information; slightly fewer had contacted state agency experts; and just over 8% had initiated some public discussion in their communities. Maybe more tellingly, 60% of respondents did not know whether any information had yet been gathered on global warming impacts in their community to date. When respondents were asked to identify which issues had served as a big hurdle in the way of planning ahead, 74.4% cited *insufficient staff resources to analyze and assess relevant information,* another 59.9% mentioned *insufficient staff time to even begin getting informed about climate change and gather relevant information,* and 46.2% mentioned *lack of technical assistance from state or*

federal agencies. Moser and Tribbia (2006/2007) discuss in more detail what actions local communities in California have or have not taken to date to prepare for global warming, including the role of other perceived obstacles to action.

When asked to rate the usefulness of different types of information (whether or not managers currently use them in their job) for determining the risks to local coastal resources, respondents shed light on the information coastal managers would find useful to begin planning for the impacts of climate variability and change. Respondents were prompted to rate from "very useful" to "not useful at all" the following types of information: weather and/or seasonal climate forecasts, climate projections for the next few years, information on how to assess the vulnerability of their community's coastal resources, and (locally or regionally) specific projections of climate changes such as changes in rainfall, temperatures, sea-level, etc. (Figure 4).

Figure 4. Perceived usefulness of information to determine climate-related risks to local resources



A physical scientist involved in climate science and impacts research might expect that managers would be most interested in temporally and spatially highly resolved information (i.e., near-term weather and seasonal climate variability forecasts, climate change projections for the next few years). From a manager's perspective, however, help with determining what is most at risk is the highest priority (51.6% rate such assistance as very useful and another 36.5% as useful). While this may not be surprising when one considers managers' key responsibilities and concerns, what is surprising is that they do

not have, do not know of, or do not find the vulnerability assessment tools currently available sufficient, and maybe that scientists have not made them more accessible or user-friendly. This is a clear example of the science–practice disconnect.

Survey respondents indicated that they would find locally or regionally specific projections of particular changes in climate also very useful (48%) or at least useful (34.6%). While sizeable numbers of local officials would find almost all weather and climate information helpful, reflecting maybe their generic interest and/or a general dearth of any sort of information, the considerable interest in locally specific projections of climate change variables points to the irresolvable time lag between science's ability to generate considerable concern about this global problem and its slower-to-mature ability to deliver credible, reliable, and locally specific information that could inform local action. Interestingly, however, survey respondents did not consider the uncertainties in climate change science huge action hurdles (31.4% considered it a big, 47.1% a small, and 21.5% no hurdle at all).

From the interviews the research team gleaned additional insights into what types of information about climate change and related impacts coastal managers would find useful. Most frequently mentioned were:

- Translation of SLR into shoreline retreat, beach erosion, and bluff retreat rates, presented for planning-relevant time horizons, such as 5, 10, or 25 years.
- Wave and climate data that could be included in bluff retreat models.
- Better understanding of the linkage between climate change, SLR, and wave climatology (i.e., their effects on storm frequency and intensity).
- Beach profile surveys that help better predict climate change impacts on shoreline change.
- Better understanding of littoral sand budgets and beach profile response to long-term SLR.
- Probabilistic climate change projections ("most likely scenario" or "at least" sea-level rise) with measurable indicators of change over 5, 10, and 20 years, and to a lesser extent, over longer time frames.
- Remapping of flood zones under different SLR projections.
- More reliable forecasting of El Niño events, and any changes in the frequency or severity of such events under climate change, including impacts on shoreline retreat rates.
- Information about potential changes in runoff, pollutant loads, salinity, and near-shore coastal and estuarine water temperatures, and exploration of the implications of such changes for water quality, water availability, and aquatic ecology.

