U.S. OFFSHORE WIND
SYNTHESIS OF ENVIRONMENTAL
EFFECTS RESEARCH

Underwater Noise Effects on Marine Life

Risk to Marine Life from Marine Debris & Floating Offshore Wind Cable Systems

November 30, 2021

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Today's Agenda

Introduction

Underwater Noise Effects on Marine Life Associated with Offshore Wind Farms

- Topic Overview
- Panel Discussion
- Q&A

Risk to Marine Life from Marine Debris & Floating Offshore Wind Cable Systems

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- Panel Discussion
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Closing Remarks

Introduction to SEER

At the direction of the U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy Wind Energy Technologies Office, Pacific Northwest National Laboratory and National Renewable Energy Laboratory are jointly leading a multi-year collaborative effort to facilitate knowledge transfer for offshore wind (OSW) research.

Project Objectives

- Summarize the international understanding of environmental effects, monitoring tools, and mitigation strategies for OSW and how it applies to the U.S. Atlantic and Pacific Coasts.
- Examine which of the state-of-the-art methods and technologies are relevant to environmental issues specific to U.S. offshore wind development.
- Identify knowledge and research gaps based on the diversity of species, habitat uses, and stressors; U.S. environmental legal/regulatory structure; and technological innovations.
- Collaboratively develop outcomes together with existing science entities and regional working groups to fully leverage community expertise.

Introduction to SEER

Research Briefs
Review state of the knowledge on stressor/receptor interactions, monitoring methods and technologies, mitigation measures, and cumulative impacts.

Webinar Series
Disseminate findings presented in Research Briefs to the offshore wind industry and others who are interested.

Research Recommendations
Summarize information gaps, barriers, and current challenges for U.S. Atlantic and Pacific Coasts to inform or guide future development efforts.

For more information, visit: https://tethys.pnnl.gov/seer

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Introduction to SEER

Underwater Noise Effects on Marine Life

Bat and Bird Interactions with Offshore Wind Energy

Risk to Marine Life from Marine Debris & Floating Cable Systems

Benthic Disturbance from Foundations, Anchors, & Cables

Introduction of New Structures: Effects on Fish Ecology

Vessel Collision: Effects on Marine Life

Electromagnetic Field (EMF) Effects on Marine Life

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Underwater Noise Effects on Marine Life Associated with Offshore Wind Farms

Moderator:

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Panelists:

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Jim Miller, Ph.D.
University of Rhode Island

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Underwater Sound & Noise

Underwater sound can be generated by biological, physical, and anthropogenic sources.

Unwanted sound sources, such as those from offshore development, are referred to as "noise."

Underwater noise associated with the life cycle of an OSW farm may affect marine life in a variety of ways.

