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Impact assessments and policy responses to sea-level rise in three US states: An exploration of human-dimension uncertainties

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Abstract

Uncertainties in the human dimensions of global change deeply affect the assessment and responses to climate change impacts such as sea-level rise (SLR). This paper explores the uncertainties in the assessment process and in state-level policy and management responses of three US states to SLR. The findings reveal important political, economic, managerial, and social factors that enable or constrain SLR responses; question disasters as policy windows; and uncover new policy opportunities in the history of state coastal policies. Results suggest that a more realistic, and maybe more useful picture of climate change impacts will emerge if assessments take more seriously the locally embedded realities and constraints that affect individual decision-makers' and communal responses to climate change.

Keywords: Climate change; Sea-level rise; Impact assessments; Policy responses; Human-dimension uncertainties; US

1. Introduction: uncertainty in the human dimensions of global change

Over the past 15–20 years, the scientific assessment of climate change impacts has improved considerably with regard to incorporating the human dimensions (e.g., Intergovernmental Panel on Climate Change (IPCC), 1997, 2001a; NRC, 1999; Rayner and Malone, 1998; Wynne, 1987). The formulation and downscaling of driving scenarios of societal development, the explosion of empirical and integrated modeling studies of vulnerability, impacts, and adaptation, and the diverse research undertaken under the auspices of the International Human Dimensions Program are just some of the indicators of this growing understanding and sophistication.

At the same time, attention to the uncertainties, unknowns, and potential surprises in the science of climate change and in impact assessments has grown considerably (e.g., Van Asselt et al., 1999; Brooks, 1986; Dovers and Handmer, 1992, 1995; Dunn, 1997; Faber et al., 1992a, b; Gallopin, 2002; Glantz et al., 1998; Holling et al., 1995; IGBP, 1992; Janssen, 2002; Kates and Clark, 1996; Ludwig et al., 1993; Myers, 1995; O'Connor, 1994; OTA, 1993a, b; Ravetz, 1993; Schneider et al., 1998; Schwartz, 2003; Svedin and Aniansson, 1987; Williams, 1995). Substantial progress has been made in expanding the canon of methodologies in quantitative uncertainty analysis (for reviews, see, e.g., Morgan and Henrion, 1990; Katz, 2002), and in standardizing the subjective assessment and communication of scientific uncertainties for policy purposes.[1] Numerous researchers have developed typologies of different kinds and degrees of these unknowns (see, e.g., van Asselt and Rotmans, 1995, 1996; Brooks, 1986; Casti, 1994; Faber et al., 1992a, b; Funtowicz and Ravetz, 1992; Rayner and Richards, 1994; Rowe, 1994; Schlanger, 1995; Smithson, 1985, 1988; Suter et al., 1987; Walker, 1991; Willows and Connelle, 2003; Wynne, 1992). Integrated assessments also have improved in incorporating certain human-dimension uncertainties. Among the human dimensions that have found entry into integrated assessment

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[1]This was quite consistently accomplished in the IPCC Third Assessment Reports, and also in the first US National Assessment of the Potential Consequences of Climate Variability and Change (IPCC, 2001b; National Assessment Synthesis Team, 2000; see also Giles, 2002).

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models are economic variables, policy options, and cultural preferences for certain responses (see, e.g., van Asselt and Rotmans, 1996; Van Asselt et al., 1999; Berkhout et al., 2002; Carter et al., 1994; Dowlatabadi and Morgan, 1993; Ingham and Ulph, 2003; Lonergan and Prudham, 1994; Nakicenovic et al., 1994; Pahl-Wostl, 2002; Rotmans and Dowlatabadi, 1998; Smithson, 1988). Deep structural uncertainties (ignorance)[2] remain, however, regarding key features of future human development and responses to the impacts of climate change (Moser, 2005a).

Arguably, these deep human-dimension uncertainties, which become ever greater the further out into the future one tries to project, cannot be deterministically resolved, but they can be better characterized and described, and more effectively communicated to those who would be interested in planning for climate change impacts (Moser, 2005a). The more reluctant policy- and decision-makers tend to claim scientific uncertainty as the cardinal reason to delay political action on environmental issues, suggesting implicitly that more research would somehow resolve the decision-making dilemmas they face (e.g., Boykoff and Boykoff, 2004; Colglazier, 1991; Fernau et al., 1993; Jamieson, 1995; Pielke Jr. and Conant, 2003; Sarewitz and Pielke Jr., 2000). As Sarewitz (2003, p. 136) describes this position, "[i]f we have more knowledge about a particular environmental problem, then we will be able to make better decisions because the competition between various interests or values will give way to a rational analysis of the problem". Others have not viewed uncertainties as fundamental obstacles to decision-making and proactive planning, even if they, too, would prefer location-specific, temporally more highly resolved, and more reliable data.[3]

Such differences in individuals' stance on climate change and action point to deep human-dimension uncertainties: varying degrees of problem awareness, perceptions of urgency, and understanding of the climate change (impacts) problem; differences in the value-based lenses, cognitive frames, and capacities available to analyze and interpret climate change information; and varying motivations, abilities, and constraints on taking action (Moser and Dilling, 2004). Research on these aspects is dispersed over a broad multi-disciplinary human-dimension community, yet often the unknowns in them are not systematically or comprehensively brought to the fore or addressed in assessments or in policy-making and management. In this paper, I argue that a more realistic, and maybe more useful picture of climate change impacts will emerge if assessments take more seriously the locally embedded realities and constraints that affect individual decision-makers' and communal responses to climate change. In turn, insights into these realities can be proactively employed in policy-making and management—even in the absence of greater scientific certainty about climate change—and thereby improve local response capacity and effectiveness.

The context in which I explore these human-dimension uncertainties here is that of state-level policy and management responses to the impacts of climate change-induced sea-level rise (SLR) in the USA. Section 2 explains the research approach and methodology. The two major strands of this investigation, summarized in Section 3, focus on (1) the knowledge base about SLR impacts and the practice of impact assessments (Section 3.1) and (2) policy and management responses to SLR derived from three US case studies (Section 3.2). In Section 4, I synthesize the findings, and conclude with some promising research directions and practical implications of assigning greater weight to these human-dimension uncertainties in assessment and praxis.

2. Research design, methods, and analysis

This study aimed to answer two key questions:

1. *How can the analysis and assessment of uncertainty be broadened to better account for the uncertainties in the human factors, which (a) co-create (along with physical factors) the impacts of SLR, (b) influence how we assess them, and (c) determine how we respond to these consequences?*
2. *How are these uncertainties addressed at present in US coastal policy-making and day-to-day management—and how could such practice be improved?*

2.1. Knowledge assessment

The examination of our knowledge base about the human dimensions relevant in impact assessments began with an iterative literature review and an expert workshop, which brought together 10 risk, uncertainty, coastal science and management, assessment, and global change experts. Workshop participants proposed and adapted a causal model of hazards[4] to structure their review and assessment of the knowledge base on SLR impacts. Particular emphasis was placed on those human factors that influence

[2] The terms "uncertainty" and "ignorance" are frequently used together, but not interchangeably here. The difference is the degree of not-knowing or ambiguity. In this respect, I loosely adhere to the conventional use of these terms in quantitative approaches, but use them qualitatively, as many human-dimension uncertainties do not lend themselves to measurement and quantification.

