



Coast Survey Mobile Integrated Survey Team (MIST) survey operation on a "vessel of opportunity" post Hurricane Irma in Key West, Florida.

NOAA Navigation Services

Florida and Caribbean Regional Report

Office of Coast Survey, Center for Operational Oceanographic
Products & Services, National Geodetic Survey

March 2018

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Florida and the Caribbean Region

This report covers Florida and the Caribbean region, including the state of Florida, the Commonwealth of Puerto Rico, and the U.S. Virgin Islands (USVI) of St. John, St. Thomas, and St. Croix. The region is bordered to the west by Alabama and the Gulf of Mexico, to the south by the Caribbean Sea, to the north by the states of Georgia and Alabama, and to the east by the Atlantic Ocean. Its largest city is Miami, but other Florida cities San Juan, Puerto Rico, also have a strong influence on Caribbean and east coast economy and transportation networks.

The Florida and Caribbean region, particularly the maritime transportation sector, faces many challenges making regional collaboration and coordination increasingly important. Natural disasters including severe storms, sea level rise, and flooding, coupled with infrastructure issues related to expanding ports, crowded anchorages, increasing ship size, and a growing population calls for a renewed fostering of partnerships inside and outside of NOAA as a key part of addressing these regional challenges.

NOAA has substantial assets within the region that focus on marine transportation challenges. This report focuses on the capabilities and assets of NOAA's navigation services.



Tanker approaching the Skyway Bridge in Tampa Bay, Florida. Credit: Tim Osborn, NOAA

National Ocean Service Responds to Hurricanes Irma and Maria

The 2017 Atlantic hurricane season was powerful, with the strongest storms occurring consecutively from late August to early October. The sequential magnitude of four hurricanes in particular—Harvey, Irma, Maria, and Nate—made response efforts challenging for the National Ocean Service. Hurricanes Irma and Maria strongly impacted the Florida and the Caribbean Region.

Hurricane Irma Response

Hurricane Irma made landfall as a Category 5 storm in the U.S. Virgin Islands (USVI) on September 6, 2017, and then as a Category 4 storm in the Florida Keys on September 10. It moved across the Keys and then up Florida's west coast through the panhandle. The communities hit by the massive storm will be rebuilding and recovering for years to come. Staff from across the National Ocean Service supported the impacted communities by delivering coastal science, management, and operational expertise. Following is a summary of some of those activities.

The **Center for Operational Oceanographic Products and Services (CO-OPS)** issued [Storm QuickLook](#) postings every six hours throughout the storm. The product provides a synopsis of near real-time oceanographic and meteorological observations at locations affected by a storm. CO-OPS issued 29 QuickLooks for Irma, matching the number issued for Hurricane Harvey. The highest water level recorded was at the I-295 Bridge, St. Johns River, Florida, at 5.26 feet above Mean Higher High Water (MHHW). Inundation is most likely to occur when water levels rise above MHHW. [Peak observed water levels for Irma can be viewed online](#). In Virginia Key, Florida, water levels reached 3.66 feet above MHHW. This eclipses the previous maximum of 2.58 feet from Hurricane Wilma in 2005.

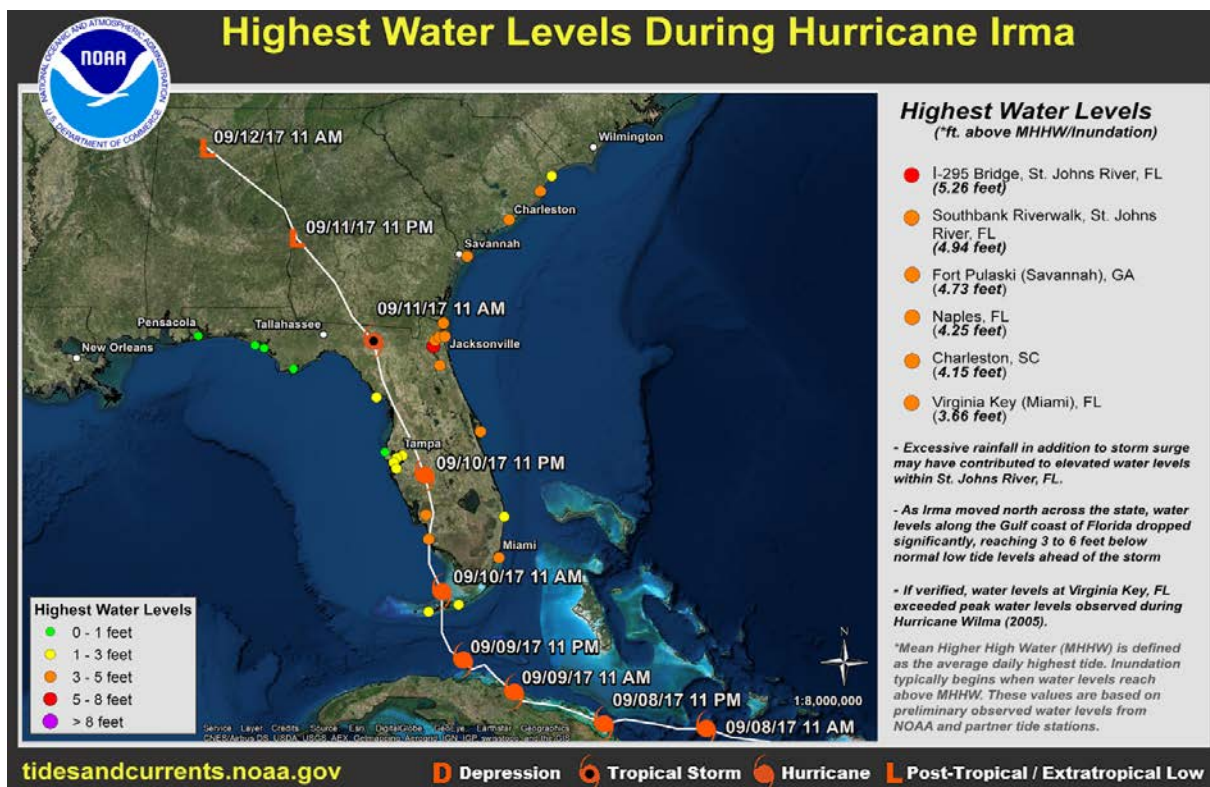
The **National Geodetic Survey (NGS)** The National Geodetic Survey (NGS) collected more than 18,000 aerial oblique images, covering more than 4,500 square kilometers along the coast. Using NOAA's Office of Marine and Aviation Operations (OMAO) Beechcraft King Air 350 CER aircraft, NGS covered areas from Savannah to Brunswick, Georgia; Jacksonville to Daytona, Punta Gorda to Naples, the Everglades to Fort Myers, and Key West to Key Largo, Florida; and St. John, St. Thomas, and St. Croix, USVI. Images were processed and posted online within hours. The [imagery](#) is used for a variety of purposes, including recovery strategies, search and rescue efforts, hazard identification, vessel locations, and damage assessment. NGS conducts surveys as requested by the Federal Emergency Management Agency (FEMA) or a state, territory, or tribe in coordination with FEMA.

The **Office of Coast Survey (OCS)** [navigation managers](#) were pre-deployed in Norfolk, Virginia, and in Miami and Tampa, Florida, to coordinate efforts with U.S. Coast Guard (USCG) District 7 and U.S. Army Corps of Engineers (USACE) Savannah District. OCS's [mobile integrated survey team](#) (MIST) traveled from the NOAA Disaster Response Center in Mobile, Alabama, to Miami. The USCG and NOAA Navigation manager ensured this valuable resource arrived on the first flight in after the storm. The team surveyed the Port of Miami aboard a vessel of opportunity provided by the Miami-Dade Police Department. [Navigation Response Team](#) (NRT) 5 traveled from New London, Connecticut, to conduct surveys in Tampa Bay. NOAA Ship *Thomas Jefferson*

transited from Norfolk, Virginia, to survey near Savannah, Georgia. The MIST team then transited the Overseas Highway to conduct surveys in Key West, Florida.



MIST team members, Lt. Cmdr. Jonathan French, John Doroba, and Mike Annis board the U.S. Coast Guard USCG CASA HC-144A Ocean Sentry to Miami to respond to Hurricane Irma.



Water levels recorded during Hurricane Irma.

Hurricane Maria Response



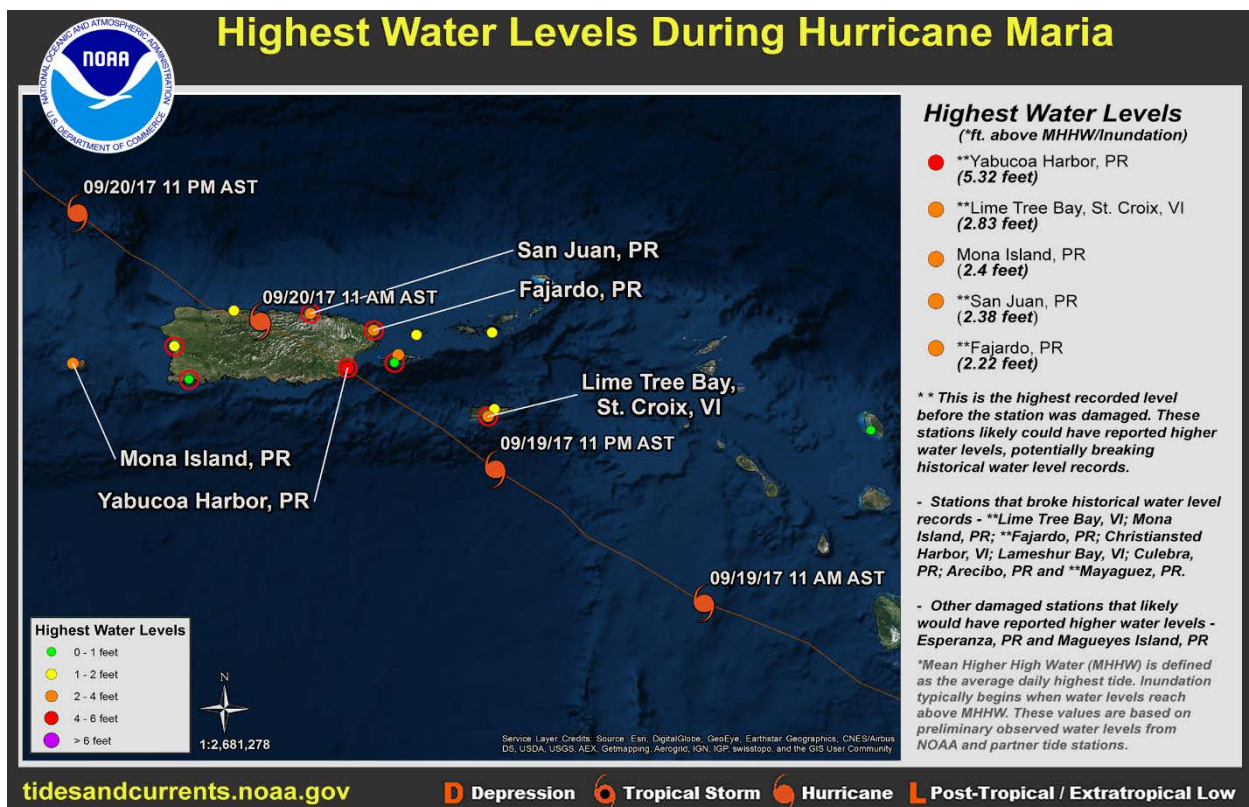
Seaman-Surveyor James Brzostek navigating a hydrographic survey launch from NOAA Ship *Thomas Jefferson* in Roosevelt Roads, Puerto Rico, during NOAA's response to Hurricane Maria. Credit: ENS Dale Gump, NOAA

Hurricane Maria made landfall as a high-end Category 4 storm on Puerto Rico on September 20, 2017. The massive storm—the 10th most intense Atlantic storm on record—devastated the U.S. territory, and communities there will be recovering and rebuilding for years to come. In Fiscal Year 2017, staff from across the National Ocean Service supported the impacted communities by delivering coastal science, management, and operational expertise. Following is a summary of some of those activities for NGS, CO-OPS and OCS.

CO-OPS issued 23 Storm QuickLooks for Hurricane Maria. The hurricane caused widespread station outages, making it difficult to determine peak water levels at many locations across the USVI and Puerto Rico. The tide station at Yabucoa Harbor, Puerto Rico—located precisely where the storm made landfall—survived and measured a peak water level of 5.32 feet above MHHW. Inundation is most likely to occur when water levels rise above MHHW. The peak wind speed (70.8 knots) and gust (98.0 knots) were also recorded there. CO-OPS issued a [graphic](#) highlighting peak water levels along the path of the storm. CO-OPS also provided critical information on tides to OCS as it responded to emergency hydrographic survey requests in the hurricane's wake.

NGS collected more than 12,000 aerial oblique images, covering more than 1,500 square kilometers affected by the storm. Using OMAO's Beechcraft King Air 350 CER aircraft, NGS covered areas of Puerto Rico including Culebra Island, Vieques Island, the east central portion of the main island, and its south and north coasts. Portions of USVI were also covered. [Images](#) were processed and posted online within hours.