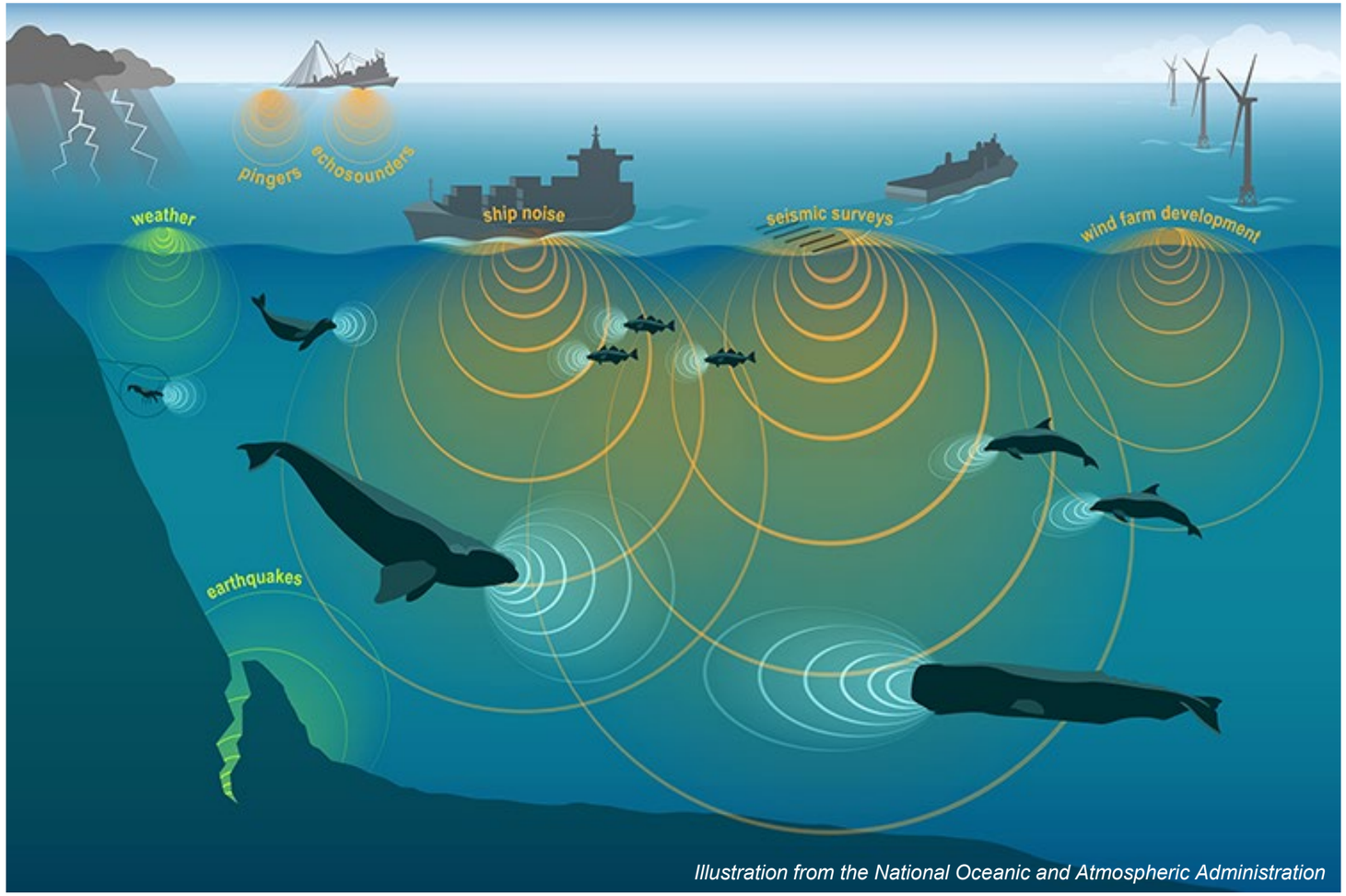


Illustration from the National Oceanic and Atmospheric Administration

Noise Generated During the OSW Life Cycle

Site Surveys

- Seafloor mapping technologies introduce noise and operate across a range of frequencies

