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Sea Level Home

Hazards of Sea Level Rise: An Introduction

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Sea level is rising worldwide and is caused by both natural and human factors. Most research indicates that sea level is rising approximately 2mm/yr. Although 2 mm/yr. seems to be a relatively small amount of change, a small increase in sea level can have devastating effects. Other factors such as glacial isostatic adjustment (GIA) are causing coastal lands to sink, increasing the rate of sea level rise for those areas. Fortunately, in some areas of the world, GIA is causing land to rise allowing for some compensation to rising sea level. Since greater than 75 percent of the human population will live within 60 km of a coast by 2000 [Michener et al., 1997], it is important that the effects of any change in sea level rise are studied. There is no physical capacity that humans have to protect against long term sea level rise. The key to coping with sea level rise is education of the effects and accurate assessments of hazards for given points in time. In this way, humans can act decisively and appropriately to minimize loss of life, and economic and ecological impacts. Education is the only long-term, far-reaching solution to sea level rise.

Sea level has fluctuated by an order of 100 meters over the last 18,000 years [Michener et al., 1997]. Global sea level can change due to three factors: 1-Change in the volume of the ocean basins, 2-Expansion or shrinking of ocean water due to changes in climate and 3-Periods of worldwide glacial advance and retreat [Davis, 1997]. Human impact has no control over changing the volume of the ocean basins. However, the greenhouse effect can cause the ocean to gather thermal inertia that will heat the continents and slowly melt the polar ice caps, increasing sea level worldwide [Michener et al., 1997].

The effects of sea level rise will be spatially non-uniform since GIA will cause some areas to uplift and others to subside [Gornitz, 1991]. Furthermore, the characteristics of a given coastline are controlled by many different variables, including interactions between lithology, geomorphology, wave climate, currents and storm frequencies [Gornitz, 1991]. Gornitz defines the following terms to be used in talking about coastal hazard assessments:

Coastal hazard — natural phenomenon that exposes the littoral zone to risk of damage or other adverse effects
Coastal vulnerability — liability of a shore to respond adversely to a hazard
Impact — negative consequences arising from assumed risk to sea level rise

Gornitz also states "sea level rise is a global-scale, long-term hazard, which may, in the long run, inflict greater damage [to a coastline] than that of a hurricane. Eustatic sea level rise over the next century will be the sum of the individual contributors from thermal expansion of sea water and ice melting from alpine glaciers and the polar ice sheets."

In 1990, the Intergovernmental Panel on Climate Change outlined five major impacts of rising sea level on coastal communities[IPCC, 1998]. Examining these five impacts is the focus of this website.

Beach erosion

The IPCC reports that 1 cm rise in sea level erodes beaches about 1 m horizontally. This becomes a

large issue for developed beaches that are less than 5 m from the ocean [IPCC, 1998]. In addition, rising sea level would create larger storm surges that would quicken the rate of beach erosion; an intense storm can erode enough shore to change its entire profile in one year [Dubois, 1990]. Duboisí's research has shown that observed values of beach erosion were two to three times greater than the erosion predicted for that year. Dubois suggests that Bruuní's theory and rising sea level may the primary force responsible for observed erosional rates [Dubois, 1990]. Bruun's rule states that a typical concave-upward beach profile erodes sand from the beachface and deposits it offshore to maintain constant water depth [Dubois, 1990]. Bruuní's rule can be applied to correlate sea level rise with eroding beaches. With present rates of sea level rise, 70% of the worldí's sandy beaches are eroding and retreating. If the rate of sea level rise continues to increase, the loss of beach to coastal erosion will increase.

Inundation of land

A 50-cm rise in sea level will inundate 8500 to 19000 km2 of dry land [IPCC, 1998]. In the US, the lowest forests and farms are in the mid-Atlantic region and the Southeast. Large port cities such as Boston, New York City, Charleston, Miami and New Orleans are located in lowland areas [IPCC, 1998].