[3] Various cases are illustrated or analyzed in Hare (1991), Kasperson et al. (1995), and Moser (1995). Stratospheric ozone depletion and skin cancer much discussed in the early 1980s could be considered another example.

[4] The causal model was developed to help disentangle complex hazard problems, to identify the range of possible outcomes of hazardous events in a disciplined manner, and—by illuminating the factors that contributed to these outcomes—to find points of intervention for hazards management (Kates et al., 1984). It has since been developed further and integrated with other theoretical approaches into a more complex and comprehensive conceptual model (e.g., Clark et al., 1998; Kasperson and Kasperson, 2001; Turner et al., 2003).

land-use and technology choices, location in hazard-prone areas, preparedness, vulnerability, initial and higher-order impacts (e.g., job losses, income losses, boosts for the local reconstruction industry), and societal responses to hazardous events (or anticipatory responses the prospects of such events as climate change and SLR accelerate). In subsequent face-to-face interviews with a variety of experts—risk and uncertainty analysts, integrated impact assessors, geographers, policy analysts, legal experts, statisticians, coastal engineers, economists, hazard experts, cultural anthropologists, and other human-dimension experts—this causal model was used to further explore and refine the knowledge assessment. (More details on the interviews are given below; see also Moser, 1997).

2.2. Case studies

The policy analysis focused on three US states—Maine ME, North Carolina (NC), and South Carolina (SC). These states were chosen on the basis of published reviews of US coastal programs, which characterized these states' responses to threats from global climate change, SLR, and related coastal hazards (Klarin and Hershman, 1989; as well as Bernd-Cohen et al., 1995; Bernd-Cohen and Gordon, 1998; Glasser, 1995; Hecht and Tirpak, 1995; Fleagle, 1992; Houlahan, 1989; University of North Carolina, 1984).[5] This selection prioritized those states that had begun to address SLR in their coastal policies—states that presumably had acted in the face of uncertainty and designed strategies to cope with uncertain and changing environmental and societal conditions. The assumption was that much could be learned from these pioneers about why and how they addressed such uncertainties. Based on the program reviews, ME, SC, and the San Francisco Bay Conservation and Development Commission (BCDC)[6] were the only programs at the time (mid-1990s) that were said to have specific SLR policies. Several others, including NC, were judged to have policies that could be adapted to the threats from accelerated SLR. Budget constraints dictated a focus on the three East Coast states—ME, SC, and NC—for this comparative study (Fig. 1).

In total, I conducted 57 semi-structured, taped, face-to-face (84%), and phone interviews (12%) of an average length of 1.5 h (30 min to 3 h range) with key informants from within coastal management, academic institutions, and non-governmental organizations actively involved in coastal policy-making, management, and impacts assessment. The interviews were aimed at understanding coastal zone policies and their histories, the challenges and realities of coastal policy-making and management, perceptions and understanding of climate change-driven SLR and coastal impacts (especially the human elements), interviewees' perception of how solid and credible that understanding was, other "hot topics" managers and stakeholders were facing, and communication and interaction between scientists and information users. Table 1 provides a simplified overview of the interviews with scientific experts and practitioners conducted for this study.[7]

The above-mentioned causal structure of hazards and Kingdon's policy windows (Kingdon, 1984, 2002) served as a conceptual and theoretical framework to organize the obtained information. The transcribed interviews were subjected to a qualitative content analysis, extracting common themes and examining the ways in which interviewees discussed uncertainty in overt and subtle ways. The obtained information was verified through triangulation among interviewees as well as with published coastal program reports, reviews, and other publications. Additional information was gleaned from legal documents, local news reports, and the scientific and policy literature. The steps involved in the research and synthesis are depicted in Fig. 2.

2.3. A note on interviewing about uncertainty

Interviewing key informants about the uncertain and unknown posed a number of significant challenges. These challenges bear special notice as they brought to light certain aspects of "dealing with uncertainty" in real life, thus serve as data input to the study itself.

Direct questions about what we do not know often led to blank faces initially or produced some discomfort for the interviewee. It became clear quickly that rapport building was hindered by immediately inquiring about the unknown. Interviewees needed to establish their expertise prior to speaking about (or "admitting to") the—sometimes significant—lack of understanding and challenges about the human-dimension side of coastal impacts and management. Especially with agency staff and policy-makers, the words "uncertainty" and "ignorance" seemed to undermine trust, possibly because these concepts were perceived as questioning their authority or knowledge. As an academic, i.e., an outsider to the policy- and decision-making world, trust-building, however, was essential to obtaining deeper insights into the real workings of day-to-day coastal management. With most scientists, it was not useful to talk about the entire range of potential impacts,

[5]Since the late 1990s, several other US states (e.g., Maryland, Delaware, Massachusetts) have begun developing coastal strategies and policies explicitly intended to address the risks from accelerated SLR (Johnson, 2000; DNREC, 2001; MACZP, 2005).

[6]The BCDC is one of two regulatory bodies overseeing coastal management along California's coast with jurisdiction over the San Francisco Bay area. The BCDC preceded the Coastal Commission by a few years in studying the impacts of SLR on its portion of the California coast, and subsequently implemented some modest policy changes pertaining to construction and development standards (Travis, 2003).

[7]Note that the categorization is necessarily oversimplified. Researchers frequently are intimately familiar with local coastal policy and management issues, while practitioners frequently are involved in management-related research.

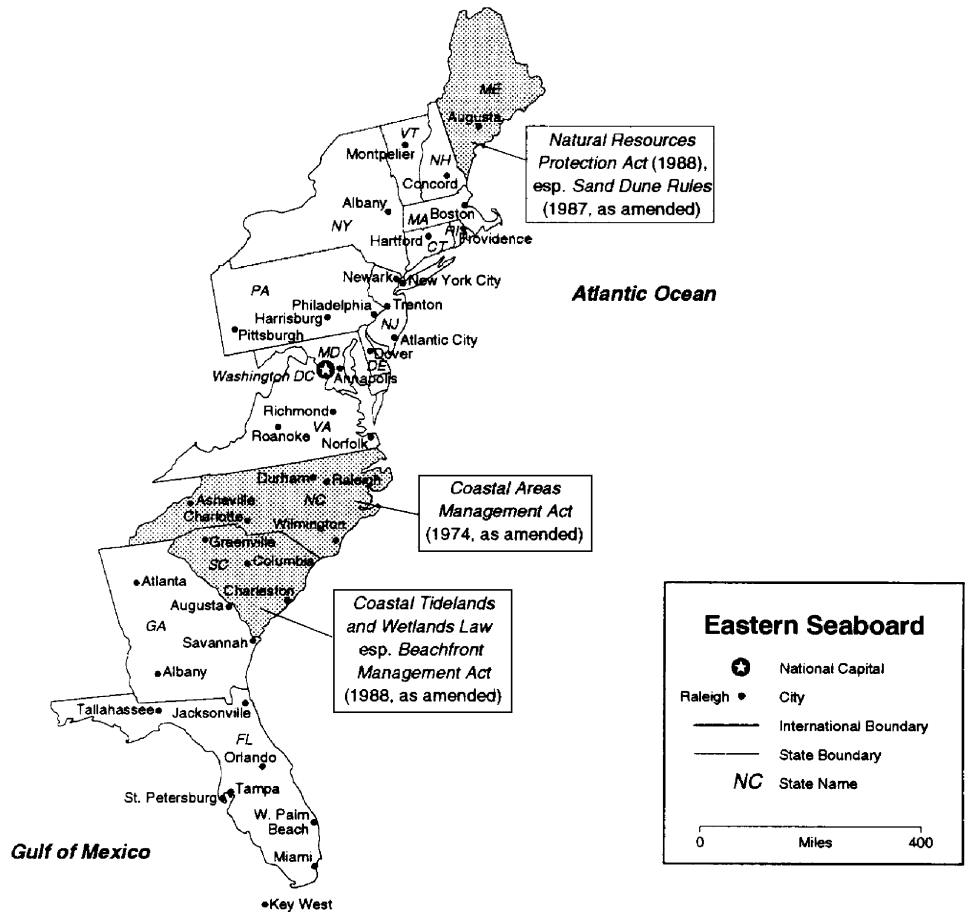

Fig. 1. US case study states and key legislation for sea-level rise.

