

Annual Science Report: Year 2020

National Ocean Service

National Oceanic and Atmospheric Administration

This report includes summaries of selected scientific projects undertaken by the program offices of NOAA's National Ocean Service (NOS) during Fiscal Year 2020 (FY20). All of these projects were submitted by each program office for consideration in the annual NOAA Science Report (2020), within which many are also featured. Each project summary includes a short description of the research conducted by NOS staff, major accomplishment(s), and links to published materials and online project information.

Assembled by the National Ocean Service Coastal Science Board

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About the NOS Coastal Science Board: The NOS Coastal Science Board serves as the forward-thinking science advisory group to the National Ocean Service. The Board provides a forum to strengthen internal connections between program offices, resulting in better service to NOS constituents and greater support of NOAA's mission. Additionally, the Board provides assistance to all NOS Program Offices in establishing and addressing priorities for coastal, ocean, and Great Lakes science, as well as in identifying current and future science and research requirements in support of NOS Program Offices, associated stakeholders, and statutory mandates. The Board reports to the director of the National Centers for Coastal Ocean Science (NCCOS), who serves as the NOS representative to the NOAA Science Council. The Board also provides annual updates of its progress to NOS program office leadership.

About the Agency: The National Ocean Service (NOS) is the nation's premier science agency for oceans and coasts. NOS delivers the applied science, modeling, tools, and services needed to understand, predict, and respond to the challenges we face along America's 95,000 miles of shoreline and 3.5 million square nautical miles of coastal, Great Lakes, and deep-ocean waters. Additionally, NOS oversees the definition, maintenance, and access to the National Spatial Reference System for all federal geospatial activities. This enables NOS to better manage the sea/shore boundary for coastal resilience and planning.

Table of Contents

Center for Operational Oceanographic Products and Services	4
National Centers for Coastal Ocean Science	6
National Geodetic Survey	16
Office of Coast Survey	22
Office of National Marine Sanctuaries	27
Office of Response and Restoration	31
Office for Coastal Management	39
U.S. Integrated Ocean Observing System	41
References	42

Center for Operational Oceanographic Products and Services

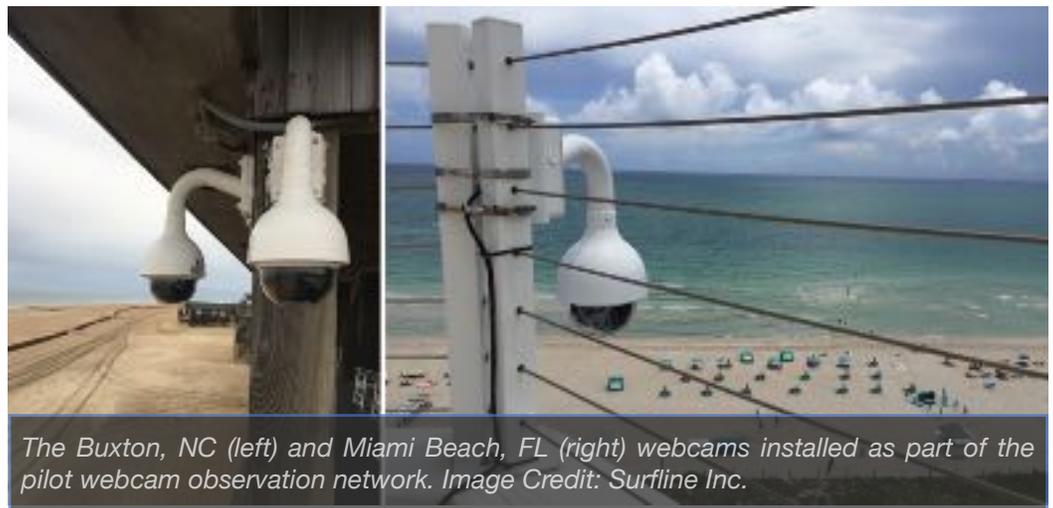
NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) is the authoritative source for accurate, reliable, and timely tides, water levels, currents and other oceanographic information. CO-OPS data, products and services support safe and efficient navigation, sound ecosystem stewardship, coastal hazards preparedness and response, and the understanding of climate change. Included below are two highlighted scientific projects by CO-OPS researchers and their partners.

NOAA Development of a Webcam Coastal Observing Network

NOAA NOS launched a pilot observation network to collect imagery from a series of web-enabled cameras mounted along the southeast coast of the United States. The collected imagery provides a new way to collect data on rip currents, high tide flooding, and other coastal hazards.

Images are also used to identify marine mammals

along the coast, as well as to track human uses of natural resources — including beach use during the COVID-19 pandemic. Images are acquired and processed in a standardized way so they may be incorporated into a wide range of downstream scientific applications and products. The pilot program is a public-private partnership that includes NOAA, the Southeast Coastal Ocean Observing Regional Association, the U.S. Geological Survey, Surfline Inc., the University of North Carolina Wilmington, and University of South Carolina.



FY20 Accomplishment(s): Published peer reviewed journal article detailing the development and goals of the network; development of a software tool to enable remote webcam imagery rectification using Lidar data (journal article submitted); and use of the network to help assess beach use during the Covid-19 pandemic.

Peer reviewed journal article: Dusek et al. 2019 *Frontiers in Marine Science*
<https://www.frontiersin.org/articles/10.3389/fmars.2019.00353/full>

Pilot site for webcam network:
<https://secoora.org/webcat/>

News article detailing camera calibration tool:
<https://secoora.org/new-open-source-tool-to-remotely-calibrate-web-camera-data/>

Development and Demonstration of Wave Measurements from Radar Tide Gauge

NOAA CO-OPS is currently transitioning the primary water level sensor at most National Water Level Observation Network (NWLON) stations from an acoustic ranging system to microwave radars. With no stilling well and higher resolution of the open sea surface, microwave radars have the potential to provide real-time wave measurements at NWLON sites. Radar sensors at tide stations may offer a low cost, convenient way to increase nearshore wave observational coverage throughout the U.S. to support navigational safety and ocean research applications.



FY20 Accomplishment(s): Completed detailed laboratory and field testing and associated analysis to demonstrate microwave radar water level sensors' capability to simultaneously measure average sea level and waves

Peer reviewed journal article: Fiorentino et al. 2019 *Frontiers in Marine Science*
<https://www.frontiersin.org/articles/10.3389/fmars.2019.00586/full>

NOAA Ocean Podcast Coverage:
<https://oceanservice.noaa.gov/podcast/oct14/mw128-taking-measure.html>

National Centers for Coastal Ocean Science

The National Centers for Coastal Ocean Science (NCCOS) is the focal point for NOAA's coastal ocean science efforts. NCCOS helps NOAA to meet its coastal stewardship and management responsibilities, and provides coastal managers with the scientific information necessary to decide how best to protect environmental resources and public health, preserve valued habitats, and improve the way that communities interact with coastal

ecosystems. NCCOS major focus areas include coastal change: vulnerability, mitigation, and restoration; marine spatial ecology; social science, and stressor impacts and mitigation. NCCOS additionally funds external research through its Competitive Research Program. Included below are ten highlighted projects by NCCOS, NCCOS-supported researchers, and their partners.

Kachemak Bay Ecological Assessment: Supporting Alaska Coastal Resource Management

NOAA NCCOS has conducted a Kachemak Bay, Alaska ecological assessment project to knit together a broad range of spatial habitat and environmental data into new information tools for Alaska coastal resource management and planning. Kachemak Bay is a productive, subarctic estuary in southcentral Alaska that contains all the coastal habitats found in the Gulf of Alaska, with fish, shellfish, marine mammal, and bird populations that support recreational and commercial harvests.

Kachemak Bay has seen an increase in [ecotourism activities](#) and tourism is a significant economic driver for the region.

NOAA, along with federal, state, tribal, industry, and non-governmental organization partners, has produced a pilot “State of Kachemak Bay” report, developed online tools to improve public data access and visualization of spatial data, and is producing an ecological status report in 2021 to highlight regional coastal changes over the past two decades. The project’s goal is to provide information tools that help Alaska communities deal with challenges from changing fish and shellfish populations, climate change, harmful algal blooms, and to explore opportunities in shellfish and kelp mariculture.



FY20 Accomplishment(s): As part of the assessment, the FY20 pilot “State of Kachemak Bay” report summarizes information on marine conditions and resources for state, Alaska Native and public coastal

stakeholders. In addition, an updated online data visualization tool (BioMapper) improves access to spatial information on coastal habitats, environmental conditions and resources.

State of Kachemak Bay Report:

https://cdn.coastalscience.noaa.gov/projects-attachments/396/StateofKachemakBay_2019Highlights.pdf

State of Kachemak Bay Report News Item:

<https://coastalscience.noaa.gov/news/state-of-kachemak-bay-report-highlights-long-term-monitoring-data/>

Project URL:

<https://coastalscience.noaa.gov/project/ecological-assessment-for-kachemak-bay-alaska-science-tools-to-inform-management/>

Testing Alternative Oyster Restoration Strategies using Novel Chemical Marking Tools

NOAA NCCOS is leading research that uses novel chemical tagging tools to test alternative oyster setting methods. Oyster setting is the process in which larvae



attach to a setting material such as shell. In partnership with the U.S. Naval Academy and the Maryland Department of Natural Resources, research divers used fluorescently-marked larvae to test releasing oyster (*Crassostrea virginica*) larvae directly onto planted oyster shells in the Chesapeake Bay. Oyster larvae are marked by placing them in a calcein (fluorescent dye) bath prior to release, after which the dye acts as a tag once absorbed by the oyster shell. NCCOS has been examining the utility of chemical markers in late-stage larval oysters to determine specific oyster recruitment and in evaluating oyster reef restoration strategies. The research shows that juvenile oysters can be established from larvae set directly at the site without using enclosures. The techniques developed in this portfolio may reduce the requirement for scarce shell or other setting material, and reduce the logistical and material handling costs associated with traditional spat-on-shell oyster practices in both restoration and aquaculture sectors. These reductions have the potential to avoid challenges commonly associated with publicly funded restoration projects using alternative substrate, and can make restoration and aquaculture seeding practices more economical. Tagging methods utilized for larval origin confirmation build on methods developed in the NCCOS funded [Oyster Marking Methodology Study](#).

FY20 Accomplishment(s): Continued release and monitoring of deployed larvae onto shell-bag reefs in the study site and of observed oyster spat recruitment.

Project URL:

<https://coastalscience.noaa.gov/news/new-technique-shows-oyster-shell-seeding-is-possible-in-open-water/>

NCCOS-funded Research Evaluates Options for Managing Dune Systems in North Carolina



Sand fencing on Bogue Banks, NC. Photo: NOAA NCCOS

An NCCOS-funded observational and dynamic modeling study assessed possible beach and dune management actions to help coastal communities make informed decisions in the context of extreme storms and sea level rise. The project, led by researchers at Oregon State University and University of North Carolina, evaluated dune shape as a function of beach nourishment, dune grass planting, sand fencing, and treatment of the wrack line on the Outer Banks, NC. The team discovered that nourishing beaches prior to the storm season, planting dunes with certain species of dune grasses, and allowing a wrack line to remain on the beach all led to taller and wider dunes systems. In contrast, sand fencing created shorter but wider dunes. The models demonstrate how management actions influence dune shape, which has implications for coastal protection during storm events, flood protection capacity, and the resilience of beaches and dunes. This study was supported through the NCCOS Effects of Sea Level Rise (ESLR) Program.

FY20 Accomplishment(s): The NOAA funded research team delivered their findings on possible dune management actions to the management advisory group, composed by beach and dune managers and city managers in May of 2020.

