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Talk Globally, Walk Locally:
The Cross-Scale Influence of Global Change Information on Coastal Zone Management in Maine and Hawai'i

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CITATION, CONTEXT, AND REPRODUCTION

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The Global Environmental Assessment (GEA) project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA Web Page at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

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FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins.

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. Academic year 1997-8 focused specifically on the past three decades of climate change, long-range transport and tropospheric air pollution assessment experience with special attention to Europe and North America. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

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ABSTRACT

A rise in sea level and potential changes in storm climatology (changes in frequency, intensity and geographic distribution of coastal storms) are of utmost relevance to coastal zone policy-making, development, and management. Human welfare, high investments, and significant environmental resources that are intimately linked to economic activities in the coastal zone are at stake. Somewhat surprisingly, however, there is currently rather scant concern with global climatic and related environmental changes among U.S. coastal managers, especially at sub-national levels.

Prior research indicates that highly functional, two-way information exchanges across various levels of scale (international to local) is a necessary if probably not sufficient condition for a greater integration of global change science into decision-making at national and sub-national levels. Thus, the questions arise as to what kind of information sub-national policy- and decision-makers need in order "to factor in" sea-level rise and other climate changes into their policies and management activities? In what form, from whom, and when do they need it? Are these needs known to, and can they be met by, information producers or providers? What is "useful" and credible information? What are the factors and processes -- both inherent in the information itself and in the institutional set-up through which information exchange takes place -- that bring about "effective" information use? In other words, how can the plethora of scientific global change information produced internationally and nationally be made more useful to those who ultimately will have to decide on and implement pragmatic responses to a changing environment at the state, regional, and local levels?

This study addresses these questions in the context of coastal zone management in two U.S. states, Maine and Hawai'i. It demonstrates that more than scale boundaries need to be crossed in order to enable a "local walk" to follow "global talk," that the integration of information and decision systems needs to be coupled such that relevant and credible information flows to practitioners with real decision-making powers, and that significant and maybe a more focused effort is necessary to create a demand for global change-related information that connects with present management problems at different levels of scale and among a broad range of agencies, interest groups, and legislative actors. The study also shows that "local walk" begins to affect at least "regional and state talk" in coastal zone management by way of creating coalitions and networks among concerned actors that are rallied around problems of a particular geographic extent rather than around institutional affiliations that correlate with different levels of scale. The findings are applied to the U.S. National Assessment on the Consequences of Climate Variability and Change and recommendations for its design and implementation are given.

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ACRONYM LIST

Federal

COBRA	Coastal Barrier Resources Act (of 1982 as amended)
CZMA	Coastal Zone Management Act (of 1972 as amended)
CZMP	Coastal Zone Management Program
DOC	Department of Commerce
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
IPCC	Intergovernmental Panel on Climate Change
NFIP	National Flood Insurance Program
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSTC	National Science and Technology Council
NWS	National Weather Service
OCRM	Office of Ocean and Coastal Resource Management (within NOAA)
ORNL	Oak Ridge National Laboratories
OSTP	Office of Science, Technology and Policy
NPS	National Park Service
SGCR	Subcommittee on Global Change Research (within the Committee on Environment and Natural Resources of the President's National Science and Technology Council)
SLR	Sea-level rise
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Service
USGCRP	United States Global Change Research Program
SSRI	Social Science Research Institute (University of Hawai'i)

Hawai'i

DBEDT	Department of Business, Economic Development and Tourism
DLNR	Department of Land and Natural Resources
DMR	Department of Marine Resources
DOH	Department of Health
DOT	Department of Transportation
EWC	East-West Center (Honolulu)
HCZMA	Hawai'i Coastal Zone Management Act (Chapter 205-A)
HCZMP	Hawai'i Coastal Zone Management Program
HHRF	Hawai'i Hurricane Relief Fund
HRS	Hawai'i Revised Statutes
MACZMAG	Marine and Coastal Zone Management Advisory Group
ORMP	Ocean Resources Management Plan
SMA	Special Management Area

Maine

DEP	Department of Environmental Protection
LURC	Land Use Regulation Commission
MCP	Maine Coastal Program
MEMA	Maine Emergency Management Agency
MEPP	Maine Environmental Priorities Project
MLI	Marine Law Institute (University of Maine School of Law in Portland)
MSPO	Maine State Planning Office
SDR	Sand Dune Rules

GLOBAL CLIMATE CHANGE, SEA-LEVEL RISE AND THE NEED FOR CROSS-SCALE INFORMATION FLOW

> "Those of us sharing a concern for increasing public awareness of global change issues know that we cannot simply transfer information from the heads of scientists into the minds of the public."
>
> (University of New Hampshire/Institute for the Study of Earth, Oceans and Space 1997, p.44)

Global change and coastal zone researchers largely agree that climate change-induced sea-level rise is no longer a matter of debate (IPCC 1996). They do still disagree, however, on matters of global to local rates of sea-level rise and the magnitude, sometimes even the direction, of its impacts (Bijlsma 1996; Moser 1997). Scientific consensus has not been reached either about potential changes in the mechanisms regulating regional climates which in turn may affect the frequency, intensity, and geographic distribution of severe coastal storms (IPCC 1996). These two interconnected sets of climatic and environmental changes are of utmost relevance to coastal zone policy-making, development, and management as human welfare, high investments, and significant environmental resources intimately linked to economic activities in the coastal zone are at stake. And still, despite extensive and ongoing international and (US) national efforts to assess the significance of sea-level rise and climatic changes, there is currently rather scant concern with these problems among US coastal zone policy-makers and managers, especially at sub-national levels.

This paradox raises intriguing questions about the apparent disconnect between international, national, and sub-national scientific efforts, and between science and policy-making or the realm of knowledge generation and knowledge application more generally: what kind of information do sub-national policy- and decision-makers need in order "to factor in" sea-level rise and other relevant climatic changes to their daily coastal zone management and decision-making? Are the information needs of decision-makers known to, and can they be met by, information producers or providers? If in fact it is true that "there is ... a grave mismatch between the knowledge that is needed to act locally and what is currently being done globally to generate knowledge about climate change, its impacts, and responses to concerns" (Wilbanks and Kates 1998, p.15), then the question arises how the plethora of scientific global change information – the "global talk" -- can be made more useful or whether new types of information are needed by those at regional and local levels of scale who ultimately will have to do the "local walk," i.e, decide on and implement pragmatic responses to a changing environment. Ultimately, all these questions get at the effectiveness and role of global environmental assessments in decision-making at national and sub-national levels of scale and at the processes that link the global and the local for the management of pervasive cross-scale environmental risks.

This paper examines under what circumstances and in what ways global change information produced at the international and national level is employed in coastal zone policy- and

decision-making at sub-national scales. The study is guided by the following research questions:

a) What are the global to national to local linkages in information collection, transfer, and decision-making?

b) What institutions and processes (including governance structures) exist which encourage or discourage the cross-scale transfer of "useful" information to users, and the transfer of users' needs to assessors?

c) What institutions and processes (including governance structures) exist which encourage or discourage coordination of cross-scale decision-making?

d) Under what conditions do these institutions operate and under what conditions are they effective?

e) How can information/decision-making systems be improved to better meet the needs of regional decision-makers who are facing prospects of climate change, climate variability, and associated environmental risks?

Below I begin the exploration of these questions with a discussion of why a cross-scale focus seems to be increasingly important in environmental management and what makes it conducive to use it as a starting point for this study. This is followed by a conceptualization of assessments that cross different levels of scale and its implications for the notion of effectiveness. After a short overview of the research methodology, the paper summarizes the empirical research in two sections: (1) findings from the national, state and local levels which draw on the review of activities at the national level and the empirical research in Maine and Hawai'i, and (2) the comparative, analytical discussion of common themes and major differences. The appendices describe in much more detail the respective findings from each of the case studies.

THE CROSS-SCALE LENS AS A STARTING POINT

The focus of this study places the concepts of scale and the interactions across different levels of scale at the center of this research. I begin with the presumption that scale is a concept that helps to hierarchically organize and think about the interactions between the global and the local, but not that scale is necessarily a perceived or experienced entity. Social interactions, biophysical phenomena and human-environment relations tend to display a characteristic spatial and temporal "boundedness" or organization (e.g., a family, a nation's population, a state government, a forest stand, or a coastal storm and its impacts on a community). Many connections – especially between people, however, also occur outside easily identifiable organizational structures, for example, in networks or coalitions, which are less well matched by characteristic spatial scales. Moreover, different agents (like scientists or decision-makers) are situated at, and act from, particular locales, but their respective research interests, concerns, resources, information services, technical capacities, and decision-making authorities vary considerably in reach. This variance actually allows for cross-scale relationships to emerge via a myriad of possible connections, but it implies also that interactions are too complex to neatly fall into scale categories (e.g., the local, regional, state, national, or global scale). So, while we

are accustomed to thinking, for example, of governance or ecological systems as organized in a hierarchical manner at various levels, real-world agents function in many capacities and roles in a variety of contexts. Scale as the organizing principle of this paper is used thus here only as a useful starting point from which to examine the structures and relationships that constitute information and decision systems capable of spanning the global and the local. The empirical research has to show, however, whether scale is the primary ordering principle behind information and decision systems that connect the global and the local, to what extent scale is a relevant mental construct for the agents that may or may not make cross-scale connections, and whether they perceive scale barriers or hurdles between the level at which they are situated and the levels at which others are located.

The question of whether scale is a relevant and perceived concept notwithstanding for the moment, there are several recent developments which suggest that scale is at least of increasing scholarly interest. First, over the course of the last half decade or so in climate change research, a shift has become apparent in the climate change debate from trying to understand the science of climate change, its impacts and possible adaptation mechanisms to developing the scientific foundation for policy choices through integrated assessments and the identification of mitigation strategies (Downing, Olsthoorn et al. 1996; IPCC 1990; IPCC 1996; O'Riordan and Jaeger 1996). This involved a shift from the global to regional, national, and sub-national scales. Only in the most recent past is there a move toward actual decisions on how to implement specific mitigation and adaptation strategies (for example at the Kyoto conference/COP3).

Simultaneously, as the possibility of global climatic changes with some potentially dramatic, and clearly unevenly distributed consequences was taken more seriously, one could observe an increasing interest in local and regional impacts and capacities to adapt to these impacts -- as evidenced, for example, in the current U.S. National Assessment effort that looks specifically at regional impacts and response capabilities; or in various efforts of the IPCC and others to assess regional, sectoral, and national vulnerabilities to particular environmental changes, like sea-level rise; or the heated international debates over the capacities of developing nations to implement technological measures to reduce greenhouse gas emissions.

A third set of reasons why this paper focuses on cross-scale dynamics is that there is a need for a better, more comprehensive theoretical understanding of cross-scale linkages. Many disciplines and cross-disciplinary researchers have dealt with scale issues, including geography, both physical and human; economics; ecology and other natural sciences; political and policy sciences, etc. all contributing to research in areas as diverse as ecological change (Holling 1995); hierarchy and percolation theories (Allen and Starr, 1982; Salthe 1985; Ahl and Allen 1996; Keitt, Urban et al. 1997); technological innovation and diffusion (Pred 1977); political ecology (Blaikie 1985; Blaikie and Brookfield 1987); policy implementation studies; federal-state authority conflicts (Holland, Morton et al. 1996); common pool resource management and institutional design studies (Ostrom 1990, 1994); regime theory; and many more. While these efforts have contributed some interesting theoretical insights and empirical lessons, an attempt to integrate some of these in order to understand better how, by what and whom different levels of scale are linked has only recently been undertaken (Cash and Moser 1998; Moser, Cash et al. 1998; Gibson, Ostrom, et al. 1998). These efforts serve as a theoretical starting point for the research reported here.

And finally, despite a long-standing interest and even significant recent efforts to produce policy-relevant science and to use it more effectively in decision-making – for example, in the coastal context (National Research Council 1995) -- little theoretical or empirical understanding exists at present of how large assessments of scientific and technical information that is gathered, constructed, and produced at one (frequently the global) scale, interacts with decision-making and risk management at other levels of scale (Global Environmental Assessment Project 1997).

GLOBAL ENVIRONMENTAL ASSESSMENTS AS PRODUCTS AND PROCESSES

Assessment Functions and Cross-Scale Flow of Information

Assessments can be thought of as more than critical syntheses and appraisals of scientific information on a particular topic -- in other words, they are more than reports or products resulting from a large scientific effort (Miller, Jasanoff et al. 1997). Rather, as previous GEA Project research has shown, such assessments encompass these outcomes (reports) and the social, dynamic, iterative processes that lead to and follow them -- the communicative, social interactions among assessors and scientists, and those among scientists, interested groups, and potential assessment users like policy-makers or managers. As such, they can serve a variety of functions (Miller, Jasanoff et al. 1997):

- integrating disparate knowledge from many different disciplines and research programs into consensus answers;
- disseminating this consensus to, i.e., informing and educating the policy-and decision-maker community;
- identifying the gaps in scientific understanding;
- reevaluating the relevance of knowledge claims;
- affecting the nature of the communities that produce scientific knowledge and that use it to inform public opinion and decision-making; and
- providing the resources and opportunities for (new) groups to interact and develop common ground with respect to policy choices.

