BUREAU OF OCEAN ENERGY MANAGEMENT

Technology and the Future of BOEM Ocean Science

Table of Contents

3 Environmental Stewardship through Science

4 Atlantic Marine Assessment Program for Protected Species (AMAPPS)

4 Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS)

4 Pacific Marine Assessment Program for Protected Species (PacMAPPS)

6 Sea Turtle Movement and Habitat Use in the Northern Gulf of Mexico

7 Determining Fine-scale Use and Movement Patterns of Diving Bird Species in Federal Waters of the Mid-Atlantic United States Using Satellite Telemetry

8 Genomics of Arctic Cod: A Sentinel Species in a Changing Environment

9 Developing the Next Generation of Animal Telemetry with CubeSats

10 DEEP SEARCH: Deepwater Atlantic Habitats II: Continued Atlantic Research and Exploration in Deepwater Ecosystems

11 Atlantic Deepwater Ecosystem Observatory Network (ADEON)

12 Cook Inlet Circulation Model Calculations

13 MarineCadastre.gov, managed by BOEM and NOAA, and winner of the Nebert National Spatial Data Infrastructure Award

14 Marine Minerals Information System (MMIS): A GIS-based system for the Marine Minerals Program

15 Environmental Studies Program Information System (ESPIS)

16 Acronyms

A short-beaked common dolphin observed during the July 2013 AMAPPS mission. Photo by Desray Reeb, BOEM.

Cover Photos

- NOAA Jason 3 weather/climate satellite used to measure ocean surface topography, including sea level, wave height, and ocean surface wind speed. *Image courtesy of NOAA*

- Roseate terns at Great Gull Island, NY, wearing nanotags to track their location for one of BOEM's offshore wind energy studies. *Photo courtesy of Peter Paton, University of Rhode Island*

- The crew lowers moored instruments for the Arctic Marine Biodiversity Observing Network (AMBON) study in the Chukchi Sea, examining everything from plankton to birds and marine mammals. *Photos courtesy of the AMBON study.*

Disclaimer: Use of any photos or technology product names mentioned in this publication does not imply endorsement. The publication was created for Oceans 2018, October 2018.

Environmental Stewardship through Science

At the Bureau of Ocean Energy Management, our mission is to manage the development of U.S. outer continental shelf energy and mineral resources in an environmentally and economically responsible way.

We strive for excellence in managing these resources, promoting environmental sustainability, economic development, and national security, while adhering to our values of responsible stewardship, science-informed decisions, and integrity and ethics.

The scientific backbone for informed decisions at BOEM is our Environmental Studies Program (ESP), which has embraced technological advances in scientific research. As innovation continues, we ask, "How can BOEM better use existing or emerging technology to make our research funding more efficient and more useful, while always producing the highest quality results?"

Throughout the ESP's history, technological advances have enabled more precise and rapid data acquisition and have revolutionized science. We have seen increasingly sophisticated software, greater computational power for modeling, high-definition cameras for observations, and the development of tracers, gliders, and animal tags with satellite-linked communications.

The miniaturization and use of satellites, and the growing field of genetics research in the marine environment are part of the science and technology (S&T) revolution. The data and information gathered help BOEM to fulfill its obligations under the Outer Continental Shelf Lands Act, the National Environmental Policy Act, and other statutes and policies that govern bureau activities.

BOEM has prepared this special publication to help familiarize our stakeholders, partners, and the public with the bureau's interest in riding the S&T innovation wave to help the nation reach five goals: job creation, economic growth, energy and national security, and environmental stewardship.

