NOS PRIORITY:

STEWARDSHIP, RECREATION, AND TOURISM

THE UNITED STATES boasts some of the most important natural, cultural, and historical resources in the world—not just on land but under the water as well. The value of the U.S. coastal tourism and recreation industry in 2009 was $62 billion. NOS plays a critical role in protecting and promoting access to these special coastal and marine places. NOS is entrusted with the responsibility to manage a network of underwater parks encompassing more than 600,000 square miles of coastal, marine, and Great Lakes waters. Across all national marine sanctuaries, about $8 billion annually is generated in local economies from activities like commercial fishing, tourism, and recreation. NOS also partners with states to manage national estuarine research reserves, a network of 29 coastal sites designated to protect and study estuarine systems. The reserves reflect the rich diversity of environments along our coasts and Great Lakes, and provide places for education, recreation, and boosting local economies.

Following are stewardship, recreation, and tourism themed projects organized according to three primary scientific priorities of the National Centers for Coastal Ocean Science (NCCOS) strategic plan.

Advanced Observation Technologies

Included below are two highlighted scientific projects by OR&R and OCM researchers and their partners, which are focused on advanced observation technologies.

Advancing the Use of Unmanned Platforms to Respond to and Assess Spills in Ice Environments

Scientists from **OR&R**, funded by the United States Coast Guard Research Development Center, and in collaboration with scientists from US EPA, Applied Research Associates, and Water Mapping LLC, are developing and testing new remote sensing tools and technologies (UAS and ROV) to more efficiently and effectively detect and characterize surface oil in icy waters. The researchers are looking at the oil both from above the slick looking down, and from beneath the slick looking up. Scientists remotely characterize oil slicks flying a quadcopter carrying multispectral sensors over various configurations of surface oil and ice, at the same time as underwater ROV mounted acoustic sensors characterize the oil from beneath. These tools are advancing our ability to 'see' oil in more complex ice-water environments. Additionally the team, in partnership with the USEPA's Office of Research and Development to monitor smoke plumes from in situ burns using UAS mounted sensor packages. These projects demonstrate the rapidly advancing utility of using UxS for spill responses and assessments.

Dr. Oscar Garcia (Water Mapping, LLC) prepares to launch the hexacopter platform with multispectral sensors for floating oil detection. Image credit: NOAA/NOS/ORR.
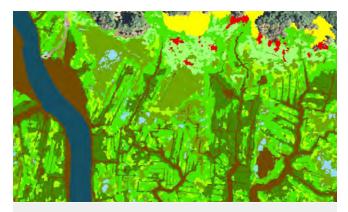
FY21 ACCOMPLISHMENT(S):
Successful completion of experiments at the Cold Regions Research and Engineering Laboratory (CRREL), an oil-ice testing facility in Hanover, New Hampshire. Eight oil thickness categories were measured in combination of various ice cover regimes. Nine successful in situ burns were conducted and monitored using fresh and weathered Alaska North Slope Crude oil.

Project URL: https://response.restoration.noaa.gov/fire-and-ice-noaa-and-us-coast-guard-partner-study-oil-ice-environments

Advancing Coastal Mapping/Management through Artificial Intelligence

OCM, through its Coastal Change Analysis Program (C-CAP), has been working to develop the next generation of land cover data for the coastal U.S. This work has focused on the research and implementation of methodologies that increase the program's efficiency and impact. By applying artificial intelligence/machine learning algorithms in a cloud-based environment, these efforts have resulted in several high spatial detail land cover and habitat datasets which serve not only as proof of concept demonstrations but are also informing coastal management decisions at regional and local levels. The

state of New Hampshire, for instance, has been utilizing saltmarsh habitat data produced through these efforts to better inform marsh resilience assessments and to inform the state's comprehensive marsh management planning.

Saltmarsh habitat data (2013) for New Hampshire. Image credit: NOAA/NOS/OCM.

FY21 ACCOMPLISHMENT:
Statewide saltmarsh habitat mapping informs New Hampshire's comprehensive marsh management planning.

C-CAP database URL: https://coast.noaa.gov/digitalcoast/data/ccaphighres.html

Ecosystem Science for Conservation and Sustainable Use

Below are five highlighted scientific projects by NCCOS and ONMS researchers and their partners, which are focused on ecosystem science for conservation and sustainable use of coastal systems.

