Committee on Offshore Science and Assessment (COSA)
Summer Meeting 2024

July 11 & 12, 2024
Washington, DC

NATIONAL ACADEMIES *Sciences Engineering Medicine*

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

BRIEFING BOOK
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July 11th & 12th, 2024

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Contact Information
&
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Directions

Contact Information

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Meeting Location

In-person attendance

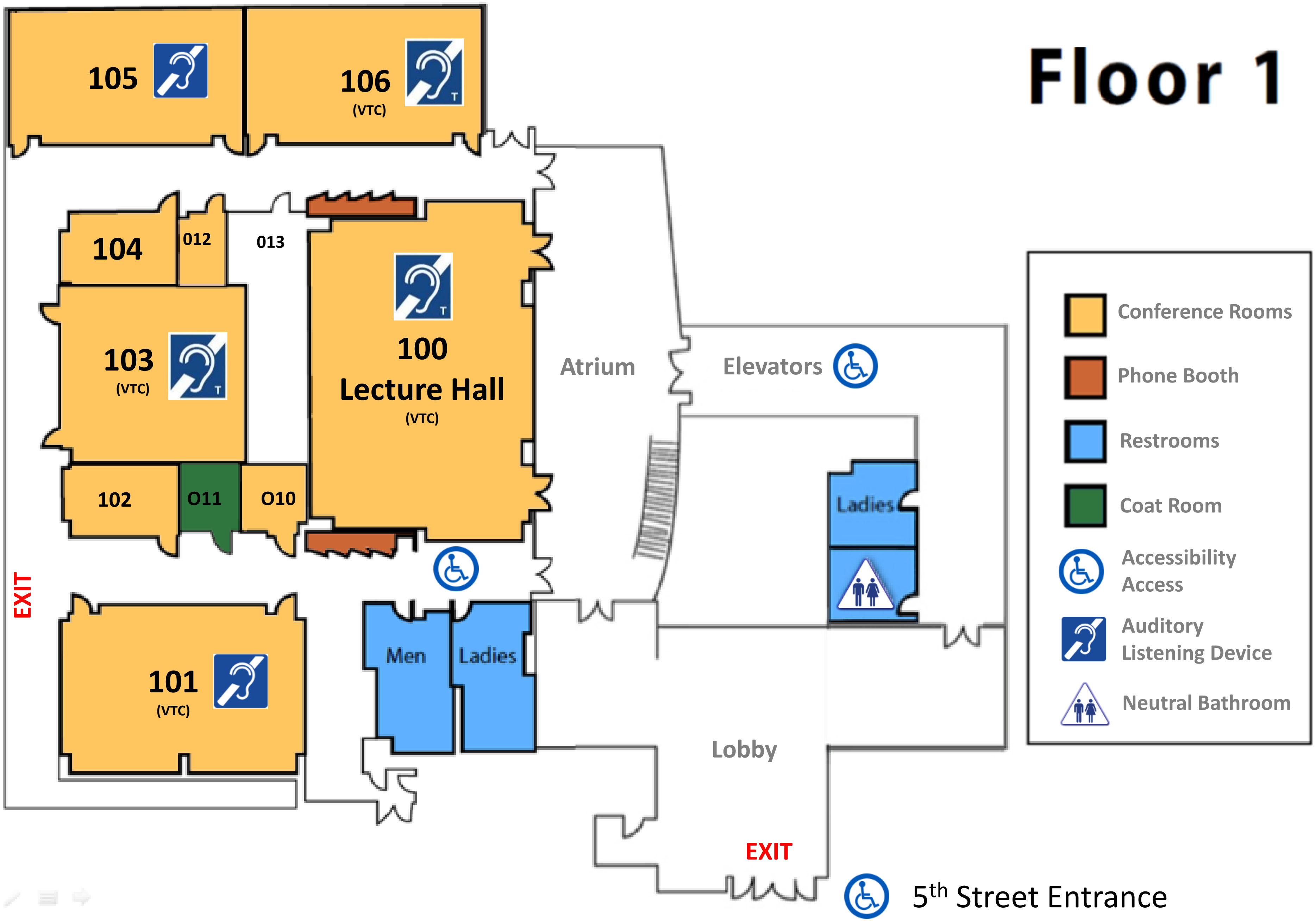
Keck Center – Room 208
500 5th St. NW
Washington, DC 20001

Parking is available in the Keck Center garage, entrance on 6th St.

Virtual attendance

https://nasem.zoom.us/meeting/register/tJIrdeuurT4sE9fCJVi6UhzxGOlZ0M67kTC8

Please note, all attendees must use this link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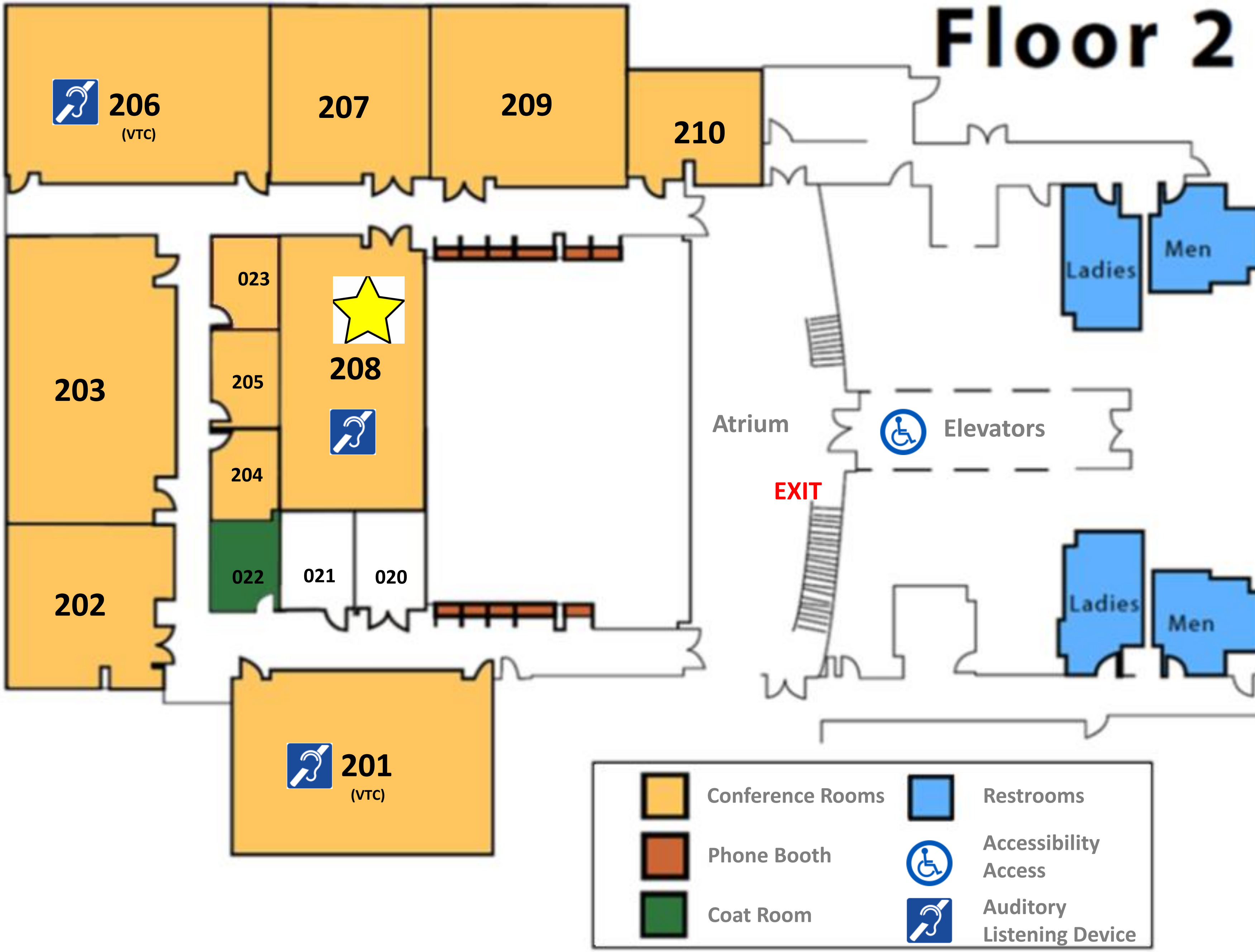
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02
Meeting Agenda

NATIONAL ACADEMIES Sciences Engineering Medicine

COSA Summer Meeting 2024

Meeting Agenda

*****PLEASE NOTE, PROFILE PRESENTERS ARE SUBJECT TO CHANGE*****

THURSDAY, JULY 11, 2024

10:30 – 11:00 AM **Welcome and Introductions**

Kevin Stokesbury, UMass Dartmouth, COSA chair
Rodney Cluck, BOEM

11:00 – 11:05 AM **Office of Renewable Energy Programs**

Desray Reeb, BOEM

11:05 – 11:40 AM Applying Distributed Acoustic Sensing Technology to Monitor Large Whales at Offshore Wind Areas

Shane Guan, BOEM
David Bigger, BOEM

11:40 – 12:15 PM Integrating High-quality Movement Data from Proxy Species into SCRAM

David Bigger, BOEM

12:15 – 1:15 PM **BREAK FOR LUNCH**

1:15 – 1:20 PM **Office of Environmental Programs**

Brad Blythe, BOEM or Yoko Furukawa, BOEM

1:20 – 1:55 PM All Impacts Are Not Equal: Artificial Intelligence Approaches for Understanding of BOEM Permitted Activities on Sperm Whale Vocal Clans

Jake Levenson, BOEM
Morgan Martin, BOEM

1:55 – 2:30 PM Modeling Carbon Dioxide Leakage and Potential Environmental Impacts from C Sequestration Projects on the Outer Continental Shelf (OCS)

Melissa Batum, BOEM
Zhen Li, BOEM

2:30 – 2:45 PM **BREAK**

2:45 – 3:20 PM Verification of OCS AQS and Development of a Satellite-based Top-down Emis Inversion System

Holli Wecht, BOEM
Cholena Ren, BOEM
Brian McDonald, NOAA
Steven Brown, NOAA

3:20 – 3:25 PM	**Pacific Regional Office** *Jeremy Potter, BOEM or Cathie Dunkel, BOEM*
3:25 – 4:00 PM	Impacts of Floating Offshore Wind Subsurface Infrastructure to Hydrodynamics, Biogeochemistry, and Primary Productivity in the Pacific OCS *Alice Kojima, BOEM* *Thomas Kilpatrick, BOEM*
4:00 PM	**Day 1 closing remarks** *Kevin Stokesbury, UMass Dartmouth, COSA chair*

FRIDAY, JULY 12, 2024

10:00 – 10:15 AM	**Welcome, day 1 summary, day 2 intro** *Kevin Stokesbury, UMass Dartmouth, COSA chair* *Rodney Cluck, BOEM*
10:15 – 10:20 AM	**Gulf of Mexico Regional Office** *Melonie Mitchell, BOEM or Melanie Damour, BOEM*
10:20 – 10:55 AM	Offshore Wind Energy Facilities Impact on Hydrodynamics and Primary Produc in the Gulf of Mexico *Mary Kate Rogener-DeWitt*
10:55 – 11:30 AM	Oil and Gas Vessel Strike Risk Analysis: Cetaceans in the Northern Gulf of Me with a Focus on the Endangered Rice's and Sperm Whale *Allen Brooks, BOEM* *Hayley Karrigan, BOEM* *Tre Glenn, BOEM*
11:30 – 11:35 AM	**STRETCH BREAK**
11:35 – 11:40 AM	**Alaska Regional Office** *Sharon Randall, BOEM or Casey Rowe, BOEM*
11:40 – 12:15 PM	Assessment and Minimization of Avian Collision and Displacement Risk Assoc Renewable Energy Infrastructure in the Cook Inlet Planning Area, Alaska *Shane Gray, BOEM*
12:15 – 1:15 PM	**BREAK FOR LUNCH**
1:15 – 1:20 PM	**Marine Minerals Program** *Jeffrey Reidenauer, BOEM or Deena Hansen, BOEM*
1:20 – 1:55 PM	Protected Smalltooth Sawfish Occurrence in BOEM OCS Sand Resource Area

	Deena Hansen, BOEM *Doug Piatkowski, BOEM* *Victoria Brady, BOEM*
1:55 – 2:00 PM	**STRETCH BREAK**
2:00 – 3:00 PM	First-in-class project: Programmatic Assessment for Enhancing BOEM's Public Participation Practices *Meghan Cornelison, BOEM* *Laura Mansfield, BOEM* *Kristen Strellec, BOEM* *Stephanie Webb, BOEM*
3:00 PM	**Day 2 closing remarks** *Kevin Stokesbury, UMass Dartmouth, COSA chair* *Rodney Cluck, BOEM*

03
Statement of Task

COSA Statement of Task

The National Research Council (NRC) will establish a standing committee to provide ongoing assistance to the Department of the Interior's Bureau of Ocean Energy Management (BOEM) in its efforts to manage development of the nation's offshore energy resources in an environmentally and economically responsible way. The committee will meet regularly to:

- convene experts from academia, industry, and other organizations to provide independent, technical input on issues of interest to BOEM's environmental studies and assessment programs, and potentially other programs;
- facilitate stakeholder discussions of controversial issues;
- enhance the understanding of developments in related fields of science and technology, and if warranted, draft proposals for potential NRC studies on specific topics;
- provide a venue for BOEM staff to meet and exchange information with staff from other federal agencies and help BOEM define its unique role in the interagency process; and
- facilitate the exchange of information and lessons learned with staff from other world class applied environmental studies and assessment programs with a view to assisting BOEM in being the best in such programs.