Embedded within these broader social functions of assessments are additional strategic functions of assessments (or any information perceived as authoritative) as rhetorical devices, symbols, or means for political legitimization or obfuscation and so on. When looking at the role and influence of global environmental assessments at lower levels of scale, there appear to be at least three principal venues for this cross-scale influence of assessments to manifest itself: (1) to design the assessment process in such a way that it actively involves actors from different levels of scale; (2) through efforts made to disseminate assessment results from a higher level of scale to lower levels of scale; (3) when local assessment initiatives attract the attention of higher levels of scale, stimulate larger assessment processes and eventually become integrated into the larger assessment efforts undertaken by supra-local actors. It is an empirical question to determine what assessment designs are or have been relevant in the chosen case studies and what effects they have had. One may expect, however, that outcomes vary with design for a number of reasons, including:

- when the first and to some extent also the third venues are chosen, the various assessment functions are preserved at every level of scale involved in the process whereas in the second case only the consensus dissemination or education function is retained at lower levels of scale;
- the different ways of assessing a problem and disseminating information about it draw to different degrees on the capacities of actors and institutions at different levels of scale;
- the number and type of actors participating in the generation, transformation, and dissemination of assessment information differ;
- consequently, the range of issues raised and the ways in which they are framed and re-framed through a single versus multiple-scale assessment process is likely to differ;
- the degree of co-production of knowledge and hence ownership of knowledge but also the degree to which information becomes politicized in the process differ; and finally,
- the assessment procedures and resulting information are scrutinized for their relevance, credibility, and usefulness more frequently and from a wider variety of perspectives and experiences as the number of involved actors from different levels of scale increases.

The range of assessments of climate change and sea-level rise done internationally and nationally in the United States over the past two decades offer somewhat of a natural laboratory to examine the role and effectiveness of differently designed assessments on sub-national decision-making. Among the most prominent ones are, of course, the climate change assessments conducted under the auspices of the IPCC, past national climate change and sea-level rise assessments by the EPA and other federal agencies, and the current, ongoing U.S. National Assessment of the Consequences of Climate Change with its regional component that depends on local participation in the assessment process. The suite is augmented by several less visible sub-national assessment efforts discussed in Appendices B and D.

Implications for the Concept of Effectiveness

Assessments (whether done at one or multiple levels of scale) fall somewhere in between pure scientific research (information generation) and the use of information by policy- and decision-makers. They can function as bridges between the realm of knowledge generation and the realm of knowledge application, i.e., action, or between science and policy. This research is interested in the processes that connect these two ends of the continuum. It assumes that the use of scientific information in environmental decision-making is desirable (if not sufficient or able to replace other types of knowledge), i.e., scientific information is assumed to support effective environmental management. On this premise, assessments must be thought of as integral of the processes that can produce effective environmental management. In order to achieve effective environmental management one also needs to consider the processes after scientific information is integrated into policy- and decision-making, i.e., also look at issues of implementation and enforcement.

As a concept and empirical outcome "effectiveness" of processes and institutions is a notoriously difficult property to evaluate (Sabatier 1988). There are, however, a number of recent studies that provide indicators of effectiveness in the context of global environmental issues which suggest that assessments (or more broadly, effective information and decision systems) are more effective if they are designed in a way that they increase:

- the level of concern for a given issue expressed by political actors,
- the credibility of the contractual relations among participating parties, and
- the capacity of relevant institutions to carry out their tasks (drawn from Haas, Keohane et al. 1994; Connolly 1996).

In addition, assessments that one may consider "useful" or "good" provide information to its potential users that is technically adequate, procedurally legitimate, and perceived to be relevant. An assessment with these characteristics may affect policy-and decision-making and hence have a demonstrable impact on the allocation of resources (drawn from Clark and Majone 1985).

While none of the above cited studies address scale or cross-scale aspects of effectiveness, they highlight that effectiveness can be sought in many places along the knowledge-action or science-policy continuum. Focusing only on the outcome end for measures of effectiveness, however (e.g., on the maintenance of coastal wetlands and other habitats, or the reduction of losses from coastal hazards), would inappropriately restrict federal and state coastal zone management programs to only select goals in spite of the fact that the federal Coastal Zone Management Act calls for a balance of many different and at times conflicting goals. There is also no societal consensus on how to address climate change issues which will likely produce winners and losers. And even if there were consensus on these goals and management strategies, a sole focus on local outcomes would shed little light on the cross-scale integration of information flow and decision-making and the role that assessments play in it. Hence, a more illustrative, process-oriented, and scale-conscious approach to assessing effectiveness is to examine empirically the nature and dynamics of the (dis)connections along the entire networked chain of knowledge production, assessment, information flow, policy- and decision-making, implementation and enforcement (which in the end presumably leads to different management outcomes).

In summary, existing research leads us to expect that assessment processes and information systems that cross different levels of scale are likely to be more effective the more of the indicators mentioned above they show at the various levels of scale they involve. In order to evaluate the role of assessments and information systems in support of environmental management, one also needs to examine the degree of integration of information in decision-making and the actual implementation of scientifically informed policies and rules. This broader view then begins to span a multidimensional space within which effectiveness is determined, where the cross-scale axis of information flow is only one dimension while the crossing of the science-policy or knowledge-practice continuum emerges as another (see **Figure 1**). Additional dimensions may involve any other dichotomy or difference that could arise as a barrier to information flow, to the integration of scientific information into decision-making, or to the implementation of decisions.

A number of postulates follow from this multidimensional conceptualization.

1. The management of cross-scale environmental risks is likely to be more effective the more bridges across scale, science-policy and other divides are built through an information and decision system.

2. Assessments and information systems that actively embrace and involve actors from different levels of scale are likely to be more effective when they exploit the comparative advantages and build the capacities of actors and institutions at different levels of scale.
3. Assessments and information systems which fulfill their education and outreach functions are likely to be more effective bridges to the user community and thus increase the likelihood of information being integrated into policy- and decision-making because education and outreach can change the level of concern for an issue and build an interested constituency for assessment information.
4. Assessments and information systems are likely to be more effective in crossing different levels of scale and in bridging the science-policy continuum when they provide resources and opportunities for groups from different levels of scale to interact. Such interaction helps to develop mutual understanding for different perspectives, alternative problem frames and information needs, and thus to co-produce knowledge that is legitimate, relevant and useable for all actors involved.

In supporting or refuting these postulates, this research aims to determine which factors and processes most facilitate effective assessment processes and effective integration of scientific information into policy- and decision-making.

RESEARCH DESIGN AND METHODOLOGY

Research Focus

The transfer of information and knowledge and its application in practice is – however much supported, facilitated, or otherwise influenced by institutions and technology -- fundamentally a communicative, interactive process between individuals acting on their own behalf or as representatives of institutions . A better understanding of the role of assessments begs for an analysis of the information being transferred, the motivations behind information transfer, and of the actual and potential linkages and the quality and frequency of interactions among these individuals and institutions (Miller, Jasanoff et al. 1997). These linkages and interactions through which information-sharing occurs and through which a mutual understanding is fostered are sought here in the context of existing or newly formed institutional structures and formal and informal networks. Based on previous empirical research (Moser 1997), I also assume that decision-making which could take global change information into account at various levels of scale most likely occurs within the context of existing management frameworks, governmental programs, and previously used decision-making settings. This assumption does not preclude the possibility of new initiatives being launched that either become embedded into ongoing management efforts, or that do not even fit into these existing institutional structures. At least within states, however, there needs to be legal consistency between new and existing programs.

This study hence aims to illuminate these formal and informal connections, interactions, and settings in the decision-making context of coastal zone management. It focuses on information-sharing about the challenges posed by sea-level rise and associated coastal hazard regimes. The study examines the role of several critical concerns or interactions, including:

- the players: information producers, gatherers, disseminators, brokers, and users and the quality of interaction among them;
- the information transfer process (e.g., research as a "one time" activity of a group versus an iterative activity repeatedly involving the same individuals or institutions);
- the degree of integration of the information (or assessment) in the decision-making process; and
- the degree of integration of information and decision-making systems across different levels of scale and other boundaries.

In order to illuminate some of the critical factors and causal mechanisms between assessment and information system design on the one hand and the effectiveness of information exchange, the integration of information and decision systems, and ultimately environmental (or coastal zone) management on the other hand, this study takes an iterative and comparative approach. It focuses on national and sub-national (regional, state, sub-state, and local) levels of scale, comparing how Maine and Hawai'i address sea-level rise and associated coastal hazards within each state's coastal zone management program.

Case Studies and Data Sources

Maine and Hawai'i as sites for this SLR/coastal hazards management study share several similarities and differences (**Table 1**). The similarities can be thought of as control variables in the research design, in that they are practically consistent for both states and thus can not account for any differences in effectiveness if such a difference is found. While it may be difficult at first to see how the northern mainland state and the tropical island state have anything in common, several similarities do in fact exist. The two states share, for example, an almost identical range of currently observed sea-level rise (ME: ~1.8-3.4 mm/year; HI: ~1.6-3.9 mm/year) with both states experiencing the highest rates of sea-level rise in parts of the states that are geologically least vulnerable to the impacts of sea-level rise. Both states also share their strong economic dependence on coastal tourism and fisheries; an overwhelming demographic concentration in coastal counties and floodprone areas; significant crucial infrastructure installations and water-dependent uses in the immediate coastal areas; and both participate in international and cross-state political alliances that are focused on the management of coastal and marine affairs.

Despite similar rates of sea-level rise, the two states arguably differ in the degree of physical and economic vulnerability to the impacts of sea-level rise and severe coastal storms. They also differ in the institutional set-up for coastal zone decision-making; in each state's physical and political closeness to federal political decision centers; and in the states' respective linkages to national and international political and scientific communities involved in climate change issues. The two states also have different histories of sea-level rise research and policy responses at the state level. There is an interesting puzzle about information flow and use in that Hawai'i as an island state is arguably more vulnerable to SLR and thus may have a greater need for useful SLR information but has as of yet not established any SLR-specific policy response, while the relatively less vulnerable Maine has already used such information in implementing SLR-specific legislation. This comparative investigation of Maine and Hawai'i allows me to illuminate what role perceived vulnerability and information need, institutional differences, political closeness between a state and federal governmental institutions, and association with international institutions play with regard to information flow and use.

This analysis of information and decision systems in support of cross-scale environmental management is based on documentary and interview evidence.[1,2,3] Specifically, I draw on existing documentary evidence available at local to international scales (with a heavy emphasis on the former) about the production of assessments and other information on climate change and variability, sea-level rise, and its more visible manifestations erosion and coastal storm impacts. Such documents include sea-level rise and global studies for the regions or states, outreach, education, and information publications from pertinent agencies, and general background information on coastal zone management, program assessments, and so on. These written materials document some of the formal and otherwise used or available bridges between scientists, interested individuals, and decision-makers.[4]

Through triangulation (i.e., multiple cross-checking of the obtained documentary and interview information and a qualitative and comparative analysis of the two states) I was able to discern the network of relevant information producers and users in the two states and their linkages to the national and international arenas. I also was able to at least begin to understand the role that assessments and other scientific information about global change play in sub-national coastal decision-making. The larger lessons learned from this research are summarized in the next two sections, whereas the more detailed description of findings is compiled in the appendices.

MAJOR FINDINGS FROM THE NATIONAL, STATE, AND LOCAL LEVELS

This section presents a summary of the factual evidence gathered in this study regarding the established information exchange networks, the types of assessments undertaken at and across various levels of scale, the information transfer processes, the degree of integration of information into policy- and decision-making, and the degree of integration of information and decision systems across scale and other boundaries. Where relevant, I highlight the commonalties and differences between Maine and Hawai'i and how the characteristics of both states and the coastal management problems they face matter in explaining these commonalties and differences. The effects on effectiveness are discussed at the end.

Information Exchange Networks and Assessments

The review of research and policy action at the national level (for details see Appendix A) revealed a myriad of legal, administrative, political, and academic structures that in principle connect between science and policy-making, and between and within governmental agencies. These institutional structures are designed to support the production of scientific information on global change and coastal matters, to provide information clearinghouses and formal information exchange channels, and to promote the linking of pre-existing (ongoing) coastal zone management efforts with the emerging challenges related to global climate change. The federal government has sponsored or contributed to a series of scientific assessments of SLR and its impacts. While it is not explicitly stated that these national assessments were meant to affect sub-national policy- and decision-making, the interview evidence from the two case studies suggests that they have had little traceable impact on state or local decision-makers. In a few instances, SLR scenarios from EPA national assessments (which adapted IPCC global

assessments to the national scale) were used sub-nationally to illustrate the SLR problem in generic terms, but they never informed sub-national decision-making. The clearest linkages between national and sub-national research and management activities on global change and coastal matters have been created through participation in sub-national workshops on climate change issues or through research funds made available by federal agencies for sub-national global change impact studies.