Table 1
Scientist and practitioner interviewees by location and affiliation

Location	Governmental	Non-governmental/ environmental/ engineering	Academic	Total
State				
Maine	9	3	2	14
South Carolina	7	2	3	12
North Carolina	5	3	6	14
US/federal	5	3	9	17
Total	26	11	20	57

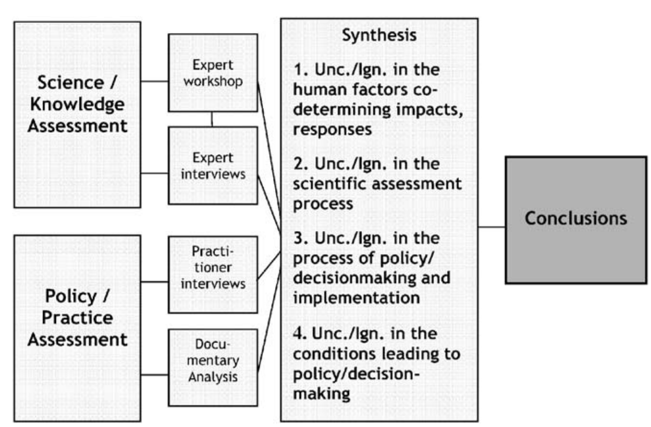

Fig. 2. Research design and analysis.

reflecting the limits of specialized expertise. Instead, probing in an expert's field of study sometimes turned the interviewing process into a collaborative work session on a tough problem. This scientific mode of interaction seemed to make respondents more comfortable to explore what was not known in their field. Importantly, and maybe unexpectedly, the challenges in the *process* of interviewing and extracting data about human-dimension uncertainties, along with the unspoken—and sometimes avoided—topics, became as much part of the findings as the specific dimensions explicitly identified by interviewees.

3. Empirical findings

3.1. Knowledge assessment

The knowledge base for any topic is constantly shifting and usually expanding, as are frequently the uncertainties.

The study findings regarding the knowledge base on the human dimensions of SLR impacts are restricted here to those general observations that seem to persist over time. Moreover, they are kept short in favor of greater empirical detail on the states' policy and management responses. The findings highlight important dimensions of the process of knowledge creation, however, which influence the kinds of uncertainties researchers may recognize and which they may ignore.

First, expert knowledge biases expert assessment of the knowledge base. Most social scientists interviewed perceived engineering and physical knowledge as more solid than that on the human dimensions, and given the evolution of the respective fields, this assessment may well be justified. Yet physical scientists vehemently countered this perception with itemized lists of knowledge gaps in their own fields. This observation points to the driver behind the pursuit of scientific knowledge: the more scientists know, the more they see what is not known yet. This leads to further investment to fill the gaps in these research areas. Interviewees suggested that such curiosity-driven research clearly has its place, but may not necessarily meet stakeholder-relevant research needs.

Second, vulnerability and societal responses to global change entail the largest uncertainties. All experts agreed that the greatest unknowns are embedded in the human dynamics leading to vulnerability and various responses (mitigation and adaptation), as well as the second-order societal impacts. Interviewees thought these unknowns were the least rigorously studied and frequently only qualitatively understood. It is thus not surprising that far more attention has been paid to these aspects in recent years (e.g., Brooks, 2003; Cutter, 2001; Cutter, 2003; Folke et al., 2002; Fraser et al., 2003; IPCC, 2001a; Kasperson and Kasperson, 2001; National Research Council (NRC), 1999; Turner et al., 2003), also reflected in the IPCC's Third Assessment Report and its forthcoming assessment in 2007.

Third, impacts of and responses to slow-onset and slowly progressing threats tend to be under-studied. According to interviewees, understanding of the impacts of episodic/short-term events, such as coastal storms, is better than that of long-term, gradual processes, such as SLR. A partial explanation may be the relative lack of understanding of human responses to "creeping hazards" (Glantz, 1988). Another partial explanation may be the relative unattractiveness of such slow hazards as objects of study. In fact, the research on SLR (impacts) that does exist is frequently justified by the potential of SLR to aggravate short-term hazards or by the dramatic impacts when viewed cumulatively over time.

Furthermore, interviewees agreed that spatial variability and cross-scale interactions render understanding and generalizations difficult. They argued that a challenge in building a solid knowledge base is the spatial variability (entailing linear and often unpredictable stochastic variation in the physical, ecological, and social dimensions) and cross-scale interaction of causes and responses to SLR and its impacts (see also a recent summary of this aspect in Young, 2002; Berkes et al., 2003). Credible assessments of SLR impacts, which are conceived and examined as compound/synergistic results of changes set in motion by interacting local and supra-local processes, have yet to be undertaken.

Fifth, impact assessments tend to be static and ignore temporal variability, change, and societal learning. Experts identified the need to better capture the temporal variability and dynamics in the human dimensions as critical. For example, the workings of markets, inefficiencies in the implementation of policies, timing, and delay in decisions, "non-rational" actor behavior, change in demographic structures and distributions, societal learning, institutional changes, and changes in people's perception and valuation of coastal resources and environmental change remain ill-understood or incompletely integrated in impacts studies. While these points of critique have been made before, they highlight critical, but under-studied dynamics that determine a more realistic understanding of response to impacts.

Interestingly, research so far has largely neglected social surprises. Potential geophysical surprises, such as major system shifts or break-downs (e.g., shut-down of the thermohaline circulation, the collapse of the West-Antarctic ice shield), are increasingly recognized as important foci of scientific investigation. Societal surprises have received far less attention. For instance, the policy impacts of major coastal disasters could shift public perception in significant ways. Other possible social surprises include an end of federal disaster assistance, the collapse of the insurance industry, major shifts in the public trust vs. private property rights debate, or unexpected technological breakthroughs. Such research would have to be justified against the pervasive perception among many policy-makers and experts that SLR is a slow, gradual phenomenon that will and can be addressed in the course of "normal" coastal management and infrastructure maintenance and replacement.

Another conclusion from the interviews suggests that assumptions and biases not only determine findings but also tend to reinforce areas of ignorance. Impact assessments are always premised on convenient, if realistically indefensible, assumptions and unspoken biases in impact assessments. That these assumptions and biases lead to slanted or partial "truths" about SLR impacts, however, is rarely explicitly acknowledged.[8] A related bias is to study only those aspects for which data and information can be found, or what can be expressed in convenient metrics (e.g., $)—a data and method-driven situation that does not

[8]Examples of such assumptions include economic or demographic growth rates, unchanging human values, or other "ceteris paribus" assumptions. Biases become apparent in such choices as the scale of analysis, the level of aggregation, in- or excluded social groups, or the selection of discount rates.

necessarily have a solution, but one that reinforces ignorance—and hence lack of awareness—of less convenient or inaccessible aspects of global change. Researchers may try to avoid some of the pitfalls of this ''lamp posting'' practice by making a conscious effort to tackle and communicate less obvious knowledge gaps.

