BUREAU OF OCEAN ENERGY MANAGEMENT | ENVIRONMENTAL STUDIES PROGRAM

YEAR IN REVIEW

Covering studies published **October 2022 through December 2023**

INTRODUCTION

The Bureau of Ocean Energy Management's (BOEM) mission is to manage development of U.S. Outer Continental Shelf (OCS) energy, mineral, and geological resources in an environmentally and economically responsible way.

To do this, the Environmental Studies Program (ESP) conducts environmental research to provide the information needed to assess and manage impacts from offshore energy and marine mineral development, as mandated by Section 20 of the OCS Lands Act. Fundamentally, BOEM's research mandate is to assess and understand how the Bureau's decision-making impacts the environment, including the human environment, and how those impacts may be avoided or minimized.

Since its inception in 1973, ESP has provided over $1.3 billion for research.

BOEM's environmental program integrates ESP with environmental assessment and policy to ensure that environmental protection is a foremost concern and an indispensable requirement in BOEM's decision-making.

Find out more about **BOEM's ESP**.[1]

This ESP ***Year in Review*** summarizes each environmental study published by BOEM from October 2022 through December 2023. It provides concise descriptions of each study's purpose, findings, and how BOEM will use the research results.

What Are Environmental Studies?

ESP's environmental studies answer specific questions needed to inform management decisions. This body of research meets BOEM scientific integrity criteria, furthers scientific knowledge, and results in products, such as data, reports, and models, which are available to the public.

Study development begins with ideas and suggestions from BOEM scientists and stakeholders in each region. Discussions lead to conferences and meetings, where scientists and managers share and refine ideas, priorities, and needs for research projects. Some of these ideas are developed into short proposals (study profiles), which are then shared with colleagues, other scientists, and the National Academies of Sciences, Engineering, and Medicine's (NASEM) Committee on Offshore Science and Assessment **(COSA)**[2] for more in-depth discussion and scrutiny.

Each study profile is rigorously reviewed, both internally and externally, discussed across the regions, and evaluated according to specific criteria. Study profiles that are included in the Studies Development Plan **(SDP)** are reviewed by COSA.

The SDP is a two-year plan that is updated annually. Drawing from the SDP, the BOEM Director issues the upcoming year's National Studies List, which specifies funding for that year for all new starts and continuing projects.

ESP studies may be funded in one of three ways: interagency agreements with other Federal agencies; cooperative agreements with state, local, and nonprofit institutions, including Native American Tribal communities; and competitive contracts.

The lifecycle—proposal, selection, research, review, collaboration, production, and dissemination—of each of environmental study follows the Department of the Interior's Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity.

For more specifics about the ESP study process from conception to execution, see the **ESP Strategic Framework.**[3]

What Types of Environmental Studies Are Under the ESP?

ESP conceives, funds, and oversees research on many topics, including atmospheric sciences, biology, economics, environmental fates and effects, physical oceanography, protected species, social sciences, and submerged cultural resources like shipwrecks.

We conduct three main types of research studies focusing on the human, marine, and coastal environments:

1. **Baseline studies** provide information needed for the assessment and management of impacts from offshore energy and mineral extraction activities in Federal and state waters.
2. **Impact studies** identify potential impacts on marine resources that may result from offshore energy development or marine mineral extraction.
3. **Monitoring studies** provide time series and data trend information for identifying changes in environmental quality and productivity, and the causes of these changes.

1. https://www.boem.gov/environment/how-we-do-research
2. https://www.nationalacademies.org/our-work/standing-committee-on-environmental-science-and-assessment-for-ocean-energy-management
3. https://www.boem.gov/sites/default/files/documents/about-boem/ESP-Strategic-Framework-Final-FY20.pdf

PUBLISHED STUDIES AT A **GLANCE**

Years to Complete

Average number of years to complete a study:

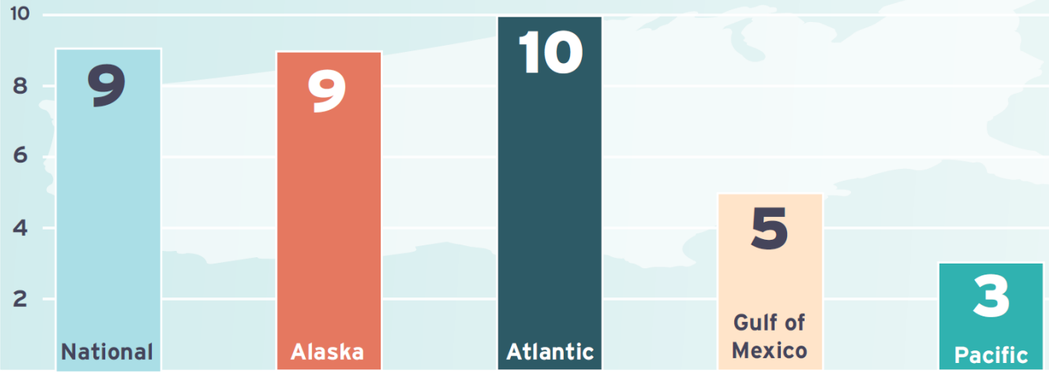
3.6 YEARS

Ranges from

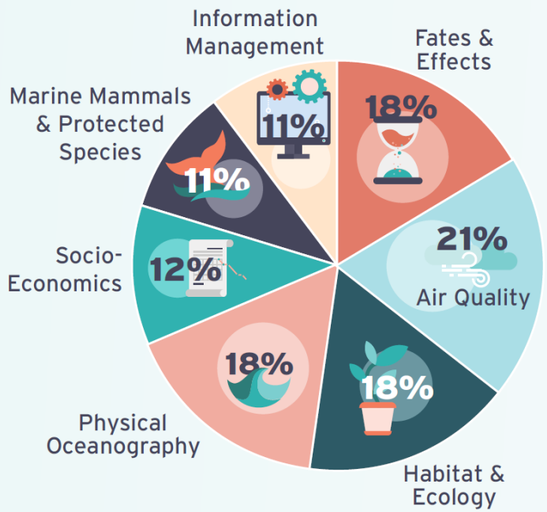
less than a year to 9 years for long-term monitoring.

Numbers of Studies

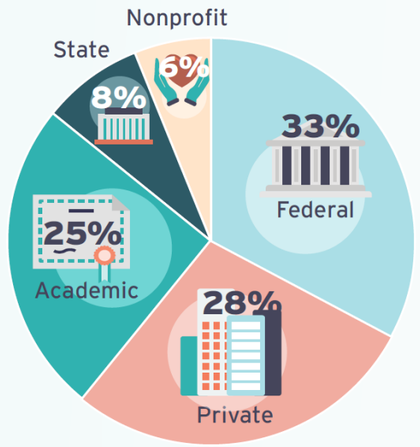
By Area



By Discipline



By Partner/ Contractor Type



OUR **PARTNERS**

BOEM collaborated with a range of partners to produce this body of research, including:

Federal

- Argonne National Laboratory
- Naval Undersea Warfare Center Division
- NOAA Fisheries
- Stellwagen Bank National Marine Sanctuary
- U.S. Fish and Wildlife Service
- U.S. Geological Survey, Wetland and Aquatic Research Center
- U.S. Environmental Protection Agency

Academic

- Occidental College, Vantuna Research Group
- Rutgers, The State University of New Jersey, Haskin Shellfish Research Laboratory
- University of Alaska Fairbanks
- University of California Santa Barbara, Marine Science Institute
- University of Maine Darling Marine Center
- University of Massachusetts Dartmouth, School for Marine Science and Technology

Nonprofit

- Biodiversity Research Institute
- Georgia Aquarium
- North Pacific Research Board
- Woods Hole Oceanographic Institution

State

- Massachusetts Clean Energy Center

Private

- APTIM
- Booz Allen Hamilton
- CPP, Inc.
- CSA Ocean Sciences, Inc.
- Eastern Research Group, Inc.
- HDR
- Industrial Economics, Inc.
- Lakes Environmental Software
- Northern Economics, Inc.
- Southall Environmental Associates, Inc.
- Xator Corporation
- WSP USA Environment & Infrastructure Inc.

BOEM provided **$17.6 million** in funding for these studies

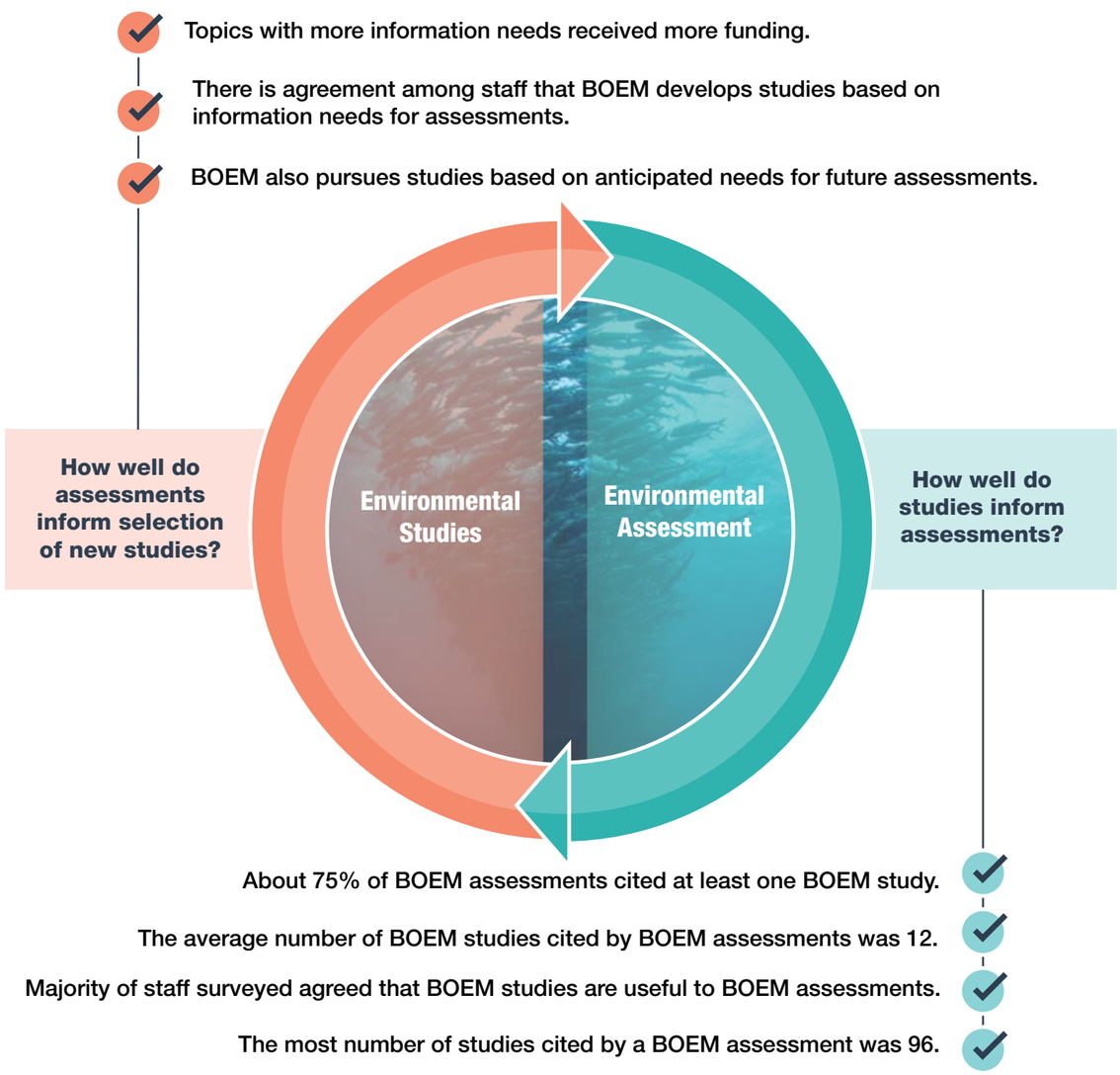
HOW IS **ESP RESEARCH USED?**

BOEM's recently published ***Evaluating Connections Between BOEM's Environmental Studies and Assessments*** details how BOEM and other organizations use the information and data gathered by ESP.

This study conducted an extensive review to answer two key questions:

- How well do BOEM studies inform assessments?
- How well do BOEM assessments inform selection of new studies?

The findings and statistics in the figure below reflect ESP studies from 1999 to 2019:



How environmental studies impact environmental assessments, and vice versa, according to the Evaluating Connections report

1. https://www.boem.gov/sites/default/files/documents/about-boem/ESP-Strategic-Framework-Final-FY20.pdf

The study also asked the question "What is the impact of BOEM's scientific research on the external environmental community? (e.g., other Federal agencies, state agencies, academia)?" and found that ESP studies:

- Directly influence decision-making outside of the bureau, particularly in the context of coastal and marine resource management for Federal and state agencies
- Fill critical knowledge gaps and meaningfully advance ocean scientific research
- Generate new information on impacts of offshore renewable energy
- Advance basic scientific research and baseline data
- Inform other entities' funding decisions
- Contribute to publicly available databases
- Inform natural resource decision-making and policy development at multiple jurisdictional levels
- Inform stakeholder understanding of ocean science

Number of articles and citation counts for top-referenced journal articles resulting from BOEM studies from 1999 to 2019

Topic Area	Publications	Average Number of Citations (Google Scholar)
Oil and Gas Surveys and Extraction	749	71.2
Oil Spill	246	86.4
Renewable Energy Development/ Wind	72	36.8
Climate Change	56	76.4
Marine Minerals Extraction	50	82.9
Submarine Transmission Lines	43	16.7
General BOEM Activities	21	37.7
Fisheries Use and Management	19	17.9

***Note:** Some publications fell within multiple topic areas.*

HIGHLIGHTED **RESOURCES**

The research from several studies also resulted in a range of useful products, such as datasets, educational materials, and videos.

BOEM 2023-068 Habitat Use of Oceanic Manta Rays (*Mobula birostris*) in the Vicinity of Marine Mineral Extraction Activities

- The Georgia Aquarium third-grade lesson plan highlights this study and coastal marine management. Publicly available and free at *https://www.georgiaaquarium.org/wp-content/uploads/2022/12/BOEM-Lesson-plan.pdf*
- Georgia Aquarium's Communications and Public Relations created a project summary video with fieldwork footage and interviews with project partners. This was shared to social media platforms and is available at *https://www.youtube.com/watch?v=3tmkvSg8YmA*

BOEM 2022-020 Arctic Ecosystem Integrated Survey, Phase II: Seabird Community Structure and Seabird-Prey Dynamics Final Report

Interviews and press articles including:
- Yong E. Why hundreds of puffins washed up dead on an Alaskan beach. The Atlantic. 29 May 2019.
- Rust S. Unprecedented die-offs, melting ice: climate change is wreaking havoc in the Arctic and beyond. Los Angeles Times. 17 Dec 2021.

BOEM 2022-039
Collaboration with the North Pacific Research Board, Arctic Marine Research Program

- North Pacific Research Board website: *https://nprb.org/arctic-program/*
- Brochure: *https://online.flippingbook.com/view/521428410/*

BOEM 2022-067 Marine Bird Distribution and Abundance in the Northern Bering and Chukchi Seas: Final Report

Interviews, cruise reports, websites, and press articles, including:
- Drew GS, Piatt JF. 2020. North Pacific Pelagic Seabird Database (NPPSD): U.S. Geological Survey data release (ver. 3.0, February 2020). *https://doi.org/10.5066/F7WQ01T3*

BOEM 2022-041
Assessing the Biological and Oceanographic Processes that Drive Fisheries Productivity in New England Sand Shoals and the Potential for Dredging-related Disruption

- "Measuring the Ocean with OpenCTD & Professional Naturalists," an ArcGIS® StoryMap, available at *https://storymaps.arcgis.com/stories/ef90c68de96b42a884cd36919dec508c*
- A free outreach program allowing teachers to plot great shearwater movements, presented at the 43rd Annual Meeting and Conference of Massachusetts Marine Educators in Woods Hole, Massachusetts and made available to teachers.
- A STEM education program was presented at the 2020 World Seabird Twitter Conference (virtual) and had over 7,000 views on Twitter.

BOEM 2022-071
Transparent Modeling of Collision Risk for Three Federally Listed Bird Species in Relation to Offshore Wind Energy Development

- Collision risk model code: *https://github.com/Biodiversity-Research-Institute/SCRAM*
- Web application: Stochastic Collision Risk Assessment for Movement (SCRAM). 2022. Version 1.0.3. Available at *https://briloon.shinyapps.io/SCRAM/*
- User manual for web application: *https://briloon.shinyapps.io/SCRAM/*

BOEM 2023-015
Sustained Monitoring of Zooplankton Populations at the Coastal Maine Time Series (CMTS) and Wilkinson Basin Time Series (WBTS) Stations in the Western Gulf of Maine: Results from 2005–2022

- Datasets currently in development are available on the ISMN ERDDAP server, *http://ismn.erddap.neracoos.org/erddap/info/index.html?page=1&itemsPerPage=1000*, including the Gulf of Maine WBTS Calanus Abundance Observations.

BOEM 2023-033/034
Field Observations During Offshore Wind Structure Installation and Operation

Video footage
- Fish swimming near a wind turbine *https://www.youtube.com/watch?v=nXyVGGNw5vs*
- Epifouling around a turbine, and the lifeforms it attracts *https://www.youtube.com/watch?v=Y45F1pb9PVc*

BOEM 2023-042 Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS): Marine Mammals

- Visual survey data is publicly available on OBIS-SEAMAP: *https://seamap.env.duke.edu/*
- Spatial density models can be downloaded or viewed in the model viewer: *https://seamap.env.duke.edu/models/SEFSC/GOM/*
- National Marine Fisheries Service datasets and slideshow presentation: *https://www.fisheries.noaa.gov/inport/item/67243*

BOEM 2023-005
Supplemental Data Regarding the Behavioral Response of Rock Crabs to the EMF of Subsea Cables and Potential Impact to Fisheries

- "Can Crabs Cross Submarine Cables?", a short film by Shaun Wolfe of Shaun Wolfe Photography. Available for viewing at *https://youtu.be/dZWCQctUNS4*

BOEM 2023-030
Demonstrating an Effective Marine Biodiversity Observation Network in the Santa Barbara Channel

- Marine Biodiversity Observation Network in the Santa Barbara Channel: *https://sbc.marinebon.org/*
- An interactive tool demonstrates the benthic organisms living in the Santa Barbara Channel kelp forest *https://sbc.marinebon.org/data/map/Imagery_BisQue/*
- A list of interactive maps and tools is displayed at *https://sbc.marinebon.org/data/map/*

ADDITIONAL **WORKS**

ESP-funded data and research are often the basis for publications in peer-reviewed professional journals. We are proud to contribute to these accomplishments.

BOEM 2023-030

Croll DA, Ellis AA, Adams J, Cook ASCP, Garthe S, Goodale MW, Hall CS, Hazen E, Keitt BS, Kelsey EC, et al. 2022. Framework for assessing and mitigating the impacts of offshore wind energy development on marine birds. Biol Conserv. 276:109795.

Miller RJ, Adeleye AS, Page HM, Kui L, Lenihan HS, Keller AA. 2020. Nano and traditional copper and zinc antifouling coatings: metal release and impact on marine sessile invertebrate communities. J Nanopart Res. 22. doi:10.1007/s11051-020-04875-x.

BOEM 2023-042

Farmer NA, Garrison LP, Litz JA, Ortega-Ortiz JG, Rappucci G, Richards PM, Powell JR, Bethea DM, Jossart JA, Randall AL, et al. 2023. Protected species considerations for ocean planning: a case study for offshore wind energy development in the U.S. Gulf of Mexico. Mar Coast Fish. 15(3):e10246. doi:10.1002/mcf2.10246.

Riley KL, Wickliffe LC, Jossart JA, Mackay JK, Randall AL, Bath GE, Balling MB, Jensen BM, Morris JA Jr. 2021. An aquaculture opportunity area atlas for the U.S. Gulf of Mexico. NOAA Technical Memorandum NOS NCCOS 299. doi:10.25923/8cb3-3r66.

BOEM 2023-015

Ji R, Runge JA, Davis CS, Wiebe P. 2022. Drivers of variability of Calanus finmarchicus in the Gulf of Maine: roles of internal production and external exchange. ICES J Mar Sci. 79(3):775–784. doi: 10.1093/icesjms/fsab147.

Ross CH, Runge JA, Roberts JJ, Brady DC, Tupper B, Record NR. 2023. Estimating North Atlantic right whale prey based on Calanus finmarchicus thresholds. Mar Ecol Prog Ser. 703:1–16.

Runge JA, Ji R, Record N, Pendleton D, Motyka J. 2022. Shifting biodiversity and effects on ecosystem services in the Gulf of Maine: the role of Calanus finmarchicus. AGU-ASLO Ocean Sciences Meeting, 2022 27 Feb–3 Mar (Virtual).

BOEM 2022-004

Jones IT, Stanley JA, Mooney TA. 2020. Impulsive pile driving noise elicits alarm responses in squid (***Doryteuthis pealeii***). Mar Poll Bull. 150: 110792. doi: 10.1016/j.marpolbul.2019.110792.

Jones IT, Peyla, JF, Clark H, Song Z, Stanley JA, Mooney TA. 2021. Changes in feeding behavior of longfin squid (Doryteuthis pealeii) during laboratory exposure to pile driving noise. Mar Environ Res. 165:105250. doi:10.1016/j.marenvres.2020.105250.

BOEM 2022-067

Romano M, Renner HM, Kuletz KJ, Parrish JK, Jones T, Burgess HK, Cushing DA, Causey D. 2020. Die-offs and reproductive failure of murres in the Bering and Chukchi Seas in 2018. Deep Sea Res Part II. 181–182. doi:10.1016/j.dsr2.2020.104877.

Piatt JF, Douglas DC, Arimitsu ML, Kissling, ML, Madison EN, Schoen SK, Kuletz KJ, Drew GS. 2021. Kittlitz's murrelet seasonal distribution and post-breeding migration from the Gulf of Alaska to the Arctic Ocean. Arctic. 74(4):482–495. doi:10.14430/arctic73992.

Drew GS, Piatt JF. 2020. North Pacific Pelagic Seabird Database (NPPSD): U.S. Geological Survey data release (ver. 3.0, February 2020). doi:10.5066/F7WQ01T3.

BOEM 2022-062

Dilliplaine K, Hennon G. 2023. Impacts of crude oil on Arctic sea-ice diatoms modified by irradiance. Elem Sci Anth. 11(1):00074. doi:10.1525/elementa.2023.00074.

BOEM 2022-020

Kuletz K, Cushing D, Labunski E. 2020. Distributional shifts among seabird communities of the Northern Bering and Chukchi seas in response to ocean warming during 2017–2019. Deep Sea Res II: Oceanogr. 181–182:104913. doi:10.1016/j.dsr2.2020.104913.

Yong E. Why hundreds of puffins washed up dead on an Alaskan beach. The Atlantic. 29 May 2019.

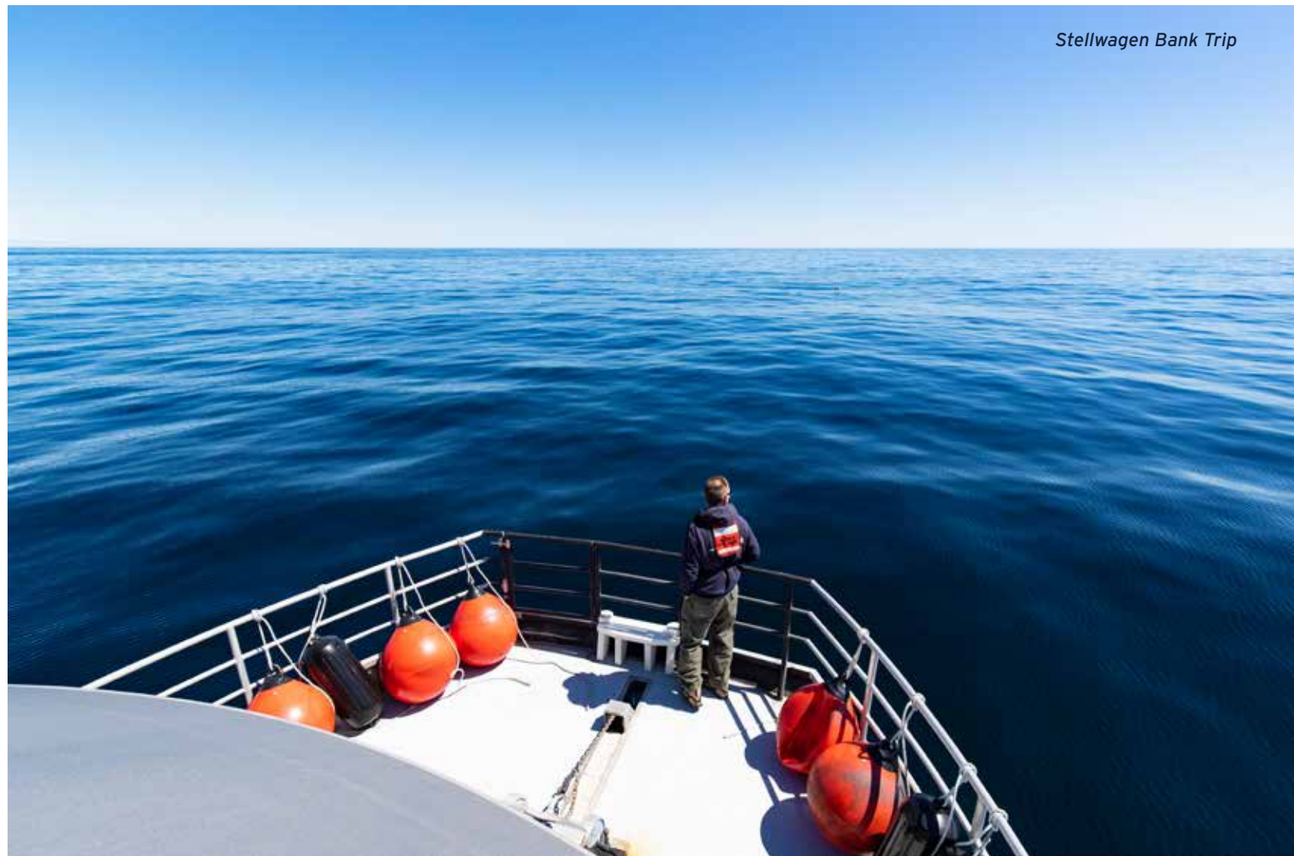
Rust S. Unprecedented die-offs, melting ice: climate change is wreaking havoc in the Arctic and beyond. Los Angeles Times. 17 Dec 2021.

BOEM 2022-068

Herman KB, Levenson J, Hoopes LA, Hansen DA, Dove ADM (Georgia Aquarium, Atlanta, GA). 2021. Habitat use of oceanic manta rays (Mobula birostris) in the vicinity of marine mineral extraction activities [white paper]. Sterling (VA): U.S. Department of Interior, Bureau of Ocean Energy Management. 29 p. Obligation No.: M20AC100006. Report No.: OCS Study BOEM 2021-026.

BOEM 2022-066

National Academies of Sciences, Engineering, and Medicine. 2019. Review of the Bureau of Ocean Energy Management Air Quality Modeling in the Gulf of Mexico Region study. Washington (DC): The National Academies Press. doi:10.17226/25600.



Stellwagen Bank Trip

ESP STUDY SUMMARIES

NATIONAL

ALASKA REGION

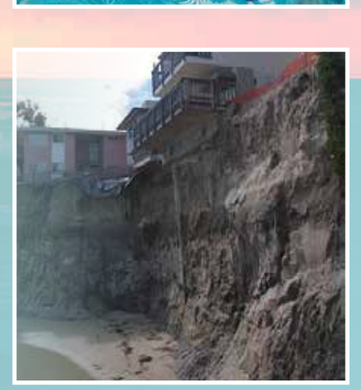
ATLANTIC REGION

GULF OF MEXICO REGION

PACIFIC REGION

Screenshot from "Can Crabs Cross Submarine Cables?", a short film by Shaun Wolfe of Shaun Wolfe Photography. Available for viewing at ***https://youtu.be/dZWCQctUNS4***

NATIONAL



Behavior, Seasonality, and Habitat Preferences of Mobile Fishes and Sea Turtles within a Large Sand Shoal Complex: Habitat Connectivity, Ocean Glider Surveys, and Passive Acoustics

Conducted by: *Naval Undersea Warfare Center Division*

National Studies List: *NT-16-08a*

>> Purpose/Information Use

Offshore sand shoals, common features of the U.S. continental shelf, support unique marine communities and are used by dozens of species. Data is challenging to collect, but long-term datasets are needed because offshore shoals are an increasingly coveted sand source. This six-year study is one of the most comprehensive surveys of a sand shoal habitat and ecosystem in the U.S. South Atlantic to date.

Canaveral Shoals is the largest sand shoal complex on the east Florida shelf and an important sand borrow site for beach nourishment projects. The greater Cape Canaveral region is important for many federally managed marine species; is consistently an overwintering area for many coastal sharks, red drum, and Atlantic sturgeon ***(Acipenser oxyrinchus oxyrinchus)***; and is a regular summer destination for federally listed sea turtles and smalltooth sawfish ***(Pristis pectinata)***.

Fish and turtles are both subject to entrainment (getting sucked into the dredge). Sea turtle entrainment, especially loggerhead, has been a regular source of mortality during suction hopper dredging projects throughout the southeastern U.S.

Four species of protected marine turtles regularly frequent the vicinity of Canaveral Shoals: loggerhead ***(Caretta caretta)***, green ***(Chelonia mydas)***, Kemp's ridley ***(Lepidochelys kempii)***, and leatherback ***(Dermochelys coriacea)***. Cape Canaveral is also within the geographic range of the protected smalltooth sawfish, giant oceanic manta ray ***(Mobula birostris)***, and Atlantic sturgeon, all of which are listed under the 1973 Endangered Species Act (ESA).

This study aimed to better quantify the habitat preferences and seasonality of federally managed fish and sea turtles associated with a large sand shoal complex at Cape Canaveral, and to compare their use of an active sand borrow area to that of a nearby undisturbed control site.