Meeting topics will be chosen in consultation with BOEM staff, based on input from BOEM and other stakeholders. Highlights of the meetings will be captured by NRC staff in the form of informal meeting recaps.

In addition to the regular meetings described above, committee discussions with BOEM may lead to NRC workshops or studies on specific topics, which will be subject to separate approval by the NRC's Governing Board Executive Committee, and possibly the attendance of individual committee members at annual environmental study program reviews by BOEM's Outer Continental Shelf (OCS) Scientific Committee. It is envisioned that future NRC studies associated with the work of this standing committee may include periodic comprehensive reviews of BOEM's programs, focused studies to address specific questions of interest to BOEM, and peer reviews of draft BOEM documents.

04
Committee Biographies

Biographical Sketches

Kevin Stokesbury, COSA chair, is a professor in the Department of Fisheries Oceanography, School for Marine Science and Technology, at the University of Massachusetts Dartmouth. His research examines the marine ecology of invertebrates and fish, and the impacts of fishing and energy development. He was awarded the David H. Wallace Award from the National Shellfish Association (2013) and the Standard-Times Southcoast Man of the Year (2018) for his two decades of science in the public interest. His research has been published in 69 scientific papers and 5 book chapters. He served the National Academies of Sciences, Engineering, and Medicine on “Fisheries Research and Monitoring for Atlantic Offshore Development” (2017) and “Assessment and Advancement of Science in the Bureau of Ocean Energy Management's Environmental Studies Program” (2021). He is a subject editor for the Journal of Shellfish Research and Reviews in Marine Fisheries and Aquaculture. Previously, Dr. Stokesbury served as an Adjunct Assistant Professor and Co-principle Investigator on the SEA Herring Project at the University of Alaska, Fairbanks’ Institute of Marine Science. He received his B.Sc. and M.Sc. from Acadia University in Nova Scotia, Canada, and went on to earn his Ph.D. from Université Laval in Quebec, Canada.

Carin Ashjian is Senior Scientist and current Department Chair in the Department of Biology at the Woods Hole Oceanographic Institution (WHOI). She previously did postdoctoral work at Brookhaven National Laboratory, the University of Miami, and WHOI before joining the scientific staff. Her research has focused on oceanography, zooplankton ecology, and biological-physical interactions in a range of the world’s oceans. Her recent work focuses on the impact of climate change on polar ecosystems and the greater Arctic system, including the human dimension. She has served on numerous national committees, including the North Pacific Research Board Science Panel, the Bering Sea Program Science Advisory Board, and the Regional Research Vessel Science Oversight Committee and she is a past chair of UNOLS Arctic Icebreaker Coordinating Committee. Ashjian received the USCG Meritorious Public Service Award (2009), the WHOI Henry Bryant Bigelow Chair for Excellence in Oceanography (2016), and the Alaska Sea Life Center Alaska Marine Research Award (2020). She earned a Ph.D. in Oceanography from the University of Rhode Island in 1991. She previously served on the National Academies’ Committee on Emerging Research Questions in the Arctic and the Committee on Polar Icebreaker Cost Assessment.

John A. Barth is a professor of oceanography in Oregon State University’s College of Earth, Ocean, and Atmospheric Sciences. He is also the Executive Director of Oregon State University’s Marine Studies Initiative, a program to unite marine-related research, teaching, and outreach and engagement across OSU and the state of Oregon. His research seeks to understand how coastal ocean circulation and water properties shape and influence coastal marine ecosystems. He has led research, technology development and ocean observing system projects off Oregon and around the world. His present research includes a focus on the characteristics and formation of low-oxygen zones off Oregon. His research team uses autonomous underwater gliders, robots beneath the sea surface. From 2013-2016, Dr. Barth served on the U.S. West Coast Ocean Acidification and Hypoxia Science Panel, and, from 2018-2022, he co-chaired Oregon's Ocean Acidification and Hypoxia Coordinating Council. He is a Fellow of The Oceanography Society and of the American Meteorological Society. He received a Ph.D. in Oceanography in 1988 from the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution Joint Program in Oceanography.

Daniel Costa is a Distinguished Professor of Ecology and Evolutionary Biology at the University of California at Santa Cruz. He was previously a postdoctoral researcher at the Scripps Institution of Oceanography. His research focuses on the ecology and physiology of marine mammals and seabirds. He has worked with a broad range of air breathing marine vertebrates and has published over 500 scientific papers. His research focuses on the movement and distribution patterns of marine mammals and seabirds to understand their habitat needs and their response to underwater sounds. This research is developing ways to assess the likelihood that a disturbance results in a population consequence. He has supervised 22 master's and 31 doctoral students as well as 18 post-doctoral scholars. He co-founded the Tagging of Pacific Predators program, a multidisciplinary effort to study the movement patterns of 23 species of marine vertebrate predators in the North Pacific Ocean and is a member of the NOAA IOOS Advisory Committee. Costa received a B.A. at UCLA and a Ph.D. at U.C. Santa Cruz. He is a member of the National Academies' Ocean Studies Board and has served on several NASEM committees, including Assessment and Advancement of Science in the Bureau of Ocean Energy Management's Environmental Studies Program.

Rónadh Cox is the Brust Professor of Geology and Mineralogy at Williams College, Massachusetts and a Visiting Professor in the School of Earth Sciences at University College Dublin. Her primary area of research is in wave impacts on rocky coasts, megagravel transport, and distinguishing the deposits of extreme storms from those of tsunami. She also studies the effects of progressive land loss on indigenous communities in coastal Louisiana. Rónadh is a Fellow of the Geological Society of America and of the American Association for the Advancement of Science, as well as an elected Member of the Royal Irish Academy; she also received the Distinguished Service Award from the Geological Society of America. She was awarded a B.Sc.(hons) in Geology from University College Dublin and a Ph.D. from Stanford University.

Jeremy Firestone is a Professor at the University of Delaware (UD). He holds his principal appointment in the School of Marine Science and Policy and is Director of UD's interdisciplinary Center for Research in Wind (CReW). Previously he was an Assistant Regional Counsel for US

EPA (1986-89) and an Assistant Attorney General for the State of Michigan (1989-96). In his research and writing, Professor Firestone focuses primarily on understanding public attitudes toward, and human behavior regarding, renewable energy technology, particularly offshore wind power, using survey research and semi-structured interviews. Other focal areas of research include the rights of indigenous peoples and marine spatial planning, along with domestic and international ocean and coastal law, regulation, and governance. He teaches courses on Offshore Wind Power, Renewable Energy, and Ocean and Coastal Law. He received a Bachelor of Science in Cellular and Molecular Biology and a Juris Doctorate from the University of Michigan and PhD in Public Policy Analysis from the University of North Carolina. In 2010, he served as a Workgroup Member, Panel Moderator and Breakout Session Leader for a National Academy of Sciences Marine Board, Offshore Wind Energy Workshop.

James Flynn joined the faculty at the University of Houston's Department of Earth & Atmospheric Science in 2013 and is currently a Research Associate Professor. His work focuses on atmospheric chemistry and air quality issues so that decision makers can develop informed policies supported by current science. His group has participated in numerous airborne, marine, and ground-based campaigns in the US and abroad as well as maintaining research networks in Texas and developing balloon-based sensors to validate satellite observations of trace gases. In 2022 James became a Senior Member of the National Academy of Inventors. He received his BS in Aviation Science from Baylor University where he continued to work in their airborne air quality research program until 2006. He earned his MS (2009) and PhD (2013) in Atmospheric Science from the University of Houston.

Katrin Iken currently is a Professor at the College of Fisheries and Ocean Sciences at the University of Alaska Fairbanks, where she is a member of the Marine Biology department. She also is the director of the Kasitsna Bay Laboratory, a coastal lab facility in Kachemak Bay, Southcentral Alaska, which is a NOAA-owned and UAF-operated facility supporting research, teaching, and outreach missions. Iken's primary research expertise is with benthic communities, especially patterns in diversity as well as food web structure. Much of her work focuses on Arctic systems but she is also active in some long-term monitoring efforts in the Northern Gulf of Alaska. She is active on international committees such as the Circumpolar Biodiversity Monitoring Program (CBMP) under the Arctic Council, as well as a member of the international steering committee of EU programs. She earned her degrees at various academic institutions in Germany before coming to the US in 1999 for a post-doctoral position, transiting to the faculty at the University of Alaska Fairbanks in 2002.

John O. Jensen is an associate professor and coordinator of the graduate program in history at the University of West Florida. Born in Alaska and a former commercial fisherman, Dr. Jensen is a social and policy historian and marine archaeologist whose research areas include historic shipwrecks, cultural heritage management, fisheries, and health and social welfare. A specialist on maritime frontiers and applied cultural landscapes, his expertise and publications encompass multiple areas of the Atlantic, Pacific, and Great Lakes regions of North America. His interdisciplinary monograph Stories from the Wreckage: A Great Lakes Maritime History Inspired by Shipwrecks received the Wisconsin Historical Society Board of Curators Book of Merit Award for the most valuable contribution to public understanding of Wisconsin's history in 2020. He has served on many professional committees, including the NOAA MPA System FAC (2012-16) and the MPA FAC Cultural Heritage Working Group (2010-2012). Dr. Jensen holds a BA in history from Lawrence University, an MA in maritime history and underwater archaeology from East Carolina University, an MS in history and policy, and a PhD in Social history from Carnegie Mellon University.

Les Kaufman is Professor of Biology at Boston University. He has worked for many years on committee assignments and field work with the New England Fishery Management Council, the National Marine Sanctuaries System, Conservation International, the Pew Charitable Trusts, the American Association of Zoological Parks and Aquariums, and the World Conservation Union. Dr. Kaufman is an active researcher in marine benthic ecology with specialization in fisheries and coral reef ecology. He leads the BU program on Coupled Human and Natural Systems (CHANS), with current field projects, modeling, and decision support in the Gulf of Maine, Florida and the Caribbean, the Great Lakes of Africa, and the Lower Mekong Basin. He is engaged in long-term studies of benthic communities, food web dynamics and forage fish population biology with the Stellwagen Bank National Marine Sanctuary and BOEM. He is on the founding science steering committee for NOAA's Mission: Iconic Reefs. Dr. Kaufman was the first Pew Marine Fellow in Conservation and the Environment and has received the Parker-Gentry Award in Conservation Biology. He received a BS and PhD from Johns Hopkins University and did postdoctoral research at Harvard's Museum of Comparative Zoology.

Kelsey Leonard is a Canada Research Chair in Indigenous Waters, Climate and Sustainability and an Assistant Professor in the Faculty of Environment at the University of Waterloo, where her research focuses on Indigenous water justice and its climatic, territorial, and governance underpinnings. Dr. Leonard seeks to establish Indigenous traditions of water conservation as the foundation for international water policymaking. Dr. Leonard has been instrumental in safeguarding the interests of Indigenous Nations for environmental planning and builds Indigenous science and knowledge into new solutions for water governance and sustainable oceans. In collaboration with a global team of water law scholars Dr. Leonard has published in Lewis and Clark Law Review on Indigenous Water Justice and the defining international legal principle of self-determination under the United Nations Declaration on the Rights of Indigenous Peoples. Her recent scholarship explores legal personhood for water and you can watch her TEDTalk "Why lakes and rivers should have the same rights as humans".