OCS MIST arrived in San Juan, Puerto Rico, via the USCG's C-130 aircraft and USCG Cutter Venturous, to support the response to Maria and the storm's impact on the island's ports. The MIST completed survey work in the Port of Arecibo, an important fuel and chemical port. NOAA Ship *Thomas Jefferson* delivered supplies to the National Weather Service at the USCG small boat pier in San Juan and provided equipment to repair the NOAA tide gauge station. At the request of USCG, the vessel then traveled to Ponce, Roosevelt Roads, and Bahia de Puerca on the island's southern shores, where OCS hydrographers conducted surveys to locate hazards to navigation and help the ports resume operations. The USCG requested hydrographic services next in St. Croix, USVI, where the ship surveyed Christiansted, Limetree Bay, and Krause Lagoon, locating multiple submerged shipping containers and shoaling. *Thomas Jefferson* then surveyed in the vicinity of a fuel terminal near the St. Thomas airport and worked with the USCG on other hydrographic survey priorities for the islands.

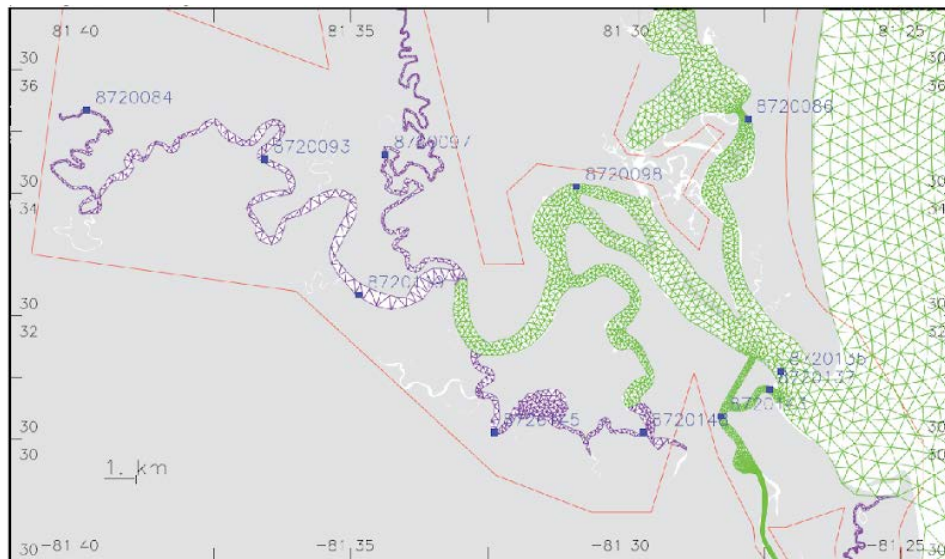


Water levels recorded during Hurricane Maria.

NGS, CO-OPS, and OCS “Tri-Office” Activities

VDatum grid updates for Florida and the Caribbean

[VDatum](#) is a tool that transforms geospatial data among a variety of tidal, orthometric, and ellipsoidal vertical datums. NOAA is in the process of updating model grids around the country to lower the uncertainty within the models for broader usage. VDatum data for Florida’s coastal areas from Naples to Fort Lauderdale and Florida Bay were updated, and transformations for South Florida’s inland waterways were created, in September of 2017. These updates and additions significantly improve the vertical accuracy of surveys conducted in the area, as well as support secondary customers for floodplain mapping and emergency response.



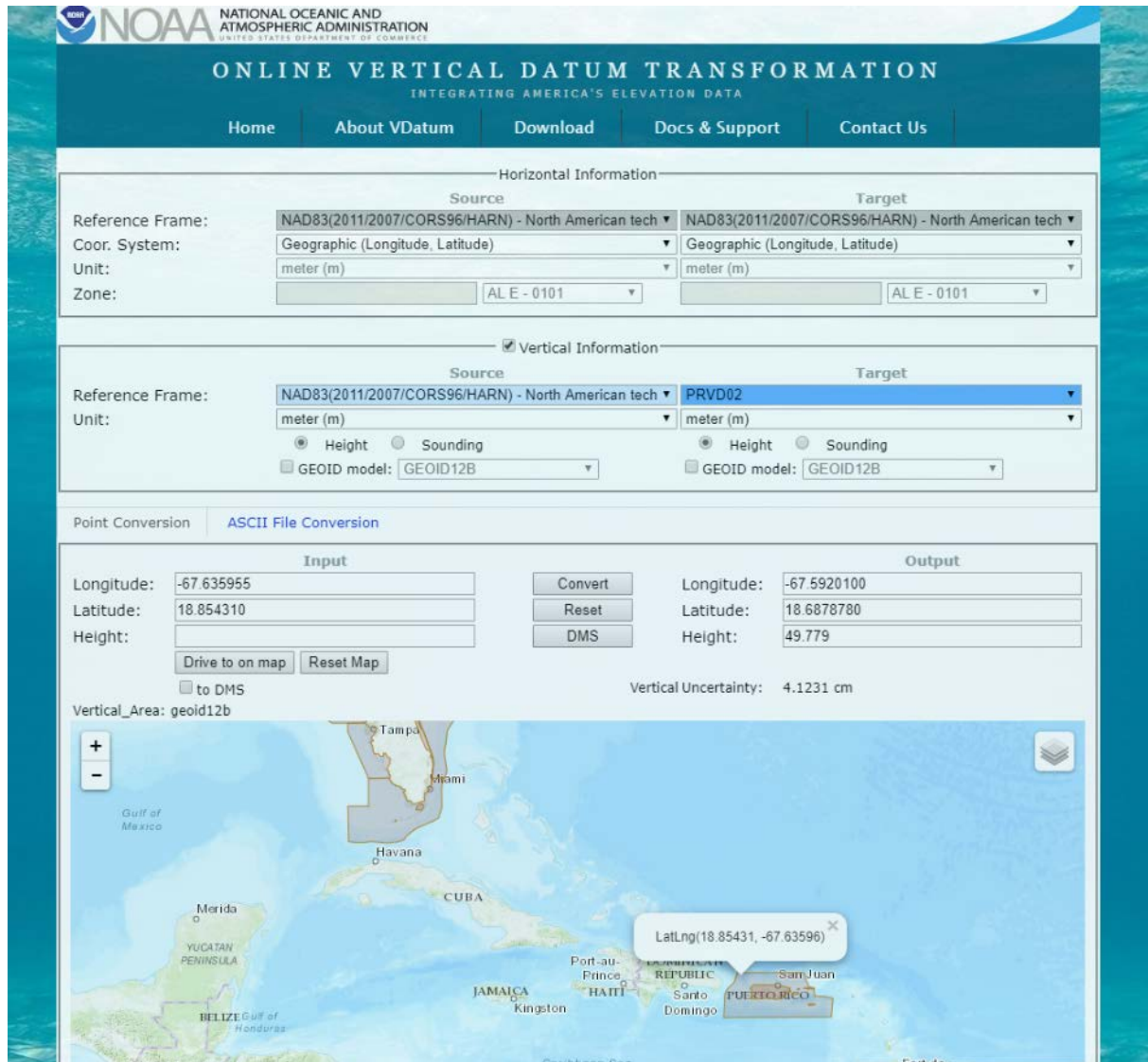
A VDatum grid for Nassau River, Florida.

Upgraded VDatum tool

In an effort to make the VDatum tool more readily accessible to users, without the need to download software and install it on a computer, the VDatum team released an initial online version. The online version provides a similar user interface and transformation functionality as the standalone application, but has reduced input/output format capabilities since it is web-based. In addition, the team released an updated standalone version (3.7) in the fall 2017 with an updated version (3.8) planned for the winter of 2018, with the following updates and improvements:

- Enhanced GeoTIFF input/output format support
- LAS 1.4 and LAZ input/output format support
- LAS Classification support

- HTDP Functionality
- Regional model grid versioning and reporting
- xGEOID16b/xGEOID17b support
- South Florida regional model update
- Bug fixes: (HTDP enhancements, 3D shapefile fix, IGLD85 grid point fix, exit code implementation)



Online version of the VDatum tool provides a similar user interface and Transformation functionality as the standalone application.

Office of Coast Survey

Personnel and products in the Florida and Caribbean Region

Coast Survey regional navigation managers

Coast Survey’s navigation managers, stationed strategically in port areas along U.S. coasts and Great Lakes, work directly with the U.S. Coast Guard, pilots, mariners, port authorities, and recreational boaters. They help identify navigational challenges facing the marine transportation system, and provide the resources and services that promote safe and efficient navigation. Coast Survey has one navigation manager position in this region that is vacant. The Southeast Navigation Manager is filling in until it is filled. Ultimately, the southeastern Florida navigation manager will be posted to Miami with an area of responsibility ranging from Canaveral to the Florida panhandle in the Gulf of Mexico. This position also serves Puerto Rico and the US Virgin Islands.

Region	Navigation manager (base of operations)	Contact information
Southeast Navigation Manager	Kyle Ward (acting) Kyle.Ward@noaa.gov Charleston, South Carolina	Phone: 301.651.4852

Navigation response and mobile integrated survey teams

Coast Survey’s highly mobile NRTs provide both routine and rapid response hydrographic surveys, helping to protect life and property from underwater dangers to navigation. During emergencies, such as following a hurricane or maritime accident, NRT surveys speed the reopening of our nation’s ports allowing shipping to resume and critical supplies to reach affected areas. Outside of emergencies, NRTs serve the maritime economy by identifying critical chart discrepancies and investigating emerging navigational concerns for 175 major ports within the U.S. marine transportation system.

The NRTs are strategically homeported around the U.S. coast and equipped with trailer-able survey launches and state-of-the-art hydrographic equipment to determine water depths and acquire high-resolution imagery of the seafloor. Coast Survey has upgraded NRT equipment. Lake Assault Boats of Superior, Wisconsin, built and delivered five new survey boats specifically designed for hydrographic surveying. Four of the five boats are fully outfitted and survey-ready. The remaining boat will be coming online in summer 2018. All five vessels will be outfitted with EdgeTech side scan sonars and Kongsberg multibeam sonars. Additionally, the NRTs began incorporating unmanned systems into their suite of equipment, including Remus 100 and Remus 600 autonomous underwater vehicles (AUV) and small autonomous surface vehicles (ASV) that will support shallow water investigations.

NRT2 is homeported in Fernandina Beach, Florida, and supports Florida and the southeast region. NRT2 has recently conducted surveys Key West, Tampa, Pensacola, Venice and West Palm as well as areas in Texas and Georgia and participated in emergency responses to Hurricanes Harvey, Irma and Maria. Additionally, NRT personnel and survey equipment from outside of the region, including NRT5 based in New London, Connecticut, were mobilized in Fall 2017 to assist with hurricane recovery efforts in Florida from Hurricane Irma and in Puerto Rico from Hurricane Maria. Preliminary plans have NRT2 conducting surveys to investigate chart discrepancies in Florida waters during the 2018 field season, though this plan is subject to change based on emerging requirements.

As part of the 2017 hurricane responses, the NRTs also employed a portable Mobile Integrated Survey Team (MIST) survey kit in Miami, Key West, Texas and Puerto Rico. The current MIST kit includes a singlebeam echosounder, side scan sonar and Universal Pole Mount (USM) designed for rapid deployment from a vessel of opportunity. Procurement of a second MIST kit with multibeam capability is under evaluation.

NOAA's MIST completed hydrographic survey work in Key West, Florida, following Hurricane Irma and was transported via USCG C-130 from Naval Air Station Jacksonville to the U.S. Naval Station Guantanamo Bay. The team then traveled to San Juan, Puerto Rico, via USCG Cutter *Venturous* and arrived on Saturday, September 23. The MIST surveyed the Port of Arecibo, an important fuel and chemical port.

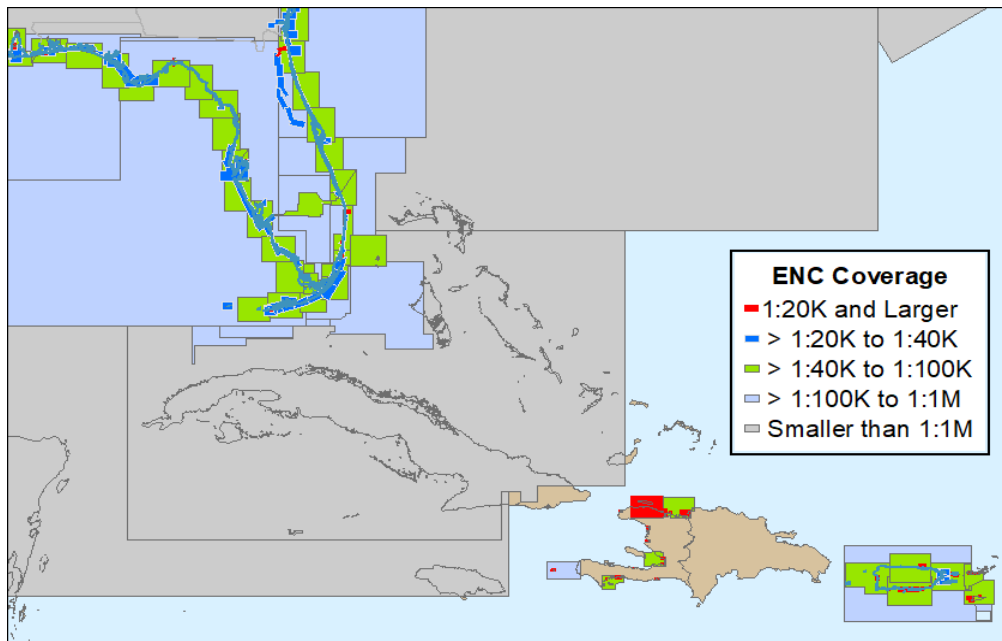


NOAA loads the MIST kit and crew on board the USCG C-130 aircraft at Naval Air Station Jacksonville.