Likewise there are dense and fairly stable information exchange networks within and across the state and sub-state levels in both states that link scientists, extension agents, state, county or regional (multi-county) officials. In the case of Maine, these networks extend to also include municipal agency officials and to varying degrees representatives of non-governmental organizations and the private sector. Typically, networks of people emerge (and get firmly established through frequent and repeated interaction over time) whose research foci, political or business interests, decision-making responsibilities, funding capacities, and education or outreach functions are related, overlap, or can compliment each other favorably to reach a wider audience or to more effectively affect a targeted group of stakeholders.

As for assessment activity at the state and local level, Maine and Hawai'i differ quite substantially. Maine has a long history of scientific interest in relative SLR. That is closely linked with an equally long history at the state governmental level of acknowledging the hazards associated with relative SLR and to use it as justification for coastal policies and programs (see Appendix B). On that dual basis, the state has engaged in several efforts to investigate the impacts and response options to climate change and climate change-induced, accelerated SLR. While coastal legislation to date has been primarily driven by resource use conflicts and political considerations, Maine has used the threat of accelerated SLR as additional leverage to strengthen its efforts at coastal areas protection (see Appendix C). The SLR projections at the base of that legislation are derived from international (IPCC) and national (EPA) sources. Another more recent SLR assessment integrates these internationally developed projections with findings from locally conducted SLSR research. More recently, there have been regional and local attempts to assess coastal erosion problems and available management options where SLR (relative historical SLR as well as accelerated SLR due to global warming) played all but a supportive role in justifying that urgent action is needed to sustainably address some severe erosion problems.

In Hawai'i (see Appendix D) there has been only little and less visible effort to assess SLR and its potential impacts on the state. In the mid-80s, the Hawai'i Coastal Zone Management Program produced a short, qualitative SLR assessment using then-popular EPA projections. That report was never exposed to any public scrutiny and there was no follow up to the study. In the early 1990s, a more sophisticated study was conducted to calculate SLR rates taking global eustatic trends, local subsidence, and SLR projections under global climate scenarios into account and the implications for beach management were discussed, but no action followed from that study. Hawai'i has also engaged with other Pacific island states in assessments of erosion and SLR problems – again, with little public visibility or follow-up. While no such international and only very limited cross-state cooperation in assessment effort is evident in Maine, the two states are more similar at the sub-state level. In Hawai'i, though initiated from the scientific community rather than from the grassroots like in Maine, there are now efforts underway to assess the implications of and management options for severe coastal

erosion and beach loss. These assessments focus on specific localities (erosion hot spots) and are increasingly designed to involve local communities and all relevant state and county agencies as well as any other local, state, or federal group that has a stake in beach preservation. These facilitated group processes establish new cooperative and information exchange links that seem to suit the beach management problem (i.e., the geo-ecological system) better than previously established governmental frameworks that did not match the physical basis of the management problem.

It is too early to tell whether these local assessment efforts will be integrated into larger assessments (one of the venues suggested earlier in which assessments can span scales). State-level assessments have not involved players from sub-state levels. Instead they typically involve interested scientists and state agency officials of the state's coastal zone management program. It is not apparent that these state assessments had any traceable impact on county or local management efforts. At best, interested local players have sought SLR information and have been pointed to existing studies and reports. The sub-state assessment efforts, on the other hand, consistently involve the range of interested players independent of the geographic, organizational, or governmental scale they belong to. These assessments are typically geographically bounded in that they involve local players from those areas most affected by the erosion problem (SLR is mostly global, erosion is regional or local), but also actors from elsewhere who are responsible for various aspects of coastal or beach management.

Assessments as Products and Processes

The national and state-level SLR assessments conducted over the past two decades have been primarily report-focused. In the cases where there was an intention to spread the assessment findings to broader governmental, scientific, or public audiences including at other levels of scale, they have followed the venue of producing information (a report) at one level and disseminating the results to other levels. Only the currently ongoing National Assessment of the Consequences of Climate Change aims to actively involve players from different levels of scale in the assessment process and to build long-term partnerships between the scientific and policy communities and other interested parties. Again, it is too early to tell what impacts this differently designed National Assessment will have in terms of effectiveness of spreading global change information, integrating it in policy- and decision-making, and in building sustainable networks of concerned and responsible parties. The interview evidence available now suggests, however, that only in concert with state and local research activities did past international and national assessments contribute at all to raising awareness or concern for SLR. There is no evidence that the large assessments themselves successfully fulfilled an education and outreach function within the broader public or within federal to local governmental institutions, but individual national, state and local actors occasionally use national and even international scientific assessments of global change and SLR to emphasize the need to address pressing coastal management problems. The only connection seen as relevant between state and local efforts on the one hand and global change science on the other was (frequently heard from state- and sub-state interviewees in both states but) best expressed by state geologist and Maine SLR expert Joe Kelley:

> "Houses are too close to the water and <u>that</u> is the problem. That it would get worse with climate change -- sure, I agree completely, but I don't like to stake

> my positions on coastal development on a hypothetical change in climate. The present situation demands we examine the way we develop the coastline, and I don't need any future changes. It's already unbelievable. Sea level is rising in Maine today faster than it has in the last 4000 years. That it might double, I agree, it's terrible. It's catastrophic. But: if I make everything contingent on climate change, then I have to persuade my audience that that might happen. And while you can do that, it's a long-winded argument when...it's an easy thing to persuade people that we got a problem now. ... And I say usually at the very end, '....oh, and here is the EPA projection for the future. It isn't likely to get better'" (Kelley 1998).

The sub-state erosion and beach management assessment efforts recently gotten underway in Maine and now in Hawai'i are much more explicitly process oriented. According to Maine interviewees where there already exists some experience with this type of facilitated stakeholder engagement, the assessment process entailed a substantial educational component, much effort at establishing a common understanding and definition of the problem, and also contributed substantially to building or deepening mutually respectful, understanding, and trusting relationships among the involved parties. While it proved to be time-consuming and required much commitment to the communication process, it resulted in a commitment of all involved parties to collaborate in finding sustainable beach management strategies and in a consensus document that is now being presented to the governor and state legislature to produce a legal change in the state's approach to coastal zone management.

Actual Information Flow and Integration into Policy- and Decision-Making

This research revealed that some of the available information exchange channels and discussion fora don't seem to be used. Moreover, most of the global change information produced at or available through federal agencies and national organizations does not seem to reach the policy-making and practitioner communities at the national or sub-national levels of scale. Among the possible explanations for this apparent lack of information flow and usage in policy- and decision-making are the following:

- little overlap between the membership and hence leadership of non-governmental organizations and the scientific community that is most interested in global change and sea-level rise;
- a lack of understanding or capability to relate state and national concerns to global change issues;
- too few people at the national level of scale who can function as translators of scientific information into lay language, who can initiate or suggest ways to reframe global or national concerns into sub-national matters or embed the global environmental issues into sub-national management strategies;
- global, long-term concerns are consistently placed lower on the political priority list compared to the more tangible management problems the nation and states face;
- the lack of a "sea-level rise lobby" to push the issue onto the agenda of professional and environmental organizations or of federal policy-making and legislative bodies;
- a dismissive stance toward global change concerns because of the perceived uncertainty of global change information;

- political pressures to either ignore available scientific information or to give higher priority to non-scientific considerations; and finally,
- because of frequent changes in political winds, periodic personnel turn-over, changes in intellectual and political direction in research programs or agencies, and institutional memory loss that can affect information production and dissemination.

At the state and sub-state levels, I heard little complaint from interviewees about the inappropriateness or unavailability of SLR information, largely because SLR per se, especially accelerated SLR due to global warming, was not people's major concern, but instead erosion and beach loss. For administrative staff at the front lines of permitting and beach management, the dearth of scientific information on beach erosion rates, sediment transport and coastal ecology is the Achilles heel of scientifically-informed decision-making about coastal development and beach management. Much responsibility lies with a permit applicant to provide information on the impacts of a proposed development which frequently is generated by consulting engineers or scientists and is augmented by agency officials' professional experience. Interviewees in Maine more often than in Hawai'i expressed a satisfaction with the access to information they have and the institutions and channels available to them through which to direct and have their information needs met. Interviewees in both states at the sub-state levels appreciated the responsiveness and professionalism with which their requests for technical information and, more frequently, for advice were met by state agencies. While examples of less congenial relationships were reported as well, individual commitment to positive relationships and outcomes seemed to be a strong factor in making cross-scale communication and cooperation work.

Information Flow Across Scale and Other Boundaries

Finally, the research conducted both at the national and especially at the state and local levels supports the ideas abstractly discussed in Sections 2 and 3 that scale and cross-scale interactions are useful starting points to understand information flow and the integration of scientific information in decision-making. The scale concept, however, also proves to be not the solely important or sufficient category to explain why or why not information flows from one place to another, why information proves useful or not, or why it is or isn't used in decision-making.

Research at the national level in conjunction with the findings from sub-national interviews indicates that the gaps between levels of scale (e.g., between levels of governance) may be secondary to those between research and policy- or decision-making at one level of scale, between representatives of opposing interests, or between the research or programmatic arms of an agency and the policy- and implementation arms of that same agency. With regard to the previously introduced **Figure 1**, this finding implies that the vertical connections may be more easily established than the horizontal ones. This, in turn, would imply that in order to improve cross-scale and other cross-boundary connections, the cross-scale linkages should be encouraged, but the more challenging work may be around bridging non-scalar boundaries. Moreover, establishing formal or even informal information exchange channels and generating or providing information appears to be insufficient to assure actual information flow and use. It seems necessary in addition to have a sustained effort at information translation and brokering

within and between levels of scale and between people or institutions with different interests, responsibilities, values, problem perceptions, approaches, etc. Until climate change information can be down-scaled to the various levels where actual responses are to be implemented, this information brokerage may only (but importantly) serve as a way to raise awareness for the issues and to slowly build a global change-literate constituency. In addition, these information translation and brokerage efforts need to also occur along the science-policy or knowledge-practice continuum in order to generate a decision-maker demand for global change information at any governmental, administrative, or individual decision-making level.

In summary, the research revealed that information flow from one locale (geographic, institutional, individual etc.) to another is not a continual and self-perpetual process. Or differently put, just because information is available does not mean that its potential users know about it, want, seek, understand, or use it. Information flow must be induced and it is motivated from the two end of information generation (supply) on the one hand and information need (demand) on the other. Its reception needs to be assured through translation and brokerage across a variety of boundaries.

Effectiveness

Because of my limited research at the national level (i.e, no recent personal interviews), little can be said about whether any one of the federally sponsored assessments has raised the level of concern for global change or SLR by itself. After two decades of such assessments and much international activity, however, global change currently ranks relatively high on the national scientific and political agenda. Over the course of time substantial financial means for research and intellectual capacity have been generated. And while there now is a national Global Change Research Act and global change concerns have entered national coastal legislation, there is no evidence suggesting that this change in contractual environment has fostered any shift in program focus, policy- and decision-making or has caused any discernible change in resource allocation (other than in terms of research funds). Too few interviews were conducted at the national level to draw any conclusions about the adequacy, legitimacy, or relevancy of the produced information for both national-level or sub-national decision-makers. As mentioned above, however, the lack of information flow and use to, from, and by sub-national policy- and decision-makers suggests that the transfer of information and/or information needs is interrupted or incomplete, in short: ineffective.

Many of the efforts currently underway in Maine are too recent to say much about the ultimate outcomes of the newly suggested beach management approach. It is possible, however, to assess the effectiveness of information exchange systems and their impacts on policy- and decision-making. The interviews revealed that there is both demand and supply of information and that the information system established over time in Maine is quite stable (i.e., "nodes" in the information exchange network are well established and known), highly functional, and frequently and purposefully used. It is also increasingly constrained by diminishing resources (time, money, personnel). The efforts individuals make to overcome these constraints, for example by engaging in time consuming processes, educating themselves and each other, and helping each other out despite political pressures and struggles over authority (state-county-local), are remarkable.

Similarly, Hawai'i has an alive and engaged scientific community, a dense network of cross-agency, cross-scale relationships, and an elaborate but less stringent set of policies than that of Maine to guide coastal development and management. While most interviewees from all positions in that network appreciated the already achieved improvements in information exchange and collaboration, they also wished for yet better communication and more technical information specifically geared toward their respective responsibilities. All Hawai'ian interviewees bemoaned the "politics that get in the way" of integrating scientific information into decision-making, i.e., of implementing the Program goals and enforcing existing rules and regulations.

While it is thus possible to say that some relationships in these two states' information exchange and decision system could be improved, it would be difficult to argue – certainly for Maine, and probably also for Hawai'i -- that there are insufficient connections between the scientific and policy- or decision-maker community or between different decision-making agencies at different levels of scale. Maine interviewees' considered both the cross-scale and cross-science/policy or cross-knowledge/action connections (see **Figure 1**) to work mostly effectively while Hawai'ian interviewees frequently argued that there is much room for improvement in cross-agency and science-policy communication and collaboration. The cross-scale relationships in Hawai'i -- with only two levels of government (state and county) – figured both less prominently and less problematic as far as the integration of information exchange and decision-making was concerned -- considerable competition over decision-making authority notwithstanding. Similarly, while officials in both states expressed their needs for more task- and locality-specific information, there are continuous efforts within the academic and the applied science community in both states to produce the kind of information needed to better respond to the management problems people have at the local level. Maine simply has a longer history of being on that task.