Ruth M. Perry is the Head of Regulatory Affairs for Shell Renewables and Energy Solutions Offshore Power Americas. In this role, she is responsible for leading and executing the permitting and regulatory advocacy, policy and research strategies for Shell's renewable power generation portfolio in the Americas. On behalf of Shell, she develops and leads public-private science collaborations, such as real-time monitoring programs, to improve industry's knowledge of the offshore marine environment and is helping to lead similar industry-wide collaborations. More so she establishes sustained ocean observation and research partnerships between offshore wind, governments, and ocean users, including the NGO community and fishing industry, to support responsible energy planning and development. Dr. Perry represents the energy sector as a member of NOAA Advisory Committees and Councils, including the IOOS Federal Advisory Committee, the Flower Garden Banks National Marine Sanctuary Advisory Council, and the NOAA Science Advisory Board. She has also recently been recognized as A Word About Wind's 2022 Top 100 North American Power leaders in offshore wind. Dr. Perry has over 15 years of ocean technology research and system implementation and ocean policy experience. She earned a Ph.D. in Oceanography from Texas A&M University in 2013. Dr. Perry previously served on the National Academies Ocean Studies Board, the Committee on Advancing Understanding of Gulf of Mexico Loop Current Dynamics, and as a representative to the U.S. National Committee for the UN Decade of Ocean Science for Sustainable Development.

Kevin St. Martin is a Professor and Chair in the Department of Geography at Rutgers University. He is a human geographer whose work is at the intersection of economic geography, political ecology, and critical cartographies. His work includes critical analyses of economic and resource management discourse as well as participatory projects that work to rethink economy and foster economic and environmental wellbeing. Dr. St. Martin's projects have in common the regulation and transformation of the marine environment. He uses the paradigmatic case of fisheries in the U.S. Northeast to better understand the power of discourse, data, and devices to shape economic and environmental outcomes. He co-edited Making Other Worlds Possible: Performing Diverse Economies, he is an editor of the Diverse Economies and Liveable Worlds book series, is an associate editor for the journal Maritime Studies, and serves on the advisory board of the Floating Laboratory of Action and Theory at Sea (FLOATS). Dr. St. Martin received his PhD from Clark University's Graduate School of Geography.

Lori L. Summa is a geologist with 40 years of experience in geoscience, basin formation research, and petroleum-systems analysis. She retired as a senior technical consultant with ExxonMobil Upstream Research Company in 2016. In this position, she advised corporate management on strategic geoscience issues to ensure appropriate research was performed in support of business objectives. She is currently an adjunct faculty member in the Department of Geosciences at Rice University and a research collaborator at the University of Texas, Jackson School of Geosciences. Her background is in basin analysis and numerical modeling, but she has done significant applied research in oil and gas exploration and drilling. She has chaired committees for both American Association of Petroleum Geologists and Geological Society of America (GSA) and has led numerous student short courses for the GSA, for which she received a 2016 Distinguished Service Award. Dr. Summa earned a B.S. in geology with honors from the University of Rochester and a Ph.D. in geology from the University of California, Davis in 1986.

She participated in NASEM's 2016 Committee on Future Directions for the U.S. Geological Survey's Energy Resources Program, and NRC's 2011 Committee on Scientific Ocean Drilling: Accomplishments and Challenges.

05
Selected SDP Profiles

Field	Study Information
Title	Applying Distributed Acoustic Sensing Technology to Monitor Large Whales at Atlantic Offshore Wind Areas
Administered by	Office of Renewable Energy Programs
BOEM Contact(s)	Shane Guan (shane.guan@boem.gov), David Bigger (david.bigger@boem.gov)
Procurement Type(s)	TBD
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	May 9, 2024
Problem	Offshore wind development may affect the distribution and migration of baleen whales in the region.
Intervention	This study would be a partnership with offshore wind developers and use existing fiber-optic cable for baleen whale monitoring, by applying distributed acoustic sensing (DAS) technology.
Comparison	Study results would be compared and validated with acoustic and visual data collected using traditional passive acoustic monitoring and ship and/or aerial surveys of baleen whale distribution and movement.
Outcome	Information from the study on whale distribution and movement in the study area, may be used to assess potential environmental impacts on the species.
Context	Atlantic OCS, but knowledge from this study can be used in other OCS regions.

BOEM Information Need(s): One of the most critical questions BOEM faces when regulating offshore wind development are the potential environmental impacts to baleen whales (Bailey et al., 2014; NAP, 2023), especially the critically endangered North Atlantic right whales (NARWs), which have a current estimated population under 370 animals (Hayes et al., 2023; Quintana-Rizzo et al., 2021). To monitor and assess the potential effects on baleen whale distribution, movement, and behavioral status from the large scale long-term offshore wind development in the Atlantic seaboard, BOEM is working with its partners to establish a regional passive acoustic monitoring (PAM) network. The network would consist of numerous hydrophones, hydrophone arrays, and vector acoustic sensors to detect the presence, abundance, movement, and possibly behavior of whales in and around the offshore wind areas. Though this effort will be funded by using a onetime earmark of approximately $5.5 M from the Inflation Reduction Act for acoustic sensor acquisition, deployment, and maintenance, it could be a challenge to meet the long-term commitment for this large-scale PAM in future years. Therefore, an innovative lower-cost long-term ocean observation approach using distributed acoustic sensing (DAS) technology could be a viable solution.

Background: DAS is a relatively new sensing technology that can be used to monitor undersea vibroacoustic disturbances, either in the water column or within the seabed, over a large (~ 100 km) distance (Wilcock et al., 2023). The approach is to attach the shore terminal of the fiber-optical cable to an interrogator, which sends a series of short laser pulses through one of the spare fibers (a.k.a., dark fiber) to measure the phase shift from the backscattering of the pulse along the cable. The backscattering of the laser pulse, caused by the nanometer-scale deformation of the fiber, is used inversely to get information on the vibroacoustic waves, such as acoustic pressure and particle motion in the water column or substrate-borne vibration, in the marine environment (Hartog, 2017; Lindsey and Martin, 2021).

Based on experimental settings, such as the distance of phase shift being measured (called gauge length), the spacing segments of scattered pulse (called channel), DAS can be used to monitor undersea vibroacoustic waves from under 0.001 Hz to above 1 kHz with a spatial resolution of a few meters (Guo et al., 2023; Wilcock et al., 2023). Over the past several years, DAS has been successfully demonstrated to monitor a variety of ocean environments, ranging from seismic activities, ocean dynamics, shipping noises, and marine life (e.g., Lindsey et al., 2019; Sladen et al., 2019; Landrø et al., 2020; Williams et al., 2019; Rivet et al., 2021; Bouffaut et al., 2022; Douglass et al., 2023; Wilcock et al., 2023) and to conduct shallow water passive geotechnical imaging (Williams et al., 2021).

Using an existing fiber optical submarine telecommunication cable that was buried in soft sediments at 0–2 m below the seafloor from Longyearbyen to Ny-Ålesund in Svalbard, Norway, Landrø et al. (2020) were able to continuously collect DAS data over 44 days with a sampling rate at 645.16 Hz. Their study detected whale calls along the 120 km of the cable with a 3D position localization of vocalizing whales for density estimation (Bouffaut et al., 2022). In another study, Wilcocks et al. (2023) used the two submarine cables operated by the Ocean Observatories Initiative Regional Cable Array off Pacific City to detect and localize blue (*Balaenoptera musculus*) and fin whale (*B. physalus*) calls as well as vessel traffic over four days in November 2021. The ship track results from DAS showed close agreement with that from the ship's automatic information system.

Because large whale detection and localization can be achieved using existing fiber optical cables on and below the seafloor, DAS technology provides a great opportunity to monitor these animals' distribution, movement, and potential behavior at a lower cost than current PAM systems.

Objective(s): The objectives of this study are: (1) Validate DAS-based baleen whale acoustic detection with those using traditional PAM in the Atlantic offshore wind energy areas (WEAs); (2) Supplement the Atlantic Regional PAM Network with DAS technology to enhance baleen whale detection and localization in the offshore WEAs; and (3) Establish an operational protocol for long-term baleen whale monitoring using DAS technologies for environmental assessments of offshore wind development.

Methods: The proposed research will first conduct a feasibility study to identify the offshore wind developers that own fiber optical cables that can be used for DAS monitoring and investigate the logistics on accessing necessary hardware and sites for the study. Interrogator(s) will then be installed to the shore terminal of the dark fiber(s) to measure backscattering of laser pulses that are emitted into the cable. DAS data collected will then be analyzed to derive information on baleen whale (in particular, NARWs) distribution, movement, and possibly behavioral status.

Specific Research Question(s):

1. Can DAS technology be a reasonable alternative to traditional PAM to conduct baleen whale monitoring at the offshore WEAs? If so, what are the pros and cons of using DAS technology rather than traditional PAM?
2. If DAS technology proves to be a low-cost way to study baleen whale distribution, movement, and behavior in the offshore WEAs, how can it be widely applied for environmental impact assessments?
3. Do baleen whales avoid windfarms construction and/or operations during the study period? Alternatively, are they attracted to these areas during the study period? Or is there no behavior
4. *If* there is a measurable change in baleen whale distributions across the Atlantic OCS, can we discern whether this change was due to offshore wind development or a different ongoing stressor?
5. What are the general sources, either natural (e.g., microseism, fishes) or anthropogenic (e.g., vessels, pile driving, turbine rotation), in the offshore WEA during the construction and operations of offshore wind farms?
6. Are there observable changes in acoustic behavior and/or behavioral ecology of baleen whales?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

References:

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Field	Study Information
Title	Integrating High-quality Movement Data from Proxy Species into SCRAM
Administered by	Office of Renewable Energy Programs
BOEM Contact(s)	David Bigger (david.bigger@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	United States Geological Survey
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	February 14, 2024
Problem	SCRAM (Stochastic Collision Risk Assessment for Movement) uses movement data from the Motus network as inputs to estimate number of ESA birds colliding with offshore wind turbines. The temporal data gap and the coarseness of the spatial data creates high uncertainty and obvious challenges in estimating the number turbine collisions.
Intervention	Use existing high-accuracy tracking data (e.g., GPS) from proxy species.
Comparison	Comparison of monthly offshore movements using Motus derived data and high-accuracy data from proxy species.
Outcome	A series of high-accuracy movement maps and data to be integrated into SCRAM
Context	Atlantic

BOEM Information Need(s): BOEM has a responsibility under the Endangered Species Act (ESA) to assess the risks of offshore wind energy development to listed species. The red knot, piping plover, and roseate tern are listed species that can migrate through areas developed for offshore wind. Information from this effort will be used to inform ESA consultations with the US Fish & Wildlife Service and NEPA analyses on the risk of offshore wind development projects to the red knot, piping plover, and roseate tern.

Background: Collision Risk Models are frequently used to estimate bird fatalities from operating wind turbines. The Band Model (2012) is widely used in Europe for common species and was recently used in the US (e.g., VOWTAP BA and Vineyard Wind BA). However, the Band Model is deterministic and does not allow biological variability (e.g., number of birds, flight heights, etc.) to be incorporated into input parameters, thus creating uncertainty in the interpretation of the model outputs (e.g., estimated number of collisions). The recently developed Stochastic Collision Risk Assessment for Movement (SCRAM) addresses these short comings (Adams et al. 2022).

However, the usefulness of the SCRAM model is hobbled by the temporal gaps and spatial coarseness and low quality of the species movement data on the Outer Continental Shelf. The movement data is key input used to estimate the number of birds that could encounter offshore wind turbines and is currently derived from data collected by a handful of shore based Motus towers. There are several shortcomings with the current approach. The Motus dataset for the three species is relatively small confined to a handful of studies. Most motus datasets cover only the fall migration and consequently SCRAM can provide only collision estimate collisions for fall migration. Currently, the Motus data from a single tower is inherently coarse with a spatial resolution of 20km. The Motus tracking stations are shore based and are only capable of detecting birds some 20 km away–falling well short of most wind farms.

