PLANNING FOR SEA LEVEL RISE AND SHORE PROTECTION UNDER CLIMATE UNCERTAINTY

GARY YOHE

Department of Economics, Wesleyan University, Middletown, CT, 06459 and Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh, PA, 15213

JAMES NEUMANN

Industrial Economics, Inc., 2067 Massachusetts Avenue, Cambridge, MA, 02140

Abstract. Attention is focused here on the effect of additional sources of uncertainty derived from climate change on the cost-benefit procedures applied by coastal planners to evaluate shoreline protection projects. The largest effect would be felt if planners were trying to achieve the first best economic optimum. Given the current view that the seas will rise by significantly less than one meter through the year 2100, present procedures should work reasonably well assuming (1) informed vigilance in monitoring the pace of future greenhouse induced sea level rise, (2) careful attention to the time required for market-based adaptation to minimize the economic cost of abandonment, and (3) firm support of the credibility of an announced policy to proceed with plans to retreat from the sea when warranted. Assumptions (1) and (2) might be satisfied in reality, even cursory review of existing policy makes it clear that meeting (3) is a "long shot" at the very best. In any case, planners should periodically revisit potential protection sites, especially in the wake of catastrophic events, to assess the impact of the most recent information on sea level rise trajectories, local development patterns, and protection costs on the decision calculus.

1. Introduction

Even in their most general incarnation, most of the valuation procedures applied by the Army Corps of Engineers and other agents and/or agencies responsible for coastal planning are rigorously rooted in the principles of cost benefit analysis - a well understood valuation procedure that relies heavily upon large quantities of well established and generally accepted data. The purpose of this paper is to judge whether or not these procedures need to be modified for coastal protection projects in the face of uncertain greenhouse induced sea level rise. There would, of course, be little to worry about if the future pace of rising seas were well known and widely accepted; but that is not the case. The most recently view published by the Intergovernmental Panel on Climate Change [IPCC (1992)], for example, still puts equal weight across a range that runs from 33 cm through almost 1 meter (through the year 2100) even as it offers 67 cm as its most likely scenario.

It stands to reason, therefore, that the enormous uncertainty with which we currently view the likely pace of greenhouse induced sea level rise might be

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expected to wreak havoc on any of cost-benefit methods to prospective projects designed to protect the shoreline from inundation. We argue, here, to the contrary. We will conclude, more specifically, that careful consideration of the nature of that uncertainty, even when compounded with uncertain perception of the integrity of policies that announce the property will not be protected, suggests that present practices should be sufficient. The effect of uncertainty that will resolve itself only gradually over time can be almost negligible except in situations in which planners try to achieve maximum economic efficiency by exploiting the market's ability to minimize the cost of retreat from the sea. Even then, vigilant monitoring of gradual sea level rise should be sufficient to allow decision makers to make timely, and relatively well informed decisions and to announce *either* that property will be protected with sufficient time for either least cost protection strategies to be followed *or* that property will not be protected with sufficient time for cost minimizing market based adaptation to proceed through completion.

Discussion in support of this conclusion follows. It begins in Section 2 with a cursory review of federal and state policies and programs that apply most directly with coastal planning. Section 3 follows with a very brief discussion of the state of our expectations of future greenhouse induced sea level rise. Dispersion in published estimates has been falling over the past decade, but uncertainty is still enormous. Section 4 casts the discussion of adaptive responses in terms of three alternative objectives. Each is described following the template offered by the IPCC technical guidelines for assessing climate change impacts and adaptations; and they are distinguished by the degree to which they instruct planners to pursue economic efficiency. A fifth section applies the three alternatives to a specific location - the five local areas contained within the Charleston, South Carolina site that was part of a national sample designed to estimate the economic cost of sea level rise in the United States. The selection of policy objective matters even at the very local level, but not to the degree that one might expect. Indeed, careful review of the illustrative Charleston application suggests a procedure by which the effect of uncertainty on coastal planning might be managed even when the first best optimum is pursued. Section 6 records a detailed description of that procedure before a short concluding section finally closes the discussion by restating the general conclusion: as large as it might be, uncertainty over the future trajectory of greenhouse induced sea level rise can be handled by small modification in current coastal planning procedures.

2. Policy Review

The influence of coastal zone management policy is significant for specific aspects of the coastal structures analysis. The analysis of various planning options that follows will utilize a concept of "foresight" to represent how coastal real estate markets might respond to the threat of greenhouse induced sea level rise. Under the perfect foresight envisioned there, coastal property owners will be assumed to consider fully the potential risks of sea level rise, respond appropriately in the context of that, and thereby minimizing potential damages to coastal property. If coastal property owners do not incorporate fully the threat of sea level rise into their decisions, however, damages cannot be minimized. Coastal planners, and the structures that define the parameters of their work, must take that into account. A brief review of some of the highlights of the current state of coastal zone policy follows to provide some context for this accounting.

2.1 FEDERAL POLICIES

Federal policies directly related to coastal erosion and development are administered primarily through four federal agencies: the Federal Emergency Management Agency, the Department of Commerce, the U.S. Army Corps of Engineers, and the Department of the Interior. The Federal Emergency Management Agency, for example, administers the National Flood Insurance Program (NFIP), a program that provides subsidized insurance for damage to structures due to flooding or coastal erosion. It is limited to communities in participating states that adopt land use regulations and building standards (e.g., elevation requirements) for development in areas vulnerable to flooding.

The influence of the NFIP on coastal development decisions ideally should be assessed on a local level. For present purposes, however, it is useful to consider its overall influence. Klarin and Hersman (1990) report that the NFIP has been generally criticized for providing incentives for development and rebuilding in flood-prone coastal areas. Because the building standards focus on elevation requirements, these regulations have shifted development primarily in a vertical rather than horizontal direction. The NFIP seems to enable landowners to maintain properties in high-risk coastal areas that, without insurance, they might abandon.

The Upton-Jones Amendment to the National Flood Insurance Act was passed in an effort to mitigate the effects of erosion and to reduce NFIP costs by encouraging property owners to remove unstable structures. This amendment authorized funds from the National Flood Insurance Fund (NFIF) for the demolition or relocation of insured structures that were about to collapse due to erosion. The NFIP also called for long-term planning for areas affected by flooding. Because eligibility was narrowly defined under the amendment, however, Platt (1992) has noted that few claims have been made.

The Coastal Zone Management Act (CZMA), administered by the Department of Commerce, called for better management of coastal land and water resources through federal and state collaboration in planning for non-federal coastal areas. The act authorized federal funds for states to develop and implement coastal zone management programs. The National Coastal Zone Management Program requires that state coastal management programs address the specific objectives of minimizing the loss of life and property due to improper development in areas vulnerable to flooding, erosion and saltwater intrusion and due to the destruction of natural protective features (e.g., beaches, dunes, wetlands, barrier islands). Klarin and Hershman (1990) provide a more complete description of these points.