In returning to the concept of a networked chain of processes that produce outcome effectiveness, beginning with the generation of scientific information, to information flow, to the integration of that information into policy-making, and its use in everyday decision-making and rule implementation, to actual management outcomes, this research revealed that

- much research and, more broadly, knowledge gathering activities are going on at each level of scale, within academia, state agencies, and at the grassroots level, but that without education and outreach efforts and the intention for that knowledge to be applicable at another level of scale it generally does not go much beyond the generating institution;
- there are instances of disconnects in the information flow between national, state, and local levels of scale, but more significantly between the knowledge generating institutions and the user communities within and outside of governmental institutions;
- scientific, especially global change and SLR-related information, has been used at the national level, in Maine, but not in Hawai'i in support of arguments to strengthen policies to protect coastal areas;
- global change and SLR-related information plays no role in the day-to-day decision-making of coastal managers, largely because much more localized, process-related information about geology, sedimentation, erosion, and ecology is needed instead;

- the degree of implementation of scientifically informed rules and regulations are independent of the amount or quality of available information at or across levels of scale, but it is not independent of the effort to educate and inform, i.e., to create a science-literate constituency that recognizes its stakes in beach preservation; and finally, that
- it is impossible to discern at this point whether the recent changes in policy approaches and decision-making at the federal, state- and sub-state levels have had any impact on actual outcomes of coastal management.

With an increasing occurrence and hence awareness of coastal erosion and beach management problems, the need and demand for relevant scientific information is becoming increasingly acute and audible. A state's physical and economic vulnerability is a driving factor behind the demand and supply of such information. As an explanatory variable behind information production and demand, however, one needs to also consider the interests and expertise of the state's scientific community and coastal program officials. International or cross-state collaboration on coastal matters or a particular institutional set-up of the information and decision system seems much less important. The information that is produced now in response to the demand for information on coastal processes comes at a time when most of the coastal areas in these two states have been largely developed, when many coastal ecosystems have already been negatively affected, and when the threat to loosing land and structures is increasingly urgent and immanent. Given the degree of already accomplished coastal development, outcome effectiveness (for example, in the form of fewer structures lost from coastal erosion) will be a politically challenging and economically expensive goal to achieve. The recent experiences in Maine and beginning efforts in Hawai'i will need to prove whether the more localized assessment and multiple cross-boundary stakeholder processes model an approach to deal with these difficult political and economic challenges.

TALK GLOBALLY, WALK LOCALLY: SOME CAREFUL GENERALIZATIONS ABOUT CROSS-BOUNDARY INFORMATION AND DECISION SYSTEMS

So what does explain whether or not and how global change information produced in international arenas (the "global talk") gets transferred to and integrated at national, state, and local levels into decision-making (the "local walk")? This final section presents some careful generalizations about the notion of "useful" information, and about the factors and processes that emerged as common themes from this research. I try to answer below what and who serves effective information production, flow, and uptake and the integration of information into policy- and decision-making. These lessons help to assess the validity of the postulates posed earlier about cross-scale assessments and cross-boundary information and decision systems in support of effective environmental management. The discussion in this section also raises several questions about the benefits and draw-backs of information sharing, capacity building, stakeholder involvement, and the need for information exchange at and across levels of scale. Hence, a section on paradoxes in the assessment process. I close the paper with a brief outlook to the National Assessment and how one may apply the lessons learned from the research presented here to the design of this ambitious and promising undertaking.

Useful Information

In the introduction to this paper, I asked how the plethora of scientific global change information produced internationally and nationally can be made more useful to those who ultimately will have to decide on and implement pragmatic responses to a changing environment at the state, regional, and local levels? This question was split up into four more pointed questions, which I attempt to answer in turn on the basis of my empirical findings:

1. **What are the factors and processes – both inherent in the information itself and in the institutional set-up through which information exchange takes place – that bring about "effective" information use?**

Many factors, some very specific to local or problem-related circumstances, affect the uptake, transmission, and use of information. I discuss in more detail here the three that emerged as the most prominent and consistent ones across location, scale, information user group, and policy problem, namely resource constraints, leadership, and turf issues. Other prominent factors like trust, credibility, legitimacy, and cognitive aspects of information usage are discussed below in answering the remaining questions.

Resource Constraints and Trade-Offs

Among the most frequent constraints mentioned by interviewees affecting inter- and intra-agency and cross-scale communication were a lack of time, personnel, or money.[5] Underlying the seemingly every-present resource constraint issue are the effects of the common modern trend toward less government. Streamlining and downsizing government means not only program cuts or mergers, agency restructuring, and job losses, but also to those officials who retain their jobs that they have to do more with the same resources or the same with less resources. While this observation is by no means new or surprising, it has very tangible implications for information flow, e.g., that less information is made available, or that more information is made available through passive databases (e.g., the web), that incoming information cannot or only very selectively be processed, and that there is little time left for information translation and brokering. The latter has implications for the extent to which information will enter decision-making. The trend also implies a need to set priorities because of limited resources, and several officials admitted that they could not follow through even on program priorities to the extent that they wished or are required to because they had too many responsibilities to juggle. This underlines how the saliency and immediacy of problems become then crucial factors in determining what kind of information about what kinds of problems will be taken up from all the information one could absorb. More than once, interviewees especially at the local level complained not about the dearth of information but about the abundance of it, asking for guidance as to how to choose from "all that is out there."[6]

This phase of tight belts (not only) for coastal zone management must also be seen in the context of an overarching concern raised by a number of non-governmental observers, namely the lack of committed political support for coastal zone management at all levels of government. This problem emerges against the backdrop of a general lack of understanding among elected officials and the public at large of coastal processes and of how the physical coastal environment is at the base of the local economy and culture, a point made more

forcefully in Hawai'i than in Maine. This highlights the need for, and significance of, ongoing and additional educational and outreach efforts to inform decision-makers in various positions by researchers, extension agents, and representatives of NGOs and governmental agencies.

Leadership, Personal Values, and Personalities

Repeatedly, the interviews revealed the importance of leadership (or the lack thereof) in breaching the boundaries between science and policy- or decision-making and between levels of scale. Leaders redefine agency missions, pursue new program directions, actively create linkages between agencies and between government and science, or set up new ways of dealing with old problems. In other words, leaders can be instrumental in crossing boundaries, and those individuals who aim to cross boundaries can emerge as leaders. Interviewees frequently wished, for example, for more leadership to initiate discussion on how to address larger concerns like global climate and environmental change. They also explicitly asked for leadership to bring together concerned groups, agencies, and informed individuals to improve communication and to learn about the problems of concern.

Personal values toward the environment, science, people of varying backgrounds and economic status, and toward their own work seems to affect the willingness of people to take on lead roles. Consistently, interviewees appreciated those individuals who "went the extra mile," individuals with a genuine ability to listen, to learn, and to "relate" to others. Recognized as being unpretentious and non-patronizing, the "trespassers" were then able – in time -- to bring their own messages to the table, i.e., to contribute their insights and understandings of an issue, to educate, to disseminate information, and to discuss the more contentious implications of scientific information. In short, personal values and personalities affect the degree to which a trusting relationship can be established and that in turn affects what information can enter into difficult debates.

Missions, Rewards, Turf Issues, and the Quest for Home Rule

When resources in the broadest sense constrain what can reasonably be done and when the engine of leadership is missing, a significant amount of extra effort is required on the part of individuals who want to (continue to) provide information services (acquiring, processing, translating, disseminating, and brokering information) to potentially interested parties. Several governmental officials indicated that such extra effort is frequently not formally appreciated, i.e., through financial or professional rewards. To "go the extra mile" then requires independent motivation and usually entails going beyond one's narrower job description, even beyond an agency's mission. For example, the main purpose of one agency or one branch of an institution may be to process permit applications (as many and as fast as possible) while a related agency or branch may be charged with studying the cumulative impacts of development in order to propose recommendations how to limit these impacts. Both agencies or branches may do the best they can and still work on opposite ends of the problem and never find in their job description that they should share their information with each other or take it into account. Several interviewees told of their accidental discoveries that work very much related to their own was going on in another agency or even just "down the hall." While interagency task forces exist precisely to remedy the problems of duplication, inefficiency, and lack of coordination and cooperation, the compartmentalization of various management efforts and its separation from research and outreach is still often a problem.

Similarly, scientists interested in doing public service in their capacity as knowledge producers and brokers commonly have to provide such services on their own time. While professional progress (e.g., tenure) is commonly said to also depend on community service, the reality is still that breaking out of academic endeavors is rewarded less than research and teaching within the institutional confines of higher education. This also underscores the still existing cleavage between pure and applied science and the fact that the latter – which frequently implies an active crossing of the knowledge-practice boundary – enjoys lesser esteem in the academic world than the former. Thus there are structural boundaries not just between science and the realm of policy and decision-making but also within each that can hinder information flow and the integration of scientific information into practice.

The issue of agency missions and professional goals and progress appears to have two sides to it that clearly affect information flow and cooperation, namely (1) contradictions in agency missions or approaches and (2) competition in cases of overlapping jurisdiction, authority, or expertise (i.e., turf issues).[7] The research revealed a number of examples where contradictory or competing missions turn into turf issues. One turf issue relates to the need to be able to claim ownership for accomplishing a particular goal or for the completion of a project. The ability to do so entails public visibility which has its benefits (e.g., to raise awareness, to educate the public, to establish a political presence, to acquire funds) and potential draw-backs (e.g., to assume responsibility for management failures or unpopularity in the case of difficult decisions).[8]

Turf issues also emerge around the struggle over state versus federal and state versus county or municipal authority in coastal management decisions, i.e., the quest for home rule. There is a great deal of ambivalence in this struggle as authorities at different functional scales (governing levels) are interdependent for political, electoral, financial, technical, and decision-making support.[9] As the case of Hawai'i demonstrated especially well, the political, historical context frames most federal-state interaction and requires – as interviewees pointed out -- that communication and cooperative relationships must be built carefully, patiently, and with a great deal of respect and humbleness on the part of federal representatives and other outsiders.

Depending on individual personalities, competition and turf issues can take on a very personal side and affect the willingness to share information and to work with each other. On the other hand, the interviews revealed numerous examples of the opposite case where individuals in different agencies and positions banked on their similar experiences and common goals to build very strong and congenial relationships, to share work burdens, to meet personally and to liberally exchange information on a regular, frequent basis. (See the discussion on credibility and legitimacy below.)

2. What kind of information do sub-national policy- and decision-makers need in order "to factor in" sea-level rise and other climate changes into their policies and management activities?

The answer to the question what kind of information on SLR is needed very much depends on who the information user is, i.e., what kinds of responsibilities she or he has, whether she or he is writing policies or implementing them, and at what level of scale these policies and decisions

are being made. I restrict the answer here to the content and technical nature of the information since issues of information presentation are discussed under the third question and issues of credibility under the fourth.

In the late 1990s, general information about the basics of global climate change (e.g., what the greenhouse effect is, how it comes about, how humans contribute to it, and what some general consequences for the global temperature and climates are or might be), and how climate change relates to global SLR exists in a broad range of formats and in the most technical-scientific to more broadly accessible lay terms. The first point to make here regarding which information is needed, is again that the need for global change and SLR information must be created. Understanding and information need emerges through demonstrating and explaining the obvious and not-so-obvious connections between ongoing policy problems or environmental decisions at any level of scale and the broader global challenges.

Another sobering if not necessarily surprising finding from this research is that global change and SLR-related information plays no role in the day-to-day decision-making of coastal managers at the local level to date for a number of reasons, including:

- Many scientific experts advising on national to local level policy- and decision-making don't see the need to "play the global climate change or sea-level rise card" when the already existing erosion problems are visible to all. This again limits the need for such information and hence its integration in decision-making.
- Local decision-makers frequently expect authorities at higher levels of scale to address a problem of global magnitude (both in cause and effect); mostly, sub-national officials tend to look to the state and federal governments to at least set a policy framework and make available the needed financial and technical resources to address the problem (see also the discussion on leadership above). Until such frameworks and resources are provided, there is little need for global change information.
- If global change and SLR are raised as issues of concern at sub-national decision levels, very general statements about them usually suffice and are simply used as additional rhetorical means to urge policy- and decision-makers to address the more tangible problems related to coastal erosion. Sources for such general statements are now widely available, and those interested in using accelerated SLR arguments to push for erosion policies are motivated to find it either from local experts, agencies, libraries or internet sources.
- Finally, local SLR curves are available only for very few localities; the rates and magnitudes of local SLR also need to be translated into erosion or sediment transport rates. It is this more localized, process-related information about geology, sedimentation, erosion, and ecology that is needed instead of global SLR data.

In short, decision-makers need very task- and locality-specific information and frequently it is still not available. Fortunately, as this research revealed, there are continuous efforts within the academic and the applied science community – both among geologists working locally and among global change modelers struggling with scaling issues -- to produce the kind of information needed to better respond to the management problems decision-makers have at the local level.