Although it would be ideal to tag listed species, there are constraints (permits, proof that it can be done without harm, limits on number of animals to tag etc.). That said, a few OSW developers have taken the initiative to put GPS tags on red knots with some success and there is a recent graduate study in Oregon that put GPS tags on a few roseate terns last year in Maine, but no such efforts with piping plovers. While these efforts are underway, there is a need to look at existing data to fill these gaps.

An alternative approach is to pool together high-quality movement data (e.g., GPS) from proxy species that are taxonomically and ecologically similar to the three ESA species. Most examples in the literature use substitute species as proxies for others to predict habitat usage (Loman et al 2021) or for predicted population responses to stressors. However, demographic data from proxy species are commonly used as inputs for population viability analyses when there are no data from the target species. This study would be similar filling in a gap in input data for a PVA.

Objective(s): The objectives are: 1) use high-quality tracking data to describe movements of proxy species for roseate tern, piping plover, and red knot, spanning land and ocean in a way that can be integrated into the SCRAM model; 2) provide relevant biological data from non-listed species to expand the utility of SCRAM for other migrating species; and 3) develop approaches to validate SCRAM model predictions at land-based turbines.

Methods: Identify list of proxy species and relevant high quality data sets. Potential species (but not limited to) include American golden-plover *Pluvialis dominica*, black-bellied plover *P. squatarola*, Hudsonian godwit *Limosa haemastica*, common tern *Sterna hirundo*, least tern *Sternula antillarum*, American oystercatchers *Haematopus palliatus*. Acquire access to data sets by reaching out to The Shorebird Science and Conservation Collective (Shorebird Science and Conservation Collective | Smithsonian's National Zoo and Conservation Biology Institute (si.edu)) and others. Model overland and ocean movements. Prepare movement modeling results in a format to be integrated into SCRAM.

Specific Research Question(s): This study will test the efficacy of using data from proxy species over data specific to federally listed species.

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

References:

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Field	Study Information
Title	All Impacts Are Not Equal: Artificial Intelligence Approaches for Understanding Impacts of BOEM Permitted Activities on Sperm Whale Vocal Clans
Administered by	Office of Environmental Programs
BOEM Contact(s)	Jake Levenson (jacob.levenson@boem.gov), Morgan Martin (morgan.martin@boem.gov)
Procurement Type(s)	TBD
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	January 11, 2024
Problem	Sperm whales seasonally use the shallow waters of the offshore continental shelf. This brings them into proximity to wind energy area construction activities that may cause localized disruption to this species.
Intervention	Evaluate the seasonal presence, demographics and site fidelity of vocal clans.
Comparison	How are sperm whale vocal clans distributed across both regions and seasons?
Outcome	This study will provide essential data on clan composition and distribution for future examination of effects of WEA activities and increased ocean noise.
Context	All BOEM Western North Atlantic planning areas.

BOEM Information Need(s): BOEM requires robust, current data to (1) fully analyze and disclose the potential for impacts to protected species from outer continental shelf (OCS) activities at the programmatic and site-specific level; (2) help ensure that a species is not jeopardized by an activity or that critical habitat is not adversely modified by that activity pursuant to the Endangered Species Act (ESA); (3) minimize incidental take of marine mammals resulting from BOEM-permitted activities, thus meeting not only the small numbers and negligible impact requirement under the Marine Mammal Protection Act but also making every effort to maintain the health and stability of marine mammals and their ecosystem; and (4) fulfill Federal assessment and consultation responsibilities. Additionally, BOEM is required to design and implement mitigation measures to reduce or eliminate impacts from regulated activities on protected and managed species.

Background: Sperm whales, *Physeter macrocephalus*, are classed as endangered. In the western North Atlantic Ocean, they are primarily thought to forage and reside in deep offshore waters even though they are occasionally sighted on the OCS. A recent passive acoustic monitoring (PAM) study has shown that sperm whales were heard in the shallow waters of the Southern New England (SNE) wind energy area (WEA) near year-round with seasonal peaks in the summer and fall (Westell et al. in press). Preliminary investigation of PAM data from other regions of the OCS also show that they are present in shallow shelf waters (e.g., NYDEC report 2022). Their use of these waters brings them into proximity to WEA development activities that may cause localized disruption to this ESA listed species.

Sperm whales have advanced cognitive abilities, communication systems, and social structure (e.g., Rendell & Whitehead 2003). Besides their well-known foraging clicks, sperm whales also use codas, which are socially learned, stereotyped sequences of clicks. Sperm whales in social units are often related, have long-term membership, and will have a vocal dialect, which can include more than 20 different coda types. A vocal clan is composed of all social units, which overlap in distribution and share the same vocal dialect. Vocal clans have been identified in the Pacific and Atlantic Oceans, and show different social behavior, dive behavior, and diet. Vocal clans are formed as a result of oceanic cultural transmission between sperm whale groups based on the acoustic temporarily patterned signals used within their own clan (Rendell & Whitehead 2003). Clan culture is thought to be a more important determinant of sperm whale population structure than genes or geography, a finding that has major implications for our understanding of the species' behavioral and population biology. It also influences how different clans may respond to environmental changes or anthropogenic disturbance. While sperm whale codas have been extensively studied, and coda libraries established in the Caribbean, Azores, Gulf of Mexico, Mediterranean, and the Eastern Tropical Pacific (ETP), codas have not been cataloged or studied in the western North Atlantic since the 1970s (Watkins & Schevill 1977).

Currently it is unknown how many vocal clans use the shallow waters of the OCS or the nearby deeper waters. The home range, seasonal distribution, and demographic composition of sperm whales clans across WEAs is unknown except for in SNE where a recent study revealed that most of the sperm whales detected in this region are likely part of social units, composed of mature females and related juveniles and calves (Westell et al. in press). Vocal clans may exhibit different behaviors, foraging strategies, and levels of site fidelity that in turn can affect their level of susceptibility to anthropogenic disturbance. Therefore, improving the understanding of sperm whale demographics and vocal clan home ranges across the OCS will allow BOEM to improve regulatory measures and monitoring requirements to mitigate harm from wind energy development.

Objective(s):

- Develop a coda library for the western North Atlantic, updating it from Watkins and Schevill (1977) and compare it to other existing coda libraries for other regions (e.g., Gulf of Mexico and the Caribbean).
- Apply machine-learning techniques to automate and speed up the detection and categorization of codas and vocal clan coda dialects across available OCS PAM data sets.
- Understand the distribution of vocal clans and their demographic composition across OCS waters to determine distribution of impacts within a population.
- Assess potential changes in vocal clan presence and/or distribution during periods of wind energy development and construction.

Methods: This study will use extensive existing PAM data from both towed arrays (2016 and 2021 NMFS cetacean abundance surveys) and from stationary bottom mounted recorders deployed since 2020 off the SNE, Gulf of Maine and the Mid Atlantic. The first step to this project will be to create a library of all distinct codas detected using subsets of existing PAM data from the Gulf of Maine, SNE and mid-Atlantic regions. Recordings will be analyzed using Pamguard (Macaulay & Gillespie 2022) to determine the inter-click intervals (ICIs) of the recorded codas and thus, their temporal structure. Clicks belonging to the same coda will be marked and grouped, so that each coda can be represented by the set of ICIs. The repertoire between the groups will then be compared using the absolute inter-click intervals (ICI) to represent the temporal structure (rhythm and tempo, defined as the production pattern of clicks within a coda) of each coda to produce a baseline library (e.g., Gero et al., 2016).

Based on the method established by Bermant et al. (2019), machine learning (ML) techniques will be applied to develop an efficient method for detecting and categorizing codas, given the quantity of acoustic data that exists and will be generated in the future. The first step would involve training a neural network to identify and categorize sperm whale coda types. The neural network would then be used to automate the categorization of codas in large acoustic datasets. In addition, vocal clan classification could be used to identify the clans detected. This will allow for large volumes of PAM data to be more readily analyzed and a comprehensive catalog to be built. Once a northwestern Atlantic coda library has been created, it can be compared across coda libraries from different regions where sperm whale clans have been studied (e.g., Mediterranean, Caribbean) to see if those clans inhabit our study region. This library can also be compared to Watkins and Schevill's 1970s recordings to evaluate any change in clan composition 50+ years later.

The seasonal presence of sperm whales will be evaluated using an automated multi-step detection algorithm built in MATLAB to identify sperm whale echolocation clicks from the audio data (e.g., Solsona-Berga et al., 2022). Standard echolocation clicks are long trains of regularly spaced clicks, lasting for several minutes and transmitted during deep dives. Detections will be grouped into encounters and manually validated in DetEdit by an experienced analyst. Demographic composition will follow the method described in Westell et al. (in press) and developed by Solsona-Berga et al. (2022), where a MATLAB based interface (referred to as an ICIgram) is used to visualize patterns in ICI over time and manually annotate encounters (5-minute intervals) if a demographic class was confirmed by the analyst. The variability in seasonal presence, demographic composition and sperm whale vocal clans will be explored across the OCS WEA's. Finally, comparative analyses of changes in the distribution, site fidelity and movement of clans throughout this region, and where possible their potential response to both anthropogenic disturbance and climatic changes in food sources (e.g., Ilex squid) will be explored.

Specific Research Question(s):

1. How many distinct coda types can be identified in existing PAM data across the OCS? How do these compare to codas described by Watkins and Schevill (1977)? How do they compare to codas identified in other regions of the western North Atlantic (e.g., Caribbean and Gulf of Mexico)?
2. How do machine-learning techniques perform for automating detection and categorization of codas? Can machine-learning techniques effectively be used to identify one or more vocal clans based on the usage of codas?
3. How does seasonal presence and demographic composition vary across OCS regions? Can variability be understood based on oceanographic, prey availability (Ilex squid) or anthropogenic activities?
4. Can the distribution and/or movement of a vocal clan be tracked based on detection of codas? Does the presence of a vocal clan vary before, during, or after WEA construction (using SNE data)?
5. What is the importance of these areas of overlap between a vocal clan and WEA development to endangered sperm whales?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Field	Study Information
Title	Modeling Carbon Dioxide Leakage and Potential Environmental Impacts from Carbon Sequestration Projects on the Outer Continental Shelf (OCS)
Administered by	Office of Environmental Programs
BOEM Contact(s)	Melissa Batum (Melissa.Batum@boem.gov), Zhen Li (Zhen.Li@boem.gov)
Procurement Type(s)	Contract
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	April 23, 2024
Problem	Potential CO_2 leakage from carbon sequestration (CS) project activities could occur via a number of pathways. Few studies model and/or measure CO_2 leakage, transport, dispersion, attenuation, and environmental impacts in the offshore environment, and those that do exist are preliminary.
Intervention	BOEM needs more information regarding the dynamics, fate, transport, and potential environmental impacts of CO_2 leakage under various scenarios, including worst-case, on the OCS to inform the new nationwide CS Program and to protect the environment from CO_2 leakage.
Comparison	The study will model CO_2 leakage under various scenarios, including worst-case scenarios, using the GOM OCS Region as a case-study and can be applied to all OCS regions.
Outcome	The leakage and worst-case scenario modeling will aid BOEM's ongoing rulemaking efforts, program development and implementation, and future operational needs including NEPA analyses, lease planning, lease stipulations, consultations, plan and permit approvals, mitigation measures, risk assessment and monitoring requirements, etc. Study results will also provide direction for future studies to include field and/or laboratory analyses.
Context	This study will be applicable to all OCS Regions, with a case-study focused on the Gulf of Mexico (GOM).

BOEM Information Need(s): BOEM needs to understand of the impacts of CO_2 leakage on the coastal, marine, and human environment to evaluate potential impacts from carbon sequestration (CS) activities on the OCS. BOEM needs background and modeling information about the dynamics, fate, transport, and potential environmental impacts of CO_2 leakage under various scenarios on the OCS. The information will inform leasing scenarios and decisions, NEPA analyses, mitigation measures, and risk assessment and monitoring requirements for CS projects and protect the environment from CO_2 leakage.

Background: Atmospheric levels of GHGs are reaching a point where a global reduction of GHG emissions is not enough to curtail the worse effects of climate change; a rapid reduction of GHG emissions to net-zero human emissions is now necessary to prevent the more catastrophic impacts of climate change from striking communities and countries around the world. CS is an necessary part of current climate mitigation models (IPCC 2023, IPCC 2005, NAS 2019, NAS 2021, IEA 2021, US State Dept 2021) and the United States' goal to reach net-zero carbon emissions by 2050, and international goals to limit global surface warming to +2˚C or lower by 2100.