Construction

- Pile driving can generate intense noise pulses for some foundations

Operations & Maintenance

- Noise transmission from turbine operation; Support vessels

Decommissioning

- Noise generated from dismantling various components of wind farm

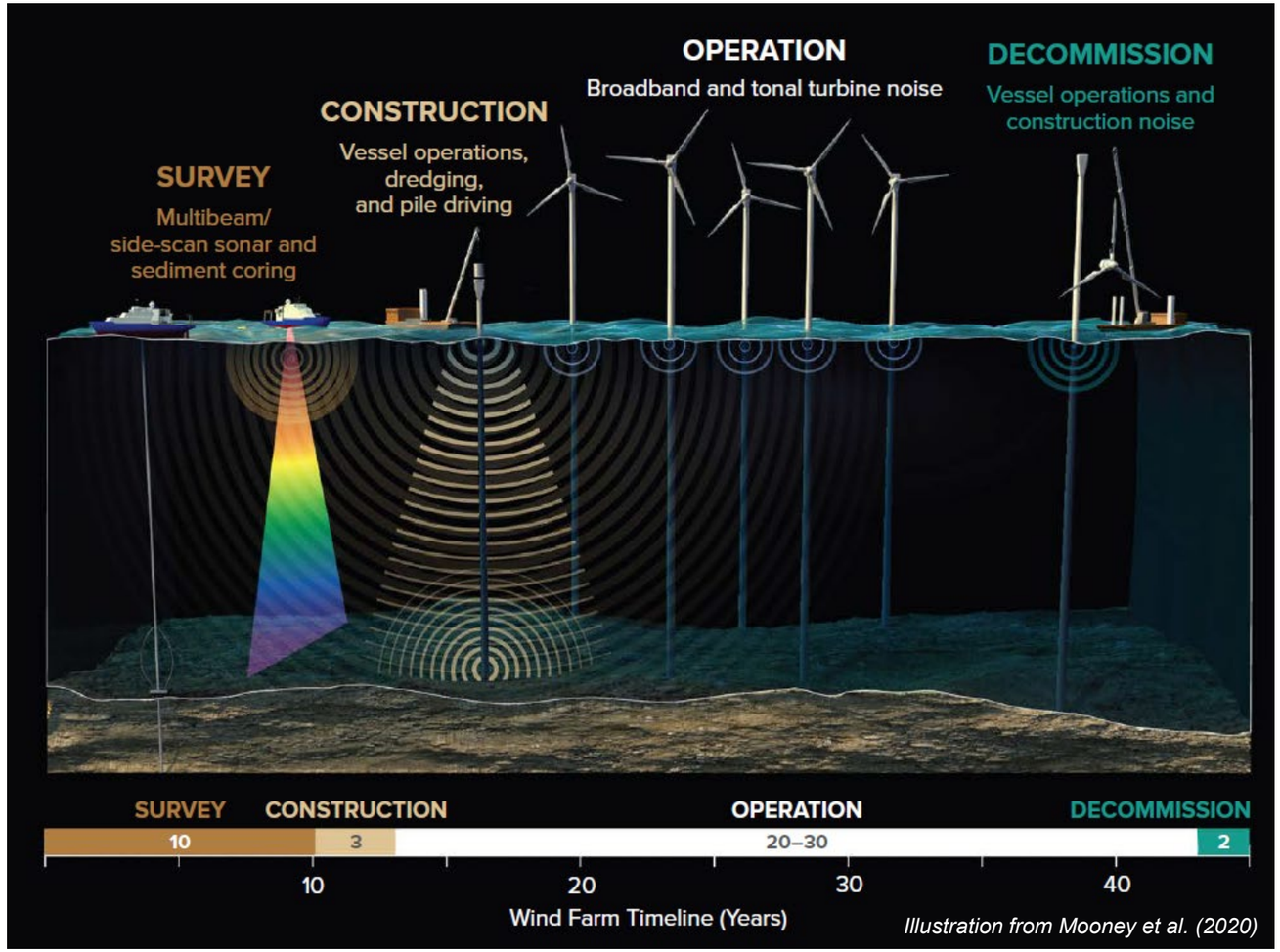


Illustration from Mooney et al. (2020)

