

**VULNERABILITY TO COASTAL IMPACTS
OF CLIMATE CHANGE:
COASTAL MANAGERS' ATTITUDES,
KNOWLEDGE, PERCEPTIONS,
AND ACTIONS**

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California Energy Commission
Public Interest Energy Research Program

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Arnold Schwarzenegger
Governor

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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.

Vulnerability to Coastal Impacts of Climate Change: Coastal Managers' Attitudes, Knowledge, Perceptions, and Actions is the second of three reports for the Assessing Potential Impacts of Climate Change on California project (contract number 500-99-013, work authorization 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 contact the Energy Commission at (916) 654-5164.

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Abstract

California's coastlines are vulnerable to the impacts from 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 impacts. This study sought to understand California's coastal managers' perceptions of current inundation-related risks, the added risks from climate change, their perceived vulnerability to the growing coastal problems, and the extent to which they are beginning to think about and tackle these increasing management challenges. Based on extensive interview and survey research in the state, this study found managers already burdened with a number of coastal challenges likely to be made even more difficult as sea levels rise and coastal climates change. California coastal managers are highly aware and personally concerned about global warming and share a modest and possibly quite superficial understanding of climate change impacts. However, local efforts to prepare and plan for climate change impacts are extremely limited at this time. Managers identified a series of hurdles that currently hinder more adequate preparation for climate change. Several of these could be addressed through state and federal leadership, guidance, and support to enhance local efforts.

Keywords: Climate change, sea-level rise, vulnerability, coastal impacts, adaptation, preparedness, coastal zone management, risk perception, attitudes, California

Executive Summary

Introduction

In post-Katrina America, coastal flooding, inundation, and erosion from sea-level rise and extreme events first bring to mind images of the Gulf of Mexico coastline. But of course, these problems are far more common, both historically and geographically, and they regularly affect the Atlantic and Pacific (and increasingly the Arctic) coastlines of the United States. California, too, has witnessed persistent sea-level rise along its southern and central open ocean coastal sections and in San Francisco Bay and adjacent estuaries over at least the past century. The state also episodically experiences severe acute flooding, coastal erosion, beach loss, and cliff retreat from winter storms, especially during El Niño events. Climate change is projected to increase the rate of sea-level rise globally and along the California coastline, aggravating existing coastal management challenges.

With the high degree of development in immediate shorefront areas, coastal managers face many daunting management problems. Moreover, countless coastal management decisions made today—such as the installation of hard shoreline protection or other significant infrastructure and development siting in coastal hazard areas or on the landward edges of wetlands—create legacies that will affect and possibly constrain management options in the future, when sea levels are higher and coastal climates have changed because of global warming.

Purpose

In response to Governor Arnold Schwarzenegger's Executive Order S-3-05 of June 1, 2005, this report aims to understand California's coastal managers' perceptions of current inundation-related risks, the added risks from climate change, their perceived vulnerability to the growing coastal problems, and the extent to which they are beginning to think about and tackle these increasing management challenges.

This project attempted to identify and illustrate coastal managers' plans (or lack thereof) to cope with and adapt to the unfolding effects of climate change, to provide information for the much needed discussion on how society might manage the changes ahead.

Project Objectives and Approach

The goals of this research were to understand (1) coastal managers' perceptions of current coastal risks, (2) their appreciation of the added risks from climate change, (3) their perceived vulnerability to the growing coastal problems, and (4) the extent to which they have begun thinking about and tackling these increasing management challenges.

In this study, "coastal management" is broadly defined to include any aspect of local management concerned with the safety, environmental protection, public infrastructure, and development of coastal cities and counties, on land and in nearshore coastal waters.

To explore coastal managers' perception of inundation risks, climate change impacts, and sea-level rise in the context of other existing coastal management problems, this study proceeded in two stages to answer the following questions:

- What are coastal managers' current coastal management challenges?
- What are coastal managers' general perceptions and attitudes about global warming and related impacts on coastal areas?
- What approaches have coastal managers taken to deal with existing problems?
- What actions have been taken to prepare and plan for the potential impacts to climate change?
- What are the barriers that coastal managers face in preparing for climate change impacts?

In the first phase, the research team interviewed 18 government staff from the regional, state and federal levels involved in California coastal management. Building on the insights gained from those interviews, the second phase of this study explored parallel questions with local coastal managers using a comprehensive, pre-tested survey instrument. The survey population consisted of 299 municipal and county government employees along the state's open ocean and San Francisco Bay coastlines who have some role in coastal management activities. The overall survey response rate was 46.1 percent, a rate considered quite good according to common survey methodology texts. The responses represented about 89 percent of coastal cities and about 89 percent of coastal counties approached.

Key Research Findings

1. Survey respondents identified water quality, shoreline change, flooding, and species and habitat protection issues among their top management challenges at present. Public access to beach areas and saltwater intrusion in coastal aquifers and estuaries were also viewed as significant management issues. All of these will be worsened by the expected impacts from climate change and sea-level rise in coastal areas.
2. California coastal managers are highly aware and personally concerned about global warming and possible impacts on coastal areas, and a majority identify themselves as "moderately well informed" about what actually may occur. Response patterns about expected impacts are not entirely consistent, however, with expert judgment.
3. Local efforts to prepare and plan for climate change impacts are extremely limited at this time. Two counties (San Luis Obispo and Sonoma) said that they had plans in place that considered the impacts of climate change on their community, but neither considered coastal impacts. Four other counties are currently preparing such plans and will look at coastal impacts. Among the coastal cities that responded to this survey, only one currently has a plan in place to deal with the impacts of global warming (Berkeley), and six are in the process of developing such plans (Solana Beach, Goleta, San Francisco, Palo Alto, Alameda, and Arcata); at least five of them will consider coastal impacts.

4. Local managers overwhelmingly see local monetary constraints as the leading hurdle to addressing global warming challenges. This barrier is followed closely by insufficient staff resources to analyze and assess relevant information, lack of funding from state and/or federal agencies to prepare a plan, the view that currently pressing issues are all-consuming, and insufficient staff time. More than half of the respondents also viewed the lack of a legal mandate to take global warming into account as a major hurdle.
5. Integrating findings from interviews and the survey suggest that there is some degree of “finger-pointing” in terms of the perceived responsibility for taking the first step on adaptation actions.
6. Without financial, technical, scientific, and staff support from federal and state agencies, local coastal managers perceive themselves as unable to adequately manage their current management challenges, much less prepare for more severe challenges in the future.

Based on a careful evaluation of this study’s results and methods, the research team cautiously views these findings as representative of those most engaged in coastal management today and those most aware and concerned about climate change, but probably as “too rosy” for coastal California as a whole.

Recommendations

That local governments need help to prepare for the impacts of a changing climate is an easy conclusion, but not one easily realized. Unfortunately, both federal and state budgets are under enormous pressures from competing priorities.