Importantly, this study paired traditional fisheries-independent longline sampling and tag-recapture techniques with passive acoustic telemetry (using sensors to listen for animal sounds) to characterize fish abundance and behavior over several annual cycles. Fixed-station acoustic telemetry tags and receivers, satellite transmitters, inertial measurement units, uncrewed ocean gliders, and ocean sound recorders proved to be powerful tools for expanding the duration and geographic scope of observations on the open continental shelf.

Top left: A deployed Wave Glider USV as viewed from beneath. Top right: BOEM Wave Glider during pre-launch checkout. Bottom left: Glider in transit to launch sit. Bottom right: On transect offshore Cape Canaveral. Photo credits: Liquid Robotics, Inc. (top left), Eric Reyier (other photos).

>> Findings/Results

Most acoustically tagged species showed low site fidelity (i.e., they did not stay in one particular location). Sharks, red drum, and cobia tagged on the shoals—as well as sawfish, cownose rays, tarpon, goliath grouper, and others tagged elsewhere—moved freely between the shoals and offshore reef tract." Delete the "red drum were regular visitor.

No evidence suggested that shallow shoal ridges—often targeted for sand extraction—were proportionally more valuable than surrounding habitat or that mobile fish or turtles used an active dredge site differently than a nearby control site.

Though animals may be habituated to frequent vessel noise, persistent noise could cause masking of biologically important sounds among animals (including prey and predators). This is an important consideration for dredge site management, particularly near fish spawning areas.

The value of automated sampling platforms is clear. The integrated sampling approach—which included acoustic telemetry, passive sound recorders, satellite and inertial measurement unit (IMU) tags, and ocean gliders—gave new insight on animal abundance and behavior at Cape Canaveral that traditional sampling never could.

>> Final Report

Iafrate JD, Reyier EA, Ahr BJ, Watwood SL, Scheidt DM, Provancha JA, Holloway-Adkins KG, DiMatteo A, Greene J, Krumholz J, Carroll A (Naval Undersea Warfare Center Division, Newport, RI). 2022. Behavior, seasonality, and habitat preferences of mobile fishes and sea turtles within a large sand shoal complex: habitat connectivity, ocean glider surveys, and passive acoustics. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 150 p. Report No.: OCS Study BOEM 2022-018. *https://espis.boem.gov/final%20reports/BOEM_2022-018.pdf*

Consumer Surplus and Energy Substitutes for OCS Oil and Gas Production: The 2023 Revised Market Simulation Model (MarketSim)

Conducted by: *Industrial Economics, Incorporated*

National Studies List: *NT-22-x06*

>> Purpose/Information Use

The OCS Lands Act requires that BOEM prepare forward-looking five-year schedules of proposed OCS oil and gas lease sales to define the size, timing, and location of the OCS area(s) to be offered for lease. This study updates and details the methodology used to measure the potential energy market response by planning areas to new production on leases issued.

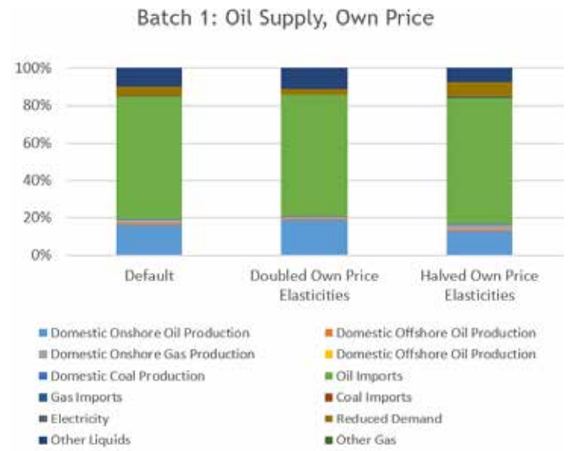
>> Findings/Results

The analytical tool that BOEM uses internally to estimate this market response is called the Market Simulation Model **(MarketSim)**. The model simulates end-use domestic consumption of oil, natural gas, coal, and electricity in four sectors **(residential, commercial, industrial, and transportation)**; primary energy production; and the transformation of primary energy into electricity.

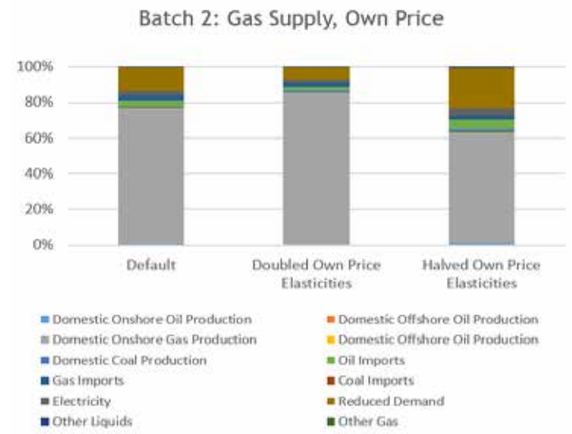
A crucial output of the model calculations is the net change in consumer surplus, an important component of the net benefits calculation for oil and gas exploration and development on the OCS.

>> Final Report

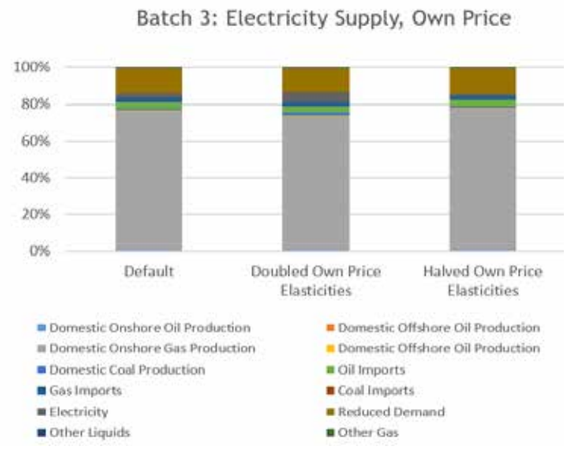
Industrial Economics, Inc. (Cambridge, MA). 2023. Consumer surplus and energy substitutes for OCS oil and gas production: the 2023 revised Market Simulation Model **(MarketSim)**. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 93 p. Report No.: OCS Study BOEM 2023-055. *https://espis.boem.gov/Final%20Reports/BOEM_2023-055.pdf*



Substitution Effect Results–Elasticity Batch 1: Oil Supply, Own Price



Substitution Effect Results–Elasticity Batch 2: Gas Supply, Own Price

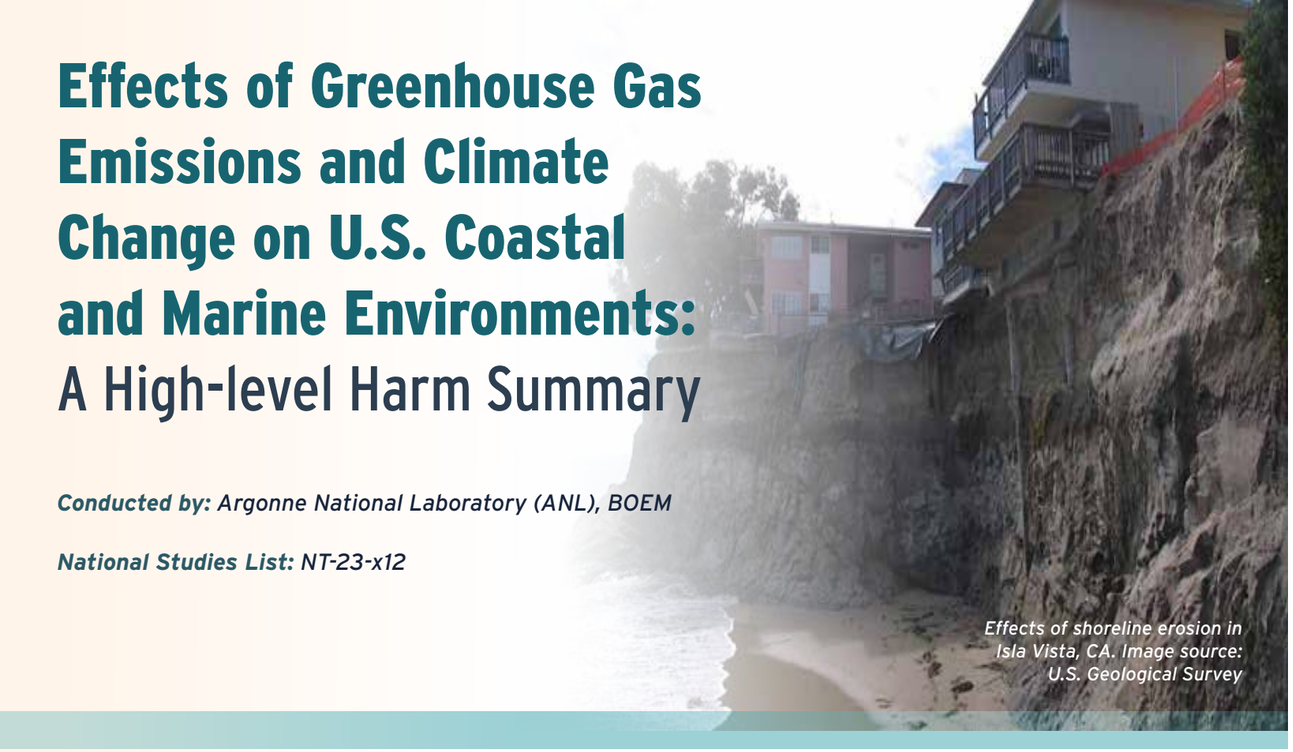


Substitution Effect Results–Elasticity Batch 3: Electricity Supply, Own Price

Effects of Greenhouse Gas Emissions and Climate Change on U.S. Coastal and Marine Environments: A High-level Harm Summary

Conducted by: *Argonne National Laboratory (ANL), BOEM*

National Studies List: *NT-23-x12*



Effects of shoreline erosion in Isla Vista, CA. Image source: U.S. Geological Survey

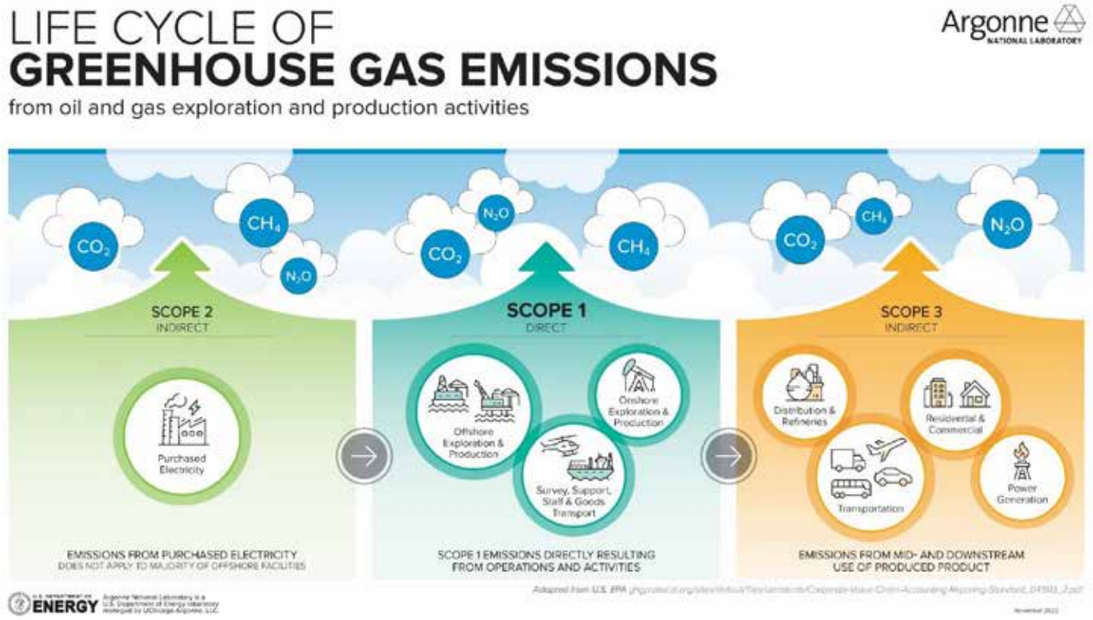
>> Purpose/Information Use

BOEM and the Department of Energy's ANL are collaborating to research greenhouse gas (GHG) emissions and climate change on the OCS. The study has two tasks: **(1)** identify harm caused by GHG emissions and climate change to the coastal and marine environments, and **(2)** evaluate GHG emissions from oil and gas operations on the OCS to identify pathways to reduce these emissions. This report is for Task 1; the Task 2 report will be published in 2024.

Task 1 conducted a literature review and convened an expert panel. The resulting report summarizes harms caused by GHG emissions and subsequent climate change on U.S. coastal and marine environments. It considers the impacts sea level rise, ocean acidification, hypoxia **(decreased oxygen in the water)**, and severe weather might have on the health of the environment, marine life and fisheries, historically significant heritage sites, and shoreline stability.

>> Findings/Results

Documented impacts of continued increases in GHG emissions on U.S. marine and coastal environments are becoming more evident. Impacts manifest in rising sea levels along U.S. coasts, which have led to coastal erosion and losses. Severe coastal storms—such as hurricanes with increased severity of storm rainfall linked to increasing sea surface temperatures—impact coastal flooding even further and lead to economic and environmental harms. Increases in ocean temperatures and ocean acidification from GHG emissions are also damaging ecosystems that support biodiversity, such as coral reefs, and directly alter the lives of marine organisms. Increasing ocean temperatures and changes in salinity can lead to changes in hypoxia events, which can damage marine organisms and habitats and directly diminish coastal fisheries. These impacts have direct consequences for the U.S. because they stress OCS natural resources, coastal infrastructure, food systems, and economies.



Definition of Scope 1, Scope 2, and Scope 3 emissions for oil and gas exploration and production activities.

Considering and understanding domestic and global energy demand is a critical aspect of GHG emissions policy adoption. Although incentivizing a slowing in activities on the OCS may lead to emissions reductions, it may have little effect on net GHG emissions because imported substitutions to meet the demand may come from countries with potentially more carbon-intensive oil and gas activities. Also, ongoing and possible future global hostilities by significant oil-exporter countries may require a revised posture of the U.S. as a producer and net exporter of energy. To support the sustainability of growth in this scenario, further requirements and incentives for cleaner operations on the OCS may carry significant global benefits. BOEM devotes significant effort to examining and projecting demand as part its National OCS Oil and Gas Leasing Program planning. With an added focus on GHG emissions, this effort appears more essential than ever.

The report recommends potential actions for BOEM to consider in the near-, mid-, and long-term timeframes. These include a review of current GHG emission reduction activities; providing guidance on technological and process improvements that may be ripe for adoption; an interagency collaboration among Federal agencies to streamline regulatory practices for controlling GHG emissions; comparing emissions data from different inventories; identifying verifiable data sources; assessing whether instrument-based sensing could be standardized to detect unexpected releases; and supporting existing and future research efforts on evaluating the effectiveness of carbon offset projects.

>> Final Report

Gevondyan E, Lechtenberg-Kasten S, Saricks C, Lindley R, Reed KA, Stansfield AM (Argonne National Laboratory, Argonne, IL; BOEM, Sterling, VA). 2022. Effects of greenhouse gas emissions and climate change on U.S. coastal and marine environments: a high-level harm summary. Argonne (IL) and Sterling (VA): U.S. Department of Energy, Argonne National Laboratory and U.S. Department of the Interior, Bureau of Ocean Energy Management. 74 p. Report No.: OCS Study BOEM 2023-009 and ANL-22/87. *https://espis.boem.gov/final%20reports/BOEM_2023-009.pdf*

Habitat Use of Oceanic Manta Rays *(Mobula birostris)* in the Vicinity of Marine Mineral Extraction Activities

Mobula birostris
Photo credit: Travelosio

Conducted by: *Georgia Aquarium*

National Studies List: *MM-20-03a*

>> Purpose/Information Use

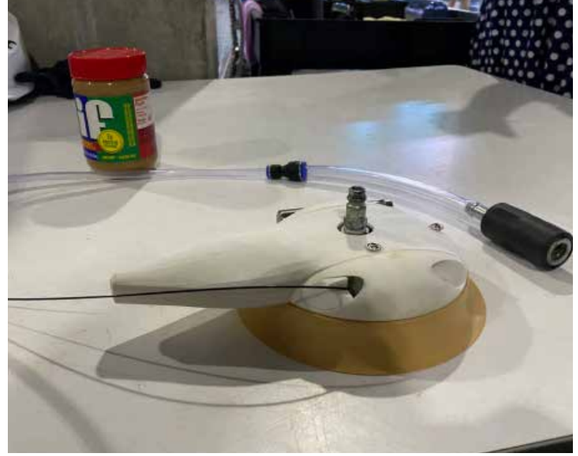
The elusive oceanic manta ray, ***Mobula birostris***, was listed on the ESA as threatened in 2018. Some of its distribution in Florida waters overlaps, spatially and temporally, with dredging and sand-mining activities on the OCS, particularly near Canaveral Shoals. Manta rays have been seen in the vicinity of dredging and trawling activities, such as mandated relocation trawling operations intended to mitigate the risk of interaction with protected sea turtles. These activities are a potential threat to this species.

Initially, this study aimed to track animals in the field using a combination of aerial surveys, satellite telemetry, acoustic telemetry, and IMU tag payloads to collect fine-scale habitat use and behavior data. Because of a number of obstacles, including the COVID-19 pandemic, the objective was modified to include designing an open-source IMU tag that can be attached to the dorsal surface via active suction created with compressed air. IMU tags allow data to be collected about animal behavior and habitat use at much finer spatial and temporal scales than either satellite or acoustic telemetry. The tags were equipped with gyroscopes, accelerometers, and magnetometers, which allow researchers to understand animal behaviors in three dimensions. Tags were tested in-house at Georgia Aquarium on an oceanic manta in human care, which allowed the researchers to refine the tag design and attachment method.

The fieldwork team included participants from BOEM, Georgia Aquarium, Shedd Aquarium, Stanford University, and volunteers. Two vessels used for on-water activities supported by an aerial team surveying from a Robinson 66 turbine helicopter.

>> Findings/Results

Through fieldwork and aerial surveys, researchers learned more about migratory times and the spatial range of manta rays, which will provide valuable input into future mitigation policies.



Updated tag design

First M. birostris application

This study significantly advanced the methods for studying the behavior and habitat use of manta rays. The researchers took an innovative capture method, previously successful on reef manta rays (***M. alfredi***), and applied it to oceanic manta rays (***M. birostris***) for the first time.

The invasiveness of traditional tagging methods, and the challenges associated with capturing, handling, and implanting tags on giant mantas in the wild, led engineers at Arribada Initiative and the team to design a new tag. Also, Arribada Initiative designed a quick-release pole applicator that allows tags to be attached from a vessel without restraining the animal. These open-source designs can be used by any academic, government, nonprofit, or NGO that would benefit in their scientific endeavors from the designs or their derivatives, including BOEM.

>> Final Report

Herman KB, Levenson J, Hoopes LA, Hansen DA, Piatkowski D, Rasser M, Dove ADM (Georgia Aquarium, Atlanta, GA; BOEM, Sterling, VA). 2023. Habitat use of oceanic manta rays (Mobula birostris) in the vicinity of marine mineral extraction activities. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 47 p. Report No.: OCS Study BOEM 2023-068. https://espis.boem.gov/final%20reports/BOEM_2023-068.pdf

>> Also

White paper: Herman KB, Levenson J, Hoopes LA, Hansen DA, Dove ADM (Georgia Aquarium, Atlanta, GA). 2021. Habitat use of oceanic manta rays (Mobula birostris) in the vicinity of marine mineral extraction activities. Sterling (VA): U.S. Department of Interior, Bureau of Ocean Energy Management. 29 p. Obligation No.: M20AC100006. Report No.: OCS Study BOEM 2021-026.

Georgia Aquarium third-grade lesson plan: Lesson plan highlighting this study and coastal marine management for a third-grade level. Publicly available and free at https://www.georgiaaquarium. org/wp-content/uploads/2022/12/BOEM-Lesson-plan.pdf

Project summary video: Georgia Aquarium's Communications and Public Relations created a project summary video with fieldwork footage and interviews with GAI and BOEM project partners. This was shared to social media platforms and is available at https://www.youtube.com/watch?v=3tmkvSg8YmA

OCS AQS: Outer Continental Shelf Air Quality System (OCS AQS): Year 2021 Emissions Inventory Quality Assurance / Quality Control (QA/QC) Study

Conducted by: *Xator Corporation and Lakes Environmental Software*

National Studies List: *NT-20-04*

OCSAQS
The Outer Continental Shelf Air Quality System

>> Purpose/Information Use

BOEM is required, under the OCS Lands Act, to comply with the National Ambient Air Quality Standards **(NAAQS)** to the extent that OCS oil and gas activities significantly affect the air quality of any state. BOEM's Gulf of Mexico Regional Office prepares Gulfwide emissions inventories and has completed inventories for 2000, 2005, 2008, 2011, 2014, and 2017. BOEM collects emissions inventories following USEPA's three-year schedule; however, the 2020 inventory was delayed to 2021 as BOEM was developing a modern web application to replace the legacy Gulfwide Offshore Activity Data System **(GOADS)**. In October 2020, BOEM issued a Notice to Lessees **(No. 2020-N031)** requesting that lessees and operators with facilities collect and report activity information and emissions covering the period January 1, 2021, to December 31, 2021. Lessees and operators were required to submit their emissions inventory data by April 22, 2022.

This report describes the approach, findings, analysis, and conclusions of a study conducted by the Xator-Lakes team to perform quality assurance (QA) and quality control (QC) and finalize 2021 emissions inventory data. Oil and gas operators operating in Federal waters in the Gulf of Mexico west of 87° 30′ West longitude were required to submit this data. The reporting requirement also applied to operators on the North Slope Borough of Alaska, but, because there was no OCS oil or gas activity in this region, this report only details the Gulf of Mexico emissions inventory finalization.

Operators reported their required activity data using the new web-based Outer Continental Shelf Air Quality System (OCS AQS), which recently replaced the legacy GOADS. OCS AQS automatically performs baseline checks at the time of operator input and submission to ensure that all required data are entered by the operators and the input values are within pre-defined ranges approved by BOEM. The team investigated the completeness of the inventory by comparing the list of facilities in OCS AQS against the Technical Information Management System database (maintained and operated by the Bureau of Safety and Environmental Enforcement) and by following up on facilities that did not report emissions.

>> Findings/Results

The team made an in-depth comparison against the 2017 inventory data to understand the changes in emission totals and reasons for these changes. The analysis reviewed emission factors and calculation methods against those used in 2017, and against the latest data in *AP-42: Compilation of Air Emissions Factors*, published by the USEPA. The changes in emission factors generally are believed to have had a negligible impact overall on the total 2021 emissions. This was the first inventory year in which the operators were asked to report their lease operations data **(non-platform facility sources)**. For this reason, no comparisons were possible to the 2017 data, but contacting and following up with the operators for outliers was done to ensure data quality.

In total, the study identified 227 facilities owned by 46 companies needing corrective action to address their platforms' activity data issues. The team incorporated the operators' revisions into the main 2021 database in OCS AQS. This revised database represents the 2021 final inventory. In the report, Table 1 gives a summary of the 2021 final total annual greenhouse gas emissions in tons per year by equipment type. Corrective action was taken on lease operations and non-platform facility sources, such as drilling rigs. A total of 10 companies were identified to review reported drilling rig activity data (including move on and off dates, vessel power, and fuel sulfur content) and to complete lease operations data by adding or subtracting drilling rigs to the 2021 OCS AQS inventory. The team incorporated the operators' revisions into the main 2021 OCS AQS database.

Final platform total annual GHG emissions (tons/year) by equipment type (2021)

Equipment Type	CO_2 (GWP = 1)	CH_4 (GWP = 25)	N_2O (GWP = 298)	CO_2-E
Amine Unit	0	0	-	0
Boiler/Heater/Burner	153,160	2.92	2.76	154,056
Cold Vent	1,038	*40,077	0	1,002,969
Combustion Flare	462,900	2,297	7.89	522,674
Drilling Equipment	22,661	1.11	-	22,661
Engine – Diesel or Gasoline Engine	225,831	5.26	-	225,831
Engine – Natural Gas	935,394	4,436	-	1,046,301
Fugitives	-	28,273	-	706,820
Glycol Dehydrator	-	325	-	8,130
Losses from Flashing	28.6	1,231	-	30,807
Mud Degassing	1.22	131	-	3,283
Pneumatic Controller	-	6,346	-	158,800
Pneumatic Pump	139	12,139	-	303,730
Storage Tank	265	265	-	6,238
Turbine – Natural Gas, Diesel, or Dual Fuel	*4,133,918	319	*111	*4,175,051

*Notes: * = highest emissions per pollutant; GHG = greenhouse gas; GWP = global warming potential; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2-E = carbon dioxide equivalent*

>> Final Report

Thé C, Johnson M, Alkabbani H, Munshed M, Torrens A, Matthews B, Gomes A, Lim D, Thé J (Xator Corporation, Reston, VA; Lakes Environmental Software, Ontario, CN). 2023. OCS AQS: Outer Continental Shelf Air Quality System (OCS AQS): Year 2021 emissions inventory quality assurance/quality control (QA/QC) Study. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 282 p. Report No.: OCS Study BOEM 2023-023. https://espis.boem.gov/final%20reports/BOEM_2023-023.pdf

Outer Continental Shelf Air Quality System (OCS AQS) Operator User Manual (Version 1.9)

The Outer Continental Shelf Air Quality System

Conducted by: Xator Corporation

National Studies List: NT-20-04

>> Purpose/Information Use

Air emissions from OCS operations are subject to regulatory programs, depending on the location of the operation. The authority of the Department of the Interior **(DOI)** to address OCS air emissions comes from the 1978 OCS Lands Act, which directs the DOI Secretary to promulgate regulations "for compliance with the NAAQS pursuant to the Clean Air Act **(42 U.S.C. 7401 et seq.)**, to the extent that activities authorized under this subchapter significantly affect the air quality of any State." DOI has jurisdiction over OCS sources in Federal waters in the western Gulf of Mexico, in most of the central Gulf of Mexico, and off Alaska's north coast. DOI or its agencies also periodically issue Notices to Lessees and Operators (NTLs), which "clarify, supplement, or provide more detail about certain requirements."

Before conducting operations on the OCS, leaseholders must submit and receive approval for activity-specific plans, such as exploration plans and development and production plans. These plans must include, among other provisions, a facility's projected emissions of sulfur dioxide, particulate matter, nitrogen oxides, carbon monoxide, and volatile organic compounds **(VOC)**. The lessee will apply these projections, and other related information **(e.g., distance from shore)**, to determine whether certain requirements apply.

DOI regulations contain an exemption formula, based on projected emissions and distance from shore. For a non-exempt OCS source, the next determination is whether projected air emissions from any pollutants would "significantly" affect onshore air quality (VOC emissions from non-exempt sources are automatically deemed to significantly affect onshore air quality). These sources must make the significance determination by using an approved air quality model.

According to the DOI regulations, lessees must monitor air emissions regardless of the source's exempt status or whether the OCS source's emissions would significantly impact air quality. The regulations require lessees to submit emission information to DOI on a monthly basis.

>> Findings/Results

OCS AQS is a comprehensive web-based software solution for managing and reporting OCS emission source data in the Gulf of Mexico and Alaska Regions. First used in 2021, OCS AQS offers benefits over the previous Gulfwide Offshore Activities Data System **(GOADS)**. It is a web-portal where operators can input their facility sources, activities, and automatically calculate emissions. Other benefits include enhanced usability; automated QA/QC to expand data quality evaluations; and advanced data analysis, reporting, and mapping tools.

The aim of the study was to develop comprehensive and helpful documentation on how to use the Outer Continental Shelf Air Quality System **(OCS AQS)** to help the Gulf of Mexico and Alaska energy operators prepare and submit emissions data in accordance with BOEM's emissions inventory requirements. The current version provides the most up-to-date information in anticipation of the 2023 inventory effort.

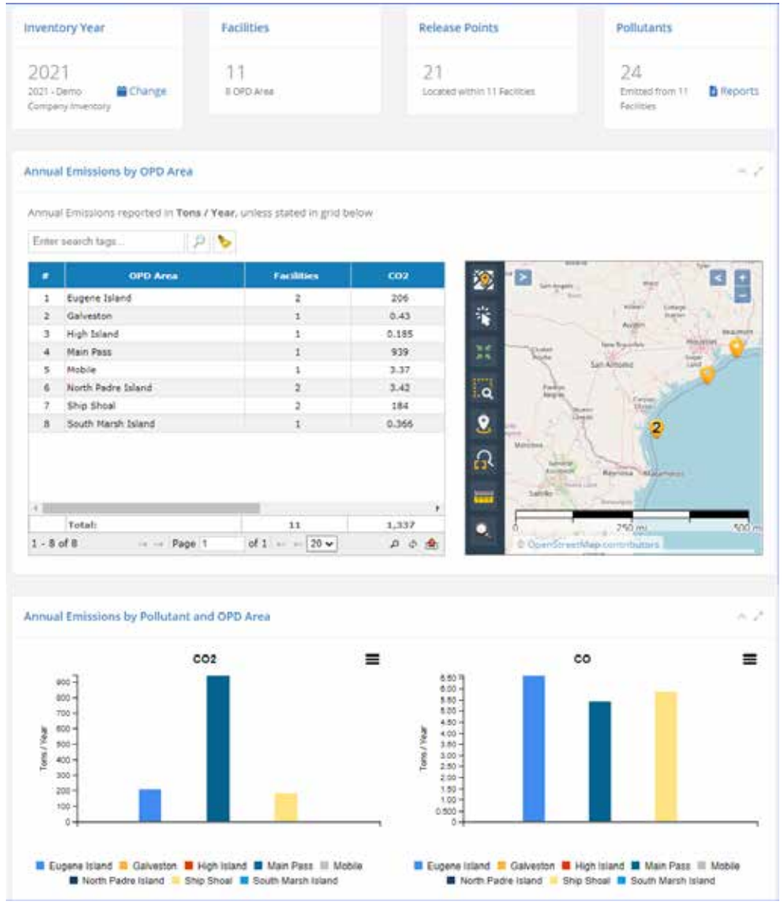


Figure 1: Main dashboard for operators

>> Final Report

Thé J, Thé C, Munshed M, Torrens A, Alkabbani H (Xator Corporation, Reston, VA). 2022. Outer Continental Shelf Air Quality System (OCS AQS) operator user manual (version 1.9). Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 201 p. Report No.: OCS Study BOEM 2022-048. https://espis.boem.gov/Final%20Reports/BOEM_2022-048.pdf

>> Also

OCS AQS website: https://ocsaqs.doi.gov

Response to Comments on the Air Quality Modeling in the Gulf of Mexico Region Study Report

Conducted by: *Eastern Research Group, Inc.*

National Studies List: *NT-20-07*

>> Purpose/Information Use

Emissions related to oil and gas development can lead to increased levels of air pollutants and add to a range of air quality impacts in the Gulf of Mexico. Some of those—such as carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide—are harmful to public health and the environment, onshore and offshore.