Once emergency hydrographic operations are complete and ports re-open, the work is far from done. During a hurricane, the shoreline can change significantly, marine debris may not have been detected in initial response surveys, and shoaling may have occurred in the approaches to ports. Survey work and chart updates must continue so that the accuracy of NOAA Coast Survey's suite of nautical charts are restored to pre-storm conditions.



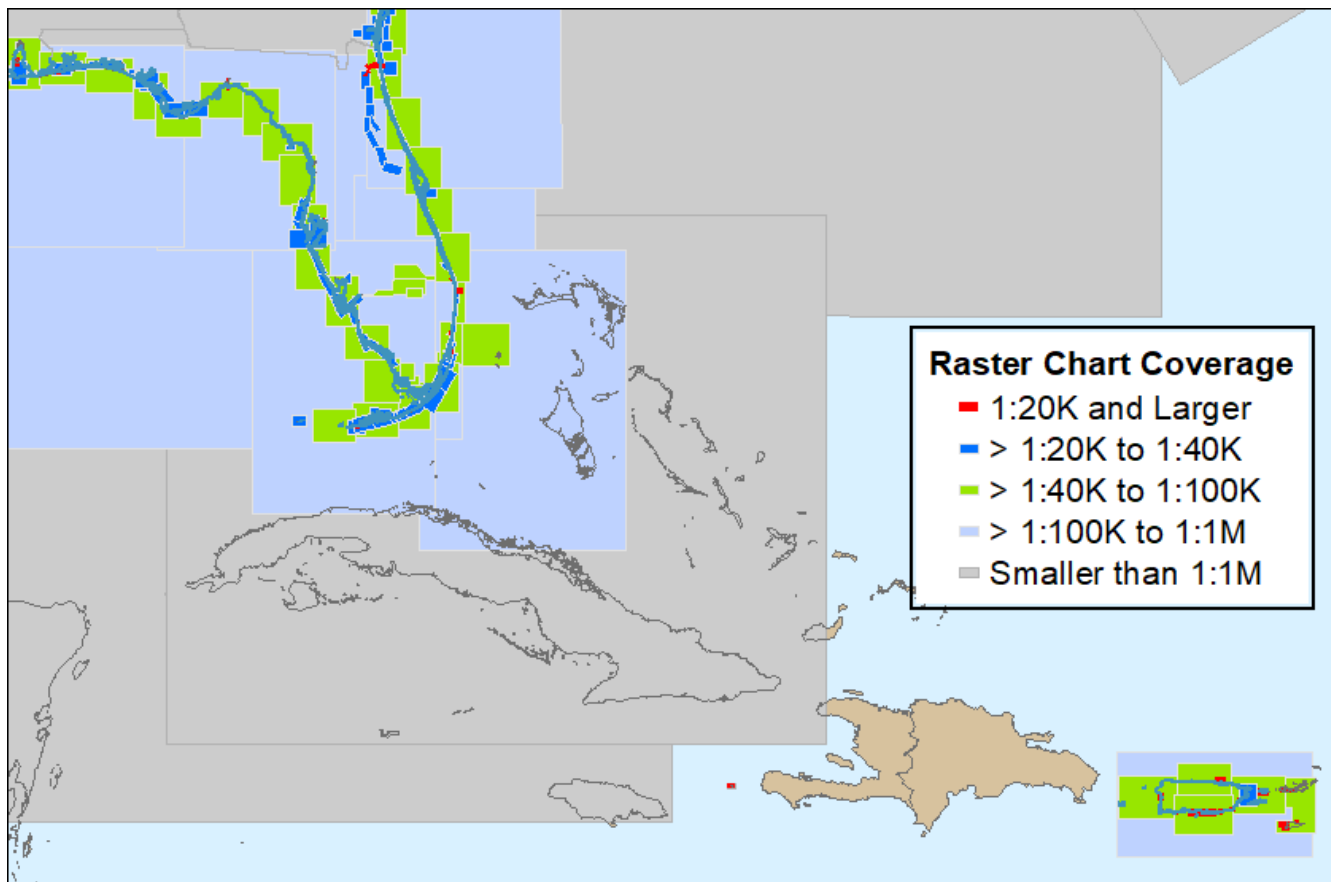
Location of navigation response teams across the country.



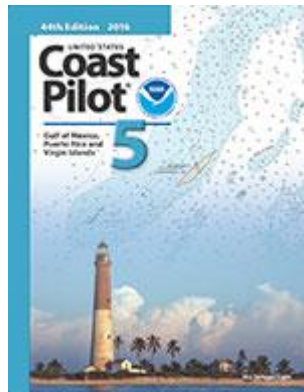
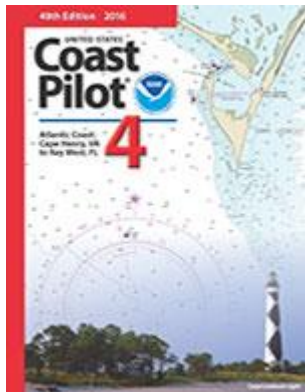
Electronic Nautical Chart (ENC) coverage for Florida and Caribbean.

Chart coverage

Coast Survey is transitioning nautical chart production into a single database—the Nautical Information System (NIS) database from the two databases that were built separately to create raster (paper) nautical charts (RNC) and electronic navigational charts (ENC). The transition allows faster simultaneous updates for all NOAA chart products. As cartographers receive new source information, they update the affected ENC and RNC products and release the updated products to the public weekly. This allows Coast Survey to keep both the ENC and RNC in agreement and provide the mariner with the most up-to-date products. With improvements in the chart production system, the raster charts are in a continual maintenance status, meaning that mariners will see shoreline and hydrographic updates more quickly, without having to wait years for a new edition.



Raster Nautical Chart (RNC) coverage for Florida and the Caribbean



United States Coast Pilot®

The [United States Coast Pilot](#)® provides information important to navigators of coastal and intracoastal waters and contains supplemental information that is difficult to portray on a nautical chart. Topics in the Coast Pilot include channel descriptions, anchorages, bridge and cable clearances, currents, tide and water levels, prominent features, pilotage, towage, weather, ice conditions, wharf descriptions, dangers, routes, traffic separation schemes, small-craft facilities, and federal regulations applicable to navigation.

[Coast Pilot 4 \(49th Edition\)](#) covers the Atlantic Coast: Cape Henry, Virginia, to Key West, Florida.

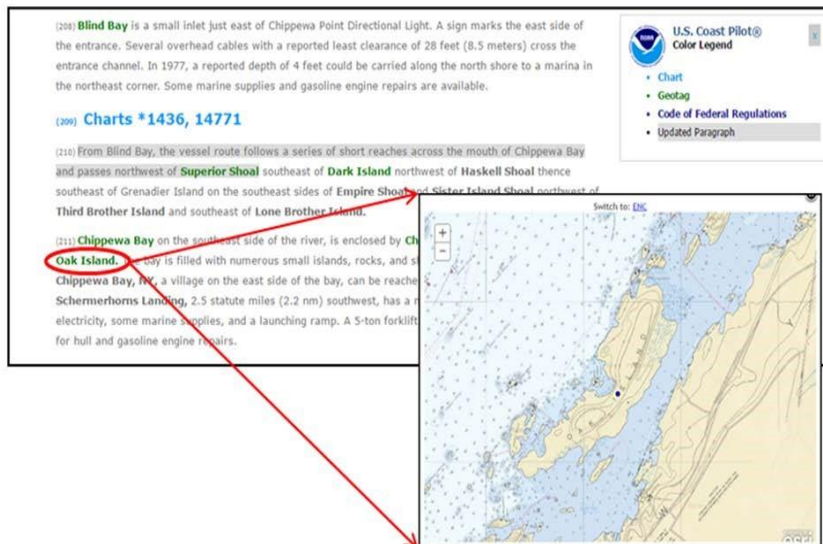
[Coast Pilot 5 \(45th Edition\)](#) covers the Gulf of Mexico, Puerto Rico and Virgin Islands.

All nine volumes of the Coast Pilot are updated and available for download weekly, and usable on mobile devices such as smart phones and tablets.

The digital version of *Coast Pilot* provides geotagged reference points that assist mariners with landmark positions and displays the associated nautical chart inset. (A geotag is a geographical location information assigned to a type of media.) In the online xml versions of *Coast Pilot*, certain place names and objects, (highlighted in green) are now viewable on a nautical chart and linked to entries in the official [U.S. Geographic Names](#) database.

Other features include:

- images that become larger when clicked
- an interactive table of contents for each book
- links to raster nautical chart, highlighted in light blue
- weekly changes, highlighted in gray, which are retained until the next annual version is published



Clicking on the geotagged place name in the online xml versions of Coast Pilot, launches a chartlet of the area.

Recent Activities

Florida and Caribbean stakeholder engagement

One of the ways that Coast Survey engages stakeholders and partners is through interactions at industry events. The navigation manager routinely meets with stakeholders in the region, including the USCG, U.S. Army Corps of Engineers (USACE), pilots associations, recreational boaters and commercial fishermen, state and local governments, and academia. The year 2017 was an exceptionally active year for the Southeast navigation manager with Hurricane Maria and Irma. As Hurricane Maria made its way toward the islands, NOAA Coast Survey monitored it closely. Kyle Ward, NOAA's southeast navigation manager, worked with USCG District 7, USCG Sector San Juan, and the USACE to coordinate response efforts prior to the storm. This laid the groundwork for positioning Coast Survey assets in strategic locations ready for deployment.

In addition to 2017 hurricane response:

At the request of the USCG, NRT2 surveyed in the vicinity of President Trump's resort near Palm Beach. This area needed to be patrolled by USCG and other federal officials. The area is very shallow and was charted poorly with antiquated survey data. The data is not available to the public.

In response to Hurricane Matthew in October of 2016, central Gulf coast navigation manager, Tim Osborn, deployed to Port Canaveral, Florida, from Baton Rouge, Louisiana. Osborn lent his expertise and experience to the Port Canaveral pilots, port officials, and USCG as they quickly resumed operations. While the port re-opened on October 8 for cruise ships during daylight hours, they needed a Coast Survey navigation team, working in coordination with a private survey company contracted by the port, to search for dangers to navigation for the deeper draft vessels. Navigation Response Team 4, homeported in Fernandina Beach, Florida, worked through the day on October 9, and the port subsequently opened for full operations.

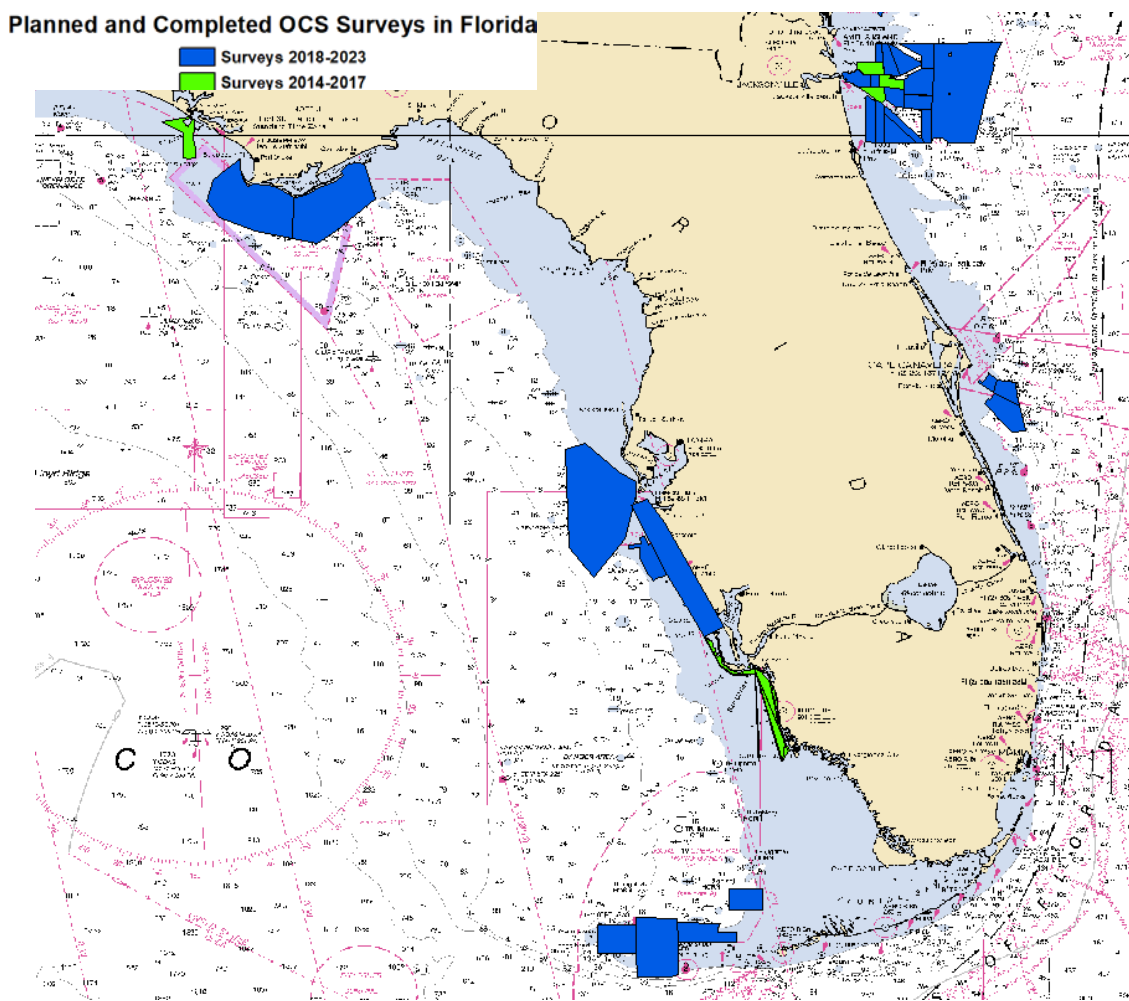
Cleaned up chart clutter in Port Everglades. Port Everglades (Fort Lauderdale) - We recently made some significant chart updates of the area. They have a new chart request pending for the port as well.