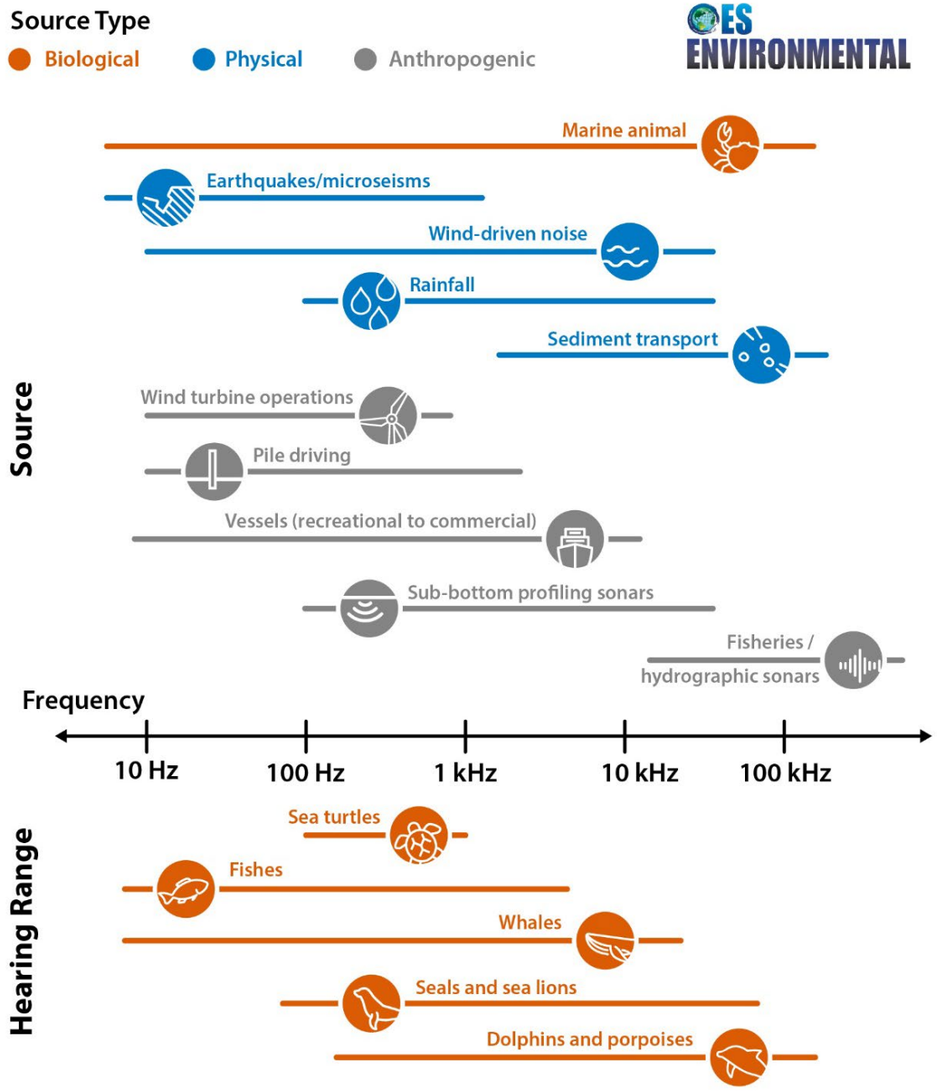
Noise: Risks & Effects

Marine animals differ in their ability to hear across sound frequencies and will respond differently to noises from different OSW farm activities.

Noise may lead to a range of effects, including:

- Auditory masking
- Behavioral disturbance
- Hearing loss
- Non-auditory injury

Injury-causing noise levels are likely to occur within relatively close range to pile driving, while levels causing behavioral effects can extend significantly further.