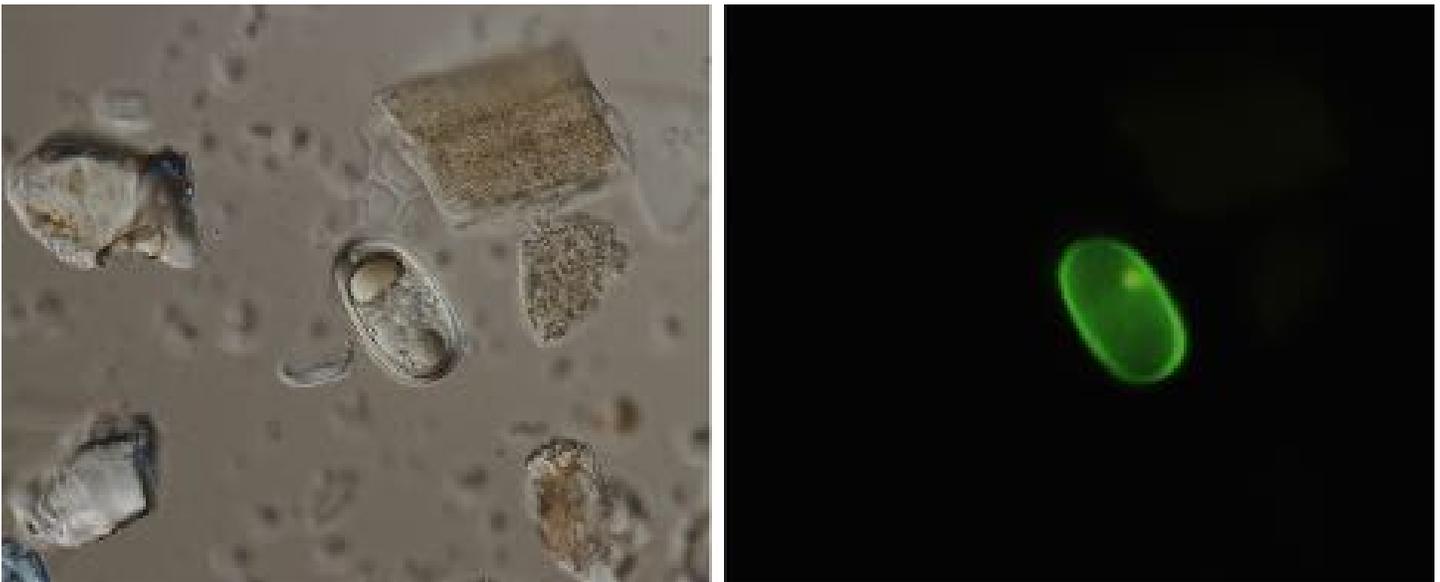
Project URLs:

<https://coastalscience.noaa.gov/news/the-effect-of-sand-fencing-on-the-structure-of-natural-dune-systems/>

<https://coastalscience.noaa.gov/news/grasses-shape-and-protect-coastal-dunes-in-different-ways/>

<https://coastalscience.noaa.gov/news/new-tool-informs-dune-recovery-after-storms/>

Application of Quantitative Molecular Methods to Characterize Abundance and Distribution of *Alexandrium* cysts for NOAA's HAB Forecasting



Light micrograph (left) of an *Alexandrium* resting cyst in the sediment. The same cyst (right) stained with a fluorescent stain for counting. Credit: S. Kibler, NOAA NCCOS.

NCCOS is developing new methods to better forecast blooms of *Alexandrium catenella*, a marine alga that causes paralytic shellfish poisoning (PSP) along the Pacific and Atlantic coastlines of the U.S. and Canada. This project supports development for two lab-based quantitative molecular methods for more rapid, accurate detection of *Alexandrium catenella* resting cysts in sediment. Scientists are working with the University of Washington Tacoma, the University of Alaska, and the Woods Hole Oceanographic Institution to map the distribution of *Alexandrium* resting cysts in the Gulf of Maine, Puget Sound, and the waters around Kodiak Island and Kachemak Bay, Alaska. Cyst distribution and abundance are used to forecast blooms of *Alexandrium* cells in the water column. Molecular detection methods and training is needed to advance research and HAB forecasting applications that reduce effort and turnaround time for cyst enumeration. New methods employing molecular-level analytical procedures known as quantitative polymerase chain reaction (qPCR) and fluorescent in situ hybridization (FISH) were developed to reduce the time and effort required for cyst identification and counting. These molecular tools are being tested to better characterize cyst distribution and speed up the forecasting process for *Alexandrium* blooms. The project will help expand NOAA HAB Operational Forecasting to new regions.

FY20 Accomplishment(s): First season of field sampling, initial design of quantitative PCR assay and in situ labeling method completed pending method refinement and validation.

Project URL:

<https://coastalscience.noaa.gov/project/application-of-quantitative-molecular-methods-to-characterize-abundance-and-distribution-of-alexandrium-cysts-for-noaas-hab-forecasting/>

Spatial Predictive Modeling for ESA-listed Corals



*NCCOS is mapping predicted distributions of ESA-listed corals, such as this lobed star coral (*Orbicella annularis*), throughout the U.S. Atlantic. Image credit: NOAA Fisheries.*

NCCOS uses spatial modeling to predict the distributions of threatened coral species in the U.S. Atlantic (Florida) and Caribbean (Puerto Rico, U.S. Virgin Islands). NOAA is partnering with scientists in academia and the federal government to develop new modeling approaches and interactive mapping applications that provide data-driven spatial predictions for the presence, absence, abundance, and population structure of multiple threatened coral species. These outputs also include associated estimates of predictive uncertainty, and a spatial database of Atlantic coral ecosystem monitoring, in accessible map formats. These products are used to inform management decisions that may affect coral species listed under the Endangered Species Act (ESA), such as spatial planning for coral restoration and place-based management.

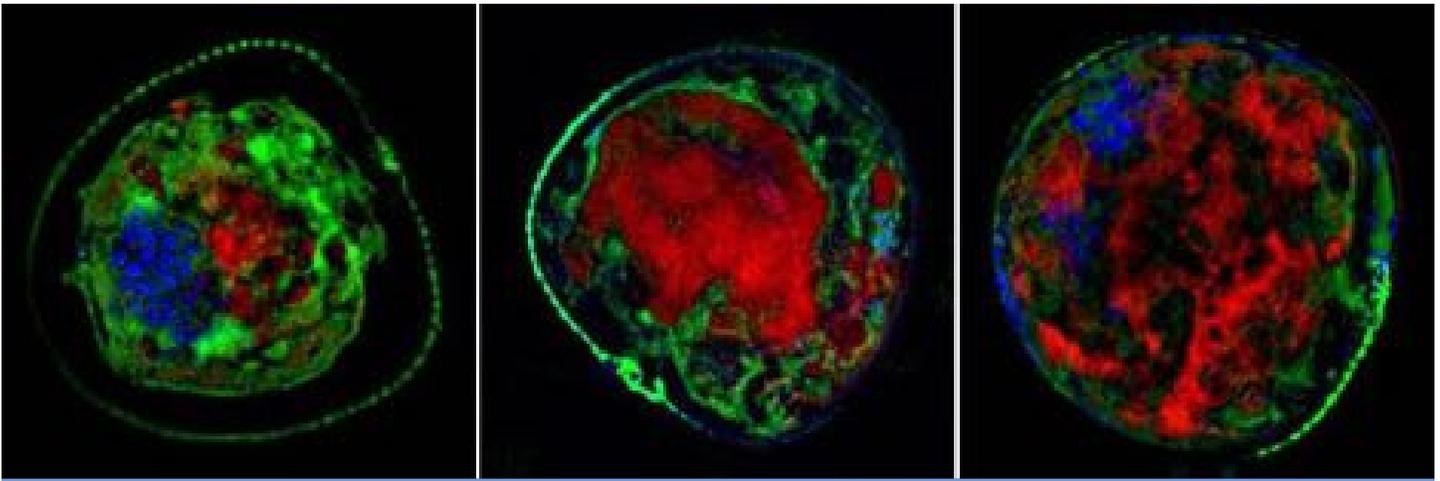
FY20 Accomplishment(s): A coral model is in development for Puerto Rico and the U.S. Virgin Islands.

Project URL:

<https://coastalscience.noaa.gov/project/spatial-predictive-modeling-threatened-esa-corals-u-s-atlantic-caribbean/>

Promising HAB Control Method Builds on NCCOS-Funded Discovery of Natural Algicide.

An NCCOS funded project, led by University of Delaware marine scientist Dr. Kathryn Coyne, characterized an algicidal compound produced by the bacterium *Shewanella*, and confirmed the compound can selectively kill marine dinoflagellate phytoplankton known to produce harmful algal blooms. Using small-scale microcosm experiments, the team found the naturally occurring compound induces programmed cell death in dinoflagellates, while having no negative impacts on other phytoplankton, fish, or shellfish. Results pointed to the compound as an effective and environmentally safe natural algicidal agent, but additional research was needed to determine a cost effective and efficient method to deploy it in the environment. This project is supported by the NCCOS Prevention, Control and Mitigation of Harmful Algal Blooms (PCMHAB) Program.



Fluorescent images of a harmful dinoflagellate before (left) and after (middle and right) exposure to the Shewanella-derived algicide. Note the impacts on the nucleus, shown in blue. The research points to the nucleus as the primary organelle targeted by the algicide, with a loss of chromosomal structure in all species; cell division is inhibited. Credit: Kaytee Pokrzywinski (NOAA NCCOS) and Jeffrey Caplan (Delaware Biotechnology Institute).

FY20 Accomplishment(s): With additional funding by Delaware Sea Grant, the Coyne team is now testing a promising and novel delivery method using mesh bags filled with gel-like alginate beads temporarily deployed in coastal waters, where needed, to prevent algal blooms from occurring, or to shut down or mitigate blooms already underway.

Project URL:

<https://coastalscience.noaa.gov/news/promising-hab-control-method-builds-on-nccos-funded-discovery-of-natural-algicide/>

NCCOS Research Provides Scientific Foundation for U.S. Supreme Court Ruling

A recent U.S. Supreme Court ruling found that pollution discharge into groundwater from a Maui County (HI) sewage treatment plant (County of Maui v. Hawaii Wildlife Fund) fueled macroalgal (seaweed) blooms along the west side of the Island of Maui. At this location, wastewater is injected into disposal wells, travels underground, and ends up in the



Maui County, Hawaii, wastewater treatment facilities at issue in Supreme Court litigation. Credit: Warren Gretz/NREL via E&E News.

Pacific Ocean, thereby violating the permitting program of the US Clean Water Act. The Act will now apply to pollution that funnels through groundwater before reaching a federally regulated waterway. Following a series of studies funded by NOAA in the 1990's, projects supported through the NCCOS Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program and Hawaii Coral Reef Initiative (HCRI) focused research efforts on the link between increased nutrients from land-based sources of pollution and the decline in coral health. Results showed that all coastal waters near injection wells had high nitrogen values and were impacted by sewage effluent high in nutrients (but no pathogens) leaking from deep injection wells. These findings demonstrated that substantial nuisance macroalgal blooms in Maui coastal waters were linked to wastewater nutrient sources.

FY20 Accomplishment(s): Understanding of the causes and solutions to algal blooms in Maui was the result of research led by NOAA and the combined efforts of numerous federal and state agencies, institutions, and other contributors over the last 25 years. Thus, the far reaching SCOTUS ruling not only highlights the value of the NCCOS Competitive Research Program (CRP), it also points out the common occurrence of CRP research providing management outcomes years, and even decades, after project funding has ended.

Project URL:

<https://coastalscience.noaa.gov/news/nccos-research-provides-scientific-foundation-for-u-s-supreme-court-ruling/>

Ozone Impregnated Nano-bubble Technology Safely Eradicates Harmful Algal Blooms and Mitigates their Impact.



Field site before (left) and 24 hours after (right) nanobubble treatment. Credit: NOAA NCCOS.

A five-year cooperative research and development agreement (CRADA) with American Marine University completes its first year to develop and deploy ozone impregnated nano bubble technology as an algal/microbial/nutrient remediation strategy. Unlike ordinary bubbles that rise and burst at the surface of the water, nanobubbles implode under the pressure of the water, releasing oxygen and ozone that help dissolve harmful algae. Referred to as “NBOT”, this patented, precise generation of bubbles of less than one thousandth of a millimeter provides efficient transfer of ozone to attack microbes and shreds toxins with oxygen as a byproduct in hypoxic systems enhancing overall water quality. This powerful action can be implemented in a manner that is safe for humans and wildlife and when coupled with NBOT’s ability to also remove nutrients, provides cleaner water for longer periods of time thus minimizing bloom retreatment regimens.

FY20 Accomplishment(s): This first year completed successful demonstration projects in Port Mayaca Lock of Lake Okeechobee, Lake Newport in Ohio, Constitution Gardens Pond, Washington DC and Loxahatchee River in Jupiter FL.

