Seagrass, Sediment, and Coastal Resilience

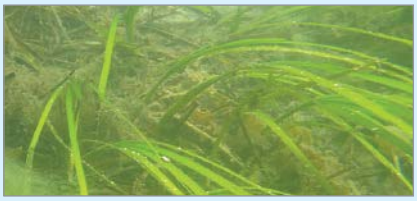
By Sara Ernst (USGS)

Seagrasses are marine flowering plants that serve as ecological engineers that can alter sediment transport dynamics of coastal environments. The presence or absence of seagrasses influence the resilience of coastal wetlands to external agents, such as storm surge and sea-level rise. Seagrass habitats are declining in many areas worldwide, and the effect of their presence or absence on coastal bay resilience and sediment transport dynamics is understudied. In a recent study, USGS scientists show how seagrasses influence the sediment budget of shallow bays using a computer model and Barnegat Bay, NJ, as a test case.

USGS used computer models to simulate velocity and sediment transport dynamics in Barnegat Bay with historical seagrass maps from 1968–2009 to investigate the role of these vegetated surfaces on the sediment storage capacity of shallow bays. Through the Coupled-Ocean-Atmosphere-Wave-Sediment Transport (COAWST) numerical modeling framework, researchers found that seagrasses are important for retaining sediments within bay systems. An abundance of sediments generally corresponds to more resilient coastal wetlands.

Such results aid the design of coastal management and protection schemes for creating resilient coastal communities.

Learn more: *https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018GL078056#.WyJ0hj3AY1l.facebook*



Seagrass in West Falmouth Harbor, MA. Photo credit: Neil Ganju, USGS

Inhabitants of Hurricane Hole

Read about hurricane impacts and recovery, story page 30. Photo credits: Caroline S. Rogers

Read BOEM's Ocean Science!

By Melanie Damour (BOEM)

The BOEM *Ocean Science* April–July 2018 issue highlights BOEM's physical sciences studies. The studies address a wide array of topics such as air quality and meteorology, physical oceanography, chemistry, oil spill fate and effects, geology, and even marine acoustics. Technological advances in instrumentation used for data collection, computer software and processing capabilities, and modeling enhance our understanding of the physical environment. Applied to BOEM's mission, they facilitate our ability to conduct the environmental analyses that are crucial to ensuring the responsible development of the Nation's offshore conventional and renewable energy, and nonenergy mineral resources.

Stay up-to-date with BOEM's Environmental Studies Program and ongoing studies through BOEM Ocean Science: *https://www.boem.gov/Ocean-Science/*. Image credit: BOEM

Illustration by Cole Goco

Removing Boats from Hurricane Hole, USVI

By Christy McManus and Dave Worthington (NPS)

In July of 2018, the NPS announced the removal of about 50 displaced vessels from Hurricane Hole, Leinster Bay, Mary Creek and Hassel Island, USVI. *See related stories, pages 30 through 34.*

Over 90 vessels either washed aground or sunk in waters surrounding Virgin Islands National Park after Hurricanes Irma and Maria; however, many of these vessels were removed by vessel owners. The remaining vessels created a hazard to boaters, swimmers, and natural resources by possibly leaking fuel, sewage, or other substances that can damage reefs and seagrass, mangroves, and shorelines. Funding for the vessel removal is provided by the NPS.

"I am pleased that the Navy is able to assist Virgin Islands National Park by removing these vessels from park waters and helping protect park resources," said acting Superintendent Rick Gupman. "We recognize the presence of these vessels is a concern to island residents and visitors, especially for those that choose to use Hurricane Hole as a storm refuge."

In August, the U.S. Navy's Supervisor of Salvage and Diving (SUPSALV) program and their contractor used barges, cranes, and other equipment to remove vessels sunk or washed aground within the park. Vessels were transported via barge to a salvage facility in the mainland United States for disposal. Because of hazardous conditions associated with the use of cranes and barges and for the safety of personnel working in park and monument waters, parts of Hurricane Hole, Leinster Bay, Mary Creek, and the waters surrounding Hassel Island were closed to park visitors and boat traffic while operations occurred.