NRT2 Survey operations in Sarasota, Florida, for indigenous peoples historic preservation. In March 2017 NRT2 finished a collaborative project with the State of Florida to investigate and survey a 7,000 year old native community burial site.

Utilized outside source data from Florida and Caribbean stakeholder to make updates to the Intracoastal Waterway and Gregory Channel, St. Thomas. OCS reviewed the external data to ensure accuracy. The removal of the shoal enables cruise ships to use an expanded area of the port.

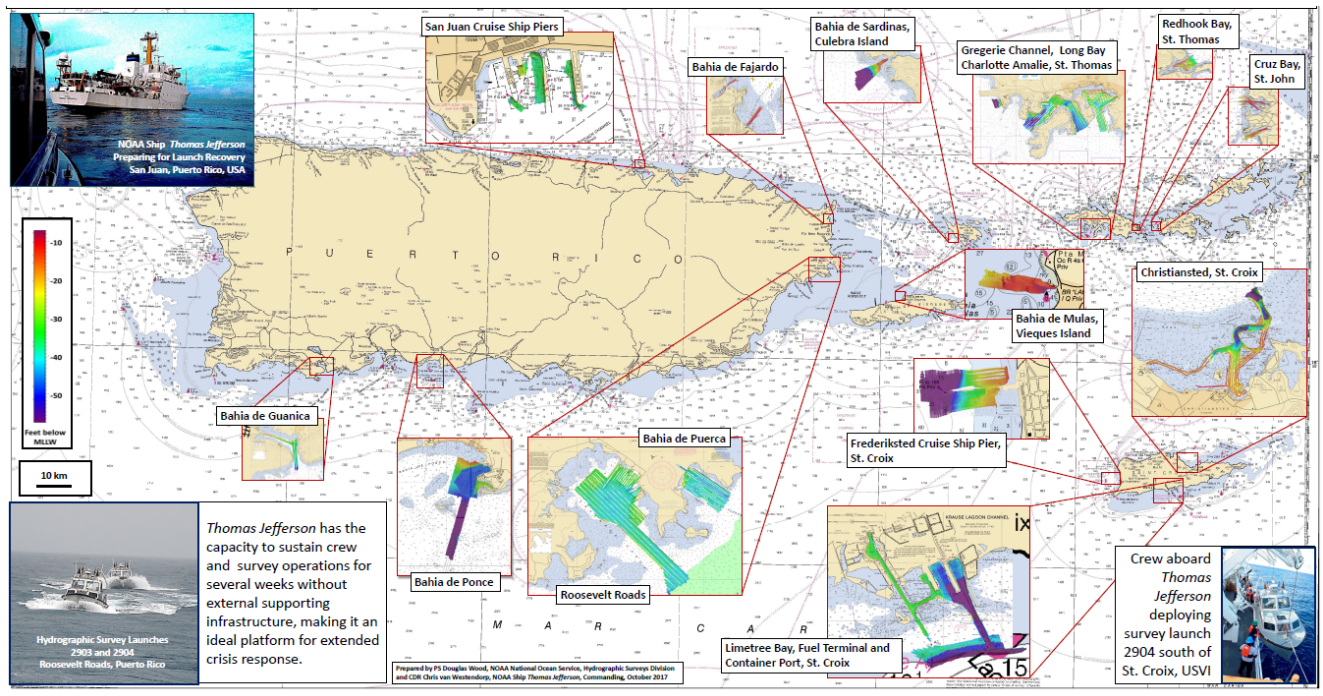
Survey operations in the Florida and Caribbean region in the past five years

Since 2014, NOAA has completed eight hydrographic surveys in Florida, including three by NOAA Ship *Ferdinand R. Hassler*, one by Navigation Response Team 2, and four by contractor field units, including work in the approaches to Jacksonville, St Andrews Bay, and Panama City.



Map of completed (green) and planned (blue) surveys in Florida.

Major recent activity in the Caribbean by Coast Survey has focused on hurricane response work, principally to Hurricane Maria in September and October of 2017.



Graphic showing areas of operations by NOAA Ship *Thomas Jefferson* during Hurricane Maria response. Credit: PS Douglas Wood, NOAA

Thomas Jefferson, in co-operation with OCS's Hydrographic Surveys Division and Navigation Services Division instructions, surveyed thirteen critical harbors around Puerto Rico and the US Virgin Islands in the immediate aftermath of the storm, re-opening them for shipment of goods to the storm-ravaged islands.

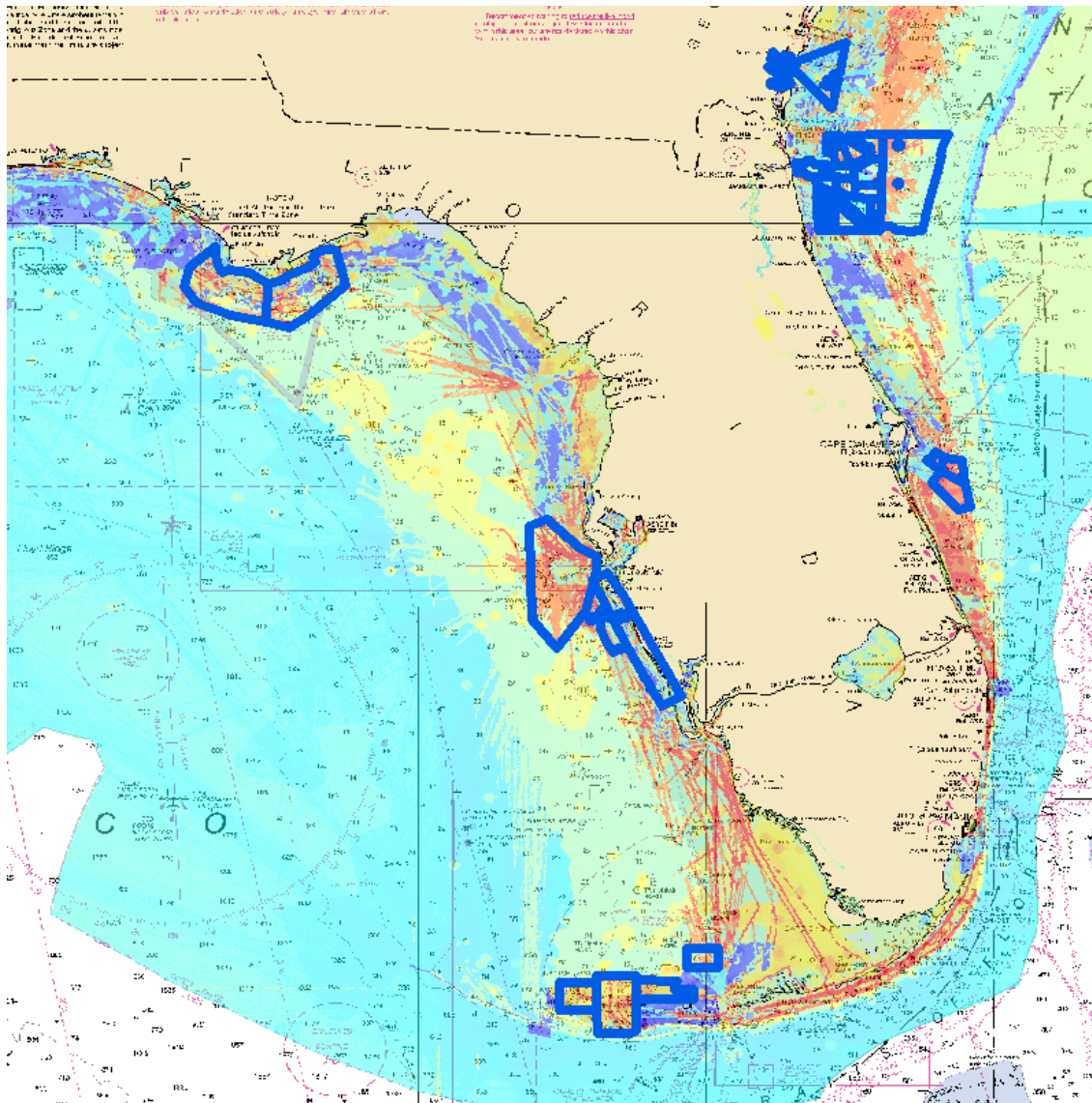
The ship also provided emergency food, water, and generators to the National Weather Service station in San Juan, enabling the station to provide forecasts despite a lack of native resources. Furthermore, its crew performed emergency repairs on National Water Level Observation Network (NWLON) gauges in Puerto Rico and the Virgin Islands, enabling CO-OPS to continue dissemination of water level data in support of navigational safety.

Florida and Caribbean survey priorities

Planned surveys in Florida include:

- A 2018 and 2019 continuation of Jacksonville approach surveys by NOAA Ship *Ferdinand R. Hassler*
- A 2018 project on the approaches to Cape Canaveral by *Ferdinand R. Hassler*
- A 2018 chart adequacy and feature investigation by Navigation Response Team 2 near Sarasota
- A 2018 contractor survey of Florida Keys National Marine Sanctuary

It is important to note that Coast Survey is in the process of developing new methodology for evaluating survey priorities, by modeling the “hydrographic health” for a given survey area. With the completion of the initial run of the Hydro Health model, Coast Survey will have better tools to assess the urgency of navigational needs in an area. This new model is still being quality controlled and having its input datasets verified, so any conclusions should be reached only with consultation with the Hydro Health team. The following two images are samples of one potential visualization option applied to the Florida coast and a larger scale image of the project areas for Cape Canaveral.

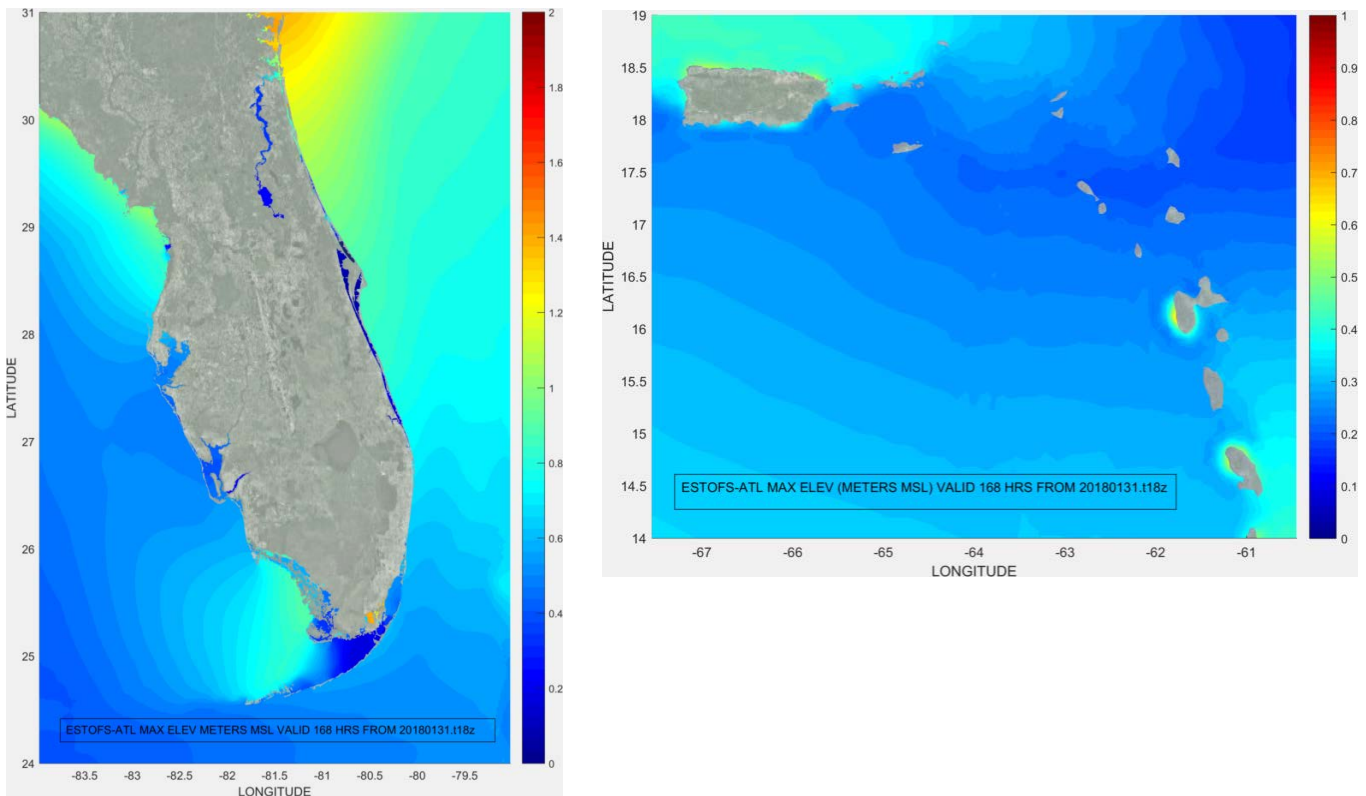


Visualization option applied to Florida offered by the Hydro Health model.

