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## Sea Surges

During a sea surge, water is pushed toward shore by the force of the strong winds associated with hurricanes in coastal areas. The storm surge combined with wave action (sea surge) can cause extensive damage to coastal highways, harbors, marinas, ships, and boats; damage oil and gas platforms; and cause severe coastal flooding along beaches, barrier islands, estuaries, and lakes on the coastal plain. The level of surge is determined by the slope of the continental shelf; thus, high sea surges develop where the coastal water depth gradually shallows toward shore. Global warming, which is raising the temperature of the sea surface, is also suggested as contributing to raising the sea level and subsequently increasing and extending the effects of the large waves that ride the surge.

### Sea Surge Disasters

Storm surges have caused massive destruction and loss of life throughout history. Near Lake Okeechobee, Florida, storm surge in 1928 caused the lake to overflow its banks and inundate the surrounding area to a depth of six to nine feet; 1,836 people died as a result. In 1995, Hurricane Opal caused extensive storm surge from Florida to Mexico, and damage estimates were near \$3 billion. Hurricane Hugo in 1989 devastated the West Indies and the southeastern United States, killing 60 people and causing \$7 billion in damages.

Hurricane Katrina in 2005 caused severe destruction along the Gulf Coast from central Florida to Texas, much of it due to the storm surge. The most severe loss of life and property damage occurred in New Orleans, Louisiana, which flooded catastrophically, and at least 1,800 people lost their lives. Damages from Katrina were extensive where coastal development had increased in recent decades. In these areas, wetlands that would have buff-

ered sea surge had been destroyed or removed by human activity and development. The storm is estimated to have been responsible for \$100 billion in damage, making it the costliest as well as deadliest hurricane in U.S. history.

Asian regions have faced even higher death tolls and destruction from sea surges. World Vision published *Planet Prepare*, a report that investigates the disaster threats facing coastal communities in the Asia Pacific region. For example, Cyclone Nargis hit Myanmar on May 2, 2008, killing as many as 140,000 people. Most of the farmers and fishermen who lived on the delta flatlands were killed not by the cyclonic winds, but also by the resulting sea surge that swept up to 22 miles inland. A great number of children, especially in Sri Lanka and Indonesia, lost all of their closest relatives and become orphaned due to the sea surge disaster. A cyclone ripped through southern Bangladesh and eastern India in 2007, killing 191 people, and leaving hundreds of thousands of people homeless as a result of the storm surges.

### Vulnerability and Disaster Reduction

The danger from storm surges along the densely populated coastlines is tremendous. As more people build in coastal areas, destruction of coastal dunes for building sites increases the vulnerability of a shore to sea surge. The increase in coastal settlement has put much economic investment at risk from sea surges and flooding, which damage households, food stocks, and crops, and cause major local supply shortages.

Warning systems, evacuation plans and shelters, insurance, and building regulations are key adjustments to mitigate these disasters. Minimizing property damage and avoiding loss of life require accurate forecasts that predict the behaviors of these storms as they approach land. The public must be warned in time to prepare or evacuate. Meteorological remote sensing, seismic monitoring, and geographic information systems (GIS) provide information on potential activity. The U.S. National Oceanic and Atmospheric Administration (NOAA) covers most of the Pacific Ocean. The Hurricane Center in San Francisco observes the eastern Pacific, the weather forecasting office in Hawaii covers the central Pacific, and the Joint U.S. Navy–Air Force Typhoon Warning System in Guam covers the western Pacific. The Japan Meteorological Organization in Tokyo also covers the western and central Pacific Ocean. Continuous storm monitoring information is also provided by Fiji, New Zealand, Australia, and French Polynesia.

Loss planning must include a wide range of institutional and structural considerations to achieve loss reduction goals, including both policy and action-oriented steps. In 1994, the Federal Emergency Management Agency (FEMA) began to provide funds to elevate, acquire, and demolish or relocate homes in disaster-prone areas. Homes and other buildings can be constructed and elevated to allow passage of sea surges. FEMA's Software Program for Estimating Potential Losses from Disasters, HAZUS, is a powerful risk assessment software coupled with the latest GIS technology to produce estimates of hazard-related damage before, or after, a disaster occurs. Potential loss estimates analyzed in HAZUS include: physical damage to buildings, schools, critical facilities, and infrastructure; economic loss, including lost jobs, business interruptions, repair, and reconstruction costs; and social impacts, including estimates of shelter requirements, displaced households, and population exposed to sea surges and hurricanes. Sea, Lake and Overland Surges from Hurricanes (SLOSH) estimates storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account pressure, storm size, and winds.