While the effects of sea level rise are not specifically addressed by the CZMA, Edgerton (1991) reports that it does provide a framework for states to mitigate the effects of coastal erosion, including erosion caused by sea level rise. Because federal guidelines give states wide latitude in designing programs, the effectiveness of this federal measure in addressing coastal management issues must be assessed by examining programs developed by the individual states. As of 1991, two of the 21 coastal states had not developed an approved coastal management plan or received federal funding (Georgia and Texas).

The Army Corps of Engineers has many responsibilities related to coastal management: identifying areas vulnerable to erosion, investigating the extent of shoreline erosion and potential response strategies, authorizing and carrying out various coastal stability projects, and so on. In general, the Corps considers local and regional rates of historical erosion and sea level rise in designing coastal protection measures; as can be deduced from reading Edgerton (1991), it is only recently that their planning procedures have thought to address potential increases in the rate of sea level rise. At the same time, the Corps increasingly brought risk-based analysis to bear on its standard procedures for evaluating of specific shore protection projects. As a result of both of these initiatives, current operating procedures do not fall very far short of a proactive stance that assumes foresight and adaptation. Indeed, Stakhiv (1993) highlights requirements for comparing futures under uncertainty defined along "with" and "without" project scenarios. The wrinkle imposed by Option CBWAF is simply that the "without" project scenarios include automatic market-based adaptation to the future as it would unfold without Corps intervention *and* with the market believing that the no-intervention policy will stand. There are times when projects that would pass the cost-benefit test without that adaptation (i.e., structure depreciation) would fail the test with adaptation and thereby confront planners with distributional issues that lie beyond their purview and test severely the credibility of the policy-makers who define the planning context.

Finally, the Department of the Interior administers the Coastal Barriers Resources Act (CBRA) which creates a national system of protected coastal barrier areas (e.g., dunes, beaches, bluffs, wetlands). To discourage development within these coastal barrier areas, federal subsidies for infrastructure and hazard insurance are prohibited. The regulations under CBRA apply to limited areas, therefore, this measure is likely to have a local rather than a broad influence on coastal zone management decisions.

2.2. STATE POLICIES

Coastal zone management policies on the state level are dominated by activities under the CZMA. To receive federal funding, states must develop approved coastal zone management programs. These programs may involve various measures including establishing construction zones (with special building codes and permitting requirements) for new development or reconstruction and establishing construction setbacks. Construction setbacks may cover a fixed distance or may "float" according to erosion rates (e.g., a 30-year construction setback defines where the shoreline is predicted to be located after 30 years of erosion). States may or may not explicitly address the potential effects of sea level rise as part of their coastal zone management programs.

The relative strength of these state coastal zone management programs varies, therefore, and so the response of coastal property owners changes from state to state. In considering the likelihood that Option CBWAF might be applicable, though, it is essential to assess the potential for current or future property owners to incorporate risk into their decisions. Some states have developed coastal management programs or plans to minimize damages from coastal erosion. Those states with policies that seem to actively manage both new development and reconstruction (i.e., existing development) in the coastal zone are likely to encourage property owners to incorporate the risks of sea level rise into their decisions.

Coastal management in South Carolina, for example, is governed on a state level primarily by the South Carolina Beachfront Management Act of 1988 (BMA). This act was preceded by the South Carolina Coastal Zone Management Act of 1977, which defined the coastal zone to include the eight counties bordering on tidal waters, defined "critical areas", and created the South Carolina Coastal Council to administer the state's coastal management program. In addition to other responsibilities, the Council was directed to carry out an erosion policy by identifying critical erosion areas and evaluating the benefits/costs of erosion control. The BMA was established to provide a regulatory framework for construction along the coastline. Under the act, the Council was required both to establish a baseline running parallel to the shore along the crest of the primate dune from which to measure erosion setbacks and to develop a state-wide, long-range comprehensive beach management plan.

Two construction zones were established by the BMA. The first setback established a "dead zone" 20 feet landward of the baseline within which new structures could not be built and existing structures "damaged beyond repair" (defined as a loss of two-thirds of the value of the structure) could not be reconstructed. The second zone, which applies to eroding coast only, designated the landward area equal to 40 times the average annual erosion rate as the 40-year setback zone. The BMA included a provision for resetting the act within ten years and every five to ten years thereafter. The BMA placed restrictions on reconstruction seaward of the setback line. Within the 40-year zone, new construction was limited to 5,000 square feet of heated space and rebuilt homes could not exceed the size, lateral extent or proximity to the ocean of those that are replaced. Melville and Platt (1992) offer a thorough review of BMA.

A test of South Carolina's coastal management policy was provided by Hurricane Hugo which caused severe damage to beach front property in and around the Charleston area. The rebuilding of coastal structures after Hugo was governed by two regulations; the federal National Flood Insurance Program (NFIP) and the state Beach Management Act. Under the NFIP, structures damaged more than 50 percent of pre-storm value would have to be elevated above the estimated 100-year-flood level plus wave heights. Under the BMA, structures "damaged beyond repair" (more than two-thirds of pre-storm value) could not be reconstructed in the "dead zone" (20-foot zone) or seaward of it.

Beatley (1992) reports that, the BMA did not prove to be a significant factor in rebuild decisions in vulnerable coastal areas after Hugo primarily for two reasons. First, following the hurricane, damage assessments were liberally interpreted with each building component evaluated separately as a percentage of structure value. Under the state's point system, the foundation makes up 25 percent and the septic system, 10 percent of the value, therefore a house could be completely swept away and not be "damaged beyond repair". At Folly Beach (a coastal barrier island about 10 miles from downtown Charleston), only 11 percent of the ocean-front lots were ineligible for reconstruction due to the dead zone requirements. Second, in 1990, the BMA was amended and the dead zone eliminated for the entire state shoreline but the 40-year setback was retained. Certain areas, such as Folly Beach however, were exempted from even the 40-year setback requirement. A survey of owners of heavily-damaged beachfront property indicated that most had repaired or rebuilt their homes and of those who had not rebuilt, only 12 percent cited restrictions under the BMA as the reason.

State septic systems regulations, which require that septic systems be restored before occupancy permits are issued, have proven to restrict reconstruction in the state more than erosion or zoning regulations. The South Carolina Department of Health and Environment requires that no part of a reconstructed sewer system be within five feet of a building or property line or within 50 feet of mean high water elevation. Therefore, storm damaged areas that rely on individual septic systems may not be rebuilt. For example, following Hugo, lots with damaged septic systems in Folly Beach will not rebuilt because these areas are not served by public water (Beatley 1992).

Case law may also influence the effectiveness of coastal policies. In the *Lucas v. South Carolina Coastal Council* case, the Coastal Commission appealed a decision that awarded the owner of two lots $1.2 million for denial of a permit by the Commission. The Coastal Commission won the appeal in 1991 but this decision was reversed in 1992 by the U.S. Supreme Court which felt that where the value of a property is essentially "destroyed" by regulation, the owner should be compensated. As noted in Melville and Platt (1992), this decision may have significant implications for both current and future coastal management policy.