Project URL:

<https://coastalscience.noaa.gov/news/nccos-validates-nanobubble-technology-for-remediation-of-harmful-freshwater-algal-blooms/>

Assessment of Fish Habitat in Tidal Waters of the Choptank River (Chesapeake Bay, Maryland) to Inform Conservation, Restoration, and Fishery Management Decisions



The Choptank River complex is located on Maryland's eastern shore, and includes the Choptank River and its major tributaries. The watershed was selected as a NOAA Habitat Focus area in 2014. Image credit: NOAA Fisheries.

The Choptank watershed is an ecologically and economically valuable resource and one of NOAA's ten Habitat Focus Areas. NCCOS is collecting and synthesizing biological, chemical, and physical data to characterize the condition of the watershed and identify land use impacts on the environment. This project builds off previous ecological assessments of the Choptank watershed and Chesapeake Bay toward improving water quality, the health of estuarine and coastal habitats, conservation and restoration efforts, and fishery management decisions.

FY20 Accomplishment(s): A report of recommendations for extending the tidal analytical/statistical framework from candidate tributary (Choptank River) to Chesapeake Bay tidal areas is in development.

Project URL:

<https://coastalscience.noaa.gov/project/ecological-assessment-choptank-complex-habitat-focus-area/>

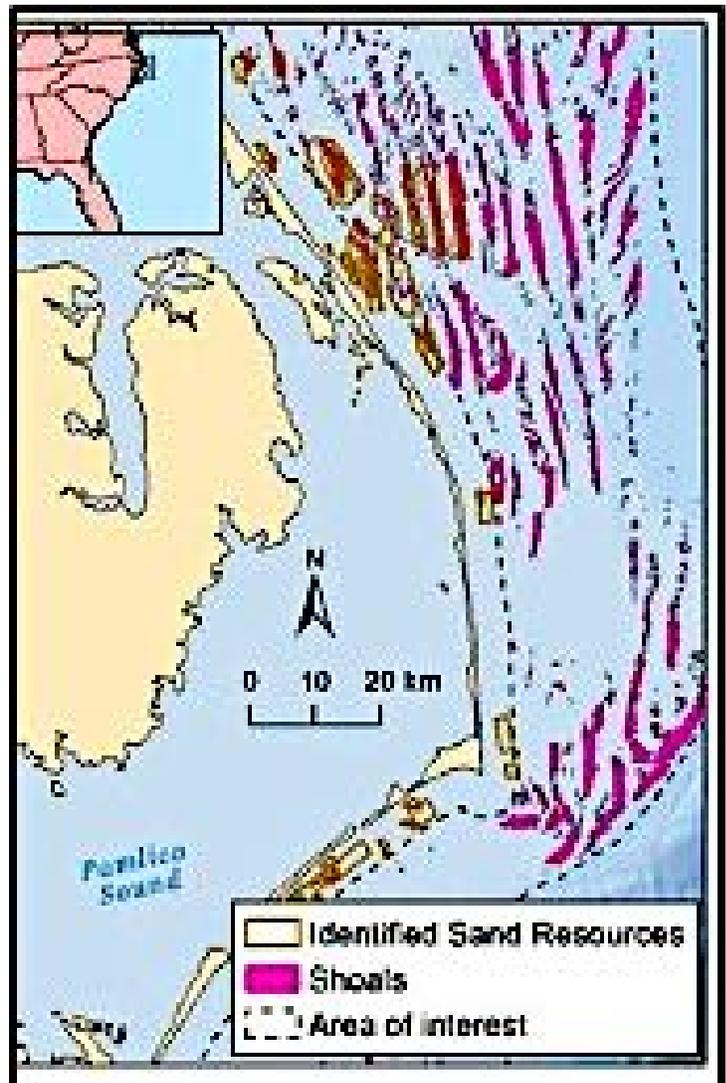
A Geospatial Assessment of U.S. Atlantic and Gulf of Mexico Essential Fish Habitat in Relation to Offshore Sand Features

Offshore sand resources, e.g., sand shoals, are increasingly being used for beach renourishment, barrier island restoration, and other uses to enhance resiliency of shorelines. However, the impact of sand dredging on fish and other marine resources is poorly understood. NCCOS is working with the Bureau of Ocean Energy Management (BOEM) and NOAA Fisheries to provide information on these effects and to develop a geospatial decision support tool that helps users determine the relative risk to fisheries species that are associated with extraction of these sand resources. As the demand for Outer Continental Shelf sand increases, BOEM is facing increasingly complex issues, such as resource allocation, cumulative impacts from repeated use, space/use conflicts, protection of archaeological sites, and Essential Fish Habitat (EFH) impacts. In particular, the Magnuson-Stevens Fishery Conservation and Management Act requires that any federal agency undertaking or authorizing an action that may adversely affect EFH or federally managed fish species consult with NOAA. Researchers are using and developing geospatial maps to investigate the link between geomorphological features (e.g., sand shoals) and EFH, to better analyze the potential impacts of sand relocation. These efforts will help to ensure that all necessary and effective precautions are taken to reduce impacts during sand dredging and conveyance to placement sites.

FY20 Accomplishment(s): Development of a model and technical report with BOEM.

Project URL:

<https://coastalscience.noaa.gov/project/geospatial-assessment-u-s-atlantic-gulf-mexico-essential-fish-habitat-relation-offshore-sand-features/>



ShoalMATE (Shoal Map Assessment Tool for EFH) is a geo-spatial decision-support tool being used to guide wise use and dredging of North Carolina offshore sand shoals. Potential sand dredging impacts to resident fisheries species in this area are being examined in concert with available biological and oceanographic data, and in consideration of EFH. Credit: NOAA NCCOS.

National Geodetic Survey

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities. NGS'

mission is to define, maintain and provide access to the National Spatial Reference System to meet our nation's economic, social, and environmental needs. Included below are six highlighted scientific projects by NGS researchers and their partners.

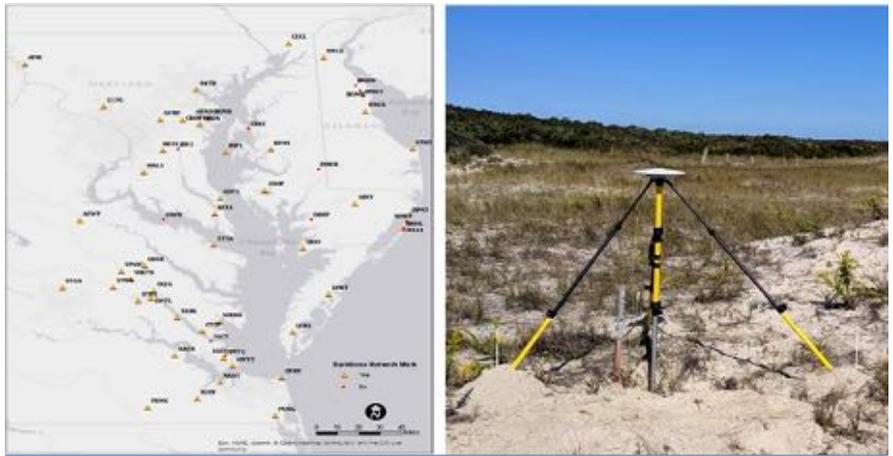
Understanding the Role of Human-induced Subsidence in Affecting Sea-level Rise Hotspots in the Chesapeake Bay

The Chesapeake Bay is experiencing some very high rates of local sea-level rise (up to 4.8 mm/yr), and the rates are variable throughout the region.

Presumably, these variations are due to differences in local vertical land motion (VLM), with subsidence being a leading cause. Unfortunately, we do not have a good handle on the spatial variations in VLM, and the last authoritative study was published back in the early 1970's.

In 2019, a coalition of scientists from Federal, academic and state institutions began a 5-year research project attempt to tease out a VLM signal across the entire Chesapeake Bay area using annual

GPS measurements spanning from the mouth of the Bay to Delaware Bay, from the coastal barrier islands of Assateague to the Shenandoah Mountains.



Map showing locations of bench marks monitored as part of the Chesapeake Bay Regional VLM Project (left). GPS monitoring on Assateague Island National Seashore (right).

FY20 Accomplishment(s): From October 5-20, 2019 (FY20), NGS, along with its collaborators, successfully obtained an average of 66 hrs of GPS data across 54 sites; the data and metadata have been published at <https://www.unavco.org/data/doi/10.7283/M6D3-T837>.

Press Release URLs:

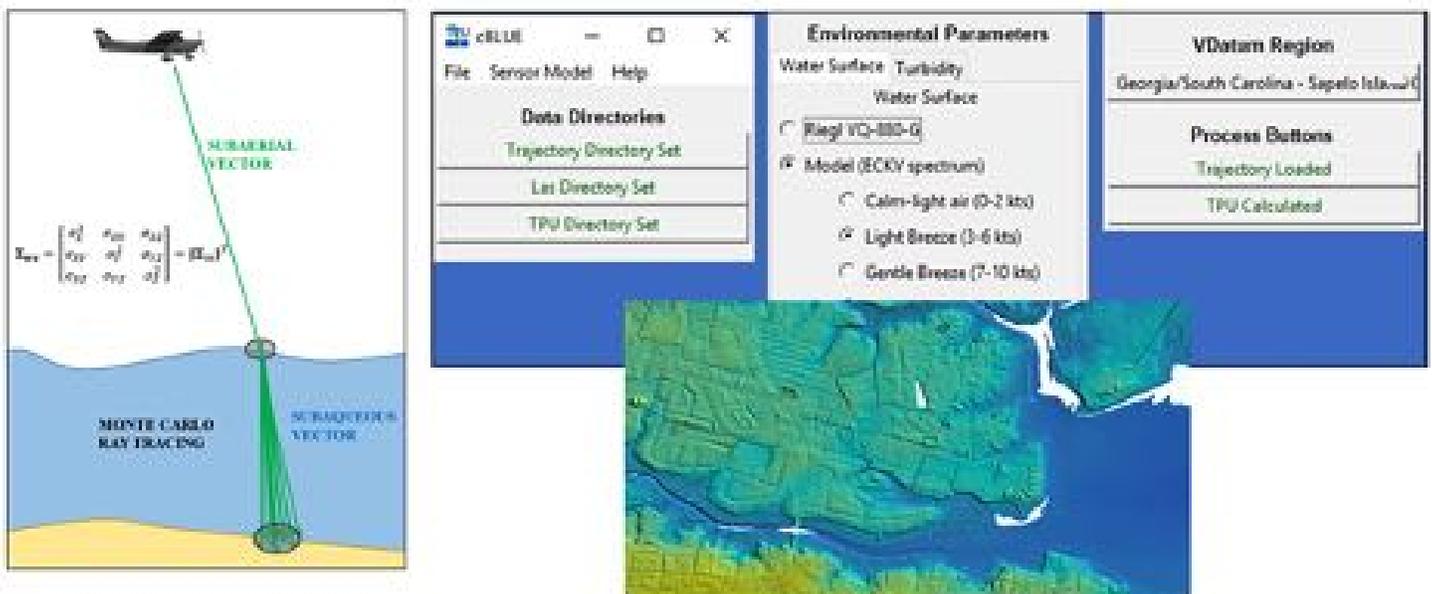
<https://www.ngs.noaa.gov/web/news/chesapeake-bay-sea-level.shtml>

https://www.usgs.gov/centers/cba/science/new-crowd-sourcing-will-contribute-study-land-subsidence-and-sea-level-rise?qt-science_center_objects=0#qt-science_center_objects

Understanding and Estimating Total Propagated Uncertainty for NGS lidar sensors

Starting in 2016, National Geodetic Survey (NGS) began research efforts with Oregon State University (OSU) and the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire (CCOM/JHC, UNH) toward the development of robust total propagated uncertainty (TPU) models. These TPU models cover the range of NGS and Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) topo-bathy lidar systems and facilitates operational use of topo-bathy lidar in the lidar community and Coast survey by providing a level of uncertainty (via cBLUE app shown below) to improve informative decisions based on the multi-use of the data. In turn, this aids NOAA in obtaining survey data in challenging, nearshore areas, including shoreward of the navigation area limit line (NALL). Additionally, the enhanced use of topo-bathy data will contribute directly to NOAA's Integrated Ocean and Coastal Mapping (IOCM) initiatives, by providing data that can simultaneously support coastal science and coastal zone management needs.