BOEM's Environmental Studies Program, established by Congress in 1973, has funded more than $1 billion in research since its beginning. The program has been a leading contributor to the growing body of scientific knowledge about the marine and coastal environment. For more information on scientific efforts conducted by the ESP, visit us at *www.boem.gov/studies*

Atlantic Marine Assessment Program for Protected Species (AMAPPS)

Conducted by: National Oceanic and Atmospheric Administration (NOAA), in partnership with the U.S. Fish and Wildlife Service (USFWS), BOEM, and the U.S. Navy, 2010–2015. Phase II is taking place from 2015-2019. Phase III is proposed for 2019-2024. *https://marinecadastre.gov/espis/#/search/study/100019*

Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS)

Conducted by: NOAA Southeast Fisheries Science Center, in partnership with BOEM, USFWS, and the U.S. Geological Survey (USGS), 2017-2021. *https://marinecadastre.gov/espis/#/search/study/100190*

Pacific Marine Assessment Program for Protected Species (PacMAPPS)

Conducted by: NOAA Southeast Fisheries Science Center, in partnership with BOEM, USFWS, and the USGS, 2017-2021. *https://marinecadastre.gov/espis/#/search/study/100179*

Video Plankton Recorder (VPR) used to measure plankton presence and density. Photo: Debra Palka, NOAA/NEFSC.

A Slocum glider is an independently mobile platform that can carry various technologies to collect and transmit oceanographic and biological data. Photo: Suzanne Yin, NOAA.

Purpose:

To assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds in inshore waters (state) and offshore waters along the U.S. Atlantic, Gulf of Mexico, and Pacific coasts

To place the species in an ecosystem context, and to obtain or update spatially explicit density estimates to inform marine resource management decisions, primarily offshore oil and gas and renewable energy development

To use this information to properly mitigate and monitor for potential impacts of human activities

Technology & Techniques:

- Aerial and shipboard observations
- Genetic analyses
- Gliders
- Line-transects (visual sightings for marine mammals and seabirds)
- Oceanographic sampling
- Passive-acoustic monitoring
- Photographic identification of target species
- Satellite tracking of tagged animals
- Spatially- and temporally-explicit species density models
- Telemetry
- Tissue samples of whales and dolphins

Scientists deploying a Drifting Acoustic Spar Buoy Recorder (DASBR) to listen for deep diving whales. Photo: Greg Sanders, BOEM

Visual shipboard observation. Photo: NOAA.

Sea Turtle Movement and Habitat Use in the Northern Gulf of Mexico

Conducted by: BOEM and the USGS through IAA (IAA- M15PG00032)
https://www.boem.gov/FY-2019-2021-SDP, p. 160.

Purpose:

To determine movements and dive behavior of sea turtles including juveniles and males to assess residency and movement patterns

To enhance dive profile data for sea turtles in the Gulf of Mexico

To combine fine-scale dive information with genetic analyses, population demographics, health and foraging studies

To provide data to inform management decisions and understanding of dredging entrainment risk

Technology & Techniques:

- Tracking package to be placed on sea turtles at select locations within the Gulf of Mexico
- Close up of acceleration data loggers (ADL) embedded with a depth-logging satellite tag and very high frequency (VHF) transmitter

A juvenile green turtle, Chelonia mydas, outfitted with a depth-logging SPLASH tag. Photo : Andrew Crowder, Cherokee Nations on contract to USGS.

A juvenile green turtle wearing a Cefas accelerometer to track its movement. Photo: Kristen Hart, USGS.

Determining Fine-scale Use and Movement Patterns of Diving Bird Species in Federal Waters of the Mid-Atlantic United States Using Satellite Telemetry

Conducted by: USFWS, in partnership with the Sea Duck Joint Venture, USGS, Biodiversity Research Institute, and Memorial University of Newfoundland, 2011– 2016, *https://marinecadastre.gov/espis/#/search/study/100060*

Purpose:

To compare the precision of satellite tags to solar-powered cellular network data loggers

To determine fine scale use and movement patterns of three diving bird species (Red-throated Loon, Surf Scoter, and Northern Gannet)

To identify high use areas during the marine birds' critical life stages

To analyze the data from the 239 adult birds captured and tracked with satellite transmitters from 2012 to 2015

Technology & Techniques:

- Satellite tags
- Solar-powered cellular-network data loggers

Red-throated Loon outfitted with a satellite tag. Photo: Ian Johnson.