A few major conclusions about the impact of South Carolina's coastal policies emerge from the above discussion. First of all, the use of a 40-year setback zone that allows special permits (the building or rebuilding of homes with up to a 5000 square foot area is allowed) indicates that although the BMA is intended to minimize future erosion damage to coastal properties, the coastal management regulations are fairly permissive. In practice, coastal management policies in South Carolina do not seem to encourage property owners to incorporate the risks from sea level rise into their development decisions. The fact that the BMA did not prove to be a significant factor in rebuilding decisions after Hurricane Hugo indicates that coastal zone management policy in South Carolina is not as effective as intended. Secondly, other state policies (e.g., state septic system regulations) may restrict reconstruction of coastal property following a storm more than the current coastal management policies. Finally, the outcome of the *Lucas v. South Carolina Coastal Council* case is likely to discourage state agencies from regulating private property through stringent coastal management legislation, which may in turn provide fewer incentives for landowners to incorporate risks from sea level rise in their investment decisions.

The coastal policies in nine other coastal states as well (California, Florida, Georgia, Louisiana, Massachusetts, New Jersey, Rhode Island, Texas, and Virginia) offer little more in the way of encouragement. These states were chosen because they contain the largest number of coastal sample sites in our previous modeling analyses (Yohe et al. 1996). Florida, Rhode Island, and Massachusetts have fairly comprehensive coastal zone management policies; and Texas has a strict coastal redevelopment policy. If these policies are successfully implemented and enforced, property owners in these four states are likely to consider the risks associated with sea level rise in their development decisions. In terms relevant for the coastal structures model, property owners in these states (relative to other states) could be expected to exhibit foresight some of the foresight required in Option CBWAF.

Coastal zone management responsibilities in California are divided between two regulatory agencies with differing approaches to coastal zone management. As a result, it is difficult to determine the general response of property owners to the threat of higher seas. Similar to South Carolina, New Jersey has a coastal zone management policy that does not seem to encourage property owners to incorporate the risks of sea level rise into their development decisions (i.e. property owners may not exhibit perfect foresight). Coastal regulations in both states do not seem to be as effective as intended by policy makers.

Georgia, Louisiana, and Virginia do not have specific coastal zone management policies for coastal development. Their coastal zone policies are governed, instead, by federal policies (i.e., by NFIP). Because the NFIP seems to enable landowners to maintain properties in high-risk coastal areas, they are not likely to consider the risks of sea level rise in development decisions (i.e., property owners may not exhibit perfect foresight).

Finally, two states (Florida and New Jersey) have established funds for beach nourishment project. Property owners in these states, located in highly developed areas, are likely to believe that the state will protect their property from the risks of sea level rise (i.e., they will not be forced to abandon their property). This concept is supported in the coastal structures analysis.

3. Representing the Uncertainty

Figure 1 expands upon the message of the IPCC trajectories to reflect some of the major contributions to the brief history of published estimates of greenhouse induced sea level rise through the year 2100. The bars drawn there represent the range of uncertainty reported by the various authors. Uncertainty is sometimes expressed in terms of conventional but unspecified "error bands" [e.g. EPA (1983), NRC (1985), WMO (1985) and IPCC (1992)]. At other times, quantified confidence intervals tied to comprehensive analyses of the sources of sea level rise are reported [(e.g., Titus and Narayanan (T&N, 1995) for which a 90% confidence interval is drawn]. Still elsewhere, quantified ranges tied to specific driving scenarios have been constructed without regard to relative likelihood [e.g., Wigley (1995) for which the bar highlights the range associated with constraining concentrations of carbon dioxide to no more than 750 ppm - a constraint deemed binding in the year 2250].

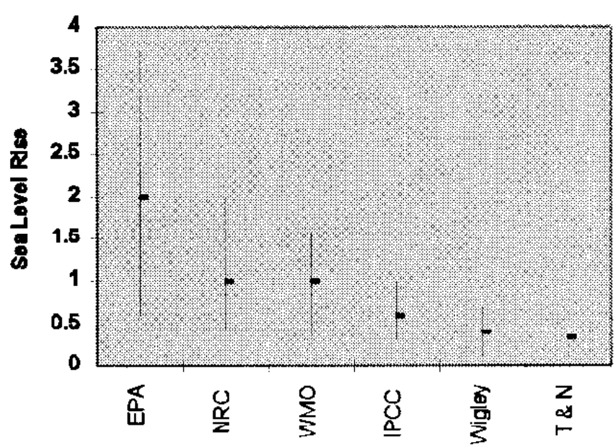

Figure 1. Ranges of anticipated sea level rise through the year 2100 (in meters) from selected sources published since 1983.

The ranges depicted in Figure 1 are thus not exactly comparable, and its coverage is far from comprehensive. Two tendencies are nonetheless obvious even from casual review of what it does portray. Estimates of the effect of warming on sea level have, first of all, shown persistent decline over the past decade or so. High, low and middle estimates of sea level rise through 2100 have all fallen steadily, over that time, t_o the point where most if not all of the subjective probability supported by any type of analysis now falls below 100cm. Secondly, the range of uncertainty, while relatively stable since 1990, is markedly smaller than it was just ten years ago. Absent any surprises, therefore, future trajectories of gradually rising seas are likely to be among the more predictable of the physical impacts of global change.

4. Developing Alternative Adaptive Responses

Table I uses the evaluation template portrayed schematically in Figure 6 of the IPCC Technical Guidelines [IPCC (1994)] to organize a presentation of three alternative modes of response to the inundation threat of greenhouse induced sea level rise. The middle option, denoted "Cost-Benefit Absent Adaptation (Option CBAA) most closely conforms with what might be construed as routine application of existing coastal planning procedures. It envisions planners observing a threat to a specific tract of developed property with sufficient time to evaluate, plan and implement a protection project. The planners must, in this case however, conduct its evaluation knowing that markets and other institutions have not had sufficient time to minimize the potential cost of the abandonment. Procedures may thus be directed toward achieving cost-benefit efficiency, but the benefit sides of their supporting calculus are constrained by limited information, myopic foresight, and perhaps jaundiced perceptions of the integrity of an announced policy that chooses to *plan* to abandon property.

The preferred option, dubbed "Cost-Benefit with Adaptation and Foresight" (Option CBWAF) modifies the timing and foresight environment so that the first best optimum might be achieved. It is assumed here that planning and evaluation can be conducted with enough advanced warning that automatic adaption prior to inundation can work to minimize the potential cost of abandonment. These are strong assumptions, to be sure; and they can apply only (1) when quality information about what the future might hold over the relatively long term is available and (2) when real estate markets firmly believe that policy decisions to abandon property made well in advance of their necessity will actually hold when the inundation becomes imminent.