New Research Informs Management of Rare Gulf of Mexico Whale

With a very small population size, the Gulf of Mexico Rice's whale (*Balaenoptera ricei*), designated as an endangered species in April 2019, is one of the rarest whales on the planet. Previously thought to be a subpopulation of the Bryde's whale species, recent genetic and morphological data now identify the filter-feeding Rice's whales as a separate species. It is more important than ever to learn about the whale's critical habitat as a first step in planning for its recovery. Since 2017, a NOAA-led project supported by the NOAA RESTORE

Rice's Whale. Image credit: Wayne Hoggard, NOAA Fisheries

on understanding Rice's whale movement habits and feeding patterns for recovery planning efforts. Investigators have conducted three research cruises dedicated to learning about the whale. Recent research has revealed that the whales spend most of their daylight hours in a constant diving and feeding pattern; and then rest just below the surface most of the night. The Rice's whale feeds on dense aggregations of fish that form just above the bottom during daylight hours, and may be selectively feeding on one or two fish species. The presence of upwelled water near the bottom, along with seasonal inputs of high productivity shelf water into the habitat, are likely important factors in maintaining enough prey to support the energetic requirements of the whales. By working closely with the people responsible for marine mammal management in the Gulf of Mexico, NOS-supported researchers are ensuring that their discoveries about the whale's feeding and movement are integrated into recovery plans.

FY21 ACCOMPLISHMENT:
The project team has greatly increased our knowledge about the whale's habitat and feeding processes and provided this information to resource managers who are designating critical habitat ahead of developing and implementing a recovery plan across the Gulf of Mexico.
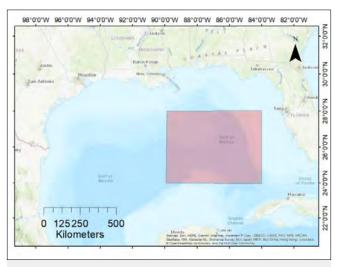
Project URLs: https://restoreactscienceprogram.noaa.gov/living-coastal-and-marine-resources/new-research-informs-management-of-rare-gulf-of-mexico-whale

https://restoreactscienceprogram.noaa.gov/projects/brydes-whales

Unlocking the food web-dynamics sustaining Atlantic bluefin tuna larvae

Atlantic bluefin tuna (Thunnus thynnus) are highly migratory and spawn in the Gulf of Mexico, but are distributed as adults throughout the Atlantic Ocean. This migratory behavior, as well as year to year changes in environmental conditions at sites where Atlantic bluefin tuna spawn, makes management of the species complex. Being able to track how changes in nutrient availability impact tuna food webs and larval survival is essential to managing open ocean ecosystems. A project supported by the NOAA RESTORE Program through NCCOS investigated the impact of

variability in a key nutrient, nitrogen, on lower food webs and the resulting availability of zooplanktonic food resources for Atlantic bluefin tuna larvae in the Gulf of Mexico ecosystem. This information will inform Atlantic bluefin tuna stock assessments by making it possible to more accurately estimate feeding, growth, and survival of Atlantic bluefin tuna larvae based on ocean conditions.

Area of the Gulf of Mexico where researchers collect Bluefin Tuna larvae (red square). Image credit: NOAA RESTORE Program.

FY21 ACCOMPLISHMENT:
The project team revealed the link between nutrients, food availability, and the survival of Atlantic bluefin tuna larvae which can be used to improve stock assessments for this commercially and recreationally important species.
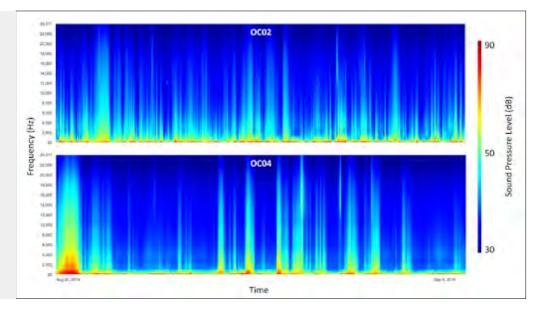
Project URL: https://restoreactscienceprogram.noaa.gov/projects/bluefin-tuna-larvae

Data and Applications from Sanctuary Soundscape Monitoring Project Now Available to the Public.

Since 2018, ONMS and the US Navy have co-led the Sanctuary Soundscape Monitoring Project (SanctSound) to monitor underwater sound at 30 locations in seven national marine sanctuaries and one Marine National Monument. Over 20 institutions participate in this nationwide effort to understand sound conditions and ocean noise impacts across the National Marine Sanctuary

Spectrograms from two SanctSound listening stations (OC02, top; OC04, bottom) in Olympic Coast National Marine Sanctuary between August 20 and September 4, 2019.

