U.S. Geological Survey
Marine and Coastal Geology Program

Effects of Major Storms on Pacific Islands

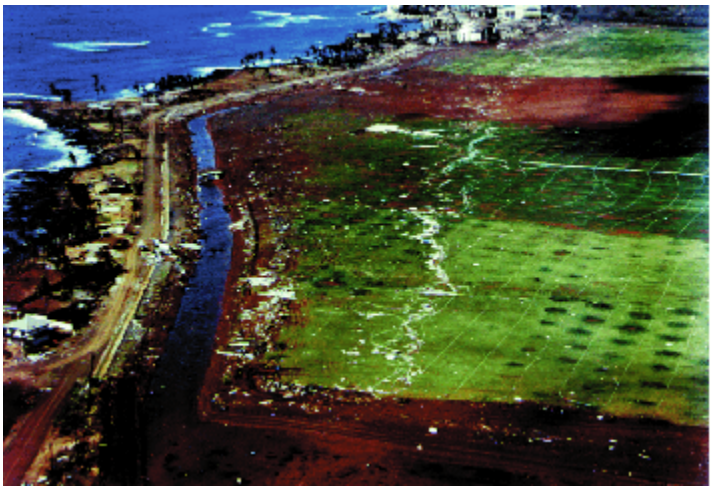
"Tropical storms of various kinds are as much a depositional event as an erosional event. Much attention is given to the destructive aspects of major storms because of the loss of life and property, but little is known about their beneficial effects to coastal accretion. While we can usually measure and map the instantaneous effects of a tropical storm, we can only speculate about the long-term effects. Geologic mapping by the U.S. Geological Survey in areas prone to storm effects can give us opportunities to minimize losses by identifying locations most likely to suffer."

- Dr. Bruce Richmond, U.S. Geological Survey

Loss of life and property damage suffered as a result of marine overwash and high winds makes tropical storms among the most catastrophic natural events in terms of insured losses.

Hurricane Iniki, for example, is ranked as the fifth-costliest catastrophe in U.S. history. Much of the damage was inflicted on the island of Kauai, Hawaii, in less than 1 hour. Hurricane Andrew ranks as the most costly in terms of insured losses. Damage comes not only from high winds, but also from the so-called marine overwash, a combination of effects resulting from tropical storm conditions that include storm surge, wind setup, wave setup, and wave swash. The primary effect is the storm surge resulting from extremely low atmospheric pressure. The vacuum created by the low pressure can raise mean sea level by several feet, a sort of upward bulge of the ocean wherever the tropical storm goes. Wind waves on top of the storm surge add to the effect, allowing sea water to run up and flood coastal areas by several tens of feet or more.

Overwash can be the most damaging effect of storms, and it is a primary focus of investigations by U.S. Geological Survey (USGS) scientists.

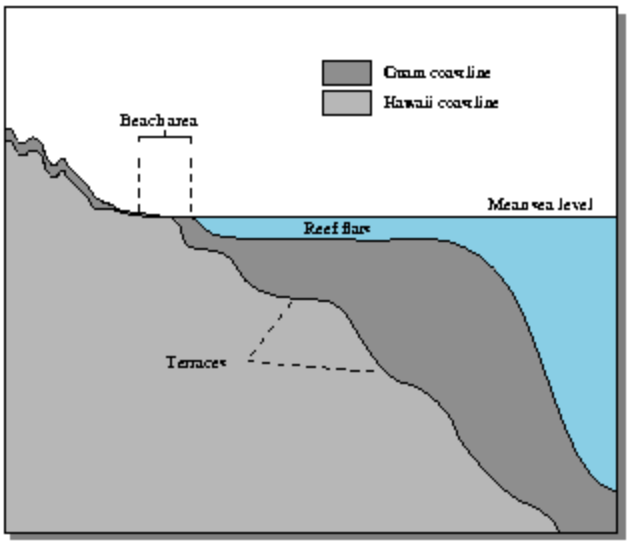


Though wind effects are severe, overwash can be more damaging causing coastal erosion, loss of recreational facilities, decreased water quality, damage to infrastructure, interruption of power and communication networks, human injury, and loss of life. Secondary effects can be equally damaging, causing landslides and other instabilities, and increased turbidity of nearshore waters which has negative effects on coastal ecosystems. There is also an increased risk of seismic activity in seismically-active areas resulting from loss of atmospheric pressure in the storm, followed by the weight of marine overwash. The combined elastic response of the Earth's surface can potentially enhance the seismic risk for areas such as the south shore of the Big Island.