cBLUE: Comprehensive Bathymetric Lidar Uncertainty Estimator

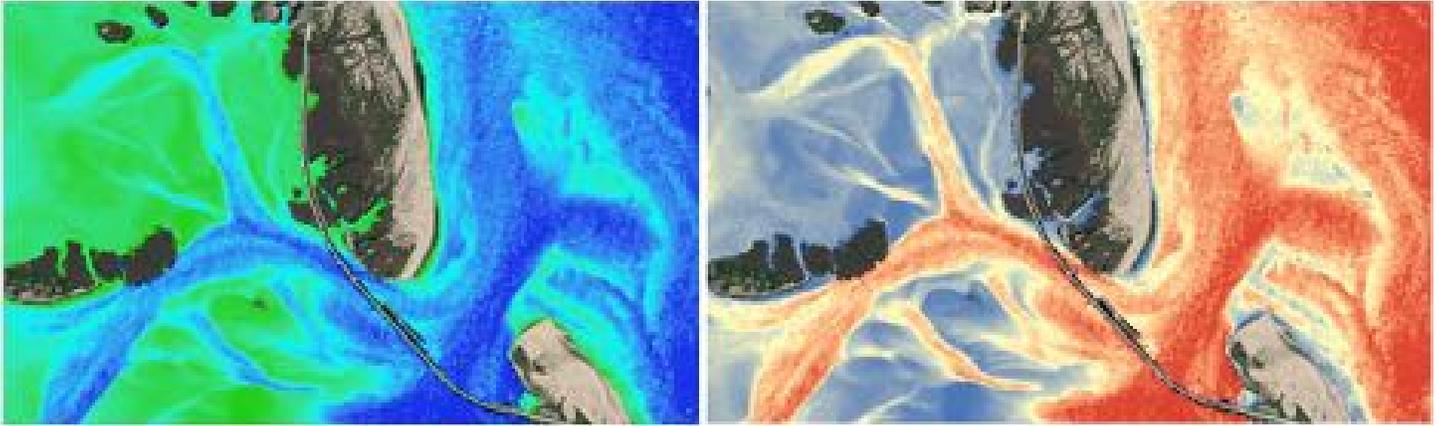


cBLUEApp Module (top right) was created using topo-bathy lidar (middle image) TPU model research (schematic on top left) by Oregon State University (OSU) and the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire (CCOM/JHC, UNH) for use by NGS.

FY20 Accomplishment(s): Incorporated research to create cBLUE, first phase of testing complete and now in use operationally at NGS for Riegl VQ-880-G topo-bathy lidar surveys.

Peer reviewed journal article: Eren et al. 2019 *Photogrammic Engineering and Remote Sensing*
<https://www.ingentaconnect.com/content/asprs/pers/2019/00000085/00000008/art00011;jsessionid=i5midxo2i62m.x-ic-live-01>

Applying New Research and Automating Satellite-Derived Bathymetry



Oregon SDB created Inlet (Oct 2020) using NGS' new pre-alpha SatBathy tool v1.0 based on research from NCCOS.

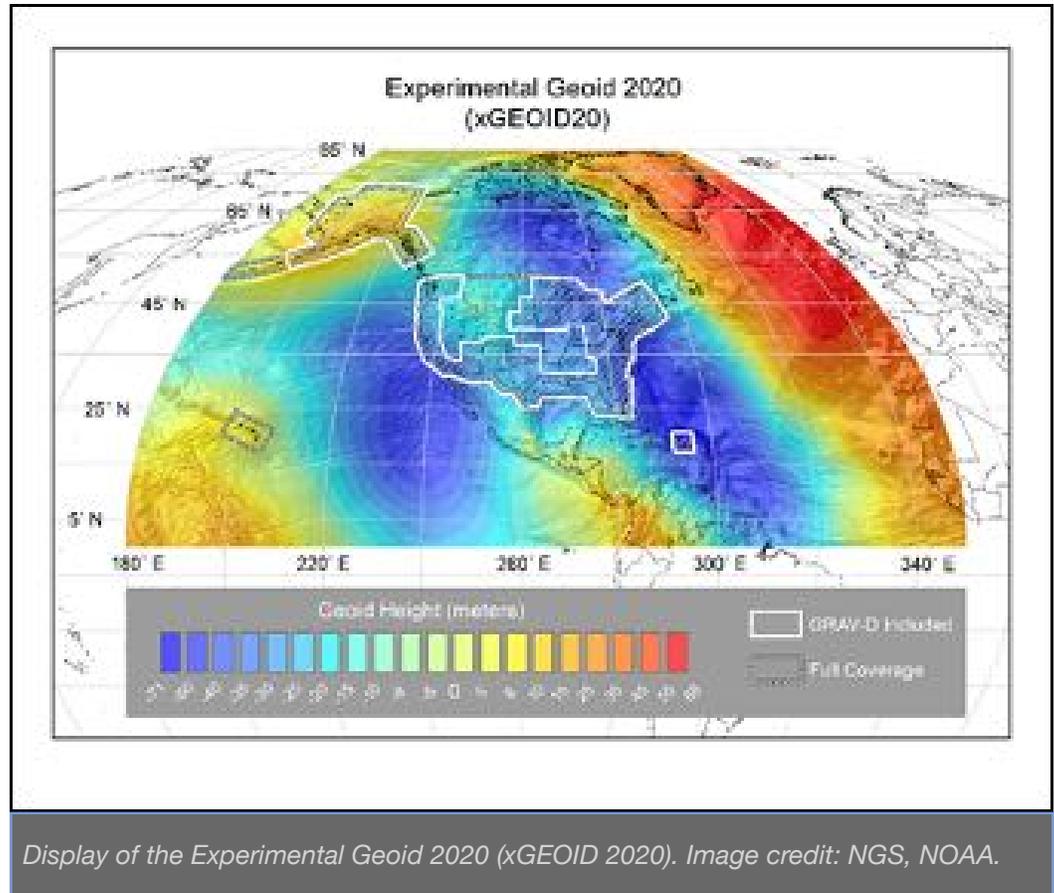
Starting in 2016, National Geodetic Survey (NGS) began collaboration efforts between the National Centers for Coastal Ocean Science (NCCOS) and the Office of Coast Survey (OCS) to create a user friendly Satellite Derived Bathymetry (SDB) tool that would provide consistent and quick results utilizing new research from Dr. Isabel Cabellero and Dr. Richard Stumpf. Since 2016, progress has been made to incorporate “a robust atmospheric correction, a multi-scene compositing method to reduce the impact of turbidity and a switching model to improve mapping in shallow water” to improve Dr. Stumpf, et al.’s 2003 SDB algorithm. In tandem to this effort, NGS has been working with NCCOS to develop a framework and began developing the NOAA SatBathy tool.

FY20 Accomplishment(s): NGS began creating the framework and creation of the SatBathy tool.

Peer reviewed journal article: Caballero & Stumpf 2020 *Remote Sensing*:
<https://www.mdpi.com/2072-4292/12/3/451>

The Experimental Geoid 2020

Starting in 2014, the National Geodetic Survey (NGS) began publishing a series of experimental geoid models annually. These models contain the gravity data from the latest satellite gravity models, the terrestrial gravity and most importantly, the airborne gravity from the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project. These experimental geoids have been developed to demonstrate the geoid improvements provided by the addition of GRAV-D data and by refining the geoid computation



Display of the Experimental Geoid 2020 (xGEOID 2020). Image credit: NGS, NOAA.

methods. The experimental geoid models provide a preliminary but increasingly-accurate view of the changes expected from the upcoming North American-Pacific Geopotential Datum of 2022 (NAPGD2022). The experimental geoid 2020 is the first model computed jointly by scientists at NGS, the Canadian Geodetic Survey, and the National Institute of Statistics and Geography in Mexico.

FY20 Accomplishment(s): NOAA worked with the Canadian Geodetic Survey and the National Institute of Statistics and Geography in Mexico to combine gravity data sets, to make the best geoid possible for North America, Hawaii, the Caribbean, Central America, and beyond.

Project URL:

<https://beta.ngs.noaa.gov/GEOID/xGEOID20/>

Geoid Determination in Mountainous Terrain



Ground truth surveys along US160 in southern Colorado. Setting up a geodetic GPS antenna for horizontal positioning

In a few years, NOAA NOS will modernize the nation's height system. Instead of measuring heights inland from a "mean sea level," heights will be measured relative to a constant geopotential surface known as the "geoid," a model of the shape of the Earth under the influence of its gravity and rotation. By providing the shape of this undulating surface everywhere, the new system allows surveyors to use GPS receivers to determine precise heights anywhere. In the *Journal of Geodesy*, NGS describes a ground-truth test of the geoid-based system in Colorado, demonstrating that it has a relative accuracy of better than 5 cm in mountainous terrain—a worst case scenario for geoid determination. When combined with earlier Texas and Iowa surveys (which demonstrated better than 2 cm accuracy in smoother terrain), these results indicate the new national height system will provide accurate elevations everywhere, with approximately 10X better accuracy.

FY20 Accomplishment(s): Peer reviewed article published in the *Journal of Geodesy* demonstrating the relative accuracy of the ground truth techniques and various experimental models.

Peer reviewed journal article: van Westrum et al. 2021 *Journal of Geodesy*:

<https://link.springer.com/article/10.1007/s00190-020-01463-8>

Total Station Astrogeodetic Control System (TSACS)



The Total Station Astrogeodetic Control System (TSACS) being tested with with a Leica TS60 robotic total station in Silver Spring, Maryland. The various components can be viewed using the URL below.

The National Geodetic Survey developed the Total Station Astrogeodetic Control System (TSACS), a system for measuring the direction of gravity with astronomical observations. The TSACS directs a robotic total station to measure the deflection of the vertical (DOV) by imaging stars. The deflection of the vertical indicates how much the direction of gravity has been shifted by local mass anomalies, like mountains. As DOV defines which way is up, measuring it in the field will be crucial for verifying the level surface that will define NGS's future geopotential height system. The TSACS will also find use in establishing precise orientations and bridging classical and modern geodetic observations. Its automated observation sequence can measure deflections of the vertical to better than ± 0.2 arcseconds in as little as 15 minutes.

FY20 Accomplishment(s): Developed and tested a system for measuring deflections of the vertical by imaging stars with a robotic total station.

Project Presentation URL:

https://www.ngs.noaa.gov/web/science_edu/presentations_library/files/aguf2020_-_ryan_hardy.pdf

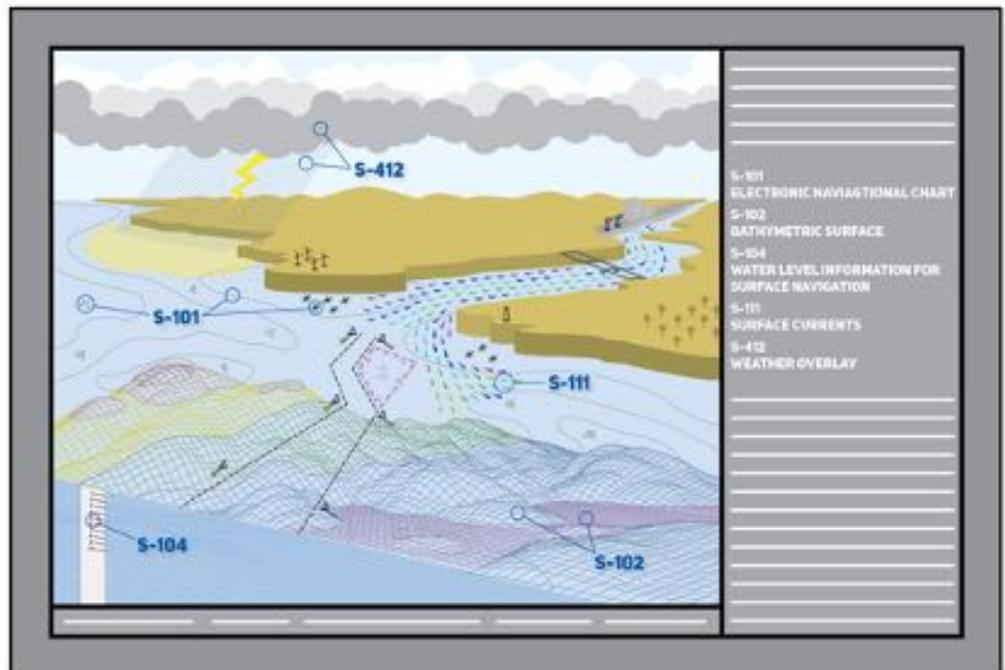
Office of Coast Survey

NOAA's Office of Coast Survey (OCS) maintains the nation's nautical charts and publications for U.S. coasts and the Great Lakes. OCS creates and maintains over a thousand charts covering 95,000 miles of shoreline and 3.4 million square nautical miles of water. OCS supports the 1.3 billion metric tons of cargo valued at \$1.8 trillion that comes in and out of U.S. ports every year. In addition, OCS

conducts hydrographic surveys to collect depth measurements for nautical charts, and to aid in navigation, provides regional navigation support, develops models for storm surge and hurricane prediction, and develops and tests new technologies to improve mapping efficiencies. Below are five highlighted scientific projects by OCS researchers and their partners.