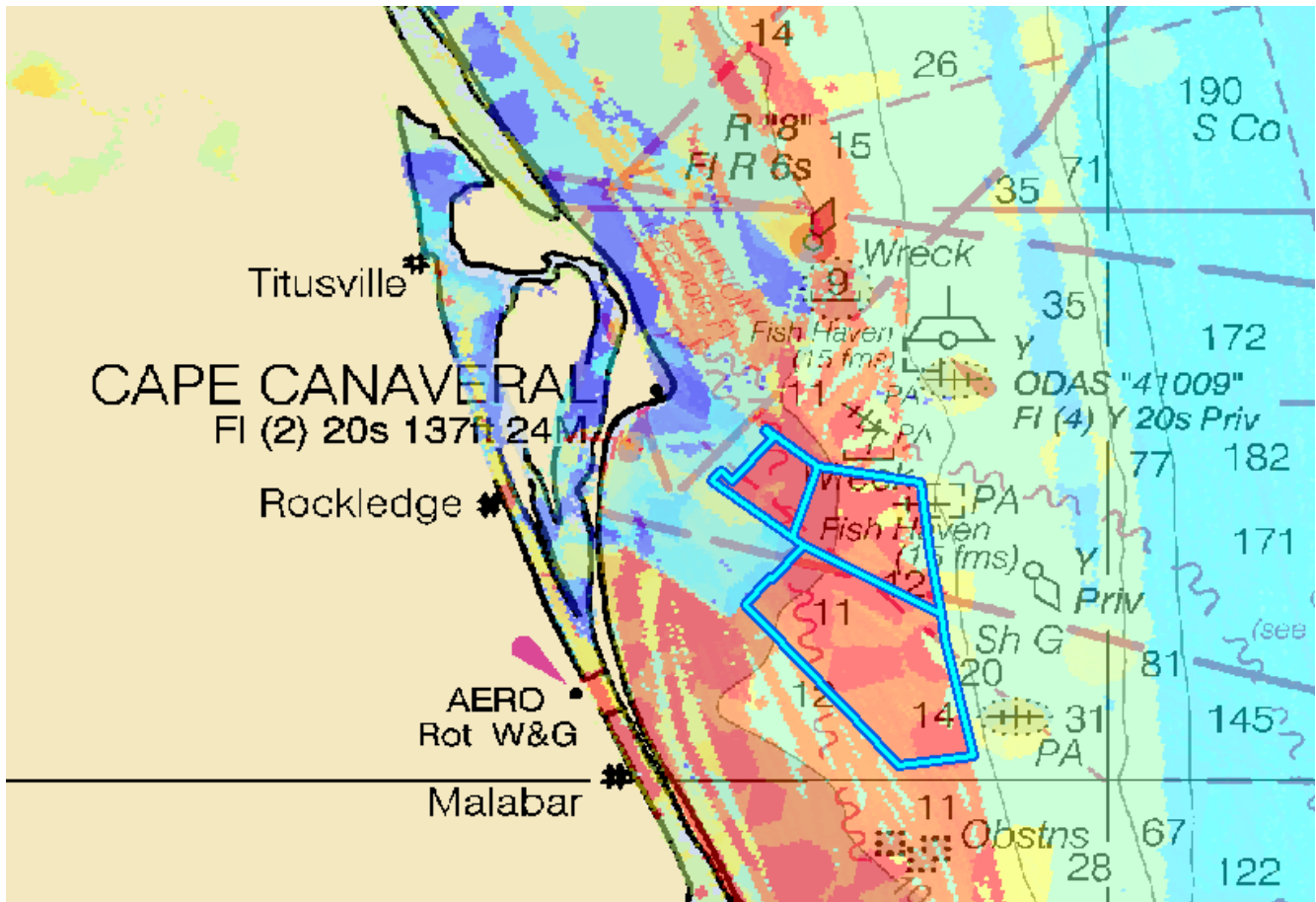
Extra-Tropical Storm Surge and Tide Operational Forecasting System for Florida and Caribbean

The Coast Survey Development Laboratory developed and currently maintains the Extra-Tropical Storm Surge and Tide Operational Forecasting System (ESTOFS) to provide operational guidance on storm surge and tidal water levels. NOAA Central Operations (NCO) runs and operates it on the high-performance Weather & Climate Operational Supercomputing System. Every 6 hours it provides 7-days surge and tide guidance for the US coastal zone. The ESTOFS framework uses a state-of-the-art advanced ocean circulation model, ADCIRC, and is part of the NOAA/National Weather Service (NWS)/National Centers for Environmental Prediction (NCEP) production suite. Local and regional forecasters, as well as other NOAA modeling components such as Nearshore Wave Prediction System actively use ESTOFS guidance.

One of the domains, ESTOFS-Atlantic, also covers Florida and Caribbean. Out of 192 high-frequency model output locations (6-min water levels and astronomical tide predictions), 19 coincide with CO-OPS tide gauges locations in Florida, 10 are CO-OPS stations in Puerto Rico, and one corresponds to a station in Barbuda. A recent upgrade in April 2017 has increased the nominal coastal resolution at the US East and Gulf coasts to 200 m. Along with high-quality forecasts of the coastal water levels; ESTOFS is capable of predicting the extent of inland inundation associated with high tides and storm surge. CSDL is actively improving ESTOFS systems with incremental upgrades of the model grids as well as implementation of new physics and data assimilation methods.



Maximal forecasted combined water levels (surge + astronomical tide) from a specific ESTOFS forecast cycle, with details shown for the Florida and Caribbean regions.



Visualization option offered by the Hydro Health model zoomed into Cape Canaveral. Planned Coast Survey projects outlined in blue.

Unmanned systems for maritime mapping: AUVs and USVs

Coast Survey is continuing to adopt unmanned systems as complementary technology to its maritime mapping capabilities, where the unmanned systems can provide a meaningful benefit by either expanding capabilities or making more effective use of manned resources.

In 2017, Coast Survey approved a formal Unmanned Systems (UxS) Roadmap and Strategy that defines four goals to enable the development and use of unmanned and autonomous technology:

- **Develop Enabling Technologies** - Support the development and adoption enabling technologies, such as high bandwidth data radios and automated processing, to advance unmanned systems and benefit conventional manned survey.
- **Maintain Operational Expertise** - Develop and maintain operational expertise with unmanned systems through training and the use of Coast Survey's current suite of unmanned systems.

- **Operational Innovation** - Support the development and transfer-to-operations of unmanned systems that benefit Coast Survey and NOAA missions.
- **Collaborate** - Collaborate with government, academic, and industry partners to share expertise and resources and to direct and expedite system development.

Current and planned activities to address those goals include:

- **Coast Survey UxS Operational Team** – Stand-up, train, and fully resource a team at Stennis Space Center to manage and operate the suite of Coast Survey’s unmanned systems on navigation safety and interdisciplinary surveys. Coast Survey’s current suite of unmanned system’s include:
 - Small Autonomous Underwater Vehicle (AUV) – Equipped to provide object detection and sonar imagery in depths up to 100 meters. Able to operate from shore, small boat, or ship. Primarily used for post-storm and navigation safety response surveys.
 - Large AUV – Equipped to provide high-resolution bathymetric data in depths up to 550 meters. Operations require a vessel with suitable deck space and handling systems. Primarily used for interdisciplinary seafloor mapping in support of NOAA scientists.
 - Small Unmanned Surface Vessels (USV) – Equipped to provide object detection, sonar imagery, and bathymetry in shallow coastal water. Able to operate from shore, small boat, or ship. Primarily used for hydrographic surveys and navigation response surveys.



Small AUV deployed for post-storm survey in Galveston Harbor.



Large AUV on NOAA Ship *Ferdinand R Hassler*.



Small USV on NOAA Ship *Thomas Jefferson*.

- **Unmanned Launch Conversion** – Coast Survey will be awarding a contract to convert two existing hydrographic survey launches converted to operate in either manned or unmanned modes. This will allow Coast Survey and NOAA’s hydrographic survey fleet to incrementally, but rapidly, evaluate unmanned systems and operational concepts while maximizes the use of existing vessels, support infrastructure, and expertise.

- **Vessel-to-Vessel Data Telemetry** – Coast Survey is conducting operational testing of high-bandwidth data radios and protocols for survey control and data transfer between ship and manned survey launches. The same technology can be used to improve communication for the command and control of unmanned systems.
- **Automated Data Processing and Workflow Improvement** – Coast Survey has multiple projects underway to automate data processing and streamline the data processing workflow. These efforts will improve traditional efforts and support the development of more autonomous unmanned systems. The goal is a 75% reduction of current shipboard data processing man-hours per acquisition hour by 2020.

NOAA's Integrated Ocean and Coastal Mapping Program (IOCM)

NOAA's IOCM program is engaged in a number of ways with Florida, the Southeast/Caribbean and Gulf regions this year. IOCM was involved in hurricane supplemental planning, to ensure that partners were at the table to provide requirements and increase awareness on planning. Also at the interagency level, one National Coastal Mapping Strategy objective is to encourage regional and recurring mapping summits, of which several are happening in 2018 in these geographies. The state of Florida just held a coastal mapping workshop on January 9-11, 2018, with a goal to coordinate on data inventory and acquisition in the 0-20m, and 20-200m ranges in Florida waters. The southeast regional team scheduled a second habitat mapping workshop for early in 2018. The goal of this workshop is to improve awareness and coordination of seafloor habitat mapping activities in the southeast U.S. to support fishery and ecosystem management and ocean planning. Objectives include:

- Summarize inventory of seafloor mapping data available through government archives
- Encourage data discovery and data sharing from non-Federal partners
- Review requirements for seafloor habitat mapping products needed for management and regulatory decisions
- Develop pathway for improved sharing of habitat mapping priority areas to effectively leverage assets, expertise and funding resources
- Introduce tool to identify priority areas for habitat mapping information

A similar Gulf Mapping Summit is in the planning stages for later spring 2018.

Other IOCM updates

IOCM continues to advance the 3D Nation requirements and benefits study, as briefed at the Portsmouth, New Hampshire, HSRP meeting in September 2017. Invitations to federal agencies to name their points of contact for the survey have been sent, and state coordinating activities will follow. The survey awaits Office of Management and Budget Paperwork Reduction Act approval, but barring Office of Management and Budget objections, will be released in March 2018. The study benefits from the 2017 Florida state survey of topographic and bathymetric lidar needs, as was also briefed by Dave Maune, HSRP member, at the Portsmouth meeting. Finally, IOCM continues to increase awareness of the global Seabed 2030 initiative to

map the world's oceans, with help from Rear Adm. Shepard Smith, director of the Office of Coast Survey, and Craig McLean, director of the Office of Oceans and Atmospheric Research and acting NOAA chief scientist.

Center for Operational Oceanographic Products & Services

Personnel and products in the Florida and Caribbean Region

CO-OPS personnel

CO-OPS has a Gulf Coast field team located in Pensacola, Florida, and a southeast field team located out of Chesapeake, Virginia, that are responsible for the operations and maintenance of the Florida and Caribbean NWLON for the collection, analysis, and dissemination of water level observations. NWLON is nationally composed of 210 primary and long-term control tide stations that provide basic tidal data for U.S. coastal and marine boundaries and for charting data. Other uses range from storm surge warnings to commercial and recreational vessel navigation to global climate change and tectonic studies.

National Water Level Observation Network

CO-OPS operates and maintains the NWLON, which is a network of 210 continuously operating water-level stations throughout the U.S., including its island possessions and territories. NWLON is the “go to” source for government and commercial sector navigation, recreation, and coastal ecosystem management. The NWLON provides the national standards for tide and water level reference datums used for nautical charting, coastal engineering, international treaty regulation, and boundary determination. NWLON supports storm surge and tsunami warnings and provides relative sea level trends. Approximately one quarter of the NWLON is located in the Great Lakes (non-tidal), providing water level data for the international management of those water resources. The NWLON is also widely recognized as the key federal component of the Integrated Ocean Observing System (IOOS).

There are 16 NWLON stations in Florida and 10 in the Caribbean. Water level stations contain the water level sensors and data collection platforms. Real-time data are transmitted every six minutes via geostationary orbiting environmental satellite. Telephone modems or cellular gateways are installed as backup communications at most locations. In addition to a primary and backup water level sensor, most stations also acquire meteorological data including wind speed and direction, air temperature, and water temperature.

CO-OPS operates the following NWLONs in Florida and Caribbean:

- **Florida** - Fernandina Beach, Mayport, Trident Pier, Lake Worth Pier, Virginia Key, Vaca Key, Key West, Naples, Fort Myers, St. Petersburg, Clearwater Beach, Cedar Key, Apalachicola, Panama City, Panama City Beach, Pensacola
- **U.S. Virgin Islands** - Christiansted, Lime Tree Bay, St. Croix; Lameshur Bay, St. John; and Charlotte Amalie, St. Thomas

- **Puerto Rico** - Culebra, Esperanza (Vieques Island), San Juan, Magueyes Island, Mayaguez, Mona Island

Upgrade in water level technology

CO-OPS is upgrading the NWLON using microwave water level sensors (MWWL) instead of traditional acoustic sensors. With a MWWL system, the sensors sit up out of the water, meaning less maintenance is needed, resulting in lower costs. It is also more accurate in high-energy conditions and has the potential to provide information on waves. In order to ensure accuracy of the data, CO-OPS leaves both the MWWL and acoustic sensors in place for one year for comparison. As of January 1, 2018, CO-OPS has installed MWWL sensors at 52 NWLON stations across the country, and 24 of those stations have been fully transitioned to use MWWL as the primary sensor. Three of those sites are in the Caribbean (Mayaguez, San Juan, and Lime Tree Bay). MWWL sensors have also been installed at 28 non-NWLON locations (PORTS, Texas Coastal Ocean Observation Networ, Global Sea Level Observing System, etc.), 25 of which are fully operational.