Given the uncertainties in climate change projections, especially those downscaled to the local level, the research team also asked interviewees what they would want to know about the uncertain projections, about the uncertainties themselves, and how important scientific uncertainty was with regard to their willingness to use scientific information. Interviewees suggested that few things they deal with are ever certain, so they do not have that expectation (a finding consistent with the opinions of survey respondents described above) that climate change information would be, and have their ways to discount information accordingly. As one interviewee acknowledged, they simply take information less certain "with a grain of salt." Managers would, however, if it could be produced credibly, like the following information:

- Uncertainty ranges around climate change impact projections to indicate scientific confidence.
- Well-founded distinctions between more and less likely impacts (e.g., "at-least" sea-level rise versus "maybe-as-much-as" sea-level rise).
- Scientific basis for uncertainty buffers (e.g., additional setbacks, extra capacity for storm water runoff).
- Basic understanding of the reasons for the uncertainty (e.g., lack of data, lack of complexity in the models, unpredictability of future state of the world, insufficient understanding of natural processes).

Both from the interviews and the survey responses, it is clear that scientific information, even if uncertain, needs to be translated into management-relevant variables or metrics. While "sea-level rise" or "changes in storm frequency or intensity" are generically interesting and important causal drivers behind shoreline change, a permitting officer deals in erosion and cliff retreat rates to determine setbacks; a planner needs cumulative projections for planning relevant time horizons not of 100 but 20–30 years; a water quality manager is interested in what does or does not run off into the coastal ocean. In some instances, science is only now improving its capacity to make defensible, reliable regional climate change projections; in other instances, the additional work (and in some instances novel research) of translating climate projections into management-relevant variables has yet to be undertaken.

4.5. Learning Opportunities to Facilitate Understanding and Use of Global Change Information

The introduction posited that "more or better information" is not always all that is needed. Therefore, survey respondents were asked to select from a number of opportunities that might be helpful to learn more about climate change and to learn to better use such information (Table 3).

Table 3. Perceived usefulness of opportunities to learn more about global warming and to improve understanding and use of technical information

	Hands-on training (%)	User manuals (%)	Conferences (%)	Better college training (%)	Web-based clearinghouse (%)	Dedicated listserves (%)	In-house sharing (%)	Other (%)
Not useful at all	2.4	4.9	1.6	1.6	0.0	2.5	9.8	0.0
Somewhat useful	25.2	34.4	42.3	38.2	31.7	41.8	39.3	0.8
Very useful	47.2	45.1	40.7	43.9	47.2	33.6	29.5	0.0
Extremely useful	24.4	13.9	13.8	9.8	18.7	15.6	10.7	0.8
Don't know	0.8	1.6	1.6	6.5	2.4	6.6	10.7	98.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The two opportunities California coastal managers would overall find most useful were hands-on training (with 71.6% judging them very or extremely useful), and web-based clearinghouses (with 65.9% judging them very or extremely useful), followed by user manuals (59%) and conferences (54.5%). These findings are consistent with the action hurdles mentioned above. They also point to important capacity-building needs that the state or federal agencies could fill.

4.6. Trusted Information Sources and Knowledge Providers

The interviewers also inquired from whom managers seek information, and—if they could obtain more information about global warming—which sources they would most trust. This question relates to the common finding in the science policy literature that trust in the information and the information source is an important predictor for whether or not information enters into policy- and decision-making (e.g., Mitchell et al. 2006).

The interviewed managers indicated various sources of climate change information that they would trust, including: the United States Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), Scripps Institution of Oceanography (SIO), and California's Ocean Protection Council. Interviewees viewed other sources as more problematic (e.g., regulatory agencies, some state agencies), and yet others were not mentioned at all, in particular other academic sources aside from Scripps. The latter finding is particular noteworthy: the most credible source of climate change expertise, of which there is plenty in the State of California, is the state's academic cohort of universities and research laboratories. This resource appears to be largely untapped, at least by coastal managers at the local level and by state-level mission agencies. These, of course, are the primary players that will have to develop and implement plans for adaptation to climate change, yet their needs for information are not yet met by the available experts. The Sea Grant college program, the California Climate Change Center (with campuses at Scripps

and the University of California, Berkeley), the state's Regional Integrated Sciences and Assessment (RISA) Program at Scripps were not mentioned or entirely unknown to the interviewees. These institutions, important potential boundary organizations in California, could play a far more significant role in reaching out to coastal managers in the future.