Scurf scoter wearing a solar tag for tracking its movement. Photo: Ian Johnson.

Genomics of Arctic Cod: A Sentinel Species in a Changing Environment

Conducted by: USGS, 2013– 2018 *https://marinecadastre.gov/espis/#/search/study/26926*

Purpose:

To increase understanding of the ability of Arctic cod to survive and adapt as the ice retreats and to separate potential effects of oil and gas development on Arctic cod and its predators from the cumulative effects of climate change

To increase understanding of the ecological role this sentinel species plays as the primary pathway funneling lower trophic food sources to many marine mammals, birds and fish

To identify genetic differences that would change BOEM's analytical approach

To build on a prior study between U.S. and Canadian researchers which demonstrated that there is a genetic break somewhere between the Chukchi/Western U.S. Beaufort and far eastern Canadian Beaufort waters.

Technology & Techniques:

- Genetics analysis of mitochondrial and microsatellite DNA to identify sub-populations among Arctic cod
- "Antifreeze" gene transcriptome analyzed for variation in gene expression across and within hypothesized sub-populations
- Construct a complete genomic sequence of a single individual to identify additional genes that may provide evidence of adaptation to a changing environment

DNA double helix

Software produces the spectrograph and optical bar code after DNA is extracted and analyzed. Photo: Marjorie Weisskohl, BOEM.

Developing the Next Generation of Animal Telemetry with CubeSats

Conducted through: Interagency Agreement between NASA and BOEM, 2017-2019, *https://marinecadastre.gov/espis/#/search/study/100181*

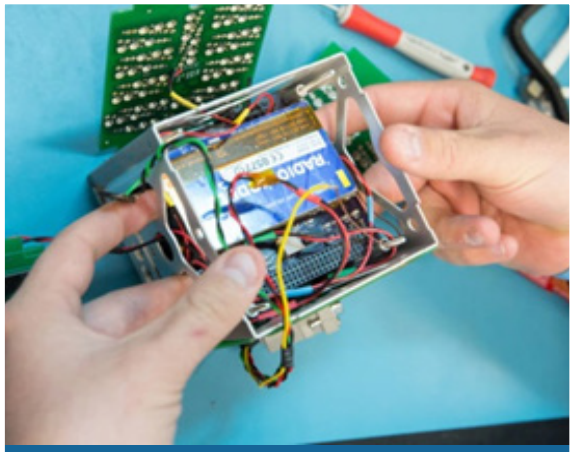
Purpose:

To use open source software and small satellites in order to improve our ability to track marine species in U.S. ocean waters

To leverage the rapidly growing small satellite industry

Technology & Techniques:

- CubeSats/small satellites
- Open source software
- Ocean-compatible wildlife tracking transceivers
- High altitude, near-space balloon
- Conducting a crowd source challenge administered by HeroX in conjunction with NASA's Center of Excellence for Collaborative Innovation, *https://www.nasa.gov/offices/COECI/index.html*
- Testing a wildlife tracking receiver mounted aboard a near-space balloon in fall 2018 to determine how well the receiver operates in space-like conditions and to characterize signal reception of a potential orbital receiver



A student holds the EagleSat-1 CubeSat. Credit: Embry-Riddle Aeronautical University, Prescott

Data flows from the tag attached to the sea turtle to a satellite, then back to the ground station. Image: NASA .