A third alternative, called "Protection Guaranteed" (Option PG) steps beyond the cost-benefit paradigm of standard planning procedures and into a regime that guarantees protection as a matter of ubiquitous policy. The question here is one of

Table I

Adaptive Strategies - Alternative Responses to Sea Level Rise

	OPTION CBWAF	OPTION CBAA	OPTION GP
OBJECTIVE:	Maximize Economic Efficiency	Constrained Maximum Efficiency	Minimize the Cost of Protecting All Developed Property
CLIMATE IMPACT:	Inundation Trajectories	Inundation Trajectories	Inundation Trajectories
ADAPTATION OPTIONS:	Will Protect: - financing?	Protect: - financing?	Protect: - financing?
	Will not protect: -cover full value of land? - cover depreciation?	Do not protect: - cover full value of land? - cover full value of structure?	
QUANTIFICATIONS:			
The Benefits of Protection	smallest	larger	n/a
The Likelihood of Protection	smallest	larger	100%
The Cost of Protection	smallest	larger	largest
Distributional Concerns	potentially large	perhaps larger (more value lost) perhaps smaller (less abandonment)	n/a
Other Tradeoffs:	Environmental impact could be significant with smallest marginal cost of preservation	Environmental Impact less likely to have an effect on decisions	Environmental impact likely to be irrelevant
Adaptive Measures:	Protect or not - 30 yrs. notice required for complete market adaptation	Protect or not - as required with sufficient time to respond	Protect as required with sufficient time to respond
Likely Context:	Threatened property with little political clout	Threatened property with considerable local clout	Threatened property with significant and widespread clout
	Small, geographically concentrated funding source	Intermediate sized funding source	Large, geographically disparate funding source
Uncertainty	Sea level rise trajectory likely to be significant	Sea level rise trajectory less important	Sea level rise trajectory less important
	Credibility of long term policy critical	Credibility of short term policy important	Policy credibility guaranteed

achieving that protection with minimum cost, and only the near term foresight that supports for Option CBAF is required.

4.1. A GENERAL MODELING APPROACH

In Options CBWAF and CBAA, planning how to respond to rising seas along a developed coastline for a specific sea level rise trajectory can be broken into two distinct decisions that are easily accommodated by general planning procedures designed to maximize the discounted value of the benefits of any protection strategy net of the cost of its implementation. The first, a decision to protect the coastline starting at some time t_0, is reversible; it is always possible to decide at some later time T to abandon property that had previously been protected. The other decision, the decision not to protect shoreline property (or to stop protection at time T), is irreversible. Planning any heroic and expensive attempt at reclaiming previously abandoned property should always have been dominated in the planning process by the less expensive option of protecting (or continuing to protect) that property all along.

The (net) benefit side of a decision to protect a shoreline from time t_0 through time T can be modeled as the opportunity cost of abandoning coastal property, and so calculation of that opportunity cost requires a time trajectory of the (future) value of property vulnerable to sea level rise along some specific scenario. What might such a trajectory include? Assuming the efficiency of perfect anticipation, foresight, and adaptation involved in computing the true economic cost of sea level rise envisioned in Option CBWAF, it will be argued that a value trajectory should reflect only the value of parcels of interior land equal in area to inundated shoreline property. Efficiency conditions need not be satisfied in every case, though. Protection decisions may, indeed, be made on the basis of second or third best behavior; and the shifting of the property gradient inland may not be as complete as contemplated in the maximum efficiency case. Option CBAA allows for incorporating values on the benefit side that have not been reduced by *any* efficient market anticipation of abandonment. In such a case, the value trajectory could easily include 100% of the value of coastline structure. Option GP ignores the benefit side, altogether. In any case, though, the trajectory is not a cumulative statistic. It is, quite simply, the value of (unprotected) property that would be lost at time T, and it is time dependent by virtue of its reliance on an underlying sea level rise trajectory. It must, therefore, incorporate appreciation in property values over time, where appropriate, regardless of the source of that appreciation (economic growth, property improvement, investment in infrastructure, etc...).

Given a value trajectory of this sort, it is important to note that the present value of the net benefit to society from protecting property from time t_0 through time T is the sum of two components. The first is the value of protection, expressed in terms of the sum of the value of property that was not lost, incrementally over time, because of the protection (discounted from the time when protection became necessary for each increment at some discount rate r). The second term captures the value of all of the property that had been protected but then abandoned at time T. All of this property will have some value at time T - the time of abandonment - but its loss should also be fully discounted.

The cost of protection from time t_0 through time T is easier to frame. For standard, fixed structure protection projects, a cost trajectory might include significant fixed costs early and relatively modest maintenance expenditure downstream. For protection projects requiring beach nourishment, however, costs would likely begin with modest investment in sand and fill but could grow dramatically over time as the volume of sand required expanded. Indeed, this sort of expanding trajectory could even be highlighted by occasional expenditure "spikes" that correspond to the construction of fixed supporting structures designed to enhance the protective capabilities of a nourished beach.

The planning problem in Options CBWAF and CBAA is thereby reduced to one of picking (t_0*,T*) which maximized the present value of the net benefit of protection. In practice, working within Option CBWAF would require identifying t_0* early in the planning process - at least well in advance of the date of possible inundation. Working with Option CBAA meanwhile requires only that t_0* be identified shortly before inundation is imminent. Option GP similarly requires that t_0* be known with enough warning that decision makers can chose among feasible protection strategies to minimize the present value of the anticipated stream of costs.

4.2 OPTION CBWAF

Turning now to some of the details recorded in Table I, consider Option CBWAF first. The set of alternative responses available under Option CBWAF along any sea level trajectory can be simply phrased: announce that property will be protected with enough credibility that least cost protection can be achieved *or* announce that property will not be protected with enough credibility that least cost abandonment can be facilitated. Option CBWAF would strive to achieve maximum efficiency, and so its cost benefit structure would rely heavily upon an ability to foresee what the future might hold both in terms how quickly the seas might rise and in terms of how the market would respond to a growing understanding of the corresponding threat to shoreline development. Economic damage that might be attributed to future sea level rise in the absence of any decision to protect threatened property (and thus the benefit side of any protection project) would be calculated in terms of the value of that property at the (future) time of inundation given any adaptation that might have occurred naturally and efficiently prior to flooding and abandonment. Portraits of both future development and efficient market adaptation would therefore be required from the very start.

Satisfactory descriptions of how future development might affect coastline real estate values could be derived from empirical market analyses of how property values might change as factors such as population and real income change. Planting scenarios of how these "driving socio-economic variables" might move as the future unfolds into accessible empirical studies could, more specifically, produce historically based portraits of how real property values might change over the same time frame. Absent any fundamental structural change in local real estate markets, the resulting development trajectories would offer representative portraits of the evolving context of the sea level rise problem.

Satisfactory descriptions of how real estate markets might respond on a more micro, local level in the face of threatened inundation from rising seas are more difficult to create, but they would be an essential part of the defining maximum economic efficiency to which Option CBWAF aspires. Yohe (1989) and Yohe et al. (1995) provide some insight into how to proceed. Both sources note, first of all, that land and structures should be considered separately. Procedures that account appropriately for the economic cost of losing land do not account accurately for the economic cost of losing structure in the context of efficient market anticipation of inundation and abandonment.

On the one hand, the land lost to rising seas should, in most cases, be estimated on the basis of the value of land located far inland from the ocean. Any price gradient which placed higher values on parcels of land in direct correlation with their proximity to the ocean would, in a very real sense, simply migrate inland as shoreline property disappeared under rising seas. The cost-benefit paradigm ignores what could be significant transfers of wealth for the purpose of computing social cost and accepts the convention that the true economic cost of inundation would be captured in most cases by the value of the land that was, in an economic sense, actually lost - interior land equal in area to the abandoned and inundated property. The exception to this procedure occurs when rising seas threaten a barrier island where the property value gradient encroaches from two sides. It is still possible to use the value of interior land to reflect costs, but care must be taken to note when interior values begin to reflect the higher values which define both gradients from the inside out.