3. In what form and when do policy- and decision-makers need information, and are these needs known to, and can they be met by, information producers or providers?

Repeatedly, interviewees discussed the quality, format, and language in which sea-level rise or coastal process-related information was presented as critical. This relates back to the resource constraint issue discussed above: when people have little time and too many other things to juggle, the receptivity for big reports with complicated, dense, or inaccessibly written text with few graphics is very small. Interviews revealed other means to be much more accessible, understandable, sought after, and hence effective in conveying SLR information, including:

- large colorful maps with some written scientific information;
- small information rich pocket-size flip charts;
- short "citizen's guides" to coastal legislation and how it addresses SLR or other coastal hazards;
- videos;
- field trips;
- vivid slide presentations; and
- panel discussions.

These help get people's attention, kindle their interest, and point them to further information sources if needed or desired. That such more accessible information "packages" are produced seems largely due to the effort and recognition of information brokers (frequently scientists deeply immersed in governmental and political activities) that the common forms of scientific communication are ineffective and inaccessible to most user groups.

The manner of presentation is closely tied to the fact that people have filters that affect which information is absorbed, which is passed on, and which is used in policy- and decision-making. For example, people's lack of understanding of environmental processes versus the more limited human goals and political and economic time scales that commonly matter in policy- and decision-making emerged as an important factor in the screening and valuing of information. Obviously, the frequently mentioned political pressures and strategic assessments by various players what can, cannot, or should be said at any given time come into play here as well. Several interviewees mentioned that given the political pressures and the contentiousness of global change information, the institutional source of the information (researchers' affiliation, private versus public funding sources, etc.) mattered greatly to them. (See the discussion below on credibility and legitimacy.)

The frequency of hearing global change information, and hearing similar messages from a variety of sources also seems to have a bearing on whether or not information is retained and considered important enough to find its way into decision-making. Persistent, iterative efforts to educate governmental officials and the public at large create a growing presence of these matters in the public and governmental consciousness. Among the sources for such information and education, are scientists, public education and outreach departments of coastal programs, environmental organizations, Sea Grant extension agents, and the news media. In fact, to those

removed from SLR (or any type) of research, the news media are frequently the first (and sometimes only) source of information on global change issues.

4. What is credible information and who are the trusted information providers?

Above I discussed how personal values affect the types of relationships between information producers and users or between representatives of different interests and institutions. That in and of itself is not surprising. At sub-national scales, however, where the number of involved players in coastal zone management and the related scientific community gets smaller, i.e., where there is a fairly constant and limited pool of actors, the importance of the interplay between message and messenger (and her or his affiliation) becomes heightened. The small pool of actors makes it possible to build personal, trustful relationships among them over time. In turn it enables habitually used information flow channels to become established, which is an important contributing factor to viewing information and information sources as credible. The flip side of the small pool of fairly constant players is that personal and personality conflicts create breakdowns in the communication network that are as permanent as the people engaged in the conflict.

The relationship between message and messenger seems, in fact, to be quite complex, especially when the message (the information) is uncertain and/or its implications politically loaded – as is the case almost always with global change information. For such information to be heard and taken seriously, the information provider (producer, transmitter, or broker) must be trusted or at least offer credible scientific information and she or he must present it in an accessible manner.

Interviewees regarded the input from scientists as essential, and this study demonstrated that there is no lack in either state of scientific activity in support of coastal zone management. The commitment of scientists to the production of high-quality and useful information, however, was only one aspect of building their credibility. Equally important was their non-patronizing willingness to work directly with communities and governmental agencies, to hear people's (especially coastal residents') concerns and to follow-through with plans and commitments. Citizens and officials have high expectations of scientists to secure funding for new projects when scientists become advocates for alternative ways of doing things. Securing resources and delivery on raised expectations thus seems to play an important role in establishing and maintaining credibility and the reputation of projects and programs.

The research repeatedly exposed that the interplay of processes that produce scientific credibility and trustful relationships between scientists and users of scientific information is not only complex but even paradoxical. This is best seen in the different tests that information has to pass – and not just once, but repeatedly and over a period of time -- to become credible. In the case of Maine, interviewees gave examples where available and certain but politically loaded information could only be made public with the added "protection" of <u>scientific peer review</u>. Apparently, the more contentious and uncertain a problem is, the greater is the need for, and the power of, <u>the</u> credibility tool of science. Information about uncertain phenomena that in their abstract, global conceptualizations go beyond (most) people's daily experience also needs to stand the <u>test of common sense</u> ("the last time I checked, water expands when you

warm it up, so with global warming, there goes your sea level...") and the test of time (predictions of impacts coming true). Information also needs to pass the test of origin and cross-check: generally, interviewees revealed a bias toward information produced by local experts, but that information gained in credibility and impact if confirmed by independent outsiders (another form of peer review with a geographic slant). And even if information passed all these tests, its credibility would still be contentious if it came from someone the potential receiver or user did not trust. To build trustful relationships with scientists, non-scientific interviewees frequently wanted scientists to emerge from their ivory tower and to be more accessible to help people understand scientific (and frequently uncertain) information; perceived aloofness or "hiding" behind allegedly solid science was seen as affecting people's openness to receive and struggle with scientific information.

In summary, all of these answers to the question how global change information can be made more useful to local decision-makers amount to a strong and convincing case for thinking of assessments as processes: if scientific information gathered and evaluated through assessments is to support decision-making and effective environmental management, the entire social and institutional context, communicative processes, and personal interactions through which the assessment and information exchange takes place need to be taken into account.

Revisiting the Notion of Assessments as Products and Processes

In the section on global environmental assessments above, I discussed two models of assessments: (1) assessments in the traditional sense of large scientific efforts that end in the compilation of a report on the state-of-the-art of a particular matter of interest, and (2) assessments as long-term, iterative, communicative processes with periodic reports as important but contingent by-products of network-building, information-sharing and problem-solving. For the investigation of assessments and their impacts at and across different levels of scale, this conceptualization suggested three possible venues: (1) the information contained in the assessment reports is either disseminated to constituents at other levels of scale; (2) constituents at various levels of scale are actively involved in the generation of that information, in the reevaluation of knowledge claims, and in the building of networks that embrace players from all levels of scale; or (3) local assessment efforts stimulate and eventually get integrated into larger assessment efforts conducted at higher levels of scale.

Pitching these two models of assessments against the three different venues of cross-scale information exchange results in a 2x3 or six-cell matrix (**Figure 2**). This research found examples of assessments falling into cells **1** (e.g., the early national SLR-assessments produced by the EPA), **3** (IPCC Regional Summaries [not further discussed here], or US-supported country studies), **5** (potentially, the U.S. National Assessment) and **6** (several local assessment efforts in Maine that may yet become part of larger state or national assessment efforts). Their effectiveness in transmitting and exchanging SLR information and in helping to integrate such information in decision-making was discussed from numerous angles above.

What is noteworthy here, is that the only attempt made in the US to date of a comprehensive, cross-scale assessment coordinated at the national level is the currently conducted National Assessment (discussed in more detail in the concluding section below and in Appendix A). The experiences in Maine and Hawai'i so far with the National Assessment highlight the finding

that the credibility of a scientific endeavor or assessment hinges not only on the quality of the information brought together or produced, but also on the follow-up and follow-through with commitments, and on the respectful involvement of stakeholders and interested individuals at all levels of scale. Assessments as processes that cross a variety of boundaries are as much scientific research efforts as educational out-reach efforts and they require a willingness at all levels of scale and in all quarters to learn from each other and to be willing to "walk in the other one's shoes."

Importantly, this study showed that crossing levels of scale are not the only boundaries that need to be crossed in order to facilitate and ensure information flow and the integration of information in decision-making. There are boundaries (or barriers) between different levels of scale; pure and applied science; scientific disciplines; science and the realm of management and policy-making; the legislative, programmatic, and implementing branches of government; and between constituents with different values and goals. These boundaries are maintained out of tradition; out of ignorance of each other; out of lack of understanding of others' modi operandi, needs, and purposes; through incentive (and disincentive) structures; missions and job descriptions that are narrower than the problems agencies or individuals are charged to address; or to defend one's turf. When people do come together around problems they clearly overcome more than scale boundaries. Concepts of advocacy coalitions or issue networks fail to acknowledge, however, that scale boundaries matter along with a suite of others.

So-called stakeholder processes as initiated through the regional component of the National Assessment, the beach management task force in southern Maine, or regionally based coastal erosion management districts proposed for Hawai'i seem to present a model to cross these various boundaries, and to begin or continue the building of networks and mutual relationships (see **Figure 2**, cell **6**). As the interviews revealed, to engage in such open, lengthy, and often unpredictable group processes requires a certain attitude because the process adds a discomforting layer of uncertainty to the assessment and management of coastal resources. It also implies a process that looks (and over the short run maybe is) inefficient and resource-consuming – something that does not earn high currency in resource-starved government agencies. Going beyond the one-time engagement in group processes is also just part of the story. The maintenance of once-made connections, the regular sharing of information, and the continuous process of educating the public, interested parties, and the revolving collectives of elected officials require perpetual, extra effort. There is much resistance, ignorance, opposing conviction, and lethargy to overcome.

Revisiting the Postulates on Cross-Boundary Assessments and Effectiveness

In the section on global environmental assessments above, several postulates emerged from the discussion of assessments as processes, assessment functions, the crossing of scale and other boundaries, and effectiveness. I discuss each of these postulates below.

> (1) Management of cross-scale environmental risks is more effective the more bridges across scale, science-policy, and other divides are built through an information and decision system.

The first of these postulates is clearly supported by this study even with the caveat that management schemes for global change-related problems are only begun to be designed in the two case study states and have yet to be tried and proven effective in terms of management outcomes. Referring back to the notion of effectiveness along a chain of related activities that link the realm of knowledge generation with the realm of knowledge application, however, allows one to judge the relative effectiveness of information and decision systems that are integrated to varying degrees. The research has found numerous instances at and across the national, regional, state, and sub-state levels where the barriers between science/research and practice or between disciplines, agencies, or interest groups were not overcome. On the other hand, it also highlighted recent and emerging experiences with long-term, iterative stakeholder processes in Maine and Hawai'i where people attempt to integrate information and management systems across scale and other boundaries and to match the scale of management with the geographic extent of the erosion problem. The National Assessment may become a third example of an alternative to the simplistic top-down or bottom-up assessment and management approaches that fail to establish linkages across a wide variety of boundaries and contexts.

These latter examples prove more effective in that they carry out several of the assessment function mentioned above: they integrate disparate knowledge from different disciplines and experiential realms and they aim for consensual understanding of problems; they entail education and outreach and identify the most pressing information needs; they expose knowledge claims to multiple tests; they open up fora for previously disenfranchised, uninterested, or marginalized groups to participate in the assessment and management process; and they usually involve efforts to secure additional resources to address the management problem.

> (2) Assessments and information systems that actively embrace and involve actors from different levels of scale are more effective when they exploit the comparative advantages and build the capacities of actors and institutions at different levels of scale.

This postulate can also be supported as true. This study revealed how the uptake, exchange, transmission, and use of information are only part of the story. Global change information – if available – does not simply get used for the shear merit of being available. There must be a perceived need for such information and the capacity to employ it. Capacity building thus comes in many guises and the needs for it are likely to differ by state, community, and scale. Not everyone will need to be able to understand and use the same global change information to the same degree or to the same ends. Some federal or state agencies may simply have the needed financial, technical and intellectual resources to fulfill an information or decision support need more efficiently than local officials or experts. Some local experts or officials will be in a better position to identify local information needs (both in terms of content and format) than distant national providers. It is important, however, to balance the notion of efficiency and comparative advantage with the need of stakeholders for ownership of information and knowledge. This balance may best be found in discussion for a that involves actors from all concerned levels.

Capacity building may involve simply providing needed information, enabling people and institutions to generate task- and locality-specific information, helping people understand and interpret information, or establishing, improving, or facilitating existing formal and informal collaboration between concerned parties. If assessments are embedded in existing information

exchange and decision support structures, capacity building may also simply mean capacity maintenance through a continued commitment to financial support and collaboration.

> (3) Assessments and information systems which fulfill their education and outreach functions are more effective bridges to the user community and thus increase the likelihood of information being integrated into policy- and decision-making.

More than just building capacity, assessment and information systems that carry out their education and outreach functions build constituencies, they legitimize assessment and management efforts, and the involved actors see their stakes in being involved in the process. When assessment efforts are to result in policy changes that require legislative action, it is crucial – as education efforts currently underway in Hawai'i show -- to build an understanding and supportive constituency along with the necessary scientific and institutional structure.

The research brought to light the great need and importance of basic environmental education, of educating about coastal processes, hazards, and how global change may affect them, of continuous outreach efforts, and of the need to provide basic technical and other resources to build the capacities of decision-makers. The study also revealed how not providing or cutting down on such education, resources, and services produces management constraints, frustration, and dismissive attitudes toward potentially useful information. In the section on paradoxes in assessments below, I discuss when and why it may be more effective at times, however, to not involve all possible or concerned agents or when it might be more fruitful to foster information exchange and capacity building only at selected levels of scale.