Many boats sank or were carried up onto shore during the storms.
Photo credit: Caroline S. Rogers, USGS

Documenting Nature's Recovery

By Caroline S. Rogers and Ann Tihansky (USGS)

Although hurricanes are part of life in the Caribbean, the combined wind and wave energy from back-to-back Hurricanes Irma and Maria in September 2017 destroyed man-made and natural structures in the USVI Islands. These hurricanes left behind battered mangrove forests and coral communities in Hurricane Hole, Virgin Islands Coral Reef National Monument, St. John.

The combined effects of the two storms over such a short period was unprecedented. The damages were comprehensive and extreme. The island's electric power and communication systems were destroyed, leaves were stripped from mangroves and other vegetation, and boats, both hauled out and anchored in the water, were strewn about the coastal areas where some remained until late August 2018.

Underwater areas were not immune to the high velocities of wind and water. Corals were smashed, overturned, and displaced, and seagrass beds were scoured. Deeper reefs generally sustained less damage than shallow, nearshore ecosystems.

Here, we describe changes within of shallow areas of bays in Hurricane Hole, so named for the refuge these bays have historically provided for boaters during the tropical storm season. It is the most highly visited part of Virgin Islands Coral Reef National Monument.

Before these powerful storms, research documented that the number of coral species in three of these bays (Princess Bay, Otter Creek and Water Creek) was remarkable, perhaps unique for mangroves in the Caribbean.

See Nature's Recovery page 33

Updated information about Hurricane Hole storm refuge: *https://www.nps.gov/vicr/learn/management/hurricane-hole-storm-refuge.htm*

Press release: *https://www.nps.gov/vicr/learn/news/removal-of-displaced-vessels.htm*

Several red mangroves were uprooted and tossed into the sea by the hurricane winds. Photo credit: Caroline S. Rogers, USGS

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USGS scientist Caroline Rogers documented that at least 30 corals grew on and near the prop roots of red mangroves (*Rhizophora mangle*), including four that are listed as threatened under the Endangered Species Act. Other scientists have documented about 80 species of fish and 60 species of sponges. See related information: *https://www.nps.gov/vicr/learn/upload/Rogers2017HHoleBiodiversity.pdf*

"Before the storms, the prop roots and adjacent substrate supported fragile communities of colorful sponges, tunicates, anemones, and seaweeds," said Rogers. Numerous fish, including grunts, snappers, and the especially conspicuous angelfish, swam among the roots. *See video 1*.

"As scientists, we were just beginning to describe the area and the organisms that lived there, much less understand why it was home to such a diverse community. But now, the destruction has been tremendous. There may have been loss of species that were not even described yet. For example, in 2014 a new genus of worm was discovered here. And we do not know if Hurricane Hole still has the characteristics that allowed it to function as a coral reef refuge and a nursery before the storms," said Rogers.

"In general, corals grow less than a centimeter per year. Because this is a unique ecosystem, it is possible that they grow faster in this area than on true coral reefs, but we will have to wait and see as we do not have previous studies of damage and recovery to compare it to," said Rogers. Red mangroves bridge the land and the sea. Extensive new settlement and growth both above and below the water will be required for this extraordinary ecosystem to recover.

Damage at Hurricane Hole

The first sight of Hurricane Hole after Irma revealed a shocking scene of desolation, with the few houses on shore in ruins, boats in the head of each of the four bays tangled and jumbled together, and trees snapped and uprooted on shore. In the past, Hurricane Hole has served as a haven for boats during hurricanes, but more than 90 boats were transported up onto the shore or sank or capsized during these storms. *See related story, page 30*.

The mangroves were hit especially hard within Hurricane Hole and at sites within Virgin Islands National Park. Although many types of trees now have new leaves, many red mangroves have died. Some of the large mangrove trees were uprooted and now lie on the bottom of the bays. But red mangrove seedings were found when USGS scientist Ken Krauss visited the site in July 2018 to evaluate the damage and set up monitoring plots. Krauss suggested that some of the mangrove seedlings possibly survived because they were submerged during the storms and therefore protected from the hurricane winds.

Along the south shore of Water Creek (see map), where especially large reef-building corals and highly diverse communities were thriving from before storms, there are now few signs of life. *See video 2*. A few sponges and a few damaged corals are present here and in Otter Creek, but many of the large corals that used to grow in shallow water under the red mangroves are gone, pulverized by piles of rock rubble that were moved around by the waves.

Many rocks were moved up into shallower water, closer to shore.