The economic value of structures would meanwhile depreciate over time as the threat of impending inundation and abandonment became known. Structures would be lost at the moment of inundation, to be sure, but their true economic value at that point could be zero with enough advanced warning and with a complete understanding that the property would, indeed, be abandoned when the time came to retreat from the sea. Despite stories of individuals' reluctance to abandon threatened property in, for example, flood plains, the literature which records the results of investigations into how markets react to low probability-high cost events strongly supports the assertion that market-clearing real estate prices do indeed decline over time in response to the pending cost of a growing threat. Brookshire, et al. (1985) examined the validity of the expected utility hypothesis as a model of homeowner behavior in the face of low probability-high severity risk - earthquakes in this case. They found evidence to support the hypothesis in peoples' response to expert and legal descriptions of risk even when the same people did not respond privately by purchasing disaster insurance. The Brookshire work reinforced similar conclusions offered by MacDonald, et al. (1987) after an analysis of homeowner behavior in the face of the treat of flooding. All of this work offers evidence to suggest that market values should accurately process information provided by experts on low probability natural hazards. The assumption made here extends that conclusion and argues that property prices should, over the very long term in the face of gradual manifestations of global warming, internalize the threat of rising seas given some validating informational authority (provided perhaps as informally as some loosely documented history of sea level rise).

While uncertainty and policy credibility will receive separate attention below, Table I highlights some secondary issues that should be highlighted, at least in passing, even now. For one thing, how would the cost of protection be financed if it were decided that protection were the right decision? Would local residents and businesses foot the bill entirely, or would it be spread more broadly over a community, a county, a state or even the nation? On the other hand, would private losses be compensated if the public decision were to retreat from rising seas? If so, would lost land be compensated at its market value (including its location premium) or at its true economic opportunity cost (the price of an equal amount of interior land)? Would anticipated depreciation of structure be covered?

These are not questions which the coastal planners must answer, but they are issues that planners would have to consider as it framed its valuation process. If compensation were to be provided as a matter or policy, then an additional cost to abandonment would have to be considered. It would be computed on the basis of property values at the time of the planning decision (in Option CBWAF, well in advance of inundation); but it could nonetheless dominate any calculation of benefits and costs. Certainly, it would turn Option CBWAF into a modified, preemptive version of Option CBAA.

Table I also notes that environmental impact assessments could easily play a significant role in evaluating protection alternatives under Option CBWAF. This is not to say that the value of, for example, preserving an existing ecosystem or helping it to survive might be higher than otherwise; it is, instead, to say that the marginal cost of that preservation would be minimized. If environmental concerns are to endure in the efficiency driven world of the cost-benefit paradigm, therefore, they are most likely to endure when that paradigm is applied in Option CBWAF.

That point notwithstanding, it would appear most likely that Option CBWAF would be pursued in situations in which the citizens who own the threatened property held the least power and faced the most organized opposition to expending public resources. Option CBWAF maximizes the likelihood of abandonment - not an option favored by property owners, but certainly one preferred by taxpayers who see the cost but not the return.

4.3 OPTION CBAA

The alternatives to be considered in applying the tools of Option CBAA can be stated with equal brevity: to decide as needed whether or not to protect property along any sea level rise trajectory. Its application would require some vigilance to be sure that protection projects could be completed (just) before the flooding starts, but that is far less time than the notice required to accommodate the complete market response to future inundation upon which the calculus of Option CBWAF would be based. The cost benefit procedures are nonetheless the same, and the cost calculations are identical. The only difference, in fact, is that the benefit side to any protection plan in Option CBAA would be the *current* (near the time of possible inundation) present value of property that might be lost i.e., the then current market value of that property under the assumption that real estate markets work efficiently.

Table I highlights several additional issues of financing and compensation, but the story is short there, too. Their magnitude might be larger or smaller than in Option CBWAF; while less property might be abandoned under Option CBAA, it might be significantly more valuable. Who pays for protection might also be an issue, but only to a limited degree. It is likely (but not certain) that the policy world has, in accepting Option CBAA, determined that funding would be drawn from a wider tax base whose membership has shown little or no opposition to public investment projects. Funding issues would, in such a policy environment, play little role in any deliberation.

Compensation, by way of contrast, would *not* be an issue under any circumstance. The benefit side calculus envisioned for Option CBAA would include as a matter of course the total value of all threatened property in its measure of the loss that would be attributed to abandonment. It would therefore be immaterial in the cost benefit comparison whether or not those losses were borne totally or partially by the public through some sort of compensation scheme or left to fall entirely upon the private property owners. The distributional consequences would be dramatically different, to be sure, but the efficiency measure employed in Option CBAA to weigh the protection option would be unaffected.

Table I also records that the benefit of protection, its likelihood, and its total cost are likely to be higher in Option CBAA than in Option CBWAF. The point is that Option CBAA benefit trajectories include up to (e.g.) 30 years more appreciation than do Option CBWAF benefit trajectories; appreciation is, in Option CBWAF, replaced by depreciation when an abandonment decision is made. Assuming that real protection costs do not climb faster than shoreline property values, then, these extra years add only to the benefit side of any protection project. It therefore becomes more likely that benefits will dominate costs and that protection will be undertaken; and because more projects are undertaken, total costs climb.

Option CBAA similarly reduces the chance that an environmental impact assessment might influence the cost benefit calculus of a protection project. Extra appreciation of property increases the marginal cost of sacrificing that property to ecological reasons. Nor is uncertainty likely to cause as much trouble. Option CBAA looks only for near term differences in sea level rise and bases decisions in the future on observing then current market values and construction costs. The only major source of significant uncertainty is the credibility of a decision to retreat from the sea; and significant doubt that a decision to abandon developed property would hold might generate enough political dissent to turn the entire process defacto into one of operating within Option GP.

4.4 OPTION GP

Option GP, a perspective that takes protection as given and questions only how to accomplish its objective with least cost, is the simplest to envision. It would, of course, also be the most expensive because it would guarantee that protection would be provided even if the second-best cost benefit calculus of Option CBAA demonstrated that protection were not warranted. The cost benefit comparisons that underlie Options CBWAF and CBAA would not be part of the decision process, though, so decision makers would never know if that were the case.

Financing could become an issue if protection expenditures grew too large, but the very selection of Option GP suggests that public expenditure would be financed across a wide tax base with little opposition being mobilized against a well connected and influential coterie of shoreline property owners. Option GP would frame an anthropogenically focused policy structure, to be sure, so environmental impact assessments would likely be irrelevant (except to the extent that they would restrict the set of alternative protection plans). Even uncertainty would play a small role. Protection decisions would be made as required, so monitoring sea level rise with enough care to provide the relatively short notice required to plan and complete a protection project is all that would be required.

