

The causes of sea level rise are changing. The relative importance of the various drivers of sea volume change (eustatic sea level change) will likely be different in this century than they were in the twentieth century. According to the IPCC, in the 20th century, the major contributors were:

- THERMAL EXPANSION OF THE OCEANS
- Mountain glacier melting
- Melting of the Greenland Ice Sheet.

Recent data from a variety of sources suggests that in the 21st century, the West Antarctic Ice Sheet will likely become the major source of meltwater, possibly replacing thermal expansion as the most important cause of eustatic rise, making the main drivers these:

- MELTING OF THE WEST ANTARCTIC ICE SHEET
- Melting of the Greenland Ice Sheet
- Thermal expansion of the oceans
- Mountain glacier melting

Reduction of carbon dioxide emissions will not halt sea level rise in the short term.

As pointed out by James Hansen and other researchers, future eustatic sea level rise will not necessarily occur in direct proportion to the amount of CO₂ in the atmosphere. Sea level rise depends on complex feedbacks within the atmosphere, oceans, and ice sheets. In addition thermal expansion has a lot of momentum that will keep the sea level rising for a long time even if CO₂ levels out. The fate of the ice on Greenland and Antarctica will ultimately play a determining role in the rate of sea level rise. Recent studies of

short-range ice sheet dynamics indicate that the ice sheets may have reached a tipping point and that disintegration should increase and sea level rise should accelerate

Assume a *minimal* sea level rise of 7 feet (2 m) by 2100 for planning purposes. At a bare minimum we recommend using 3 ft for a 50 to 100 years planning horizon in communities where the politics would not permit the consideration of a more forward looking coastal management. This is not a prediction; it is a scenario, a recommendation. But a rise of this magnitude is a real possibility. Seven feet is a catastrophic sea level rise. Three feet will doom much, if not most barrier island development. Storm surge, storm waves, shoreline erosion, groundwater salinization and infrastructure destruction will force a retreat from the shoreline before actual inundation occurs.

Prohibit the construction of high-rise buildings in areas vulnerable to future sea level rise. Decisions concerning community planning and development should be based on minimizing or avoiding altogether the damage from the expanding ocean. This means, first and foremost, no more high rises. Instead of making major repairs on infrastructure such as bridges, water supply, sewer and drainage systems, go the extra mile and place them out of reach of the sea. Buildings placed in future hazardous zones should be small and movable or disposable. No new sewer and water lines in zones that will be adversely affected by sea level rise in the next 50 years and no more government funding for those who choose to ignore global changes.

Relocation of buildings and infrastructure should be the guiding philosophy for beach communities in their response to sea level rise. Relocation of some properties could be implemented after severe storms or with financial incentives. Holding shorelines in place is costly and will eventually end up destroying the recreational amenities (including the beach) which were the reasons for the beach community's existence to begin with. Maintaining a static shoreline is also a long-term impossibility. Beach nourishment, the currently preferred method of fighting coastal erosion, is becoming increasingly expensive. In the future, beaches will need more sand, more frequently. In most cases, the sand resources are simply not available to fight this battle into the 22nd Century. In light of this, relocation may begin to seem like a more reasonable option.

Stop all public assistance for post-storm rebuilding on the oceanfront. The guarantee of recovery is perhaps the biggest hurdle in the way of a sensible response to sea level rise. The goal in the past has always been to restore conditions to what they were before a storm or flood. In the United States hurricanes have become urban renewal programs. The replacement houses become larger and larger and even more costly to replace again in the future. The problem is compounded because even people whose rental investment houses were destroyed are considered victims and there is a huge outpouring of sympathy for them. But maybe people who build adjacent to eroding shorelines facing the open ocean should be considered fools rather than victims?

Underlying this problem in the US is the Stafford Act. Passed by the US Congress in 1988, the act allows the expenditure of money to restore community

infrastructure once the president issues a disaster declaration. It is an unquestioning, automatic response to a disaster. No environmental impact statement is required and money may even be spent on coastal areas where other expenditures of federal money are prohibited (CoBRA zones for example). Those who invest in vulnerable coastal areas need to assume responsibility for that decision. If you stay; you pay.

Stop asking coastal engineers for a solution to coastal erosion. If a coastal community asks a coastal engineer for a solution to a coastal erosion problem, that community gets a coastal engineering response (e.g. build a seawall, build a groin, renourish the beach). Coastal engineers are selling a product. They will not suggest that the community relocate property. This would put them out of business. Coastal communities need to include a broader circle of experts in their quest to seek solutions to coastal erosion and global sea level rise.

Get the Corps off the Shore. The US Army Corps of Engineers, more or less by default, is the government agency in charge of much of the planning and the funding for the nation's response to sea level rise. It is an agency ill suited for the job. It has too long a history of incompetence, high cost construction, and inefficiency due in significant part to its close dependence on Congress for pork barrel funding, as many critics have pointed out. Part of the problem is that the engineer's "we can fix it" mentality is the wrong mentality for a response to changing sea level (the agency's motto is "essayons," let us try).

Take the reins from local government. Sea level rise is a national crisis, an issue of national interest that must be solved on a national scale and not simply for the benefit of those unwise enough to build at low elevation near an eroding ocean shoreline. In addition, the resources needed to respond to sea level rise are typically far beyond those of the local communities.. Local governments typically follow the self-interests of oveanfront property owners and developers, so preservation of buildings is inevitably a very high priority. In the local debate over which is more important, buildings or beaches, buildings always win. Even beach nourishment has as its primary goal the preservation of property, not the beach (regardless of how it is sold). We can't rely on local governments to respond sensibly to the long-term realities of rising sea level

Sea level rise will threaten coastal ecosystems. However, direct destruction of coastal marshes, mangroves and coral reefs by human activities is currently having a greater impact than sea level rise. If we do not immediately act to better protect these critical ecosystems, the combination of rising sea level and human development will destroy them.

Large coastal cities are likely to warrant engineered protection from sea level rise.

Would we ever consider abandoning Manhattan to the sea? Of course not. Coastal cities have unique qualities that will make it difficult for society to abandon the: high population density, critical ports, financial services. Cities are inhabited largely by individuals living in primary residences unlike coastal tourist towns which are dominated by investment property. Cities also have a unique set of problems that sea level rise will

dramatically worsen: storm water drainage, subway flooding, inundation of critical port facilities, difficulty of evacuation. Will cities beat out the barrier islands for funding to protect buildings? Most likely they will.

Sea Level Rise provides an opportunity and a challenge for all, but especially for the next generation. Sea level rise is not just a natural catastrophe that is to be fought hard on all fronts. It is an opportunity for society to design with nature, to anticipate the changes that will occur in the future and to respond in such a fashion as to maintain a coast that future generations will find both useful and enjoyable. It provides a challenge to scientists, planners, environmentalists, and politicians alike to stretch the limits of their imagination to respond with flexibility and with careful foresight to an eventuality that humankind has never before had to face. Opportunities will abound for entrepreneurs with fresh ideas on how to live with a rising sea.

The science tells us that the world's shorelines will look different 100 years from now. These changes need not end the coastal economy as we know it. But, preserving our coastal resources, and the businesses that depend on them will require insightful and long-term planning. Beginning an honest assessment of how we may deal with future sea level rise can help ensure that our coastal communities remain the vibrant places that they are today. There is no doubt that change is coming and difficult decisions will need to be made.