1. The research results presented here reveal a number of ways in which federal agencies involved in coastal management (for example, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), and the U.S. Army Corps of Engineers) can complement California’s state-funded research efforts through a variety of funding mechanisms, such as federal research funds, planning grants (such as Section 309 improvement grants), conference and meeting support, or additional money for Sea Grant extension services or similar ways of linking the state’s enormous scientific capacity with managers “on the ground.”
2. California state agencies concerned with various aspects of coastal management (for example, the California Coastal Commission, the San Francisco Bay Conservation and Development Commission, Department of Boating and Waterways, Coastal Conservancy, the state Environmental Protection Agency, State Parks, and others) should make climate change and related inundation risks a higher priority in their own planning and operations and support and/or require local jurisdictions to include such considerations in projects that require state approval.
3. The results presented here suggest that state and federal agencies can play critical roles in providing guidance, motivation, information, and help with incorporating scientific information into future management and planning:

- Legal mandates are likely to provide the strongest motivation to plan ahead and prepare for climate change. They must be accompanied, however, with adequate funding mechanisms and additional staff resources to implement such mandates (for example, to assess community vulnerabilities to various coastal impacts and identify response strategies).
- Regular doses of relevant and accessible information on the latest climate change science, especially that relevant to coastal areas. Such information also must highlight feasible management strategies to counter perceptions that “there are no viable response options.”
- Opportunities for coastal managers to learn from each other (for example, in conferences and workshops), to learn what others in similar management situations are doing to address climate change and inundation risks, and how they are funding effects/vulnerability assessments and response strategies.

Benefits to California

California, more than most other states, has illustrated exemplary leadership on climate change, both in terms of support for state-specific research and for a variety of emissions reductions efforts. There is now a parallel focus emerging on the need to adapt to those effects that can no longer be avoided, or that will unfold as global warming accelerates.

The effects on California’s coastline caused by sea-level-rise and other effects related to the changing climate will need to be dealt with by local-, regional-, state-, and federal-level management. In a broad attempt to understand current management challenges and the possible added complications from future consequences of climate change, this study

- Provides a first “on-the-ground” perspective on the actual state of the state’s preparedness for climate change impacts in coastal areas.
- Identifies real and perceived hurdles to plan ahead.
- Specifically suggests ways to increase the state’s ability to address adaptation to climate change.

Given the enormous economic, environmental, and cultural resources at stake (including the welfare and well-being of millions of Californians), the time for planning ahead and seriously considering ways in which policy-makers and managers can increase the state’s ability to adapt to climate change is now. A comprehensive debate over appropriate societal response to climate change must include mitigation and adaptation to preserve the state’s critical resources and precious environment.

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, forestry, and coastal areas. In addition, the executive order requested that future impact assessments include a "report on mitigation and adaptation plans to combat these impacts." This report is a response to this request.

This research sought to understand California's coastal managers' perceptions of current inundation-related risks, the added risks from climate change, their perceived vulnerability to the growing coastal problems, and the extent to which they are beginning to think about and tackle these increasing management challenges. This report follows an earlier report that examines California coastal managers' information needs regarding climate change impacts on the coastal zone (Moser and Tribbia 2007). It builds on a complementary report (Luers and Moser 2006) that offered a conceptual framework for how to assess resource managers' preparedness and capacity to deal with existing stresses from climate and to evaluate the opportunities and constraints in preparing for potential future impacts from climate change.

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. Especially after the release of the Intergovernmental Panel on Climate Change's latest report on climate change impacts, adaptation options, and vulnerability (IPCC 2007), the state's growing focus on adaptation is welcome and timely.

This report examines California's current state of preparedness for the impacts of climate change on coastal areas. In particular, it explores how support from state and federal entities could support local government in preparing for climate change and associated inundation-related risks. Section 2 juxtaposes the physical vulnerabilities coastal California is experiencing with local coastal managers' perceived vulnerabilities to the growing coastal problems. Section 3 describes this study's data sources and methodology, and the major findings are presented in Section 4. Section 5 discusses the implications of these findings for current and future coastal management as the risk of inundation increases with climate change, and some preliminary recommendations are offered in Section 6.

2.0 Introduction

In post-Katrina America, coastal flooding, inundation, and erosion from sea-level rise and extreme events first bring to mind images of the Gulf of Mexico coastline. But of course, these problems are far more common, both historically and geographically, and they regularly affect the Atlantic and Pacific (and increasingly the Arctic) coastlines of the United States (e.g., National Research Council 1987, 1990a, 1990b; Dolan et al. 1990; Hanson and Lindh 1993, 1996). Climate change and related sea-level rise (SLR) projections—even just the more conservative ones based on thermal expansion and gradual ice melt—suggest that these historic trends will persist, if not accelerate, over coming decades and centuries (Church et al. 2001; Meehl et al. 2005; Wigley 2005). However, if recent observations of rapid ice sheet decay, especially from Greenland (Krabill et al. 2004; Shepherd et al. 2004; Alley et al. 2005; Dowdeswell 2006; Rignot and Kanagaratnam 2006), become further substantiated, the possibility of dramatic rates of SLR can no longer be denied. Such rapid SLR (several feet per century) would imply catastrophic impacts for many U.S. and other low-lying coastal regions around the world from inundation, erosion, and land loss—impacts that are almost too daunting to consider for coastal managers.

As it is, eustatic¹ sea-level rise, episodic flooding, and erosion are common along most of the U.S. coastline today. With the high degree of development in immediate shorefront areas, coastal managers already face daunting problems. Moreover, many coastal management decisions made today (e.g., installation of hard shoreline protection or other significant infrastructure; siting of development in coastal hazard areas or on the landward edges of wetlands) create legacies that will affect and possibly constrain management options in the future when sea levels are higher and coastal climates changed because of global warming. Based on the extant review of the scientific literature on climate change impacts on coastal regions (McLean et al. 2001; Nicholls et al. 2007), there is no plausible future scenario one can imagine that would alleviate these existing problems.

The goals of this research were to understand (1) coastal managers' perceptions of current risks, (2) their appreciation of the added risks from climate change, (3) their perceived vulnerability to the growing coastal problems, and (4) the extent to which they have begun thinking about and tackling these increasing management challenges.

2.1. Sea-Level Rise and Inundation Risks along the California Coast

This research focused on coastal California, which has witnessed persistent sea-level rise along its southern and central open ocean coastal sections and in San Francisco Bay and adjacent estuaries over at least the past century (e.g., California Coastal Commission, 2001). The state also episodically experiences severe acute flooding, coastal erosion,

¹ *Eustatic* refers to global changes in sea level.

beach loss, and cliff retreat from winter storms—especially during El Niño events (Flick and Cayan 1984; Flick 1998; Ryan et al. 1999; Storlazzi and Griggs 2000; Moore and Griggs 2002; Sallenger et al. 2002). Recent research suggests that historical sea-level rise along these stretches of California coastline has ranged from 10 to 20 centimeters (cm) per century (based on available reliable tide gage records), a rate comparable to global estimates of eustatic SLR over the past century (Cayan et al. 2006).