Precision Marine Navigation Dissemination

OCS is creating new online navigation services that will enable mariners to access critical marine navigation data in one convenient place. The Data Processing and Dissemination System uses cloud technology to enable machine-to-machine dissemination of integrated datasets, allowing mariners to make decisions efficiently when planning, transiting, and approaching ports. This new system was developed and deployed on Amazon Web Services (AWS) using open source software. It allows mariners' existing navigation software to automatically discover if NOAA has made new data available and ingest the data directly into their system. NOAA is working closely with industry partners to ensure that the service NOAA develops effectively disseminates navigation data. In September 2020, NOAA hosted a workshop with navigation equipment and navigation system manufacturers, pilots, and other federal agencies to collect feedback on the new online services. In July 2020, NOAA NOS released a new reformatted data service for surface water current forecasts. These data are now available for



Integrated multi-source information available through the OCS-developed Precision Marine Navigation System. Image credit: NOAA OCS.

companies to test using different types of navigation software. The S-100 compliant NOAA datasets will be made available to manufacturers of Portable Pilot Units and Electronic Charting Systems to integrate these datasets into their navigational systems. The integrated datasets will reduce the number of websites a mariner visits when planning, transiting, and approaching a port, allowing them to make decisions efficiently.

FY20 Accomplishment(s): NOAA's Office of Coast Survey targeted a beta release of the dissemination system in July 2020 with a goal for initial operations by late 2020.

Project URL:

<https://nauticalcharts.noaa.gov/learn/precision-navigation.html>

OCS Expands the Extratropical Surge and Tide Operational Forecast Systems

OCS is transitioning a global version of the Extratropical Surge and Tide Operational Forecast System (ESTOFS) into operations in fiscal year 2020-2021. Global ESTOFS will replace the existing regional ESTOFS-Atlantic, ESTOFS-Pacific, and ESTOFS-Micronesia systems and add enhancements to ESTOFS capabilities. Expected benefits include extending the system to cover all OCONUS (outside contiguous United States)

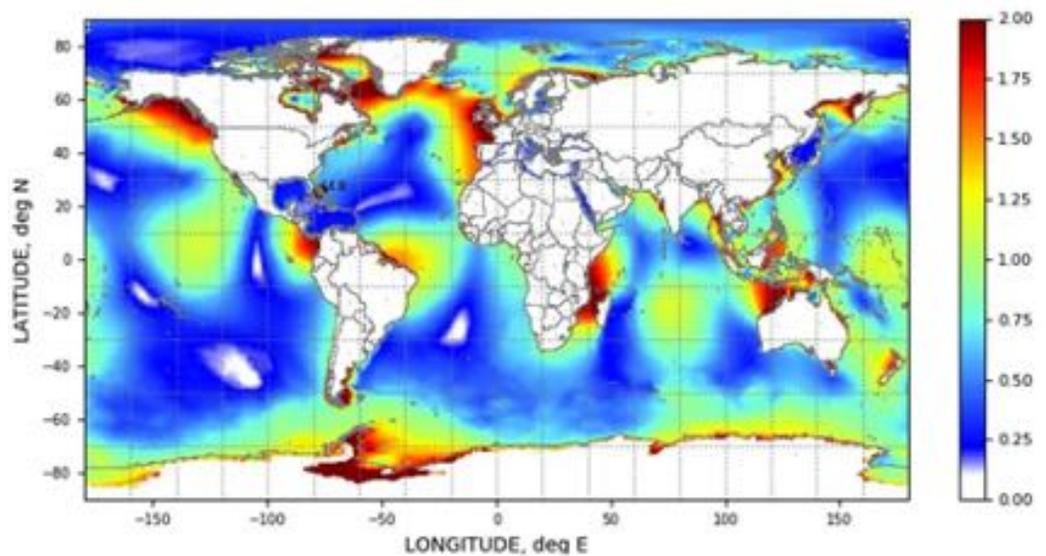
territories, providing boundary and initial conditions for nearshore wave models, and improving spatial resolution for the U.S. coastal regions. Global ESTOFS will improve NOAA capabilities in coastal inundation prediction and open the doors for new applications, including precision navigation, risk assessment analysis, and on-demand coastal inundation prediction systems on a global scale.

FY20 Accomplishment(s): Global ESTOFS is anticipated to be transitioned to operations in FY20 and will unify existing regional ESTOFS systems into a unified model with enhanced resolution.

Project URLs:

https://ocean.weather.gov/estofs/estofs_surge_info.php

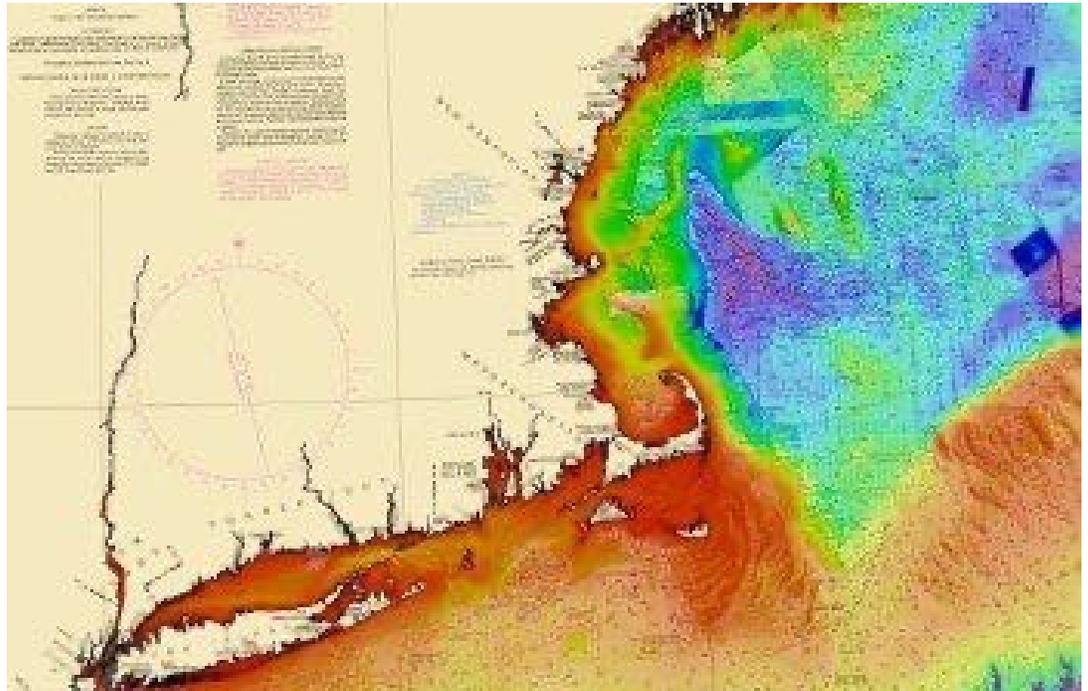
<https://nauticalcharts.noaa.gov/updates/model-upgrade-extratropical-surge-tide-operational-forecast-system-estofs-is-now-global/>



An example of maximum forecast water levels (m MSL) from a forecast cycle of Global ESTOFS. Image credit: NOAA OCS.

National Bathymetric Source project

The National Bathymetric Source (NBS) project creates and maintains high-resolution bathymetry composed of the best available data. This project enables the creation of next-generation nautical charts while also providing support for modeling, industry, science, regulation, and public curiosity. Primary sources of bathymetry include NOAA and U.S. Army Corps of Engineers hydrographic surveys and topographic bathymetric (topo-bathy)



A preliminary build of the bathymetry for the New England region. Image Credit: NOAA OCS.

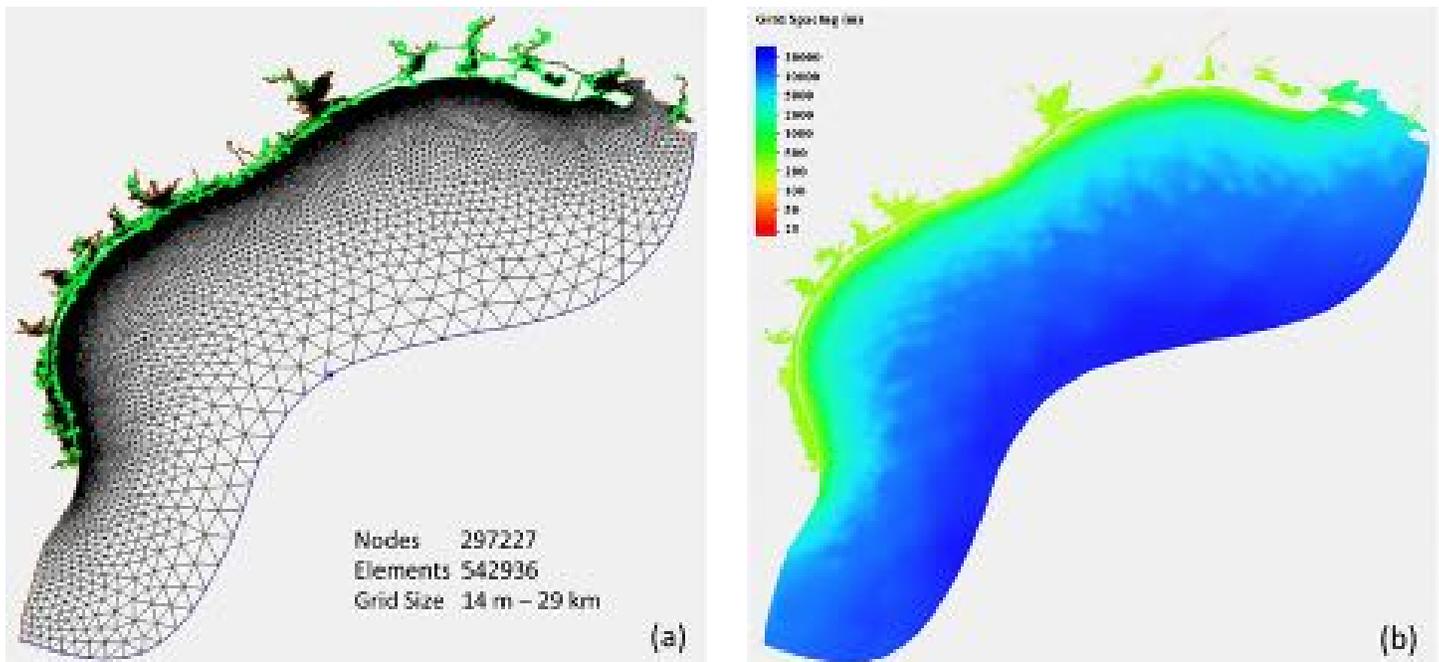
lidar (light detection and ranging) data. Data submitted through the NOAA Office of Coast Survey's external source data process are also included, with gaps in deep water filled through Global Multi-Resolution Topography, a merged model of bathymetry. While there are other models of bathymetry for the United States, the NBS effort is unique because of the techniques used to combine the various sources into one nationwide model of the seafloor. These techniques are designed specifically to serve maritime navigation, but they are equally valuable to other oceanographic modelling and scientific endeavors. As new source data becomes available, OCS updates the national bathymetry for that immediate region. Automated processes all enable efficient inclusion of these new sources. With the completion of the New York region, OCS is expanding the national bathymetry throughout New England first. The NBS project also supports node selection for the Coast Survey modeling team as well as Precision Navigation efforts in major ports like Los Angeles and Long Beach, California. Overall, the resulting bathymetry directly supports the transition from product to data-driven workflows by increasing quality, accessibility, and timeliness of source data.

FY20 Accomplishment(s): A bathymetric buildout of the New England Region.