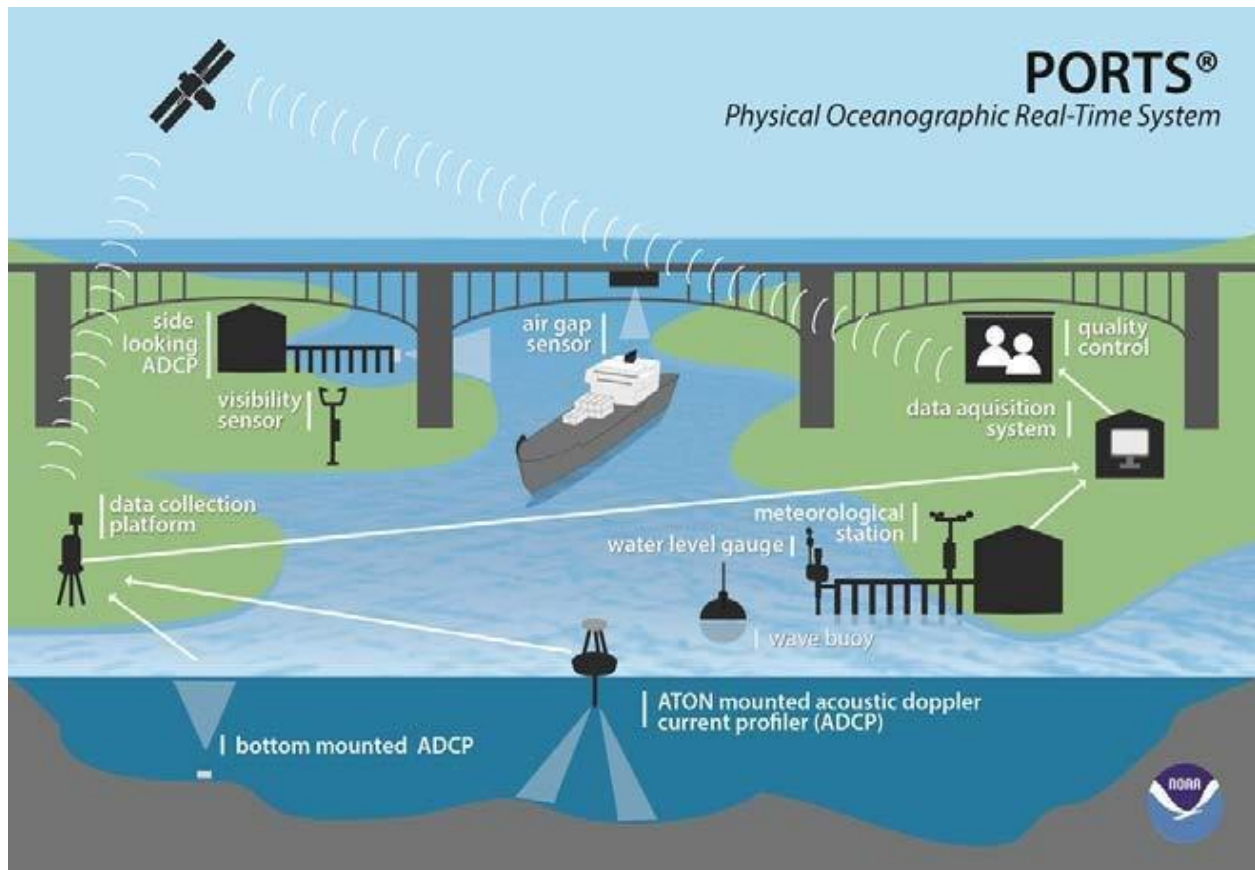
Partner stations in the Caribbean

CO-OPS works closely with the U.S. NWS Manager of the Caribbean Tsunami Warning Program/Chair of The Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (UNESCO IOC CARIBE EWS), which assists Caribbean entities with collecting water level information for tsunami and sea level hazards. CO-OPS has participated in a short course for Operators of Sea Level Stations in the Caribbean and Adjacent Regions. The sixth annual training is scheduled for Mexico City, Mexico, February 26 -March 2, 2018.

CO-OPS has a long-standing partnership with the Puerto Rico Seismic Network (PRSN), the regional authority for monitoring earthquakes and tsunamis in the Puerto Rico and USVI. United States Geological Survey (USGS) established PRSN in 1974 for the Puerto Rico Electric Power Authority (PREPA). CO-OPS has been involved with tsunami detection and warning for coastal hazard mitigation since the 1940's through the operation of a specific subset of its long-term tide stations in support of the national tsunami warning system. However, following the devastating 2004 Indian Ocean tsunami, CO-OPS began a system-wide upgrade of its instrumentation to increase the rate of data collection and transmission at all coastal NWLON stations, to better support the National Tsunami Warning System's tsunami detection and warning capabilities, as well as to provide critical inundation model input. CO-OPS worked to support the upgrading of equipment at existing long-term NWLON stations in the Caribbean. CO-OPS completed this initiative in 2007. Currently, CO-OPS operates tide stations on all U.S. coasts in support of tsunami warning.

Physical Oceanographic Real-Time System (PORTS®)

PORTS® is a decision-support tool that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, waves, and meteorological parameters (e.g., winds, atmospheric pressure, visibility, and air and water temperatures) that mariners need to navigate safely. NOS operates 31 PORTS®, four of which operate in Tampa Bay, Miami, Port Everglades and Jacksonville, FL.



Tampa Bay PORTS®

In May of 1980, an inbound freighter, *Summit Venture*, collided with the Sunshine Skyway Bridge in Tampa, Florida. A section of the bridge collapsed and 35 people lost their lives. The accident underscored the need for mariners to have a more robust understanding of their operating environment. In 1991, the Physical Oceanographic Real Time System, or PORTS®, began providing observations that help mariners in Tampa Bay make the best safety and operational decisions possible based on real-time local conditions.

This first PORTS® in the country and is operated cooperatively with the Greater Tampa Bay Marine Advisory Council Ports, Inc. to provide real-time data quality-controlled and disseminated to local users for safe and efficient navigation. Real-time data is available from three current meter stations, seven water level stations with meteorological data, two visibility stations, and one wave buoy.

Miami PORTS®

A PORTS® operates cooperatively with Miami-Dade County through its seaport department (PortMiami) and provides real-time data quality-controlled and disseminated to local users for safe and efficient navigation. Real-time data is available for three current meter stations and one water level station with meteorological data.

[Everglades PORTS®](#)

The newest PORTS® operates cooperatively with Broward County at Port Everglades to provide real-time data quality-controlled and disseminated to local users for safe and efficient navigation. Real-time data is available for one water level station with meteorological data.

[Jacksonville PORTS®](#)

A PORTS® operates cooperatively with Jacksonville Marine Transportation Exchange to provide real-time data quality-controlled and disseminated to local users for safe and efficient navigation. Real-time data is available for seven current meter stations, three water level station, and six meteorological stations.

Current surveys in Florida and Caribbean

Recently, CO-OPS conducted several current surveys in Florida to update the tidal current tables with modern predictions. In 2008, CO-OPS recovered 14 current meters within [Miami Harbor](#) and seven current meters in [St. Andrews Bay](#). During the winter of 2008-2009, CO-OPS collected tidal current information along some of the embayments and parts of the Intracoastal Waterway along [Florida's east coast](#). In the winter of 2011, six current meters were recovered off [Fernandina Beach](#). Then in 2013, seventeen current meters were recovered in the [Florida Keys](#).

With the improvements in measurement and computing technology available today, the accuracy of these modern predictions are significantly improved from past observations. Data and predictions are available to partners, stakeholders, and the public in the NOAA tidal current tables and through [NOAA Current Predictions website](#).

Operational forecast systems

Operational nowcast and forecast hydrodynamic model systems support NOAA's mission goals and priorities by providing automated integration of observing system data streams, hydrodynamic model predictions, product dissemination, and continuous quality-control monitoring. State-of-the-art numerical hydrodynamic models driven by real-time data and meteorological, oceanographic, and/or river flow rate forecasts, form the core of these end-to-end systems. The operational forecast system provides nowcast and short-term (0 hour – 48 hour) forecast guidance of pertinent parameters (e.g., water levels, currents, salinity, temperature, and waves) and disseminates them to users.

A [Tampa Bay Operational Forecast System \(TBOFS\)](#) serves the maritime user community. TBOFS is a joint project of OCS and CO-OPS, and NCEP NCO using Rutgers University's Regional Ocean Modeling System. TBOFS generates water level, current, temperature and salinity nowcast and forecast guidance four times per day.

Using data from the model, a new integrated product has been released, the [Tampa Bay Marine Channels Forecast](#), to aid local pilots by providing meteorological and oceanographic forecasts at 13 stations along the shipping channels. It creates a centralized website for obtaining weather conditions from the NWS Tampa Bay Area Weather Forecast Office, combining water level and meteorological observations from Tampa Bay PORTS® with the TBOFS marine forecasts.

Ecological forecasting

[Harmful algal blooms](#) of *Karenia brevis*, the organism responsible for red tide in the Gulf of Mexico, can impact the health of humans and animal life. The blooms are patchy in nature and the impacts vary by location and throughout the day depending on nearby bloom concentrations, ocean currents, surf conditions, and wind speed and direction. NOAA CO-OPS and National Centers for Coastal Ocean Science work in partnership with Florida partners to forecast the potential for HAB formation, intensification, movement, and associated respiratory irritation. The forecasts support the event response efforts of local coastal resource managers, public health officials, and research scientists, as well as inform the decisions of beachgoers enabling them to find unaffected beaches. The Florida Fish and Wildlife Conservation Commission provides algal cell concentration data, including *K. brevis*, obtained from water samples collected routinely from monitoring sites along the Florida coast. The Mote Marine Lab provides the [Beach Conditions Reporting System](#) consisting of daily observations of the red tide impacts for 36 of Florida's Gulf Coast beaches via an interactive map. The Florida Department of Agriculture and Consumer Services Division of Aquaculture provides the daily status of shellfish harvesting areas and red tide. For health information and resources, see the [HAB Health Information page](#).

Hurricane impacts:

The 2017 Hurricane season left major impacts in Florida and the Caribbean. The NWLON stations at Charlotte Amalie and Lime Tree Bay, USVI; Esperanza (Vieques Island), Puerto Rico; and Mayaguez, Puerto Rico, were completely destroyed. The station at Magueyes Island, Puerto Rico, sustained major damage. These stations will be reinstalled if supplemental funds are appropriated. It also damaged partner water level stations in Puerto Rico and Barbuda.

National Geodetic Survey (NGS)

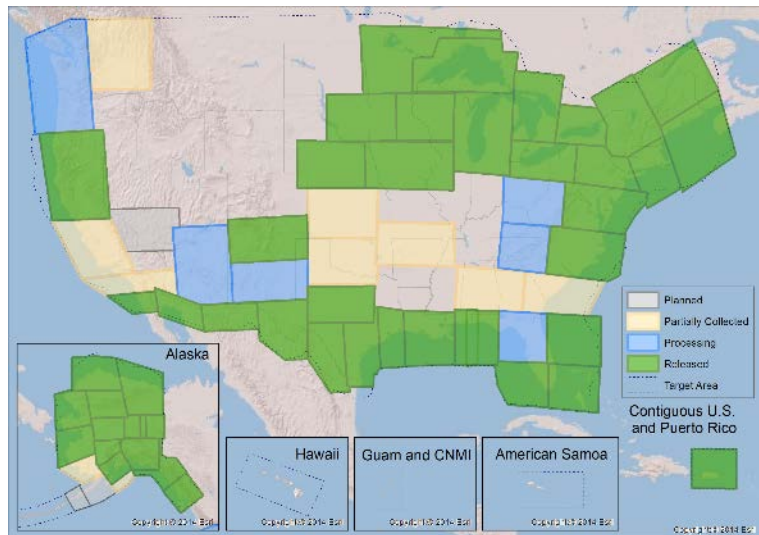
Regional mission summary

NGS supports a wide variety of programs and activities in Florida and the Caribbean focused on monitoring elevation changes, updating the national shoreline, improving accuracy of the [National Spatial Reference System \(NSRS\)](#), and producing a gravity-based vertical datum. The [NGS regional geodetic advisor program](#)—that provides subject matter experts in geodesy and regional geodetic issues—collaborates internally across NGS and NOAA to further the organizations’ missions. The program maintains awareness of current developments in geodetic science and technology, updates and improvements to geodetic reference systems, and application to geospatial activities. NGS regional geodetic advisor for Florida (Gulf Coast Region) is Denis Riordan (denis.riordan@noaa.gov). NGS regional geodetic advisor for the Caribbean Region is Scott Lokken (scott.lokken@noaa.gov).