Left above: Oblique aerial photograph showing overwash debris (the line of light colored material near the middle of the picture) near Kukuiula, southern Kauai (view to west).

USGS studies indicate that damage to coasts depends on the shape of the offshore area.

Recent studies in Guam provide a quantitative analysis of how the coastal profile influences the dissipation of wave energy. In areas where broad reef flats are a part of the coast, wave energy is spread over a larger area; in locations where steep, rocky coastlines prevail, wave energy tends to concentrate on a smaller area. In many places where storm damage required rebuilding the infrastructure, such as after Hurricane Iwa in 1981, examination of geologic and storm-susceptibility maps would have suggested that a reasonable construction setback would have reduced insured losses.



Right: Schematic coastline profiles of Guam and Hawaii. Establishing baseline profiles will help USGS scientists measure changes to coastlines resulting from tropical storms.

USGS research shows that storms are also depositional events.

Considerable evidence is available that demonstrates the powerful sediment-carrying capacity of storm overwash. Hurricane Iniki deposited huge quantities of sand and rubble on the island from coastal and nearshore areas. Indeed, a considerable volume of sediment also disappeared offshore. Evidence for movement offshore is found in household items, such as television sets, deposited offshore of the Poipu area in southern Kauai. In other cases, such as the formation of atoll islets, storms fulfill a needed building function. As atoll islets form, their continued growth depends on storms to bring offshore materials to the reef-top area.

Above left: View of atoll islets on the reef rim of Ulithi Atoll in Yap State, Federated States of Micronesia. Storms are a necessary process in delivering debris from the living reefs to the reef top.

USGS scientists have begun a multi-year program to profile the beaches and offshore areas of Hawaii.

This program is a cooperative effort with Dr. Charles Fletcher and his colleagues at the University of Hawaii in which key sites will be monitored prior to the arrival of a tropical storm to determine baseline conditions. Such profiling efforts are needed to establish a baseline state-of-the-coast. It is expected that data collected will help scientists to understand the factors affecting long-term stability of a coastline. Scientists, in turn, will provide planners, engineers, and resource managers with quantitative information for developing appropriate management guidelines. At present, no longterm monitoring program is in place. Advanced surveying techniques will be used, including use of Global Positioning Satellites, so other complicating factors, such as vertical movement of the islands, can be properly accommodated.

Researchers in Hawaii have also measured the effects of human activity on the stability of the beaches of Hawaii.

Oahu has lost nearly 9 miles of beach since 1940, probably the result of a combination of factors such as

sediment being diverted by construction of seawalls and declining water quality that becomes detrimental to reef biological productivity. Scientists and engineers do not know the ultimate fate of sediment whose natural movement is altered by engineered solutions to erosion. Preliminary results from studies conducted after Hurricane Iniki suggest that beach erosion was greater in some areas that were "protected" by seawalls. It is clear however that such solutions trade construction stability for recreational opportunities. Because all the beaches in Hawaii are publicly owned, beach loss resulting from shoreline hardening destroys coastal resources that are normally available for all people to enjoy. In addition, studies are needed to determine coastal sand volumes and sand production rates that may be impacted by non point-source pollution. High nutrient effluent from agricultural activity, coastal siltation fro soil erosion, and excessive freshwater runoff from urbanized areas may change the abundance of calcareous sand-producing organisms in coastal waters. A decrease in the availability of sand may increase rates of beach erosion.

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