Over the past few years, the U.S. Geological Survey (USGS) conducted assessments of physical vulnerability to future SLR along the Atlantic, Gulf, and Pacific coastlines, including that of California (Hammar-Klose and Thieler 2001; Thieler and Hammar-Klose 2000). They developed a coastal vulnerability index (CVI) based on six factors: tidal range, wave height, coastal slope, historical shoreline erosion rates, geomorphology, and historical rates of relative SLR. These factors together determine the risk of inundation and erosion, and provide a reasonable approximation of areas likely to experience impacts from future SLR.

Along soft coasts, also common along the California coast, the CVI tends to underestimate cliff retreat and thus the significance of higher sea levels for this process. The USGS recently completed a complementary assessment of the California shoreline, which compensates for this shortcoming of the SLR vulnerability assessment by better accounting for shoreline change and the importance of cliff retreat along this state’s coast (Hapke et al. 2006). It is important to note that the CVI does not incorporate projections of *future* SLR under different assumptions of climatic change and hence does not delineate the extent of areas likely to be inundated or eroded in the future. Rather, the CVI indicates past and current (that is, *experienced*) SLR effects, and by extension suggests which coastal areas are more or less vulnerable to future SLR impacts. Areas of highest vulnerability to future SLR are likely to be those that are today’s hotspots of coastal management problems related to flooding, levee stability, coastal erosion, cliff retreat and beach loss (Figure 1).² Recent research suggests that this simple conceptual extension from today into the future may be too conservative, especially on complex coastlines (Slott et al. 2006), but it can serve as a reasonable first approximation.

² Again, it is important to recall that the CVI tends to underestimate cliff and shoreline retreat along soft coasts (see discussion in text). Moreover, the concept of “vulnerability” as used by Thieler and colleagues (Thieler et al. 2000) only captures the physical risk to which coastal areas are *exposed*. It does not encompass socioeconomic variables that would reflect a coastal community’s *sensitivity* to these changes (e.g., are there any hard shoreline protection measures such as sea walls and levees to protect communities from their exposure to sea-level rise?). Nor does their index capture a community’s *resilience*, (i.e., its ability to deal with and recover from the consequences of an inundation event).

Figure 1. California's physical vulnerability to future sea-level rise



Source: Map based on data from Hammar-Klose and Thieler (2001)

To assess what future rates of SLR the state of California can expect, Cayan et al. (2006) used the standard set of emissions scenarios underlying the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4, released throughout 2007), run on three different climate models (PCM, HadCM3, and GFDL). They conclude,

“Relative to sea levels in 2000, by the 2070–2099 period, sea level rise projections range from 11–54 cm (4.3–21 in) for simulations following the lower (B1) greenhouse gas (GHG) emissions scenario, from 14–61 cm (5.5–24 in) for the middle-upper (A2) emission scenario, and from 17–72 cm (6.7–28 in) for the highest (A1fi) scenario” (Cayan et al. 2006, p. ix).

They further illustrated through composite analysis of secular changes in sea level and variation in tides and wave climates that when the higher sea-level baseline coincides with storms, astronomical high tides, and/or El Niño Southern Oscillation (ENSO) events, resulting flooding and wave action increase “the potential for inundation of levees and other structures.” They continue, “There may also be increased risk of levee failure due to the hydraulics and geometry of these structures. Rising sea levels from climate change will increase the frequency and duration of extreme high water levels,

causing historical coastal and San Francisco Bay/Delta structure design criteria to be exceeded” (Cayan et al. 2006, p. x).

In recent years, California has emerged as a strong leader in assessing the risks of climate change on the state. Specifically, in June 2005, Governor Arnold Schwarzenegger issued Executive Order S-3-05, in which he not only set stringent emission reduction targets and asked for regular updates on the science of climate change and its impacts, but also for “report[s] on mitigation and adaptation plans to combat these impacts.” In addition, California’s Ocean Protection Council released its strategic plan in 2006 (California Ocean Protection Council 2006)—a plan that also calls for a better understanding of climate change impacts on coastal and marine areas and the development of appropriate response strategies.

As part of a large effort to provide an initial science update to the governor and California state assembly, the authors conducted a study of local and state coastal managers’ preparedness for the impacts of climate change on coastal areas. This report discusses selected results from that study, focusing on coastal managers’ perceptions of current and future problems associated with SLR.

3.0 Data Sources and Methodology

Based on past research by the lead author (Moser 2000, 2005, 2006), this study did not attempt to assess coastal managers' perception of sea-level rise *per se*, but rather that of the more immediate, more easily visible problems associated with this underlying cause, including: coastal erosion, beach loss and cliff retreat, coastal flooding, and saltwater intrusion into coastal aquifers. These more immediate problems are at the core of many coastal managers' daily work and correspond well with the physical vulnerability index described in Section 2.1 above (Thieler 2000; Hammar-Klose and Thieler 2001; Thieler and Hammar-Klose 2000).

To explore coastal managers' perception of inundation risks, climate change impacts, and sea-level rise in the context of other existing coastal problems, this study proceeded in two phases.

In the first phase, the authors conducted 18 semi-structured interviews with state, regional, and federal coastal zone managers involved in California's coastal management. Interviewees included 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, Department of State Parks, the Resources Agency, Office of Emergency Services, Department of Boating and Waterways, and the Water Resources Control Board; as well as 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. On average, the interviews with coastal managers lasted between 60 and 90 minutes. Interviews were transcribed and qualitatively analyzed to extract common themes and concerns.

In the second phase, the authors developed a comprehensive survey instrument to understand local coastal managers' current coastal management challenges and to elicit their perceptions and attitudes about global warming and related impacts on coastal areas. The authors also inquired about their approaches to dealing with existing problems, their perceptions of global warming, and the need to prepare now for climate change, as well as actions that had already been taken at the local level to plan for the potential impacts. The survey was developed based on insights gained from the interviews. The survey population consisted of 299 municipal and county government employees along the state's open ocean and San Francisco Bay coastlines who have some role in coastal management activities. The California Coastal Commission and Bay Conservation and Development Commission provided lists of contacts; additional names were identified through an extensive web search. The goal was to obtain at least two or three individuals from each coastal county or municipality. In larger communities, a half dozen or more individuals were often identified.

In this study, “coastal management” was broadly defined to include any aspect of local management concerned with the safety, environmental protection, public infrastructure, and development of coastal cities and counties, on land and in nearshore coastal waters. Table 1 lists the type and number of staff that responded to the survey administered in the summer of 2006 (note that additional types of local government officials were approached, but only those who actually replied are listed).

Table 1. Types of survey respondents (n=135)

Planner	Permitting Officer	Public Works Engineer	Env. Specialist	Developm't Coordinator	Harbor/Beach 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

The comprehensive, 18-page mail survey mailed in June 2006 inquired about respondents’:

- Community/county characteristics, including degree of development.
- Types of current coastal management challenges, policies, and strategies.
- Attitudes about global warming and 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).

Survey questions included open-ended and multiple-choice informational questions, attitudinal questions using a Likert scale, and check-all and forced-choice questions. This report’s main focus is on questions relating to current management challenges, attitudes, and perceptions regarding global warming and whatever actions California local governments have taken to date to address climate change impacts. Other forthcoming publications will focus on other survey results.