Image Credit: NOAA/NOS/ONMS SanctSound**.**

System. SanctSound results and management applications were disseminated in FY 2021 through a multi-faceted outreach campaign to reach audiences ranging from students to decision-makers, including: a web story series highlighting place-based results, an interactive StoryMap, a Congressional briefing, two published and four accepted peer-reviewed publications and over 20 virtual presentations and webinars. SanctSound data are archived and publically accessible through NOAA's National Centers for Environmental Information and the public can explore results via a web portal under construction in partnership with NOAA's IOOS program. It will go live at the project's completion in spring 2022. The objectives of SanctSound are to 1) build collaborative research capacity to monitor and assess sanctuary resources, and 2) support natural resource management by providing baseline standardized time-series data that can be used to detect changes in sanctuary ecosystems and support noise impact management.

FY21 ACCOMPLISHMENT:
 In FY 2021, SanctSound released an interactive StoryMap, published 10 web stories, was featured in two magazines, presented at nine conferences/international workshops, provided reports to eight Sanctuary Advisory Councils, hosted four educational webinars, and headlined a Congressional briefing.

Project URL: https://sanctuaries.noaa.gov/science/monitoring/sound/sanctsound-storymap.html

Revisiting an Octopus Nursery and a Whale Fall

In 2018 and 2019, E/V Nautilus expeditions discovered extensive octopus nurseries in at least two areas in the southeastern flanks of Davidson Seamount at 3,200 m depth. These nurseries each featured thousands of mother octopus brooding their eggs within seeps of elevated water temperature (up to 10.4°C).

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.

Also in 2019, an extremely rare find was made: a relatively fresh whale fall, and samples revealed a new species of bone-eating worm, Osedax, living on the whale's bones. In October 2020, **ONMS**, Monterey Bay, and Greater Farallones national marine sanctuaries teamed up on E/V Nautilus to explore Pioneer Canyon, then revisited the two previously discovered octopus nurseries and whale fall. Collecting 10 hours of video footage, they surveyed 15 acres of seafloor and counted 3,647 octopus, of which 2,938 (81%) were brooding mothers. The whale fall was more decomposed than we expected, but flourishing populations of Osedax and ampheretid worms were still present. Samples were collected along with whale bones, baleen, worms, sediment and water for eDNA analyses (results are pending).

FY21 ACCOMPLISHMENT:
Confirmation of second distinct massive octopus brooding colony, documentation of the changes in a whale fall after 12 months, and characterization of deep-sea corals in Pioneer Canyon and at Davidson Seamount.

Special Issue of Oceanography (see pp. 34-35): https://tos.org/oceanography/assets/docs/34-1_ocean_exploration.pdf

Video - Discover Wonder: The Octopus Garden: https://sanctuarysimon.org/2021/04/discover-wonder-the-octopus-garden-wins-best-short-film-at-the-international-ocean-film-festival/

AWARDS:
The video, *Discover Wonder: the Octopus Garden*, summarizing previous work at the "octopus garden" in 2018 and 2019 won the "short film" category at the International Ocean Film Festival in April 2021.

Findings from West Coast Deep-Sea Coral Initiative Will Inform Management for Years to Come

In 2018, a NOAA-led steering committee was formed with members from National Marine Fisheries Service, **ONMS**, the NOAA Office of Exploration and Research, **NCCOS**, and the NOAA Deep Sea Coral Research and Technology Program to guide the West Coast Deep-Sea Coral Initiative, a four year research program dedicated to increasing scientific understanding of deep-sea coral and sponge ecosystems. The Initiative's highest priority science and management needs were determined at a kick-off workshop in 2018, which was attended by over 40 key partners representing state and federal management agencies, academics, NGOs, the fishery management council, and first nation communities, with the following objectives: (1) collecting baseline information on deep-sea coral and sponge communities in areas prior to essential fish habitat and rockfish conservation protection changes; (2) identifying areas with the highest deep-sea coral and sponge bycatch; and (3) exploring and assessing deep-sea coral and sponge habitats within national marine sanctuaries.

A sponge garden on Daisy Bank off the coast of Oregon.

Image Credit NOAA Deep Sea Coral Research & Technology Program.

Since 2018, the Initiative has supported extensive field surveys, mapping, modeling, and data analysis projects by relying on strong, multi-agency partnerships, and has resulted in substantial areas of new protection for seafloor habitats in the five west coast marine sanctuaries. In its final year (2021), Initiative collaborators across the U.S. are concluding the remaining data analysis to generate new, publicly available information that will contribute to outreach products, describe newly discovered species and habitats, advance new modeling techniques and technologies, and inform fishery management decisions, sanctuary condition reports, and management plan updates.