The INVEST in America Act (i.e., Bipartisan Infrastructure Law) of 2021 amended the Outer Continental Shelf Lands Act's (OCSLA's) leasing provisions to authorize the U.S. Department of Interior (DOI) to grant leases, easements, and rights-of-way on the OCS for the purpose of carbon sequestration (See 43 U.S.C. § 1337(p)(1)). BOEM and BSEE are currently developing regulations to implement a nationwide OCS CS Program, with the anticipation of a CS lease sale in the Gulf of Mexico (GOM) after final regulations are published.

The protection of the environment is central to every aspect and phase of the implementation of CS projects on the OCS, especially protection of the environment from potential CO_2 leakage. Understanding the impacts of CO_2 leakage on the environment is paramount to informing regulatory, policy, and environmental decisions and facilitate effective protection of the environment during project implementation. There are preliminary studies modeling several CO_2 leakage scenarios in the GOM (e.g., Oldenburg and Pan 2020, RISCS Consortium 2014) that could inform the development of a CO_2 leakage model for the OCS. The modeling results from this study will inform CO_2 leakage and worst-case scenarios for NEPA analyses, consultations, mitigations measures, conditions of approval, and other environmental issues and decisions. The study results will also inform ongoing rulemaking efforts, CS program development and implementation, and future operational lease planning, plan and permit approvals, risk assessment and monitoring requirements.

Objective(s): The objectives of this research include:

- Collect and evaluate existing data and information on "background" levels of CO_2 in the marine environment for the GOM OCS Region. Information should include seasonal and other types of and mechanisms for variability in naturally occurring CO_2 levels.
- Evaluate existing CO_2 leakage models and pilot tests (small-scale field tests) that analyze the dispersion, fate, and transport of CO_2 in the ocean from various potential leakage pathways (e.g., Oldenburg and Pan 2020, RISCS Consortium 2014) and determine how they can be applied the GOM OCS region.
- Model CO_2 leakage, dispersion, fate, and transport under various scenarios, including worst-case scenarios from multiple projects for the GOM OCS Region. Scenarios, at a minimum, should include varying volumes and pressures from pipeline ruptures, injection well blowouts, and leakages via legacy wells and geologic pathways such as reactivated faults.
- Model potential chemical oceanography and environmental impacts from the various leakage scenarios.
- Recommend methods and protocols for most effectively incorporating modeling scenarios into risk assessment and monitoring requirements for CS projects.

Methods: The study will compile, review, and synthesize existing information and models for modeling CO_2 leakage scenarios from CS project activities via a number of pathways (e.g., pipeline rupture, well blowouts, and leakages via legacy wells and geologic pathways such as reactivated faults) that may be applicable for each OCS Region (e.g., Oldenburg and Pan 2020, RISCS Consortium 2014). The study will identify the types of models currently being used in the offshore environment to inform the development of a national OCS CO_2 leakage model.

The study will also collect and evaluate existing data and information on "background" levels of CO_2 in the marine environment for the GOM Region of the OCS. Information should include seasonal and other types of and mechanisms for variability in naturally occurring CO_2 levels. Most of the world's ocean CO_2 measurement technologies and methods are conducted by NOAA, which is responsible for measurements of surface ocean CO_2 and ocean carbon chemistry including dissolved inorganic carbon (DIC), pH, and calculated surface ocean pCO_2. EPA also contributes by publishing trends in pH and related properties of ocean water, based on a combination of direct observations, calculations, and modeling. In addition, the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL) also study ocean CO_2 measurement and processes. NASA's ICESAT-2 mission also offers opportunities to monitor ocean carbon fluxes including as air-sea fluxes of CO_2, ocean primary production, lateral fluxes, and the inventories within these fluxes such as, ocean phytoplankton biomass, ocean alkalinity, and open ocean dissolved organic carbon.

The study will model CO_2 leakage under various scenarios, including worst-case scenarios, from multiple projects to determine CO_2 dispersion, fate, and transport for the GOM OCS Region. Region specific geologic scenarios will be evaluated. The study will also model impacts to chemical oceanography and potential environmental impacts using the CO_2 background data/information and various CO_2 leakage and worst-case modeling scenarios. The study will deliver modeling methods and modeling analyses for the CO_2 leakage, dispersion, fate, transport, and potential impacts. The study will deliver methods and protocols for most effectively incorporating modeling scenarios and results into leasing planning and scenarios, NEPA analyses, consultations, leakage modeling, mitigation measures, lease stipulations, conditions of approval, risk assessment and monitoring requirements, and other environmental needs and decisions (above) for CS projects. The study will also assess the gaps in understanding CO_2 background levels, CO_2 leakage modeling, and leakage impacts, and recommend direction for future studies to include field and/or laboratory analyses.

Specific Research Question(s):

1. What are the existing models and pilot tests that analyze the dispersion, fate, and transport of CO_2 in the ocean from various potential leakage pathways (e.g., Oldenburg and Pan 2020, RISCS Consortium 2014)?
2. What are appropriate CO_2 leakage modeling scenarios for the GOM OCS Region that can be developed into a national OCS CO_2 fate and transport model? What are appropriate worst-case CO_2 leakage scenarios for the GOM OCS Region?
3. What are considered "background" CO_2 levels in the GOM OCS Region?
4. What are the dispersion patterns, fate, transport, and potential environmental impacts from the various CO_2 leakage scenarios? What are the most important factors affecting CO_2 leakage dispersion, fate, and transport (e.g., water depth)?
5. What are the most effective methods and protocols to incorporate the study results into risk assessment and monitoring requirements for CS project? What are the gaps in understanding background CO_2 levels, CO_2 leakage modeling, and modeling potential environmental impacts from CO_2 leakage?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Environmental Studies Program: Studies Development Plan | FY 2025–2026

Field	Study Information
Title	Verification of OCS AQS and Development of a Satellite-based Top-down Emissions Inversion System
Administered by	Office of Environmental Programs
BOEM Contact(s)	Nellie Elguindi (nellie.elguindi@boem.gov), Holli Wecht (holli.wecht@boem.gov), Cholena Ren (cholena.ren@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	NOAA Chemical Science Laboratory and NESDIS
Total BOEM Cost	TBD
Performance Period	FY 2025–2028
Final Report Due	TBD
Date Revised	March 20, 2024
Problem	BOEM needs to evaluate its inventory, quantify the uncertainties, and develop a modern framework for monitoring and quantifying air emissions that incorporates atmospheric-based measurements and recent technological advances.
Intervention	Conduct a comprehensive aircraft campaign to measure air pollutant and greenhouse gas (GHG) concentrations and estimate basin-wide emissions fluxes. Develop a satellite-based inverse modeling system for long-term monitoring and tracking of emissions in the Gulf of Mexico (GOM) to complement OCS air quality standards(AQS).
Comparison	OCS AQS and satellite-based emissions estimates are compared to the atmospheric-based top-down emissions basin-wide fluxes.
Outcome	An evaluation of the OCS AQS inventory and a quantification of the associated uncertainties. An inversion modeling system to estimate regional emissions fluxes from available satellite data in the GOM to complement OCS AQS, which improve impact assessments required by NEPA and OCSLA.
Context	Gulf of Mexico

BOEM Information Need(s): BOEM has jurisdiction over Outer Continental Shelf (OCS) air emissions in the GOM west of 87.5 degrees West longitude on a limited set of air pollutants. Oil- and gas-related activities authorized under the Outer Continental Shelf Lands Act (OCSLA) must comply with the National Ambient Air Quality Standards (NAAQS). This study supports BOEM's ability to monitor air emissions over the OCS, improve quantification approaches, and work towards assessing the impact of regulated and unregulated air emissions. BOEM needs to evaluate its emission inventory and quantify the associated uncertainties to fully characterize the impact of its oil and gas activities in the GOM.

Background: An accurate emissions inventory is critical to properly assess the impact of BOEM authorized oil and gas activities on air quality and climate. Inaccuracies and gaps in the emissions inventory can lead to significant errors in air quality modeling efforts aimed at quantifying the impact of oil and gas air pollutant and greenhouse gas emissions on the States' air quality or in quantifying their contribution to climate change (i.e., social cost of carbon, etc.).

Previous studies have highlighted significant discrepancies in BOEM's OCS AQS inventory. Based on airborne surveys, results from the F3UEL project indicate that methane emissions reported in OCS AQS are underestimated by a factor of two (Gorchov-Negron and others, 2020). This trend has been observed in other studies as well (Ayasse et al., 2022). Gorchov-Negron et al. (2023) report that their atmospheric-based estimation of carbon intensity, a measure of the climate impact per unit of energy of produced oil and gas, was nearly three times as much as the government inventory-based estimate in the GOM.

Methane is not the only pollutant that has been identified as exhibiting large discrepancies in government bottom-up inventories of oil and gas emissions. NO_x, a pre-cursor to O_3 which is associated with adverse health effects, has been reportedly over-estimated in government oil and gas inventories. Gorchov-Negron and others (2018) found that the EPA's inventory overestimated NO_x in 75% of the basins. NOx was also measured during the F3UEL campaign and while the discrepancy was not as large, the atmospheric-based inventory total (322 kg NO_x/h [283 to 360, 95% confidence interval]) was significantly less than BOEM's activity-based bottom-up estimate (418 kg NO_x/h). A NO_x discrepancy of this magnitude can have a large impact on the modeling of atmospheric photochemical processes (e.g., formation of ozone) and lead to significant biases in the estimations of air pollutant concentrations.

Bottom-up inventory verification is even challenging offshore since no offshore air quality monitors exist due to the harsh marine environment. Comprehensive airborne surveys, measuring multiple pollutants, are the only practical means of evaluating BOEM's OCS AQS inventory on a basin-wide scale and quantifying the associated uncertainties. This type of information would be highly informative for NEPA analyses, as well as in improving and interpreting results from BOEM's air quality modeling efforts that assess single sale and cumulative impacts of both current and projected oil and gas activities in the GOM on the States' air quality and the climate.

While an airborne survey would provide BOEM with a snapshot of Gulf-wide air emissions from oil and gas operations, in terms of long-term solutions, these campaigns are too costly to be repeated on a regular basis. On the other hand, high-resolution satellite technologies have made significant advances in recent years and can offer a more practical and feasible means of continuous long-term monitoring of air pollutants and GHG concentrations which can then be used to derive regional emission fluxes through techniques such as inverse modeling. Moreover, the scientific community and the National Strategy to Advance an Integrated U.S. GHG Measurement, Monitoring and Information System are working towards developing a modern framework for monitoring and tracking emissions that incorporates atmospheric-based observations, to the extent possible, in a so-called multi-tiered observing system that can complement and enhance activity-based bottom-up inventories (MacDonald and others, 2023; White House, 2023). This includes nascent technologies such as high-resolution, multispectral/hyperspectral satellite imagery which need rigorous verification. BOEM has already invested in such studies (e.g., SCOAPE I and II cruise, NASA's CSDA GHGSat evaluation program).

NOAA is planning to lead a series of airborne campaigns in 2024–2026 to provide comprehensive and quantitative top-down emissions data for methane, other GHGs, and major air pollutants from major U.S. oil and gas basins. Currently, the NOAA's AirMAPS campaign is only focused on the five largest onshore oil and gas regions, but with additional funding the campaign can be extended to other regions such as the GOM.

This study will capitalize on information gained from previous flight and ship campaigns performed in the GOM (i.e., SCOAPE cruises I and II, F3UEL air campaigns). Note this study overlaps and complements the study profile *GM25AQ Airborne Air Emission Survey* submitted to the Gulf regional office.

Objective(s):

1) Conduct a comprehensive aircraft campaign to measure multiple air pollutant and greenhouse gas concentrations over the GOM in 2026 to estimate basin-wide (top-down) emissions fluxes from oil and gas activities.
2) Compare BOEM's OCS AQS activity-based bottom-up emissions inventory to the top-down atmospheric measurement-based estimates of basin- or sub-basin-wide emissions fluxes to assess its accuracy.
3) Develop an inverse modeling system to derive basin-wide emissions flux estimates of selected air pollutants and greenhouse gases from satellite data in the GOM. Independently verify these satellite-based estimates with the aircraft-derived emissions fluxes described in (1) to assess the uncertainty and potential of using satellite data for long-term, continuous monitoring of trends and regional emissions fluxes in the GOM to complement the triennial bottom-up inventory.