Of the 299 surveys, 14 were returned blank or because of an inadequate address; eight additional respondents considered their location non-coastal. The overall response rate was 46.1%, a rate considered quite good according to common survey methodology texts. Maybe more important, the 135 usable responses represented about 89% of coastal cities and about 89% of coastal counties approached. The obtained data was tabulated and analyzed using simple statistical analyses. Any meaningful correlation analysis comparing the physical vulnerability index with the human perceptions from the survey could not be conducted (for more discussion on this issue see Section 5). However, the

qualitative comparisons yielded interesting contextual insights that place managers' perceptions and concerns in perspective. These findings are discussed below.

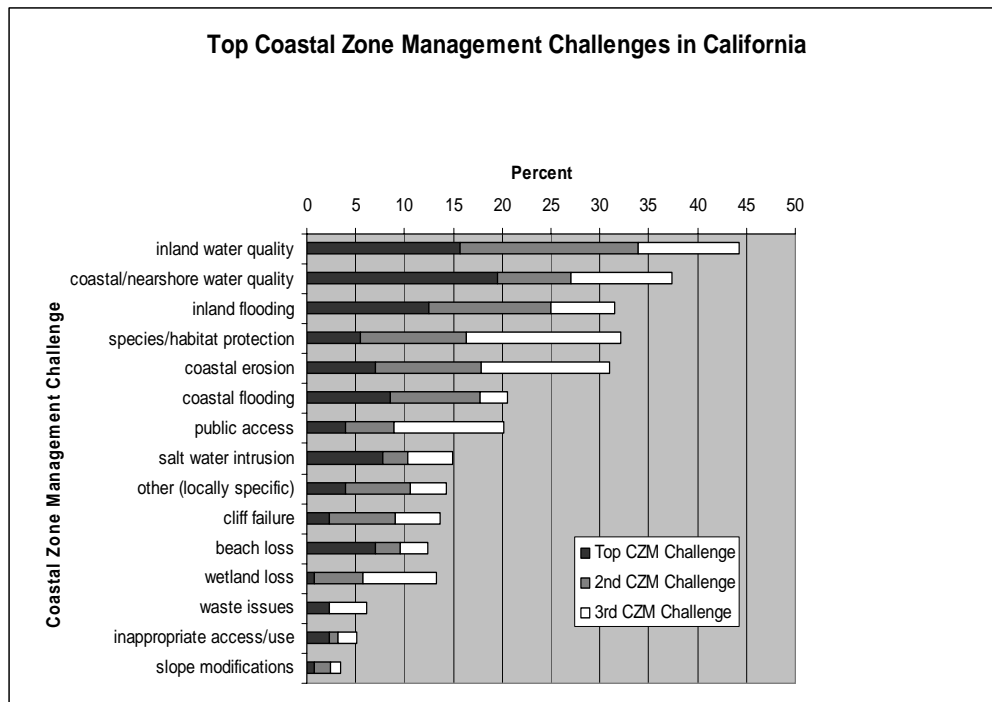
4.0 Findings

4.1. Coastal Managers' Perceptions of Current Coastal Zone Management Challenges

4.1.1. Top Management Challenges

The authors asked survey participants about the kinds of coastal management challenges their community or county currently faced. They first identified all relevant problems from a list of 14 given options and one write-in option, and then prioritized the top three challenges in their area (Figure 2).

Figure 2. The top coastal zone management challenges in California today



Integrating these findings further, it is apparent that nearly a third of all respondents (32.7%) identified water quality issues (in coastal and nearshore areas as well as in local streams, estuaries, and inland areas) as one of the top three coastal zone management problems in California. Twenty percent of respondents identified shoreline change (including coastal erosion, beach loss, cliff failures/retreats, and related nourishment questions) among the top three management challenges. Flooding in both shorefront and inland areas (related to extreme precipitation events) was mentioned by 17.7%, and species and habitat protection issues (including wetland loss concerns) followed closely, with 14.6%.

Five coastal management challenges (coastal flooding, coastal erosion, beach loss, cliff failure, and saltwater intrusion) were identified as most directly related to sea-level rise and inundation, and the authors examined how many cities considered these as their top management challenges. In seven cities at least one respondent identified coastal flooding as the community's top coastal management challenge; coastal erosion was the top management challenge in six cities; cliff retreat in two; beach loss in five communities; and saltwater intrusion in another five. Of the 54 cities for which data was obtained on this question, 74% named at least one of these five problems among their top three management challenges.

The results highlight how the most critical management challenges arise from the interaction of intense development in coastal areas with a dynamic shoreline, fragile ecosystems, and a variable coastal climate. For example, point and non-point source pollution from highly urbanized areas is washed into coastal streams and waters during extreme precipitation events, negatively affecting water quality. Ongoing sea-level rise and episodic coastal storms drive dynamic shoreline changes while homeowners and business are trying to stabilize the shorefront and/or maintain wide beaches for coastal recreation, tourism, and as a buffer against natural forces. Both development and high recreational or economic usage of coastal areas disturb and/or constrain the ability of species and habitats to adapt to a rising sea level.

4.1.2. Severity of Top Coastal Zone Management Challenge and Perceived Changes Over Time

The initial identification of coastal zone management challenges (described above) provides some basic information on the actual presence of any given set of challenges that communities deal with. This compilation provides some indication of the perceived pervasiveness of these challenges along the California coast. The identification of the "top three" begins to speak to the perceived severity. To ascertain more about the perceived relative importance of these issues, survey participants were asked to rate the severity of the coastal management challenge they had identified as their top concern on a scale from 1 (not serious at all) to 5 (very severe), with the midpoint indicating "moderate severity." Table 2 lists the top ten management challenges according to their average severity scores.

Note that the top management challenge must not necessarily be particularly "severe." This survey did not define for the respondents what was meant by "challenge" or "severity." It is in principle conceivable to have a management challenge that raises difficult debates among concerned parties or is a policy priority, but is not necessarily physically severe or urgent. Thus, the "top" management challenge in Table 2 must not correspond one to one with the most severe as identified by California coastal managers.