FY21 ACCOMPLISHMENT:
The West Coast Deep-Sea Coral Initiative fully funded four field expeditions and provided partial support to 14 others for field surveys, mapping, and sample collections, producing over 450 hours of video, tens of thousands of still images, samples, and over 28,000 km2.of newly acquired seafloor data.

West Coast Deep Sea Coral Initiative Science Plan (2018-2021): https://deepseacoraldata.noaa.gov/library/WCDSCI%20Science%20Plan_Final.pdf

Detecting, Monitoring, and Mitigating Impacts of Chemical and Biological Stressors on Coastal Ecosystems

Below are two highlighted scientific projects by NCCOS, OR&R, and ONMS researchers and their partners, which are focused on detecting, monitoring, and mitigating the impacts of chemical and biological stressors in coastal systems.

Great Lakes microplastic pollution pilot field study

Plastic pollution has been identified as one of the most critical environmental problems of our time. A pilot field study was executed by **OR&R** researchers in Milwaukee Estuary on Lake Michigan.

NOAA researchers process mussels from Lake Michigan at the University of Wisconsin-Milwaukee School of Freshwater Sciences. Mussel samples were analyzed for body burdens of chemical contaminants, metabolomics, and biomarkers.

Image credit: NOAA/NOS/ORR.

Invasive mussels (*Dreissena sp.*) were used to monitor microplastics. This project increases the capability of NOAAs Mussel Watch Program to characterize the magnitude and extent of microplastic pollution and its potential to adversely impact fish and wildlife and possible humans. Funding for this project was provided by NOAAs Marine Debris Program to support the field pilot study and laboratory analysis of samples.

FY21 ACCOMPLISHMENT:
Results revealed the potential utility of dreissenid mussels as biomonitors of microplastic pollution, the impact of microplastic on mussels, and the relationship between emerging and legacy chemical pollutants, and inform models of chemical contaminants in the Great Lakes and other freshwater ecosystems around the world.
NOAA Ocean Podcast Coverage: NOAA Ocean Podcast: episode 39 https://oceanservice.noaa.gov/podcast/sep20/nop40-microplastic-mussels-part-two.html

Using Citizen Science Data to Assess Shoreline Marine Debris Within Two US National Marine Sanctuaries

Researchers from NOAA's Marine Debris Program (**OR&R**), together with staff from the NOAA Southeast Fisheries Science Center, **ONMS**, Olympic Coast National Marine Sanctuary (OCNMS), and Greater Farallones National Marine
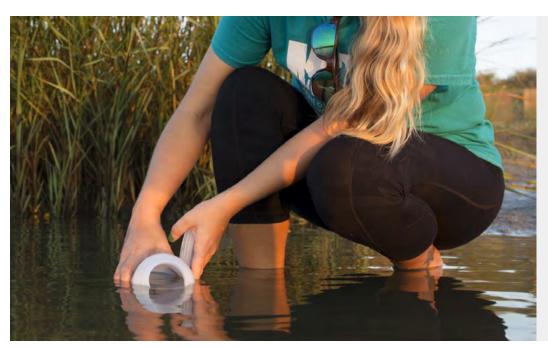
Sanctuary (GFNMS), analyzed multi-year shoreline monitoring data collected by citizen scientists from OCNMS and GFNMS to estimate marine debris abundance and temporal trends, and identify drivers of debris loads. Data were gathered by 57 individuals as well as by students from five area schools using the established protocols of MDP's Marine Debris Monitoring and Assessment Project, a citizen science initiative that facilitates a national network of shoreline monitoring to guide marine debris research, prevention, and policy-making. Changes in debris counts and composition within each Sanctuary reflect seasonal patterns of coastal upwelling and downwelling, but longer temporal trends in overall debris loads depend on the sampling window. A linear increase in total expected debris counts was observed when up to five participants are conducting a survey, suggesting a need to standardize the number of participants and their search pattern. Results from this study have contributed to the refinement of MDMAP on-site monitoring protocols.

FY21 ACCOMPLISHMENT:
Results from this NOS-NMFS collaboration were published in the journal, Frontiers in Environmental Science.

Project URL: https://blog.marinedebris.noaa.gov/using-citizen-science-understand-marine-debris

Peer-reviewed journal article URL: https://doi.org/10.3389/fenvs.2020.604927

Citizen scientists collect water samples for microplastic debris analyses.

Image credit: Florida Sea Grant.