Project URL:

<https://www.nauticalcharts.noaa.gov/updates/building-the-national-bathymetry/>

Updated VDatum for the Coastal Waters of Texas and Western Louisiana: Modeled Tidal Datums and their Associated Spatially Varying Uncertainties



(a) The updated triangular model mesh grids for the TX and western LA coastal waters. Blue line denotes the model's open ocean boundary, brown line denotes land boundary, and green lines denote island boundaries. (b) The grid spacing in the model domain. Adapted from Wu et al. 2020, NOAA OCS.

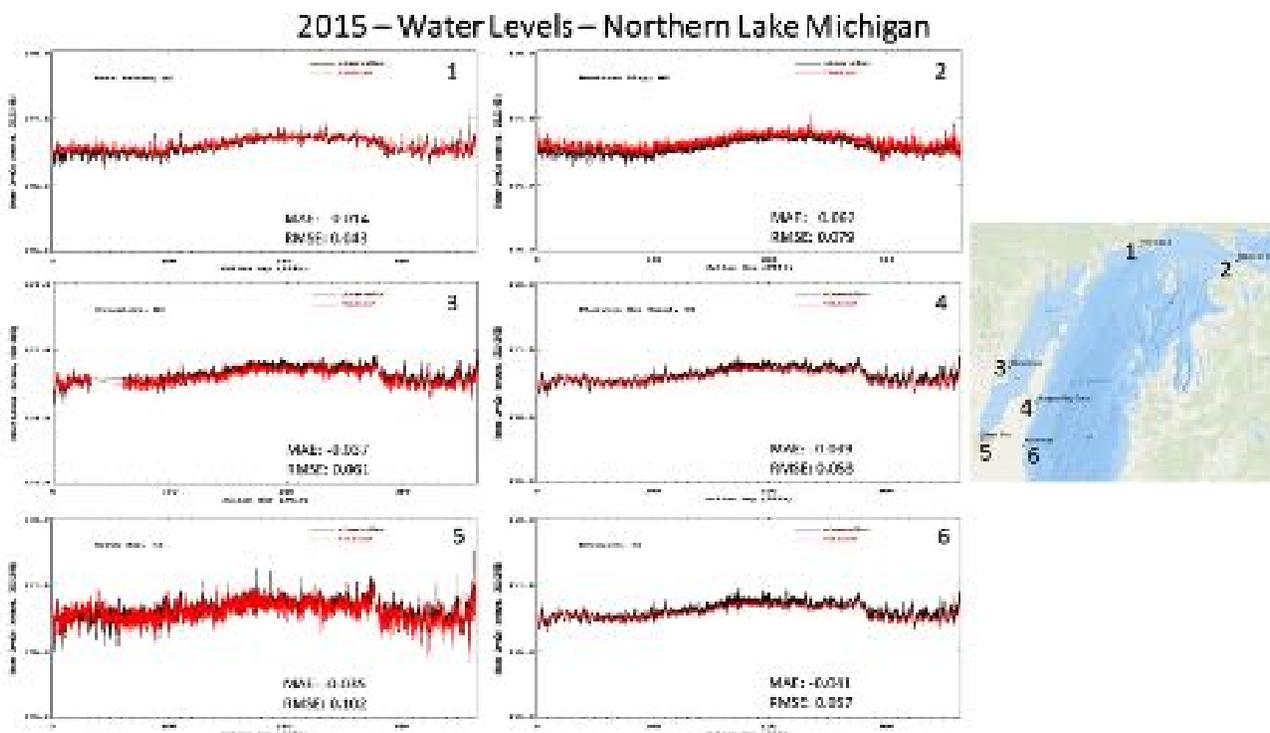
This work by OCS updates the tide model and modeled tidal datums in Texas and western Louisiana coastal regions by using the most currently available shoreline, bathymetry, and tide station data and by using a two-dimensional depth-integrated barotropic version of the ADvanced CIRCulation (ADCIRC) hydrodynamic model (version 51.52.34, released in January 2016). Several techniques were used to reduce the errors in the modeled tidal datums for improving model performance. A Spatially Varying Uncertainty (SVU) statistical interpolation method was implemented for correcting the ADCIRC modeled tidal datums and computing associated uncertainties, and the existing non-tidal polygons in the coastal regions were upgraded by incorporating the modeled tidal datums for improving the quality of tidal datum marine grid population.

FY20 Accomplishment(s): A technical memorandum on updating the tide model and modeled tidal datums in Texas and western Louisiana coastal regions was successfully completed.

Technical Memorandum: Wu et al. 2020 *NOAA Tech Memo* NOS CS 43

<https://repository.library.noaa.gov/view/noaa/24752>

Upgrade of NOS Lake Michigan and Lake Huron Operational Forecast Systems to FVCOM: Model Development and Hindcast Skill Assessment



Time series plots of hourly hindcasts and operational nowcasts of water level (red) vs. observations (black) at CO-OPS National Water Level Observation Network (NWLON) gauges (1. Port Inland, MI, 2. Mackinaw City, MI, 3. Menominee, MI, 4. Sturgeon Bay Canal, WI, 5. Green Bay, WI, and 6. Kewaunee, WI) at northern Lake Michigan during 2015. Mean Absolute Error (MAE; meters) and Root Mean Squared Error (RMSE; meters) at each station are shown individually on each panel.

NOAA GLERL and NOS have collaborated to upgrade the NOS Lake Michigan and Lake Huron Operational Forecast Systems to improve forecast guidance of water temperature, water levels, and currents by migrating to FVCOM and using a single model grid domain covering both lakes. Hindcasts from the new Lake Michigan and Huron Operational Forecast System were conducted for 2015, 2016, and 2017 and compared to observations from U.S. and Canadian observing networks using NOS skill assessment procedures. The results of the skill assessment of water level and surface water temperature hindcasts for 2015 and 2016 and evaluation of subsurface water temperature hindcasts for 2014-2017 were published in a NOS Technical Report.

FY20 Accomplishment(s): An evaluation of water levels and water temperature hindcasts for 2015, 2016 and 2017 from NOS' new Lake Michigan and Huron Operational Forecast System was completed and the results published in a NOS Technical Report.

Technical Memorandum URL: Kelley et al. 2020 *NOAA Tech Memo CS 42*:
<https://repository.library.noaa.gov/view/noaa/23891>

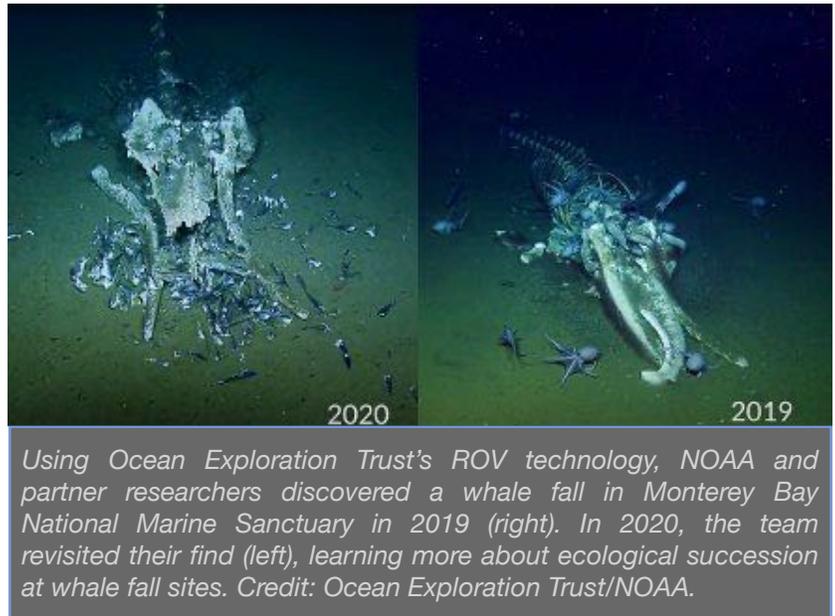
Office of National Marine Sanctuaries

NOAA's Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks encompassing more than 600,000 square miles of marine and Great Lakes waters. The network includes a system of 14 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments. The system works with diverse partners and stakeholders to promote responsible, sustainable ocean uses that ensure the health of our

most valued ocean places. The Office of National Marine Sanctuaries also leads the National Marine Protected Areas Center, the nation's hub for building innovative partnerships and tools to protect our special ocean. In addition, ONMS staff conduct and support research and monitoring programs tailored to the information needs of each sanctuary. Below are four highlighted scientific projects by ONMS researchers and their partners.

Telepresence Science Missions in National Marine Sanctuaries

Increasingly, science missions in NOAA's National Marine Sanctuaries invite the public aboard through remote access. In 2020, ONMS invited the public to participate in science missions facilitated through the use of underwater exploration systems. Using ship-to-shore technology, scientists led remotely operated vehicle exploration at Cordell Bank, Greater Farallones, Monterey Bay, and Flower Garden Banks National Marine Sanctuaries. In addition, other missions have taken place at Stellwagen Bank, Olympic Coast, and Channel Islands sanctuaries. Students and the public participated in dozens of virtual, interactive sessions as well as live feeds of the exploration and sample collection. In total, more than 1.3 million people viewed the videos. The objectives included exploring deep-sea canyon and coral communities, assessing changes over time at octopus brooding areas and the sites of decomposing whale carcasses, and surveying biological and archaeological features of shipwrecks. These missions were made possible through partnerships with groups including the Global Foundation for Ocean Exploration, Ocean Exploration Trust, and Woods Hole Oceanographic Institution.



FY20 Accomplishment(s): The discovery of a whalefall in the middle phases of successional degradation was a rare encounter, and a highlight of an exploration mission in Monterey Bay National Marine Sanctuary.

Project URL:

<https://sanctuaries.noaa.gov/earthisblue/wk256-whale-fall.html>

Octopus Gardens



Octopus brooding their eggs within a warm water seep near Davidson Seamount in Monterey Bay National Marine Sanctuary. This genus has an unusual upside-down brooding posture. Credit: Ocean Exploration Trust/NOAA.

After the discovery of a large number of deep-sea octopus brooding their young in 2018, Monterey Bay sanctuary scientists returned to Davidson Seamount with Woods Hole Oceanographic Institution aboard the submersible *Alvin*, Monterey Bay Aquarium Research Institute aboard the R/V *Western Flyer*, and with Ocean Exploration Trust (OET) aboard the E/V *Nautilus*. With *Alvin* dives highlighted on BBC’s live television broadcast of “Blue Planet Live,” the team confirmed that warm water was venting from the seafloor where octopus were brooding. With OET, the team estimated octopus population size (more than 1,000 individuals), and installed instruments to track temperature, dissolved oxygen, and water chemistry at the warm water seeps harboring the animals.

FY20 Accomplishment(s): The project team discovered a second octopus nursery occupying thermal vents on Davidson Seamount, confirming the importance of this protected area to a species not previously known to occur there.

Project URL:

<https://sanctuarysimon.org/2018/11/mbnms-scientists-discover-octopus-gardens-and-film-a-dumbo-squid/>

Transitioning Science to Protect Right Whales via Corporate Responsibility



Seven new calves were born to North Atlantic right whales this year. The NOAA Fisheries speed regulation and the Right Whale Corporate Responsibility Project give these calves a better chance at surviving in Stellwagen Bank National Marine Sanctuary. Image credit: NOAA.

Since 2012, Stellwagen Bank National Marine Sanctuary’s highly regarded “Report Card” has been detailing compliance of vessels with speed restrictions while traversing Right Whale Seasonal Management Areas (SMAs) in the Gulf of Maine. In 2008, NOAA began requiring large ships to slow down to 10 knots or less while passing through SMAs. Some of these areas overlap the sanctuary, which is a critical seasonal feeding area for right, humpback, fin, and minke whales. In these areas, large commercial ships converge to enter the Port of Boston. When ships slow down, any collisions they have with whales have a smaller chance of delivering a lethal strike. In 2018, the project sent report cards to 228 ships and 115 companies, helping them better understand the impacts of their vessel practices. In 2019, 85% of vessels received grades of A or A+ and only 5% receive a grade of F. Report cards were sent to ships and companies in December 2019, to be influential during the 2020 SMA season. Companies that receive an A or A+ grade also receive a certificate recognizing their achievement. This positive reinforcement has been crucial to the success of the project.

FY20 Accomplishment: The use of vessel tracking data to assess compliance with speed restriction is now used as a model for numerous other areas where ship speed poses a risk of collision between whales and ships.