Table 2. California coastal managers' perception of the severity of the top coastal zone management (CZM) challenge, and changes over time

Top CZM Challenge	(a) Perceived Severity at Present ¹	(b) Perceived Change in Severity in Past 5 Yrs ²	(c) Expected Change in Severity in Next 5 Yrs ²
Public access	4.20	4.00	3.80
Saltwater intrusion	4.10	3.40	3.10
Spec./habitat protect.	4.00	3.57	3.86
Inland flooding	3.69	2.88	2.56
Cliff Failure	3.67	3.67	3.67
Coastal flooding	3.60	2.70	2.30
Coastal erosion	3.56	4.11	4.11
Water quality	3.37	3.63	2.89
Coastal water quality	3.32	3.48	2.76
Beach loss	3.11	4.00	3.00

¹ Scale: The top CZM problem currently is: **1** – not serious at all; **2** – slightly problematic; **3** – moderate; **4** – severe; **5** – very severe

² Scale: The top CZM problem has/will have: **1** – significantly decreased; **2** – decreased; **3** – not changed; **4** – increased; **5** – significantly increased

The severity ratings (Table 2, column a) give a more differentiated picture of today's coastal management challenges in California. Nearly 90% (89.9%) of the management challenges that the survey respondents identified as the primary challenge fall into the moderate and severe categories. It is interesting to note that, according to the average severity ratings, managers perceive the three most severe issues (public access issues, saltwater intrusion, and species or habitat protection) as distinctly worse than the remaining seven (note the jump in average ratings between the third and fourth currently most severe entries). Eight out of the ten pertain to the immediate shorefront and can—at least in part—be directly related to sea-level rise or storm-related inundation and to associated shoreline change processes. Public access, while a direct reflection of property rights and development patterns in the immediate shorefront, is also and will be further affected by an encroaching sea as unmitigated erosion, beach loss, and cliff failures can reduce public access to beach areas.

The survey further revealed that 55.6% of all respondents perceive their top management challenge to have gotten worse or significantly worse over the past five years. Managers view eight out of ten management challenges listed as having become aggravated to at least some degree over the past five years (Table 2, column b; all scores of 3 or higher indicate aggravation of the problem in the past five years). The greatest worsening is seen for coastal erosion, beach loss, and public access issues. The perceived improvement of essentially event-driven problems (inland and coastal flooding) may be related to fewer severe storm events in the most recent past (the one to two winters prior to the survey), and/or simply reflect that single events tend to diminish in importance in people's mind, especially if difficult, chronic problems concern them almost daily.

In terms of expected change (Table 2, column c), the total distribution of responses is bimodal, with 37.3% of respondents expecting at least some or significant improvement, and 41.3% expecting some or significant further deterioration regarding the management problem they considered the top challenge today. More specifically, the averages of perceived increases in future severity indicate respondents expect to see a worsening of coastal erosion, public access, and species and habitat protection (all averages greater than 3.80 on a scale of 5) five years ahead. Of all these, coastal erosion is expected to worsen most over the next five years. Survey respondents seem more optimistic (averages of 3 or less) about flooding and water quality problems, both inland and in coastal and near-shore areas (see Table 2).

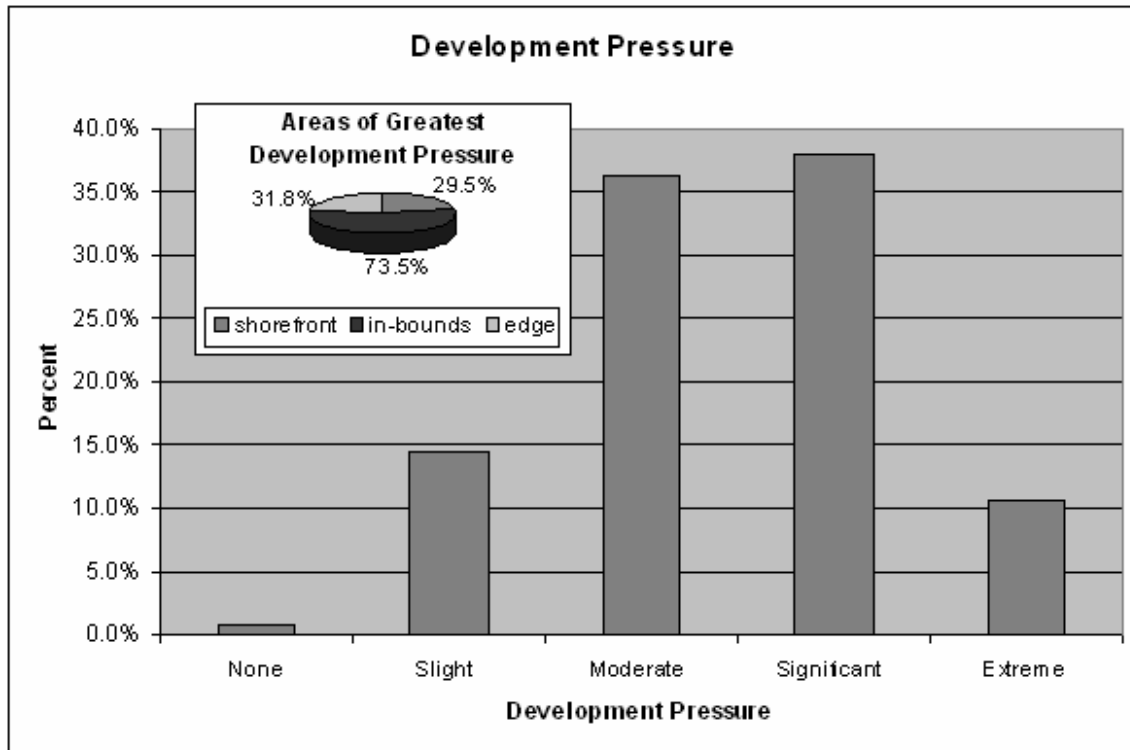
It is reasonable to suspect that these expectations of future problems are driven in no small part by the experience of current challenges, for example, in terms of perceived severity of the problem (detailed above), but also the respondents' views on ongoing development pressures, political contentiousness surrounding an issue, and efforts underway to alleviate these problems.

Indeed, when respondents were asked about development pressures in their communities and counties, the average development pressure on a scale from 1 (no development pressure) to 5 (extreme development pressure) was 3.4, with a majority of respondents experiencing moderate to significant development pressures (Figure 3).

As may be expected given the already high degree of development along the immediate shorefront, communities now witness the greatest pressures inland from the shoreline, with some ongoing additional pressures from infilling and redevelopment along the shorefront and problems with sprawl at municipal boundaries (Figure 3, insert). As development continues, pressure on species and habitat and public access issues is likely to continue to increase—in short, an internally consistent influence on respondents' expectations about the future.

When respondents were asked to characterize the political atmosphere around the most challenging coastal management issue on a scale from 1 (highly contentious) to 4 (consensual), the average rating was 2.5 (moderately contentious). More specifically, however, the respondents rated the political atmosphere around two of the top three problems listed in Table 2 (public access issues and species/habitat protection) among the most contentious issues with average ratings of 1.80 and 1.86, respectively. Other issues from Table 2 considered politically contentious included beach loss (2.33), coastal erosion (2.44), and coastal water quality (2.52). While in-depth interviews with respondents would be needed to reveal particular reasons behind their expectations of the future, it is reasonable to assume that these judgments of the political atmosphere also affect managers' perceptions of how coastal zone management challenges may change in the next few years.

Figure 3. Perceived development pressures in California coastal cities and counties



Note: Areas of greatest development pressure were defined roughly as follows: “**shorefront**” – the immediate first one or two blocks along the water front; “**in-bounds**” – all areas away from the “shorefront” as defined above and away from the landward municipal boundaries; and “**edge**” – areas along the landward municipal boundaries.