> (4) Assessments and information systems are more effective in crossing different levels of scale and in bridging the science-policy continuum when they provide resources and opportunities for groups from different levels of scale to interact.

This final postulate can be supported when it is made more comprehensive: there need to be opportunities for groups to interact not only from different levels of scale, but also for groups with divergent goals and interests, knowledge claims, for different agencies and non-governmental organizations, etc. As this study has shown, it takes time and money to create fora for these groups to come together, often it takes independent facilitators to establish a mutual understanding of others' perspectives, problem frames, and to understand their concerns and information needs. Again, when it happens, assessments attain procedural legitimacy, they open up opportunities to exchange or seek needed information, and they build support for difficult decision-making. Such support is often what decision-makers need to implement and enforce policies, rules, and regulations.

While the evidence gathered through this study generally supports these postulates, and has shed light on several assessment and management efforts that promise to result in more effective environmental management, it also has raised several questions or concerns that seem to complicate the issues. These are discussed in turn in the next section.

Some Paradoxical Aspects of Assessments

The Benefits of NOT Knowing (Or of NOT Sharing All One Knows)

Importantly, policy- and decision-makers don't only need information. As mentioned above in fact, the scientific content of an assessment – even if highly credible and useful – may still not be used because of inadequate guidance on how to deal with the implications of such information. Frequently, interviewees asked not just for more specific technical information, but for legal advice and professional guidance in how to resolve management dilemmas that alternative approaches to beach management fostered and in part were made possible through the availability of new information. In Maine, for example, several interviewees cautioned that the shear existence of technical information does not guarantee its use or even that people will be made aware of the existence of potentially useful information. The provision as much as the withholding of information pertaining to public safety and welfare can create difficult political and ethical dilemmas for governmental institutions. Thus, the benefit of not knowing more or of not sharing what is actually known, is to avoid such dilemmas. In other words, instituting global change policies at the local level means also having to resolve some of the associated difficult ethical dilemmas, for example, how to deal with winners and losers, or how to design equitable regulations that account for an inequitably dynamic natural environment. This paradox highlights once more the social embeddedness of information exchange and that the challenges in providing appropriate information are met if not superseded by the difficulties of using information because actions have tangible and assailable (legal) implications.

The Comparative Advantages of Involving and Not Involving Individuals or Institutions

When coastal zone management involves as many players at several levels of scale and in as many different institutions as it does in federal, democratic systems like that of the United States, questions of comparative advantage and the value of strategic decisions over the involvement of particular individuals or institutions arise. During this research, two seemingly contradictory approaches emerged, each with its own set of trade-offs: (1) to broaden the involvement of actors from agencies, academia, and the public to create more support and understanding for difficult CZM policies and decisions, and (2) to strategically reduce the number of players and – as one framed it -- to "use the right tools and people for the right job." Several examples I was told lead to the conclusion that when a new project or approach is launched – especially ones that are likely to encounter political, financial, legal, or technical hurdles – it may be more effective to do it with people and institutions "where the skill level and enthusiasm is high" (Shea 1998a). This conclusion is echoed in some writings on the spread and adoption of technological innovations which recognized the important role of "early adopters" (e.g., Johnston and Clark 1982). One may suspect that a combination of both approaches may work best over the long run, but that requires long-range, comprehensive planning and a flexible adaptation in the approach to information sharing at various stages in the process.

Information Exchange is NOT Always Needed and Not Always USEFUL

A related paradox emerges around the question when and where information exchange is actually important. It may be more strategic and useful, for example, to not launch a broad and general information and outreach campaign on the pretense of "keeping everyone informed" (or worse under the guise of "participation") but instead to focus one's efforts on improving and facilitating information exchange between very specific players within the science, policy, and other target communities at just those level(s) where most decision-making power resides. Choices and trade-offs regarding information exchange pose many questions to the designers of a cross-boundary assessment like the National Assessment (see the concluding section)..

As discussed in the section on Useful Information above, the broad spectrum of involved actors in cross-boundary assessments and management efforts, divides the question of "what is useful information?" really into a two-fold question of purpose/use and information need. The first aspect – information what for? -- relates to what an assessment is supposed to achieve and that varies with the level of scale. If an assessment is meant as a political tool to force international, national, or sub-national policy action, i.e., to convince and mobilize, then an assessment like that produced by the IPCC can at best be considered successful at the global/international level of scale, but not with any persuasive evidence at sub-global levels of scale. If an assessment like the National Assessment would fail to engage sub-national entities as partners, it is unlikely to produce useful information in the sense of influencing sub-national policy-making. Its influence on national policy-making may even be doubtful given that Congressional leaders will find it difficult to gain support from a disappointed constituency. As Pielke suggests,

> "neither scientists nor policy-makers know what usable information is in the context of global changes. ... Instead, usable global change information must be discovered... Dealing with global environmental change ... is impossible if the policy process depends solely upon scientific information gathered from the laboratory and the ivory tower to inform the legislative chamber. .... If science programs are to provide usable information to policy-makers, they must 'build policy in.' Policy relevance refers to a process not to information" (Pielke 1994, pp.317-318).

If on the other hand an assessment (or global change information more generally) is meant as the concrete basis for policy-making (i.e., the technical information needed for rule-writing), then its usefulness needs to be judged by whether or not the needed data are delivered. This research has yielded little evidence that any global change assessment or research completed so far has been "useful" to the national, state, or local governments in that sense. At best, global change assessments have been used to support research or management programs, general coastal hazard management approaches, or arguments in support of more stringent regulation or alternative beach management approaches. Without the reframing of global change issues into visible, experienced, and locally pressing management concerns (SLR >> erosion >> beach loss >> property loss etc.) and without the presence of at least some locally generated data to support the problem statement and the proposed management solutions, global change assessments have generated little if any "useful" information for sub-national constituents.

Science-Practitioner Linkages Exist and Sometimes They Are Dead Ends

The type of linkage between science and the various institutions in the practice realm (policy-making, decision-making/implementation) emerged as an important variable regarding whether scientific information was effectively integrated in the realm of practice. CZM in both states is housed in planning departments, which do not by design have any direct or compelling connection to legislators.[10] Program managers may feel that their job is done when a study was completed, recommendations were delivered, a program got set up, or a policy was composed. But there is no compelling reason for planning offices to take their work into the legislature and to push for an implementation in terms of rules and regulations. Thus, the science-practitioner pathway of information flow in these cases could be considered a dead end. A connection to actual decision-makers and rule-makers may have to be forced -- either from

within (if planning office individuals are so inclined, but that could be rather difficult politically) or from the outside through interested parties. In addition there are the more direct connects between science and decision-makers through testimony, legislative hearings, and providing specific, technical information to those implementing existing rules (e.g., maps, erosion rates). Both states are strong as far as the latter connections are concerned: Maine is further along already in generating such information through an entire agency -- the Maine Geological Survey -- in place for technical support; Hawai'i on the other hand does not have a geological survey,[11] but has institutionalized an expert review system that can be called upon on very short notice to comment on legislative proposals and problematic permit decisions.

What this study as a whole and these final complicating factors demonstrate then is that many boundaries need to be crossed in order to enable a "local walk" to follow from "global talk," that the integration of information and decision systems needs to be coupled such that relevant and credible information flows to practitioners with real decision-making powers. They also emphasize that significant (and maybe more focused) efforts are necessary to create a demand for global change-related information that connects with present management problems at different levels of scale and among a broad range of agencies, interest groups, and legislative actors. The study has also shown that "local walk" begins to affect at least "regional and state talk" in coastal zone management by way of creating coalitions and networks among concerned actors that are rallied around problems of a particular geographic extent rather than around institutional affiliations that correlate with different levels of scale. It appears that cross-scale and cross-boundary networks are forming that match or embrace the scale of the environmental problem more closely than conventional management regimes.

In the concluding section below, I will try to apply the findings of this research to the design and conduct of the National Assessment.

Design Implications for the National Assessment of Climate Change

In 1997, the US Global Change Research Program, in cooperation with the Office of Science and Technology Policy, initiated the National Assessment of the consequences of climate variability and change as mandated through the U.S. Global Change Research Act of 1990. The National Assessment aims to aggregate climate change information across regions and sectors (or impact domains) and resembles in many ways earlier large-scale scientific assessments. It aims to examine the vulnerabilities and response opportunities of the United States, its ecosystems, major economic sectors, and social infrastructure to climate variability and change. In addition, it integrates a strong process component by which the regional assessments are initiated through a series of 19 regional workshops and one workshop involving geographically dispersed native peoples (USGCRP, 1998e).

If implemented as originally conceived, this regional component of the National Assessment would operationalize the assessment-as-process model and embrace agents from various levels of scale, from the science and policy arenas, and from a wide variety of interest groups. Through this bottoms-up component, the assessment has already generated a level of momentum, interest, and active engagement at sub-national scales that no other national, much less international assessment has enjoyed before.

Under mounting time pressure (the First Assessment is due for presentation to Congress in January 2000 and will be the U.S. contribution to the Third Assessment of the IPCC) and significant differences among the responsible authorities and the regional constituency over design, process, and goal questions, the National Assessment has become the focus of heated debate (see Appendix A).

Based on my findings, I offer some suggestions for the design and implementation of a National Assessment that is cognizant of the notion of assessment as process and of the necessity to cross scale and other boundaries in order to make the connection between global or national science and local decision-making. Highlighted recommendations are not or incompletely implemented at present in the First National Assessment.

- **Clear identification of assessment goal(s)** – A conscious effort at clearly defining the goal(s) of an assessment is essential. Goals may differ by scale and by intended use. Hence, assessment participants, audiences, products, time frames and long-term intentions may differ. It is important to realistically assess the compatibility and mutual enhancement of assessment goals and their implications. Goals motivate, set expectations and are the benchmarks against which the success of an assessment will be judged. The National Assessment seems to lack some of this desirable clarity in goal identification.

- **Clear and iterative identification of actors, audiences and stakeholders at each level of scale** – Along with the goals goes the identification of participants, user groups, and potentially interested or affected parties. This may change as the assessment is conducted and new stakes are discovered over time. So far, iteration and scale awareness are missing.

- **Establishment of goal-specific steering committee(s) and of coordinating institutions** – If several major assessment goals have been identified, each should be steered by independent committees. Coordinating institutions should ensure regular communication and interaction between them, compatibility of goals, and overall delivery. The steering committees set in place and motion the most appropriate process to conduct a goal-specific assessment. It providers oversight and guidance to the actual assessment team (see below). An oversight committee and coordination office are in place, but the National Assessment is currently lacking a steering committee for the regional assessments.

- **Identification of, and embedding of assessment in, existing information and decision systems** – The specific assessment effort should become embedded in existing information and decision systems to increase efficiency, make use of comparative advantages at various levels of scale and of existing formal and informal communication and interaction channels. **Figure 1** may be a useful heuristic to map existing channels of communication and routinely used pathways of interaction. At best, this is currently done by chance.

- **Identification of key players, leaders, and nodes in the existing structure -- Figure 1** may further be used to help identify key actors in the existing information and decision structure. This needs to be a deliberate, comprehensive, and goal-specific effort, not simply an exercise in rounding up "the usual suspects" (i.e., sectors, agencies, organizations,

disciplines, or particular individuals). Special attention should be paid to central nodes of know-how, and to institutions or individuals placed at key positions in the system and known for their knowledge brokering ability and for assisting the crossing of scale and science-policy boundaries (boundary organizations; see Guston 1998).

- **Creation of goal-specific assessment fora/teams** – once these experts and other key players are identified, assessment teams can be formed. The goal-specific assessment team will be responsible for carrying out the actual assessment. It does not alone determine the scope of the assessment (see scoping fora below), but it will conduct it. The group of key players may decide to extend their team by inviting additional individuals, for example, as a result of the scoping process. The National Assessment Synthesis Team (NAST) and sectoral and regional assessment teams are now in place.

- **Engagement or creation of boundary organizations** – Individuals and institutions that have already emerged or could be used as trusted boundary organizations, should be a deliberate and continuous part from early on in the assessment process. They are less involved in the actual conduct of the scientific assessment but instead are responsible for information exchange, frequent interaction and communication between different players involved in the process. The outreach efforts currently underway are not meeting this goal.

- **Commitment and leadership to the assessment as process** – Conducting an assessment that is conceived from the beginning as a process with a variety of goals is different from the familiar, straight forward production of an assessment report. All players involved in the process need to be educated about the difference. Commitment to and leadership through the unfamiliar new process is essential at all times.

- **Early and ongoing creation of awareness and information needs among various user groups** – Assessment steering committees and teams should awareness and a desire or need for global change information through audience-appropriate education. Again, existing information exchange channels and the general media should be used. This will generate interest and build a constituency for global change information and policy-making. This is only partially achieved through the White House global change campaign.