Project URL:

<https://sanctuaries.noaa.gov/news/jun19/right-whale-corporate-responsibility-project-stellwagen-bank-national-marine-sanctuary.html>

Wave Glider Transits over 2,500 NM to Survey Soundscape of Papahānaumokuākea Marine National Monument

NOAA's Office of National Marine Sanctuaries, the US Navy, and Jupiter Research Foundation used a wave glider autonomous surface vehicle to collect acoustic recordings, weather and ocean data, and surface and underwater imagery on a 2,500 nautical mile survey in the Papahānaumokuākea Marine National Monument. The SV3 Wave Glider Europa departed Hawai'i Island in January 2020 and spent 67 days transiting the Monument as far as Lisianski Island, covering a distance equivalent to a roundtrip from Washington D.C. to Denver. The wave glider navigated rough winter seas and surveyed 18 banks, shoals and seamounts that had either been unsurveyed in the past or had been under surveyed in the winter season, and documented the first recorded presence of humpbacks at several of these locations.

FY20 Accomplishment: The SanctSound Project, a collaboration between NOAA and the U.S. Navy, employed autonomous surface vehicles to collect sound and other data in the winter season in remote areas of largest MPA in the United States and identified previously unknown humpback whale distributions.

Project URLs:

<https://sanctuaries.noaa.gov/science/monitoring/sound/>

<https://jupiterfoundation.org/humpacs-1>



Humpback whale observed during the Humpback Pacific Survey (HUMPACS), which included the Papahānaumokuākea Marine National Monument. Original image has been altered to include the Wave Glider to demonstrate operations. Image credit: Ed Layman, NOAA ONMS; Jupiter Research Foundation.

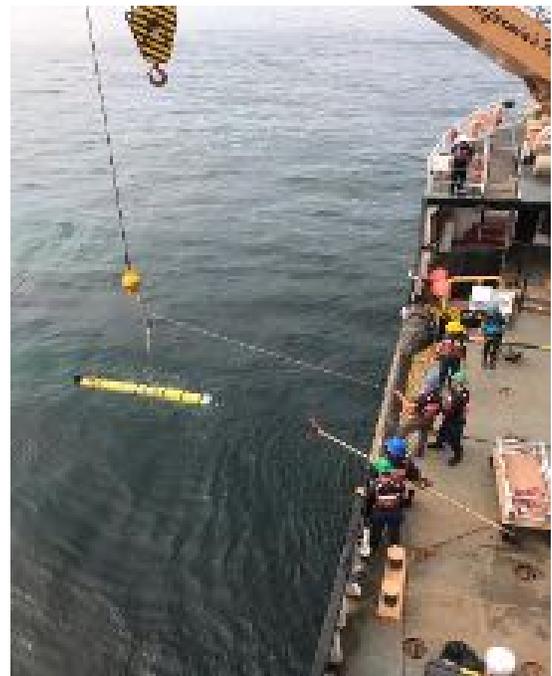
Office of Response and Restoration

NOAA's Office of Response and Restoration (OR&R) is a center of expertise in preparing for, evaluating, and responding to threats to coastal environments, including oil and chemical spills, releases from hazardous waste sites, and marine debris. OR&R's mission is to develop scientific solutions to keep the coasts clean from threats of oil, chemicals, and marine debris. To fulfill its mission of protecting and restoring NOAA trust resources, OR&R provides scientific and technical support to prepare for and respond to oil and chemical releases; determines

damage to natural resources from these releases; protects and restores marine and coastal ecosystems, including coral reefs; and works with communities to address critical local and regional coastal challenges. OR&R comprises four divisions: Emergency Response, Assessment and Restoration, Marine Debris, and the Disaster Preparedness Program. Collectively, OR&R provides comprehensive solutions to marine pollution. Below are eight highlighted scientific projects by OR&R researchers and their partners.

Using Uncrewed Platforms to Characterize Oil in the Water

The ability to rapidly characterize oil dispersed in the water column and floating on the water surface during and after an oil spill is a primary need of oil spill response teams, and is an important objective of natural resource damage assessments (NRDAs). OR&R worked with multiple partners to develop and test a novel autonomous underwater vehicle (AUV) platform and multispectral uncrewed aircraft systems (UAS) for characterizing oil in the water after oil spills. Rapid characterization of oil in the water column and floating on the water surface during and after oil spills is critical information for both oil spill response and natural resource damage assessments. Testing from a U.S. Coast Guard (USCG) vessel at the Coal Point oil seep site near Santa Barbara, CA, demonstrated how these systems have advanced the ability to respond to and assess impacts from oil spills. The AUV REMUS 600 and sensor/sampling systems conducted three-dimensional mapping of dissolved hydrocarbons and oil droplets in the water column beneath the oil slick while the UAS conducted surface mapping of the oil slick. These data can be provided to spill responders for situational awareness and rapid response decision-making. The project was conducted by a partnership that includes NOAA, Woods Hole Oceanographic Institute, the Bureau of Safety and Environmental Enforcement, the Environmental Protection Agency, the USCG, Water Mapping LLC, and the NOAA/University of New Hampshire Coastal Response Research Center (CRRC).



Recovery of the AUV REMUS 600. Image credit: Dipinto 2019. NOAA ORR.

FY20 Accomplishment(s): Results of this project are publicly available on the CRRC website and have been presented at multiple scientific venues.

Project Final Report: DiPinto 2019 Report to the Bureau of Safety and Environmental Enforcement: <https://unh.app.box.com/s/ctjc6ipuzrm4fs0iqnnd0z4gv26wrsga>

Fishing for Marine Debris

In the same way as bycatch and incidental species catch are modeled, OR&R's Marine Debris Program (MDP), the NOAA Pacific Islands Fisheries Science Center and Walsh Analytical Service estimated the relative abundance of marine debris "caught" by Hawaii-based pelagic longlines as reported by fisheries observers. Nine years of observer data from this fishery were analyzed and modeled. The snagged debris was dominated by derelict fishing gear (~90%) from other fisheries operating in the North Pacific Ocean. Modeling revealed that the relative abundance of derelict fishing gear "caught" by the Hawaii longlines has declined by two thirds (~66%) in less than a decade (2008-2016).



Fishery observers from the Hawaii-based pelagic longline fishery haul in marine debris that has been snagged. Image credit: NOAA.

FY20 Accomplishment(s): Results of this project were published in the online open access journal, *Scientific Reports*.

Peer reviewed journal article URL: Uhrin et al. 2020 *Scientific Reports*
<https://www.nature.com/articles/s41598-020-64771-1>

Nature Sustainability Community invited blog article:
<https://sustainabilitycommunity.springernature.com/posts/fishing-for-marine-debris>

Examining Observer Bias in Marine Debris Data Collected by Citizen Scientists

OR&R's Marine Debris Program (MDP) collaborated with the University of Washington's Coastal Observation and Seabird Survey Team (COASST) to evaluate and identify ways to correct for observer bias in shoreline monitoring protocols developed as part of MDP's Marine Debris Monitoring and Assessment Project (MDMAP). MDMAP is a citizen science initiative that engages both domestic and international volunteers in conducting standardized shoreline surveys for marine debris



MDP and COASST staff together with volunteers conduct a shoreline monitoring field trial. Image credit: COASST.

items larger than 2.5 cm. These monitoring surveys help us answer fundamental questions about the types and distribution of debris on shorelines, such as where debris originates, what beaches accumulate the most debris, how debris patterns change over time, and if preventative measures lead to debris reductions. A series of field trials were conducted on a handful of beaches across Washington State. Findings show there are ways to improve the MDMAP protocols and the quality of data being collected by observers which will strengthen debris density estimates generated from MDMAP data. Protocol improvements include, streamlining walking patterns to search for marine debris, limiting the number of people actively searching for debris during a transect, adding an option to remove debris during all surveys, and providing more detailed information on the debris within the back barrier of the beach.

FY20 Accomplishment(s): Results of this project are publicly available in the Marine Debris Clearinghouse; the project team is drafting a publication to be submitted to the journal, *Citizen Science Theory & Practice*; MDP is currently updating MDMAP protocols based on these findings

Project Final Report: Burgess et al. 2020, Report for the NOAA Marine Debris Program: <https://clearinghouse.marinedebris.noaa.gov/project?mode=View&projectId=838>

Using Invasive Mussels as Sentinel Organisms for Monitoring Microplastic Pollution in the Great Lakes: A Case Study

OR&R's Marine Debris Program (MDP) collaborated with the National Centers for Coastal and Ocean Science (NCCOS) Great Lakes Mussel Watch Program, and Loyola University Chicago to understand the distribution and abundance of microplastics across the Milwaukee Estuary, WI. This project took advantage of the Great Lakes Mussel Watch Program (GLMWP) by sampling additional mussels to assess whether those same invasive freshwater mussels may be good candidates as biomonitors for microplastic occurrence. Mussels were collected from relatively clean reference sites in Lake Michigan and deployed for 1 and 2 months in experimental cages near the outfall of a WWTP and at the confluence of two rivers that drain the Milwaukee metro area and empty into Milwaukee Bay. The amount of microplastic found in mussel tissue was very different among different sizes of mussels and very different between sampling months. There was partial evidence for greater microplastic ingestion near a wastewater outfall, but only for larger mussels. There was no clear relationship between presence of microplastics and legacy contaminants in mussels.



NCCOS staff deploy a mussel cage at one of the study sites in the Milwaukee Estuary, WI. Image credit: NOAA

FY20 Accomplishment(s): Results of this project are publicly available in the Marine Debris Clearinghouse and have been presented at a number of scientific conferences; the project team is drafting a publication to be submitted to the journal, *Frontiers in Marine Science*

Project Final Report: Hoellein & Rovegno 2020, Final Report for the NOAA Marine Debris and NOAA Mussel Watch Programs:

<https://clearinghouse.marinedebris.noaa.gov/project?mode=View&projectId=839>

Guidelines for Assessing Exposure and Impacts of Oil Spills on Marine Mammals.

OR&R's Assessment and Restoration Division (ARD) partnered with NOAA Fisheries Office of Protected Resources and external partners to publish a NOAA Technical Memo on Guidelines for Assessing Exposure and Impacts of Oil Spills on Marine Mammals. These guidelines were developed from a workshop that was held to discuss, develop, and document methods and processes to evaluate the nature and



Mother sea lion and pup. Image credit: NOAA.

extent of potential injuries to marine mammals from oil spills. The technical memo and its guidelines provide a review of considerations for marine mammals under NOAA's jurisdiction, incorporating knowledge gained from previous oil spills, especially the 2010 Deepwater Horizon spill. The report describes NOAA's response and assessment activities for marine mammals due to oil spills, descriptions of oil exposure and potential injury, and summaries of methods and approaches currently available for marine mammal assessment. This guidance will help NOAA and co-trustees to implement effective studies for assessing exposure and impacts to marine mammals affected by spills.

FY20 Accomplishment(s): Results of this project were published as a NOAA Technical Memo.

Technical Memorandum: Sullivan et al. 2019 *NOAA Tech Memo* NMFS-OPR-62
<https://repository.library.noaa.gov/view/noaa/22425>

Oil Spill Assessment for Marine Mammals Story Map:
<https://storymaps.arcgis.com/stories/867559ca52cd43a6b347ca13f0c4bff9>

Publication to Support Natural Resource Damage Assessment



OR&R worked with NOAA Fisheries Office of Habitat Conservation (OHC), the Office of General Council for Natural Resources (GCNR), and external partners to publish a new, rigorous, and more legally defensible method for scaling habitat injury that supports NOAA’s most challenging damage assessment cases. The team introduced the new method, Habitat Based Resource Equivalency Method (HaBREM), that evaluates injury by relating the biomass of organisms that use specific habitats to the ecological functions of that habitat. By focusing on organism-based metrics HaBREM removes subjective aspects of traditional methods and increases both repeatability and defensibility.

FY20 Accomplishment(s): Results of this project were published in a peer reviewed article in the journal *Environmental Management*.