Finally, to the extent environmental changes such as climate change are of sufficient concern to rise as high as or above other pressing concerns, expectations about the climatic or environmental future may also influence expectations of future severity of management challenges. The authors asked about concerns about global warming *after* inquiring about ongoing pressures, so as not to influence respondents’ views. Findings regarding awareness, attitudes, concerns, and knowledge about climate change are summarized in the next section.

4.2. Coastal Manager’s Attitudes Toward Global Warming and Coastal Impacts

4.2.1. Attitudes Toward and Knowledge about Global Warming.

To assess survey participants’ awareness and attitudes toward global warming, they were asked to indicate their level of agreement with various statements regarding global warming. California coastal managers exhibited very strong opinions. More than half (53.5%) strongly agreed with the statement, “Global warming is real and already happening now.” Another 38.6% slightly agreed with this same statement. This attitude was also reflected in the 84.1% who agreed – either slightly or strongly – with the

statement “Global warming is probably happening and we will start seeing impacts in the near future.” The control statement, “Global warming is probably not happening now and will not cause problems in the future” had 95.1% respondents disagreeing.

Equally strong were respondents’ levels of personal concern with global warming. Almost half (47.4%) said they were concerned personally and another 39.1% said they were very concerned about global warming. Only 3% were not concerned at all. For 72.9% of the respondents, this concern translated into thinking about what implications global warming might have for them personally and for their work.

When managers were asked to self-assess how well informed about global warming and its implications they felt, 18.8% said they felt well informed, 68.4% felt moderately well informed, with the remainder either not well or not at all informed or unable to judge. These responses were confirmed when managers were asked to indicate their estimate of the possibility that their area might experience certain impacts from global warming: the general pattern of responses was quite consistent with expert judgment. At least four out of five respondents thought there was a moderate to high possibility that global warming would produce changed rainfall patterns (93.8%), higher rates of sea-level rise (89.4%), more frequent storms (84.8%), higher ocean temperatures (84.4%), more flooding (82.2%), and higher air temperatures (82%), as well as higher-order impacts such as more algal blooms (87.9%), changes in water quality (84.4%), and other impacts on marine life (81.7%).

It is likely that if survey participants had simply been asked to write in the kinds of impacts they expected, fewer and less confident answers would have been received. This was the case often in the open-ended questions in the interviews with state, regional, and federal managers. Considering, however, that the survey respondents are not necessarily experts on global warming, the responses are overall internally consistent, and reflect a moderate level of understanding of climate change impacts. Clearly, the response pattern does not reflect general expert judgment of confidence in these impacts. For example, the somewhat surprising response rate for higher air temperatures (scientifically most certain, but rated less likely by respondents) versus changes in rainfall patterns (scientifically less certain but rated most likely by respondents) may have to do with the critical importance that rainfall has in much of California for water supply (especially in the form of snowfall over the Sierra Nevada). As a result, climate change news coverage in the state frequently focuses on water-related impacts, and thus may be higher on people’s radar screens.

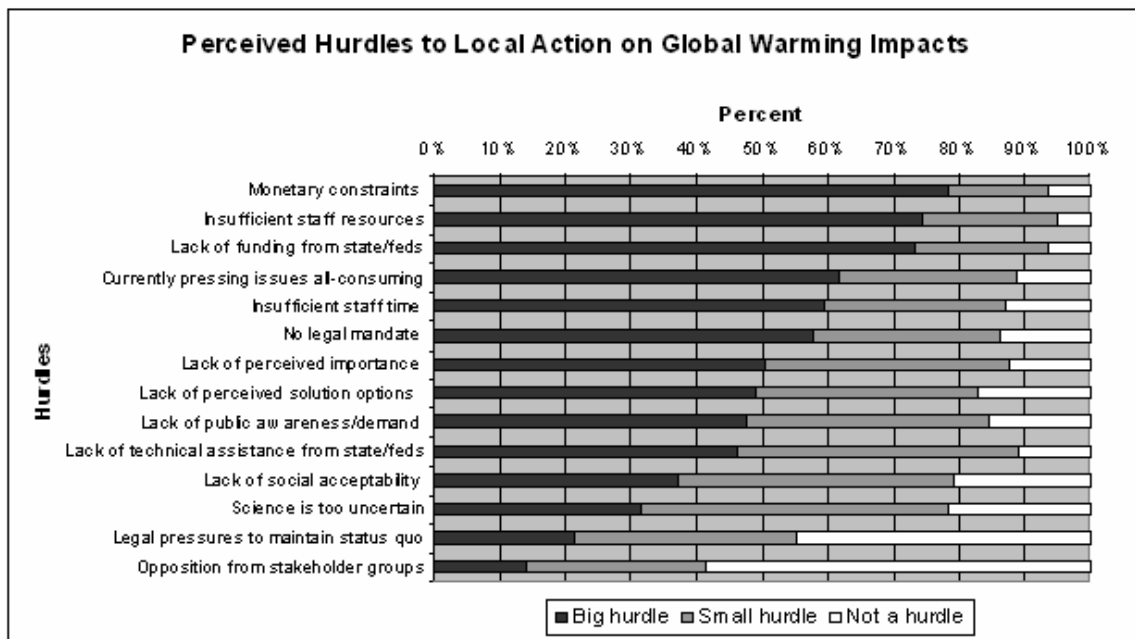
4.2.2. Local Government Response to Date to Global Warming.

It is interesting to note that, despite respondents saying they had considered what global warming could mean for them personally and in their work, very few expected their actual job responsibilities to change or had any opinion on that question. Similarly, when respondents were asked whether their local government had begun gathering any information about global warming impacts, half did not know. About 30% had

consulted some government or external expert or convened public discussions in their communities on the issue.

When respondents were asked whether local governments had formally developed any plans to deal with the potential impacts from global warming, responses were sobering. Two counties (San Luis Obispo and Sonoma) that responded to the survey said that they had such plans in place; however, neither plan considers coastal impacts. Four other counties are currently preparing such plans and will look at coastal impacts. Among the coastal cities that responded to the survey, only one (Berkeley) currently has a plan in place to deal with the impacts of global warming, and six (Solana Beach, Goleta, San Francisco, Palo Alto, Alameda, and Arcata) are in the process of developing such plans; at least five of them will consider coastal effects. It is significant to note that close to 20% of respondents did not know whether their city or county had any such plan. Respondents were then asked to identify hurdles that prevented them from addressing the effects of climate change. Their answers reveal important constraints on local action (Figure 4).

Figure 4. Perceived hurdles to local action on global warming impacts



Managers overwhelmingly (78.2% of respondents) see monetary constraints at the local level as the leading hurdle to taking on global warming impacts, followed closely by insufficient staff resources to analyze and assess relevant information (74.4%), lack of funding from state and/or federal agencies to prepare a plan (73.4%), and the view that currently pressing issues are all-consuming (61.6%)—that is, leaving little room to take on anything seemingly new, unfamiliar, or overwhelming. Concern about insufficient staff time (59.7%) confirmed this view. More than half of the respondents (57.7%) also

viewed the lack of a legal mandate to take global warming impacts into account as a major hurdle.