Additionally, interviewees indicated that they would be interested in having opportunities (e.g., regular meetings with colleagues or participation in working groups) to help exchange and understand information, and discuss the management implications of global warming. One interviewee explained training workshops could help improve the way information is retained and translated. Painting a rather elaborate and hopeful vision of entraining coastal managers on climate change, the interviewee described it as follows:

> "A delivery of information in a forum that focuses on coastal zone managers and you pay their travel to come to this forum; you spend two or three days briefing them on the science; you provide them some tools to communicate what the issues are; you provide them mitigation tools and examples of policy options that are applicable; and you plant the seed. Then you hope that you have enough time that those seeds grow into actual governmental actions and mitigations."

In short, interviewees and survey respondents expressed a desire for more than just information. With concerns about global warming high, and a considerable readiness to act (see Moser and Tribbia 2006/2007), California coastal managers now need interactive forms of learning, forums for discussing this information, and action-oriented case examples to explore and learn about management options for adaptation.

5.0 Discussion

The findings presented in previous sections highlights the many dimensions of information needs and use in day-to-day coastal management in California. Against a backdrop of already pressing management challenges, coastal managers have very specific information needs, most of which are not about future problems but about the current conditions, and many of which are already not entirely met. Lack of resources, staff, and time form major hurdles for them to even get informed about how global warming may affect the problems they deal with on a daily basis, including risks to public safety, private property and public development, as well as the precious environmental resources that coastal California depend on economically and culturally.

The majority of coastal managers at any level of governance does not presently use information about projected climate change in their planning or decision-making, though awareness and concern are high (Moser and Tribbia 2006/2007). If these managers were to begin planning for climate change, relevant information would have to be presented and explained in understandable language and offered in accessible format. It would also have to more closely relate to the management functions decision-makers carry out. Managers also want explanations of associated uncertainty, not simply a probability or narrowing of range of future conditions.

Moreover, not all information is created equal. This study illustrates that managers prefer certain types of information and information sources and would enjoy a number of different learning opportunities to be able to make sense of and appropriately use global change information. To date, coastal managers do not benefit from the scientific information on coastal impacts of climate variability and change and SLR, as it exists in largely untapped scientific journals, few experts are ever consulted, and relevant institutions in California are not yet linked into the "management on the ground." This report's findings thus indicate that coastal managers are interested in the topic and would be willing to address climate change impacts in their work, but they require financial and technical assistance from other agencies at the state and federal level or from one or more boundary organizations that can play the intermediary role between science and management.

Clearly, coastal managers already deal with the kinds of problems (e.g., erosion, flooding, wetland loss) that climate change is likely to aggravate in the future (see Figure 1 above). They also use various types of information (e.g., climatic and geologic) that, if appropriately augmented with climate change information, could be easily integrated into existing information processing and management procedures. The additional information would be integrated most easily if it were provided in formats and on platforms that managers already commonly use. More complex information or sophisticated presentation would require additional training and capacity building, and managers expressed a desire to learn in this fashion. However, in reality, top-level leadership and support, if not formal expectation, may be required for busy coastal

managers to attend and actively participate in yet more meetings, workshops, and conferences.

In what way could boundary organizations help coastal managers address climate change in their work? A major objective at this time would be for coastal managers to more fully understand what climate change and SLR could mean to their local communities (or for state-led management efforts), and what tools and options are available to address them through existing management procedures and institutions. As one interviewee suggested "climate change and global warming are not on top of [managers'] priority list because they do not know how to go about dealing with it in their own jobs."