Several different species of corals grown on the red mangrove prop roots that also provide shelter for fish. Photo credit: Caroline S. Rogers, USGS

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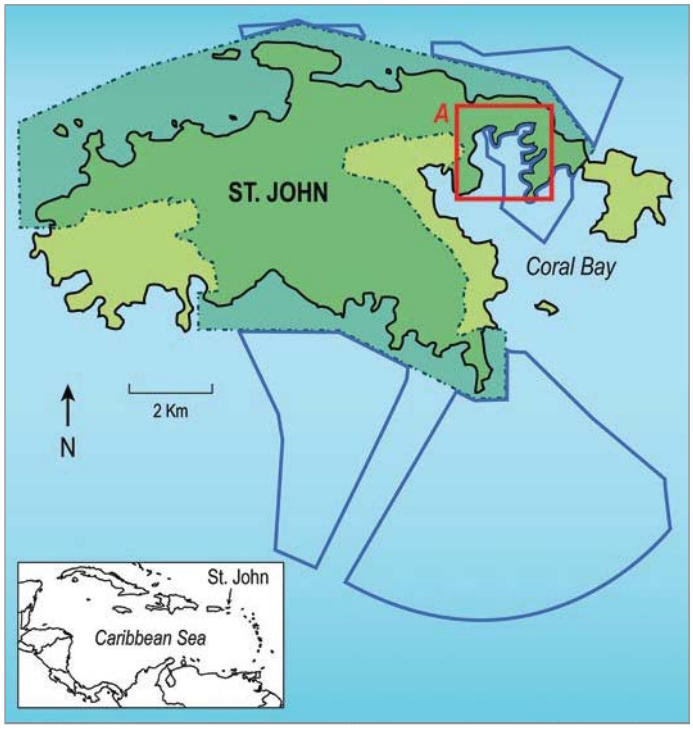
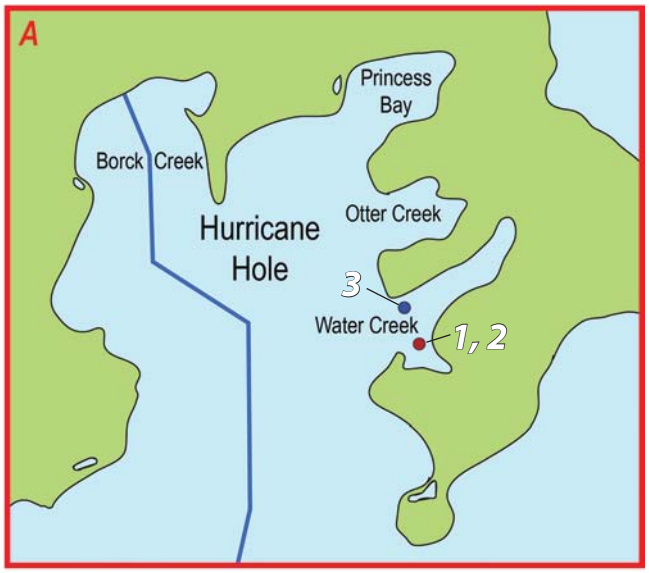
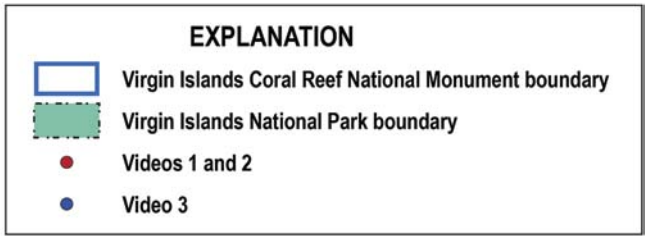






Map of the Hurricane Hole area showing park and monument boundaries and locations where video footage was captured. Image credit: Betsy Boynton, Cherokee Nation Technologies (base map credit: Scott Pittman, NOAA)

State of the Reefs

A program for the St. John community hosted by the Friends of Virgin Islands National Park, is available in a series of videos available online.