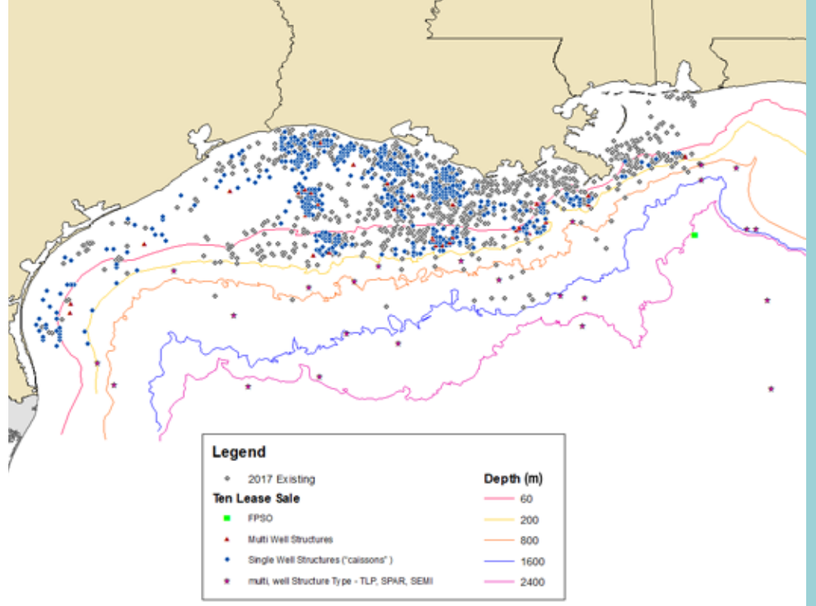
BOEM published the report ***Air Quality Modeling in the Gulf of Mexico Region*** in 2019. BOEM contracted with a team (Eastern Research Group, Inc., Ramboll US Corporation, and Alpine Geophysics, LLC) to develop emissions inventories, and to conduct meteorological modeling, photochemical modeling in support of cumulative impact analyses, and dispersion modeling and photochemical modeling in support of the emissions exemption threshold (EET) analyses. Air quality modeling was conducted to assess the existing pre- and potential post-lease impacts from OCS oil and gas exploration, development, and production to the states, as required under the OCS Lands Act. This information is used in National Environmental Policy Act (NEPA) environmental impact statement cumulative and visibility analyses. It is also used to assess post-lease impacts using EET formula screening methods to determine whether a proposed source may cause or contribute to a violation of the NAAQS.

In accordance with BOEM ESP's policy, NASEM peer reviewed BOEM's modeling report because of its highly influential scientific information, which might be used to develop future air regulations. A formal NASEM Consensus Report based on independent peer reviewers was delivered to BOEM **(NASEM 2019)**. NASEM met with BOEM in July 2019 to describe their comments and answer BOEM questions.

In addition to the NASEM peer review report, the U.S. Environmental Protection Agency **(USEPA)**; the states of Texas, Louisiana, Mississippi, and Alabama; and industry also had a chance to comment on the modeling report. Comments were submitted by NASEM, USEPA **(Headquarters and Region 4)**, Offshore Operators Committee, American Petroleum Institute, and two industry representatives.

>> Findings/Results

The study produced a report that documents all comments received on BOEM's modeling report as well as the BOEM and project modeling team responses. In many cases, additional clarifications and discussion are provided in response to the comments. In other cases, the report presents recommendations that may apply to future meteorological and photochemical modeling efforts.



Corrected figure of the modeling report for 10-sale placement of anticipated future structures

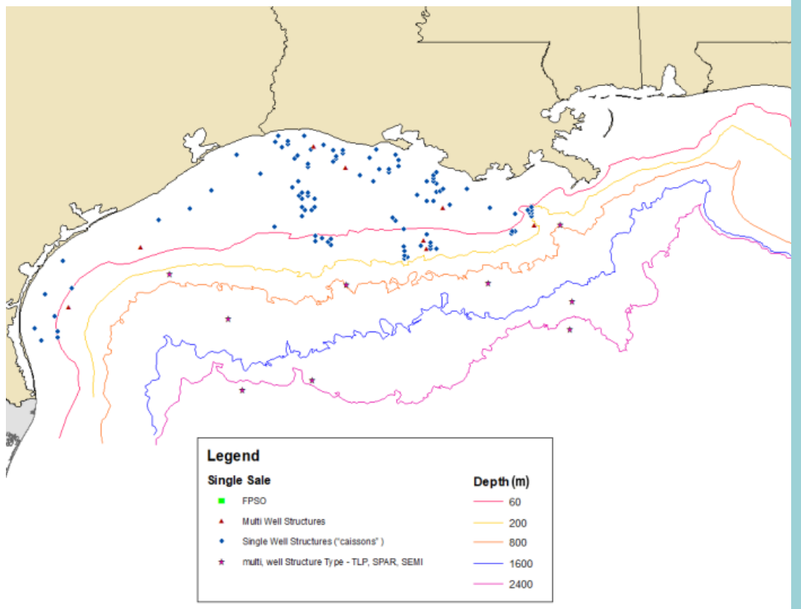
>> Final Report

Wilson D, Stoeckenius T, Brashers B (Eastern Research Group, Inc., Morrisville, NC). 2021. Response to comments on the Air Quality Modeling in the Gulf of Mexico Region study report. Sterling (VA): U.S. Department of Interior, Bureau of Ocean Energy Management. 96 p. Report No.: BOEM 2022-066. https://espis.boem.gov/final%20reports/BOEM_2022-066.pdf

>> Also

National Academies of Sciences, Engineering, and Medicine. 2019. Review of the Bureau of Ocean Energy Management Air Quality Modeling in the Gulf of Mexico Region Study. Washington (DC): The National Academies Press. https://doi.org/10.17226/25600.

https://www.nationalacademies.org/our-work/review-of-the-boem-air-quality-modeling-in-the-gulf-of-mexico-study



Corrected figure of single-sale placement of expected future structures.

Shallow-Water Geophysical Mapping by Autonomous Vehicle(s): Feasibility Assessment for Autonomous Surface Vehicles (ASV) and Autonomous Underwater Vehicles (AUV)

Conducted by: *CSA Ocean Sciences, Inc., APTIM*

National Studies List: *MM-21-01*

>> Purpose/Information Use

Restoration sedimentology through beach nourishment and/or habitat restoration has become a reliable mitigation strategy for coastal restoration and resilience building. The aim of restoration sedimentology is re-establishing natural processes of sediment erosion, transport, and deposition, processes that are necessary for river deltas.

The success of these restoration efforts depends on locating sufficient volumes of sediment that are suitable for use on beaches and dunes, and for creating and/or nourishing wetland habitat. Locating potential borrow sites with suitable sediment resources that are extractable at acceptable costs is important to the success of restoration goals.

This report provides a market and feasibility assessment, technology overview, and outline of field techniques for using AUVs or ASVs for reconnaissance marine mineral geophysical surveys. The state of these systems is assessed in relation to traditional vessel-based, towed-system investigations currently in use. The report discusses three primary deployment and recovery methods: Beach/Shore, Vessel/Mothership, and launch from a Pier/Dock/Boat Ramp.

Specifically, this report discusses the feasibility of using various AUV and/or ASV platforms with multiple geophysical sensors to collect geophysical data, and related analytical and geospatial services, in shallow-water environments (10- to 30-m [33- to 98-ft] water depth) for seafloor morphology, shallow geologic framework, and benthic habitat mapping in support of the delineation and characterization of offshore marine minerals for shore protection projects. With this information, BOEM can better evaluate the advantages and disadvantages (including cost and productivity tradeoffs) of shallow-water geophysical mapping from single or multiple AUV and/or ASV deployment.

>> Findings/Results

ASV and AUV deployment methodologies continue to develop; each mission gives manufacturers and vehicle users valuable lessons learned to better improve operations for future use.

Specific project goals, operational requirements, project budgets and timelines, and other limitations (regional and local logistics considerations, vessel, vehicle and sensor availability, regional/seasonal weather, and oceanographic conditions) must be considered on a case-by-case basis to truly determine if an AUV, ASV, or traditional vessel-based towed survey is the best solution for any given project. At this point, the state of the industry supports the use of AUV, ASV, and traditional towed sensor survey vessels depending on these variables.

The fundamental challenge is one of devising a Concept of Operations suitable to the specific geographic and policy considerations of the various survey regions and specific survey goals. While these issues require careful consideration before embarking on an ASV or AUV survey, they are not fundamental obstacles. In the current commercial, scientific, and military survey applications, these tools have delivered favorable economics compared to more traditional crewed vessels. It is likely that similar cost and efficiency improvements will be seen in sand resource assessments, leading to a long-term shift toward AUV and ASV surveys over the current standard of traditional towed sensor survey vessels.

>> Final Report

CSA Ocean Sciences Inc (Stuart, FL) and APTIM (Tampa, FL). 2023. Shallow-water geophysical mapping by autonomous vehicle(s): feasibility assessment for autonomous surface vehicles (ASV) and autonomous underwater vehicles (AUV). Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 64 p. Report No.: OCS Study BOEM 2023-063. *https://espis.boem.gov/final%20reports/BOEM_2023-063.pdf*

Submarine Canyons of the United States Exclusive Economic Zone Atlas

Conducted by: CSA Ocean Sciences, Inc.

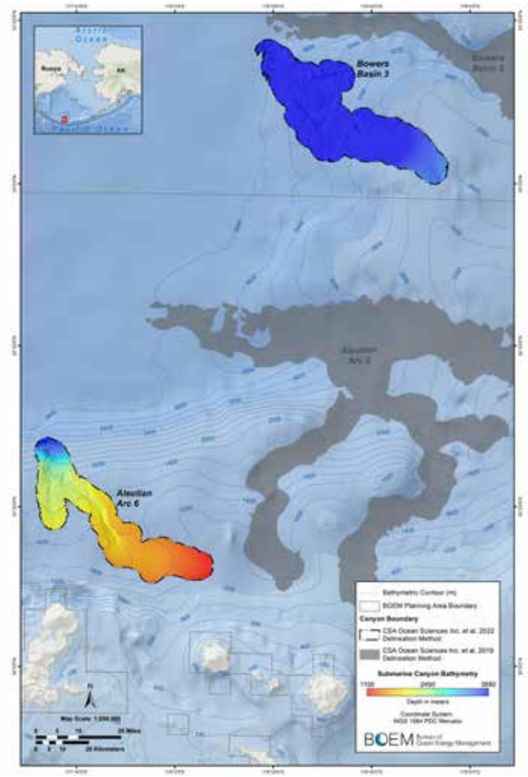
National Studies List: NT-21-x12

>> Purpose/Information Use

This study developed an atlas of submarine canyons to provide geospatial and resource information needed to assess potential environmental impacts of energy development activities on the OCS.

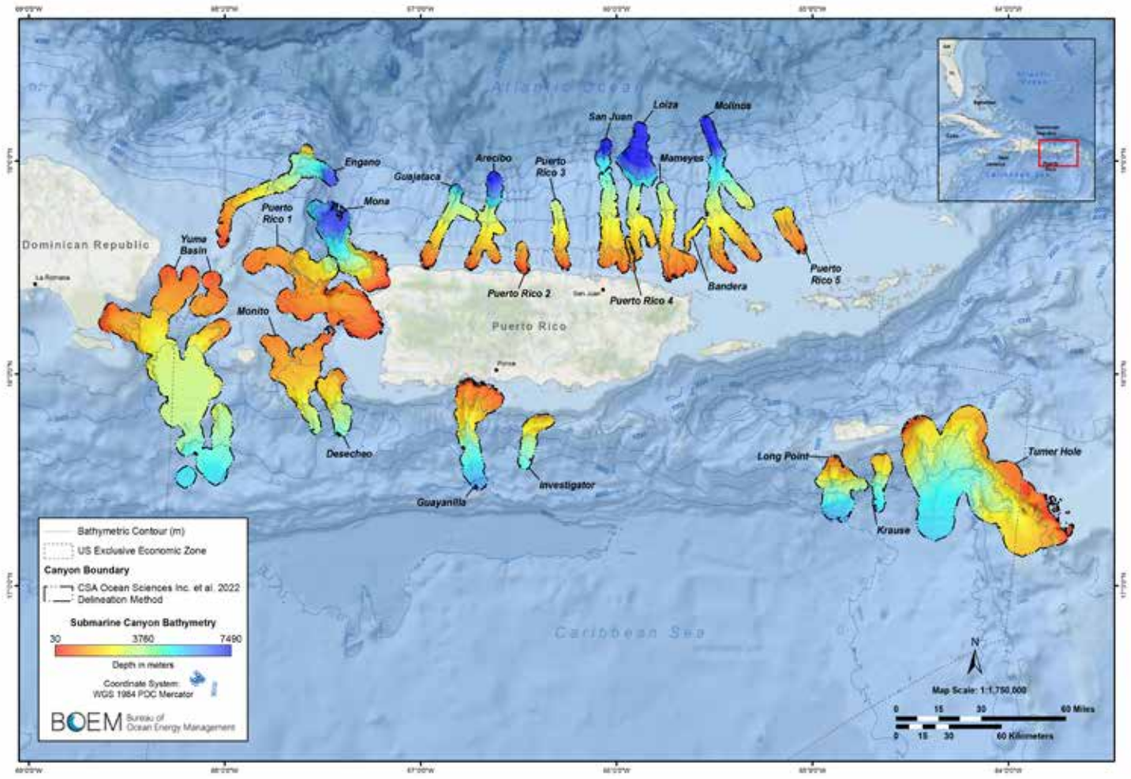
Submarine canyons—channels cut into the seafloor—are major geologic features of continental margins that connect the upper continental shelf to the abyssal plain (the flat, deep seafloor). During past ice ages, when sea level was much lower than it is today, rivers cut deep channels into the land, creating large canyons that were then submerged when the ice melted, and sea levels rose. These massive canyons are found offshore of such rivers as the Hudson and the Mississippi. Canyons can also form when steep slopes of the continental shelf edge fail, and the resulting submarine landslides leave gullies and scarps that may expand and become submarine canyons. There are around 9,000 canyons globally, according to surveys, but most are poorly known.

These geologically and morphologically diverse environments support a wide variety of habitats. In only a few submarine canyons have patterns of benthic (bottom) community structure and productivity been studied. Canyons support deepwater coral communities and many other sessile (immobile) filter feeders. Their taxonomic richness is also found to be higher in areas of exposed hard substrate. Canyons are unique in that they provide habitat for a variety of sessile taxa that are not found in other slope environments.



Bowers Basin 3 and Aleutian Arc Canyons

Several processes influence the biological assemblages we see in submarine canyons: the flow environment, food supply, and underlying geology all interact to support discrete communities of organisms that thrive in the heterogeneous canyon environments. Benthic communities in canyons tend to be more diverse and productive than other deepsea habitats.



Caribbean canyons Overview

>> Findings/Results

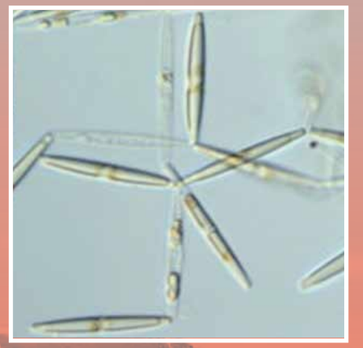
The study inventoried and delineated selected submarine canyons in the U.S. OCS and Exclusive Economic Zone (EEZ) using a methodology consistent with terrestrial watershed mapping. A criteria-based algorithm generated spatial polygons that were used to calculate canyon slope, length, and depth.

This edition builds on the 2019 Large Submarine Canyons of the United States Outer Continental Shelf Atlas by including mapping of additional medium to large submarine canyons. The 2022 atlas was developed to improve environmental management of the lands of the OCS—which consists of the submerged lands seaward of state jurisdiction—and the U.S. EEZ. The EEZ extends up to 200 nautical miles (370 km) from the coastline and comprises the areas adjoining the territorial sea of the U.S., Puerto Rico, the Northern Mariana Islands, and U.S. overseas territories and possessions. Canyon depths range from 150 to 3,960 meters.

>> Final Report

CSA Ocean Sciences Inc., Ross SW, TSC Strategic. 2022. Submarine canyons of the United States Exclusive Economic Zone atlas. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 56 p. Report No.: OCS Study BOEM 2022-058. https://espis.boem.gov/Final%20Reports/BOEM_2022-058.pdf

ALASKA REGION



An Analysis of Surface Currents in the Western Beaufort and Northeastern Chukchi Seas

Conducted by: *University of Alaska Fairbanks, College of Fisheries and Ocean Science*

National Studies List: *AK-19-02-04*

>> Purpose/Information Use

Studying ocean surface and subsurface circulation on Alaska's Arctic continental shelves is crucial to understanding ecosystem dynamics, bowhead whale foraging behaviors, oil spill trajectory calculations, effects of offshore drilling, sea ice melt patterns, and tracking of other water-borne constituents.

This study provides a newly updated scientific understanding of the surface circulation in the northeastern Chukchi Sea near Hanna Shoal and Barrow Canyon, in the western Beaufort Sea from Point Barrow to Smith Bay, and of the surface-to-subsurface flow relationships throughout the study region.

Researchers processed and analyzed six years (2013–2018) of high-frequency radar data from the western Beaufort Sea and northeastern Chukchi Sea, funded by BOEM (BOEM OCS studies 2012-079 and 2017-065). Researchers evaluated the relation between surface currents measured by the high-frequency radar systems and subsurface currents measured by year-round oceanographic moorings, and the relation among the wind and the surface flow field structure and evolution and satellite-tracked drifters.

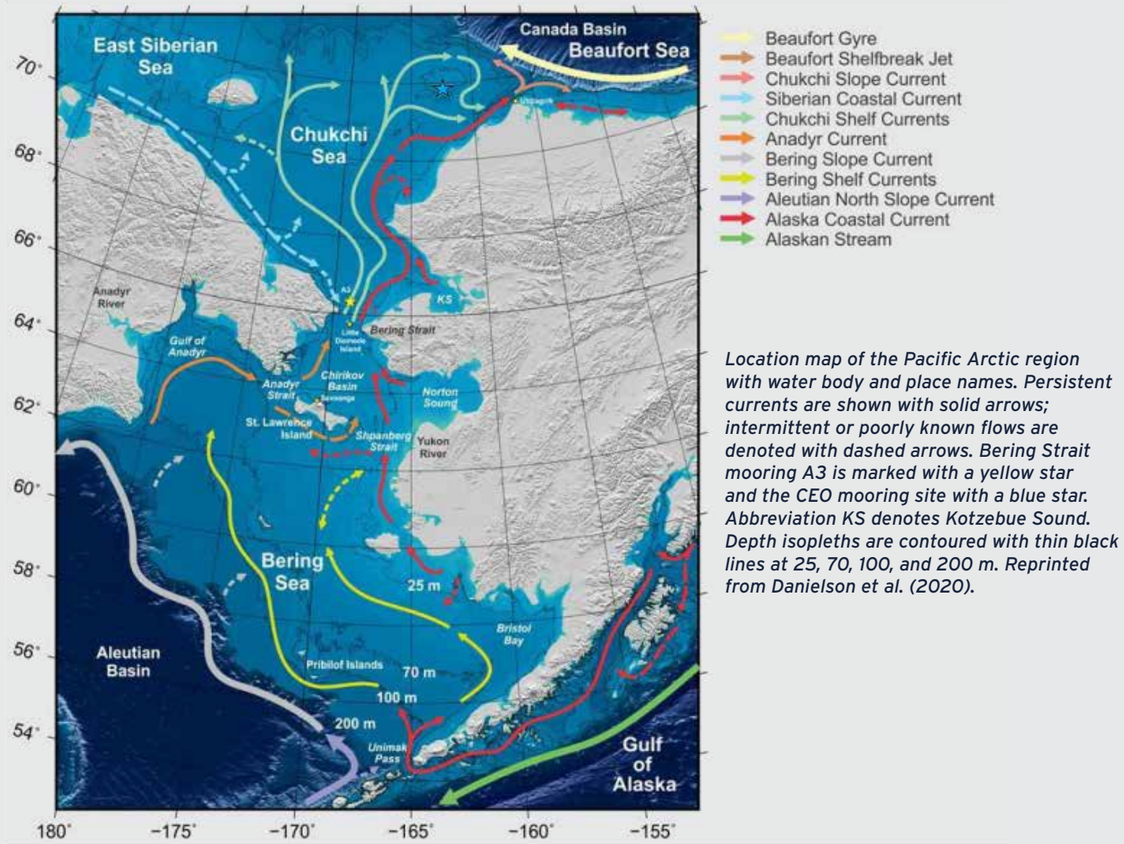
>> Findings/Results

Aggregated results show a complex flow field in the vicinity of Barrow Canyon; variations can be largely understood in terms of time-varying local wind field stresses along with interactions of the ocean currents with the seafloor bathymetry.

Researchers identified a recurrent anticyclonic gyre that straddles the northwestern Beaufort continental shelf and slope. Though the gyre typically circulates in a clockwise fashion, winds from the south and southwest can reverse the rotation. Flow field maps suggest three key locations where flow convergences, divergences, and changing rotations hint at the dynamics that regulate the flow field. The gyre seems to be a consequence of the Alaska Coastal Current flow through Barrow Canyon, the prevailing wind, and the coastal constraint on the western Beaufort shelf.

>> Final Report

Potter RA, Danielson SL (University of Alaska Fairbanks, Fairbanks, AK). 2022. An analysis of surface currents in the western Beaufort and northeastern Chukchi Seas. Final report. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 87 p. Report No.: OCS Study BOEM 2022-014. https://espis.boem.gov/Final%20Reports/BOEM_2022-014.pdf



Location map of the Pacific Arctic region with water body and place names. Persistent currents are shown with solid arrows; intermittent or poorly known flows are denoted with dashed arrows. Bering Strait mooring A3 is marked with a yellow star and the CEO mooring site with a blue star. Abbreviation KS denotes Kotzebue Sound. Depth isopleths are contoured with thin black lines at 25, 70, 100, and 200 m. Reprinted from Danielson et al. (2020).

Arctic Ecosystem Integrated Survey, Phase II: Seabird Community Structure and Seabird-Prey Dynamics

Conducted by: *U.S. Fish and Wildlife Service*

National Studies List: *AK-16-07*

Short-tailed shearwater. Photo by Z. Pohlen.

Gliding northern fulmar. Photo by K. Kuletz.

Mixed flock with black-legged kittiwakes on ice. Photo by E. Labunski.

>> Purpose/Information Use

Data on the distribution of marine birds is needed for ESA Section 7 consultations, NEPA analyses, and other documentation. Basic information on marine bird timing and duration of use within BOEM planning areas is necessary to better define the impacts of perturbations and, ultimately, population effects.

This at-sea survey program for seabird observations provided current data, and seasonal and interannual comparisons, on the distribution and abundance of marine birds, and secondarily for marine mammals, within BOEM's Arctic planning areas during two integrated ecosystem studies: Arctic Shelf Growth, Advection, Respiration, and Deposition Rate Experiments (ASGARD) and the Arctic Integrated Ecosystem Survey, Phase II; Upper Trophic Level (Arctic IES). Seabirds spend most of the year dispersed offshore, and this study provides a more complete and current dataset on seabird communities and their distribution in the northern Bering and Chukchi seas.

Researchers conducted seabird surveys for a total of 14,247 km within the Arctic Integrated Ecosystem Research Program (AIERP) study area from June 2017 through September 2019. They observed high abundance of seabirds and marine mammals in the Chirikov Basin and Bering Strait, and in the eastern Chukchi Sea in Hope Basin, over Barrow Canyon, and Hanna Shoal. The study integrated environmental and prey data from the ASGARD and Arctic IES projects to examine seabird distribution in relation to annual conditions.

>> Findings/Results

The study developed and made available to the public the North Pacific Pelagic Seabird Database v3, which includes seabird data from this project through 2019 and seabird distribution maps. Researchers carried out many workshops, education outreach projects, and conference presentations 2018–2021.

For both projects, five to nine species accounted for 90% of total birds, with the most abundant including thick-billed murre (***Uria lomvia***), crested auklet (***Aethia cristatella***), least auklet (***Aethia pusilla***), black-legged kittiwake (***Rissa tridactyla***), and short-tailed shearwater (***Ardenna tenuirostris***).

The seabird surveys and studies provide evidence of rapid changes in seabird distribution in response to changes in physical oceanography, prey species, and the influx of large predatory fish. Reproductive success in the northern Bering Sea was poor, and seabird die-offs occurred in the Bering Strait region.

A series of seabird mortality events (die-offs) occurred along the coastlines and islands of the AIERP study area. These events were unusual and caused concern for local communities and subsistence harvesters; they also signaled ecological changes. Dead birds were also recorded at sea during the ASGARD and Arctic IES. Die-offs also occurred 2017–2019, south of the study area; short-tailed shearwaters made up over half of all recorded mortality. The majority of birds died of starvation. The 2019 die-off in southeastern Bering Sea may have reduced the number of short-tailed shearwaters that could complete the full migration into the Chukchi Sea that year.

Results suggest that seabirds (at least as a group) were not able to respond to the rapid changes in prey that occurred the 2017 survey year. AIERP was conducted during several years of anomalously warm ocean temperatures, changes in the zooplankton community, and a massive influx of large predatory fish into the northern Bering Sea, with repercussions throughout the food web. These were concurrent with changes in oceanography, zooplankton, and fish, following the absence of winter sea ice and the subsequent loss of the deep cold pool that formed a thermal barrier to large predatory fish, such as walleye pollock and Pacific cod. Murres breeding in the northern Bering Sea failed to nest or failed to fledge chicks, and both planktivores and piscivores showed detrimental response to the conditions associated with the heat wave.

>> Final Report

Kuletz KJ, Labunski EA, Morgan TC, Bankert A, Gall AE (U.S. Fish and Wildlife Service, Anchorage, AK). 2022. Arctic Ecosystem Integrated Survey, Phase II: seabird community structure and seabird-prey dynamics final report. 169 p. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. Report No.: OCS Study BOEM 2022-020. https://espis.boem.gov/Final%20Reports/BOEM_2022-020.pdf

>> Also

Drew GS, Piatt JF. 2020. North Pacific Pelagic Seabird Database (NPPSD): U.S. Geological Survey data release (ver. 3.0, February 2020). https://doi.org/10.5066/F7WQ01T3

Interviews and press articles include

- Yong E. Why hundreds of puffins washed up dead on an Alaskan beach. The Atlantic. 29 May 2019.
- Rust S. Unprecedented die-offs, melting ice: climate change is wreaking havoc in the Arctic and beyond. Los Angeles Times. 17 Dec 2021.

Kuletz K, Cushing D, Labunski E. 2020. Distributional shifts among seabird communities of the northern Bering and Chukchi seas in response to ocean warming during 2017–2019. Deep Sea Res II: Oceanogr. 181-181:104913. https://doi.org/10.1016/j.dsr2.2020.104913

Collaboration with the North Pacific Research Board, Arctic Marine Research Program

Conducted by: *North Pacific Research Board (NPRB)*

National Studies List: *AK-16-02*

>> Purpose/Information Use

The NPRB and BOEM partnered to collaboratively support the AIERP from 2016–2022. The program's geographic scope included the northern Bering Sea, Bering Strait, Chukchi Sea, and the adjacent Beaufort Sea.

BOEM and NPRB identified where collaborative research studies could improve understanding of the sustainable use of marine resources. The multiple tasks of this collaborative effort included several individual study proposal topics, such as the influence of sea ice dynamics and advection on biotic phenology, magnitude, and location of primary and secondary production; distribution and life history of upper trophic predators in response to availability of lower trophic prey resources; and quantification of rates of consumption, growth, and reproduction of benthic and pelagic organisms.

The AIERP integrated multiple streams of marine data, from physical forcing factors to the processes driving marine ecology, human dimensions, and ecosystem services. Research from this multidisciplinary collaboration supported mutually identified information needs on the physical, biological, and social processes in the Arctic marine environment to improve scientific understanding of large marine ecosystem dynamics.

>> Findings/Results

The research documented significant changes in water temperature, large shifts in the distributions of species that represent important nodes in the Arctic marine food web (e.g., Arctic cod), and changes in the distribution, abundance, and timing of subarctic species presence in the Chukchi Sea (e.g., Pacific cod, walleye pollock, subarctic marine mammals). These results contribute to updating environmental assessments related to permitting activities in the Alaska Region.

Integrated, multidisciplinary research provides updated information about the processes that govern how the marine ecosystem in the Chukchi Sea is structured under a changing climate. NPRB, a leader in facilitating integrated ecosystem research, attracts highly qualified scientists affiliated with a wide range of Federal and non-federal institutions and the active participation of Alaska Native and industry partners.

The study report appendices include several reports: Arctic Shelf Growth, Advection, Respiration, and Deposition Rate Experiments (ASGARD) final reports on oceanography and lower trophic levels; Arctic IES reports on oceanography and lower trophic levels; and Chukchi coastal communities understanding of and responses to environmental change.

NPRB created a substantial **website for the AIERP** where information about the program is shared publicly. Videos about what is being studied and why; data and reports; a blog; field notes; resources for investigators; and more are available on the website. This website will be publicly available as long as NPRB exists.