- **Conduct of assessment scoping fora** -- Interested and potentially affected groups and institutions, especially those that will have to implement decisions based on the assessment, should be invited to discussion for a in which the scope of the assessment is staked and decided. This was done in the Regional Workshops and the National Forum though not all potentially interested or affected groups were represented.

- **Early assessment of information needs** – In order to avoid creating another "dusty report on the shelf," specific information needs, both in terms of content and presentation format need to be a part of the assessment scoping. While the regional workshops asked for information needs, little was said about most useful formats in connection to applications.

- **Capacity assessment and long-range planning** – Beginning about at the same time as the actual scientific assessment, a parallel (or integrated) capacity assessment should be conducted (mostly by agency heads and others involved in implementing decisions) regarding the ability to understand and process assessment results, and implement decisions based on them. This would include the adequacy of intellectual, technical, financial, personnel, and other resources. Results should enter into a long-range strategic planning process to build and maintain capacity. This is currently not being done.

- **Assessment teams conduct assessment banking on comparative advantages** – Assessment teams consist mainly of scientific experts, modelers and analysts, though strict modeling may not be the only or main activity. This is currently underway for impact domains (sectors) and in a more restricted way for the regions. Not all regions have begun, nor do they all have the same level of capacity to conduct the analysis in the given time.

- **Timely delivery of desired assessment products** – In order to maintain political credibility, to build trust, to constructively help establish routinely used communication and interaction pathways, to build and maintain capacity, and to not waste time, money, and involved actors' momentum, timely conduct of the assessment and delivery of the assessment products agreed upon is important. Because of the tight schedule, this goal is questionable for at least the First Assessment results due in January 2000.

- **Periodic assessment updates and review by user groups** – To keep interested parties informed and mentally engaged and interested, to continue the education and outreach effort, to maintain the budding constituency, and to have an external "reality check" for the assessment, periodic updates and reviews by concerned and affected parties are crucial.

- **Constant awareness of boundaries** – Assessors and coordinating authorities should expect boundaries and obstacles in the communication and interaction among involved parties and actively approach them. To assume difficult road blocks yet the best intentions of all involved actors may be the most useful stance.

- **Periodic review of the adequacy in scale match and boundary crossing** – The constant mental awareness of boundaries must be accompanied by a periodic review of the assessment process regarding whether it addresses climate change impact problems at relevant scales and of achieving cross-scale integration by crossing all relevant boundaries.

- **Active removal of obstacles** – Awareness of boundaries and obstacles must be followed by active minimization or elimination of competition, contradictory or narrow agency missions, turf issues, and restrictive policies and regulations. Attention should be paid to scale, as policies at one level of scale may affect the abilities to collaborate and communicate at lower levels of scale.

- **Periodic review and adjustment of participation process** – If effective information usage, constituency building, capacity building, and process legitimacy are among the goals of the assessment, meaningful, appropriate participation is essential. Participants

together with coordinating and responsible authorities need to judge repeatedly what that means. While discussions are alive about participation (how, when, by whom, to what end), no formal review process is currently in place.

- **Periodic review of leadership and coordinating authorities** – For reasons of transparency, legitimacy, credibility, trust and effectiveness, the authority structure of the assessment needs to be evaluated by all involved parties (top-down and bottom-up). No formal provisions are currently in place for a comprehensive periodic review.

- **Constant attention to trust and credibility issues** – Effective communication and information use requires trust and credibility. Parallel to the constant awareness of the importance of boundaries, there should be perpetual vigilance and effort to build trust and credibility, or at the very least, not to loose it.

- **Routine communication** – The most promising means, if tautological, to achieve cross-scale and cross-boundary integration through assessment, is routine, frequent communication by all means. It raises awareness of problems, creates mutual understanding and trust, establishes familiar interaction pathways, allows easy follow-up, and increases the chances that assessment results will actually be used in decision-making.

In summary, to become truly successful, the National Assessment will require even more than already expended effort at all levels of scales and along the entire knowledge-action spectrum.

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TABLES

Table 1: Cross-State Comparison Between Hawai'i and Maine

	Hawai'I	Maine
Similarities	• historical record of sea-level rise, incl. Subsidence (1.6-3.9mm/yr.) (1.8-3.4 mm/yr.) • strong economic dependence on coastal water uses (beach and other coastal tourism, fishing) • overwhelming demographic concentration in coastal zone, esp. flood-prone areas • significant crucial infrastructure installations in the immediate coastal zone (lifelines, harbors, roads, etc.) • vulnerability to coastal storms • same development/beach preservation conflicts • cross-state and international institutions to deal with coastal zone management issues (AOSIS, SPREP) (Gulf of Maine Council) • past (and present) interest in SLR research (some) (comparatively extensive)	
Differences	• vast stretches of beaches are vulnerable to SLR-induced erosion • no SLR-specific policy response • institutional structure of CZM • pre-Regional Assessment • large-scale insurance withdrawal from the coastal zone • military presence (economic and strategic importance) • politically strategic alliance with internationally visible small island states • competition for attention among various global change issues (biodiversity, tropical forests, coral reefs, SLR)	• only a small faction of the coast is highly vulnerable to SLR • nationwide strongest SLR-specific regulations since 1988 • institutional structure of CZM • post-Regional Assessment • continued insurance coverage despite major recent losses • military installations of declining economic importance • no international visibility in the politics of climate change • other global change impacts of minor perceived importance

Table 2: Time Scale, Magnitude, and Predictability of Sea-Level Variability Associated with Specific Phenomena

Phenomenon	Time scale	Magnitude	Predictability
Global warming	50->100 years	2-10 mm/year	unpredictable
Interdecadal oscillation	10-20 years	10-40 cm	unpredictable
El Niño	4-5 years	30-60 cm	6-9 months lead
Annual Cycle	1 year	10-40 cm	predictable
Intraseasonal osc.	40-60 days	10-20 cm	15-30 days lead
Fortnightly tide	14 days	4-5 cm	predictable
Synoptic weather	3-7 days	10-30 cm	0-10 days lead
Tides	½-1 day	1-3 m	predictable
Storm surges	5 hours	2-4 m	0-2 hours lead
Wave group setup	20 minutes	1 m	10 minutes lead
individual waves	15-25 seconds	2-15 m	unpredictable

Source: adapted from (Lukas 1998)

Table 3: Sea Level Rise-Relevant Rules in Hawai'i and Maine

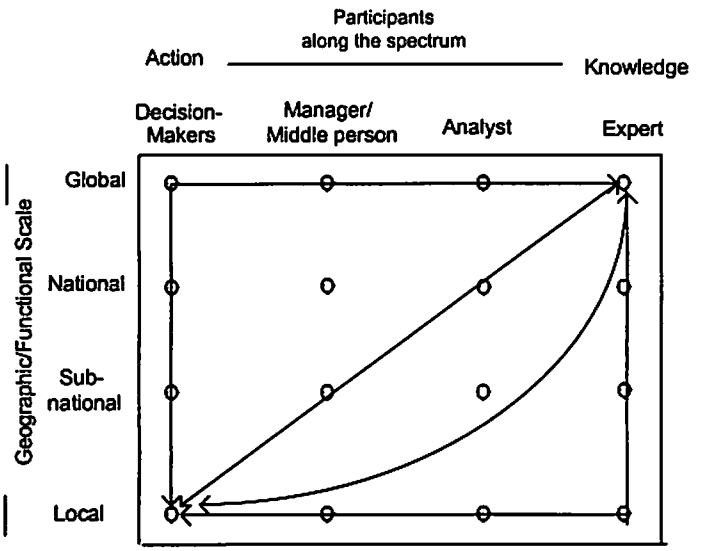
Rules & Measures	Hawai'i	Maine
Regulated Areas	entire island through zoning law; coastal margin via rules for Special Management Areas (landward) and Conservation Districts (on land and water)	all areas in sand dune system potentially affected by a 3-foot rise in sea level
Setback rules	YES state-certified shoreline (mean high water or debris line or interpolated equivalent) none 20-40 ft. (increasingly, the 40 ft. setback is urged as the minimum; larger setbacks are strongly encouraged for large developments) 20 ft.	YES current mean SL none inland reach of 3 feet of SLR over the next 100 years behind V-flood zone or frontal dune
(from baseline)		
Permit Standards	NFIP requirements (stricter for counties participating in the community rating system)	50-yr storm standard in A- and B-flood zones and other NFIP standards if communities participate
Retreat Policy (Buildings and structures have to be moved landward at the time of "damage beyond repair" as defined)	none structures that are rebuilt have to meet current setback rules	Damage beyond repair is set at 50%; structures that are rebuilt have to meet setback regulations
Erosion Control	all forms of new hardening of shoreline discouraged; seawalls permitted only in exceptional circumstances; efforts to lower permitting hurdles for beach nourishment	no new hardening of dune systems; repair and maintenance of hard structures allowed (incl. enlargement of seawall base); bulkheading only if no negative impacts; beach nourishment
Land-Use Planning	No legal requirement; professional planners in and	YES (through separate law), but only weak implementation

Rules & Measures	Hawai'i	Maine
	outside of government; no mention of SLR	requirements; no mention of SLR
Development	regulated via above rules, frequently with permit conditions to mitigate hazards, in Special Management Areas (minimum width 300 ft. from shoreline); state and county zoning laws	limited in the 250-foot shoreland zone; size, height restrictions in area potentially affected by 3 feet SLR

Sources: (Hawai'i Revised Statutes 1977; Maine Revised Statutes Annotated 1993)

FIGURES

Figure 1 **Communication and Decision-Making Across Scale and the Science-Policy Continuum**



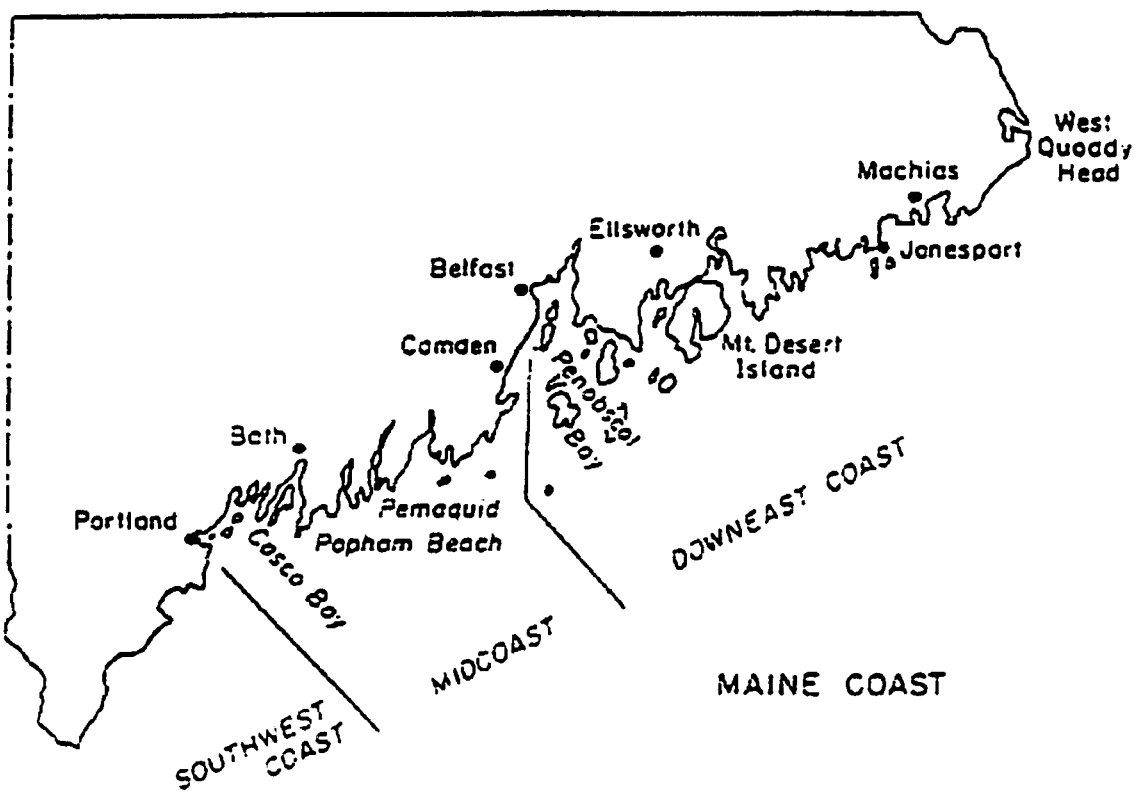
The bi-directional arrows indicate stylized pathways of communication and interaction among different actors in an assessment process. The two-dimensional template can also be used to map assessments to visualize the degree of cross-scale and science-policy integration.

I would like to acknowledge William C. Clark and the participants of the Scale Working Group during the GEA Summer Study at Bar Harbor, ME (June 17-25, 1998) who greatly helped with graphically depicting and fine-tuning the cross-boundary ideas contained in this paper and reflected in this figure.