5. An Illustrative Application.

Table I provides a convenient organizational framework within which to describe some insight drawn from applying the methods underlying Options CBWAF and CBAA to five coastal communities located in or around Charleston, South Carolina. The results quoted are designed to show that choosing a valuation option does make a difference in the sort of decisions that would be made and the cost that would be incurred. They were reported in Yohe et al. (1996) as part of a national sample designed to produce national estimates of the potential cost of greenhouse induced sea level rise in the United States, so some national statistics will be reported, as well.

Tabular portraits of how the five communities would fare along a quadratic trajectory that reaches 100 cm by the year 2100 were constructed first. The Charleston site was chosen for the diversity reflected in the communities that would be threatened by higher seas. Dorcester and Mount Pleasant were found to face immediate threats - one with relatively low property values and the other with middle of the range values. Charleston and Avondale might be threatened by inundation late in the next century and they display similar differences in initial property value. Sullivan's Island would also be concerned with rising seas in the relatively distant future, but high property values that would characterize its future would clash with the complication of engineering protection through long term beach nourishment that would have to begin now.

Descriptions of how future development might affect coastal real estate values were then produced for each community from empirical analyses of how real estate markets respond to changes in such as factors as population and real income [see, e.g., Abraham and Hendershott (1993)] - estimates constructed with and without foresight so that the data were applicable to both Option CBWAF and Option CBAA.

Estimates of the cost of protection from time t_0 through time T were simply based on seven published studies that offered specific cost estimates for various protection structures [See Weggel et al. (1989), Sorenson et al. (1984), San Francisco BCDC (1988), Leatherman (1989), Gleick and Maurer (1990), URS Consultants (1991) and Leatherman (1994)]. For protecting against a 1 meter rise in sea level, review of this work suggested a central estimate of $750 per linear foot for a generic hard structure. The robustness of the results was, however, tested in the extreme where protection costs amounted to $4000 per linear foot. Maintenance costs were also incorporated as the variable cost of a decision to protect. Since the central fixed cost estimate was drawn from Gleick and Maurer (1990), their representation of annual maintenance expenditure as a percentage of construction was adopted. Four percent per year was chosen as the central estimate, but ten percent was applied to hard structures that might be built along coastline that directly faced the ocean.

Structure and maintenance costs were changed for different scenarios, under the assumption that protection for the full measure of sea level rise expected through 2100 would be constructed when it was needed. Weggel et al. (1989) and Sorenson et al. (1984) both indicate that construction costs increase geometrically with height. Weggel offered an exponential cost factor of 1.5. Nicholls, et al. argue that protection structures are trapezoidal in shape with 1:2 slopes on the sides and with the width of the crown on top matching the height. This was enough information to compute a relationship between the cost of hard structures and their required height along 33 cm and 67 cm scenarios as fractions of the cost along a 100 cm scenario.

A different methodology characterized the cost of protecting beaches and beachfront property. Experts agreed that beach nourishment alone would protect inland property (1) if nourishment were an ongoing operation from the very start of any trajectory and (2) if sea level rise did not exceed some threshold. The cost of nourishment was computed from estimates of the requisite volume *and* the expected (regional) price of sand, and 33 cm was selected as the appropriate threshold. Once the threshold was crossed, however, a hard structure constructed at the back of the beach was required both to preserve the nature of the beach and to protect interior property. The cost assumptions just described were applied to these structures, and the open coast (10%) maintenance cost rate was assumed.

Table II shows the expected cost that was associated with three sea level rise trajectories in the Charleston site for two discount rates - 3% and 5%. The costs reported there include both the cost of abandonment and the cost of protection for decisions that were made on a cell by cell basis with 30 year foresight assumed in the application of Option CBWAF. Table III does the same with under the no foresight assumption inherent in the application of Option CBAA. Several observations can be drawn from these results, the detailed description of which can be found in Yohe et al (1995).

Notice, first of all, that protection is more likely when Option CBAA is applied, but it is by no means guaranteed. Mount Pleasant, for example, would be protected under Option CBAA but abandoned under Option CBWAF along 100 cm and 67 cm trajectories. Dorcester, with its low property values, would not be protected under either option even along a 33 cm trajectory; and Sullivan's Island, despite high property values that would likely appreciate well into the next century, would not be protected along the 100 cm trajectory even if appreciation continued under Option CBAA right up to 2090. Moving to Option GP would thus be expensive.

Secondly, it is clear that moving from Option CBWAF to Option CBAA for whatever reason is costly, but perhaps not excessively so. Along a 100 cm scenario, the Option CBAA is twice as expensive, adding over $9 million in real total cost (denominated in 1990 dollars) when expressed in terms of discounted value given a 3% discount rate. The added cost shrinks to approximately $500,000 along a 67 cm trajectory and little more than $100,000 along a 33 cm trajectory. National estimates reflect even smaller differences; Yohe et. al (1995) report only $900 million in extra cost along a 100 cm trajectory and as little as $31 million along a 33 cm scenario. Figure 2 illustrates the anticipated annual national cost estimates that support these aggregate statistics. Figure 3 contrasts the Option CBWAF total cost trajectory with its protection cost component along the 100 cm trajectory. Slightly more than 50% of total cost is typically devoted in any one year along the 100 cm trajectory to protection - a proportion that increases dramatically as the anticipated pace of future sea level rise slows.

Compensation issues were highlighted in the previous discussion of Option CBWAF. Current values 30 years prior to the dates of inundation were the relevant statistics, and they were estimated by depreciating the values that supported the data of Table II. They turned out to be significant, and so they underscored the potential for mandated compensation to undermine the maximum efficiency

Table II

The Discounted Cost of Sea Level Rise in Charleston

Protection Decisions Made under Option CBWAF[a]

	3% Discount Rate	5% Discount Rate	Strategy/Notes
100 cm Trajectory			
Charleston City	0.746	0.180	Protect
Mount Pleasant	4.058	2.641	Do Not Protect
Avondale	0.177	0.028	Partial protect
Dorcester	0.962	0.685	Do not protect
Sullivan's Island	2.677	0.388	Do not protect
TOTAL	8.620	3.922	
67 cm Trajectory			
Charleston City	0.157	0.022	Protect
Mount Pleasan t	2.607	1.445	Partial protect
Avondale	0.000	0.000	No inundation
Dorcester	0.792	0.580	Do not protect
Sullivan's Island	0.000	0.000	No inundation
TOTAL	3.562	1.969	
33 cm Trajectory			
Charleston City	0.000	0.000	No inundation
Mount Pleasant	0.407	0.199	Protect
Avondale	0.000	0.000	No inundation
Dorcester	0.596	0.422	Do not protect
Sullivan's Island	0.000	0.000	No inundation
TOTAL	1.003	0.621	

Note:
[a] Source: Yohe, et. al. (1995b); denominated in millions of 1990 dollars.