Methods:

1) NOAA will conduct an airborne campaign in 2026 in Texas, deploying a comprehensive and detailed chemical payload on the NOAA WP-3 aircraft to measure GHGs and co-emitted pollutants in the GOM to provide comprehensive and quantitative top-down emissions data for methane, other GHGs, and major air pollutants from oil and gas activities at basin scale. A mass balance approach will be used to estimate emissions using the difference between upwind and downwind mixing ratios. BOEM's OCS AQS inventory will be compared to the atmospheric-based emissions estimates derived from the aircraft campaign described in (1) to determine which air pollutants or GHGs may be under- or over-estimated in OCS AQS for the month(s) of aircraft measurements. Repeat flights will be performed to improve the robustness of the comparison and spatial coverage for a basin-level evaluation.
2) NOAA will collaborate with BOEM to assess satellite-based emission inversions by the Greenhouse And Air Pollutant Emissions System (GRAAPES) for the GOM. GRAAPES will ingest satellite retrievals of trace gases over the GOM using weather-chemistry models and chemical data assimilation to estimate basin-level emissions. The aircraft mass balance emissions estimates and Doppler lidar will be used to evaluate the performance of the meteorological model and fluxes estimated by GRAAPES.

Specific Research Question(s):

1. What are the quantified errors of the OCS AQS emissions estimates for selected GHGs and air pollutants?
2. Are satellite-based top-down emissions (derived from a modeling inversion system) of oil and gas operations in the Gulf of Mexico reliable enough to be used to supplement the OCS AQS inventory? If yes, for which species and in what capacity?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Field	Study Information
Title	Impacts of Floating Offshore Wind Subsurface Infrastructure to Hydrodynamics, Biogeochemistry, and Primary Productivity in the Pacific OCS
Administered by	Pacific OCS Region
BOEM Contact(s)	Alice Kojima (alice.kojima@boem.gov); Thomas Kilpatrick (thomas.kilpatrick@boem.gov)
Procurement Type(s)	Interagency Agreement or Cooperative Agreement
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	May 2, 2024
Problem	Recent and ongoing modeling studies examine the impact of wind wakes (i.e., atmospheric disturbance) from Pacific Outer Continental Shelf (OCS) offshore wind farm development on upwelling and related nutrient availability. However, these studies do not consider fluid-structure interactions between oceanic flow and subsurface wind farm infrastructure (i.e., floating substructures).
Intervention	This study will fill a knowledge gap by modeling interactions between oceanic flow and underwater infrastructure of wind farms to determine how they may influence hydrodynamics (HD), biogeochemistry (BG), and primary productivity (PP).
Comparison	Model simulations that incorporate oceanic flow-floating substructure interactions (ocean wakes) will be compared against a control simulation with no wind farms and available observational data in the region for model validation. There will also be a comparison with a “no-ocean wake” scenario to characterize contribution of ocean wakes to changes in HD, BG, and PP.
Outcome	This study will help provide the full picture of how Pacific OCS offshore wind development may impact HD, BG, and PP via changes in both atmospheric and ocean circulation. Outcomes of this study will be crucial for productive interactions with stakeholders and will inform both the National Environmental Policy Act (NEPA) review process and future construction and operation plans.
Context	The modeling domain will be the Pacific OCS region extending from southern California to Washington, with particular focus on existing lease areas (California) and wind energy areas (Oregon).

BOEM Information Need(s): To support offshore wind (OSW) development in the Pacific Outer Continental Shelf (OCS) region in an environmentally responsible way, BOEM must evaluate the potential impact of OSW infrastructure on the physical upwelling properties of the California Current and associated biogeochemistry (BG). By bringing nutrient-rich waters to the surface, upwelling forms the foundation of the exceptional productivity of the California Current Large Marine Ecosystem (CCLME). Modeling studies to date investigate the potential impact of wind wakes (i.e., reduced wind stress) produced by Pacific OCS wind farm infrastructure on upwelling volume transport and nutrient delivery (Raghukumar et al., 2023) and related BG (NT-23-09). However, these studies do not consider the subsurface interactions between oceanic flow and the floating substructures of the wind farms (i.e., ocean wakes). Environmental impacts of the floating substructure will be considered in the National Environmental Policy Act (NEPA) review process and may inform the designs proposed in construction and operations plans submitted by lessees.

Background: The California Current flows along the Pacific coast of the U.S. and is highly productive due to the upwelling of deep, nutrient-rich waters to the surface. This delivery system of nutrients to the surface allows organisms of all trophic levels to thrive in this region and is thus of primary interest to stakeholders. A recent modeling study funded by the State of California demonstrates a modest impact of OSW infrastructure to patterns of upwelling near the Morro Bay wind energy area (WEA) in central California (Raghukumar et al. 2023). In particular, Raghukumar et al. (2023) observed a slight reduction in upwelling strength on the lee side of the wind farm and a change in the spatial signature. Ever since the results of this study were made public, many stakeholders of the Pacific OCS have expressed concern about the impacts of OSW development on upwelling during the various comment periods of the OSW leasing process (most recently, in response to the Oregon draft WEAs). BOEM has invested in a subsequent modeling study (NT-23-09) to investigate OSW farm impacts more broadly on ocean BG and PP offshore California and Oregon. Both studies represent the presence of floating wind farms as a reduction in wind stress (i.e., wind wake) at the sea surface, but do not include interactions between subsurface infrastructure and oceanic flow (i.e., ocean wakes) as part of their impact.

The dynamics of these ocean wakes produced by floating substructures remain poorly understood in both well-mixed and stratified pelagic waters due to the relatively new expansion of the OSW energy sector into deeper waters (Dorrell et al. 2022). The semi-submersible type of floating substructure is most commonly used in global floating offshore wind farms to date (Musial et al. 2020), and is also the most likely and preferred technology to be used for Pacific floating offshore wind development (Trowbridge et al., 2023). This study will employ the semi-submersible substructure type together with wind wake parameterizations to demonstrate how turbines and substructures together impact HD, BG, and PP.

Objective(s): The objectives of this study are as follows:

- Model interactions between oceanic flow and floating semi-submersible substructures and combine with parameterized wind wake effect to characterize impacts of Pacific OCS wind farms on local HD, BG, and PP.
- Create an engaging communication product (e.g., ArcGIS StoryMap) to share the outcomes of this study with stakeholders and develop related talking points that can be used by BOEM Pacific staff when answering questions about upwelling and public-facing meetings.

Methods: This study will develop a model framework that couples an established general circulation model (e.g., MITgcm) with an ecosystem model (e.g., Darwin package), or use a similar approach. Oceanic flow can be simulated at 10-m resolution (in both x and y) and as high as 3-m resolution (z) using MITgcm (Hughes et al. 2022). The model simulations produced by this framework will be of sufficient resolution to distinguish changes in physical currents beneath and around a semi-submersible floating substructure and the associated HD, BG, and PP impacts. The semi-submersible substructures will have dimensions that support 10- and 15-MW wind turbines.

First, these simulations will be compared against a "no-turbine" control run to determine the full magnitude of impact on HD, BG, and PP. Second, these simulations will be compared against a "no-ocean wake" control to quantify the added influence that the ocean wake has on HD, BG, and PP. The magnitude of change from the "no-ocean wake" control will also be compared against the results of previous modeling studies that incorporated only wind wake effects to demonstrate model differences (e.g., MITgcm vs. ROMS). Relevant observational data (e.g., glider data) will be used to help validate these model simulations. This study will provide a more complete picture of how Pacific OCS offshore wind farm infrastructure will impact HD, BG, and PP of the surrounding area and provide a basis for potential higher trophic level responses.

Specific Research Question(s):

1) How will ocean wake effects from oceanic flow-floating substructure interactions combine with wind wake effects from wind field-turbine interactions of offshore wind farms to impact HD, BG, and PP?
2) How will interactions between oceanic flow and floating substructures influence ocean stratification and thermocline depth in WEAs?
3) How do these changes (ocean stratification and thermocline depth in WEAs, local and regional HD, BG, PP) compare to those that occur due to natural variability (Jacox et al. 2015) and climate change?
4) How do HD and BG changes simulated in MITgcm compare to those simulated in ROMS?
5) How can these modeling results inform a monitoring effort focused on turbine-scale oceanic flow-structure interactions?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Environmental Studies Program: Studies Development Plan | FY 2025–2026

Field	Study Information
Title	Offshore Wind Energy Facilities Impact on Hydrodynamics and Primary Production in the Gulf of Mexico
Administered by	Gulf of Mexico Region
BOEM Contact(s)	Mary Kate Rogener-DeWitt (Mary.rogener-dewitt@boem.gov)
Procurement Type(s)	Contract, Interagency Agreement, or Cooperative Agreement
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	February 1, 2024
Problem	The Louisiana-Texas shelf is a highly productive, broad continental shelf with complex hydrodynamics. Modeling studies from other regions indicate that offshore wind energy facilities may have an impact on local and regional hydrodynamics, raising stakeholder concerns about potential impacts to the northern Gulf of Mexico (GOM). The Bureau of Ocean Energy Management (BOEM) needs information to assess the potential impacts to the northern GOM for mitigation efforts and future environmental analyses.
Intervention	A coupled hydrodynamic-nutrient phytoplankton zooplankton detritus (NPZD) biogeochemical model will be used to estimate the potential impacts of offshore wind energy facilities and various wind turbine configurations on the hydrodynamics, water quality, and primary productivity in the GOM region, specifically within planned Wind Energy Areas (WEAs).
Comparison	This study will use model simulations to investigate hydrodynamics, water quality, and primary productivity prior to offshore wind construction, post installation of a single facility, post full build-out of a realistic configuration of multiple facilities across the wind energy areas, as well as various turbine configuration scenarios in the GOM region.
Outcome	This study will estimate the potential impacts of offshore wind energy facilities, at different stages of development and various turbine configurations, on GOM Outer Continental Shelf (OCS) hydrodynamics, water quality, and primary productivity. This information is necessary for mitigation efforts and future environmental analyses.
Context	Western GOM, Central GOM

BOEM Information Need(s): Per 30CFR585.101(c), BOEM needs to ensure that renewable energy activities on the OCS are conducted in a safe and environmentally sound manner. To satisfy this obligation and support the sustainable development of offshore wind in the GOM, BOEM needs to understand and estimate the potential impact of offshore wind development on local and regional hydrodynamics, and resulting impacts on water quality and primary productivity.

This study would help BOEM estimate potential impacts of offshore wind energy facilities–during the various stages of construction and/or operation and configuration scenarios–on the hydrodynamics, water quality, and primary productivity of the GOM; provide information to stakeholders through impact assessments and consultations; and guide potential mitigation measures. These results would be included as part of impact assessments pursuant to the National Environmental Policy Act (NEPA), Endangered Species Act, and the Magnuson-Stevens Fishery Conservation and Management Act.

Background: The GOM is a highly productive, broad continental shelf system with complex hydrodynamics due to multiple river plumes with varying spatial distributions, Loop Current, Loop Current eddies, and seasonally driven shelf circulation resulting in stratification along the shelf (Hetland and DiMarco, 2012). As a result of the complex oceanographic regimes, the GOM is prone to low oxygen conditions. Research in the North Sea, a similar low oxygen prone system, has shown that wind energy facilities further decrease dissolved oxygen concentrations (Daewel et al., 2022). Studies from other regions have shown that offshore wind energy facilities alter regional and local hydrodynamics, surface wind fields, biogeochemistry, and primary productivity (Slavik et al., 2019; van Berkel et al., 2020; Johnson et al., 2021; Christiansen et al., 2022; Daewel et al., 2022; Raghukumar et al., 2022; 2023). However, the relevance of the impacts found in other regions (North Sea, California Current, and the Mid-Atlantic Bight) to the GOM is unknown, as the GOM has a significantly different oceanographic regime than these areas. Due to the productive and dynamic nature of the GOM, it is important to understand how offshore wind energy development in the GOM may impact hydrodynamics, water quality, and primary productivity.