Figure 2 Assessments and Cross-Scale Information Exchange

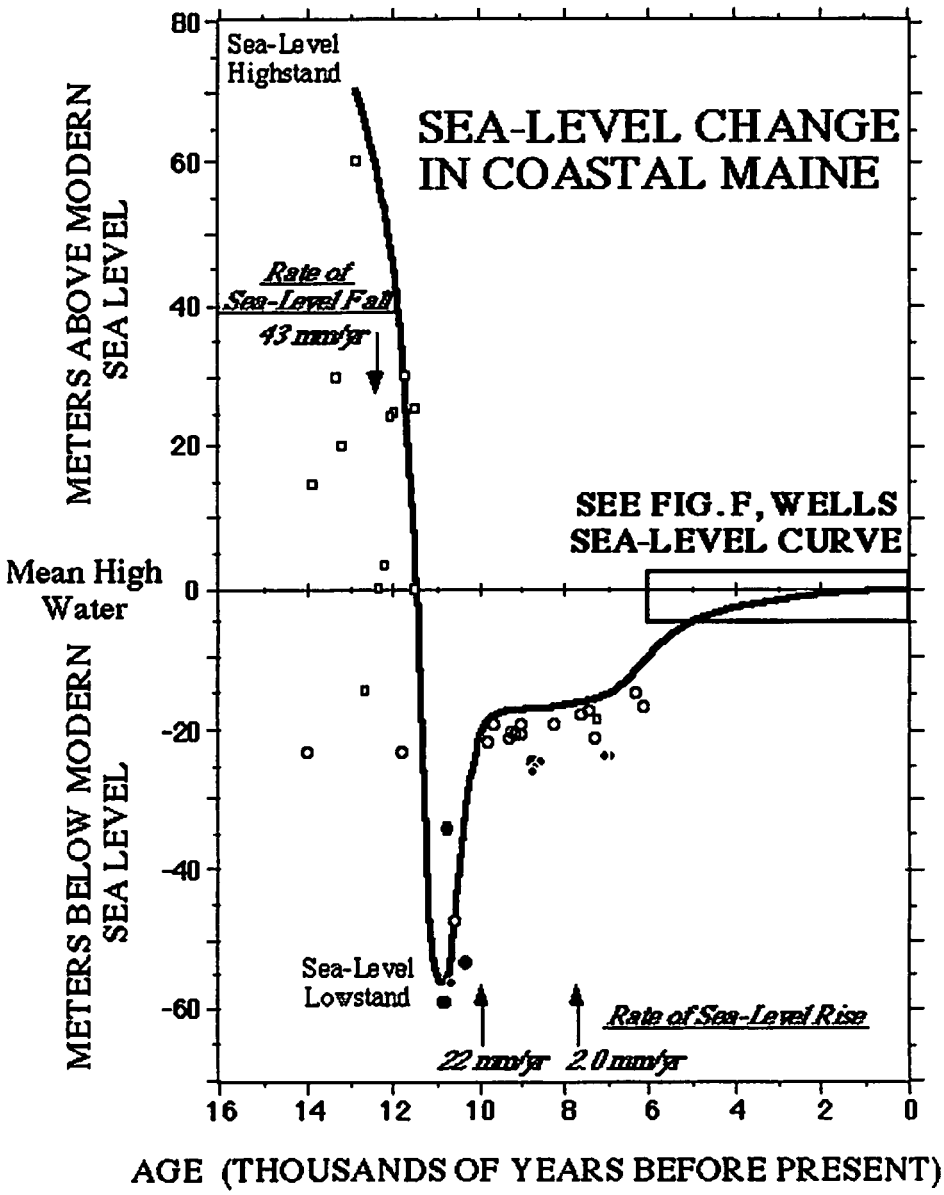
	Cross-Scale Information Exchange via		
	Top-down info. Dissemination	Involvement of actors from different levels	Integration of local effort in larger assmt.
Assessment as Product (exclusively report-Focused)	e.g., EPA (1989) nt'l SLR-assessment; EPA-sponsored ME state assess-Ment 1	2	e.g., IPCC Regional Assessments, US-supported country studies 3
Assessment as Process (networking, capacity-building, periodic reports)	4	e.g., US National Assessment (?) 5	e.g., local coastal erosion and SLR assessment efforts in Maine and Hawaii 6

Figure 3 Subregions of Coastal Maine



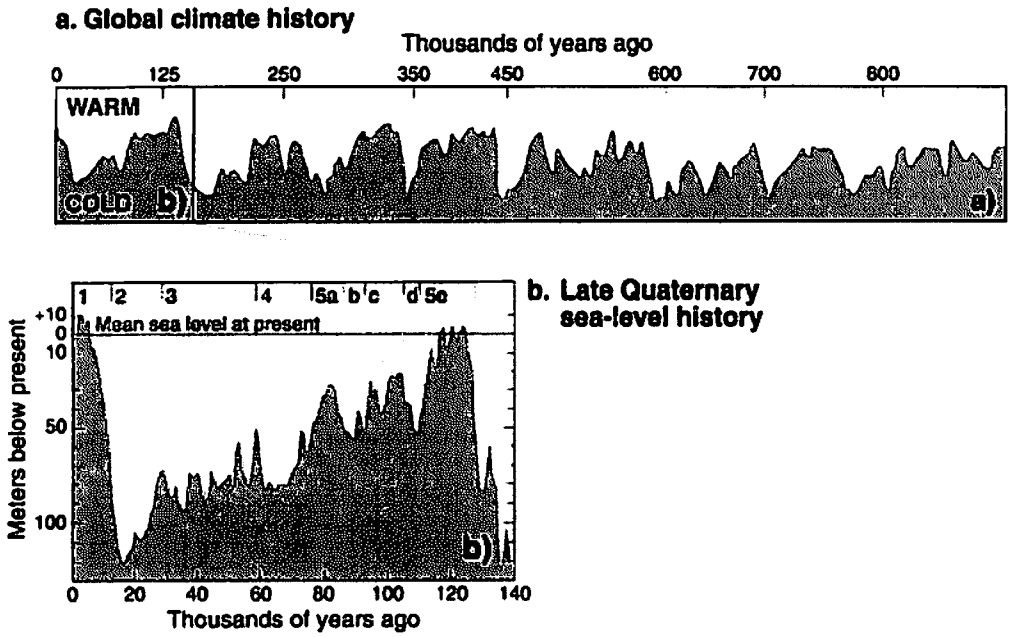
Source: Kendall, 1987, p.50

Figure 4 **Maine Sea-Level Curve**



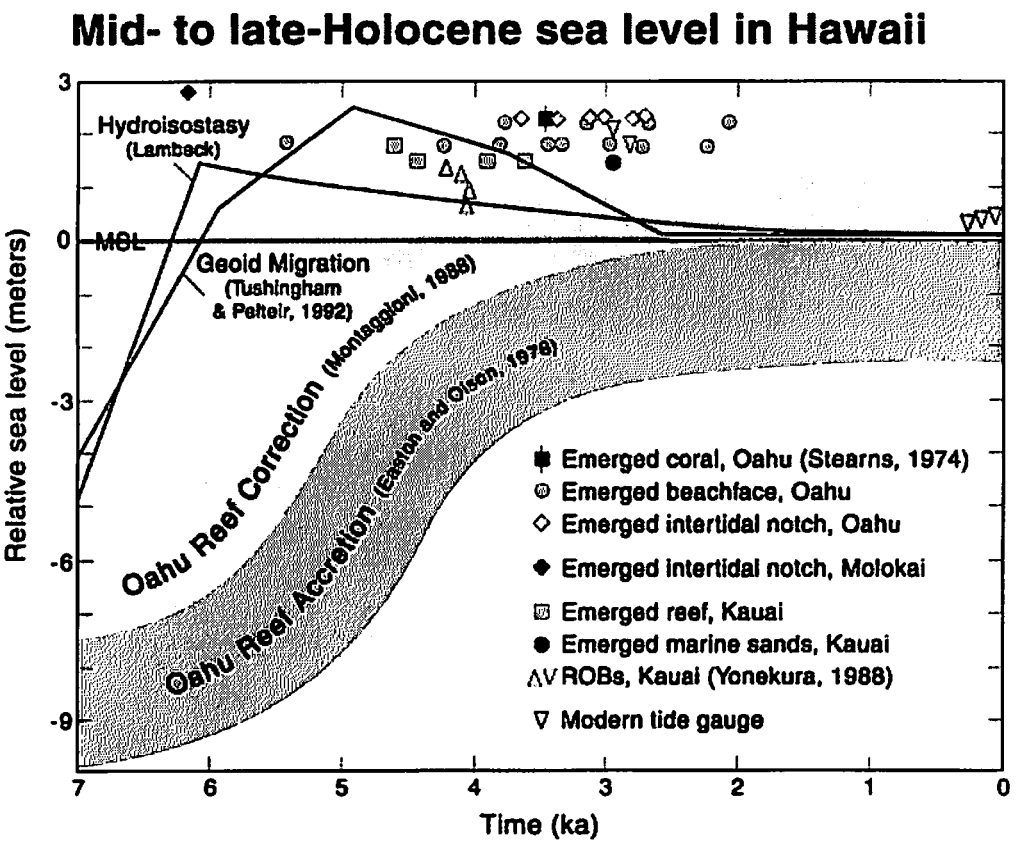
Source: Kelley, Joseph T., Steven M. Dickson et al. 1996. *Maine's history of sea-level change.* MGS Fact Sheet, DOC: Augusta, ME (available from http://www.state.me.us/doc/nrimc/pubedinf/factsht/marine/sealevel.htm).

Figure 5 Late Quaternary Sea-Level History, Hawai'i



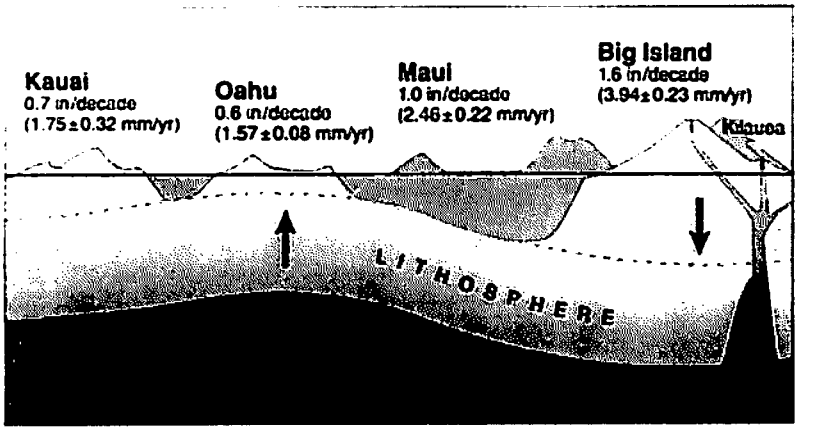
Source: Coastal Geology Group, 1997b (available from http://www.soest.hawaii.edu:80/coasts/csrg1.html).

Figure 6 Mid-to-Late Holocene Sea Level in Hawai'i



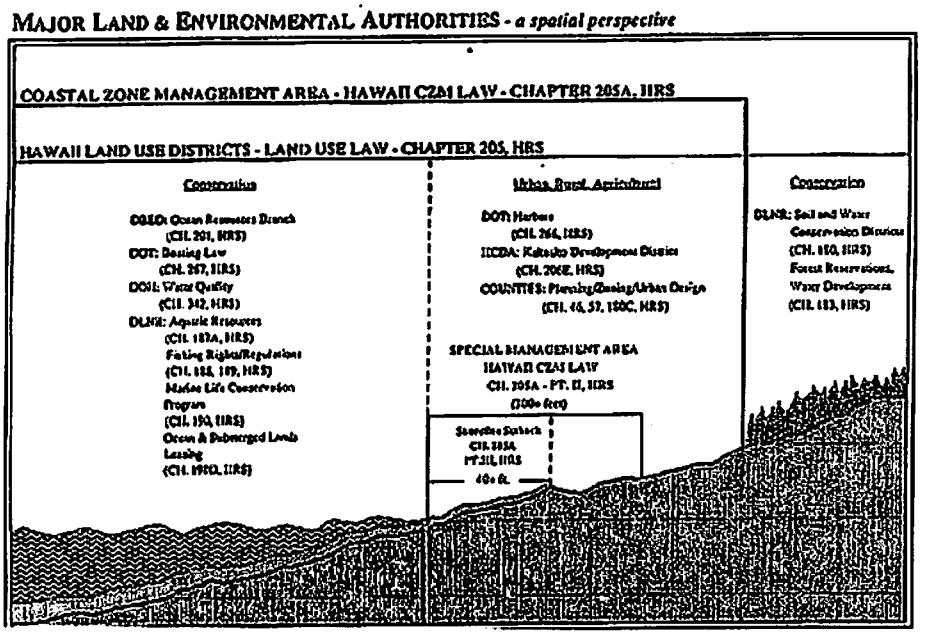
Source: Coastal Geology Group, 1997b (available from: http://www.soest.hawaii.edu:80/coasts/csrg3.html).

Figure 7 Sea-Level Rise Rates for Four Hawai'ian Islands



Source: Mulane, 1998b

Figure 8 Major Land and Environmental Authorities in Spatial Perspective



Source: Hawai'i Office of State Planning, HCZMP 1990, p.21