DEEP SEARCH: Deepwater Atlantic Habitats II: Continued Atlantic Research and Exploration in Deepwater Ecosystems

Conducted by: NOAA, BOEM, USGS, seven academic institutions, including Temple University, plus a private company (TDI Brooks International), under the National Oceanographic Partnership Program (NOPP), 2017– 2022, *https://marinecadastre.gov/espis/#/search/study/100208*

Purpose:

To explore deep-sea coral, canyon, and gas seep ecosystems offshore the U.S. mid- and South Atlantic coast, in areas that have not received much research focus previously

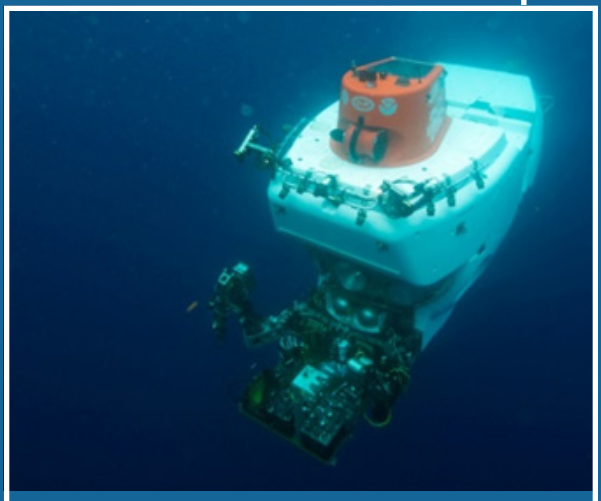
To collect baseline data about these deepwater habitats, including water, sediment, and benthic faunal samples, and imagery of benthic habitats

To increase our knowledge of U.S. continental margin geology, the types of communities found on the seafloor, and the mid-water communities that interact with those seafloor communities

To identify resources that must be protected should there be future energy activity off the coast

Technology & Techniques:

- The Research Vessel (RV) *Atlantis*, and the Human-Occupied Vehicle or HOV *Alvin*, both owned by the U.S. Navy and operated by Woods Hole Oceanographic Institution
- *Alvin* contains state-of-the-art high-definition imaging systems, sensors, data acquisition and download speed; 400 pound science basket payload capacity; an improved command and control system; and diving range to 4,500 meters (2.7 miles).
- Alvin dove 11 times in DEEP SEARCH, Aug. 19-Sept. 2, 2018.



The Alvin. Photo: Chris Linder © Woods Hole Oceanographic Institution.

Atlantic Deepwater Ecosystem Observatory Network (ADEON)

Conducted by: The University of New Hampshire, School of Marine Science and Ocean Engineering, in partnership with NOAA Southwest Fisheries Science Center, BOEM, the Office of Naval Research, and the National Office of Pollution Prevention, 2015– 2021, *https://marinecadastre.gov/espis/#/search/study/100143*

Purpose:

To establish an integrated system for conducting long-term monitoring of biological, physicochemical, and human use dynamics on the OCS

To track sounds from natural and anthropogenic sources by deploying seven benthic bottom landers to the mid- and South Atlantic equipped with instrumentation for passive acoustic monitoring

To monitor for presence of zooplankton and fish, and record oceanographic properties by using active acoustics and additional sensors

To increase understanding of sound in the ocean and its effects on marine organisms, through the International Quiet Ocean Experiment, and to help manage human impacts on the ocean

Technology & Techniques:

- Acoustic Buoys (Marine Acoustic Recording Units, MARU)
- Benthic Bottom Landers

Acoustic buoy (Marine Acoustic Recording Unit [MARU]), Photo taken under ESA Research Permit # 1576. Photo: Heather Haas, NOAA/ NEFSC.

ADEON bottom lander. Photo: Bruce Martin, JASCO.