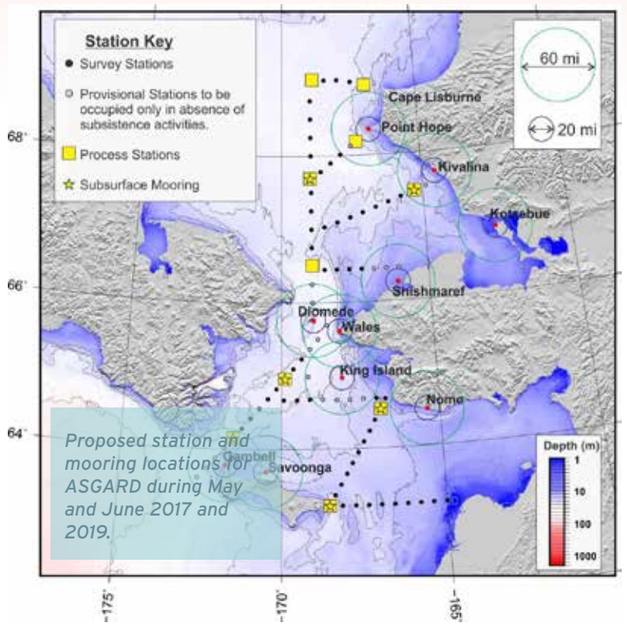
>> Final Report

Dickson DMS (North Pacific Research Board, Anchorage, AK). 2022. Collaboration with the North Pacific Research Board, Arctic Marine Research Program. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 1,989 p. Report No.: OCS Study BOEM 2022-039. https://espis.boem.gov/Final%20Reports/BOEM_2022-039.pdf

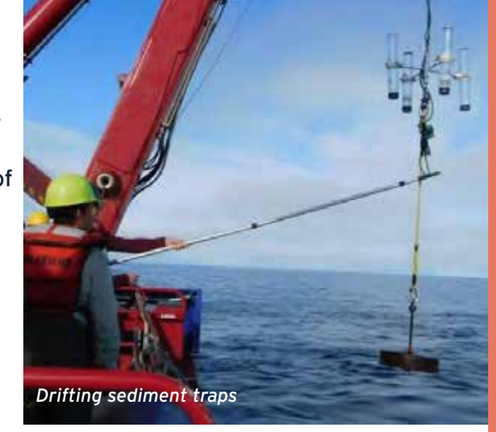
>> Also

NPRB website: https://nprb.org/arctic-program/

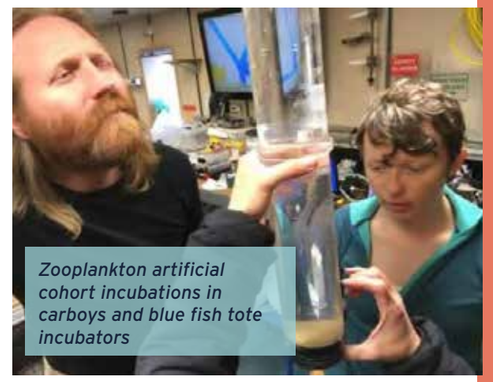
Brochure: https://online.flippingbook.com/view/521428410/



Proposed station and mooring locations for ASGARD during May and June 2017 and 2019.



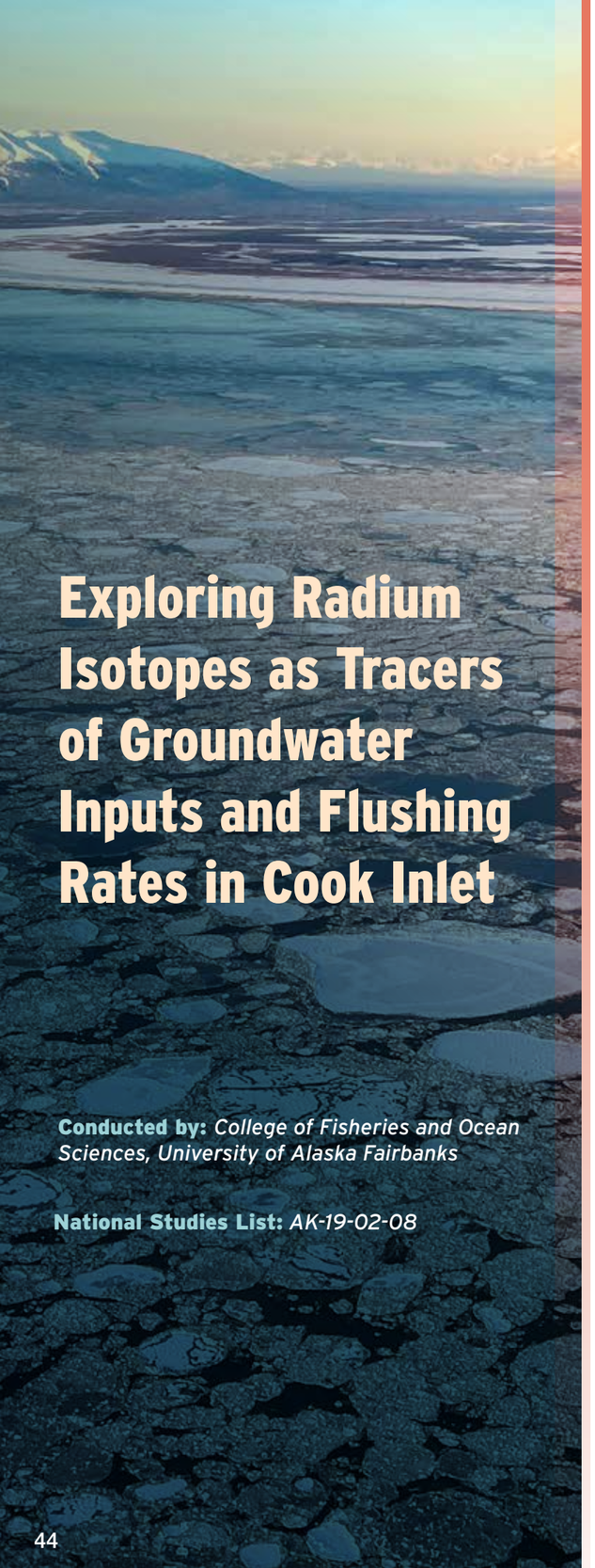
Drifting sediment traps



Zooplankton artificial cohort incubations in carboys and blue fish tote incubators

Zooplankton egg production incubations

Collecting hydrographic profiles and water samples with the CTD



Exploring Radium Isotopes as Tracers of Groundwater Inputs and Flushing Rates in Cook Inlet

Conducted by: *College of Fisheries and Ocean Sciences, University of Alaska Fairbanks*

National Studies List: *AK-19-02-08*

>> Purpose/Information Use

A key component of oil spill risk analyses and environmental impact statements is constraining the rates at which waters are flushed through and out of Cook Inlet. Radium is a well-established water mass tracer for coastal systems. Four radium isotopes are present in marine systems: two short-lived species (Ra-223 and Ra-224, with 12- and 4-day half-lives, respectively) and two long-lived species (Ra-226 and Ra-228, with 1,600- and 6-year half-lives, respectively). These can be used to trace marine processes across a wide range of time scales.

Radium has been used to trace the flux of produced water in the coastal system, but in a river-dominated system, the naturally occurring radium from rivers may obstruct the signal of radium from other sources.

This project tested novel methods for tracing the flow of seawater and its dissolved constituents into, through, and out of Kachemak Bay, Alaska. Oceanographic surveys in Kachemak Bay collected radium isotope samples to assess the feasibility of creating radium budgets to characterize groundwater inputs, a potentially dominant source of freshwater, carbon, and nutrients to the Gulf of Alaska. Because the low concentration of Ra-223 in seawater led to challenges in the collection and analysis of this isotope, researchers instead analyzed a select group of samples for longer-lived radium isotopes.

>> Findings/Results

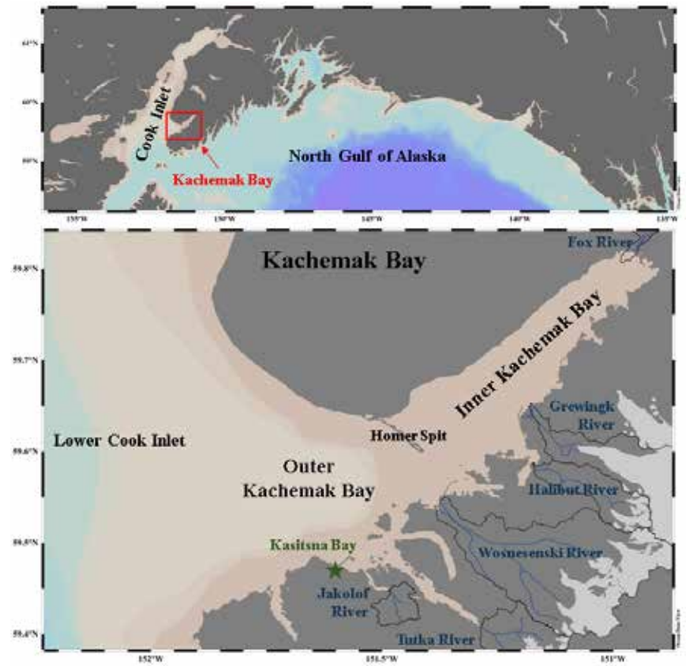
The study sampled six rivers in Kachemak Bay for Ra-224, Ra-226, and Ra-228 to determine the relationship between the concentration of radium in rivers and watershed characteristics: Fox Creek, Jakolof Creek, Tutka River, Halibut River, Wosnesenski River, and Grewingk River.

Results showed that offshore waters entering Kachemak Bay from the northern Gulf of Alaska are relatively enriched in long-lived radium, violating a key assumption needed to perform residence time calculations.

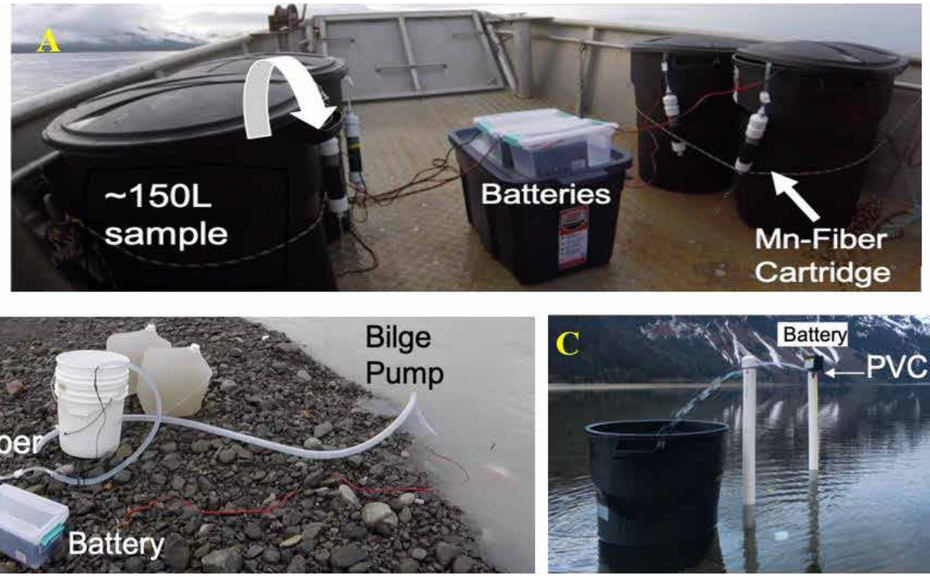
This study revealed that suspended materials in rivers are a significant source of radium to the marine system, one that may be overlooked in studies that simply measure radium in fresh river water. Underlying geology and river discharge need to be considered when applying radium-based approaches to other locations within Cook Inlet. As seawater moves away from the coast, radium decays and mixes with less concentrated offshore water, so it is quickly depleted of radium. Water samples taken away from the coastline are likely to be highly depleted in Ra-224, with potential "hotspots" such as a shallow bank where sediments are mixed into the water column and desorb Ra-224, an offshore spring where groundwater Ra-224 is released, or other natural or human-introduced discharges carrying detectable short-lived radium signals compared to seawater's short-lived radium concentration.

>> Final Report

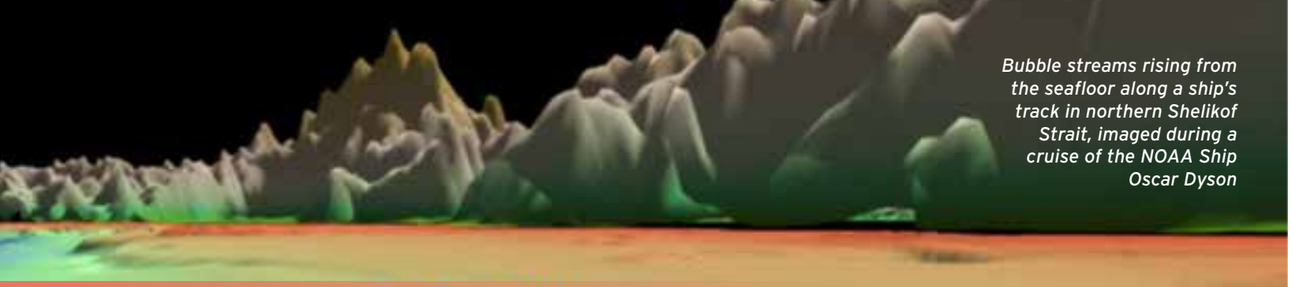
Kelley A, Burt W, Haag J (University of Alaska Fairbanks; Planetary Technologies, Nova Scotia, CN). 2022. Exploring radium isotopes as tracers of groundwater inputs and flushing rates in Cook Inlet. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 37 p. Report No.: BOEM 2022-045. https://espis.boem.gov/Final%20Reports/BOEM_2022-045.pdf



Map of the study area. (Top) Kachemak Bay within the greater Northern Gulf of Alaska and (Bottom) the Cook Inlet region showing the locations of the six rivers (Blue) relevant to this study and their respective watersheds (Black).



Field sampling photos: (A) Radium extraction from four large-volume seawater samples while onboard the Munson boat operated by the Kasitsna Bay Laboratory. Water is pumped out of the garbage cans and through a plastic cartridge packed with manganese oxide-impregnated (MnO_2) fiber before spilling onto the boat deck. (B) River samples were collected by placing bilge pumps directly into streams. (C) Groundwater sample being collected from a PVC well in Jakolof Bay.



Bubble streams rising from the seafloor along a ship's track in northern Shelikof Strait, imaged during a cruise of the NOAA Ship Oscar Dyson

Hydrocarbon Seeps in the Lower Cook Inlet, Gulf of Alaska, Chukchi Sea and Beaufort Sea OCS Planning Areas

Conducted by: *University of Alaska Fairbanks*

National Studies List: *AK-18-x11*

>> Purpose/Information Use

Submarine seepage is the flow of fluids from the seabed into the ocean. These fluids can be groundwater, hot hydrothermal fluids, or hydrocarbon-rich fluids.

Hydrocarbon fluid flow and associated gas hydrate formations have implications for seafloor geologic features, slope stability, marine biological processes, and ocean composition.

Hydrocarbon seeps on the seafloor are called cold seeps to distinguish them from hot hydrothermal fluid venting. Cold seeps occur in a variety of seafloor environments from coastal waters to the continental shelf and slope, and into the deep ocean. Seeping hydrocarbons may be methane or other gaseous hydrocarbons, oil, tar, or mud.

The primary goal of this desktop study was to help BOEM evaluate the potential for offshore petroleum resources in the Lower Cook Inlet, Gulf of Alaska, Chukchi Sea, and Beaufort Sea. Patterns of seep occurrence on the seafloor provide insights into the geologic history, materials, and subsurface structures, improving our geological understanding of the Alaska offshore region.

Information about seeps helps BOEM manage energy development on the U.S. OCS in several ways. Distribution and chemical fingerprints of natural seeps may provide an important baseline for monitoring impacts of petroleum exploration and development on the Alaskan environment. Seep-associated hazards, such as gas hydrate decomposition and submarine landslides, can affect exploration and infrastructure development. Hydrocarbon seep emissions can support local chemosynthetic seafloor communities and may impact primary productivity and fisheries. These chemosynthetic seep communities may also include benthic organisms that are capable of metabolizing hydrocarbons for oil spill mitigation and remediation. Methane and other fluids emitted by seeps may affect ocean chemistry and physical properties of the ocean.

>> Findings/Results

To meet the goals of this desktop study, a total of 1,486 seeps were interpreted within the Alaska OCS from a variety of sources

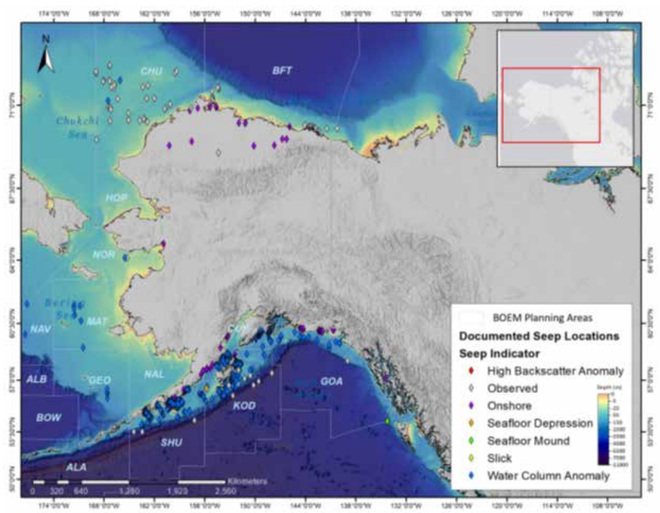
Number of seeps interpreted by BOEM planning areas and onshore regions

BOEM Planning Areas	Number of Seeps (Total)	Interpreted from Literature or BOEM Documentation	Interpreted from Sonar Data (this study)	Interpreted from Sonar Data (crowdsourced)
Gulf of Alaska	109	55	27	27
Kodiak	739	16	7	716
Cook Inlet	122	33	65	24
Shumagin	355	10	0	345
Western OCS	17	6	0	11
Chukchi Sea	82	82	0	0
Beaufort	62	62	0	0
Total	1,486	264	99	1,123

This study also provided a geodatabase with the locations and metadata for the seeps. The geodatabase includes publicly available geophysical data used in interpreting the spatial distribution of the seep locations. Where possible, the study discussed the settings and patterns of seep locations in geological context. Literature sources cited in the database and in the final report have been compiled into a bibliography. The final report concludes with recommendations for future field programs aimed at understanding patterns of occurrence, seafloor expression, and geochemistry of the hydrocarbon seeps.

>> Final Report

Brumley K, Reynolds JR, Heffron E (University of Alaska Fairbanks, Fairbanks, AK). 2021. Hydrocarbon seeps in the Lower Cook Inlet, Gulf of Alaska, Chukchi Sea and Beaufort Sea OCS Planning Areas. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 75 p. Report No.: OCS Study BOEM 2022-057. https://espis.boem.gov/Final%20Reports/BOEM_2022-057.pdf



Seep locations discussed in this study (bathymetry from NOAA-NCEI).

Investigating the Impacts of Oil Exposure and Changing Snow Cover on Sea Ice Microbial Communities

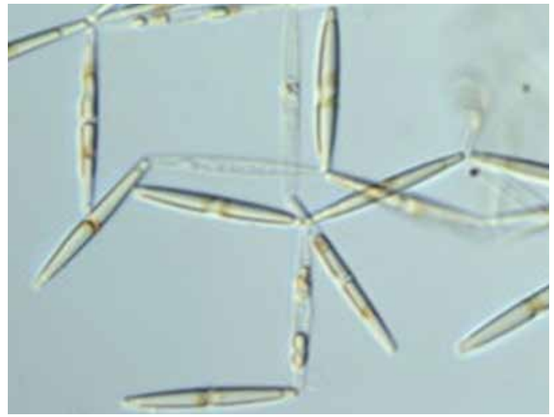
Conducted by: *College of Fisheries and Ocean Sciences, University of Alaska Fairbanks*

National Studies List: *AK-19-02-11*

>> Purpose/Information Use

In the Arctic, the base of the marine food web is supported by sea ice algae and phytoplankton. Diatoms, a prolific group of marine algae, contribute considerably to Arctic algal biomass in both ice and water. Oil and gas lease areas in the Beaufort Sea are adjacent to subsistence hunting and fishing areas that support the economies of many Arctic communities. Reasonably foreseeable effects of allowing oil and gas drilling in the Beaufort Sea include the potential for oil spills and gas blowouts that could contaminate the marine environment with crude oil and potentially alter algal productivity, which could result in large-scale changes to the Arctic marine food web.

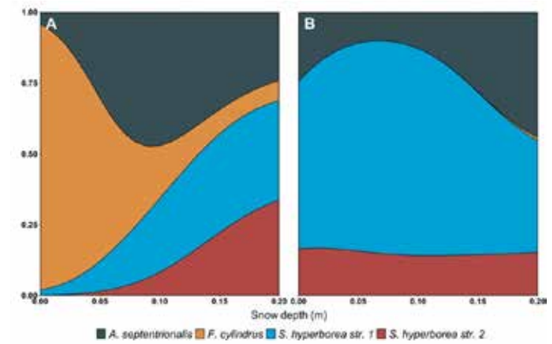
The objectives of this study were to 1) determine the impact of varying crude oil concentrations and irradiance (a measure of solar power) on the growth and carrying capacity of cultured sea ice diatoms and a natural sea ice microbial community from the Alaskan Arctic and 2) identify gene expression patterns indicative of Arctic North Slope crude oil exposure and decreased snow cover.



Sea ice diatoms Nitzschia frigida from Arctic pack ice

>> Findings/Results

Researchers combined the acquired data with observations of sea ice thickness and irradiance to create a model to assess how exposure to crude oil would impact sea ice algal biomass and diversity under different snow conditions. Algal diversity and biomass both decreased in a simulated crude oil spill in the Alaskan Arctic, particularly under low snow conditions. Data show that sea ice diatoms from the Alaskan Arctic have diverse responses to crude oil contamination, and responses can be modified by sea ice thickness and snow cover. Factors, such as ice and snow conditions and sea ice algal community composition, should be considered in determining the appropriate response to a crude oil spill in the Alaskan Arctic. Low snow conditions and thin ice are likely to exacerbate crude oil toxicity for the most abundant sea ice diatoms.



Modeled sea ice diatom composition and biomass modified by snow depth and crude oil spill. Sea ice diatom community composition in unoiled (A) and exposure to Arctic North Slope crude oil spill (B) scenarios over a range of snow depths at the end of a modeled spring bloom.

>> Final Report

Hennen G (University of Alaska Fairbanks). 2022. Investigating the impacts of oil exposure and changing snow cover on sea ice diatom communities in the Alaskan Arctic. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 33 p. Report No.: OCS Study BOEM 2022-062. https://espis.boem.gov/final%20reports/BOEM_2022-062.pdf

>> Also

Dilliplaine K, Hennon G. 2023. Impacts of crude oil on Arctic sea ice diatoms modified by irradiance. Elem Sci Anth. 11(1):00074. https://doi.org/10.1525/elementa.2023.00074

Kenai Peninsula Borough Economy, 2008 to 2020

Conducted by: *Northern Economics, Inc. and Industrial Economics, Inc.*

National Studies List: *AK-20-x09*

>> Purpose/Information Use

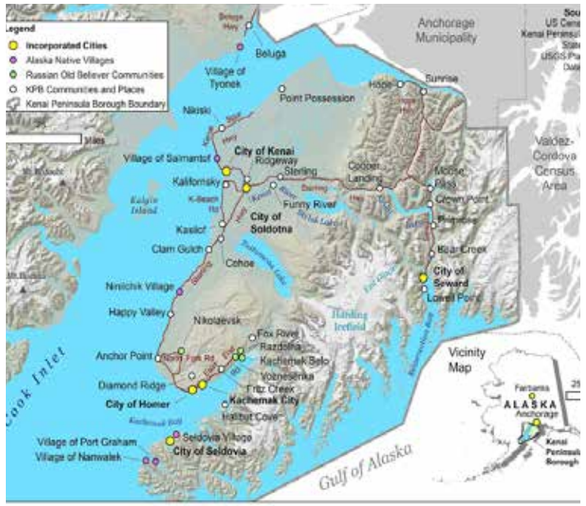
The Kenai Peninsula Borough (KPB) has a population of around 60,000 people. The economy is dependent on its rich natural resources, including fish and wildlife to support commercial fishing, recreation, and subsistence harvests; the oil and gas resources of Cook Inlet; and the magnificent landscapes and waterways, which attract tourists. As a result, the economy is sensitive to internal and external stressors that affect these natural resources.

The main purpose of this study was to document baseline conditions and trends in the KPB economy during a period marked by external events that influenced the resources and economy of the borough and its communities, including the Great Recession of 2008, the cyclical effects of the boom and bust of oil and gas exploration and development, and the COVID-19 pandemic of 2020. The study describes the socioeconomic structure of the borough and its communities and evaluated the role of the Alaska Native Claims Settlement Act regional and village corporations in the borough.

The findings will help BOEM understand the major socioeconomic trends and changes in the region to better evaluate impacts of potential future projects and planning efforts. Specifically, the report characterizes the baseline socioeconomic conditions for affected environment, environmental consequences, and cumulative effects analyses required in NEPA analysis, and may be useful for other planning efforts in the region.

>> Findings/Results

This study offers a comprehensive account of the socioeconomic characteristics of the KPB over a 13-year period **(2008–2020)**. The data are a combination of publicly available sources and primary information collected from outreach to regional agencies and organizations. This included stakeholder outreach facilitated through the Kenai Peninsula Economic Development District. Researchers describe the components of the KPB economy with focus on oil and gas, recreation, tourism, healthcare, social services, commercial fishing, and subsistence.



Map of the KPB and Borough Communities

In general, the KPB economy is a microcosm of the state economy with the oil and gas industry, commercial fisheries, tourism, and government as major economic drivers and employment sectors. Declining salmon populations, climate change, and limited access for tourism impacted economic activities over the analysis period.

Participation in outdoor recreation experienced moderate fluctuations between 2008 and 2019 and then a significant reduction in 2020 due to the effects of the global pandemic. Beyond the acute effects of the pandemic, sportfishing opportunities have been influenced by increasingly weak salmon runs and declining salmon sizes in the area. While salmon fishing declined, anglers fished for other species and the overall level of angling licenses in the region was relatively steady across the study before the pandemic.

KPB community members take part in non-commercial harvesting of wild resources by obtaining permits for subsistence, personal, or educational use. Data on subsistence and personal use of wild resources in the borough are limited but underscore the critical importance of access of rural communities in the borough to subsistence resources, both for food security and to maintain customary and traditional connections across generations of Alaska Native communities.

>> Final Report

Cuyno L, Schug D (Northern Economics, Inc., Anchorage, AK), Flight M, Bhattacharya A, Horsch E (Industrial Economics, Inc., Cambridge, MA). 2022. Kenai Peninsula Borough economy, 2008 to 2020. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 271 p. Report No.: OCS Study BOEM 2022-053. https://espis.boem.gov/final%20reports/BOEM_2022-053.pdf

The Kenai Peninsula Borough. Photo credit: KPEDD.

Cover image. Photo credit: KPEDD.

The University of Alaska Fairbanks' R/V Sikuliaq in offshore waters of Alaska. Photo by Jennifer Johnson, NOAA.

Marine Bird Distribution and Abundance in the Northern Bering and Chukchi Seas

Conducted by: *U.S. Fish and Wildlife Service*

National Studies List: *AK-17-03*

>> Purpose/Information Use

Seabirds are good indicators of changes in marine ecosystems, in part, because they are wide-ranging upper trophic level predators. Though seabirds spend most of the year offshore, data gaps are greatest for the portion of their lives spent on the open sea. This study provides a more complete and current dataset on Arctic seabird communities and their distribution in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea, including Hope Basin, Norton Basin, St. Matthew-Hall, and Navarin Basin.

Data on the distribution of marine birds is needed for ESA Section 7 consultations, NEPA analyses, and other documentation. Basic information on marine bird timing and duration of use within BOEM planning areas is necessary to better define environmental change impacts on seabirds.

This study provided current data and seasonal comparisons of the distribution and abundance of marine birds, and, secondarily, for marine mammals, within BOEM's Arctic planning areas. This project built on an established at-sea survey program to collect distribution data on marine birds via partnership and collaboration among the U.S. Fish and Wildlife Service (USFWS), BOEM, NPRB, and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS). The study determined the current species composition, distribution (including seasonal), and abundance of seabirds during the open water seasons of 2017–2021. The final report also presented results from examining migratory movements and nearshore and marine habitat use of red phalaropes in concert with at-sea surveys.

>> Findings/Results

Researchers conducted at-sea seabird surveys—for a total of 32,779 km within the focal study area from May to December 2017–2021—and recorded 78,403 marine birds representing 43 species and 4,580 marine mammals representing 18 species. The data from these collaborative vessel-based projects contributed 43,443 km of transects to the North Pacific Pelagic Seabird Database, from the northern Gulf of Alaska to the Arctic.

The University of Alaska Fairbanks's Research Vessel Sikuliaq offshore Alaska

For all planning areas combined, 10 species For all planning areas combined, 10 species accounted for 90% of total birds recorded on transect and species composition was similar between summer (June–August) and fall (September–November). Seabird density was highest in Hope Basin, followed by Navarin Basin and Norton Sound.

The most common planktivores (plankton eaters) were least auklet (***Aethia pusilla***), crested auklets (***A. cristatella***), and phalaropes, primarily in Norton and Hope basins, and the Chukchi Sea. High numbers of shearwaters (***Ardenna sp.***) were seen in Navarin Basin. The most common piscivores (fish eaters) were thick-billed murres (***Uria lomvia***), common murres (***U. aalge***), black-legged kittiwakes (***Rissa tridactyla***), and northern fulmars (***Fulmarus glacialis***). Murres were seen primarily in Navarin Basin, black-legged kittiwake densities were similar across the northern Bering and Chukchi seas, and northern fulmar were most abundant in Navarin Basin. Tagged red phalaropes often foraged in areas with areas of greater food availability, with stopover locations both on land and at sea.