Peer reviewed journal article: Baker et al. 2020 *Environmental Management*
<https://doi.org/10.1007/s00267-019-01245-9>

Project URL:

<https://response.restoration.noaa.gov/new-publication-habitat-based-resource-equivalency-method-habrem>

Detection and Removal of Sunken Oil Mats (SOMs)

Available information on the processes that influence the formation of submerged and buried oil mats along sand beaches following an oil spill was reviewed and synthesized. This included a review of case histories, field-collected datasets (particularly the extensive field data and modeling studies of the submerged oil mats at the Deepwater Horizon spill), as well as recent publications on sand beach geomorphology and sediment dynamics and interactions with oil. Simplified response guidelines were then developed for: 1) when buried and submerged oil mats and deposits are (and are not) likely to form and persist; 2) the best survey methods to detect them; and 3) removal methods that are most effective and minimize environmental impact. This project was carried out by OR&R's Emergency Response Division in partnership with the Canada Department of Fisheries and Oceans.



OR&R responders gather oil samples as part of a Shoreline Cleanup and Assessment Technique (SCAT) operation along the west shore of the Mississippi River, following a 2008 vessel collision near New Orleans, La. Observations and data from SCAT surveys are critical to the decision-making process for shoreline cleanup at oil spills. Image Credit: ORR, NOAA.

FY20 Accomplishment(s): Results of this project were used to develop a Response Guide for Sunken Oil Mats (SOMs), which is available online.

Project URL:

<https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/shoreline-cleanup-and-assessment-technique-scat.html>

Assessing the Effectiveness of Repair and Stabilization Actions Conducted in Damaged Seagrass Beds



A survey being conducted by OR&R researchers in turtle grass (Thalassia testudinum) to evaluate repair and stabilization efforts in St. Croix.

Response activities in the aftermath of Hurricane Maria caused damage to seagrass beds in St Croix, U.S. Virgin Islands. Repair and stabilization activities were conducted to limit further damage due to scour, erosion, and/or sediment migration and to allow seagrass re-growth and recovery. Recent snorkel surveys of the affected areas by OR&R's Emergency Response Division revealed that repair and stabilization activities resulted in enhanced seagrass recovery and recolonization as measured by seagrass species composition (dominant, co-dominant, secondary), cover class, and canopy height, as well as the bottom elevation differential between the scarred areas and adjacent undamaged areas.

FY20 Accomplishment(s): Results of this project will inform future repair and stabilization activities in seagrass habitats.

Project URL:

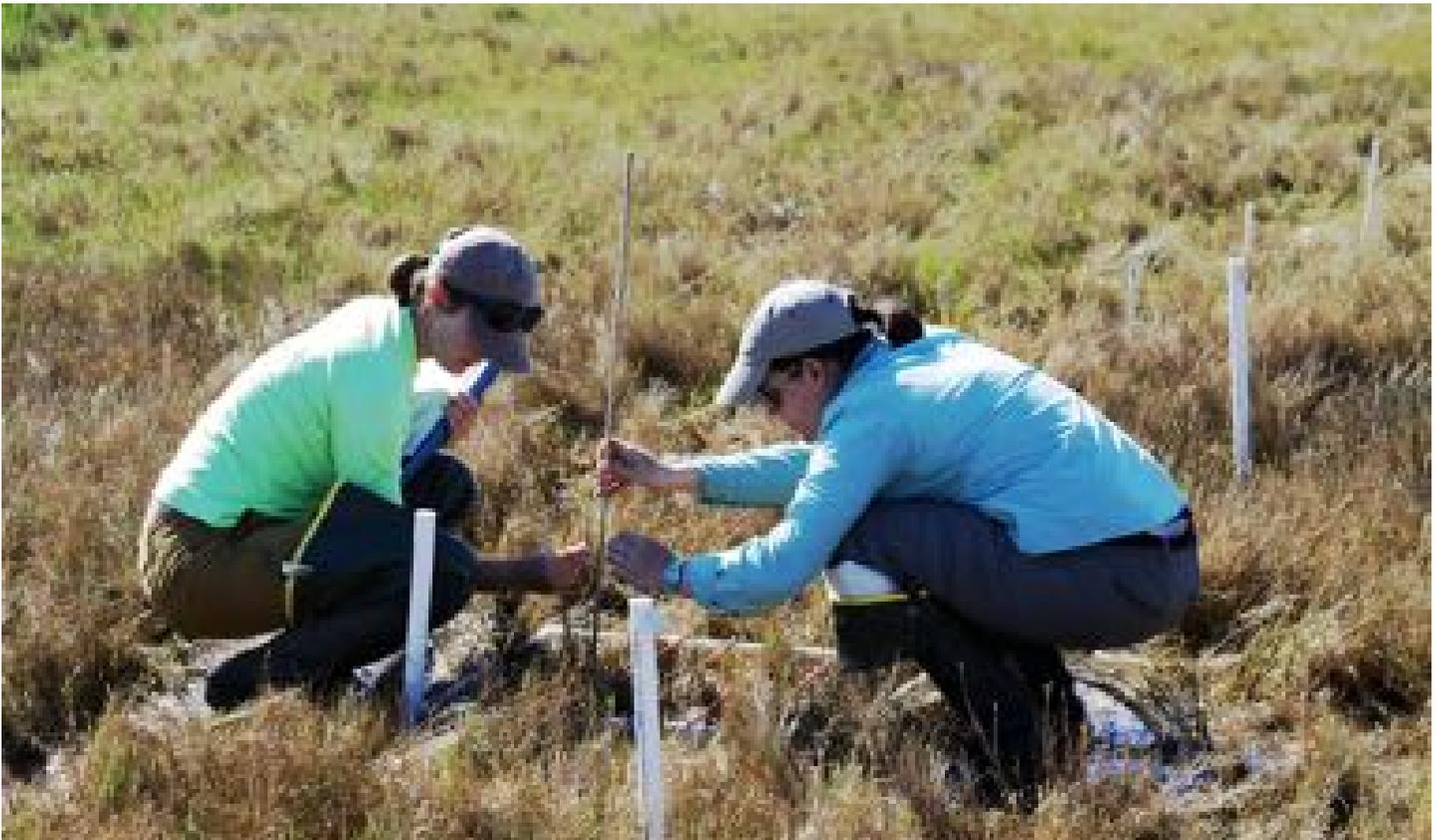
<https://response.restoration.noaa.gov/hurricane-maria-sea-grass-bed-damage>

Office for Coastal Management

NOAA's Office for Coastal Management (OCM) is the federal agency tasked with implementing the Coastal Zone Management Act, which is the guiding legislation for the decisions and actions taken to keep the natural environment, quality of life, and economic prosperity of coastal areas in balance. As a scientific organization, NOAA provides access to the science and environmental intelligence communities need for these tasks. Four major

programs make up the Office for Coastal Management, and each counts on active partnerships with all sectors to be successful. They include the National Coastal Zone Management Program, the National Estuarine Research Reserves, the NOAA Coral Reef Conservation Program, and NOAA's Digital Coast web-based resources. Included below are two highlighted scientific projects by OCM researchers and their partners.

Understanding and Mitigating Marsh Vulnerability to Environmental Changes



NERRS scientists in Maryland inspect a test plot where dredged sediment was applied. Image credit: Chesapeake Bay Maryland NERR.

Tidal marshes, which provide key habitat for fisheries and valuable community protection against storm surge, are increasingly threatened by sea level rise. Scientists are using consistent monitoring protocols in National

Estuarine Research Reserve System (NERRS) sites around the nation to better track marsh vulnerability and research the interactions of fauna, habitat, and inundation. Because of this effort, a NOAA-funded team has developed and released guidance for coastal managers on new approaches of sediment addition (thin layer placement) as a restoration strategy.

FY20 Accomplishment(s): NOAA is working with state and university partners to understand and monitor coastal marsh vulnerability and implement effective restoration techniques to protect these valuable resources.

Guidance Report: Raposa et al. 2020 (in collaboration with the National Estuarine Research Reserve System Science Collaborative)

<https://www.nerra.org/01/wp-content/uploads/2020/02/TLP-Guidance-for-Thin-Layer-Placement-20200217-HRes.pdf>

Project URL:

<http://www.nerrsciencecollaborative.org/project/Raposa17>

National Marine Economy Statistics

OCM, the NOAA Chief Economist's Office, and the Bureau of Economic Analysis are working to produce a "Marine Economy Satellite Account (MESA)" measuring the U.S. marine economy. This three-year effort builds on decades of research on defining and measuring the marine economy, with significant contributions by the Middlebury Institute's Center for the Blue Economy. The prototype results, published in June 2020,

show that the U.S. marine economy, including goods and services, yielded \$617 billion in gross output (total production) and contributed about \$373 billion to the nation's gross domestic product in 2018. These experimental results include statistics for 55 marine industry groups, organized into ten major sectors: tourism and recreation, including recreational fishing; national defense and public administration; offshore minerals, including oil and gas; transportation and warehousing; living resources, including commercial fishing and aquaculture; ship and boat building; power generation; research and education; construction; and professional and technical services. These data show that the marine economy is vital to the nation, with total production that is greater than the agriculture or public utility industries. The data, currently spanning 2014 to 2018, will help national policy makers, marine industries, and investors make informed decisions about how to plan for the future — protecting our people, our economy, and our environment for future generations. In addition, this data can serve as a baseline to measure the magnitude of the impacts of COVID to the marine economy.

FY20 Accomplishment(s): For the first time, the United States has ocean data that can be compared with official statistics regarding other U.S. industries and with the ocean economies of other nations.

Project URL:

<https://www.bea.gov/data/special-topics/ocean-economy>



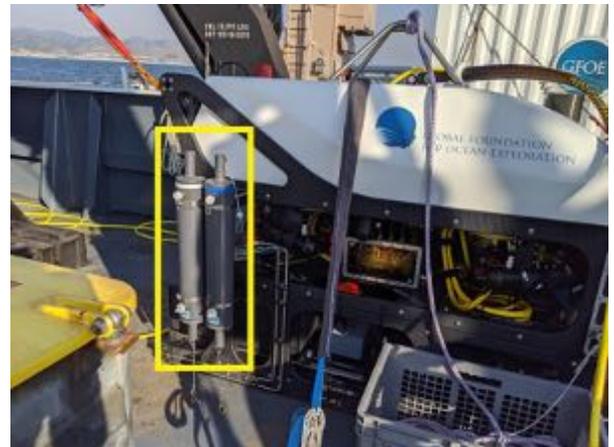
U.S. Integrated Ocean Observing System

The U.S. Integrated Ocean Observing System (IOOS) is a national-regional partnership working to provide new tools and forecasts to improve safety, enhance the economy, and protect our environment. Integrated ocean information is available in near real time, as well as retrospectively. Easier and better access to this information is improving our ability to understand and predict coastal events - such as storms, wave heights, and sea level change. Such knowledge is needed for everything from retail to development planning. IOOS' mission is to

produce, integrate, and communicate high quality ocean, coastal and Great Lakes information that meets the safety, economic, and stewardship needs of the Nation. IOOS' Operations Division coordinates the contributions of Federally-owned observing and modeling systems and develops and integrates non-federal observing and modeling capacity into the system in partnership with IOOS regions. Included below is a highlighted project by IOOS-supported researchers and their partners.

eDNA can Provide Detailed information about Ecosystem Dynamics and Key Species as Indicators of Change

NOS is using environmental DNA (eDNA) to study organisms across trophic levels and ecosystems and provide critical information about species interactions in the face of ecosystem change. The U.S. Marine Biodiversity Observation Network (MBON) Sanctuaries Team — coordinated by IOOS with interagency funding and support — has been a key player in developing best practices for eDNA and demonstrating its utility for biological observing and biodiversity assessment. A team of MBON partners across multiple research institutions and state government agencies used eDNA methods to survey biodiversity in Monterey Bay, CA, during an 18-month period (2015-2016). The researchers created a dataset from the resulting seawater samples, encompassing 663 taxonomic groups from microorganisms to mammals. The team concluded that “eDNA-based analyses can provide detailed information about marine ecosystem dynamics and identify sensitive biological indicators that can suggest ecosystem changes and inform conservation strategies.”



Niskin bottles for eDNA collection, as shown here on a Global Foundation for Ocean Exploration cruise, were used by the research team aboard the R/V Rachel Carson and Western Flyer. Image credit: NOAA.

FY20 Accomplishment(s): Findings from this study were published in the journal *Nature Communications*.

Peer reviewed journal article: Djurhuus et al. 2020 *Nature Communications*
<https://www.nature.com/articles/s41467-019-14105-1.pdf>

IOOS MBON Website:
<https://ioos.noaa.gov/project/bio-data/>

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