Table III

The Discounted Cost of Sea Level Rise in Charleston

Protection Decisions Made under Option CBA[a]

	3% Discount Rate	5% Discount Rate	Strategy/Notes
100 cm Trajectory			
Charleston City	0.746	0.180	Protect
Mount Pleasant	6.290	3.392	Do Not Protect
Avondale	0.186	0.031	Partial protect
Dorcester	1.616	1.032	Do not protect
Sullivan's Island	8.852	1.301	Do not protect
TOTAL	17.690	5.936	
67 cm Trajectory			
Charleston City	0.157	0.036	Protect
Mount Pleasant	2.647	1.445	Partial protect
Avondale	0.000	0.000	No inundation
Dorcester	1.221	0.580	Do not protect
Sullivan's Island	0.000	0.000	No inundation
TOTAL	4.025	2.061	
33 cm Trajectory			
Charleston City	0.000	0.000	No inundation
Mount Pleasant	0.407	0.199	Protect
Avondale	0.000	0.000	No inundation
Dorcester	0.711	0.472	Do not protect
Sullivan's Island	0.000	0.000	No inundation
TOTAL	1.118	0.671	

Note:
[a] Source: Yohe et. al, (1995b); denominated in millions of 1990 dollars.

objective of Option CBWAF. Compensation similarly affects the amount of public money required under Option CBAA. Only Dorcester and Sullivan's Island would be abandoned in this regime, though, so the decadal totals are not as large as might have been anticipated. Indeed, their totals are generally smaller than the corresponding totals for Option CBWAF.

Finally, it is important to note that a "protection hierarchy" exists across scenarios. Any site that is deemed worthy of protection along a given sea level rise trajectory would be similarly worthy of protection along any slower trajectory. This observation holds for either Option CBWAF or Option CBAA, and the reason is simple. As reported above, slower sea level rise allows for more appreciation and so it adds to the benefit side of the protection decision calculation. The converse is, of course, not necessarily true; and for the very same reason. Indeed, cells that would be abandoned along a high trajectory might be protected along a slower trajectory.

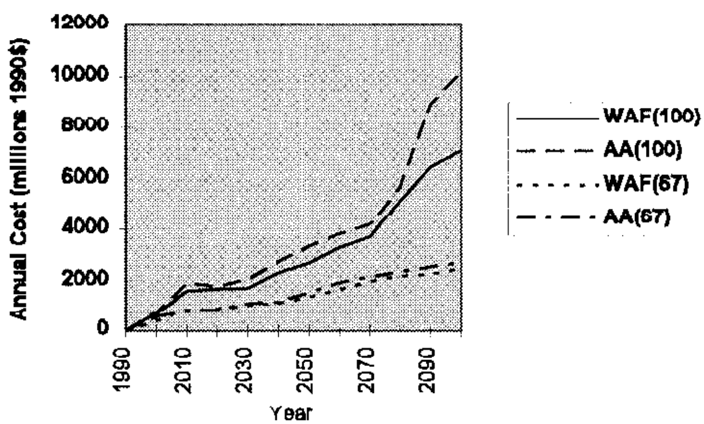

Figure 2. Annual total costs along 100 and 67 cm trajectories for Option CBWAF (denoted WAF(100) and WAF(67), respectively contrasted with corresponding estimates for Option CBAA (denoted AA(100) and AA(67), respectively.

6. Uncertainty

Two fundamental sources of uncertainty have been identified. The first is the long term pace of future sea level rise, itself. Even the smaller divergence of most recent opinion for the year 2100 reflected in Figure 1 is large and thus potentially troublesome. It is, however, an uncertainty that would effect only the viability of

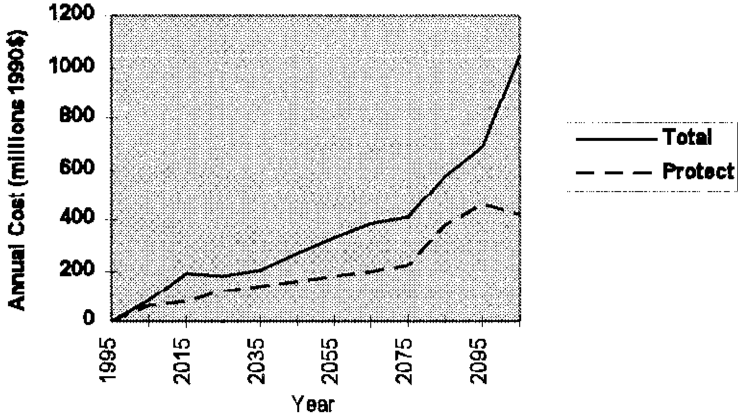

Figure 3. Estimated annual total cost attributed to sea level rise along a 100 cm trajectory contrasted with the component that reflects the cost of protection.

Option CBWAF with its presumed long (e.g., 30 year) planning horizons. Operating under the structure of either Option CBAA or Option GP would require only a relatively short lead time and would use information that would, at the (future) time of decision, be routinely available from careful observation of (then) current conditions. Some brief discussion of how long term sea level uncertainly might be handled in the context of Option CBWAF will be the focus of this section.

The second major source of uncertainty finds its foundation in the credibility of announced policies that developed property will actually be abandoned. Indeed, the viability of Option CBWAF and its pursuit of the first best optimum rests squarely on the presumption that individuals and markets will believe the government and its decision makers when they say that certain property will be lost in thirty years as part of a general retreat from the sea. Absent that belief, the automatic market-based adaptation envisioned in Option CBWAF will not be forthcoming, and the efficiency that Option CBWAF offers will be out of reach.

Turning now to long term uncertainty about future sea level rise, it is almost enough to repeat the observation with which the last section closed. Recall that the Charleston illustration suggested that property for which protection was deemed warranted along any given sea level rise scenario would also be protected along any slower trajectory. The logic of discounting in the context of appreciating property supports this observation rigorously, and it can therefore form the basis of an iterative planning procedure designed to offer the efficiency of Option CBWAF even as it confronts the type of uncertainty displayed in Figure 1.

The first step in the planning procedure is simple. Apply the cost and benefit methods described above for Option CBWAF to any collection of vulnerable sites along a sea level rise trajectory that is representative of the highest range of current thought. Given Figure 1, for example, 100 cm through the year 2100 would be a prudent choice in 1995. Planning to protect property as needed against the highest trajectory will be the dominant strategy for some of the sites in the original set; and for them, the complication of Option CBWAF is over. These are sites for which protection would be preferred along any slower trajectory, and so planning simply to undertake some sort of least cost protection strategy when required [technically, planning to confront rising seas as if Option GP were in force] would guarantee efficiency.

Dealing with the other sites for which protection is not warranted along the highest trajectory is a bit more problematical. Planners will always have to return to a site that is hit with a catastrophic storm; and determining the degree to which development should be allowed to be rebuilt can always accommodate the latest information about warming induced sea level rise. More routinely, however, it should also be possible to work the valuation methodology to compute a highest sea level rise trajectory for which protection would be warranted at any particular site; and that trajectory can be used by planners to identify the latest date at which they conduct a careful Option CBWAF analysis and still leave enough time for a complete market accommodation should they decide to abandon the site and retreat from the sea. Some notation and some simple algebra will help explain exactly how that could be accomplished.