Cook Inlet Circulation Model Calculations

Conducted by: BOEM, the University of Alaska Fairbanks, and Rutgers University, 2013– 2016,

https://marinecadastre.gov/espis/#/search/study/26920

Purpose:

To acquire and better understand the best data on ocean currents

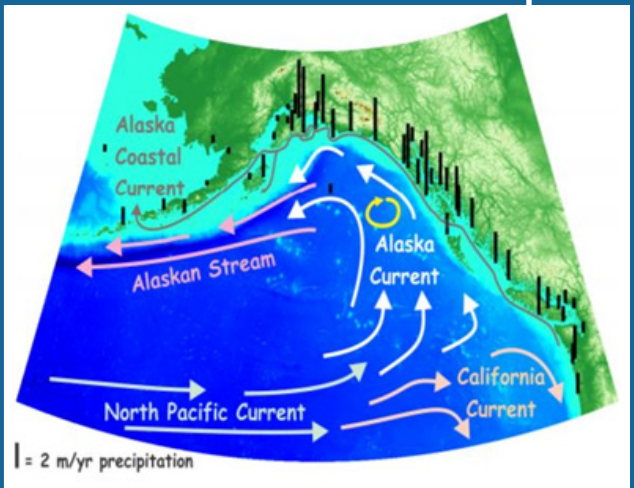
To estimate the probability of oil-spill occurrence associated with development of offshore energy resources, the probability of oil-spill contact, and the combined probability of oil-spill occurrence and contact with resources or land

To use BOEM's oil spill risk analysis (OSRA) model of the probability of spill occurrence with a statistical description of hypothetical oil-spill movement (trajectory) on the ocean surface

To conduct risk assessments and validate with environmental observations

Technology & Techniques:

- Model-simulated ocean currents, sea ice movement and concentration, and winds, in summer and winter, based on recent and historical information
- Use sophisticated computational power to assess and predict possible scenarios under various physical conditions, based on the Regional Ocean Modeling System (ROMS)
- Pursue continuous improvement of OSRA estimates and environmental impact analyses, and use the results of new field and modeling studies.



Map of the Gulf of Alaska surface mean circulation features and precipitation rates (vertical bars). Image from the report.

MarineCadastre.gov, managed by BOEM and NOAA, and winner of the Nebert National Spatial Data Infrastructure Award

https://marinecadastre.gov

Purpose:

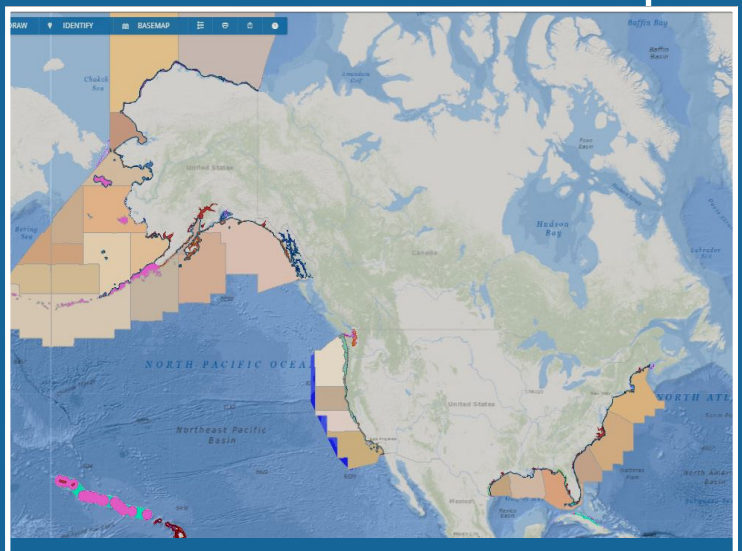
To supplement basic location and topographical/bathymetric information with data about the coastal, marine and human environment, including biological resources that could be affected by energy or marine mineral development

To provide authoritative and regularly updated ocean information, including offshore boundaries, infrastructure, human use, energy potential, and other data sets

To help assess suitability for ocean activities, such as siting of energy facilities

Technology & Techniques:

- Geospatial data search and viewer
- Vessel tracking (AIS) data, existing infrastructure and uses, jurisdictional and environmental layers
- Environmental Studies Program Information System (ESPIS) to access completed reports and ongoing study profiles
- Links to regional ocean portals



Display of data layers in MarineCadastre.gov.