An internal logic of values, interests, and preferences among researchers (and not necessarily the need for better understanding) drives the research agenda. Perceptions of the severity of expected impacts, as well as personal expertise and values, often guide experts in identifying research priorities (another way to elicit knowledge gaps). From their ''prescriptions'' several factors could be discerned that affect such expert weightings. The choice of region and thus relevant impact categories, and their importance relative to each other emerged as a logical factor in prioritization. Similarly, mostly implicit assumptions about the relative importance of coastal industries now and in the future (e.g., fisheries will decline, tourism will expand) guide research priorities. The choice of scale or level of aggregation determined how much attention researchers pay to distributional effects. Further, the interviews revealed assumptions of what structures, environmental resources, and/or processes they deemed critical to the functioning of society. Anticipation (or not) of cumulative impacts and system thresholds also affected impact weighting. Many researchers also tended to favor research into the near-term, first-order, easily discernible, and measurable impacts rather than those that result from complex interactions, unfold from stochastic events, are hard to trace causally, or are difficult to express in non-monetary terms. Many also exhibited or commented on a bias toward studying negative impacts as opposed to potentially positive ones. Finally, interviewees more strongly emphasized human impacts as opposed to ecological ones, even though researchers deemed the latter—ultimately—as more serious.

And finally, preventing the erosion/loss of the knowledge base may be as or more important (but less attractive) than developing new knowledge. Many of the likely problems associated with SLR are neither new to science and impact analysis nor to coastal zone management (e.g., the economic impacts of salinization or infrastructure maintenance costs). For any specific locale (or from other, similar locales), there is a good chance that at least some of the needed information and relevant research exists, albeit in basements, on dusty shelves, or simply forgotten, unknown, or inaccessible. Some of the observed ''ignorance'' is thus not absolute, but nonetheless ''real'' for anyone charged with identifying existing knowledge and possible solutions—a non-trivial result of collective forgetting, loss of institutional memory, or barriers to information exchange.

The findings from the knowledge assessment are synthesized in Tables 2 and 3. First, I summarize those uncertain or unknown human factors, which co-determine the impacts of SLR (Table 2). As discussed above, humans have a strong influence over the causal sequence, from the underlying drivers of the nature–environment relationship to the initiating event to the higher-order impacts of SLR by making land-use and technological choices, affecting their degree of vulnerability, and choosing response options. To what extent and how this influence manifests is pervaded by uncertainty.

In addition, the influence over impacts extends to a meta-level, namely that of how we perceive, assess, and

Table 2
Uncertainties in the human factors that co-determine the impacts of sea-level rise

Human wants
Land-use and technology choices
• Human values
• Education and degree of informedness
• Cost-benefit calculation underlying choice of living in hazardous areas
• Degree of scientific and technological sophistication
Vulnerability
Exposure
• Population (numbers, density, type) at risk
• Planning, zoning, and regulations
• Economic profitability and utility of being in the coastal zone
• Amenity of being in the coastal zone
• Degree of risk-seeking/risk-aversion
Resistance
• Structural mitigation measures in place (protection for home, property)
Resilience
• Wealth
• Mobility and flexibility
• Degree of sustainability of current land use
• Insurance availability, acceptability, necessity
Consequences
Immediacy of experience
Intensity of experience
Concentration in time and space vs. distributive effects
Scale
Degree and tightness of coupling between affected systems
Sensitivity/resistance/resilience
Degree of dependence on single resources, sectors, space, or other affected system
Response/adaptation
Problem detection, definition, and appraisal
• Saliency, perceived control, perceived and actual ability to control outcomes, newness of problem, perceived and actual responsibility, ability to detect and explain causes, voluntarism
Institutional setup
Decision-making
• Rational vs. irrational decisions and behaviors, availability and use of scientific information, priority setting, utility, communication
Implementation of response choices
• Effectiveness, efficiency, timing
Political climate

Table 3
Uncertainties in the human factors that co-determine the assessment of sea-level rise impacts

Expectations about "How the World Works"
What is "normal"?
- Focus on no change, gradual/slow change, linearity, constancy

What would constitute surprises?
- Focus on the big, the bad, the ugly
- Focus on non-linearities, thresholds, synergisms, coincidences

Valuation of scientific knowledge and progress
Research
- Priorities and funding (e.g., short-term vs. long-term)
- Foci (e.g., low probability/high consequence events vs. slow and common processes; the new/exciting vs. the existing/mundane)

Science in the political context
- Degree of influence of scientific knowledge on policy-making (vis-à-vis other types of knowledge, information, decision criteria)

State of the art in relevant disciplines
- Perception of certainty of different areas of knowledge (engineering, physical science, ecological science, social science)

Valuation of other types of knowledge
Valuation of different values
Valuation of different ways of knowing
Weight and credence given to other types of knowledge

Attitudes toward uncertainty
Fatalism vs. managerialism
Wait-and-see vs. precaution
Pessimism vs. indifference vs. optimism

Valuation of impacted systems/of impacts
Recognition of impacts
- Visibility vs. obscurity of impacts (1st–*n*th order of impacts, timing, location, concentration)

Perceived importance
- Criticality to society
- (Future) importance of economic sector
- Research and management priorities
- Vulnerability

Measurement aspects
- Ability to assess monetary vs. non-monetary values (comparability)
- Underlying assumptions and biases (e.g., choice of discount rates, economic and demographic growth rates, choice of scale, choice of region, level of aggregation, variables in-/excluded)
- Future valuation of impacts
- Benchmark against which impacts are measured; impacts to whom

value emerging impacts—another human-dimension uncertainty (Table 3). Given the important role of science in policy and management, how impacts are assessed and communicated becomes linked to how society responds. In short, the first set of human-dimension uncertainties describes those *aspects that are part of the problem* (and which can be studied), the second circumscribes a set of uncertainties pertaining to *which problems scientists focus on and how they study it*.

There is a continuum between the factors that contribute to the problem and the factors that determine how researchers view, study, and value it. Clearly, the two sets mutually influence each other. They are distinguished here because the latter set captures human-dimension uncertainties at a meta-epistemological level, while the former captures those relevant from within a particular epistemology. This distinction allows us to account for the fact that different actors involved in the societal response to SLR may act with very different epistemologies, coloring their assumptions, values, perspectives, attitudes, and theoretical or methodological approaches. It also accounts for the fact that the issues researchers do study have a better chance to being addressed in societal responses than those left unattended—thus indirectly affecting the impacts and response options. In Section 3.2, I turn to the empirical findings on these policy and management responses to SLR in three US states.