Activities in the Florida and Caribbean Region

GRAV-D update for Florida and Caribbean Region

The Gravity for the Redefinition of the American Vertical Datum (GRAV-D) program is producing a gravity-based vertical datum that will be accurate at the ~2 cm level where possible. GRAV-D flights in Florida and Puerto Rico are complete. This new information will be included in revised gravity models for the region and will culminate in a new national vertical reference system. This system will result in an estimated \$522 million in nationwide annual economic benefits once implemented, allowing users to determine more precise elevations using the Global Positioning System (GPS), with approximately \$240 million saved from improved floodplain management alone. For more information go to the [NGS GRAV-D web page](#) or contact Monica Youngman (monica.youngman@noaa.gov).

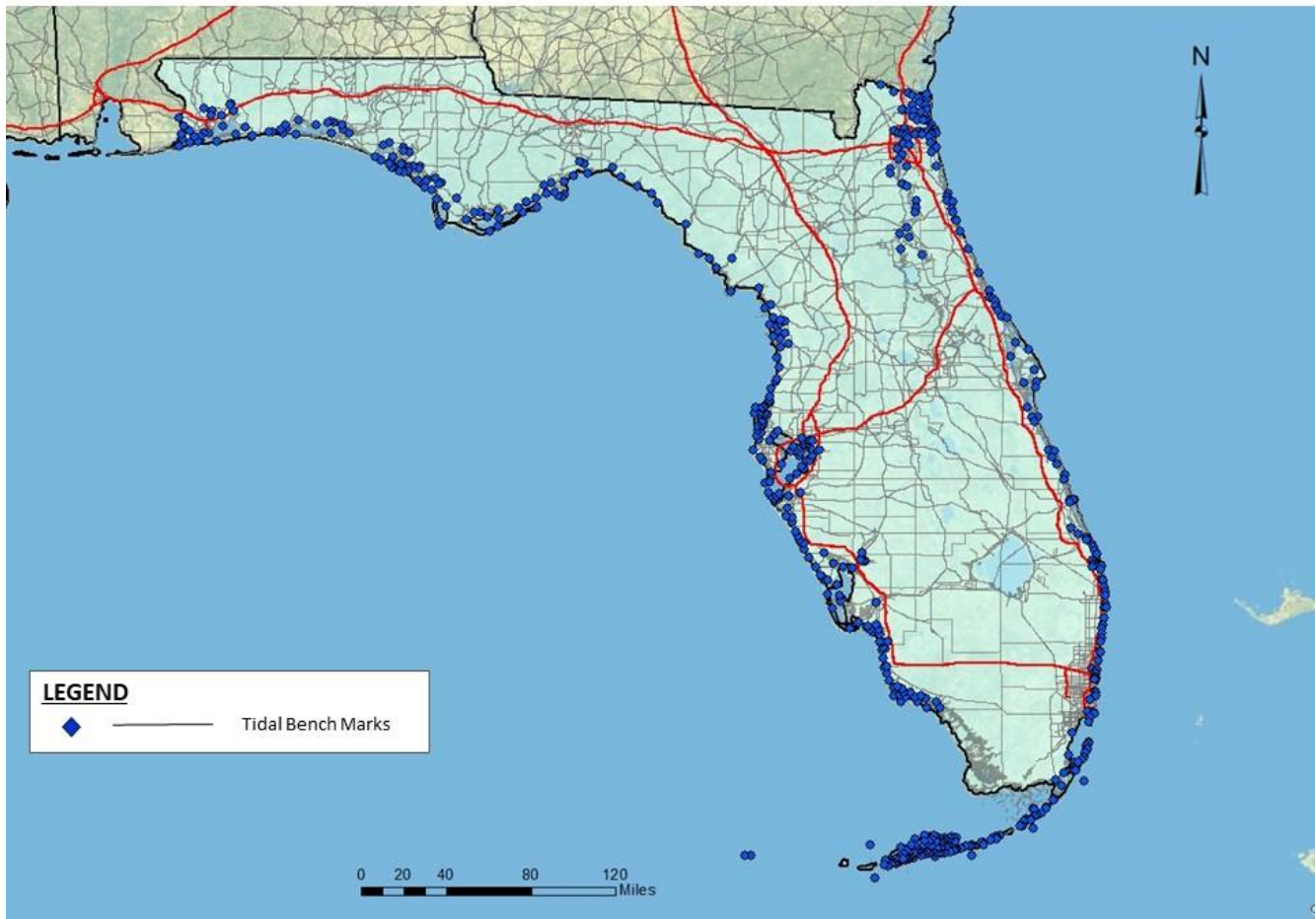


Geodetic activities in Florida and the Caribbean Region

Florida

The Florida Department of Transportation operates and maintains a GNSS, the Florida Permanent Reference Network (FPRN) [real-time network](#) that currently consists of nearly 100 stations. This network covers the entire

Florida Tidal Bench Marks – OPUS Share Positioning



Florida tidal benchmarks via OPUS Share positioning.

Puerto Rico

NGS operates a CORS in Lajas, Puerto Rico, and supplies GNSS data. Ten additional CORS from outside agencies are also part of the NGS managed CORS network. The Federal Aviation Administration CORS is located in San Juan, Puerto Rico, [UNAVCO](#)'s is located in Ponce, Puerto Rico, the [HLCM Group](#) operates and maintains an eight-station GNSS real-time network providing coverage throughout Puerto Rico. Their GNSS data is freely shared with the NGS managed CORS network. UNAVCO has three remote location CORS which are offline since Hurricane Irma.

The University of Puerto Rico at Mayagüez is a regular contributor to [Shared OPUS Solutions](#).

U.S. Virgin Islands

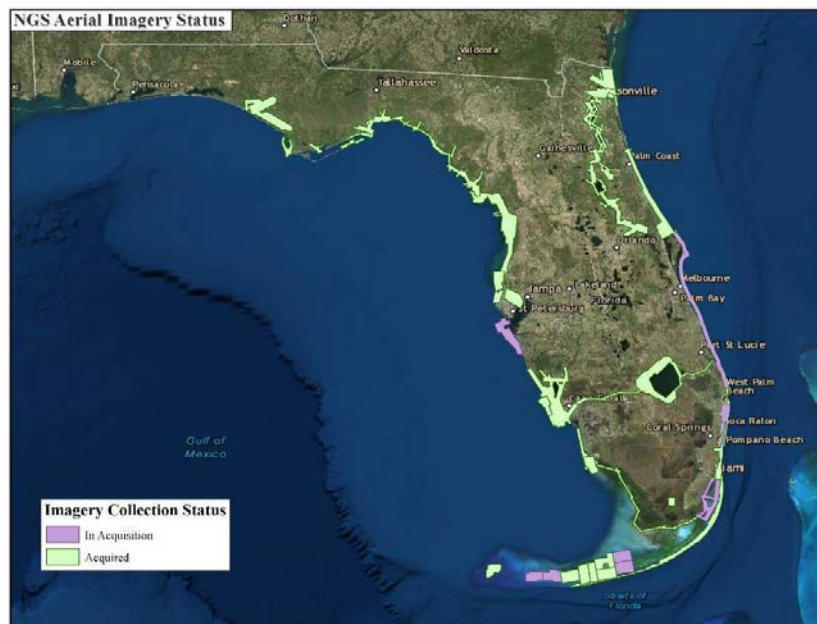
NGS operates two CORS in the USVI supplying GNSS data (one currently offline, not hurricane related). Two other CORS operated by the Jet Propulsion Lab and UNAVCO are disabled since Hurricane Irma.

The week of May 9, 2017, an NGS survey team conducted a local site survey at the National Radio Astronomy Observatory's St. Croix, USVI, Very Long Baseline Array antenna station. The station is co-located with a GNSS tracking station. The NGS survey team measured a high-precision tie vector between the reference points associated with two instruments. The International Earth Rotation and Reference System Service uses the information from local site surveys, along with observations from four different space geodesy techniques, to compute realizations of the International Terrestrial Reference Frame—the global coordinate system.

Shoreline coverages for the Florida and the Caribbean Region

NOAA continues to acquire and compile the national shoreline for Florida and the Caribbean. FY18 coastal mapping aerial imagery plans include the collection of aerial imagery in Florida from Cape Canaveral to Jupiter and Lauderdale-By-The-Sea.

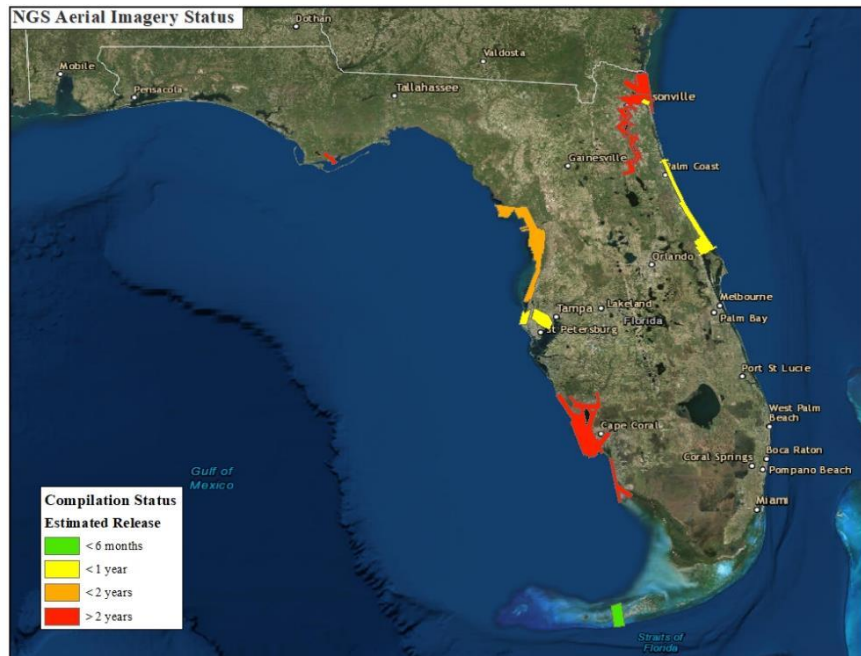
NOAA also acquires topographic-bathymetric (“topobathy”) lidar data to update shoreline and nearshore areas on NOAA Charts. NOAA uses the approach to ‘map once, use many times’ by planning and coordinating with multiple parties interested in using our topobathy lidar data. In 2017, NGS completed processing Key West and Florida Keys Outer Reef surveys. These datasets were collected to support the USCG navigational safety of their fleet and Coast Survey's need to update charts in this region. Some of these areas are in great need of a modern survey. In some areas a survey has not been conducted since the 1900-1930's.



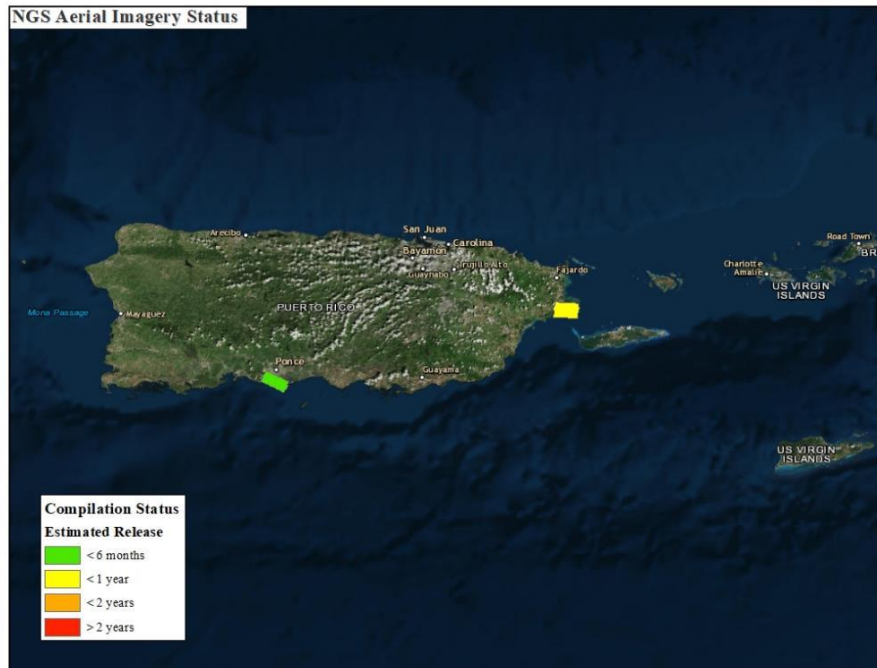
NGS aerial imagery acquisition status of Florida.



NGS aerial imagery acquisition status of Puerto Rico and Virgin Islands.



Compilation of NGS aerial imagery status.