4.2.3. Perceived Responsibility for Taking the Lead on Adaptation Planning and Action

In addition to asking local coastal managers about their perceived hurdles to taking action on global warming impacts, individuals from state, regional, and federal agencies engaged in California coastal management were also interviewed about similar perceptions. What do they feel is in the way of taking action to prepare for the impacts of climate change? What hinders taking action aside from “not enough information”? What would it take for the State of California to begin addressing climate change impacts (not just emissions, which the state is a leader in addressing already)? Interviewees reiterated some of the themes identified at the local level: a clear directive from Governor Schwarzenegger or from state agency leaders; federal agency/government initiative; provision of technical assistance; and—pervasively—more financial resources. Interviewees also thought that a significant disaster affecting California, which somehow could be related to climate change, might initiate action. Several interviewees alluded to the takings issue, local development pressures, and “politics” as significant hurdles toward more environmentally cognizant and forward-looking planning. Others identified overlapping authorities among state and federal agencies and resulting confusion over who is or should be doing (and funding) what, and the occasional disharmony among state policy mandates, as reasons for inaction or ineffective action. These observations prompted several interviewees to express their desire for better interagency communication and interaction.

Of the twelve interviewees that responded to this set of questions, 50% believed that state government institutions would be best placed to lead and facilitate adaptation actions; the next most frequent response called for leadership from Governor Schwarzenegger. One federal-level interviewee aptly summarized the importance of support from the governor and from state agency leads:

“I think the push has to come from there [the California State Governor] but I [also] think it has to come at a level below him...I think it has to be the agency and the commission heads that have agreed to it and talked to their staff about it, because there is a good possibility that Schwarzenegger will not be here in two years.”

The interviews and surveys also revealed varying attitudes toward whose responsibility it is to take action on global warming impacts. At both the local and state level government officials are waiting for funding, technical assistance, the development of tools to assist with identifying vulnerabilities and needed adaptation strategies, as well as for political leadership to initiate, facilitate, or press for action. At the same time, local coastal managers dreaded any unfunded mandates or policies. Federal agency staff interviewed for this study, in turn, suggested that they are waiting for congressional leadership and funding. At the state level, in an informal briefing of state legislative staff

in Sacramento in October 2006, the authors learned that state lawmakers are waiting for political pressure from the local level before they would consider legislative initiatives or changes to existing laws to begin to address the impacts of climate change.

These findings and observations suggest some degree of “finger-pointing” in terms of the perceived responsibility for *taking the first step on adaptation actions*. Differently put, coastal managers at all levels seem to hesitate to take action on global warming impacts unless there is a directive from higher-level authorities and/or political, technical, and financial support from allied agencies or stakeholders to support them.

5.0 Discussion

How representative are the findings presented here of all of coastal California? At first glance, one could argue that they capture the situation quite well: as mentioned above, surveys were received from 89% of all approached cities, and 89% of all contacted coastal counties. The types of communities represented include everything from metropolitan areas to retirement communities, tourist towns, farming communities, and working or recreational harbors to mixed urban centers. Similarly, cities and counties varied in population size, adequately representing the range of communities of coastal California.

While coastal management—as broadly defined as it was in this study—is spread out over numerous departments, commissions, boards, and services, this study focused primarily on “implementing staff” and to a lesser extent on elected officials or bodies. To the extent that any plans were passed in those elected, policy-setting institutions and are now being put into action, department staff would know about them. The authors thus believe that the local government situation “on the ground” was adequately captured, even if only very limited responses were received from elected officials.

After the initial survey mailing, the authors did, however, receive a number of calls or e-mails from individuals who said they did not consider themselves “coastal,” felt they could not speak for their entire local government, or were not experts on global warming. Reassurances about these matters (and clarification in subsequent reminder mailings) resulted in some answering the survey; others not. Based on previous in-depth interviews with state and local coastal managers in California and elsewhere, the authors assume there is a bias among non-responders to not answer because they either felt similarly (as those who contacted the research team for clarification), or simply did not have any time or interest in participating. The bias to not respond may be stronger in cases where no action on climate change has been taken. Differently put: those who have something to tell are more likely to want to share it. If these assumptions are anywhere near fact, the results presented here are, if anything, overly optimistic. The degree of time, staff, and resources constraints overall may be felt even more acutely; the level of awareness, concern, and knowledge of global warming and coastal impacts is probably lower than captured here; thus, the motivation to act may be lower and the perceived hurdles to taking action even higher. Thus, the authors cautiously view these findings as representative of those most engaged in coastal management today and those most aware and concerned about climate change, but probably as “too rosy” for coastal California as a whole.

One may also ask how transferable these findings are to other U.S. states. The authors are not aware of any other studies that have conducted broad surveys of local coastal management staff regarding their current challenges or anticipated future problems

from climate change.³ Thus, there is no comparable basis on which to judge transferability of findings.

One study explored SLR response options and obstacles for local governments generically (Burby and Nelson 1991). Another nationwide study nearly two decades ago tried to assess what policies states and local governments had actually put in place to deal with sea-level rise (Klarin and Hershman 1989). A more detailed study of the few states and local entities they had identified as having begun to deal with these inundation-related risks revealed that Klarin and Hershman's assessment was slightly too optimistic (Moser 2005). Undoubtedly, additional states and communities have since begun to tackle this challenge, but the authors are not aware of a nationwide update of the Klarin and Hershman review. Moreover, states and particular localities will differ in what they perceive to be their most challenging management problems at present, as physical characteristics of the coast, regional climate variability, coastal development patterns, and policy histories differ across the nation. However, several in-depth studies by Moser (2000, 2005, 2006) of state and local coastal management of sea-level rise and coastal erosion in Maine, Hawai'i, North and South Carolina, New York, Texas, Oregon, and Washington reveal very similar concerns and pressures, staff and funding constraints, as well as legal limits on managers' ability to address inundation risks and other climate change impacts. These were—less specific to the topic of this paper, yet geographically more comprehensive—confirmed by the independently arrived at, yet almost identical findings of the two U.S. ocean commissions (U.S. Commission on Ocean Policy 2004; Pew Oceans Commission 2003). Both identified funding and staffing constraints—lack of coordination in coastal governance across sectors and levels of decision-making, lack of scientific input in decision-making, and shortsighted pro-development policies—as undermining the effectiveness of integrated, forward-looking coastal management today. Thus, these findings are cautiously viewed as having broad applicability outside California, even if a number of specifics—such as the ranking of current management challenges, or the degree of awareness and understanding of global warming effects—are likely to differ from location to location.

As for California survey participants' responses about current coastal management challenges (Section 4.1), they are internally consistent with those regarding expectations of future coastal management. They also are internally consistent with expected changes related to global warming and why so little action has been taken to date to address coastal impacts of climate change. Being overwhelmed and understaffed with current problems, leaves little room to get informed about (much less begin addressing) the growing risks related to climate change and sea-level rise. Such constraints do not even allow managers to find out that many of the expected effects from global warming are not “new” and “extra” or “different” but mostly more severe versions of what they are

³ The Coastal States Organization (CSO) is, as of July 2007, preparing a survey to assess state coastal management staff's information and tools needs to begin addressing the consequences of climate change in coastal management across the U.S.

already intimately familiar with. These internal consistencies give us further confidence that these results adequately capture the current perceptions of coastal managers regarding inundation-related risks.