There are two types of inundation that will be caused by sea level rise: 1-permanent inundation and 2-episodic inundation. The effect that permanent inundation will have on areas is dependent on the local gradient [Gornitz, 1991]. Areas that have low gradients at a coast are beach ridges, chenier plains, deltas, mudflats, estuaries, lagoons, and bays [Gornitz, 1991]. Episodic inundation is a result of storm surges [Gornitz, 1991]. As sea level rises, episodic inundation will be more frequent for these low-lying areas.

Increased Flood and Storm Damage

A higher sea level will provide a higher base for storm surges [IPCC, 1998]. A one-meter rise in sea level would enable a 15-year storm to flood areas that today are only flooded by 100-year storms [IPCC, 1998]. Flood damages would increase 36-58% for a 30-cm rise in sea level and increase 102-200% for sea level rise greater than 90 cm [IPCC, 1998]. Larger storms cause loss of beach width and force large sediments into inlets.

Increased salinity of estuaries and aquifers

Rising sea level would allow saltwater to penetrate farther inland and upstream [IPCC, 1998]. Higher salinity impairs both surface and groundwater supplies [IPCC, 1998]. This effect would impair water supplies, ecosystems, and coastal farmland [IPCC, 1998]. Saltwater intrusion would also harm aquatic plants and animals as well as threaten human water supply [IPCC, 1998]. Salinity intrusion has already been cited as the primary reason oyster harvests have been reduced in the Delaware and Chesapeake Bays [IPCC, 1998]. In Louisiana, cypress swamps are becoming open lakes due to increasing salinity [IPCC, 1998]. In humid equatorial climates, gradual sea level rise would cause a brackish-water zone to migrate inland [Gornitz, 1991].

The penetration of saltwater can be compared to what occurs during extreme droughts when river runoff is diminished, forcing a fallow period in agriculture [Gornitz, 1991]. As sea level rises, the tidal saltwater zone penetrates further upstream [Gornitz, 1991]. The zone then becomes unfit for tidal harvests such as swamp rice [Gornitz, 1991]. Salinity has also been found to decrease seed germination

in a variety of wetland species and higher salinities may decrease recruitment of seed bank species [Balwin et al., 1996].

In addition to damage to ecosystems, sea level rise promotes saltwater intrusion into coastal aquifers [Gornitz, 1991]. A freshwater lens overlies saltwater along barrier coasts, and volcanic and coral islands [Gornitz, 1991]. This freshwater lens is 40 times thicker than the elevation of the water table above mean sea level [Gornitz, 1991]. Therefore each increment of sea level rise reduces the freshwater capacity of the lens by 40 times [Gornitz, 1991]. On low coral atolls, less permeable Holocene sediments overlie a highly permeable Pleistocene karstic subsurface through which seawater can infiltrate [Gornitz, 1991]. Coastal communities will be forced to find alternative sources of freshwater.

Other impacts

Although the IPCC lists five impacts as the main consequences of sea level rise there are many others. Sea level rise has a profound effect on the rate of sedimentation for different parts of the coastal gradient [Olff et al., 1997]. Peak rates of sedimentation occur at higher elevations on the march and less sedimentation occurs on the lower elevations [Olff et al., 1997]. Varying of sedimentation rates will result in changing vegetation zonation and succession on marshes [Olff et al., 1997]. In addition, storm surges would force large quantities of shoreface sediments through inlets and create tidal deltas on which barriers would later transgress [Dubois, 1990].

There are many places to find research on specific, but individual impacts of sea level rise. However, there are some sources that incorporate these variables into a comprehensive picture of the effects of sea level rise. Coastal communities are affected by many variables and only a handful of the most important variables have been fully realized in their relation to sea level rise. As more research is done and the knowledge base is expanded and incorporated into existing research, more accurate assessments about the impacts and hazards of sea level change can be made.

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