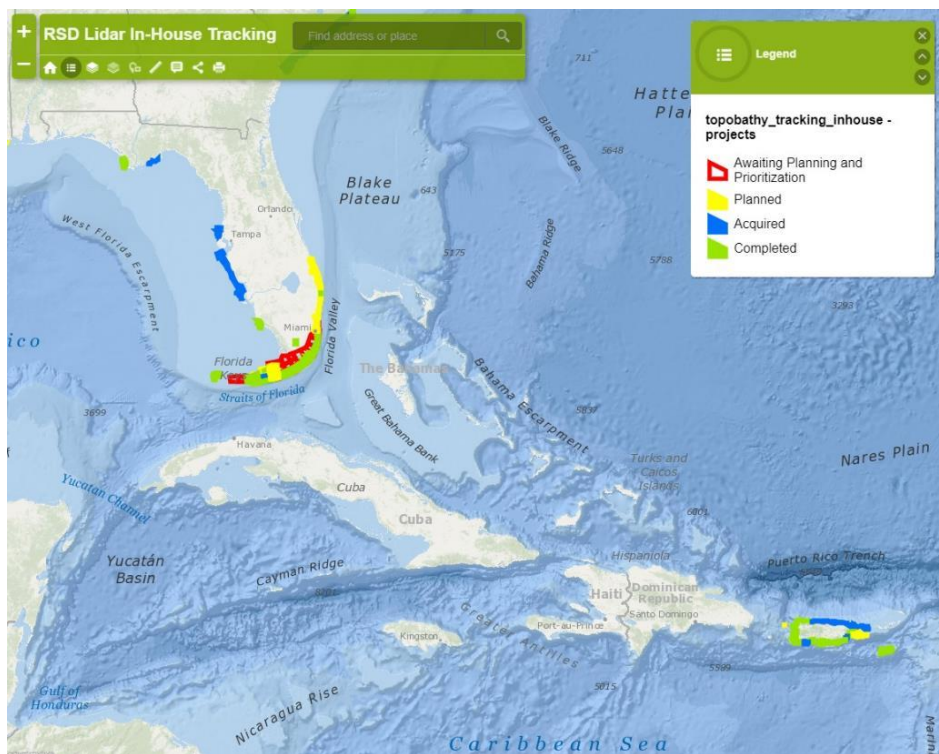


Compilation of NGS aerial imagery status.

2018 Supplemental funds allocated to the National Geodetic Survey's Remote Sensing Division will be used to acquire aerial imagery and topobathy lidar in support of shoreline and nearshore bathymetry needs for Texas, Florida Keys, and Puerto Rico nautical chart products.



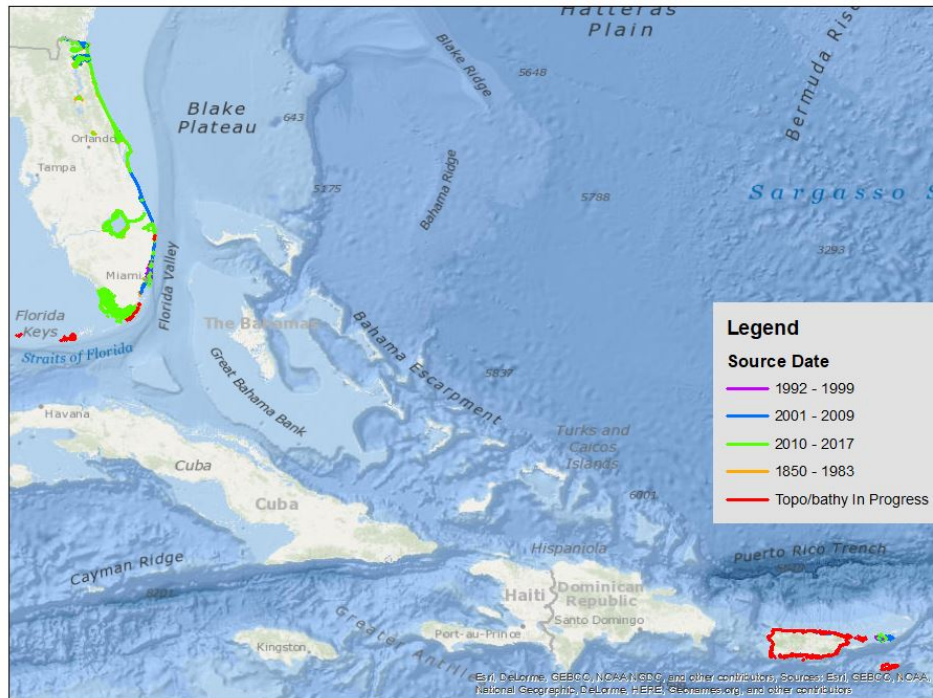
Geographic extent of 2018 Supplemental funds allocated to acquire aerial imagery and topobathy lidar.



NGS topobathy lidar status.

NOAA's [continually updated shoreline product](#) (CUSP) provides the most current shoreline representation of the U.S. and its territories. CUSP is built upon NGS national shoreline data and uses both NOAA and non-NOAA contemporary sources to replace vintage shoreline areas. The goal of CUSP is to represent the dynamic interface between land and water; therefore, CUSP is designed to deliver continuous shoreline with frequent updates.

Age of Shoreline in East Florida and Caribbean (2018)



CUSP coverage in Florida and Caribbean.

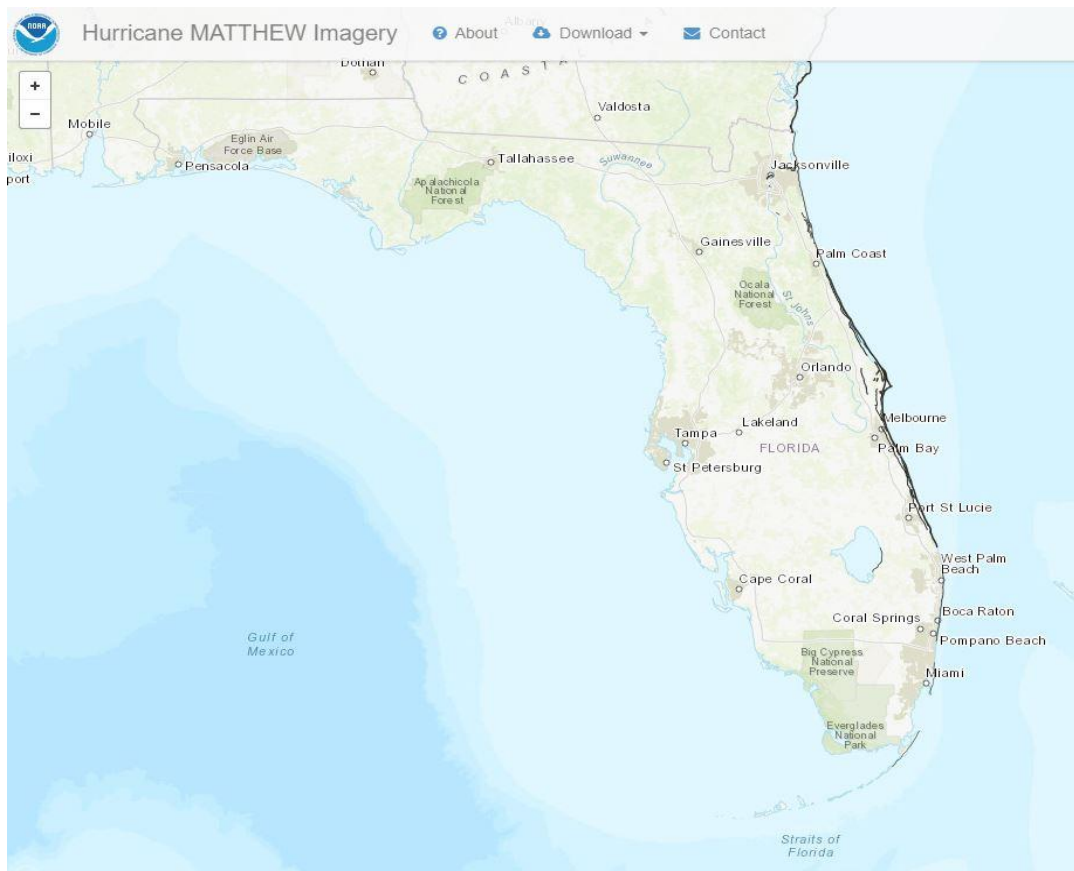
Emergency response imagery

NGS conducts flights to collect imagery after natural (hurricane, earthquake, tsunami, flood, and tornado) and man-made (oil spill) disasters. The high-resolution, geo-referenced airborne imagery, which support NGS' coastal mapping program, also support homeland security and FEMA requirements, as well as state and local interests. NGS posts the images on the web, often within hours, to make them available to the public.

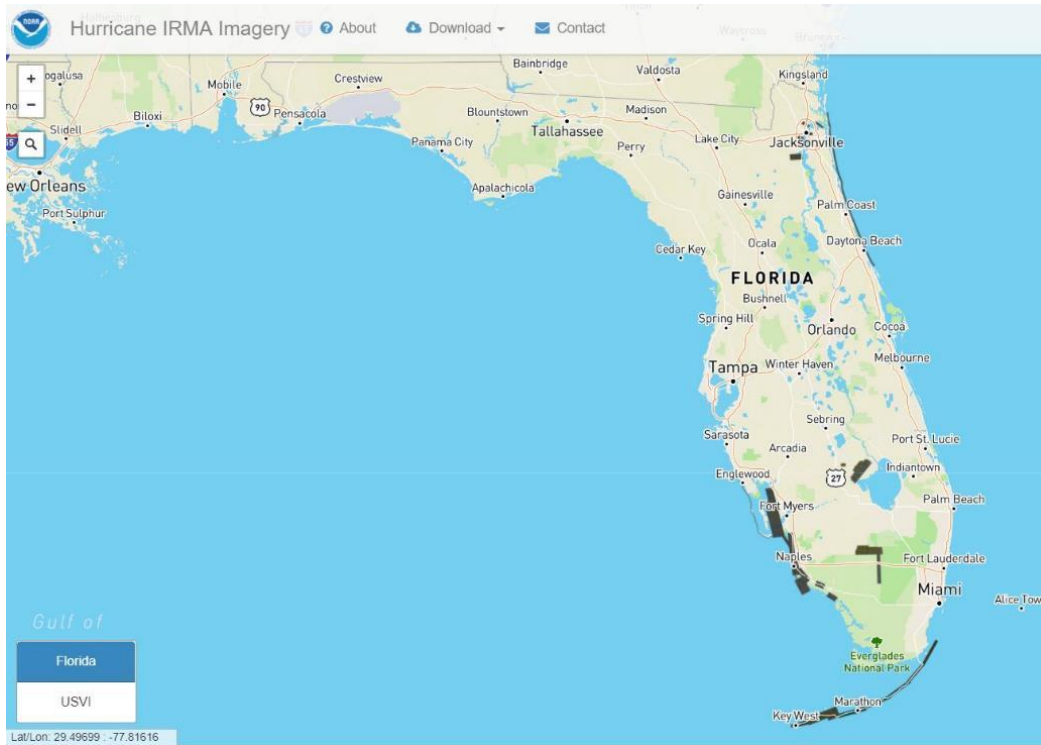
NGS was on to collect [emergency response imagery](#) following many different types of disasters in 2016-2017, including the aftermath Hurricanes Matthew, Harvey, Irma, and Maria. At the end of FY17, NGS calculated 64,848 [images](#), 24,279 sq km, and 198.8 flight hours for these four hurricanes. NGS conducts surveys as requested by the Federal Emergency Management Agency (FEMA) or a state, territory, or tribe in coordination with FEMA.

NGS has collected emergency response imagery for all major hurricanes since 2003. From the imagery, those in charge of response and restoration can determine the effect of disasters on the land; for example they can

determine where flooding has wiped out parts of barrier islands and affected their formation. In 2013, NGS enhanced its imagery collection by developing hardware, software, and processes to allow for the collection of oblique aerial imagery. In 2015, NGS began collecting pre-event imagery along most of the U.S. shoreline using oblique imagery. Currently, NGS has collected pre-event imagery for the majority of the contiguous United States outer coast.



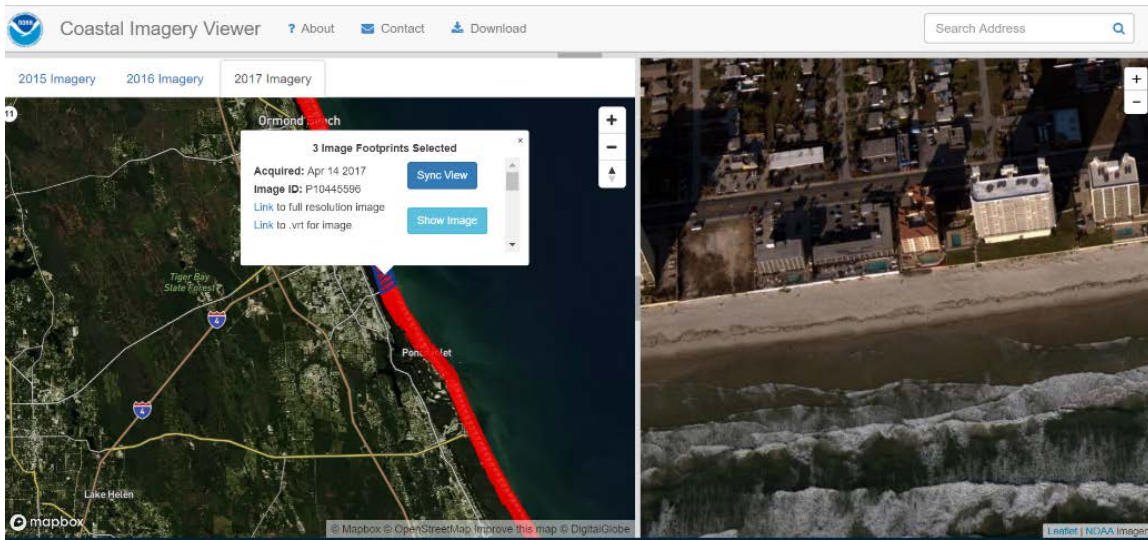
NGS 2016 Emergency Response imagery collected in Florida after Hurricane Matthew.



NGS 2017 Emergency Response imagery collected in Florida after Hurricane Irma.



NGS 2017 Emergency Response imagery collect in the Caribbean.



NGS 2017 oblique aerial imagery from Florida Atlantic Coast.

[Please note: The availability of Hurricane Supplemental funds in 2018 could help expedite lidar and aerial imagery surveys in these areas.]