NOS FUNDING OPPORTUNITIES:

RESEARCH GRANTS AND FELLOWSHIP SUPPORT

NOS **SUPPORTS SCIENTIFIC RESEARCH** *that addresses its aforementioned priorities through multiple internal and extramural funding opportunities. Several program offices oversee annual competitive research programs to foster enhanced knowledge and scientifically informed management of coastal ecosystems, including efforts to advance coastal resilience, sustainable transportation and commerce, and marine stewardship. These also include multi-year fellowship awards to graduate students and support to NOAA Cooperative Science Center institutions working to increase the number of graduates, particularly from underrepresented communities, with degrees aligned with the NOAA mission. Below is information about NOS funding programs that provide applied research support to grantees:*

In addition to supporting efforts by its Regional Associations, **IOOS** also funds the US Marine Life Observations: Coordinated Marine Biodiversity Observation Network (MBON) and Animal Telemetry Network (ATN) Activities to Ensure Resilient, Productive Ecosystems and Human Communities in the Face of Change funding opportunity. This effort, together with National Oceanographic Partnership Program (NOPP) partner agencies, funds research that builds upon the foundation established by MBON, ATN, and the US IOOS Regional Associations to work across sectors and disciplines towards an integrated, sustained marine life observing capability for the U.S. ocean, coasts and Great Lakes, from estuaries to the deep ocean; advance technologies for efficient and/or automated collection of species and associated habitat observations; enable open access to biodiversity data and information; and utilize these observations, technologies, and data to address place-based (e.g., sanctuaries, reserves, protected areas, leasing blocks, etc) management, conservation and restoration needs.

NCCOS supports the Competitive Research Program (CRP) and the RESTORE Science Program that provide the critical information and predictive capabilities required to manage the nation's coastal resources in an ecosystem context. NCCOS addresses these issues via a stressor-based or regional ecosystem approach in support of investigations related to sea level rise, harmful algal blooms, hypoxia, coral reefs, and related to the long-term sustainability of the Gulf of Mexico. These issues typically require multidisciplinary research teams and a significant long-term commitment of resources because of their complexity and the effort required to reach a new level of understanding sufficient to support NOS priorities and drive future coastal management decisions. Applications for funding are submitted through Federal Funding Opportunity (FFO) notices posted on the Grants. gov website. Notices of specific Announcements of Opportunity posted on the NCCOS Funding Opportunities page are provided as a courtesy to the research community.

NGS has funded extramural grants in support of Height Modernization and Geospatial Modeling. The National Height Modernization Program was created to enable access to accurate, reliable, and consistent heights. Elevation information contributes to informed decision making and impacts a wide range of important activities including mapping and charting, flood risk determination, transportation, land use and ecosystem management. Height Modernization is currently being implemented through a combination of NGS activities and state and local efforts. The program began because of critical needs identified in California and North Carolina, and it grew to include nearly two dozen states across the nation. Many states have received funding through either Congressional

earmarks or competitive grants. In other states, local agencies and organizations have provided resources. NGS has also funded research in support of geospatial modeling on topics related to workforce development in the geospatial industry, national and regional outreach plans, subsidence monitoring in the Gulf of Mexico, improving the alignment of national and regional reference frames, remote sensing technology, and gravity and astronomical observations. The funding objectives of the Geospatial Modeling Grant are to modernize and improve the National Spatial Reference System (NSRS) in the Gulf Coast region and to improve the awareness, coordination, and use of geospatial data.

OCM provides multiple extramural funding opportunities and fellowships in support of coastal resilience and management. Opportunities include the National Coastal Resilience Fund, which supports projects that restore, increase, and strengthen natural infrastructure to ultimately protect coastal communities from storm and flooding impacts

and enhance fish and wildlife habitat. Additional programs fund projects of special merit, including those related to the Coastal and Estuarine Land Conservation Program, National Estuarine Research Reserves (NERRs) and their Collaborative Science Program, as well as on topics of coastal resilience, bay watershed education and training, and Great Lakes Areas of Concern land acquisition. The Coral Reef Conservation Program, a partnership between NOAA Line Offices, also oversees multiple funding opportunities in support of coral reef research and management. OCM provides support to graduate and post-graduate students through several fellowship opportunities, including the Coastal Management Fellowship to provide on-the-job education and training opportunities in coastal resource management and policy and project assistance to state coastal zone management programs. Additional fellowship opportunities include the Coral Reef Management Fellowship in support of state and territorial agencies, the Margaret A. Davidson Fellowship that provides the opportunity for graduate students to conduct