The responses regarding current or future inundation-related management challenges did not meaningfully correspond to the physically based Coastal Vulnerability Index (CVI, described above, with majority values assigned to city boundaries). This lack of significant correlation is attributed to a range of factors, including lack of awareness of the CVI among managers, variations in the degree of development of vulnerable coastal areas, other challenges competing for managers' top concern and attention, the objective and subjectively perceived severity of other management problems, as well as the fact that the survey included several management challenges that predominate in non-shorefront areas and/or are not just related to sea-level rise. This finding just highlights the fact that coastal managers (broadly defined) have broader responsibilities and must address and balance their time commitment to more than shorefront (inundation-related) issues. At the same time, most coastal managers' job responsibilities do not expressly include attention to future risks, and in that sense are more narrowly focused than climate change risks may demand.

Clearly, not taking action with climate change impacts explicitly in mind does not mean coastal communities are entirely unprepared for climate change and inundation-related impacts. Based on state law and/or the local coastal management plans implementing these state regulations, numerous policies, regulations, planning guidelines, and informational approaches are in place now to address current coastal issues, and these are certainly useful as coastal risks increase. However, as the projections of future climate change and related inundation risks discussed in earlier sections suggest, even more strictly implemented existing coastal management strategies may not be sufficient for dealing with the growing risks from climate change (see also, Nicholls et al. 2007). In some instances, additional science (e.g., to translate increased rates of SLR into legally defensible setbacks) is necessary to inform future decision-making, but scientific information alone is not the primary obstacle to greater action on preparedness (for further discussion see Moser and Tribbia 2007).

The sobering conclusion from both the very small number of local entities that have begun thinking about a future under climate change conditions and the perceived hurdles to begin doing so is that California is inadequately prepared and inadequately preparing for the impacts of climate change on coastal areas at this time. Coastal managers at all levels are waiting for leadership, clear mandates, and various forms of political support and other forms of assistance, especially financial, to begin preparing, but only few are taking pioneering leadership roles at present. The results presented here suggest that especially local governments will need substantial support if the level of preparedness for climate change and related inundation-related risks in California is to be elevated in the future.

6.0 Conclusions

This research aimed to understand (1) California coastal managers' perceptions of current management risks, (2) their understanding of the added risks from climate change, (3) their perceived vulnerability to the growing coastal problems, and (4) the extent to which they have begun thinking about and tackling these increasing management challenges.

This study's survey respondents identified water quality, shoreline change, flooding, and species and habitat protection issues among their top management challenges at present. Perceived severity of the management challenges added public access to beach areas and saltwater intrusion in coastal aquifers and estuaries to this list of priorities. All, one can argue, will be worsened by the expected impacts from climate change in coastal areas. Indeed, California's coastal managers expect such worsening, except for flooding—a perception that may be influenced by relatively fewer storm/flooding incidences and relatively greater concern for other chronically pressing issues. Despite these expectations, considerable concern about global warming in general and a moderate understanding of what climate change may bring to coastal communities in the future, California local governments have taken only very limited action to prepare for future coastal risks. This report identified monetary constraints, limited staff resources and time, a sense of being overwhelmed with currently pressing issues, and a lack of a legal mandate among the key reasons why these communities have done so little to date.

That local governments need help to prepare for the impacts of a change climate is an easy conclusion, but not one easily realized. Both federal and state budgets are under enormous pressures from competing priorities. California, more than most other states, has illustrated exemplary leadership on climate change, both in terms of support for state-specific research and for a variety of emissions reductions efforts. Its state-funded global change research program is now turning greater attention to adaptation questions. This type of research will be enormously helpful if it identifies adaptation options available at different levels of decision-making, as well as the realistic constraints that need to be addressed to realize the state's substantial adaptive capacity (Luers and Moser 2006).

The research results presented here reveal a number of ways in which federal agencies involved in coastal management (e.g., the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), and the U.S. Army Corps of Engineers) can complement these state-funded research efforts through a variety of funding mechanisms, such as federal research funds, planning grants (e.g., via Section 309 improvement grants), conference support, or additional money for Sea Grant extension services. Similarly, California state agencies concerned with various aspects of coastal management (e.g., the California Coastal Commission, the San Francisco Bay Conservation and Development Commission, Department of Boating and Waterways, Coastal Conservancy, the state Environmental Protection Agency, Department of State

Parks, and others) could not only make climate change and related inundation risks a higher priority in their own planning and operations but also support and/or require local jurisdictions to include such considerations in projects that require state approval. For example, the Bay Conservation and Development Commission, regularly interacting with local governments around San Francisco Bay, has prominently raised climate change and sea-level rise to a top priority in its recent strategic management plan. Likewise, the California Coastal Commission in late 2006 launched a series of public workshops on global warming and its implications for areas under its jurisdiction. Such actions can help raise broader awareness and pave the way for local assistance.

It is important to note that future coastal management efforts in California, if they are to assist local governments in preparing for the consequences of sea-level rise, inundation, and other climate change effects must address the hurdles identified by local officials as major encumbrances. The results presented here suggest that legal mandates, and in particular funding mechanisms and additional staff resources to implement such mandates (e.g., to assess community vulnerabilities to various coastal impacts and identify response strategies), must play a prominent role in such state guidance and assistance. In addition, local coastal managers would benefit from regular doses of relevant and accessible information on the latest climate change science; especially that relevant to coastal areas. Such information also must highlight feasible management strategies to counter perceptions that “there are no viable response options.” Maybe more important even than the written word are opportunities for coastal managers to learn from each other (e.g., in conferences and workshops), to learn what others in similar management situations are doing to address climate change and inundation risks, and how they are funding impacts/vulnerability assessments and response strategies.

Consistent with the priorities of California’s Ocean and Coastal Protection Council’s Strategic Plan, this research – through its exploration of managers’ understanding and expectations of global warming impacts and their perceptions of action hurdles – also suggests that there is a need to improve not only managers’ and the public’s awareness, but maybe more importantly their deeper understanding, of the nature and potential urgency of climate change effects on coastal communities. Such awareness and understanding will – from the bottom up – support and create demand for greater local preparedness as climate change creates ever growing challenges from sea-level rise and storm-related inundation along California’s resource-rich and beautiful shoreline.

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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
CVI	coastal vulnerability index
ENSO	El Niño Southern Oscillation
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	greenhouse gas
HadCM3	Hadley Centre Coupled Model, version 3
IPCC	Intergovernmental Panel on Climate Change
NOAA	National Oceanic and Atmospheric Administration
PCM	Parallel Climate Model
PIER	Public Interest Energy Research Program
RD&D	research, development, and demonstration
SANDAG	San Diego Association of Governments
SLR	sea-level rise
USGS	U.S. Geological Survey