### Damages and Response

Although evacuation is a difficult, costly, and uncertain process, especially for vulnerable populations, it is still the most powerful tool of emergency management. From a disaster management standpoint, Hurricane Katrina was especially devastating. Even though an estimated 1.2 million people evacuated from the affected area, with 400,000 seeking public shelters in 18 states, evacuation was especially problematic in New Orleans, where an estimated 250,000 people had no transportation. In the first 10 days after the disaster, Coast Guard boats, ships, and aircraft rescued tens of thousands of people. Nearly half of the deaths from Hurricane Katrina were people 75 years of age or over, many of those unable to evacuate themselves.

The November 1977 cyclone/sea surge disaster that affected a population of 700,000 in Andhra Pradesh, India, killed at least 10,000 people, but left only 177 orthopedic cases (mostly arm and leg fractures) that required evacuation. Deaths resulted mainly from drowning, and were most common among the weakest members of the population. Even though the region was desperately in need of body bags and sanitation, there was no way of getting the outpouring of aid where



*Sea surge from Hurricane Ike overtakes the Bolivar Peninsula bridge near Galveston, Texas, September 12, 2008.*

it was most needed. Michael Enquist, the head of the United Nations Organization for the Coordination of Humanitarian Affairs, noted that even getting aid out of the airport was an enormous problem. In some areas, food and medicines were in desperately short supply. Compounding the problem was the huge number of people left homeless. Tens of thousands spent the night huddling in emergency relief camps as the government stepped up relief efforts and the Indian Red Cross appealed for food and clothes.

Drinking-water wells can be badly contaminated with seawater, and chemical contamination is a threat. Hurricane Katrina left many communities dealing with environmental pollution, including oil and sewage contamination. But the biggest post-disaster concern is water contamination by decomposing bodies, which can cause epidemics of cholera and typhoid.

**See Also:** Evacuation; Federal Emergency Management Agency (FEMA); Floods; Hurricanes/Typhoons; Volcanoes; Vulnerable Populations.

### Further Readings

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## Second Congo War (1998–2003)

Also called Africa’s World War, the Second Congo War broke out in 1998 in the Democratic Republic of Congo, formerly Zaire (DRC), and officially ended in 2003. However, hostilities continued in the eastern region. The war was the largest in the modern history of Africa, and took the lives of almost four million people. Nine African nations and more than 20 armed groups were directly involved in the conflict. It created one of the worst humanitarian disasters in the world, leaving a heavy toll of death, famine, and disease.

In May 1997, Zaire’s government was overthrown, and its leader, Mobutu Sese Seko, left the country. The armed rebels were led by Laurent-Désiré Kabila and supported by Rwanda, Uganda, and Angola. Kabila proclaimed himself as president of the country and renamed it the Democratic Republic of Congo (DRC). After gaining control over the country, Kabila began to distance himself from Rwandan and Ugandan support, until he ordered their military forces to leave DRC in July 1998. These steps caused the uprising of Banyamulenge people—ethnically Tutsi, who live in east DRC. The Tutsis, a large ethnic group in Rwanda, at that time

also dominated its government. The Banyamulenge established armed forces called the Rally for Congolese Democracy (RCD) and received military support from Rwanda and Uganda. Later, Uganda established a new organization in the north, Movement for the Liberation of Congo, and its relationship with Rwanda grew increasingly tense until it reached the point of military clashes from 1999 to 2000. Following the Banyamulenge uprising, DRC’s President Kabila allied with Hutu militant groups in the east to suppress the rebellion. In less than a month, a coalition of RCD, Ugandan, and Rwandan forces took control over an important diamond center, a port, a hydroelectric station, and many towns, while moving toward the capital, Kinshasa. However, several African countries (Namibia, Angola, Zimbabwe, Chad, Libya, and Sudan) decided to join the military conflict on Kabila’s side and saved his government.

### Fallout From Death, Disease, and Cruelty

Although there weren’t huge military battles between the parties, the vast numbers of deaths—almost four million—were caused by malnutrition, disease, and cruelty toward the civilian population. In addition to the organized forces, various militia groups from both sides also took part in the war. These militia groups greatly increased the violence in the country by killing and raping civilians, committing ethnic cleansings, and looting.

Throughout the war, there were attempts to end it. The first attempt, in January 1999, wasn’t successful, but a ceasefire was signed by all parties (except for RCD) in July 1999 with the support of the United Nations. In January 2001, President Kabila was assassinated, and his son Joseph Kabila became president. In February 2001, Rwanda and Uganda began to withdraw their forces, and the violence decreased. In 2002, DRC signed peace treaties with Rwanda and Uganda. Following that, in December 2002, all of the internal DRC’s parties met and signed the Global and All-Inclusive Agreement, which described a plan for transitional governance, parliament, and presidential elections. The establishment of the Transitional Government in July 2003 marked the official end of the war. However, stability in the country wasn’t completely reached, and the biggest challenge was refusal of the former warring parties to give up power to a neutral national administration. This fragility of governance didn’t provide the complete end of hostilities in the east, although the central government became increasingly powerful.