Interviewees and survey respondents suggested that education about and discussion of global warming issues related to coastal management could be facilitated through a variety of efforts not commonly undertaken by academic experts, including learning in workshops and in inter- and intra-agency working groups, improvements to (and integration of) existing information and knowledge resources, provision of training programs, and so on. Because scientists do not typically offer such services, and managers are busy dealing with their day-to-day responsibilities, a boundary organization could provide precisely these convening, translating, and facilitating services, and thereby help improve coastal managers' efficacy in preparing for climate change. Through the co-production of relevant information, knowledge, and training resources, managers and scientists would begin to understand their respective needs and capacities, and—over time—meet information needs with use-inspired knowledge (Stokes 1997).

Such opportunities may work most effectively if supported over time through state and federal resources. Interviewees and survey respondents emphasized that beginning to deal with climate change in coastal management would be enormously facilitated through adequate funding, technical support, directive and leadership from "on high," and more political pressure from "below." In short, there will be a true information need, and need to better link science to policy, when there is a real demand for action. This research did not reveal any institution that currently plays such boundary-spanning functions between science and coastal managers in California, though some actively engaged organizations like San Francisco BCDC and the California Coastal Commission serve informal information exchange and translating functions by providing aid to local jurisdictions seeking to address climate change in their planning activities. And while the state is exemplary in its leadership on greenhouse gas emission reductions, its efforts to prepare for and adapt to the impacts of climate change lag behind, as does widespread public recognition that adaptation is now an inevitable complement to mitigation of climate change.

A cursory look at differences in responses from communities and counties located along the open ocean coast versus those around the San Francisco Bay suggests some interesting differences and similarities. These differences may be particularly important

to improve targeted information and knowledge services to specific local managers. These differences will be explored in a full comparison in a forthcoming publication.

6.0 Conclusions

Climate change and related impacts to coastal areas can be classified as a "creeping environmental problem" (Glantz 1998), punctuated by occasional extreme storm or flooding events, which together threaten California's coast. Glantz (1998) argues, "graduated societal responses to slowly compounding environmental changes may not resolve the problem. Dealing with such problems requires getting ahead of them." Based on this study's findings, the research team argues that coastal managers in California may be better able to deal with the potentially severe, if gradual, impacts from climate change if they began preparing for them now. Improving the transfer of relevant scientific information and knowledge resources from scientists to decision-makers, where necessary, with the help of intermediary boundary organizations, will help managers to prepare in advance of these emerging and worsening problems.

Certainly, linking climate change knowledge to coastal mangers is easier said than done. Still, California has several highly promising resources available to draw on:

- World renown expertise in state-based universities and research laboratories on climate change impacts.
- A considerable number of highly concerned and willing-to-act coastal managers (not everyone has to be on board from the start, but model communities ready to act can lead the way).
- Several institutions that could play boundary-spanning roles.
- A strong political leadership on global warming.

What is missing is to bring them together on the question of adaptation to climate change impacts. The state's Sea Grant program, for example, could play this critical role. Its Coastal Community Development Program concentrates on "community planning and growth management in coastal areas" and to "provide services to coastal communities to aid in efforts to protect their environmental amenities, strengthen their economies and improve their quality of life … by providing the enhanced science-based support needed to balance environmental, social and economic considerations" (National Sea Grant, no date). Nevertheless, the program does not mention "climate change" or "global warming" as a focal point or even a marginal consideration in achieving these goals. Additionally, informal communication channels mentioned above, especially those already committed to facilitating inclusion of climate change impacts in coastal planning, have an opportunity to formalize their actions and/or help burgeoning formal boundary organizations with their facilitation of climate change knowledge transfer.

Although future research may explore the precise shape and roles such a boundary organization could play, how the science-practice relationship could be improved, and what novel opportunities could be created to incorporate climate change issues into outreach efforts, already existing and highly effective institutions could dedicate some

resources and effort now toward meeting the growing information and learning needs of coastal managers to help them prepare for climate change.

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8.0 Glossary

BCDC	San Francisco Bay Conservation and Development Commission
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
CalEPA	California Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	geographic information systems
NOAA	National Oceanic and Atmospheric Administration
SANDAG	San Diego Association of Governments
SIO	Scripps Institution of Oceanography
SLR	sea-level rise
USGS	United States Geological Survey