3.2. Policy/practice assessment

3.2.1. State-level policy and management approaches to SLR

SLR as a problem for policy-making and management is marked by a number of characteristics that it shares with several other types of global change impacts. It is a slowly progressing ("creeping"), long-term, common-place, and—by itself—rather unspectacular, and thus largely "invisible" problem. It is difficult to isolate from, or perceived as merely aggravating other, more apparent coastal processes such as coastal erosion, flooding, or saltwater intrusion. As for its future prospects, its magnitude and rate are scientifically uncertain,[9] but the ecological and economic impacts could be significant (e.g., Nicholls and Lowe, 2004), especially in light of the potential for surprises or non-linear trajectories. These characteristics predispose SLR to be a problem easily hidden beneath the more visible, dramatic, or acute coastal problems which managers face on a day-to-day basis. Paradoxically, SLR is easily postponed because it is not perceived as an immediate management concern, yet it cannot be postponed because of its potential for long-lasting and irreversible implications for coastal land use, populations, and ecology (e.g., Meehl et al., 2005). The fact that some states have begun to address this unwieldy issue at all is an astonishing finding.

ME, SC, and NC face rather different management situations and challenges. The length and type of affected shoreline, the degree of shoreline development, percentage of state population in coastal areas, and types and relative importance of potentially affected industries vary consid-

[9]While SLR is generally considered one of the more certain impacts of climate change, the relative importance of thermal expansion and eustatic sea-level rise continue to be significantly debated (see, e.g., Vaughan, 2005; Meehl et al., 2005; Miller and Douglas, 2004; Meier and Wahr, 2002; Munk, 2002; Cabanes et al., 2001).

Table 4
Sea-level rise as a management challenge in South Carolina, North Carolina, and Maine

	South Carolina	North Carolina	Maine
Coast affected			
Length of coast	2876 miles	3375 miles	5200 miles
Sandy beaches	181 miles/~90 miles developed	300 miles/~120 miles developed	60–330 miles/most of it developed
Estuarine coast	504,000 acres	2.2 million acres	~660 miles
Coastal population[a]			
Total	904,460	710,903	885,703
Percent of state	22.5	8.8	73
Historic relative SLR (mm/year)	1.8 (North)–3.35 (South)	3.1 (Nags Head)–1.8 (Wilmington)	2.2 (Portland)
Special features	Two-thirds of state net revenue from coastal tourism; fisheries important; highly developed areas separated by large protected areas	Dramatic shoreline change rates; 72% of coastline eroding; huge tourism and fisheries industries; significant risk from hurricanes and other storms	Many islands, bluff erosion, most beach areas also highly developed; coast highly dependent on tourism, fisheries and ocean-related industries

Sources: NOAA (2003). State and Territory Coastal Management Program Summaries; available at: http://www.ocrm.nos.noaa.gov/czm/czmsitelist.html; US Census Bureau (2003). State and County Quick Facts; available at: http://quickfacts.census.gov/qfd/; Sea-level rise rates: Kelley et al. (1996) (Maine); Daniels, (1996) (North Carolina); Daniels, (1992) (South Carolina).
[a]Population in 2000, coastal counties only.

erably, as does the historical rate of relative SLR experienced in each state (Table 4).

The set of regulatory tools and policies to address SLR and related coastal hazards include:

- the extent and types of regulated areas;
- the setback rules (including determination of baseline, base rate, setback line, and minimum setbacks);
- the existence or absence of minimum permitting standards for regulated areas;
- the specifics of a retreat policy;
- the permission (and circumstances allowing different types) of erosion control measures (soft and hard protection); and
- any land-use and development planning guidelines in shorefront and adjacent areas.

The existence or absence of any one of these rules, overall complexity and range of possible combinations, duration over which the rules are in place, and strictness of implementation against the backdrop of the different geographical and socioeconomic settings result in unique approaches and challenges to dealing with SLR in each state. Brief histories of the emergence of these policies and more detail on each state's set of policies, rules, and implementation practices are given below.

3.2.1.1. North Carolina. NC was one of the first states in the US to develop and codify its coastal zone management program in the early 1970s. The impetus for the state to establish its coastal program arose out of a general growing environmental consciousness and awareness of development-related local problems, recent experience with damaging storms, growing academic and management concerns and know-how regarding coastal problems, and the federal Coastal Zone Management Act of 1972 that offered financial assistance to put institutions and regulations in place. Bi-partisan support and leadership were instrumental in 1974 for pushing the law through the state legislature without weakening amendments.[10] The rules and regulations put in place over the following 5–10 years with strong academic and public input eventually acquired the reputation of an exemplary program nationwide.

Key features of NC's coastal management approach include the definition of nine areas of environmental concern to each of which certain regulations and management rules apply (of particular interest here are "natural hazards areas"); a no-hardening rule along the open oceanfront; a 30- or 60-year setback requirement for open oceanfront development along eroding shorelines; and a requirement that coastal counties and communities write and regularly update comprehensive development plans. The setback requirement varies by size of the development and uses historical erosion rates as the basis for determination of the setback distance. Future acceleration of coastal erosion due to SLR is not considered. Since 1990, however, local governments are required to consider SLR impacts on areas below 5 ft of mean sea level in their development plans. Because planning is a local prerogative not enforced by the state, interviewees judged this requirement to have

[10]NC's state coastal zone management program was federally approved in 1978. See policy histories in Heath and Owens (1994) and Owens (1985).

"no teeth" in terms of realizing SLR-conscious development.

During the late 1980s, leaders of the NC coastal management program and academics (one of whom acquired the nickname "Mr. Sea-Level Rise") began promoting awareness of potential SLR impacts on the state. Cognizant interviewees could not fully explain how SLR actually entered the local planning guidelines. Interestingly, several policy windows in the late 1980s and 1990s (e.g., program reviews, hurricanes Hugo (1989), Bertha (1996) and Fran (1996), the Year of the Coast in 1994, major coastal conferences, and other coastal governance initiatives in the state in the 1990s) opened and closed without bringing SLR issues to the forefront of policy-makers' and managers' attention. Interviewees suggested that more pressing concerns (e.g., water quality crises, acute recovery from hurricanes, and legal battles over property rights) together with waxing and waning federal support for coastal management, lack of relevant knowledge among state policy-makers, general anti-regulatory sentiments and an adversarial political climate in the state diverted people's attention from the long-term problem.

3.2.1.2. South Carolina. SC's coastal management history and engagement with SLR shares some important similarities with NC. The state began addressing oceanfront management with its first coastal act passed in 1977. Its management program was administered at first through an independent Coastal Council until 1993 when the program became incorporated into the state's Department of Health and Environmental Control. From the beginning the program's emphases reflected concerns with maintaining coastal wildlife habitat and beaches for the ever-more important coastal tourism sector and with protection from coastal hazards. SC's coastal law was significantly strengthened—with academic, business, and other stakeholder input—in 1988, one year *prior* to Hurricane Hugo, which devastated the state's shoreline. This revision recognized the growing problem of coastal erosion and gave the state greater regulatory authority over oceanfront development.

Interestingly, the 1993 revised coastal law does not recognize SLR in its text, but educational documents from the program do. Interviewees suggested that awareness had been raised throughout the late 1980s and early 1990s, but that the issue was strategically left out of the law to limit controversy and ensure the revised law's passage. The act—resembling some aspects of the NC program—defines critical areas along the oceanfront to which regulations and permitting requirements apply, allows shoreline hardening as a last resort measure only if they would not cause negative impacts on adjacent areas, establishes a 40-year retreat policy implemented via setback and relocation requirements after damaging storm events, but includes no mandatory planning or zoning provisions for local communities.