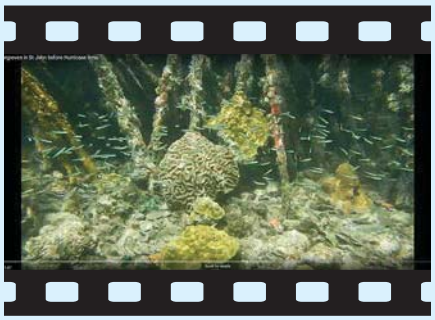
Presentation by Jeff Miller, NPS: *https://www.nps.gov/media/video/view.htm?id=8099A9EE-1DD8-B71B-0B0351F38B0FDD05*

Presentation by Caroline S. Rogers, USGS: *https://www.nps.gov/media/video/view.htm?id=5417D29B-1DD8-B71B-0BBA6705CD3D95CD*

You can find more video resources on the USVI NPS YouTube Channel: *https://www.youtube.com/channel/UCn-pUWBbMPijDsFHqLsTB2w*

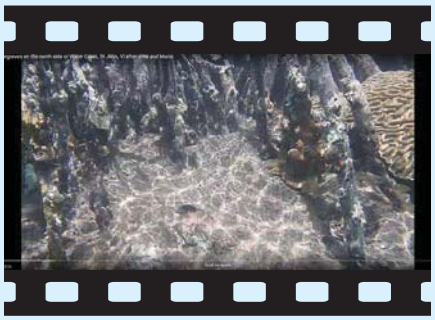
Underwater videos of Hurricane Hole before and after hurricane damages: (locations shown on map at upper right)

Snorkle along at the Buck Island Reef National Monument before Hurricane Maria: *https://www.youtube.com/watch?v=THfML-8QCuw&feature=youtu.be*



Video 1: Snorkeling in the mangroves in Water Creek, Hurricane Hole, St. John USVI in 2017 before Hurricane Irma. Video credit: Caroline S. Rogers, USGS *https://youtu.be/uEEVv_WQxqs*

Video 2: Snorkeling in the mangroves in Water Creek, Hurricane Hole, St. John USVI February 2018 after damages caused by Hurricanes Irma and Maria in September 2017 Video credit: Caroline S. Rogers, USGS *https://youtu.be/EbgUlnfhOLw*



Video 3: Snorkeling in the mangroves on the north side of Water Creek, Hurricane Hole, St. John USVI in March 2018 after damages caused by Hurricanes Irma and Maria in September 2017. Video credit: Caroline S. Rogers, USGS *https://youtu.be/FO8cYYUs5F0*

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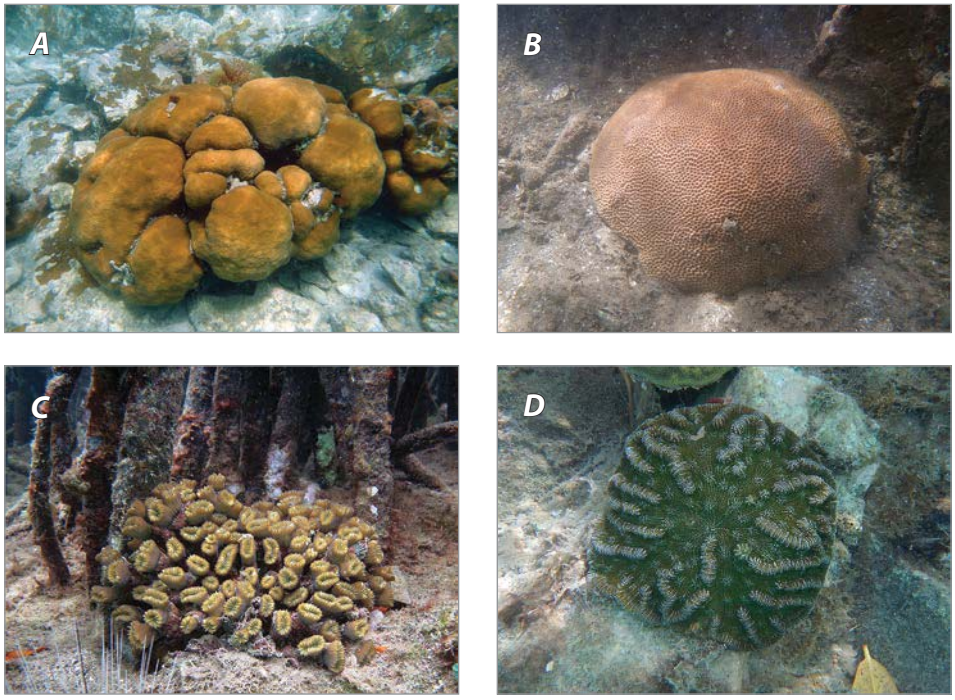
These rocks contribute to hindering the settlement of mangrove seedlings and other organisms. Although a few mangrove prop roots are visible, many have been scoured, stripped bare, and now lack the outer bark. Similar severe damage was also observed in Otter Creek, whereas Princess Creek had less damage.