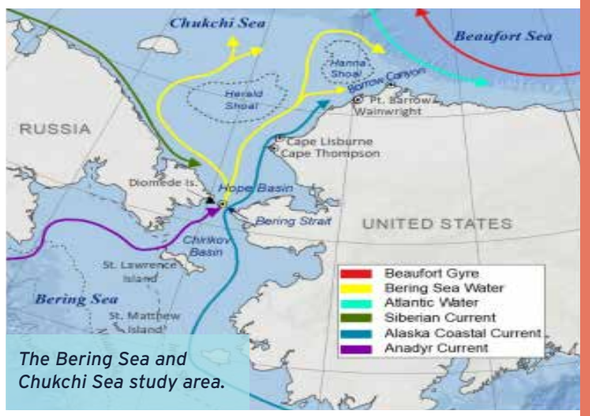
>> Final Report

Labunski EA, Kuletz KJ, Lanctot R, Saalfeld S, Morgan TC, McGuire RL, Gall AE (U.S. Fish and Wildlife Service, Anchorage, AK). 2022. Marine bird distribution and abundance in the northern Bering and Chukchi seas: final report. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 193 p. Report No.: OCS Study BOEM 2022-067. https://espis.boem.gov/Final%20Reports/BOEM_2022-067.pdf

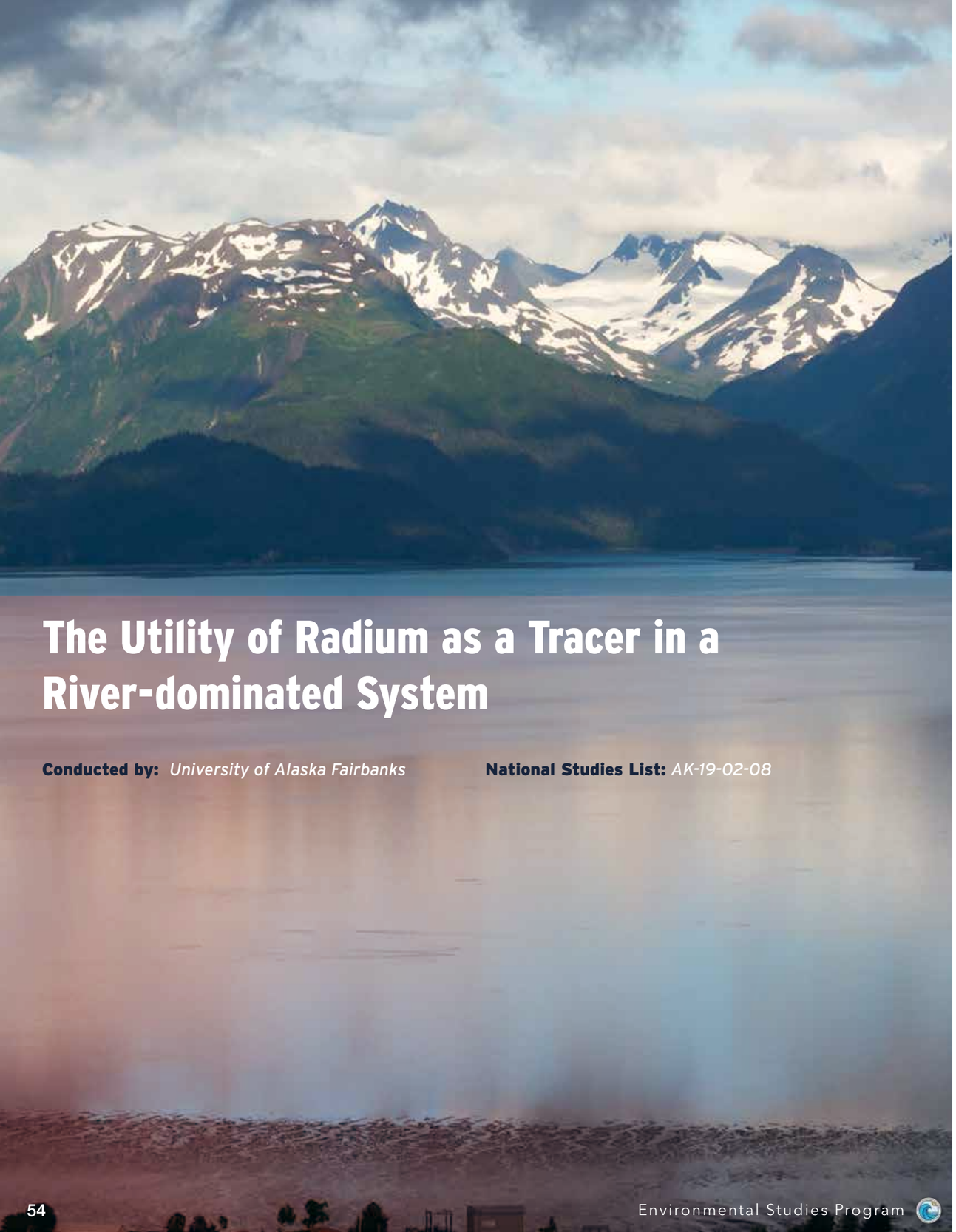
>> Also

Workshops, education outreach, and conference presentations 2018–2021
Interviews, cruise reports, websites, and press articles, including:

- Romano M, Renner HM, Kuletz KJ, Parrish JK, Jones T, Burgess HK, Cushing DA, Causey D. 2020. Die-offs and reproductive failure of murres in the Bering and Chukchi Seas in 2018. Deep Sea Res Part II. 181–182. https://doi.org/10.1016/j.dsr2.2020.104877.
- Piatt JF, Douglas DC, Arimitsu ML, Kissling, ML, Madison EN, Schoen SK, Kuletz KJ, Drew GS. 2021. Kittlitz's murrelet seasonal distribution and post-breeding migration from the Gulf of Alaska to the Arctic Ocean. Arctic. 74(4):482–495. https://doi.org/10.14430/arctic73992
- Drew GS, Piatt JF. 2020. North Pacific Pelagic Seabird Database (NPPSD): U.S. Geological Survey data release (ver. 3.0, February 2020). https://doi.org/10.5066/F7WQ01T3



The Bering Sea and Chukchi Sea study area.

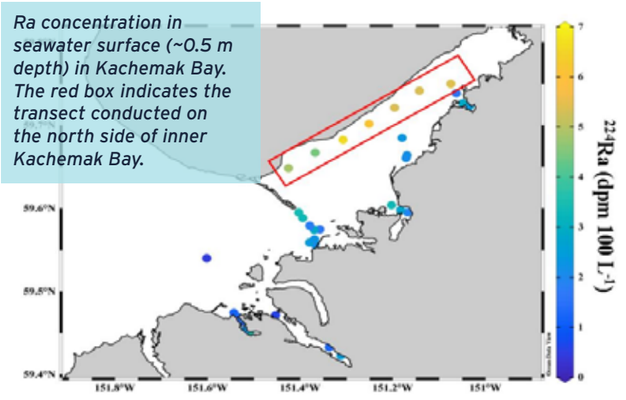


The Utility of Radium as a Tracer in a River-dominated System

Conducted by: *University of Alaska Fairbanks* **National Studies List:** *AK-19-02-08*

>> Purpose/Information Use

Submarine groundwater discharge **(SGD)** is an essential driver of biogeochemical cycles, but it is often difficult to estimate. SGD can enhance coral calcification, primary productivity, fisheries, denitrification, and pollutant reduction. However, SGD can also negatively alter a coastal ecosystem by eutrophication, algal blooms, deoxygenation, and localized ocean acidification.



Ra concentration in seawater surface (~0.5 m depth) in Kachemak Bay. The red box indicates the transect conducted on the north side of inner Kachemak Bay.

Unfortunately, there is a lack of SGD research in areas with extreme tidal ranges. High rates of SGD are expected in Kachemak Bay, an arm of Cook Inlet in southcentral Alaska. Cook Inlet has some of the world's greatest tidal ranges and has soft permeable sediment on most of the seafloor. SGD in Alaska can rival river fluxes as a nutrient source across the entire northern Gulf of Alaska.

This project examined the usefulness of radium-based approaches in Kachemak Bay in southcentral Alaska. Radium is a common tracer of groundwater nutrient inputs to the coastal ocean and is used to better understand coastal ocean ecosystems. Naturally occurring radium isotopes are well established as ideal groundwater tracers in coastal systems and have been used in a wide range of nearshore studies for nearly three decades. Because the four naturally occurring radium isotopes (Ra-223, Ra-224, Ra-226, Ra-228) decay at different rates (half-lives of 12 days, 4 days, 1,600 years, and 6 years, respectively), researchers can study processes at various oceanographic timescales.

Radium samples were taken from Kachemak Bay and six rivers that discharge into the bay. Exchangeable radium makes up the largest portion of the radium budget in a river and can desorb from riverine suspended solids, potentially masking groundwater radium signals.

>> Findings/Results

Results show strong correlations between radium isotopes and watershed characteristics shown by satellite imagery of the region, including elevation, area, slope, and land type (forest, glacier, wetland, and barren land).

This study revealed that suspended materials in rivers are a significant source of radium to the marine system, one that may be overlooked in studies that simply measure radium in fresh river water.

Underlying geology and river discharge need to be considered when applying radium-based approaches to other locations within Cook Inlet. Groundwater radium was only detected in bays and coastlines with minimal river discharge. The concentration of radium in offshore waters is depleted by groundwater and river inputs, such as Ra-244 concentration in exiting Kachemak Bay; therefore, short-lived radium can only be used as a tracer close to its source. Water samples taken away from the coastline are likely to be highly depleted in Ra-224, with potential "hotspots" only occurring in the presence of a shallow bank where sediments are mixed into the water column and desorb Ra-224, an offshore spring where groundwater Ra-224 is released, or other natural or human-introduced discharges carrying detectable short-lived radium signals compared to seawater's short-lived radium concentration.

>> Final Report

Haag J (University of Alaska Fairbanks, Fairbanks, AK). 2022. The utility of radium as a tracer in a river-dominated system. Anchorage (AK): U.S. Department of the Interior, Bureau of Ocean Energy Management. 20 p. Report No.: BOEM 2022-046. https://espis.boem.gov/Final%20Reports/BOEM_2022-046.pdf

ATLANTIC REGION

Examples of adult (left) and young of the year (year 0) settler sand lance captured in beam trawl tows.

Conducted by: *Stellwagen Bank National Marine Sanctuary*

National Studies List: *MM-17-05a*

Assessing the Biological and Oceanographic Processes that Drive Fisheries Productivity in New England Sand Shoals and the Potential for Dredging-related Disruption

>> Purpose/Information Use

Sand habitat is ecologically and economically critical, in part because it supports the sand-dependent sand lance (***Ammodytes dubius***)—a slender, silver fish—through all critical life history stages. Seabirds, whales, fish, and other species rely on the sand lance, one of their favorite foods.

The little sand lance, then, is vital to activities from fishing to whale watching that support coastal economies.

As climate change accelerates erosion, coastal habitats and economies can be protected through beach nourishment. But, when done poorly, sand dredging can harm offshore sand habitats that support fish and wildlife populations, ecosystem functions, and economic activities.

To assess how sand dredging may disrupt marine sand habitats, BOEM collaborated with the Stellwagen Bank National Marine Sanctuary (SBNMS), east of Boston, Massachusetts, between Cape Ann and Cape Cod, to learn more about the ecology of these habitats.

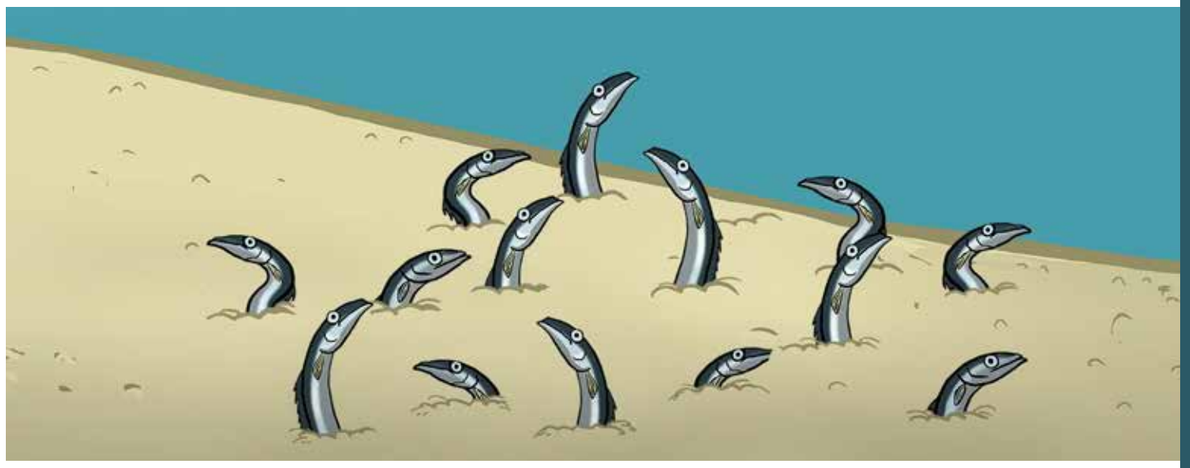
Because SBNMS is a federally designated national marine sanctuary, sand removal is prohibited. That, and SBNMS's long-term databases, made it the ideal place for studying the value of sand habitat, effects of sand habitat disruption, and identifying temporal windows when dredging might be reduced.

>> Findings/Results

Monitoring showed that spatial distributions of sand lance, humpback whales, and great shearwaters were highly correlated. Shipboard transects for seabirds showed that most species aggregated over sand habitat. Great shearwaters (***Ardenna gravis***) prefer using shallow sand habitat, according to data from 58 shearwaters tagged and tracked from 2013 to 2018. Sand lance, then, are key in shearwater habitat use.

Relationships among sand habitat, sand lance, and commercial fisheries show that sand habitat provided the most pounds landed for 8 of the 19 species examined, including the bluefin tuna and scallop fisheries. Sand habitat was the second most productive habitat in 10 other species, including cod and haddock. It was highly productive for 18 of the 19 species.

The outreach component of this study included a cartoon video about the importance of sand habitat and sand lance forage fish, and the BOEM-SBNMS collaboration about ocean mining of sand habitat. "Studying the Sand Lance" can be seen at *https://www.youtube.com/watch?v=bYxExZ3Ic98* (3:06 minutes).



A Twitter account (@trackseabirds) proved popular for keeping people aware of the project and related seabird information. Over 1,000 people followed the account. A free outreach program allowed teachers to plot great shearwater movements on specially designed charts.

>> Final Report

Wiley DN, Silva TL, Thompson MA, Baumann H, Kaufman L, Llopiz JK, Suca JJ, Valentine P (Stellwagen National Marine Sanctuary, Scituate, MA). 2021. Assessing the biological and oceanographic processes that drive fisheries productivity in New England sand shoals and the potential for dredging-related disruption. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 144 p. Report No.: OCS Study BOEM 2022-041. *https://espis.boem.gov/Final%20Reports/BOEM_2022-041.pdf*

>> Also

"Measuring the Ocean with OpenCTD & Professional Naturalists," an ArcGIS® StoryMap, available at *https://storymaps.arcgis.com/stories/ef90c68de96b42a884cd36919dec508c*

A free, outreach program allowing teachers to plot great shearwater movements, presented at the 43rd Annual Meeting and Conference of Massachusetts Marine Educators in Woods Hole, Massachusetts and made available to teachers.

A STEM education program was presented at the international 2020 World Seabird Twitter Conference (virtual) and had over 7,000 views on Twitter.

Behavioral Effects of Sound Sources from Offshore Renewable Energy Construction on the Black Sea Bass *(Centropristis striata)* and Longfin Squid *(Doryteuthis pealeii)*

Conducted by: *Woods Hole Oceanographic Institution*

National Studies List: *AT-17-02*

>> Purpose/Information Use

Black sea bass (***Centropristis striata***) and longfin squid (***Doryteuthis pealeii***), commercially important species, live in BOEM offshore renewable energy lease areas along the Atlantic coast north of Cape Canaveral. Offshore wind construction noise, especially that produced through pile driving of the foundations and support structure of wind turbines, could have significant impacts on these species.

Anthropogenic (human-caused) sound can have substantial effects on fish physiology and behavior (e.g., changes in migration routes, feeding or breeding grounds) and cause physical injury.

Lower level and/or chronic noise also can mask acoustic signals, and so interfere with behaviors, such as feeding, predator avoidance, group cohesion, and/or spawning success. Black sea bass could be vulnerable because they are known to use acoustic communication and because their habitats overlap within renewable energy lease areas.

Such effects on an animal's behavior may then also affect populations and ecosystems. They may move away from breeding or feeding grounds or divert from migration routes. Interfering with animals' acoustic communication can affect reproductive behaviors and prevent correct detection of other biologically relevant sounds, such as predator detection. For example, black sea bass produce sounds, such as grunts and thumps, associated with feeding and escape.

With multiple, potentially concurrent, construction efforts taking place along the northeast coast, the sound—not just from the nearest development regions, but also those at a distance—may affect the fishes in these regions.

These six controlled-exposure studies examined the response of black sea bass and longfin squid to pile driving sounds using playbacks of recorded sound pile-driving within a tank environment to evaluate behavioral and physiological effects during sound exposure.

>> Findings/Results

Together, the results of these studies suggest that antipredator and feeding behaviors may be changed during exposure to noise.

Black sea bass exposed altered their behavior and reduced activity. They showed diminished behavioral response within an exposure period, which could indicate habituation, but with increased responses among exposure periods, which could indicate re-sensitization.

Squid exposed to pile driving noise responded with alarm behaviors, suggesting that they detected and were dramatically influenced by this noise. But responses over several noise impulses suggested an increased tolerance, over time, to the noise source and suggested these squid may have behaviorally habituated.

Black sea bass

Overall, results indicate that black sea bass and longfin squid responses to sound are most likely to occur when noise begins. Rapid habituation is expected, with some re-sensitization, and reproductive behaviors may be relatively resilient to noise stressors.

>> Final Report

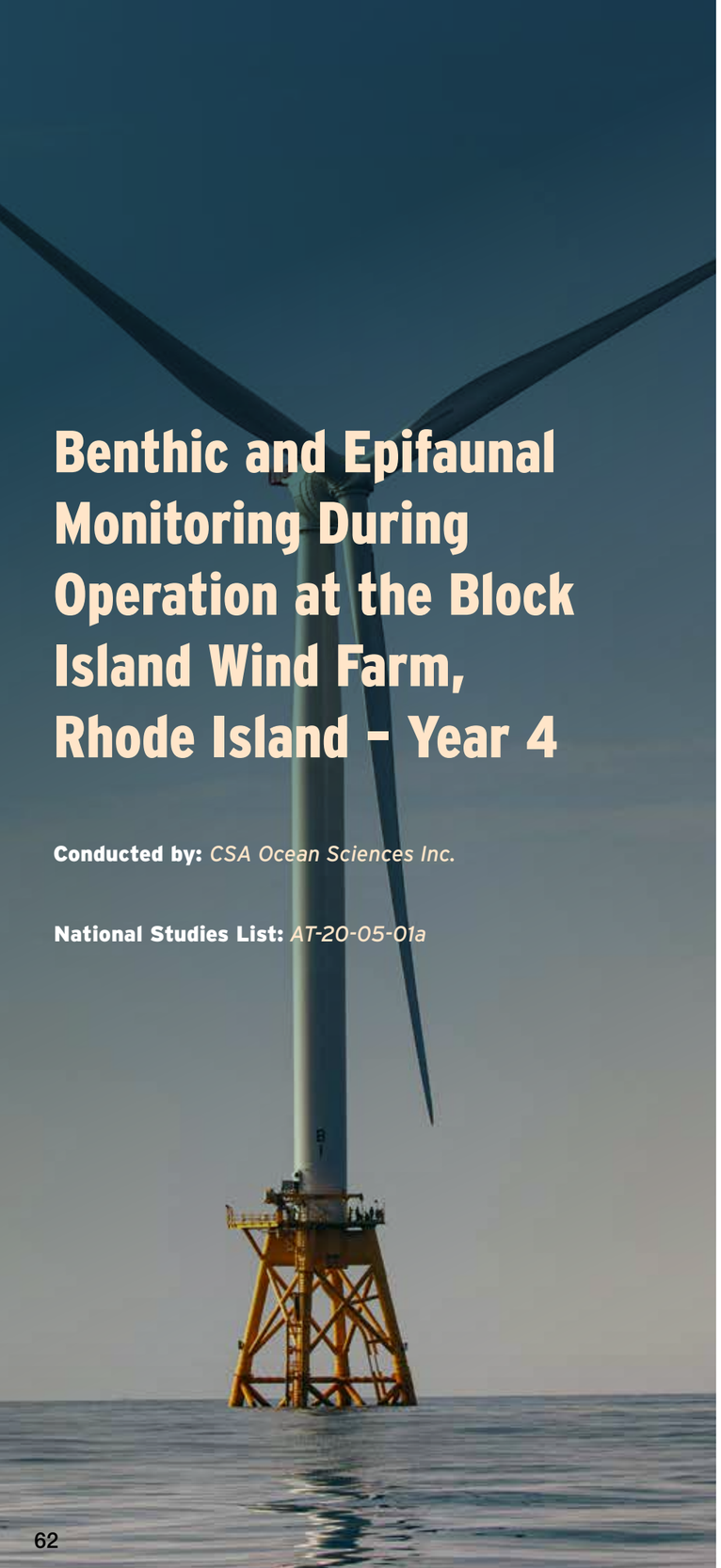
Stanley J, Mooney TA, Jones IT, Phelan B, Van Parijs SM, Shelledy K. (Woods Hole Oceanographic Institution, Woods Hole, MA). 2023. Behavioral effects of sound sources from offshore renewable energy construction on the black sea bass (Centropristis striata) and longfin squid (Doryteuthis pealeii). Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 140 p. Report No.: OCS Study BOEM 2022-004. *https://espis.boem.gov/final%20reports/BOEM_2022-004.pdf*

>> Also

Jones IT, Stanley JA, Mooney TA. 2020. Impulsive pile driving noise elicits alarm responses in squid (Doryteuthis pealeii). Mar Poll Bull. 150: 110792. *https://doi.org/10.1016/j.marpolbul.2019.110792*.

Jones IT, Peyla, JF, Clark H, Song Z, Stanley JA, Mooney TA. (2021). Changes in feeding behavior of longfin squid (Doryteuthis pealeii) during laboratory exposure to pile driving noise. Mar Environ Res. 165:105250. doi.org/10.1016/j.marenvres.2020.105250

Longfin squid



Benthic and Epifaunal Monitoring During Operation at the Block Island Wind Farm, Rhode Island – Year 4

Conducted by: *CSA Ocean Sciences Inc.*

National Studies List: *AT-20-05-01a*

>> Purpose/Information Use

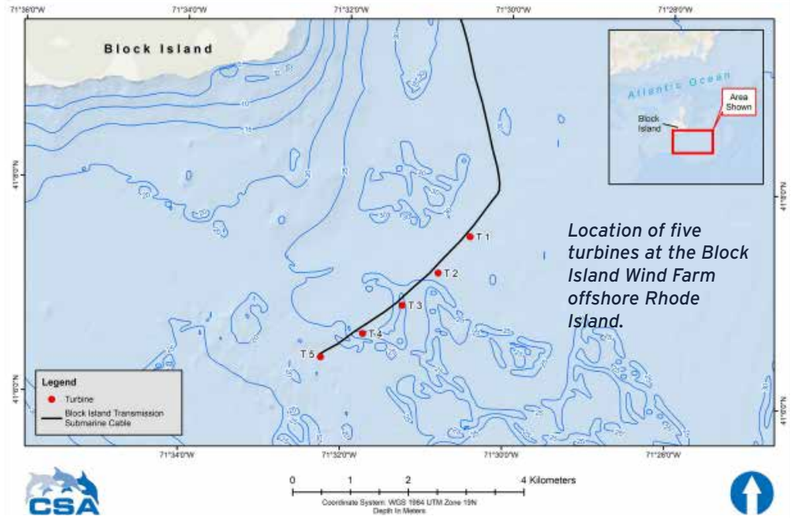
Because offshore wind energy development is relatively new to the U.S., data are needed to assess environmental impacts. To collect the necessary data, BOEM initiated the Realtime Opportunity for Development Environmental Observations (RODEO) Program, which makes direct, real-time measurements of the nature, intensity, and duration of potential stressors during the construction and initial operations of selected offshore wind facilities.

The overall goal of the multiyear monitoring study at the Block Island Wind Farm (BIWF) off the coast of Rhode Island is to better understand the nature and the potential spatial and temporal scales of the expected changes in benthic macrofaunal community characteristics caused by the BIWF. Those characteristics include species abundance, richness, and diversity; assemblage structure; and localized effects of structure-related macrofaunal communities on associated environments.

Changes in benthic conditions may result from the presence of the offshore wind turbine structures, which can modify local hydrodynamic conditions and sediment grain size distribution. The underwater structures provide substrate with vertical relief for the growth of epifaunal marine organisms (biofouling), not unlike drilling platforms. Benthic habitat and biota near offshore turbines likely will be influenced by the epifaunal communities—such as crabs, sea stars, barnacles, and mussels—developing on the structures. Over time, these structure-related communities can provide continuous organic input to the surrounding seabed from biomass sloughing due to predator activity, storms, senescence, and feces. As it accumulates at the base of the foundation, this organic enrichment could influence sediment characteristics, which may lead to changes in benthic macrofaunal community diversity and abundance.

Based on preliminary studies in Europe, changes in benthic composition due to wind farm operation can be anticipated within 50 m of the foundation scour protection systems, with the possibility of a long-term shift in community composition, which may extend farther.

For this study, the field components of the benthic and epifaunal monitoring consisted of grab sampling (both vessel- and diver-based); seabed video using a camera affixed to the grab sampler; and diver-collected epifaunal scrape samples and video imagery.



Location of five turbines at the Block Island Wind Farm offshore Rhode Island.

>> Findings/Results

Seabed characteristics studied include species abundance, richness, and diversity; assemblage structure; and localized effects of structure-related macrofaunal communities on associated environments. While long-range and large-scale changes in benthic conditions were not expected from the presence of the five BIWF turbines, localized alterations to seabed characteristics near the foundations were anticipated but poorly understood. Benthic habitat and biota in the immediate vicinity of offshore turbines may be influenced by the epifaunal communities developing on the structures.

A total of 135 grab samples were collected and analyzed for sediment grain size, total organic carbon, total organic matter, and benthic infauna. Benthic habitat and Coastal and Marine Ecological Classification Standard biotic classifications were based on interpreted videos and images from the grab sampler camera.

Substantial changes to the seabed sediments and faunal composition were observed mainly in the immediate footprint of the turbine foundations. Aside from a shift in particle size, there is little evidence of a pattern of change in seabed physical and biological composition in the surrounding environment (i.e., farther than 10 m from the foundation footprint). Lack of a systematic pattern suggests that much of the intra- and interannual differences may be attributed to natural fluctuations, especially in epifauna, including that on the turbine structure itself.

Many of the trends found in Year 1–3 of this study continued in Year 4, which had a more continuous and comparative statistical design. The area of sampling was large enough to observe environmental changes (when they were present) stabilizing with distance.

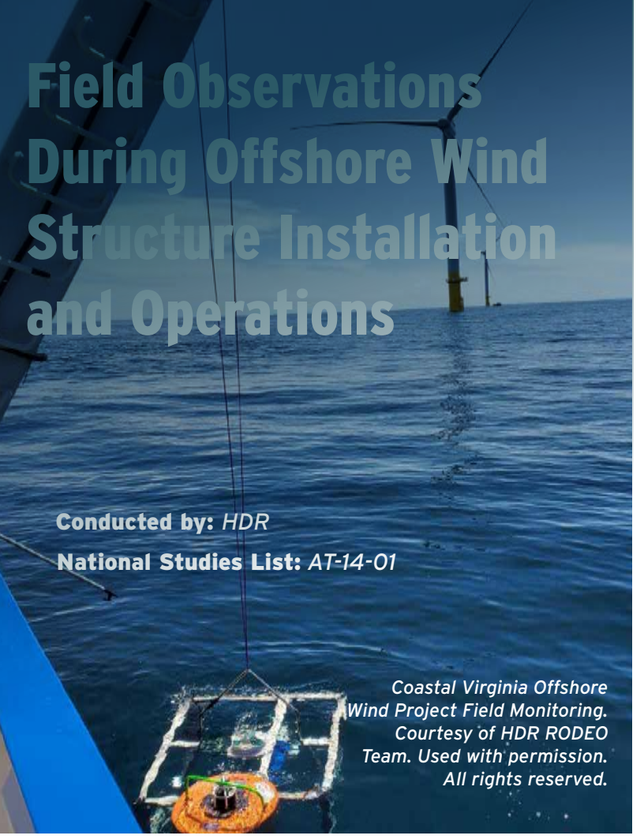
>> Final Report

Erickson R, Kelly C, Fonseca M, McMahon A, Tiggelaar J, Graham B (CSA Ocean Sciences Inc., Stuart, FL). 2022. Benthic and epifaunal monitoring during operation at the Block Island Wind Farm, Rhode Island – technical report - year 4. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 405 p. Report No.: OCS Study BOEM 2022-068. *https://espis.boem.gov/final%20reports/BOEM_2022-068.pdf*

Field Observations During Offshore Wind Structure Installation and Operations

Conducted by: *HDR*

National Studies List: *AT-14-01*



Coastal Virginia Offshore Wind Project Field Monitoring. Courtesy of HDR RODEO Team. Used with permission. All rights reserved.

>> Purpose/Information Use

BOEM's RODEO program made direct, real-time measurements of the nature, intensity, and duration of potential stressors during the construction and initial operations of selected offshore wind facilities. This study monitored the construction of 1) a meteorological tower in the proposed Maryland Wind Energy Lease Area, and 2) two monopile wind turbines installed in May 2020 off the coast of Virginia. The Coastal Virginia Offshore Wind Pilot Project is the second location (after BIWF) where offshore wind turbines were constructed.

The program also recorded direct observations during the testing of different types of equipment or methods that may be used during future offshore development to measure or monitor activities and their impact-producing factors. Data collected under RODEO may be used as input to analyses or models to predict effects from future offshore wind farm construction and operation activities.

Study objectives for the Maryland Offshore Wind Farm Project included measuring underwater sound generated by pile driving during the installation of the proposed meteorological tower.

Study objectives for the Coastal Virginia Offshore Wind Pilot Project

- Measure and analyze underwater sounds generated by pile driving during the installation of two monopile turbines
- Measure and evaluate the efficacy of an underwater noise mitigation system (double big-bubble curtain)
- Measure and analyze underwater sound levels within the water column and seafloor sediment vibrations generated by the operating monopile turbines
- Gather and analyze data to improve understanding of the dynamics of marine growth (biofouling) on offshore structures, detect any influence on local turbidity levels that may occur due to increased seabed sediment disturbance and mixing of the water column in the tidal wake of the foundation structures, and characterize the corrosion of steel plates following different treatments.