Like in NC, implementation of these stricter shoreline development rules has been put to the test of political will and in legal battles (in particular, the Lucas case which challenged SC's regulations on the basis of the constitutional right to private property all the way to the Supreme Court) (e.g., Lyman, 1993). The state also had several opportunities to take SLR into account in its management decisions and did not do so (e.g., in the Charleston Harbor development project or the revamping of the Charleston storm water drainage system in a city that already during heavy storms has several streets under water). Importantly, institutional changes that moved coastal management from an independent state agency with policy-making and permitting authority to a sub-bureau within another agency no longer with the authority to proactively propose forward-thinking policies may have curtailed the program's ability to proactively address long-term issues like SLR.

3.2.1.3. Maine. ME's coastal program has roots dating back to the 1960s, but was codified into law only in 1978, the year of the big "Blizzard of '78". The storm did not trigger but underscore the necessity for the management program. It emerged out of the same systemic political agenda from which the other two states' programs arose. Leading concerns were resource use conflicts and the environmental and aesthetic impacts of coastal development. The program, established in 1978, was built on 13 different pieces of legislation, carried out by seven state and four federal agencies and eight state-based non-governmental institutions. Viewed by some as "fragmentation", by others as "shared responsibility", this institutional arrangement largely persists today.

The rules and regulations focused on hazard area development (e.g., building on sand dunes in the southern part of the state) used SLR as a justification from 1979 onward—at that time, of course, simply referring to the natural post-glacial rise. In the late 1980s, however, accelerated SLR due to global warming—found entry into ME's coastal laws (sand dune rules, SDRs) and became a pioneering example in nationwide coastal policy-making.[11]

The key elements of the SDR include a prohibition of new hardening structures (e.g., seawalls) while allowing repair or maintenance of existing structures only if failing to do so would cause "unreasonable" flooding hazards; restrictions on development in high-hazard (500-year) flood zones as delineated on flood risk maps; and the nationwide strictest retreat policy, operationalized by not allowing any structure to be rebuilt if it was damaged more than 50% in a storm unless the permittee can demonstrate with clear and convincing evidence that the building site will remain stable after allowing for a 3 ft rise in sea level over 100 years (38 MRSA §§ 471–478, as revised in 1993).

[11]The SDRs are part of Maine's Coastal Wetlands Act, which in 1988 along with several other resource protection laws became part of the state's Natural Resources Protection Act.

Interviewees regretted that several legal challenges (focused on property right takings) and minor revisions have somewhat weakened the rules (at present again under review and up for renewal), but the basic tenets of the law continue to stand. Not only does ME continue to be the only state in the US that uses the prospects of future SLR as a basis for its rules; it is also the only law that makes in its text reference to uncertainty. An explanation added at the end of the rules states:

> A Preamble has been added to the Standards section which expresses the Board's[12] intent to limit the density, location and size of structures due to its concern for rising sea level. A number of commentators objected to an earlier version which stated "sea level is expected to rise at an accelerated rate in the future." The wording was subsequently revised to reflect that theories have been developed which predict an accelerated rise in sea level, but the amount which will occur remains uncertain…

With regard to complaints about the requirement to demonstrate site stability under a 3-ft rise scenario, the addendum continues:

> Although the three foot figure for sea level rise is uncertain, a substantial amount of research has been conducted which supports a 3 foot rise, and the Board considers it appropriate given the more permanent nature of these [large] structures.

Interviewees understood the origin of these remarkable regulations not as a reflection of ME's unmatched concern for future global climate, but as a more opportunistic response to several key events and trends in the mid-1980s, including a proposed dam project at the upper end of the Bay of Fundy, a building boom in southern ME causing residents to want to avoid the heavy development common along coastlines further south and the associated influx of "out-of-staters", the tireless efforts of state geologists to raise public awareness of coastal hazards, the rise of climate change on the national agenda, and continuous pressure from advocacy groups. Notably, no coastal disaster, but contingent pressures combined with expertise and policy entrepreneurship led to this policy change. (For a more detailed policy history and the more explicit confluence of coastal hazard and climate change concerns in more recent years, see Moser, 2005b.)

3.2.2. Constraints and opportunities for SLR management

The on-the-ground, day-to-day realities of managing coastal hazards, both acute and chronic, reveal some of the commonly known and other lesser known shortfalls, challenges, and constraints on coastal management, which—in the end—will determine the full impacts of SLR. They reflect political, economic, managerial, and social variables that do or do not create an "enabling environment" for building adaptive capacity or implementing adaptation options (Brooks and Adger, 2005; Adger and Vincent, 2005; Adger et al., 2005). The findings from the three case studies summarized below thus also give empirical reason to believe that the ability of developed and rich nations and communities to adapt to the impacts of climate change may be less promising than is often assumed.

First, the case studies reveal that mitigation of acute hazards is not an adequate substitute for long-term planning for SLR (but often the dominant mode of response today). Storm hazard mitigation is a useful but insufficient (and possibly maladaptive) way of addressing SLR. For example, insurance schemes—a common mechanism for risk or loss sharing—that do not account for a changing shoreline as a result of SLR will incur greater and greater losses until the scheme itself becomes financially unviable (The Heinz Center, 2000). Similarly, building code-based fortification of structures in the "first row" could easily result in buildings on stilts, surviving storms until the ocean is well beneath the house.

Second, interviews revealed that severe losses of shorefront development can only be avoided or postponed through rules that recognize a changing shoreline. Setback regulations, if founded on a moving (i.e., periodically remapped) baseline, in combination with a retreat policy similar to those established in the three states, are able to incorporate SLR and thus to postpone the impacts from SLR.[13] Ideally, however, they should be combined with measures that restrict and redirect shorefront development to eliminate or minimize the impacts from SLR.

Third, using these case studies as indicative of the challenges faced by other coastal states, the question whether or not to harden the shoreline remains contentious and promises to become a focus of greater conflict in the future. States view no-hardening rules as reasonable and essential components of their coastal laws because they allow the natural dynamics of erosion and accretion to take their course. This common opinion corresponds with the relatively recent turning of the tide in the coastal engineering community away from shoreline hardening toward beach nourishment (see, e.g., NOAA Coastal

[12]The "Board" is Maine's Department of Environmental Protection's Board of Environmental Protection which makes policy decisions within that department.

[13]A moving baseline is one that is recognized to shift landward (e.g., through frequent remapping) as the sea encroaches. If combined with a setback rate determined on the basis of the local erosion rate (a rate likely to accelerate as sea level rises), an undeveloped safety buffer to shorefront development could be maintained. The challenge obviously arises from the fact that such baselines and erosion rates may be determined more frequently (e.g., every 5–10 years) than the average lifetime of a construction (e.g., 70 years), and that development inland may prohibit easy retreat. A retreat policy based on degree of damage can serve as a complementary strategy. A no-hardening shoreline protection policy would be a fourth component, allowing natural shoreline change dynamics to proceed. Implementing such a combined approach faces major social justice, political, and technical challenges given historical legacies, grandfathering provisions, existing development patterns, and frequently limited property parcel sizes.

Services Center, 2003; The Heinz Center, 2000; Dean, 1999). It also reflects the growing importance of "natural" beaches for coastal tourism (e.g., King and Symes, 2003; Houston, 1996; Terchunian and Smith, 1994; Central Oregon Coast Association, 1998). However, the long-term feasibility of this option has yet to be assessed and the battle between economic interests (e.g., development, tourism, and associated tax generation) continues unabated. No-hardening rules and improved planning along estuarine shorelines have yet to be put in place or more strictly enforced in these and most other US states to assure the viability of estuaries and the ability of coastal wetlands to move landward as sea level rises.