The north side of Water Creek was less damaged than the south side, and some large reef-building corals in very shallow water are intact. *See video 3*.

A few stretches of the shoreline now have prop roots with colorful sponges and other organisms growing on them. The shade once provided by the canopy of red mangroves seemed to allow recruitment and growth of many organisms that would not otherwise have persisted. The loss of shade in the mangroves and over the entire island of St. John is one of the most conspicuous consequences of the hurricanes. Now much more sunlight reaches the shallow nearshore water. Research shows that Hurricane Hole has been functioning as a refuge from some aspects of climate change (by providing variable water temperatures and lower light levels). As a result of the damage to the mangroves, much more sunlight now reaches the shallow nearshore waters.

It is difficult to estimate how long it might take for this unique ecosystem to recover. The small bays of Hurricane Hole shielded this habitat from the destructive forces of previous hurricanes, but the damages from Irma and Maria have established a new historical marker that can be used for quantifying biological response to tropical storms, which are predicted to have increased intensity and perhaps also the frequency of major storms associated with changing climatic conditions.

One of the great challenges to recovery is that sponges and particularly corals sponges grow slowly. It is possible that the surviving sponges and corals could produce larvae to repopulate this area with additional larvae coming from nearby sites in the British Virgin Islands (though they too sustained severe damage). The full recovery to anything resembling the uniquely diverse, colorful coral/



A, Star corals are listed as threatened under the U.S. Endangered Species Act although they are abundant in Hurricane Hole. *B*, Massive starlet corals (*Siderastrea* spp.) survived better than many other species. *C*, Flower corals are usually found on deeper reefs although they grow in the shade of the mangroves. *D*, Very few of these cactus corals were seen in Hurricane Hole before the storms, and so far none have been found since. Photo credits: Caroline S. Rogers, USGS

Waves moved rocks and dead coral around during the storms, depositing them up near shore where they could hinder regrowth of corals. Photo credit: Caroline S. Rogers, USGS

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Hurricane Damage in the U.S. Virgin Islands

Hurricane Irma, a category 5 storm, with sustained winds of 185 miles per hour (mph) and gusts over 220 mph, was followed less than two weeks later by Hurricane Maria, a category 4 storm in St. John and a category 5 in St. Croix and Puerto Rico. Over the course of only a few hours on September 6, 2017, Hurricane Irma caused massive destruction in the British and U.S. Virgin Islands, particularly on St. John, the site of Virgin Islands National Park and Virgin Islands Coral Reef National Monument.

USGS scientist Caroline Rogers prepared for the storm and safely sheltered in her home, but her office sustained major damage, providing additional challenges to conducting the science needed to help evaluate the impacts and recovery from these storms. Because it was not possible for anyone to safely get out and see the conditions either above or below the water, it is not clear whether Irma or Maria caused the most overall damage, although it is suspected that Irma was the most destructive because its eye went right over the island of St. John.

Left, Caroline Roger's office before the hurricane (with the computer and other electronics covered in plastic in preparation for the storm). Right, after the storms. Note the blue sky where the roof would have been. Photo credits: Jeff Miller, NPS

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mangrove ecosystem that existed in Hurricane Hole before the 2017 hurricanes will take time, possibly decades, and, given the unique nature of this ecosystem, is not guaranteed.

The highly destructive storms offer the opportunity to learn more about how mangroves, corals, and other marine communities respond to natural disasters and changing climate and more about the different responses of various reef-building corals to a severely altered environment.

USGS and NPS scientists are hoping to see more signs that the system is resilient and beginning to recover. They will be working together and with partners such as Santa Fe College in Gainesville, FL, to evaluate the hurricane effects and the potential for recovery.

The remains of the NPS building adjacent to Caroline's that housed Chief of Resources and Administrative support offices. Photo credit: Jeff Miller, NPS