>> Findings/Results

Volume 1 (*BOEM 2021-025*)

- Due to several factors, the meteorological evaluation tower was not constructed.
- Preliminary analyses of data collected over a four-week period indicated that ambient noise was largely dependent on sea state.
- Analysis of noise from shipping activity, storms, and marine fauna revealed spatial variations in the lower levels of acoustic energy in the lower frequencies, and higher energies in the higher frequencies.
- Two of the four monitoring sites were located near the shipping lanes. Unexpectedly, the sites closer to the shipping lanes had lower overall cumulative noise levels than sites farther away.
- Overall, data recorded had a similar range of sound levels compared to those observed during other passive acoustic monitoring studies conducted in the southern part of the Maryland Wind Energy Area (WEA).

Volume 2 (*BOEM 2023-033*)

- Operational sound was measurable and similar to ambient sound in the ocean.
- Particle acceleration levels were below hearing thresholds for Atlantic cod, dab, and Atlantic salmon.
- Intensity and propagation of underwater sounds associated with offshore wind structure construction pile driving were site- and season-specific, and greatly influenced by both the pile driving technology and type of foundation (jacket structure versus monopile).
- Underwater sounds created by monopile turbine operations were below the temporary and permanent threshold shift onset criteria for marine mammals recommended by the NMFS. Operational phase underwater sound levels, especially at frequencies below approximately 120 Hz, appeared to vary with the foundation type.

Volume 3 (*BOEM 2023-034*)

- Turbidity due to the presences of the turbines was not observed at distances of 400–500 meters; however, there could have been localized sediment suspension.
- Corrosion rates for untreated steel coupons exceeded published guidance for the first six months of immersion but fell below guidance values after this time. After six months, corrosion rates were comparable with those recorded in historical studies within the wider region. No consistent pattern of corrosion rates with depth was detected. Localized but aggressive corrosion, in the form of pitting, was noted on some treated coupons.
- Biofouling was observed within the first three months with the attachment of hydroids. This was followed by mussels, which developed into dense clumps. Growth of biofouling fauna after two years (mostly Mytilus sp.) at intermediate and near seabed depths (15 and 20 m, respectively) were very prolific and beyond expectations.

>> Final Reports

HDR. 2020. Field observations during offshore wind structure installation and operation. Volume 1: final report. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 343 p. Report No.: OCS Study BOEM 2021-225. *https://espis.boem.gov/final%20reports/BOEM_2021-025.pdf*

HDR. 2023. Field observations during offshore wind structure installation and operation. Volume 2: final report. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 48 p. Report No.: OCS Study BOEM 2023-033. *https://espis.boem.gov/final%20reports/BOEM_2023-033.pdf*

HDR. 2023. Field observations during offshore wind structure installation and operation. Volume 3: final report. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 225 p. Report No.: OCS Study BOEM 2023-034. *https://espis.boem.gov/final%20reports/BOEM_2023-034.pdf*

>> Also

BOEM RODEO web page includes links to related publications and BOEM's RODEO Flickr page

Fish around a turbine *https://www.youtube.com/watch?v=nXyVGGNw5vs*

Epifouling around a turbine, and the lifeforms on it *https://www.youtube.com/watch?v=Y45F1pb9PVc*

Coastal Virginia Offshore Wind Project Field Monitoring. Courtesy of HDR RODEO Team. Used with permission. All rights reserved.

Larval Lobster and Fish Neuston Net Survey for Regional Fisheries Monitoring in Southern New England Offshore Wind Development

Conducted by: *University of Massachusetts Dartmouth, School for Marine Science and Technology*

National Studies List: *AT-21-x06*

>> Purpose/Information Use

The southern New England offshore wind lease areas begin roughly 25 km south of Rhode Island. Several lease areas have been awarded to companies for development. Establishing a larval abundance baseline in the WEAs is important because native species may be affected by the turbines generating noise, altering habitats, introduction of electromagnetic fields, and shifting physical oceanographic parameters.

As part of extensive pre- and post-construction research initiatives in the first Vineyard Wind lease area, this study estimated the relative abundance and distribution of larval lobster and fish. Vineyard Wind is 15 miles south of Martha's Vineyard and Nantucket, and 35 miles from mainland Massachusetts.

Lobster stocks in the Gulf of Maine have increased to record highs, while those in southern New England have declined to very low levels. The southern New England lobster resource and associated fishery have moved to offshore areas where the stock redistribution overlaps with wind farm lease areas. This was likely caused by increased water temperatures inshore and lobster's sensitivity to heat; lobster larvae are planktonic for about two months and are distributed by the ocean currents from offshore spawning locations to the nearshore of southern New England.

Installing offshore wind turbines may introduce an artificial reef effect, which occurs when a hard substrate put into an environment provides a surface for species like bivalves, bryozoans, crustaceans, and sponges to colonize and form the basis of a food web. Larger predator and reef associated species may visit or stay at this new habitat for shelter and food. The increased suitable habitat and number of predators may affect post-settlement lobster densities.

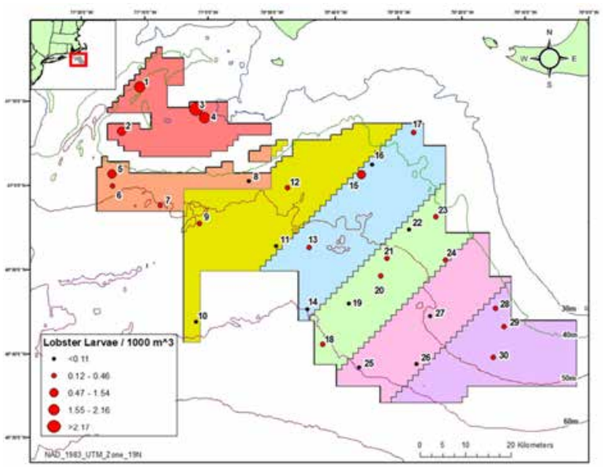
The researchers conducted ventless lobster trap, black sea bass pot, and plankton surveys using Neuston nets (long, conical fine-mesh nets that sample the upper layer of the ocean, the Neuston layer) to assess the pre-construction environment. This study was conducted from May to September 2020 and May to June 2021 at 30 randomly distributed stations.

An example of a larval sample with stage II, II, and IV lobster larvae from Buzzards Bay.

>> Findings/Results

The larval lobster and fish Neuston net surveys provided strong baseline abundance and distribution data for larval species in the Massachusetts-Rhode Island WEA. The survey showed the pre-construction presence of species and, moving forward, can be compared to post-construction larval abundance. Patterns of larval abundance show seasonal variations, with larval lobster and crab detections highest in June, and fish abundance highest in September.

This larval survey is the first regional assessment of its kind and is intended to provide strong baseline data for future comparisons as the wind companies develop lease areas. Results from this study a) estimated distribution of larval species in the areas of concern, b) correlated abundance data with environmental factors (temperature, salinity, pH, and dissolved oxygen), and c) determined the seasonal variations of larval species in the wind energy lease areas. Baseline data may be used in future studies and analysis as the planned wind farm projects continue.



Larval lobster abundance throughout all sampling periods (May and June 2021).

>> Final Report

Stokesbury KDE, Cassidy K, Lowery TM, Norton R, Painten A. 2023. Larval lobster and fish Neuston net survey for regional fisheries monitoring in southern New England offshore wind development. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 86 p. Report No.: OCS Study BOEM 2022-070. https://espis.boem.gov/final%20report/BOEM_2022-070.pdf

Passive Acoustic Telemetry as a Tool to Monitor the Baseline Presence and Persistence of Highly Migratory Fish Species in Popular Recreational Fishing Grounds within the Southern New England Wind Energy Area

Conducted by: *Massachusetts Clean Energy Center*

National Studies List: *AT-21-x06*

>> Purpose/Information Use

Southern New England's offshore waters are important feeding grounds and migratory corridors for many highly migratory pelagic fish species (HMS), such as sharks, tunas, billfish. This region includes Essential Fish Habitat (EFH) for at least 14 HMS and also supports extensive recreational fisheries. Much of this EFH is concentrated on popular fishing grounds that are also within areas leased for offshore wind development. To assess baseline conditions for gauging potential impacts, researchers conducted a two-year pilot study during the summers of 2020 and 2021. The aim was to ascertain the usefulness of passive acoustic telemetry for directly monitoring the presence, persistence, and movements of recreationally important HMS in and around popular recreational fishing locations within the Massachusetts-Rhode Island WEA.

Researchers focused acoustic transmitter deployments on commonly captured HMS and monitored their presence with a stationary array of acoustic receivers. Fifteen acoustic receivers were placed in and around popular recreational fishing areas within the WEA, and 60 transmitters were deployed on five different species of HMS (bluefin tuna, blue shark, shortfin mako shark, sandbar shark, and smooth hammerhead shark). Environmental data collected by each receiver was assigned to each detection to examine patterns of environmental preference. All detection data were shared with the Mid-Atlantic Acoustic Telemetry Observation System (MATOS); the researchers exchanged information on detections of fish tagged as part of the study and detected by other researchers, as well as fish tagged by other researchers detected within the study area.

>> Findings/Results

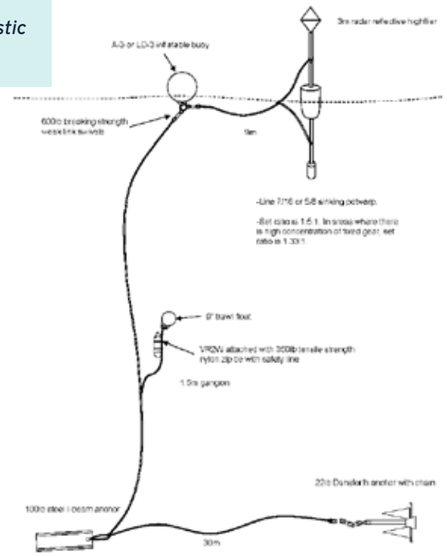
Of the 60 tagged individuals, 35 were detected by the receiver array, totaling 1,296 detections. Movement patterns of each species were variable between 2020 and 2021, with movement between each of the popular fishing locations in both years. The 37 individuals tagged for this study were detected in receiver arrays deployed for other research purposes, with detections as far south as North Carolina and as far north as the Scotian Shelf. Over the course of the study, 206 transmitters deployed by other researchers across 17 species (with eight unknown transmitters) were detected (4,931 total detections) within the study area.

Results demonstrate the capabilities of passive acoustic telemetry to effectively collect baseline data on the presence, persistence, movements, and habitat use of HMS within the WEA. Deploying acoustic receivers at fixed locations at or adjacent to popular fishing locations also allowed the researchers to evaluate species presence and availability to the large, directed seasonal recreational fishery for HMS in the region.

The detection of large numbers of individual transmitters from a wide range of tagged species also demonstrates the utility of passive acoustic telemetry as a multispecies monitoring system and underscores the need for coordination and data sharing between acoustic telemetry monitoring studies being conducted along the U.S. East Coast.

Mooring configuration used to deploy VEMCO VR2-AR receivers

VR2-TX acoustic receivers



>> Final Reports

Gervelis B, Kneebone J (Massachusetts Clean Energy Center, Boston, MA). 2022. Passive acoustic telemetry as a tool to monitor the baseline presence and persistence of highly migratory fish species in popular recreational fishing grounds within the southern New England Wind Energy Area. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 40 p. Report No.: OCS Study BOEM 2022-059. https://espis.boem.gov/final%20report/BOEM_2022-059.pdf

Sustained Monitoring of Zooplankton Populations at the Coastal Maine Time Series (CMTS) and Wilkinson Basin Time Series (WBTS) Stations in the Western Gulf of Maine: Results from 2005–2022

Conducted by: *University of Maine Darling Marine Center*

National Studies List: *AT-18-x01*

>> Purpose/Information Use

Plankton is made up of phytoplankton (microalgae) and zooplankton (tiny aquatic animals, such as crustaceans, insect larvae, mites, and copepods). Plankton is a crucial part of the aquatic food chain because larger invertebrate predators and fish feed on them. Extremely sensitive to changes in aquatic ecosystems, zooplankton species' composition, abundance, and distribution can help determine effects of environmental disturbances.

Calanus finmarchicus, a planktonic copepod, is vital to pelagic ecosystems in the North Atlantic Ocean and is a foundation species of the Gulf of Maine subarctic food web. A decrease of ***C. finmarchichus*** could be detrimental to the North Atlantic right whale, for whom it is a primary prey, and many fisheries species.

Two currents are the sources of the ***C. finmarchis*** supply: the southward flow of the coastal Nova Scotia Current and shelf-break Labrador Current. However, these currents appear to have been constricted by a landward shift in the position of the Gulf Stream, which has forced warmer, saltier slope water on the northwest Atlantic shelf and into the Gulf of Maine. Over the past decade, mean water column temperatures in the Gulf of Maine have been rising rapidly, on the order of 0.12°C per year. There is evidence of a marked shift in oceanographic conditions around 2010.

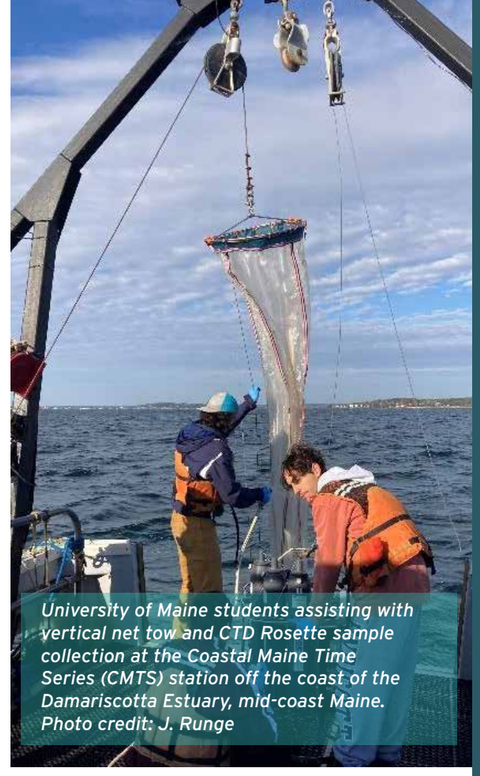
One dramatic ecosystem effect of this shift has been the displacement of summer foraging habitat for North Atlantic right whales, from the eastern Gulf of Maine to the Gulf of St. Lawrence, because of a substantial shift in the abundance of ***C. finmarchicus*** at these locations.

The goals of this study were to collect and analyze samples from the WBTS and CMTS stations, as part of the Integrated Sentinel Monitoring Network (ISMN) Gulf of Maine Marine Biodiversity Observation Network (MBON) project. The WBTS and CMTS stations are strategically located in the western Gulf of Maine to monitor planktonic ecosystem characteristics in the Maine Coastal Current, which is a regional production driver, and in Wilkinson Basin, the primary overwintering habitat for the energy-rich foundation species, ***C. finmarchicus***.

>> Findings/Results

The WBTS and CMTS datasets show a zooplankton response to the oceanographic regime shift that was reported to have occurred in 2010. ***C. finmarchicus*** abundance in summer through winter declined (to 15–40% of 2005–2010 levels). At the same time, abundance of smaller species and biodiversity increased, reflecting increases in phytoplankton food availability in summer through winter months. Overall, zooplankton biomass and size structure has decreased in the Gulf of Maine since 2010.

The seasonal Calanus Index developed as part of this study shows promise as a useful tool for near real-time assessment of ***C. finmarchicus*** abundance. Because ***C. finmarchicus*** is the dominant mesozooplankton species (organisms representing the link between primary producers and higher trophic levels) in the Gulf of Maine—and there is no obvious replacement for it in the food web—the real-time assessment of ***C. finmarchicus*** is an indicator of the health of the subarctic Gulf of Maine food web and could be useful as a predictor of abundance and condition trends of higher trophic levels, such as the North Atlantic right whale, forage fish, and possibly lobster.



University of Maine students assisting with vertical net tow and CTD Rosette sample collection at the Coastal Maine Time Series (CMTS) station off the coast of the Damariscotta Estuary, mid-coast Maine. Photo credit: J. Runge

>> Final Report

Runge J, Karp Boss L, Dullaert E, Ji R, Motyka J, Young-Morse R, Pugh D, Shellito S, Vandemark D. (University of Maine, Orono, ME). 2023. Sustained monitoring of zooplankton populations at the Coastal Maine Time Series (CMTS) and Wilkinson Basin Time Series (WBTS) stations in the western Gulf of Maine: Results from 2005-2022. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 40 p. Report No.: OCS Study BOEM 2023-015. https://espis.boem.gov/final%20reports/BOEM_2023-015.pdf

>> Also

The datasets currently in development are available on the ISMN ERDDAP server, http://ismn.erddap.neracoos.org/erddap/info/index.html?page=1&itemsPerPage=1000, including the Gulf of Maine WBTS Calanus Abundance Observations.

Ji R., Runge JA, Davis CS, Wiebe P. 2022. Drivers of variability of *Calanus finmarchicus* in the Gulf of Maine: roles of internal production and external exchange. ICES J Mar Sci. 79 (3): 775– 784. https://doi.org/10.1093.

Ross CH, Runge JA, Roberts JJ, Brady DC, Tupper B, Record NR. 2023. Estimating North Atlantic right whale prey based on *Calanus finmarchicus* thresholds. Mar Ecol Prog Ser. 703: 1–16.

Runge JA, Ji R, Record N, Pendleton D, Motyka J. 2022. Shifting biodiversity and effects on ecosystem services in the Gulf of Maine: The role of *Calanus finmarchicus*. AGU-ASLO Ocean Sciences Meeting, 2022 27 Feb–3 Mar (Virtual).

Transparent Modeling of Collision Risk for Three Federally Listed Bird Species in Relation to Offshore Wind Energy Development

Juvenile red knot

Conducted by: *Biodiversity Research Institute, USFWS*

National Studies List: *AT-21-x07*

>> Purpose/Information Use

The risk of avian collisions with offshore wind turbines is often estimated by using collision risk models. These models typically use avian density data derived from observational survey datasets for a location, along with a suite of behavioral and site-specific variables that predict collision risk.

This study developed a model to assess exposure and collision risk of federally protected birds from offshore wind energy development in the U.S. Atlantic. Currently, a stochastic (randomly derived) collision risk model for seabirds is used to estimate collision impacts from offshore wind energy development in parts of Europe.

However, very limited survey data are available for the three federally protected bird species in the U.S. Atlantic: the roseate tern (***Sterna dougallii***), piping plover (***Charadrius melodus***), and red knot (***Calidris canutus***). The majority of available data in the U.S. Atlantic on the offshore movements and distributions of these taxa come from BOEM-funded studies that used automated radio telemetry to track individuals in the proximity of receiving stations along the coast. This work was conducted in collaboration with the Motus Wildlife Tracking System, an international automated radio telemetry network on coordinated frequencies.

In order to use the best available data for understanding collision risk for these species, researchers used movement modeling to determine monthly occupancy rates over a portion of the U.S. Northeastern Continental Shelf Ecosystem (NES) and then linked those values to monthly population estimates to estimate density across the NES. The collision risk model then used these density estimates at specific flight heights along with other species and site characteristics (i.e., species-specific flight speeds, number of turbines in a specified turbine array) to estimate collision risk for locations across a portion of the NES where tracking data were available.

>> Findings/Results

To help estimate collision risk for the three federally protected bird species from offshore wind farms in the U.S. Atlantic, this study developed and made publicly available an online web application of the model, called Stochastic Collision Risk Assessment for Movement (SCRAM), an accompanying user manual, and fully annotated computer code. The Motus movement models, species data, flight height distributions, and collision risk models are all publicly accessible via the SCRAM online web application and accompanying user manual. The underlying code is available in a GitHub code repository.

This report accompanies the published model and presents associated case study data to guide evaluation of collision risk of roseate tern, piping plover, and red knot at offshore wind energy areas in the U.S. Atlantic. It also includes a framework for using site-specific data to estimate cumulative collision risk across spatiotemporal scales.

SCRAM will continue to be updated with model improvements, bug fixes, and additional functionality in the coming years; future changes will be documented in the GitHub repository and on the SCRAM web page at briwildlife.org/SCRAM.

>> Final Reports

Adams EM, Gilbert A, Loring P, Williams, KA (Biodiversity Research Institute, Portland, ME, and U.S. Fish and Wildlife Service, Charlestown, RI). 2022. Transparent modeling of collision risk for three federally listed bird species in relation to offshore wind energy development: final report. Washington (DC): U.S. Department of the Interior, Bureau of Ocean Energy Management. 79 p. Report No.: OCS Study BOEM 2022-071. *https://espis.boem.gov/final%20reports/BOEM_2022-071.pdf*

Also:

Model code: *https://github.com/Biodiversity-Research-Institute/SCRAM*

Web application: Stochastic Collision Risk Assessment for Movement (SCRAM). 2022. Version 1.0.3. Available at *https://briloon.shinyapps.io/SCRAM/*

User manual for web application: *https://briloon.shinyapps.io/SCRAM/* (Available via the book link at the header of the application UI)

Understanding Economic Impacts to the Commercial Surfclam Fishing Industry from Offshore Wind Energy Development

Conducted by: *Rutgers, The State University of New Jersey; Haskin Shellfish Research Laboratory*

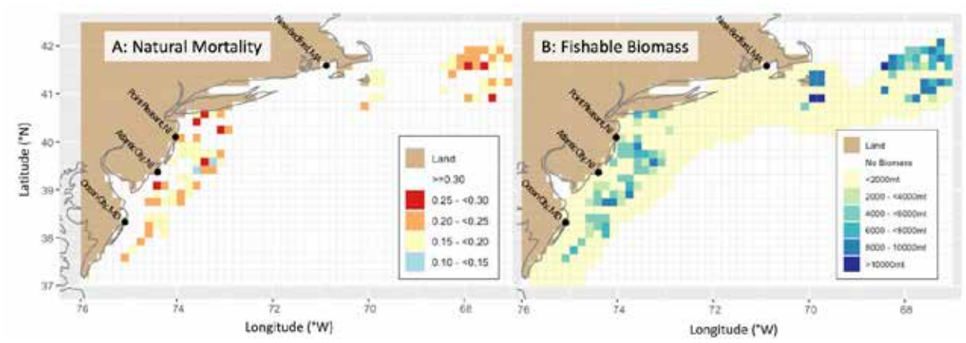
National Studies List: *AT-19-03*

>> Purpose/Information Use

The Atlantic surfclam (***Spisula solidissima***) fishery is one of the most exposed fisheries to impacts from offshore wind energy development because of port location, an overlap of fishing grounds with WEAs, and the nature of the gear and vessels used. Understanding and anticipating potential effects of offshore wind energy development on marine fisheries resources are important because fisheries and resources may be affected in terms of habitat alteration, changes to sound and energy landscapes, fisheries exclusion, and fishing effort displacement (changes in the spatial distribution of fishing activity).

In the U.S., there are no legal restrictions on fishing activities or vessel transit in offshore wind facilities. However, fishing effort displacement may result from direct or indirect exclusion, or because, in response to changes in transit routes, operational considerations, or fishing conditions. alternative fishing locations become more or less advantageous.

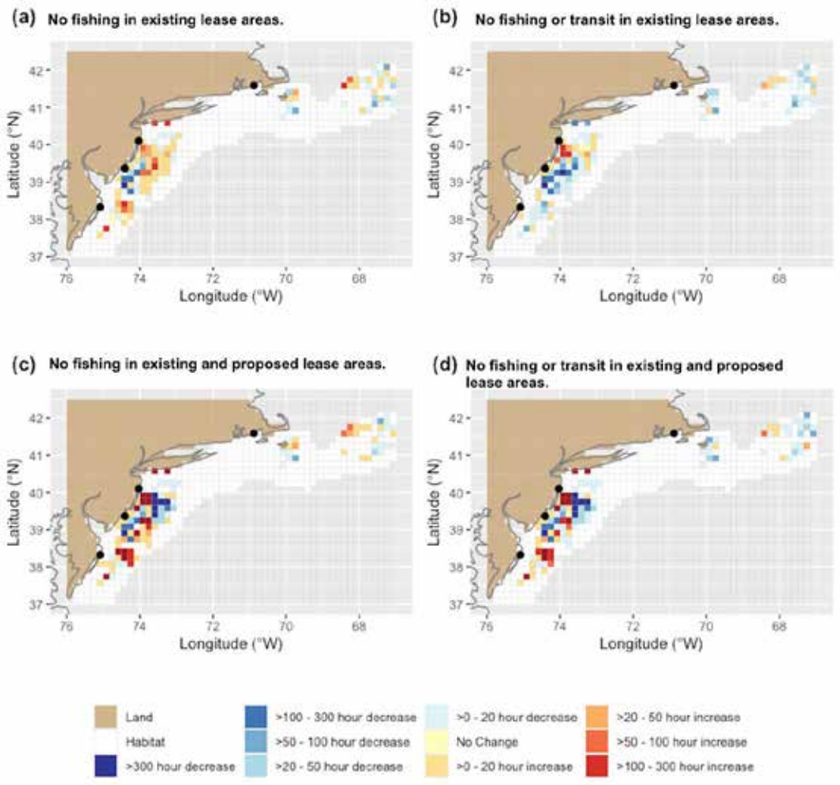
This study used a modeling tool that integrates spatial dynamics in Atlantic surfclam stock biology, fishery captain and fleet behavior, Federal management decisions, and fishery economics. Fishing activity and economic outcomes were simulated under different offshore wind energy development scenarios that impose spatial restrictions on Atlantic surfclam vessel fishing and transiting behavior. This evaluation of the possible scale of impacts of offshore wind development on the Atlantic surfclam fishery and its management can help inform strategies to allow the coexistence of multiple sectors of ocean users.



Map of surfclam mortality and biomass in the SEFES model domain.

>> Findings/Results

This study developed a spatially explicit, ecological-economic agent-based Atlantic surfclam fishery model to quantitatively evaluate the fishery and its economics. Model simulations show that, cumulatively, across all offshore WEAs, revenue losses across the fishing fleet range from 3% to 15% depending on the scenario simulated. Simulations also show that exclusion of the stock assessment survey from WEAs will make approximately 3% to 17% of the Atlantic surfclam spawning stock biomass inaccessible to the survey, which will effectively remove that stock from the fishery. Additionally, perceived fishing mortality will increase, by 0.7 to 7.3%, due to a combination of a reduction in the observable stock biomass and changes in fishing behavior.



Simulated fishery effort displacement for cumulative impact simulation scenarios.

>> Final Report

Munroe DM, Powell EN, Klinck JM, Scheld AM, Borsetti S, Hofmann EE (Rutgers University, Port Norris, NJ). 2022. Understanding economic impacts to the commercial surfclam fishing industry from offshore wind energy development. Sterling (VA): Department of the Interior, Bureau of Ocean Energy Management. 70 p. Report No.: OCS Study BOEM 2022-065. *https://espis.boem.gov/final%20reports/BOEM_2022-065.pdf*

Zooplankton Survey for Regional Fisheries Monitoring in Southern New England Offshore Wind Development

Conducted by: *University of Massachusetts Dartmouth*

National Studies List: *AT-21-x06*

>> Purpose/Information Use

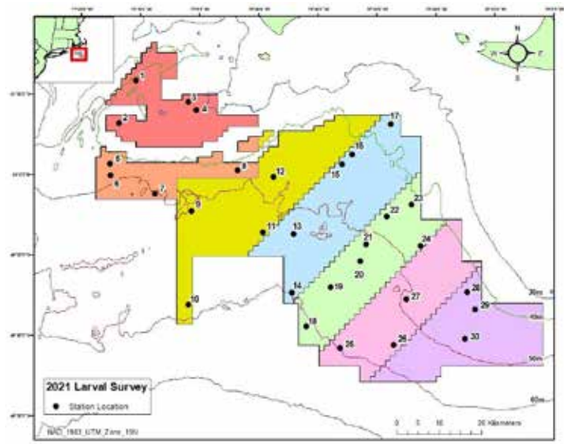
The cold-water planktonic copepod, ***Calanus finmarchicus***, is one of the most important zooplankton species in the northern part of the North Atlantic because of its abundance and role in food webs. It is also the preferred prey of the endangered North Atlantic right whale (***Eubalaena glacialis***). Right whales feed primarily on zooplankton at the surface, particularly late juvenile developmental stages (copepodites) and adults of the copepod ***C. finmarchicus***.

North Atlantic right whales forage on zooplankton in and around waters off southeastern New England during parts of the spring and summer. In particular, right whales are known to occur in waters near WEAs on the continental shelf offshore from Rhode Island, and in waters off southeastern Massachusetts between Martha's Vineyard and Nantucket. To understand temporal and spatial distributions of North Atlantic right whales in WEAs off southeastern New England, BOEM needs to understand spatial and temporal distributions of ***C. finmarchicus***.

As part of extensive pre- and post-construction research, the University of Massachusetts Dartmouth School for Marine Science and Technology, with the Massachusetts Lobstermen's Association, sought to estimate the relative abundance and distribution of zooplankton, specifically copepods. Sampling was conducted from May through June 2021 at 30 random stations.

>> Findings/Results

The zooplankton survey provided baseline abundance and distribution data for species in the Massachusetts-Rhode Island WEA. It showed the presence of species pre-construction and, moving forward, can be compared to post-construction samples.



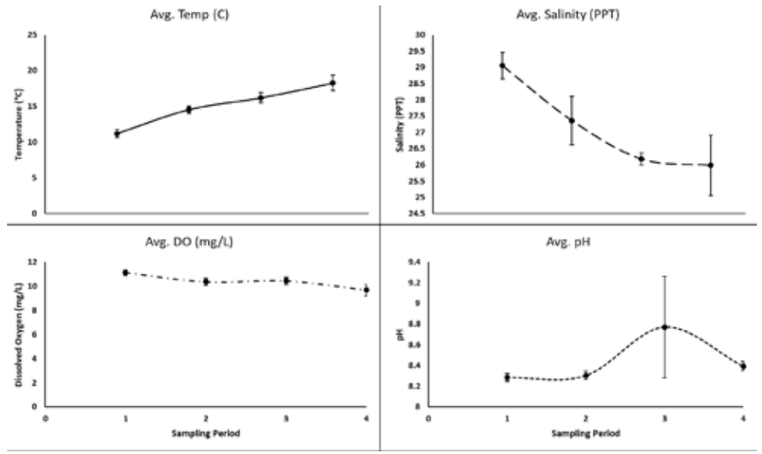
Simulated fishery effort displacement for cumulative impact simulation scenarios.