Fourth, the most important measures for equitable, long-term coastal management may be the weakest. The long-term component of coastal management—through comprehensive planning, density restrictions on development, or zoning—is the weakest of current coastal zone management in all three states, though experts consider it an important part of long-term adaptation to SLR (Beatley et al., 2002; Fischer, 1989). Immediate shorefront planning sits within the broader geographic and socioeconomic context in which coastal development continues. Development restrictions tend to be viewed as unjust or economically indefensible if neighboring areas or the larger region press for development unabated. This then elevates the importance (and challenge) of supra-local planning (e.g., at the watershed or even higher levels) and other efforts such as land acquisition, buy-out programs, and public and private conservation easements and land trusts—all of which are employed to varying degrees in the three case study states (see also Godschalk, 1998). Importantly, however, acquisition of the most valuable land—the immediate shorefront—is least likely due to the lack of necessary funds.

In trying to understand whether, how, when, and which policy responses to SLR arose in each state, Kingdon's policy windows framework (Kingdon, 1984, 2002; Solecki and Michaels, 1994) helped elucidate the conditions under which policy windows open and close, including:

- changes in political context (elections, changes in administrations, shifts in power balance, etc.);
- the emergence of new management problems that engage government officials or other influential individuals (policy entrepreneurs);
- the magnification of existing problems;
- disasters or other crises that can alert and help mobilize people and play a role in problem definition;
- the systemic agenda of the populace, which is based in larger societal problems or conflicts, can produce a general societal readiness to address a specific problem;
- the existence of civic and professional coalitions that help detect, define, popularize, and possibly solve a given problem; and
- the availability or readiness of policies, strategies, and mechanisms for implementation that offer a potential solution to the problem.

The following additional lessons can be drawn from the policy analysis in ME, SC, and NC.

First, careful policy histories reveal significant differences in state "responses" to SLR. Somewhat surprisingly, and counter to the findings from the study used to select the case studies (Klarin and Hershman, 1989), ME is the only state that has a policy in place that uses climate change-driven SLR as its justification and specifically in the definition of its setback rules. Since 1990, NC also demands that SLR be addressed in land-use planning, but—as described above—this is probably that state's weakest coastal management element. SC interviewees explicitly denied that their coastal policies were put in place in response to climate change-driven SLR. However, the issue is officially recognized and valuable mechanisms that can be applied to the management of SLR are in place in all states, albeit in different combinations.

Interestingly, disasters not just open but frequently close policy windows. The policy windows approach considers crises and disasters among the essential necessary conditions for a policy change to occur. Gradual SLR by itself does not lend itself to the makings of a crisis, and the more visible and immediate problems from coastal storms and erosion—though logically connected—have played only a minor (and clearly not a consistent) role in triggering policy changes. To the contrary, erosion crises and storm disasters seem to have played a much more significant role in weakening or at least threatening to weaken existing coastal legislations. Disasters also lend an air of certainty to coastal hazards that can drown out concerns with lower-salience processes such as SLR. Crises not only put issues such as SLR "on the back burner", but they also require immense—and immediate—attention and financial and human resources, which are then not available to less imminent problems. Finally, unless clear and well-established retreat policies have been in place for some time before a disaster, the human response to crisis typically is one of wanting to reestablish the pre-disaster status as quickly as possible, rather than establishing new "rules of the game" in a situation of great distress.

Furthermore, the "real" reasons behind SLR responses suggest important points of policy intervention. The more relevant factor in bringing SLR "to the front burner" in these states can be labeled "opportunities and opportunism". Opportunities included funding from state and federal sources to study SLR impacts, coastal program evaluation processes,[14] and individuals and groups of

[14]Common state program reviews are undertaken under Section 309 of the US Coastal Zone Management Act—the Coastal Zone Enhancement Grants Program. This program provides funding for states to address various areas requiring additional attention, such as wetlands use, restoration, and reclamation, coastal hazards management, access to coastal areas, and Special Area Management Planning. It aims specifically at supporting the implementation of policies and attainment of state and federal coastal zone management goals, thus strengthening accountability of state programs to the federal program.

people having the time, inclination, or interest to look into the SLR issue more closely. Opportunism was evident in situations where the SLR-related policy change primarily served other political goals—as the example of ME illustrated where policy change occurred to help restrict a certain type of shoreline development (e.g., "New Jersey-ization") during the development boom of the late 1980s. These findings could serve as important guides for federal policy intervention to encourage states to address SLR.

Fourth, leaders and expert networks can exert an important and indispensable influence on policy-making, rule-making, and public education. Credible, well-connected, and persistent experts exert considerable influence in political circles, on rule-making processes, and on public opinion. In the cases examined here, they educated and kept SLR on the front burner, and they worked closely with state planners and policy-makers to move issues onto the political stage and to inform policies through occasional expert testimony, ongoing technical advice, and countless public talks. Each state has its own close-knit coastal "epistemic community" (Haas, 1992; Sabatier and Jenkins-Smith, 1993), whose professional ties frequently extended beyond and into the other two states. This makes individual scientists and expert networks important drivers of the SLR policy issue, if not necessarily a visible one.

Where the sea meets the land, deeply ingrained—and conflicting—social values also clash. One of the most significant systemic agenda items in contemporary coastal management—on the waves of which US shorefront management rides—is the clash between the defenders of private property rights and those of public trust and safety. While space limitations prevent an adequate discussion of this issue, findings from these three case studies suggest that this debate is producing legal and social crises, and can intimidate coastal policy-makers into leniency in implementation of rules and regulations, or at least into maintaining a pro-property-rights, pro-development status quo.

Another conclusion from the case studies is that policy choices must simultaneously contend with natural variability, social justice, and historical legacies. States already find it challenging to design and legally defend rational policies that are socially just (in process and outcome), and that account for a natural environment that is dynamic and variable (e.g., variable erosion rates along the shoreline within one jurisdiction). In addition, past management decisions involve not just social and political legacies, but have physical implications that can narrow current management options. For example, the old adage of "seawalls beget seawalls" can be interpreted both in a legal and a geophysical sense. The implications of this well-established finding are at least two-fold: concerted efforts are needed to adjudicate (and identify appropriate financiers of) remedial action where past management choices have caused present-day crises. Moreover, as present-day management decisions create the physical, social, and legal liabilities of tomorrow, far greater educational effort is needed to create awareness and management options for practitioners and coastal residents today.

Finally, known best practices can address scientific and human-dimension uncertainties. This study demonstrated that, while scientific uncertainties matter in the formulation and implementation of coastal policies, they were only rarely used as an excuse for inaction or overt delay tactic. This is not surprising given the choice of "policy pioneers" for this study. Still, in each case, certain individuals—both academics and managers—were essential in persuading others, identifying comprehensive and forward-thinking policies, and pushing them through lengthy and contentious regulatory processes. What is more interesting is that these states model options for addressing such uncertainties, e.g., through flexible baselines, remapping and updates of erosion rates (as a base for setback rates), successively more stringent retreat policies, or planning guidelines. Human-dimension uncertainties also played a significant role, such as when and how the problem was detected, perceived, and framed; who the involved players were; the design, stability, and flexibility of institutions coordinating societal response; and the differences in strategies and policies employed. The three states employed different mechanisms through which these uncertainties were, or could be, addressed, including institutional reforms, greater stakeholder involvement, conflict resolution efforts, program streamlining, insurance arrangements, educational outreach, and various efforts to strengthen policy implementation.