Suppose that planners were running a vulnerability planning review of potentially vulnerable sites at time t_o. If sea level rise trajectories were linear in time, as supposed by the IPCC (1992), then

$$SLR_j(t) = SLR_j(t_o) + [a_j + b]t, \qquad (6.1)$$

would represent sea level rise t years into the future at any site j; in writing equation (6.1), a_j represents local subsidence at site j and b represents the global pace of the greenhouse induced contribution to $SLR_j(t)$. Now let b_j^* be the largest global pace for which protecting site j would be warranted. The corresponding anticipated greenhouse induced sea level rise from the planning date t_0 through 2100 would then simply be

$$SLR_j^*(2100) = b_j^*(2100-t_o). \qquad (6.2)$$

Meanwhile, there would also exist a time t_j^* and a threshold SLR_j^{**} along the trajectory defined by b_j^* at which protection must begin.

Assuming (e.g.) that 30 years notice would be required for the market-based depreciation of structure and transfer of land gradient envisioned in Option CBWAF to be completed, equation (6.1) can be combined with the observed SLR_j^{**} in a way that relates the pace of more rapid greenhouse induced sea level rise to the time at which a protection decision would have to be made. Notice that protection would be efficient along slower trajectories along which $b < b^*_j$, so Option GP would again apply. Denoting that time $t_j(b)$, more specifically,

$$t_j(b) + 30 = \{SLR_j^{**}/[a_j+b]\}. \qquad (6.3)$$

The contour defined by equation (6.3) describes a series of vulnerability threshold that would inform planners who monitor the pace of greenhouse induced sea level rise about the timing required to support the application of Option CBWAF. It succinctly relates the observed pace of more rapid sea level rise to a date by which a careful 30 year analysis of the relative merits of protection must be completed. Waiting with all due vigilance until that date to conduct the Option CBWAF analysis would both reduce the uncertainty surrounding the anticipated pace of sea level rise *and* allow the Option CBWAF calculations to be informed with the most current and presumably most reliable cost, local real estate, and regional growth data.

Figures 4 and 5 show how this procedure might be applied by illustrating the prescribed contour for one specific location in downtown Charleston under maximum protection costs - $4000 per linear foot for protection against a one meter rise through 2100. Local subsidence in Charleston is estimated to be 2.2 cm per

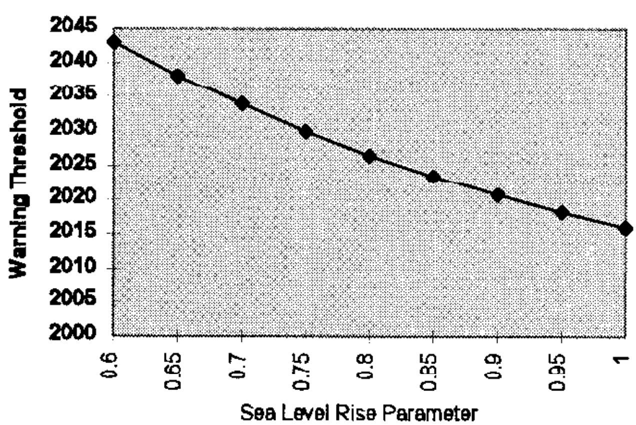

Figure 4. Warning thresholds computed for Charleston as a function of the sea level rise parameter defined implicitly in Equation 6.1.

decade, and the site in question would be inundated if the seas were 62 cm higher. The maximum trajectory for which protection would be necessarily warranted turned out to be one which would produce 67 cm in greenhouse induced sea level rise by the year 2100. As a result, $b^*_{CHARLESTON} = .609$, and

$$t_{CHARLESTON}(b) = \{62/[b+.22]\} - 30. \qquad (6.4)$$

Figure 4 displays the contour described in Equation (6.4); it relates the threshold planning dates to the pace of greenhouse induced sea level rise. Figure 5 tracks the threshold dates against the more usual sea level rise targets in 2100. It shows, for example, that the Option CBWAF "will or will not protect" decision would be required by 2020 if it turned out that prevailing thought placed the likely pace of sea level rise on the 100 cm trajectory; and by 2035 if 75 cm were more probable.

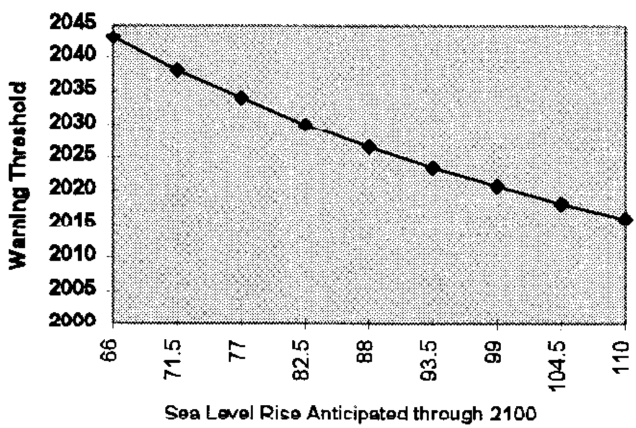

Figure 5. Warning thresholds computed for Charleston as a function of sea level rise anticipated through the year 2100.

7. Conclusions

Review of the potential sources of uncertainty that might affect planning for shoreline protection has been conducted in the context of three different decision regimes. The largest effect of introducing the complication of climate change would be felt if coastal planning were targeted at maximum efficiency. Option CBWAF outlined how that might be achieved. It was argued that even the current wide range of subjective anticipation could be handled reasonably well with (1) informed vigilance in monitoring the pace of future greenhouse induced sea level rise, (2) careful attention to the time required for market-based adaptation to minimize the economic cost of abandonment, and (3) firm support of the credibility of an announced policy to proceed with plans to retreat from the sea when warranted. Requirements (1) and (2) might be met, easily; but review of existing policy makes it clear that (3) is a "long shot".

The first best economic efficiency that is the target for what was termed Option CBWAF is probably not in the cards, therefore, so two other options were reviewed, here. Option CBAA proposed making the underlying benefit-cost calculations for any protection project only in the face of an imminent threat. In that case, present procedures would work fine toward achieving a second best outcome if there were enough warning; i.e., enough time for either the planning and implementation of a protection project in a complex legal, financial and environmental context or the systematic abandonment of existing property in an even more complicated legal, political and social context. Total protection expenditure would climb over time, in this case. Indeed, along a mid-range 67 cm sea level rise trajectory, protection costs across the United States could sum to as much as \$50 million (real 1990\$) per year by 2050 and more than \$100 million per year by the turn of the next century.

The third option abandoned the benefit-cost methodology in favor or a potential political decision to protect *all* developed property. Limited warning would again be required, but the decision process would obviously be much simpler. Total expenditures would perhaps be twice as high as those seen in Option CBAA - a difference that could be offset to a significant degree by lower legal fees.

Analysis of these three options supports a continued application of benefit-cost evaluation by the coastal planners. A simple policy addendum would require that planners periodically revisit potential protection sites to assess the impact of the most recent information on sea level rise trajectories, local development patterns, and protection costs on the decision calculus. As large as the uncertainty over the future trajectory of greenhouse induced sea level rise might be, this review suggests that it can be accommodated by only small modification in current procedures if the underlying policies of protection and/or systematic abandonment have long-term credibility.

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