Offshore wind facilities reduce local wind speeds by drawing energy from surface winds, and the turbines alter the turbulence of currents flowing past the structures (Dorrell et al., 2022; Raghukumar et al., 2022). Both effects may alter regional and local hydrodynamics, resulting in impacts to water quality (e.g., sediment and nutrient transport and resuspension) and primary productivity. To date, BOEM has funded studies to analyze the impacts of offshore wind energy facilities on physical and oceanographic processes in the California Current, Nantucket Shoal, and Mid-Atlantic Bight (Chen et al., 2016; Johnson et al., 2021; BOEM Study AT-22-01A&B; BOEM Study NT-23-09; NASEM 2023). Conditions in those regions differ from the physical and biological dynamics of the GOM.

Recently, BOEM issued one lease for offshore wind development on the OCS of Louisiana and has finalized four more WEAs for future development[1]. Stakeholders have expressed concern regarding the impacts of large and multiple wind projects on circulation patterns in response to recently published findings on the impacts of wind energy facilities on hydrodynamics, primary production, and local oxygen concentrations. To address the knowledge gaps in the GOM and determine potential mitigations, BOEM needs to estimate the potential effects of wind turbine structures, field structure configurations, and development of multiple wind energy facilities within the WEAs on the surrounding ecosystem. The first wind energy lease sale in the GOM was in the summer 2023 and this study would provide vital information during the development and environmental review of future lessees' Construction and Operation Plans.

[1] https://www.boem.gov/renewable-energy/state-activities/gulf-mexico-activities

Similar to the impacts of offshore wind energy facilities on regional and local hydrodynamics, little is known about the hydrodynamic impacts of various wind turbine configurations (i.e., spacing distance, layout orientation, and turbine size) and how layout design might mitigate potential impacts of altered hydrodynamics as wind turbine size and capacity increase. Thus far, wind turbine siting has focused on minimizing the wind wake between turbines for maximum energy output and providing ample space for navigation of vessels and fishing activities. A recent atmosphere-only modeling study of WEAs in the Mid-Atlantic determined that wind speed, turbulence, friction velocity, and sensible heat fluxes at the surface of the water are reduced in wind farms with turbines 10 MW or larger (Golbazi et al., 2022). These results suggest that there may be impacts to local oceanic circulation patterns from varying sized turbines. By running various model scenarios, this study would help identify optimal turbine orientation, size, and configuration to ensure the least amount of local hydrodynamic impact on the environment as practicable.

Objective(s): Use model simulations to estimate the potential impacts of offshore wind energy facilities in the GOM on hydrodynamics, water quality, and primary production. Investigate various development scenarios and turbine configurations and evaluate how the scenarios and configurations affect the hydrodynamics, water quality, and primary production. Synthesize available empirical data and use data to inform, verify, and validate model results. This modeling effort would require open-source modeling tools, which would be made publicly available to allow for the transfer of model simulations to other regions and to provide code base and configurations for future projects to build upon. This objective aligns with administration priorities to make Federally funded research and development accessible to the public in a transparent, reusable, equitable, secure, and trustworthy way (White House memo, 2022).

Methods: A GOM regional modeling approach will be used, and the spatial domain of the model will include the WEAs on the Louisiana-Texas OCS. This study will start with a synthesis of available empirical data in the region where the wind energy facilities are planned, which may include satellite data, current profiles, meteorological measurements, geophysical surveys, and archived biogeochemical data (macronutrients and other available data). These data would inform an existing coupled hydrodynamic-nutrient, phytoplankton, zooplankton, detritus (NPZD) biogeochemical model that offers the best approach and resolution to complete the objectives and specific research questions. Possible models include but are not limited to HYCOM, FVCOM, ROMS, Delft3D. The hydrodynamics of different scenarios will be simulated. Example scenarios include conditions before offshore wind farm construction, after installation of a single facility, and a realistic configuration of multiple facilities across the WEAs. Additional scenarios may include configurations of varying turbine sizes, spacing, and future forecasts of climate change scenarios over 30 to 50 years.

Specific Research Question(s):

1. How could potential offshore wind energy facilities alter local and regional hydrodynamic processes in the planned WEAs on the Louisiana-Texas OCS? How might these impacts change because of climate change and a warming ocean?
2. How might potential changes in hydrodynamic processes impact water quality (e.g. sediment and nutrient transport and resuspension), and subsequent primary production throughout the area?
3. How might alternative siting or turbine configurations act as mitigation efforts and limit impacts on hydrodynamics?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Field	Study Information
Title	Oil and Gas Vessel Strike Risk Analysis: Cetaceans in the Northern Gulf of Mexico with a Focus on the Endangered Rice's and Sperm Whale
Administered by	Gulf of Mexico Region
BOEM Contact(s)	Allen Brooks (Robert.Brooks@boem.gov); Hayley Karrigan (Hayley.Karrigan@boem.gov); Tre Glenn (Tre.Glenn@boem.gov);
Procurement Type(s)	Contract
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	September 2027
Date Revised	February 1, 2024
Problem	The Bureau of Ocean Energy Management (BOEM) is required to analyze effects to Endangered Species Act (ESA)-listed and proposed species, ESA-listed species critical habitat (designated and proposed), and Marine Mammal Protection Act (MMPA) protected species resulting from ongoing and future actions associated with BOEM-regulated activities. Based on recent information concerning the possible distribution of Rice's whale (*Balaenoptera ricei*) within the northwestern Gulf of Mexico (GOM) and proposed designation of critical habitat for the Rice's whale, there is a need to evaluate vessel strike risk to this species, and other protected cetaceans (i.e., ESA-listed sperm whales [*Physeter macrocephalus*]), relative to BOEM-regulated vessel activities.
Intervention	Evaluate vessel strike risk for the ESA-listed Rice's and sperm whales in the GOM; using recommendations provided in the BOEM study *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and Recommendations for Future Efforts to Predict Strike Risks* to perform a rigorous, statistically-meaningful vessel strike analysis.
Comparison	The risk from oil and gas vessel collisions in the northern GOM will be put into context of the possible distribution of Rice's whale and other cetacean species within the northwestern GOM.
Outcome	Assessment of vessel strike risk to Rice's and sperm whales in the GOM from BOEM-regulated vessel activities, identification of assumptions and knowledge gaps, and informing of future analyses.
Context	Northern GOM

BOEM Information Need(s): To fulfill requirements under the ESA and MMPA relative to the endangered Rice's and sperm whales, BOEM's Gulf of Mexico Regional Office (GOM) must inform its future efforts to predict reasonable and defensible vessel strike risk for these species**.** Specifically, BOEM needs to use recommendations from previous assessments, including the BOEM study, *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and*

Recommendations for Future Efforts to Predict Strike Risks, to conduct a rigorous, statistically-meaningful vessel strike analysis; identify the assumptions (e.g., limitations) that are part of the assessment; and identify additional information that is needed to inform future vessel strike analyses. The study will result in more accurate predictions of risk from oil and gas activities.

Background: BOEM is required to analyze effects to ESA-listed species or species proposed for ESA-listing, and designated or proposed critical habitat, and species protected under the MMPA, resulting from ongoing and future actions associated with BOEM-regulated activities. One risk to protected marine mammal species is strikes (i.e., collisions) from vessels conducting BOEM-regulated activities (i.e., oil and gas [O&G]). Collisions between whales and large vessels could injure or kill a whale.

Most reports of vessel collisions with marine mammals involve large whales, though collisions with smaller species also occur (van Waerebeek et al. 2007). Laist et al. (2001) compiled data and found that most severe and lethal whale injuries involve large ships (> 80 meters) at higher speeds (>14 knots). The risk of encounter and possible strikes also depend on species-specific characteristics (e.g., time at surface, migration patterns), and factors such as the location of ports, transit areas, vessel numbers, geographic region, and time of year. To date no strikes to Rice's whale have been observed attributed to Federal O&G-related activities. The only known and documented strike of a sperm whale by an OCS O&G-related vessel was in December 2020. To avoid and minimize the potential for vessel strikes for permits, plans, and other authorizations, the following protocols were and are applied: *Vessel Strike Avoidance and Injured and/or Dead Aquatic Protected Species Reporting* and *Condition of Approval for Vessel Transit within Rice's Whale Core Distribution Area.*

Evaluating the risk of collision is reliant upon the methodology used (both quantitative and qualitative), baseline data incorporated (e.g., suitability, inclusiveness, spatial/temporal extent), and key assumptions made. BOEM recently initiated the *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and Recommendations for Future Efforts to Predict Strike Risks* study to inform the design of future assessments of vessel strike risks in the GOM.

BOEM has also completed a study of vessel strike risk for whales along the U.S. East coast: *Encounter Rates Between Large Whales and Vessel Traffic from Offshore Wind Energy Study* (Offshore Wind Strike Risk Study). The calculator derived from that study provides a risk assessment based on predicted animal-vessel encounters aggregated either along a vessel route or within a wind farm over a user-defined period of time. The user-created scenarios of vessel activities provide the ability to explore different "what-if" scenarios to address planning issues and assess potential cumulative risk to animals from development of offshore wind across the OCS. Phase II of the Offshore Wind Strike Risk Study (*Risk Assessment to Model Encounter Rates Between Large Whales and Vessel Traffic from Offshore Wind Energy, PHASE II Study, AT-23-03*) is currently being initiated; one objective is to expand applicability of the calculator to include other areas, including the GOM. This proposed GOM Strike Risk Study will differ from the Offshore Wind Strike Risk Study in that:

- Most important, this study will incorporate recommendations for methodology and data input that are derived from the *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and Recommendations for Future Efforts to Predict Strike Risks* study. These recommendations may inform Phase II of the Offshore Wind Strike Risk Study if applicable and feasible to incorporate, but they will be the focus of the GOM study.
- This study is interested in predicting how future GOM OCS development may affect risk and also in assessing strike risk based on the current programmatic-level of O&G activities (i.e.,

assessment of actual recent vessel activity). Risk is to be assessed OCS-wide, not at a user-defined individual project (or cumulative project) level.

- The Offshore Wind Strike Risk Study focuses on the vessel type, number, function, and dimensions expected to operate during wind farm site investigation surveys, construction, operations, and maintenance, creating seven categories of vessels. But this study will focus on the O&G vessel categories known to occur in the GOM, at least initially. The similarity of O&G vessel categories to that of offshore wind is yet to be fully determined.
- The Offshore Wind Strike Risk Study has two components: a port-to-wind farm route (transit) component and an on-site (within the wind farm) component. The concern for the Rice's whale in this GOM study will focus on transits through the 100-m to 400-m depth contour. The best methodology to assess risk from transits through this area will need to be determined and should be available from the *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and Recommendations for Future Efforts to Predict Strike Risks* study.
- This study will include an evaluation of how best to include the current Conditions of Approval (COA) that are assigned for Rice's whale protection into the strike risk model.

Objective(s): Predict vessel strike risks to protected cetaceans in the northwestern GOM, focusing on the Rice's and sperm whale, from BOEM-regulated O&G activities when using the current "Vessel Strike Avoidance and Injured and/or Dead Aquatic Protected Species Reporting Protocols". This study will generate a written synthesis that provides a critical analysis of strike risk, a summary of assumptions that were built into the analysis, and recommendations for going forward with future analyses. This study will also provide a tool that BOEM staff can use to predict risk across the northwestern GOM given inputs of differing vessel activity levels and patterns. The tool can also be expanded in the future to other cetacean species.

Methods: Use the recommendations provided in the *Vessel Strike Risk to Rice's Whale in the Gulf of Mexico: Review of Previous Methodologies, Information Gaps, and Recommendations for Future Efforts to Predict Strike Risks* study to a conduct a rigorous, statistically-meaningful vessel strike analysis for protected cetacean species in the GOM with a focus on Rice's and sperm whales. Generate a tool that BOEM staff can incorporate location and vessel information into to make strike risk predictions.