Thus, conscious or not, coastal managers working toward coastal management that accounts for future risks function under a chronic lack of certainty—in the physical environment, the scientific basis, and the socio-political context. Moreover, given that sea level is already rising along the shores of these three states (and most everywhere else in the US), "dealing with sea-level rise" may in fact be what is happening now: crisis management under perpetual uncertainty.

The uncertain dimensions of the *policy-making and management process* are summarized in Table 5 while the uncertainties in the *conditions* that restrict or allow policy change are summarized in Table 6.

These two summary tables elaborate on the adaptation aspect in Table 2, in that the conditions that affect policy-making and management determine the degree and types of adaptation options that will be considered and chosen. The findings here also correspond to those summarized in Table 3 in that they reinforce the importance of values, cognitive processes, and attitudes toward scientific knowledge, uncertainty, and the environment.

Table 5
Uncertainties in the policy-making and management processes

Signal detection and problem perception
Nature and clarity of signal
Proximity of experience with the process from which signal emanates
Values
Education
Availability of information
Problem definition
What is natural?
Interpretation of the nature of the problem
Source, credibility of those identifying and defining the problem
Political influences
Underlying systemic agenda
Actors
Involved players, changes among them over time
Not involved players, missing players
Degree of influence and effectiveness
Degree of connectedness
Communication among actors
Steadfastness, constancy, persistence
Policy-making and management institutions
Design
Stability
Flexibility
Reach (horizontal, across scale, constituencies)
Effectiveness and efficiency
Policy choices/strategies/operationalization
Cost/benefit
Geographic variability of adapted policies
Physio-geographic variability of affected coastal systems
Social equity
Loci of intervention (upstream/downstream; preventive/adaptive)
Effectiveness in achieving the desired end
Legal feasibility
Policy implementation
Degree and timing
Efficiency
Effectiveness
Unanticipated side effects

Table 6
Uncertainties in the conditions for policy-making/policy change

Disasters and crises
Trigger for more stringent/for loosening policy
Distraction
Issue suppressor
Consumption of financial and human resources
Opportunities for agenda-setting
Funding
Mandate from above/public demand from below
Regular policy review process
Personal interest
Time availability
(Un)intentional connection with unrelated agenda item
Epistemic communities
Strength and stability of expert community
Breadth of expertise (geographic and disciplinary)
Quantity and quality of contact points to political/governmental actors
Political savvyness/effectiveness of experts
Credibility
Coalitions and stakeholder involvement
Opportunities for public participation
Opportunities for and actual coalition-forming
Constituents (and their respective problem definitions)
Strategies (cooperative vs. adversarial)
Capacity (technical, scientific, political know-how)
Political effectiveness
Political context
Underlying systemic agenda (issues of contention, conflicts, perpetual concerns)
Mobilization of interest groups
Political balance (included within judicial system) and changes therein
Degree and direction of impact on policy-makers and managers

4. Synthesis and conclusions

The research presented here aimed to answer, first, how impact assessments can be broadened to better account for the uncertainties in the human factors, which (1) co-create (along with physical factors) the impacts of SLR, (2) influence how they are assessed, and (3) affect how society responds to these impacts. And second, the study looked at how the uncertain impacts of SLR are (or could be) addressed in policy-making and management.

Through an assessment of the scientific knowledge base and a detailed policy analysis in three US states, I detailed four sets of human-dimension uncertainties: (1) human factors that co-determine the impacts of SLR (i.e., those that beg to be addressed in future scientific research); (2) human factors that affect how SLR impacts are studied and assessed (contextual elements of the assessment itself); (3) human factors that pervade the policy-making and management process; and finally, (4) human factors that affect the external conditions for policy/management change. Underlying all of these are deeper sources of human-dimension uncertainties related to differences in human values, cognition, decision-making, and institutionally embedded behavior (see also Burton et al., 1993; Finucane et al., 2003; Jamieson and VanderWerf, 1994; Svenson, 2003).

The study components produced several complementary findings that point to important future research directions, while suggesting a more cautious optimism regarding developed nations ability to adapt to the impacts of climate change. For example, experts identified that societal response to ‘‘creeping’’ environmental hazards are less intensely studied than responses to acute hazards, that non-linearities in the physical system are studied more than in social systems, and that our paradigmatic and disciplinary ‘‘blinders’’ may reinforce existing areas of uncertainty and ignorance. Given the important role science can play in setting policy and management agendas and in helping to get appropriate policies in place, these findings suggest that science could play an even stronger, more conscious role in fostering societal response to gradually unfolding hazards and alerting the public to potential surprises or at least to the possible feasibility limits of common response options.

The policy histories of the three pioneer states further illustrate that gradual hazards do not easily compel or sustain policy and management attention in a resource-constrained, crisis-driven, and frequently contentious political environment. Past and ongoing research suggests that this situation is not unique to the three coastal states examined here, or to the coastal sector.[15] Continued movement toward devolution, growing anti-regulatory and pro-private property sentiments, and ongoing fiscal crises at the federal, state, and local levels suggest that the management situation for coastal managers in the US will not significantly ease in the foreseeable future. Besides SLR, creeping problems such as desertification, biodiversity loss, and urban sprawl also progress away from the radar screens of political attention until they reach crisis stage. Underlying drivers are similarly deeply embedded in values, ways of thinking, rights, habits, institutional arrangements, and social change processes that—if and when addressed—feed political conflicts and competition over scarce resources.

Another implication of this research puts into question a common assumption in impacts studies. Informed by the policy windows literature, assessors frequently assume that policy innovation (and hence implementation of adaptation measures) will occur in the wake of disaster. The empirical studies presented here suggest, however, that disasters create human crises that make it extremely difficult for local managers and elected officials to respond with anything but "back-to-(the pre-existing)-normal". Resource and staff demands during those times make policy innovation even less likely. More studies are needed to test these divergent findings. Further empirical insights into such deep-seated human dynamics and the uncertainties therein may also prove useful in current attempts to understand the difference between *potential* and *actually realized* adaptive capacity (Kasperson and Kasperson, 2001, p. 17) and social learning. In particular, research aimed at better understanding behavior change and barriers to understanding, decision-making, and action could prove especially helpful for direct policy applications.

The combination of insights from the states' studies that mitigation of acute hazards is inadequate for long-term SLR preparation, but often the dominant response; that long-term losses of shorefront development can only be avoided if rules and regulations incorporate a moving shoreline (which only some states do); that long-term development planning is the weakest link in current coastal management; and that few mechanisms currently exist to address inequities, historical legacies, and conflicts among entrenched interests suggest that future impacts on coastal areas may be far more costly—financially and socially—than most current coastal impacts studies for developed nations acknowledge. Greater attention on these human-dimension pressures and the uncertainties therein could produce more realistic impact assessments and more effective coastal zone management options to deal with present and future coastal hazards.

[15]See Moser (2000) for a comparative study of five communities along the Atlantic, Gulf, and Pacific coasts of the US dealing with chronic coastal erosion. For a comparison of Maine's and Hawaii's responses to SLR see Moser (2005b). Current research by the author focuses on adaptive capacity of coastal California (see: http://www.isse.ucar.edu/moser/research.html).

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