Marine Minerals Information System (MMIS):
A GIS-based system for the Marine Minerals Program

https://www.boem.gov/Building-a-National-Offshore-Sand-Inventory/

Purpose:

To provide estimated sediment volume in federal waters, its location, accessibility, and character (i.e., matching the grain size, color, and composition)

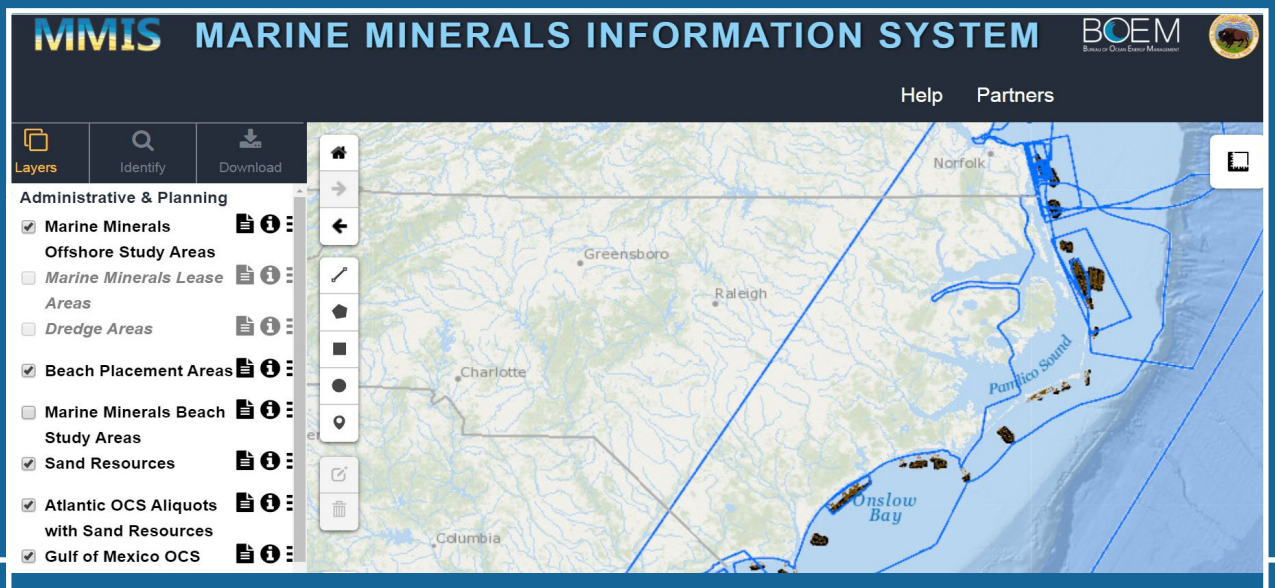
To help coastal managers identify available sand and gravel resources and their suitability to the ecosystem in which they will be placed

To reduce response time in emergencies, facilitate long-term planning, and reduce conflicts with other ocean uses

To share data from federal, state, and local government, and academic research

Technology & Techniques:

- GIS-based system
- Usable formats such as databases or digital maps



The Marine Minerals Information System, MMIS, provides a wide range of data layers about offshore sand and gravel resources, including bathymetry, sediment analysis, beach placement, and other maritime uses of an area.

Environmental Studies Program Information System (ESPIS)

https://marinecadastre.gov/espis/#/

Purpose:

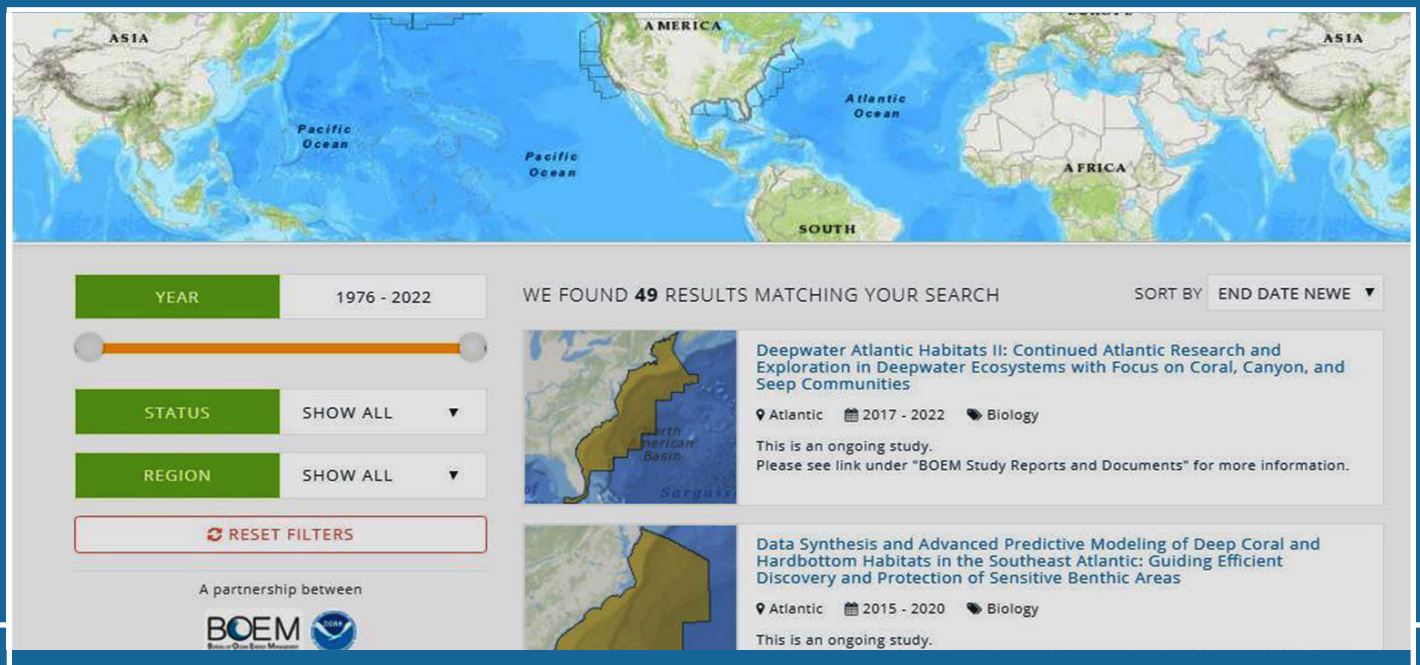
To meet the Congressional and Open Data mandates to make federally-funded research available to the public, which the ESP has done since its inception 1973

To provide information about ongoing and completed studies funded through BOEM's Environmental Studies Program

To provide online access to technical summaries of more than 1,800 BOEM sponsored environmental research projects and more than 3,600 research reports

Technology & Techniques:

- Unprecedented access and discovery of ESP data and information with text, map-based queries, and other tools for use by the ocean science community
- Hosted on *MarineCadastre.gov*, developed through a BOEM-NOAA partnership



A sample list of reports and ongoing studies that can be found in the Environmental Studies Program Information System, ESPIS.

ACRONYMS

BOEM - Bureau of Ocean Energy Management

ESP - Environmental Studies Program

ESPIS - Environmental Studies Program Information System

GIS - Geographic Information System

GPS - Global Positioning System

MMIS - Marine Minerals Information System

NASA - National Aeronautics and Space Administration

NOAA - National Oceanic and Atmospheric Administration

NOPP - National Oceanographic Partnership Program

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

Environmental Program
www.boem.gov/Environmental-Stewardship

Oil & Gas Program
www.boem.gov/Oil-and-Gas-Energy-Program

Renewable Energy Program
www.boem.gov/Renewable-Energy

Marine Minerals Program
www.boem.gov/Marine-Minerals-Program

Contact Us-Boempublicaffairs@boem.gov

202.208.6474

www.boem.gov

BOEM
Bureau of Ocean Energy Management