The Gulf of Maine and Scotian Shelf underwent a regime shift in 2010, with warming by Gulf Stream-driven warm slope waters entering the region. This created a less-favorable foraging environment for North Atlantic right whales during their seasonal migrations from the western Gulf of Maine in winter and spring, to the eastern Gulf of Maine and Scotian Shelf in summer and autumn. Such movements of right whales track abundance of late-stage copepodites of ***C. finmarchicus***. By the 2010s, in concert with poleward shifts in abundance of ***C. finmarchicus*** coincident with warming in the Gulf of Maine, right whales had moved their late spring-summer foraging areas from the Gulf of Maine and western Scotian Shelf northward to the Gulf of St. Lawrence.

By the mid- to late-May and June 2021 sampling periods, right whales appear to have already departed from the WEAs south of Martha's Vineyard. This was likely related to the paucity of ***C. finmarchicus*** and other larger copepods, and was indicated by the failure to observe any right whales during sampling. This northward phenological shift will likely be exacerbated by further warming due to ongoing climate change. Future efforts to investigate relationships between presence of right whales and abundant copepods in the wind farm areas of southern New England would benefit from sampling earlier in the spring than periods of mid-May through late June.

>> Final Report

Turner J, Weig E (University of Massachusetts Dartmouth, New Bedford, MA). 2023. Zooplankton survey for regional fisheries monitoring in southern New England offshore wind development. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 33 p. Report No.: OCS Study BOEM 2023-027. https://espis.boem.gov/final%20reports/BOEM_2023-027.pdf



Environmental data by sampling period A) average temperature in degrees Celsius B) average salinity in parts per thousand C) average dissolved oxygen in milligrams per liter D) average pH. The timeframe of this dataset is May through June. All data points have their respective standard deviations (vertical lines) included.

GULF OF MEXICO REGION

An Analysis of Seafloor Impacts on the Gulf of Mexico Outer Continental Shelf for an Adaptive Strategies Desk Reference

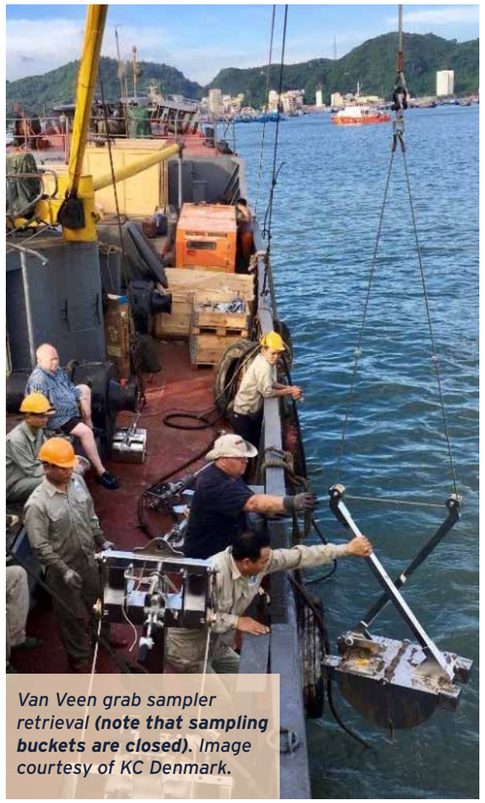
Conducted by: *Booz Allen Hamilton*

National Studies List: *GM-19-01*

>> Purpose/Information Use

BOEM manages a range of energy activities through regular evaluation and monitoring of regulated and permitted activities that have the potential to impact natural and cultural resources, including those on the seafloor, such as shipwrecks.

This study was conducted to develop a desk reference to inform BOEM subject matter experts (SMEs) about the scale and extent of seafloor impacts to assist with effective and efficient protection of natural and cultural resources during environmental assessments.



*Van Veen grab sampler retrieval **(note that sampling buckets are closed)**. Image courtesy of KC Denmark.*

>> Findings/Results

The desk reference provides briefs on the full lifecycle of oil and gas activities. The briefs include short explanations of the scale, scope, and extent of seafloor impacts from oil and gas activities in the following categories: (1) geological and geophysical activities; (2) exploration activities; (3) development activities; (4) production activities; (5) decommissioning activities; and (6) vessel anchoring.

Each of the 85 briefs provides details of the seafloor impacts from the activities discussed in the brief. These include impacts such as sediment disruption by seafloor equipment, seabed footprints for production platforms, sampling of the seafloor, drilling byproducts, anchoring, maintenance and repair, and decommissioning. The specific dimensions of seafloor impacts depend on a number of factors, such as soil type, water depth, platform type, vessel type, and anchor type and size. Each of the briefs are cross referenced to allow for transition from one related description to another.

Additional supporting materials, such as the annotated bibliography, enable SMEs to quickly refer to additional authoritative sources. The annotated bibliography describes the various sources selected for inclusion in the briefing documents.

Free swimming ROV with dredge attachment. Oceaneering 12 Inch XL Electric Dredge. Image courtesy of Oceaneering, 2017.

Small suction dredge operated by a diver. Image courtesy of Diver's World Antzoulis, 2017.

>> Final Report

Krieger A, Samuel B, Ped J (Booz Allen Hamilton, McLean, VA). 2023. An analysis of seafloor impacts on the Gulf of Mexico Outer Continental Shelf for an adaptive strategies desk reference. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 291 p. Report No.: BOEM 2023-065. *https://espis.boem.gov/Final%20Reports/BOEM_2023-065.pdf*

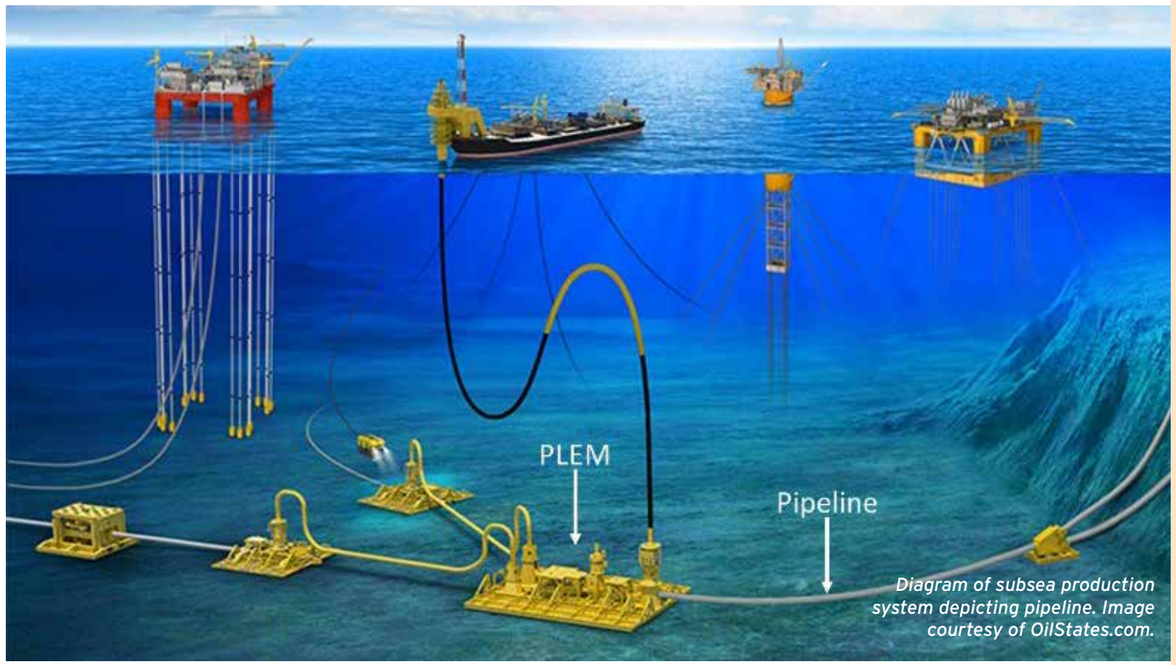


Diagram of subsea production system depicting pipeline. Image courtesy of OilStates.com.

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

Conducted by: *NOAA NMFS*

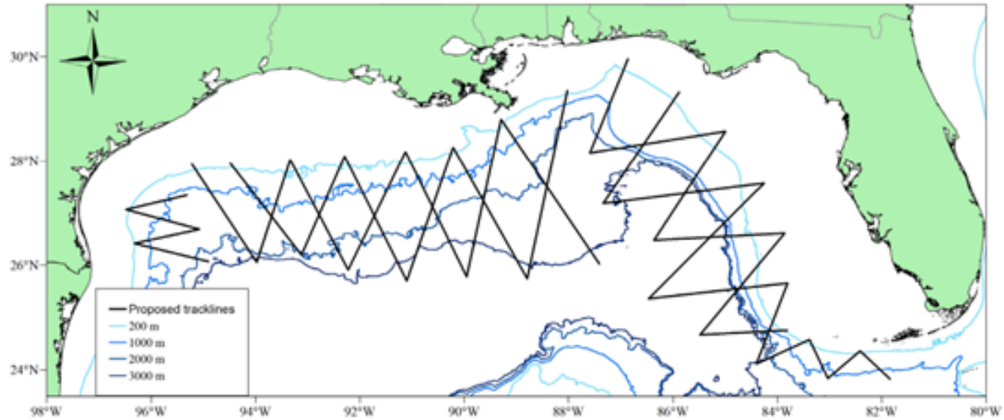
National Studies List: *GM-16-09b*

*Spinner dolphins (**Stenella longirostris**) tend to occur in waters with steep-bottom depth gradients.*

>> Purpose/Information Use

Since the late 1980s, the NMFS Southeast Fisheries Science Center (SEFSC), with the USFWS, has conducted seasonal broad-scale aerial and vessel surveys to support marine mammal and sea turtle stock assessments within U.S. Gulf of Mexico waters. These surveys have provided critical information and are the primary data source for spatially explicit density models (SDMs) used in impact assessments. However, there are critical spatial and temporal gaps in the data currently available for marine mammal population assessments in the Gulf of Mexico.

The overall goal of GoMMAPPS was to collect broad-scale temporal information on the distribution and abundance of marine mammals and sea turtles in the Gulf of Mexico to inform seasonally and spatially explicit density estimates for priority species.



Planned tracklines for GoMMAPPS vessel surveys.

In U.S. continental shelf waters, aerial surveys for cetaceans and sea turtles were part of the Deepwater Horizon Natural Resource Damage Assessment during 2011–2012. No survey of shelf waters had been conducted since then. The last seasonal surveys of Gulf of Mexico oceanic waters were conducted in the 1990s as part of the GulfCet I and GulfCet II programs and included both vessel and aerial surveys. Before GoMMAPPS, three out of the 20 oceanic stocks had unknown abundance estimates in the NMFS Stock Assessment Reports because the data were over eight years old, and the last survey for the remaining 17 stocks was in summer 2009. Only the three Coastal and Continental Shelf bottlenose dolphin stocks had more recent abundance data (2011–2012). Updating the survey data to estimate the abundance of oceanic species is crucial.

This study collected data during three large vessel surveys of oceanic waters (winter, summer, and summer-fall) and three aerial surveys of continental shelf waters (winter, summer, and fall). Shipboard and aerial survey data were analyzed to estimate the density and overall population size of species encountered within the surveyed regions of the northern Gulf of Mexico. The primary statistical approach for these analyses was distance sampling from line-transect surveys. Sea turtles were also recorded during aerial surveys and the same analytical methods were applied to estimate their abundance. Sea turtle research was completed with the U.S. Geological Survey (USGS) and is also in *Gulf of Mexico Marine Assessment Project for Protected Species: Sea Turtles* (BOEM 2023-064).

For the development of SDMs, line-transect surveys designed for marine mammal and sea turtle abundance estimation were conducted between Florida and Texas. Aerial surveys of continental shelf waters were conducted 2017–2018. Vessel-based surveys of oceanic waters were conducted 2017–2018. Mark-recapture

distance sampling methods using independent observers were used to estimate detection probability within the survey strip and account for perception bias. These data were combined with data from similar previous surveys to develop SDMs with environmental predictors describing oceanographic conditions drawn from remotely sensed data and hydrographic models. Passive acoustic surveys using a towed hydrophone array were conducted to estimate the abundance of sperm whales and to improve acoustic species classification of delphinids.

Orca (killer whale) in the Gulf of Mexico.

Bottlenose dolphin in the Gulf of Mexico.

Data about the distribution and abundance of marine protected species are key for understanding potential impacts of offshore energy and marine minerals resources extraction. Such information is also needed in Federal consultations under the ESA; for authorizations under the Marine Mammal Protection Act; and to comply with other applicable statutes. As part of ESA Section 7, BOEM is required to consult with NMFS and/or USFWS on ESA-listed marine mammal species. BOEM, NMFS, and USFWS have overlapping information needs to help inform their analyses of potential impacts of offshore energy and marine minerals resources development on protected species in the Gulf of Mexico.

>> Findings/Results

The GoMMAPPS surveys were the first broad-scale vessel surveys conducted in the northern Gulf of Mexico after the 2010 *Deepwater Horizon* oil spill and the first broad-scale aerial surveys after 2012. These data resulted in updated and improved abundance estimates for 25 cetacean stocks occurring in coastal, continental shelf, and oceanic waters. The resulting seasonal SDMs for 19 species offer predictive power for assessing and managing human impacts on protected and endangered species.

Aerial surveys covered a total of 34,464 km of trackline. Nearly 850 marine mammal sightings and 2,050 sea turtle sightings were recorded. Comparison of seasonally averaged abundance estimates for Atlantic spotted and bottlenose dolphins with similar surveys conducted during 2011–2012 generally indicated increased abundance. The SDMs indicated that bottlenose dolphin density was highest in nearshore coastal waters and the inner portion of the continental shelf, while Atlantic spotted dolphins generally occurred in deeper waters of the outer shelf. Sea turtle SDMs indicated that green and loggerhead densities were highest close to shore, with peaks in loggerhead density at intermediate depths. Kemp's ridley density was highest in intermediate depths, and leatherback density was higher in offshore waters deeper than 50 meters. The densities of all species were correlated with environmental factors—including depth, surface temperature, and surface chlorophyll concentrations—and showed seasonal variability.

Kemp's ridley sea turtle.

Overall, the number of species and number of individuals of small whale and oceanic delphinids appear to have decreased in recent years. Most notably, there are reduced densities of pantropical spotted dolphins and the other stenellid dolphins, such as Clymene and spinner dolphins. SDMs for 15 marine mammal species and four sea turtle species highlighted important dynamics between marine mammal density and oceanographic features. In general, in recent years, reduced productivity in the northeastern Gulf of Mexico resulted in a shift of some species into the western Gulf of Mexico. This was particularly evident for sperm whales and pantropical spotted dolphins.

The GoMMAPPS data products will ensure that the exploration and development of offshore energy and marine mineral resources, and regulatory decisions related to wind energy leases, are balanced with mandated protection of marine species and affected habitats. The SDM products also benefit Deepwater Horizon restoration planning and monitoring at the project, resource, and ecosystem levels, and inform management actions to reduce the risk of vessel strikes for large whales and help to understand the impacts of ocean noise on marine mammals.

>> Final Reports:

Rappucci G, Garrison LP, Soldevilla M, Ortega-Ortiz J, Reid J, Aichinger-Dias L, Mullin K, Litz J (NOAA Southeast Fisheries Science Center, Miami, FL). 2023. Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS): marine mammals. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. Report No.: OCS Study BOEM 2023-042.

Volume 1: Report (104 p.): *https://espis.boem.gov/Final%20Reports/BOEM_2023-042_v1.pdf*

Volume 2: Appendix C: Gulf of Mexico Marine Mammal Spatial Density Models (1,264 p.): *https://espis.boem.gov/Final%20Reports/BOEM_2023-042_v2.pdf*

Volume 3: Appendix D: Gulf of Mexico Sea Turtle Spatial Density Models (358 p.): *https://espis.boem.gov/Final%20Reports/BOEM_2023-042_v3.pdf*

>> Also

Visual survey data is publicly available on OBIS-SEAMAP: *https://seamap.env.duke.edu/*

Spatial density models can be downloaded on viewed in the model viewer: *https://seamap.env.duke.edu/models/SEFSC/GOM/*

NMFS datasets and slideshow presentation: *https://www.fisheries.noaa.gov/inport/item/67243*

Riley KL, Wickliffe LC, Jossart JA, Mackay JK, Randall AL, Bath GE, Balling MB, Jensen BM, Morris JA Jr. 2021. An aquaculture opportunity area atlas for the U.S. Gulf of Mexico. Report No.: NOAA Technical Memorandum NOS NCCOS 299. doi:10.25923/8cb3-3r66

Farmer NA, Garrison LP, Litz JA, Ortega-Ortiz JG, Rappucci G, Richards PM, Powell JR, Bethea DM, Jossart JA, Randall AL, et al. 2023. Protected species considerations for ocean planning: a case study for offshore wind energy development in the U.S. Gulf of Mexico. Mar Coast Fish. 15(3):e10246. doi:10.1002/mcf2.10246

Gulf of Mexico Marine Assessment Project for Protected Species (GoMMAPPS): Sea Turtles

Conducted by: *USGS, Wetland and Aquatic Research Center*

National Studies List: *GM-16-09d*

>> Purpose/Information Use

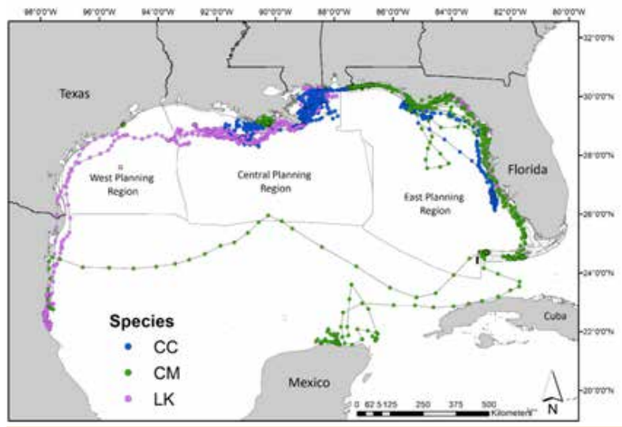
The Gulf of Mexico is one of the most biodiverse ocean basins in the world. Five sea turtle species, all listed under the ESA, inhabit the northern Gulf of Mexico, including the threatened loggerhead (***Caretta caretta***), critically endangered Kemp's ridley (***Lepidochelys kempii***), threatened green turtle (***Chelonia mydas***), threatened leatherback (***Dermochelys coriacea***), and endangered hawksbill (***Eretmochelys imbricata***). Gulf of Mexico nearshore waters and coastal bays provide sea turtle foraging habitat. Sandy beaches across the northern Gulf of Mexico support green sea turtles, leatherbacks, and a genetically distinct group of nesting loggerheads; they also are the only historic nesting habitat for Kemp's ridleys in the world.

The Gulf of Mexico is also one of the most threatened habitats in the U.S. Overfishing, habitat loss, and pollution are some of the top threats to marine biodiversity in the Gulf of Mexico. Additionally, in April 2010, over three million barrels of oil leaked into northern Gulf of Mexico waters after the Deepwater Horizon drilling rig exploded. These stressors may impact sea turtle species and life-stages disproportionally depending on species-specific trends in habitat use and locations of migratory pathways.

One important and persistent knowledge gap in sea turtle ecology in the Gulf of Mexico, and globally, is an understanding of sea turtle dive behavior. This is especially significant because, of all marine mammals, sea turtles demonstrate the longest reported breath-hold dives and spend more than 90% of their time underwater.

The overarching goal of the GoMMAPPS study on sea turtles was to collect broad-scale information on the distribution and abundance of sea turtles in the Gulf of Mexico to inform seasonally and spatially explicit density estimates for priority species. GoMMAPPS represents a multiagency partnership between BOEM, USFWS, NOAA, and USGS, all of whom collect information on large marine vertebrates to provide improved spatially explicit density distributions for multiple management objectives.

This sea turtle project included three primary tasks undertaken by USGS: satellite tracking, time-at-surface estimation (defined by the top 2 meters of the water column), and genetic analyses. Gulfwide sea turtle density and distribution data were gathered during aerial surveys conducted as part of the marine mammal (NOAA) and seabird (USFWS) portions of the GoMMAPPS program.



State space modeling track in BOEM planning areas from satellite tags on sea turtles.

Satellite tags with depth sensors were deployed on turtles throughout the Gulf of Mexico. Similar tags were deployed on adult female green turtles after nesting on beaches in the northern Gulf of Mexico. The study also collected skin and blood samples for genetic analyses at the University of Georgia, and used telemetry data, and state space modeling to identify spatial distribution, home ranges, and dive patterns.

>> Findings/Results

The primary method of documenting broad-scale distribution and density of marine animals is aerial surveys. But these surveys count only individuals that are at the ocean's surface. To account for turtles that are underwater, species-specific dive data are needed. This study provides information on turtle dive behavior, specifically time-at-surface, for juvenile and adult (male and female) loggerhead, Kemp's ridley and green turtles in BOEM's Eastern, Central, and Western Gulf of Mexico Planning Areas. Researchers deployed satellite tags with depth sensors on 48 loggerhead, Kemp's ridley and green turtles in the Gulf of Mexico from 2017 to 2019.

An adult female Kemp's ridley turtle that was captured via trawler in Mississippi Sound in November 2017 and then recaptured while nesting on Rancho Nuevo, Mexico, in April 2018. Photo credit: USGS.

Green turtles spent more time in the top 2 meters of the water column than did Kemp's ridleys or loggerheads. Time-at-surface was greater for all species in summer but did not differ between BOEM's Eastern and Central Gulf of Mexico Planning Areas except for Kemp's ridleys, which spent more time at the surface in the Western than in Eastern Gulf of Mexico Planning Area.

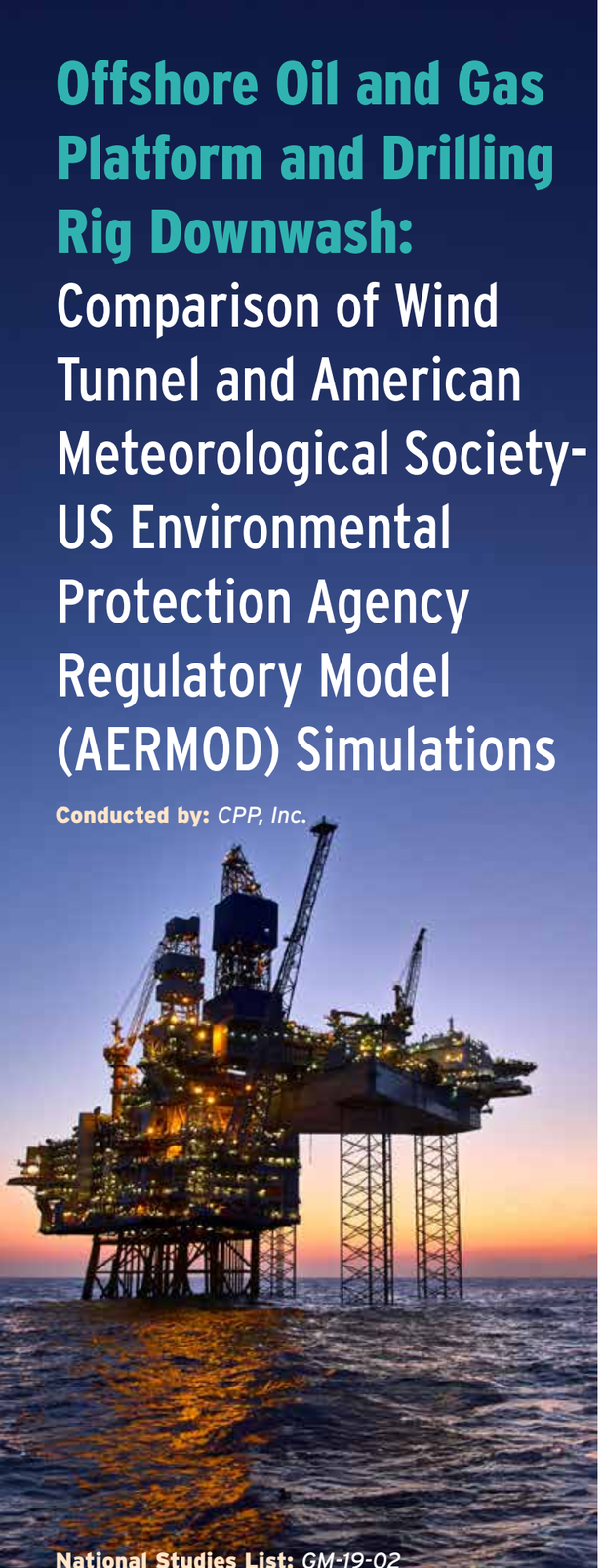
The dive-surface behavior data collected during GoMMAPPS can be applied to improve the accuracy and precision of abundance estimates for sea turtles derived from visual survey data, in particular aerial surveys. Results will contribute to broad-scale SDMs that incorporate environmental and oceanographic parameters and will improve aerial survey counts. Also, the model output can be used by other management and regulatory agencies in decisions that may impact the OCS habitats and for critical habitat designations.

>> Final Report

Lamont MM, Hart KM (U.S. Geological Survey, Gainesville, FL). 2023. Gulf of Mexico Marine Assessment Project for Protected Species: sea turtles. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 38 p. Report No.: OCS Study BOEM 2023-064. https://espis.boem.gov/Final%20Reports/BOEM_2023-064.pdf

Offshore Oil and Gas Platform and Drilling Rig Downwash: Comparison of Wind Tunnel and American Meteorological Society-US Environmental Protection Agency Regulatory Model (AERMOD) Simulations

Conducted by: *CPP, Inc.*



National Studies List: *GM-19-02*

>> Purpose/Information Use

The OCS Lands Act requires that offshore oil and gas structures comply with the NAAQS. The current approved model for assessing NAAQS is a software program called AERMOD with PRIME (Plume Rise Model Enhancements), intended to model overland dispersion around solid monolithic obstacles, such as buildings.

BOEM previously assessed the air quality impacts of air emissions released from OCS sources using the older Offshore and Coastal Dispersion (OCD) model from the U.S. Environmental Protection Agency (USEPA), but the OCD has not been substantially changed since 1997; it does not provide outputs that are directly comparable to the statistical forms of the more recent NAAQS. AERMOD is the current approved model for assessing NAAQS; BOEM seeks USEPA approval of AERMOD for overwater applications.

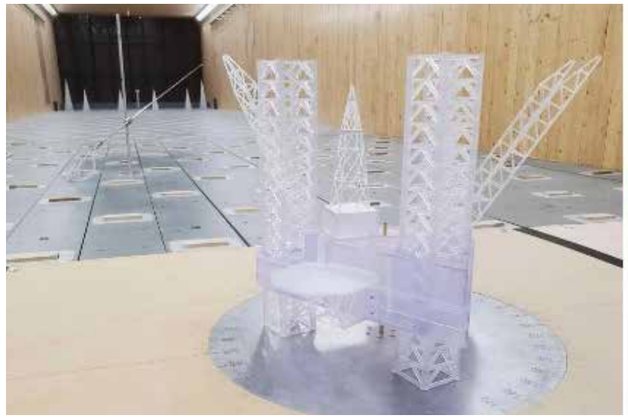
This wind tunnel modeling study was designed to provide data needed to appropriately apply AERMOD for modeling overwater dispersion for platform and mobile offshore drilling units, where downwash influences plume dispersion.

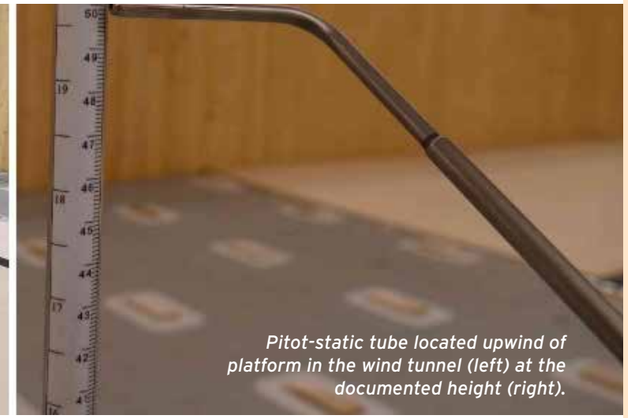
This study's objectives were to (1) identify and experimentally model various representative offshore oil and gas structures; (2) design and test wind tunnel models at 1:200 length scaling; (3) collect and analyze wind tunnel data of downwash velocities and concentrations downwind of the models; (4) compare measurements with predictions by AERMOD; and (5) identify potential improvements to AERMOD.

>> Findings/Results

This study built four platform types and a generic porous model, each at 200 times smaller than actual size, and tested the models in an atmospheric boundary-layer wind tunnel using a tracer gas to model platform stack emissions. Three-component turbulent wind velocities and tracer concentrations downwind of each platform were simultaneously measured. Flow visualization was completed for all platforms. This is the first database with sufficient data to define plume rise, horizontal and vertical dispersion, velocity field and turbulence field in a porous offshore platform wake.

Overall, results show that AERMOD can be updated for better agreement with wind tunnel observations for platform type structures. For optimal agreement with observations, more research is needed to validate and





Pitot-static tube located upwind of platform in the wind tunnel (left) at the documented height (right).

update certain formulations in PRIME. The PRIME2 equations and original PRIME equations were compared with wind tunnel measurements. Both theories were modified to obtain better agreement with observations. The updated equations can potentially be used in AERMOD to model platform type structures.

A new theory, which combines PRIME and PRIME2 with a modified vertical distribution, would provide well-founded and accurate prediction of downwash and pollutant dispersion around platform structures. Additional complexity to be modeled includes gap flow under the platform deck (lack of cavity plume), platform porosity, platform plan shape, and approach wind direction, and stack exit location relative to above-deck equipment.