Specific Research Question(s):

1. How can the probability of encounter risk be translated into a scale of relative risk, with a focus on transits through the 100-m to 400-m depth contour and risk to the Rice's whale?
2. What is the vessel strike risk in the GOM from BOEM-regulated O&G activities to Rice's and sperm whales?
3. What additional information is needed to inform future vessel strike analyses?
4. What tool can BOEM staff use to make strike risk predictions from specific ports in the northern GOM?
5. How do the results relate to the Rice's whale output of specific transit corridors using the tool derived from Phase II of the Offshore Wind Strike Risk Study?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

References:

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Field	Study Information
Title	Assessment and Minimization of Avian Collision and Displacement Risk Associated with Renewable Energy Infrastructure in the Cook Inlet Planning Area, Alaska
Administered by	Alaska Regional Office
BOEM Contact(s)	Shane Gray (shane.gray@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2027
Final Report Due	TBD
Date Revised	10 February 2024
Problem	Avian collisions with infrastructure are a primary obstruction for migratory bird movements. Unlike many other stressors (e.g., disease, invasive species), collision and displacement risk can be mitigated when movement patterns and responses to artificial attractants, such as lighting is better understood (FCC 2021, Longcore et al. 2012). A recent report by the National Renewable Energy Lab (Meadows et al. 2023), showed that Cook Inlet, Alaska has the potential to generate 95 gigawatt (GW) of energy from wind (1 GW can power 300,000 to 750,000 homes representing 2-5x the number of homes in all of Southcentral Alaska). Lower Cook Inlet including Shelikof Strait, northern Kodiak Archipelago, and the Kenai Peninsula support ≈325 seabird colonies totaling >500,000 breeding birds.
Intervention	This study will identify locations and seasonal use of avian migratory corridors in the Cook Inlet Planning Area using technologies including radar, telemetry, and publicly available datasets that when completed will result in a temporal and spatial assessment of collision and displacement risk.
Comparison	This study will first complete a review of available publications, reports, and data from federal and state agencies including the U. S. Geological Survey Alaska Science Center and U.S. Fish and Wildlife Service Migratory Bird and Refuge Programs; Alaska Department of Fish and Game; academic and research institutions; industry; conservation groups (e.g., Cook Inlet Keepers, Prince William Sound Science Center, Alaska Sea Life Center), and citizen science organizations including the University of Washington Coastal Observation and Seabird Survey Team (https://coasst.org/). This review will: (i)inform seabird and sea duck habitat use in Lower Cook Inlet to produce maps of currently known high use areas and (ii) provide insights and ultimately inform the design of field methods and data collection.
Outcome	Results from this study will assist BOEM with: (i) marine spatial planning of potential renewable energy wind facilities in Cook Inlet, (ii) fulfill obligations related to National Environmental Policy Act (NEPA), Endangered Species Act (ESA) and Migratory Bird Treaty Act (MBTA), and (iii) ultimately serve to reduce

	impacts to marine birds associated with permitted infrastructure in coastal Alaska. Deliverables will include an outreach component to ensure best management practices are shared broadly with pertinent government, nongovernment organizations, and private industry stakeholders, improving their conservation value.
Context	Lower Cook Inlet

BOEM Information Need(s): To assess the potential impacts of renewable energy facilities to migratory birds in Cook Inlet, BOEM needs (i) information on the number, location, and seasonal use of migratory bird corridors; (ii) estimates of number, seasonal use, and types (e.g., seabird, sea duck, shorebird) of migratory birds using corridors across Cook Inlet, (iii) altitudes used by migratory birds to fly across Cook Inlet, (iv) how weather impacts migratory behaviors, (v) risk and consequences of collisions with renewable energy infrastructure; and (iv) recommendations to avoid or mitigate impacts.. BOEM needs this information to address regulatory requirements under the Endangered Species Act, Migratory Bird Treaty Act, and the National Environmental Policy Act.

Background: Avian collisions and displacement from infrastructure are a primary concern for migratory bird movements. The increase in offshore industrialization via offshore wind turbines increases risks and consequences of migratory bird collisions and disruptions of migratory movements. Given increased risks of collision and the substantial declines in many species of migratory birds (Hüppop et al. 2016), regulatory agencies should increase efforts to design and implement relevant and feasible mitigation to reduce impacts. Over 40 million or ≈75% of North America's seabirds breed in Alaska (Sowls et al. 1978; Stephensen and Irons 2003). Lower Cook Inlet including Shelikof Strait, northern Kodiak Archipelago, and Kenai Peninsula support ≈325 seabird colonies totaling >500,000 breeding birds. Between 1950 and 2010, the global seabird population declined by 69.7% (Paleczny et al. 2015). In addition to seabirds, Cook Inlet provides winter habitat for Steller's eiders (*Polysticta stelleri*; Larned 2006, Martin et al. 2015) of which the Alaska-breeding population is a threatened species and protected under the Endangered Species Act. Avian collision with offshore infrastructure, including wind turbines presents an additional stress to migratory birds, particularly seabirds and sea ducks. However, unlike many other stressors (e.g., disease, invasive species), collision or displacement risk can be mitigated when movement patterns and responses to artificial attractants, such as lighting are better understood (FCC 2021, Longcore et al. 2012). The National Renewable Energy Lab (Meadows et al. 2023) showed that Cook Inlet, Alaska has the potential to generate 64.5 gigawatt (GW) of renewable wind energy, enough electricity to support all of Southcentral Alaska. In 2023, the State of Alaska revised the Energy Security Task Force to assess not only oil and gas but to increase efforts to develop all forms of energy including wind, solar, hydro, tidal, geothermal, micronuclear, and hydrogen.

Objectives:

1. Determine location and relative importance of avian migratory corridors and seasonal movements in the Cook Inlet planning Area.
2. Describe the number and proximity of migratory corridors and seasonal movements of migratory birds for two sites identified in Cook Inlet as having the greatest potential for wind facilities.

3. Develop a spatial and temporal model of migratory bird movements in Cook Inlet to determine risk and severity (frequency, magnitude, conservation status) of collisions with offshore wind facilities.
4. Develop conservation measures to avoid, minimize and mitigate impacts to avian migratory corridors from renewable energy infrastructure in Cook Inlet.

Methods: A brief description of proposed methods and estimated costs include:

- Review available scientific peer-reviewed publications, reports including agency gray literature, and data sets from federal and state agencies; universities, colleges, and research institutions; industry, conservation organizations, and citizen-science programs to describe location and seasonal use of avian migratory corridors in the Cook Inlet Planning Area, that would produce maps of currently known high use areas. $40K
- Determine seasonal migratory bird movements from the currently available NEXRAD radar sites that have coverage in Lower Cook Inlet, including PAHG (Kenai) WSR-88D radar operated by the NOAA National Weather Service in Anchorage, Alaska and PAKC (King Salmon) WSR-88D radar operated by the NOAA National Weather Service in Anchorage, Alaska. $130K
- Install localized radar equipment to identify bird movements near Barren Islands or Augustine Island. $200K.
- Assess daily movements and seasonal migrations of seabirds including but not limited to murres, kittiwakes, puffins, and storm-petrels to compare with results described in literature and existing data sets, weather station radar, and localized experimental radar. GPS telemetry of a sample of seabirds in Lower Cook Inlet $300K.

Specific Research Question(s):

1. What are the locations of avian migration corridors in Cook Inlet?
2. What is relative importance of avian migratory corridors across Cook Inlet as measured by seasonal use, frequency of use, and types and numbers of migratory birds?
3. What is the proximity and relative importance of avian migratory corridors to potential sites of renewable wind facilities?
4. How do diurnal movements and seasonal migrations of seabirds compare to corridors identified by weather and localized radar data?
5. Given findings of this study, what marine spatial planning and conservation measures may be designed and implemented to avoid or decrease risks of migratory bird collisions with offshore renewable energy infrastructure?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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Field	Study Information
Title	Protected Smalltooth Sawfish Occurrence in BOEM OCS Sand Resource Areas
Administered by	Marine Minerals Program
BOEM Contact(s)	Deena Hansen (deena.hansen@boem.gov); Doug Piatkowski (douglas.piatkowski@boem.gov); Victoria Brady (victoria.brady@boem.gov)
Procurement Type(s)	Interagency Agreement or Cooperative Agreement
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2025–2029
Final Report Due	TBD
Date Revised	April 8, 2024
Problem	Recent evidence indicates that the endangered Smalltooth Sawfish is present in BOEM OCS lease areas. However, BOEM lacks a full investigation of the extent of endangered Smalltooth Sawfish overlap with BOEM Marine Minerals activities, and potential impact to the species.
Intervention	Existing telemetry and tagging data will be analyzed for occurrence of Smalltooth Sawfish at different spatial and temporal scales near OCS sand resources (from proven to unverified). If the data analysis determines that certain OCS areas have sufficient presence of Smalltooth Sawfish, then a tagging effort may be pursued to identify site-specific habitat occurrence and movements.
Comparison	Smalltooth Sawfish overlap with sand resources on the OCS may be compared to presence at other habitat types.
Outcome	Determine environmental correlates, including sand resource characteristics, that influence Smalltooth Sawfish distribution. Results will not only improve BOEM's leasing and mitigation recommendations, but they may inform resource managers' species conservation decisions.
Context	Florida's east coast, from coastal waters to 50-m depths.

BOEM Information Need(s): Little is known about Smalltooth Sawfish use of the Outer Continental Shelf (OCS), where marine minerals are managed by the Bureau of Ocean Energy Management (BOEM). Smalltooth sawfish, listed under the Endangered Species Act (ESA), have been detected by an acoustic array at Canaveral Shoals, an active dredge lease area. Not only do these detections of 21 individuals indicate a need for further site-specific analysis but on a broader scale, overlap with other sand resources (whether proven or unverified) is understudied. This study would help establish a baseline and fill data gaps about the habitat use and movement patterns of Smalltooth Sawfish on the OCS to help inform future BOEM decisions. Specifically, ESA Biological Assessments and National Environmental Policy Act (NEPA) documents would integrate findings into analyses and conclusions.

Background: Smalltooth sawfish, listed as endangered under the ESA since 2003, faces habitat loss as one of the biggest threats to recovery. The species historically ranged from Texas to North Carolina, but now the primary population is known to inhabit the waters of southwest Florida (Brame et al. 2019). Recent studies suggest management efforts have been successful in stabilizing the population, and the population may be increasing (Wiley and Brame 2018), though a 2024 rise in deaths linked to unexplained circling behavior in shallow waters near the Florida Keys may complicate this species' recovery (NPR, 2024). A growing population may partially explain a rise in smalltooth sawfish detections in coastal Atlantic acoustic arrays; the increase may also be due to more tags at-large. Most studies on smalltooth sawfish have focused efforts on juveniles and southwest Florida which serves as critical habitat for the species. Tagging efforts show that some adult sawfish display site fidelity to Florida Bay in southwest Florida, while others may migrate north during the summer. One particular study tagged sawfish in Florida Bay and observed three males migrating north in the GOM, but the study was limited due to tag retention issues (Papastamatiou et al. 2015).

BOEM has funded an active acoustic telemetry array at Canaveral Shoals II, an active lease area, since 2013 (Iafrate et al. 2022). From 2016 through 2023, 21 total sawfish were detected on Canaveral Shoals, mostly during spring and summer. The sawfish were originally tagged and released hundreds of kilometers from the shoals, mostly from Florida's Gulf coast through the Keys, with some individuals returning for up to four consecutive years. The active array continues to opportunistically detect individuals that are tagged by other researchers; the current study (MM-20-x04a), however, includes neither robust data analysis nor additional field efforts specific to this protected animal. Their presence along the Atlantic in central Florida is somewhat surprising, therefore warranting further investigation into their movement. Understanding how smalltooth sawfish activity may overlap with BOEM dredging activities is critical to effective environmental compliance and mitigation measures.

Objective(s): The main objective of this study is to characterize the occurrence and movement of smalltooth sawfish near existing and potential sand resources on the Florida - Atlantic OCS to better understand any correlating environmental factors and how BOEM-authorized activities may affect this endangered species and its habitat.

Methods: The study will achieve the objective by taking a two-phase approach.

- Phase 1: Analyze existing telemetry data for smalltooth sawfish occurrence at different spatial and temporal scales around Florida - Atlantic OCS sand resources (e.g., Canaveral Shoals II). This may include both BOEM-funded and other acoustic arrays, depending on cooperation throughout the tagging and array network. Additionally, data from fishery-dependent and fishery-independent surveys will be supplemented with interviews with researchers, fishermen, and other stakeholders to obtain information that may not be published in the literature, and in areas where telemetry data are limited. (Estimate 1 year/$150,000 of effort.)
- Phase 2: If the data analysis determines that certain OCS areas have sufficient presence of smalltooth sawfish, then a tagging effort may be carried out. These data would be integrated and reanalyzed with the original Phase 1 dataset to identify site-specific habitat occurrence and movements, and any correlating environmental factors. (Estimate 3 years/$450,000 of effort.)

Specific Research Question(s): How do smalltooth sawfish spatially and temporally overlap with potential sand resources on the OCS? What environmental factors correlate with their occurrence?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

References:

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