>> Final Report

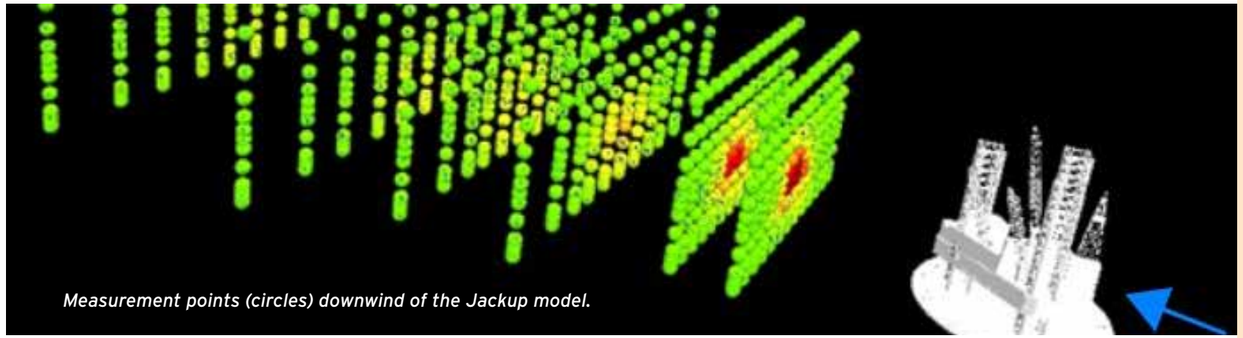
Carter JJ, Beyer-Lout A, Lin W, Lawton T, Fleckenstein K, Paumier JO, Petersen, RL (CPP Inc, Windsor, CO). 2023. Offshore oil and gas platform and drilling rig downwash: comparison of wind tunnel and American Meteorological Society-US Environmental Protection Agency Regulatory Model (AERMOD) simulations. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 193 p. Report No.: OCS Study BOEM 2023- 050. *https://espis.boem.gov/Final%20Reports/BOEM_2023-050.pdf*

>> Also

Microsoft® Excel spreadsheet describing volumetric porosities, available at *https://opendata.boem.gov/CPP14256_Appendix_I_-_Volumetric_Porosities.xlsx*

Wind Tunnel Data, a Microsoft® Excel spreadsheet, available at *https://opendata.boem.gov/CPP14256_Appendix_J_Wind_Tunnel_Processed_Data.xlsx*.

Computer-aided design (CAD) files, Appendix I, are available on request (*espis@boem.gov*)



Measurement points (circles) downwind of the Jackup model.

Scoping Study for Shoreline Fumigation from Offshore Emissions

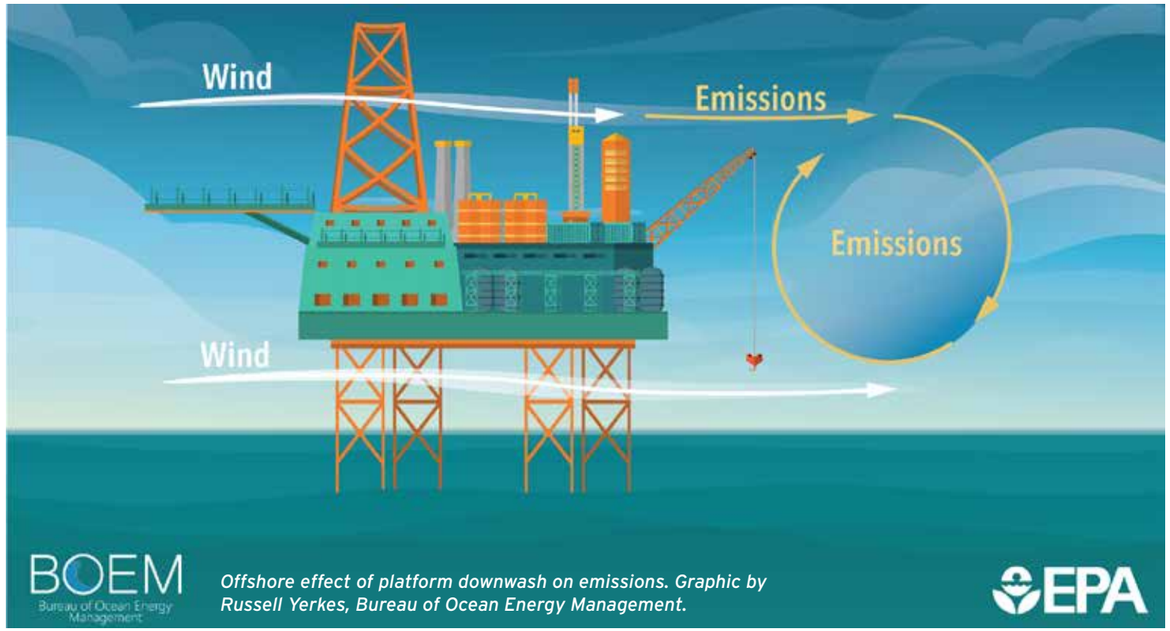
Conducted by: *USEPA and WSP USA Environment & Infrastructure Inc.*

National Studies List: *GM-19-x05*

>> Purpose/Information Use

BOEM is required under the OCS Lands Act to comply with the NAAQS to the extent that OCS oil and gas exploration, development, and production sources do not significantly affect the air quality of any state (43 U.S.C. §§ 1334(a)(8)). Modeling is one way that BOEM determines possible air quality impacts caused by OCS oil and gas activities as required under the OCS Lands Act and NEPA. Companies must submit plans to BOEM before conducting exploratory drilling or production activities. These plans include data that estimates air emissions as required under 30 CFR 550.218 and 30 CFR 550.249. These estimates of emissions must be compared to an exemption level (30 CFR 550.303) to determine if the plan could potentially impact onshore air quality. If the plan's annual emissions in tons per year are above these exemption levels, the operator must conduct further air quality analysis, including modeling.

The OCD model is the USEPA preferred dispersion model for overwater sources for short-range or near-field transport (source-to-receptor distances less than 50 km) because of its treatment of downwash effects from raised offshore drilling platforms and its ability to model coastal fumigation at and beyond the shoreline. AERMOD—the USEPA preferred dispersion model for overland, near-field modeling—represents current state-of-the-science methodology and is continuously being updated and maintained.



Offshore effect of platform downwash on emissions. Graphic by Russell Yerkes, Bureau of Ocean Energy Management.

BOEM and USEPA want to use AERMOD for near-field modeling by adding platform downwash and coastal fumigation to the AERMOD system, eventually replacing the OCD model. This project provides a scoping study for incorporating coastal fumigation into the AERMOD model. A separate study focuses on the integration of the platform downwash from OCD into AERMOD (OCS Study BOEM 2023-043).

>> Findings/Results

This scoping study on shoreline fumigation included a literature search of past and present research. The literature search identified existing models capable of estimating concentrations affected by shoreline fumigation. These candidate models included the Screening Model Based on AERMOD, USEPA Single Source Gaussian Model, Misra Shoreline Fumigation Model, Shoreline Dispersion Model/Shoreline Fumigation Model, and OCD. The methodologies and formulations of those models were reviewed and summarized, as were model inputs, outputs, and source code (when available) for future assessment for compatibility with AERMOD.

Comparison of candidate model algorithms for inclusion into the AERMOD system did not find one single "state-of-the-science" algorithm but instead provided a list of necessary features, model capabilities, and areas for further exploration. Additional information is needed to make an informed determination of the state-of-the-science of shoreline fumigation and whether there is an existing algorithm for shoreline fumigation that is compatible with AERMOD. Future work to develop a path forward to include shoreline fumigation in AERMOD will include additional literature and model reviews, developing a white paper to communicate this work as a priority to the modeling community and stakeholders, determining the intended path forward, and ultimately implementing, testing, and evaluating the final shoreline fumigation algorithm in AERMOD.

>> Final Report

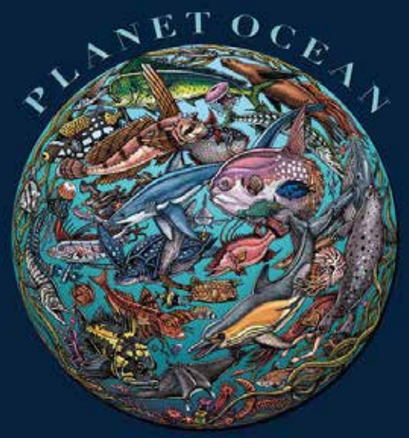
Snyder MG, Thakur S, Paumier JO (WSP USA Environment & Infrastructure Inc., Durham, NC). 2022. Scoping study for shoreline fumigation from offshore emissions. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 41 p. Report No.: OCS Study BOEM 2023-044. https://espis.boem.gov/final%20reports/BOEM_2023-044.pdf

PACIFIC REGION

Demonstrating an Effective Marine Biodiversity Observation Network in the Santa Barbara Channel

Conducted by: *Marine Science Institute, University of California Santa Barbara*

National Studies List: *PC-15-05*



Ray Troll's rendition of life in the sea, colorized by Grace Freeman. Originally featured in the 1994 book, Planet Ocean: A Story of Life, the Sea and Dancing to the Fossil Record, *by Bradford Matson and Ray Troll, Ten Speed Press, 133 pp. Used with permission of Ray Troll.*

>> Purpose/Information Use

Marine biodiversity is critical to ecosystem and human health. It also serves as an indicator of the state of the ecosystem. Managing marine resources in a way that conserves marine biodiversity also helps address other ocean management objectives. Although we monitor marine resources annually, these efforts are often uncoordinated and have major information gaps.

BOEM needs marine biodiversity information gathered through broad-scale, comprehensive, ecosystem-based monitoring that uses a well-accepted, systematic methodology. A coordinated approach to biodiversity monitoring provides substantial benefit in characterizing marine regions, understanding potential impacts from offshore energy, understanding cumulative effects from multiple stressors, and identifying relevant indicators for monitoring outcomes of management decisions.

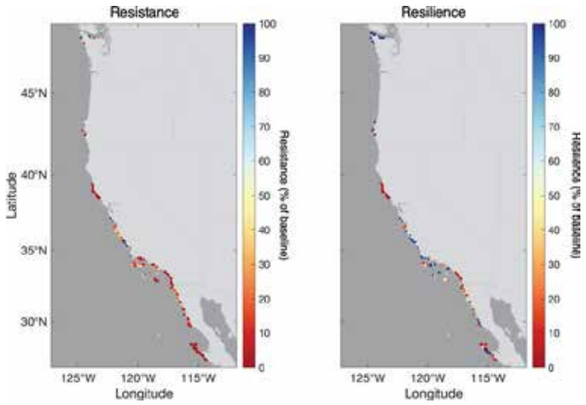
To begin addressing these challenges, NOAA, NASA, BOEM, and the National Science Foundation collaborated on three five-year demonstration marine biodiversity demonstration projects. For this demonstration project, scientists developed a scalable and transferable MBON in the Santa Barbara Channel (SBC), one of the most monitored areas of the world. The overall objective was to provide a complete picture of biodiversity in SBC using a transferable system that integrates and augments existing monitoring programs. This study sought to develop a prototype framework—across a range of habitats, trophic levels, and species—that uses both recent innovative techniques for data discovery and analysis, and expands on existing data collection systems and programs by incorporating historical data and past modeling efforts.

>> Findings/Results

The study integrated 36 distinct datasets (19 of which were published by SBC MBON) spanning a full range of environmental resources. A team of researchers used advanced techniques in spatial statistics to integrate the wide-ranging data and to provide multiple biodiversity-related data products, including indices on ecosystem diversity and health. This allowed the team to conduct new analyses on a regional scale, including models to predict ecological outcomes from different options in decommissioning oil and gas platforms.

Researchers developed advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity in partnership with ongoing monitoring and research programs. Implementing a tradeoff framework optimized allocation of sampling effort; this framework can be used to make recommendations for how resources should be allocated in a full-scale MBON.

To monitor giant kelp, a foundational species in the SBC and the West Coast, remote sensing data



Kelp canopy resistance and resilience to the 2014–2016 marine heat wave events in the NE Pacific.

were combined with integrated datasets to identify spatial scales of variation over large areas. This was an effective method to produce a predictive understanding of biodiversity patterns.

Remote sensing data are critical for scaling up local observations of biodiversity and for relating physical and ecological variables to marine biodiversity. The SBC MBON focused on several activities linking remote sensing to observations of marine biodiversity, including monitoring giant kelp populations and ocean color analysis.

This study found that environmental DNA (eDNA) metabarcoding can outperform visual surveys to capture the spatial patterns in biodiversity at fine scales with less field effort and more power than traditional methods, supporting the notion that eDNA can be a critical scientific tool for detecting biodiversity changes in marine ecosystems.
This study also proposed a broadly applicable framework (adaptable to any region) to assess and mitigate the impacts of offshore wind development on marine birds, also published in Biological Conservation.

All SBC MBON datasets have an immutable copy archived for citation with a Digital Object Identifier to ensure reliability and consistency. The EDI Data Repository (*https://EnvironmentalDataInitiative.org*) supports both provenance and tracking and revision control essential applications and ongoing time series. SBC MBON data are available via DataONE (Data Observation Network for Earth), alongside data from Axiom Research Workspace and the National Centers for Environmental Information.

>> Final Report

Miller RJ, Siegel D, Carlson C, Lafferty K, Rassweiler A, Reed DC, Kyriakidis P, Iglesias-Rodriguez D, Manjunath BS, Love MS, Thompson A, Hildebrand J, Nishimoto M, Kui L, O'Brien M, Meyer-Gutbrod E, Lamy T. 2023. Demonstrating an effective Marine Biodiversity Observation Network in the Santa Barbara Channel. Camarillo (CA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 96 p. Report No.: BOEM 2023-030. *https://espis.boem.gov/final%20reports/BOEM_2023-030.pdf*

>> Also

MBON in the SBC: *https://sbc.marinebon.org/*

An interactive tool demonstrates the benthic organisms living in the Santa Barbara Channel kelp forest *https://sbc.marinebon.org/data/map/Imagery_BisQue/*

List of interactive maps and tools are displayed at *https://sbc.marinebon.org/data/map/*

Full dataset list: https://sbc.marinebon.org/data/catalog/

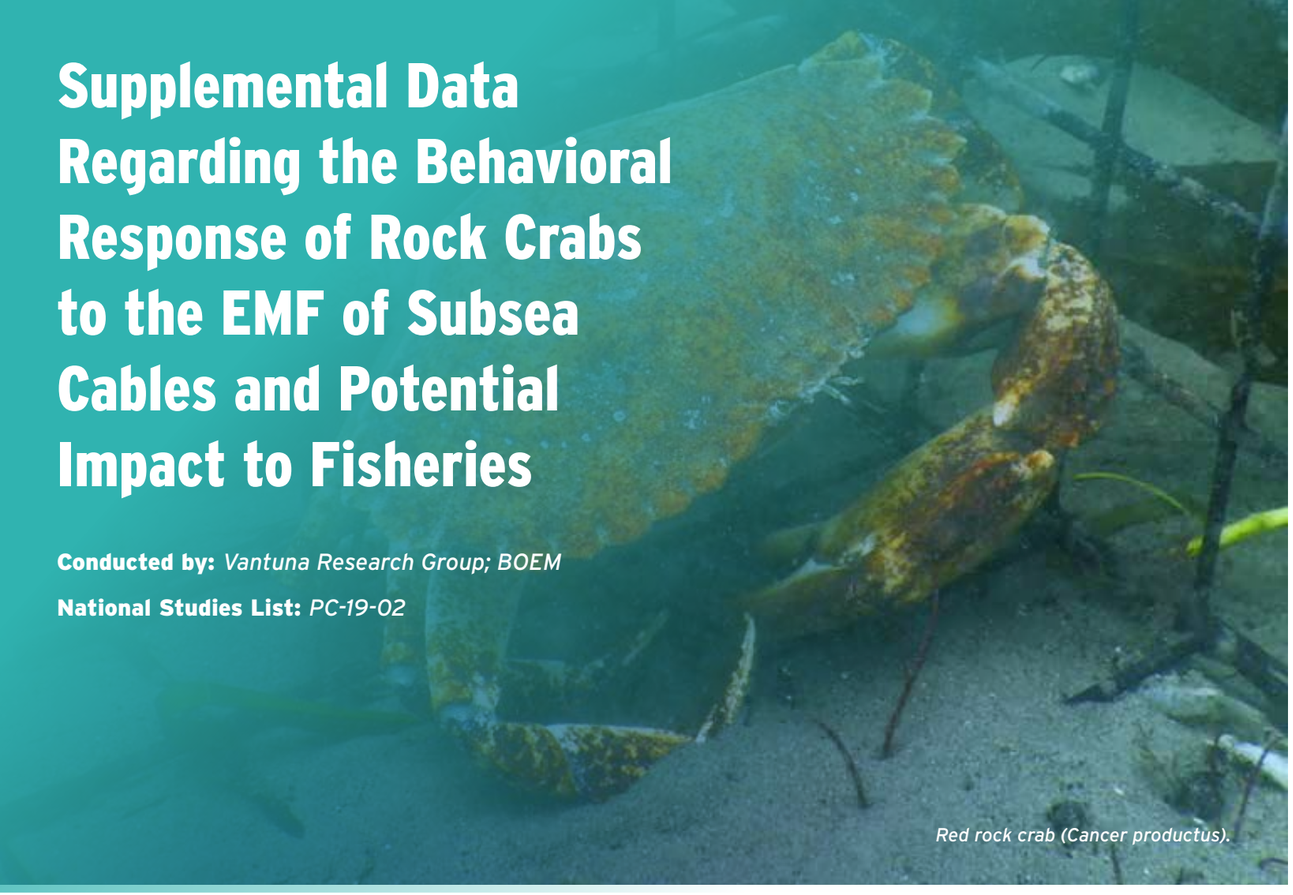
The SBC MBON was instrumental in the publication of *120 scientific papers*, including

Croll DA, Ellis AA, Adams J, Cook ASCP, Garthe S, Goodale MW, Hall CS, Hazen E, Keitt BS, Kelsey EC, et al. 2022. Framework for assessing and mitigating the impacts of offshore wind energy development on marine birds. Biol Conserv. 276: 109795.

Supplemental Data Regarding the Behavioral Response of Rock Crabs to the EMF of Subsea Cables and Potential Impact to Fisheries

Conducted by: *Vantuna Research Group; BOEM*

National Studies List: *PC-19-02*



Red rock crab (Cancer productus).

>> Purpose/Information Use

Anticipating the results of renewable energy infrastructure projects on the marine environment and local fisheries is increasingly important as marine renewable energy (MRE) development continues. One potential impact is a localized change in electromagnetic fields (EMF). EMF from power cables can affect marine organisms, causing behavioral, developmental, and physiological changes. Most studies on EMF effects have focused on the responses of fishes. But strong conclusions about how EMF affects invertebrates have been lacking.

Compared to fishes, crabs may be subject to stronger and more direct EMF currents as they traverse the sea floor. Because the U.S. West Coast is a hot spot for emerging MRE development and home to the largest crab fisheries in the nation, there is concern about the potential impact development may have on fisheries. Crab fishers are concerned that EMF from subsea cables may reduce catch by creating de facto "electrified fences" that deter crabs from crossing over cables to get to baited traps.

The objectives were to (1) quantify and map local magnetic fields near an energized cable at the study site, (2) determine if the energized cable altered crab responses, and (3) describe and quantify variables that were most likely to affect crab responses, such as water current direction and velocity, magnetic field strength, and physical characteristics of each crab.

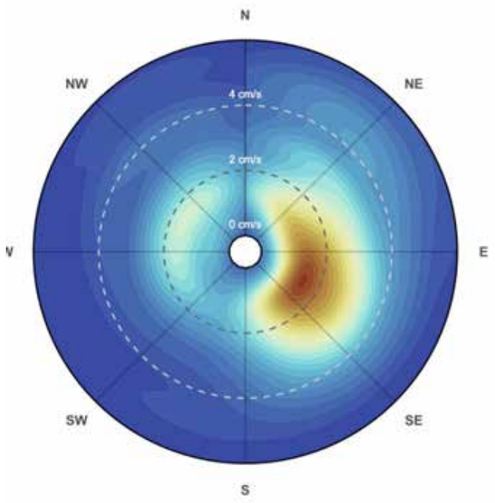
The study used experimental cages that consisted of two baited, rectangular crab traps connected by a mesh tunnel. Cages were placed in a control area away from submarine cables and artificial magnetic fields or along an energized cable; they were situated on the substrate so that the energized cable was directly under the opening of one trap. Crabs were placed equidistant from the two traps at either end of the cage and allowed to enter their trap of choice. Researchers measured current speed and direction in situ using an acoustic doppler velocity meter, measured local magnetic fields at the seafloor along the running length of energized cable, and measured magnetic field strength during every experimental trial.

The ADV was mounted to a bracket that was anchored to the seafloor about 1 m away from the ADV to avoid interfering with water current measurements (left). The ADV was mounted 10 cm above the seafloor to measure the currents at 5 cm above the seafloor (right).

>> Findings/Results

This is the first time that magnetic fields produced by a submarine cable have been quantified and illustrated across the seafloor in situ. Researchers ran 1,209 experimental crab trials (750 along the cable, 459 in the control area) and determined that crabs showed no preference for whether or not to cross the cable. Crabs showed a strong overall preference for traveling to the west against the flow of the predominant measured current. They did not show any preference or aversion to crossing the energized cable and crossed the cable in nearly half of the trials. This study suggests that the artificial magnetic field generated by MRE-associated submarine power cables is unlikely to affect crab harvest rates.

The study also was able to model the magnetic field strength-distance to cable relationship and determined that the magnetic field decayed to background level just 0.9 m from the energized cable. Burial of submarine power cables to 1–2 m below the seafloor often is suggested as a way to reduce the magnitude that magnetic fields interact with the local environment; these results suggest that this mitigation measure could be an effective strategy. Even directly over the energized cable, the magnetic field anomaly is at the lower end of what sensitive marine species can detect.



Cumulative frequency of water current speed and direction.

>> Final Report

Williams JP, Jaco EM, Scholz ZM, Williams CM, Pondella DJ, Rasser MK, Schroeder DM (Vantuna Research Group, Los Angeles, CA; BOEM, Sterling, VA; BOEM, Camarillo, CA). 2022. Supplemental data regarding the behavioral response of rock crabs to the EMF of subsea cables and potential impact to fisheries. Camarillo (CA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 24 p. Report No.: OCS Study BOEM 2023-005. https://espis.boem.gov/Final%20Reports/BOEM_2023-005.pdf

>> Also

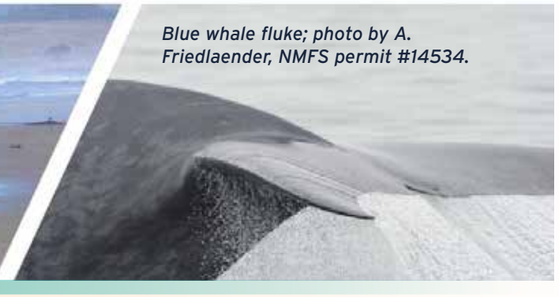
Short film by Shaun Wolfe of Shaun Wolfe Photography: "Can Crabs Cross Submarine Cables?" Available for viewing at https://youtu.be/dZWCQctUNS4

Vulnerability Index to Scale Effects of Offshore Renewable Energy on Marine Mammals and Sea Turtles Off the U.S. West Coast (VIMMS)

Leatherback sea turtle with a temporary tracking transmitter; photo by K. Cummins.

Long-beaked common dolphin; photo by T. Pusser, NMFS permit #14534.

Elephant seal; photo by B. Southall, NMFS permit #14636.



Blue whale fluke; photo by A. Friedlaender, NMFS permit #14534.

Conducted by: *Southall Environmental Associates, Inc.*

National Studies List: *PC-21-04*

>> Purpose/Information Use

Because of the novel and nascent nature of technologies and environmental contexts for industrial development of offshore sustainable energy, there is considerable uncertainty about potential environmental impacts. It is early in the development and impact assessment of offshore wind and hydrokinetic energy off the U.S. West Coast, and broad-scale assessment of the potential vulnerability of key species is critical for identifying and filling key data gaps.

This study adapted and applied a structured semi-quantitative assessment process involving many SMEs to systematically evaluate the potential vulnerability of all West Coast marine mammal and sea turtle species to disturbance from offshore energy in defined geographical areas and oceanographic "seasons" based on species, time, and area-specific population, life history, acoustic, and other environmental factors.

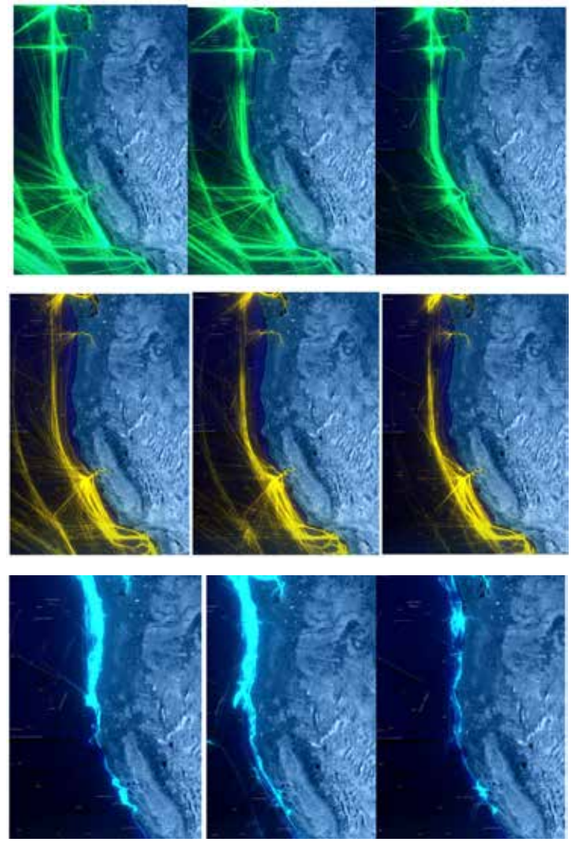
>> Findings/Results

This report is neither intended to be nor should be interpreted as a complete risk assessment of potential impacts from any specific industrial development or operation. It is a starting point using semi-quantitative, structured, and consistent methods and assumptions for evaluating relative vulnerability to generalized potential disturbance from offshore energy development over what are quite large spatial areas. Additional steps and analyses are clearly required and will be informed and guided by the vulnerability analysis conducted here.

Extensive variability in vulnerability was seen within and across species and area-time contexts considered. As expected, species with higher vulnerability scores were generally those that are listed as endangered; had decreasing population trends or low sample size; had either high site fidelity or concentrated periods of key behavior; and were most susceptible to direct physical impacts.

The study found relatively lower overall vulnerability in winter relative to upwelling and especially post-upwelling seasons, and relatively lower vulnerability in oceanic depth regimes relative to slope and especially shelf zones. Also, higher vulnerability across species was found in high-density species habitat use areas that overlap with areas of high existing human presence (e.g., off central California and northern Washington). Strategic research and monitoring priorities based on data gaps and evaluated vulnerability were identified.

Relativistic vulnerability results were generated and are presented, with variable levels of confidence, for most but not all possible species/stock/distinct population segment and time-area combinations. Some species are known not to occur in certain areas and/or seasons. For other species, data limitations, largely related to their presence and behavior in an area and/or season, were so great that experts were unable to provide even a low confidence assessment. In addition to presenting results by species by area and/or season, results were also presented across all species for each zone across the three seasons.



Spatial and temporal distribution of various vessel traffic used in expert elicitation for evaluating chronic anthropogenic noise. Example automatic identification system (AIS) data for cargo (top panels), tanker (middle), and fishing (bottom) vessels along the U.S. West Coast for representative months in each season of 2019 (June: left panels; October: center: December right).

>> Final Report

Southall B, Mazurek R, Eriksen R (Southall Environmental Associates, Inc., Aptos, CA). 2023. Vulnerability index to scale effects of offshore renewable energy on marine mammals and sea turtles off the U.S. West Coast (VIMMS). Camarillo (CA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 137 p. Report No.: OCS Study BOEM 2023-057. https://espis.boem.gov/Final%20Reports/BOEM_2023-057.pdf

>> Also

Microsoft® Excel spreadsheets with raw data:

Mysticetes: https://opendata.boem.gov/Vulnerability-Scoring-Mysticetes.xlsx

Odontocetes: https://opendata.boem.gov/Vulnerability-Scoring-Odontocetes.xlsx

Pinnipeds: https://opendata.boem.gov/Vulnerability-Scoring-Pinnipeds.xlsx

Sea turtles: https://opendata.boem.gov/Vulnerability-Scoring-SeaTurtles.xlsx

ABBREVIATIONS & ACRONYMS

AERMOD	Agency Regulatory Model
AIERP	Arctic Integrated Ecosystem Research Program
ANL	Argonne National Laboratory
ASGARD	Arctic Shelf Growth, Advection, Respiration, and Deposition
ASV	autonomous surface vehicles
AUV	autonomous underwater vehicles
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
CAD	Computer-Aided Design
CMTS	Coastal Maine Time Series
DataONE	Data Observation Network for Earth
DOI	Department of the Interior
EET	emissions exemption threshold
EEZ	Exclusive Economic Zone
EMF	electromagnetic field
ESA	Endangered Species Act
GHG	greenhouse gas
GOADS	Gulfwide Offshore Activities Data System
GOM	Gulf of Mexico
GoMMAPPS	Gulf of Mexico Marine Assessment Program for Protected Species
HMS	highly migratory pelagic fish species
IES	Integrated Ecosystem Study
IMU	inertial measurement unit
ISMN	Integrated Sentinel Monitoring Network
KPB	Kenai Peninsula Borough
MATOS	Mid-Atlantic Acoustic Telemetry Observation System
MBON	Marine Biodiversity Observation Network
MRE	marine renewable energy
NAAQS	National Ambient Air Quality Standards
NASEM	National Academies of Sciences, Engineering, and Medicine
NEPA	National Environmental Policy Act
NES	Northeastern Continental Shelf Ecosystem
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPRB	North Pacific Research Board
OCD	Offshore and Coastal Dispersion
OCS	Outer Continental Shelf
PRIME	Plume Rise Model Enhancements
QA	quality assurance
QC	quality control
RODEO	Realtime Opportunity for Development Environmental Observations
SBC	Santa Barbara Channel
SBNMS	Stellwagen Bank National Marine Sanctuary
SCRAM	Stochastic Collision Risk Assessment for Movement
SDM	spatially explicit density models
SEFSC	Southeast Fisheries Science Center
SGD	submarine groundwater discharge
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WBTS	Wilkinson Basin Time Series
WEA	Wind Energy Area

Department of the Interior

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).

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