Noise: Risks & Effects

Zones of Auditory Impact


Photo by Senu Sirnivas, NREL

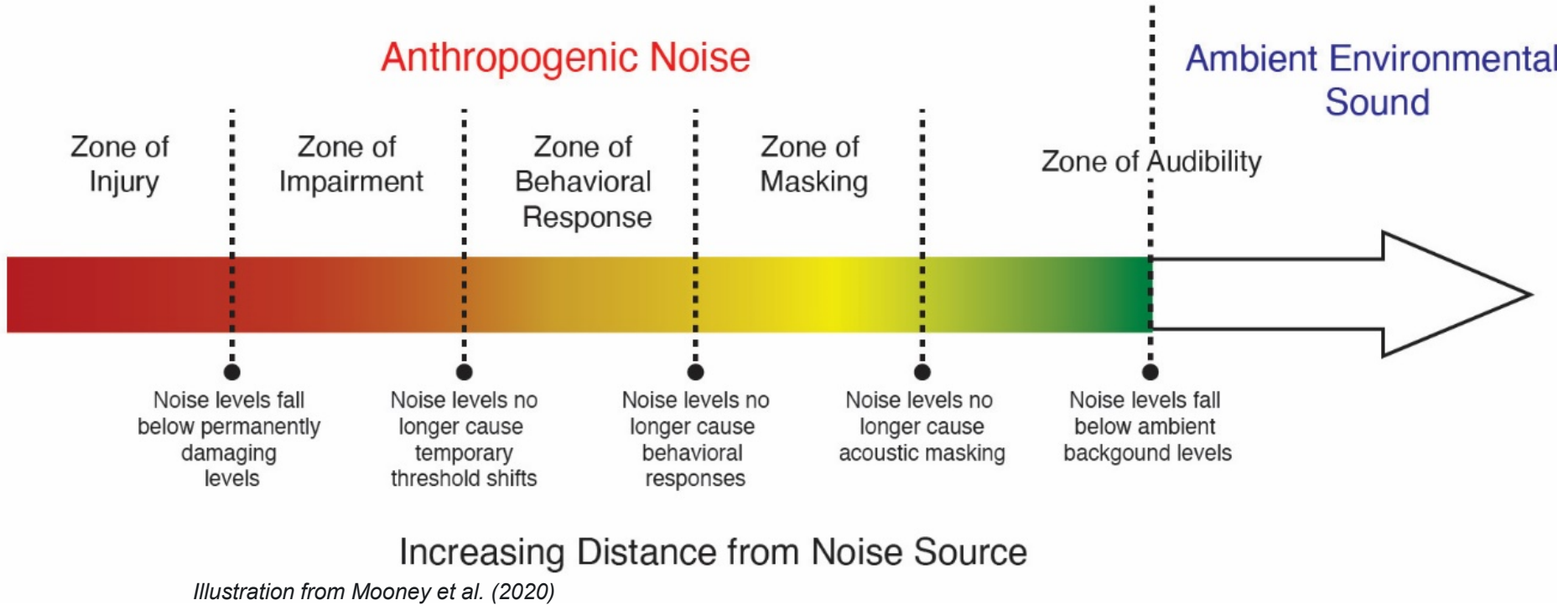


Illustration from Mooney et al. (2020)

Risk of injury decreases with distance from the pile driving, but the exact distances are dependent on the nature of the sound, environment, and species present.

Noise: Risks & Effects

Noise Associated with Fixed-Bottom Foundations

- The installation of foundations through pile driving, including for monopiles, tripods, and jacket foundations, generates more noise than other installation methods.

Noise Associated with Floating Foundations

- Mooring line anchors can be installed using relatively low-noise methods, so there is a smaller anticipated impact compared to those used for fixed-bottom foundations.

Noise Associated with Other Phases of OSW Development

- Seafloor mapping technologies used for OSW site surveys operate at lower intensities than those used in the O&G industry but may cause behavioral impacts on some species.
- Vessel noise can mask communication in marine mammals and certain fish species and may induce physiological stress and impair foraging in fish and invertebrates.
- Operating turbines can produce nearly continuous, but relatively low amplitude sound that may have some behavioral impacts to nearby marine species (though some may adapt).
- Decommissioning activities may cause masking, displacement, physiological stress, and other impacts (especially if marine life has aggregated around the foundations).

Noise: Monitoring & Mitigation Methods

Monitoring Methods

- Passive acoustic monitoring
- Use of animal tagging
- Vessel-based surveys
- Aerial surveys

Mitigation Methods

- Noise reduction technologies
  - e.g., Bubble curtains, Isolation casings, Cofferdams, Hydro sound dampers
- Time of year restrictions
- Protected Species Observers
  - Maintain exclusion areas
- Soft start for pile driving
- Shut down and delay of pile driving

Noise: Knowledge Gaps & Research Needs

Common research needs include understanding the:

- Cumulative impacts from OSW farms and other pressures, at both the individual and population levels for sensitive and protected species
- Impacts from future larger-scale OSW in the U.S., including those associated with unique species, habitats, and larger turbines

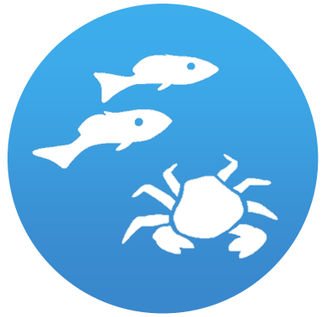
Key Questions for Species of Concern

- Could animals be displaced from the area by noise associated with OSW development?
- Could animal behavior and/or physiological parameters change in response to noise?
- Could noise disrupt fish and prey species' availability?
- How do we improve noise mitigation and monitoring to reduce potential impacts?

Noise: Knowledge Gaps & Research Needs

Marine Mammals

- More information is needed to understand:
  - How noise impacts accumulate over time and multiple exposures
  - How multiple acoustic and non-acoustic stressors interact
  - How effects on individuals affect a population as a whole



Fish & Invertebrates

- Further research on animal hearing thresholds is needed to better understand potential impacts of particle motion, sound pressure, and substrate vibration

Sea Turtles

- Need to better understand turtle hearing to inform predictions of both physical and behavioral effects of noise

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Panel Discussion

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For more information on the literature reviewed to develop the Research Brief, visit:
https://tethys.pnnl.gov/summaries/underwater-noise-effects-marine-life-associated-offshore-wind-farms

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Pacific Northwest National Laboratory

Panelists:

Lauren Saez
National Oceanic and Atmospheric Administration

Desray Reeb, Ph.D.
Bureau of Ocean Energy Management

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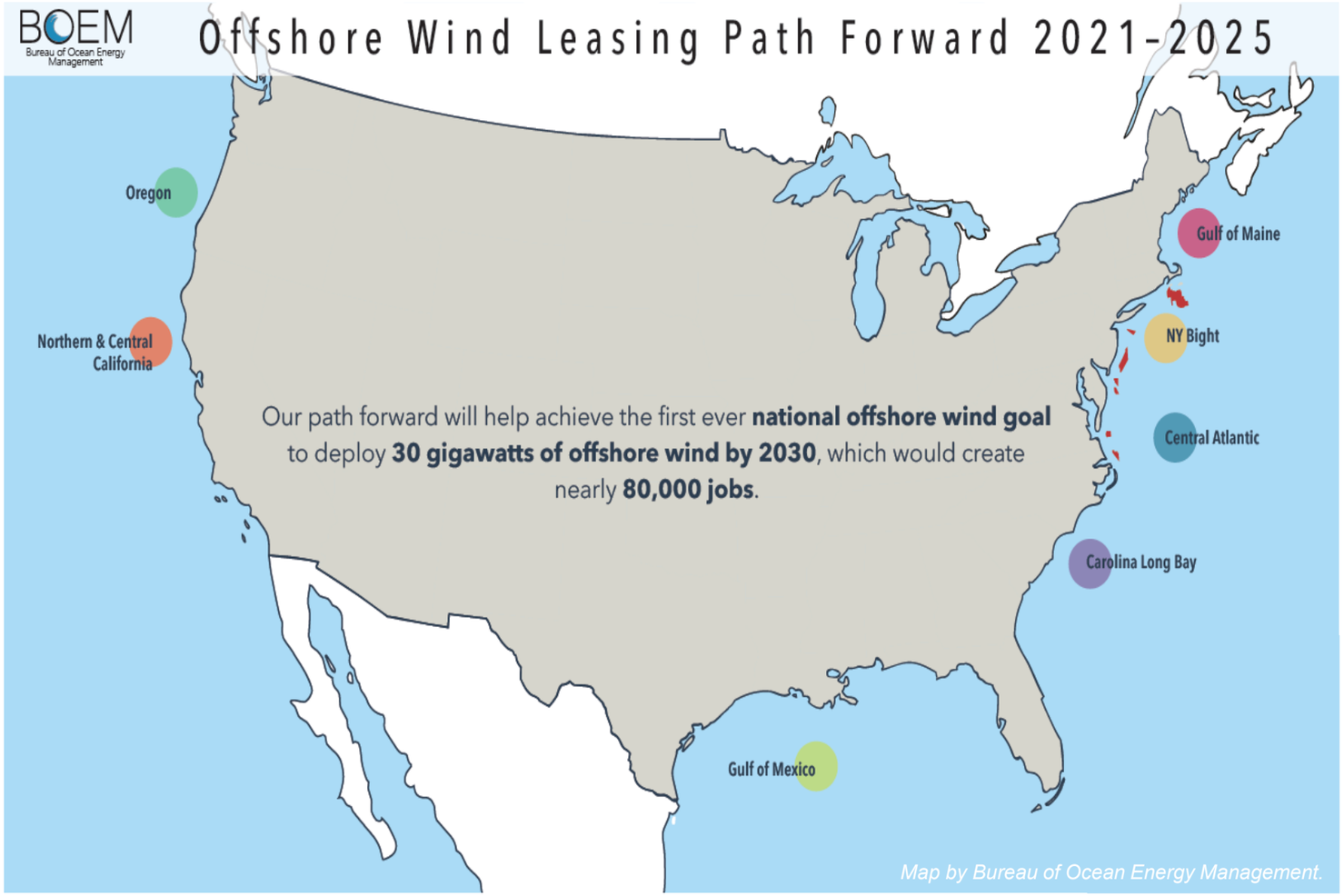
Floating Offshore Wind

In the United States, floating offshore wind (OSW) is being planned on the Atlantic and Pacific Coasts in water depths ranging from 60 to 1,300 m.

Floating cable systems associated with these developments, including mooring lines and inter-array cables, may present physical hazards to marine life.



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Floating Offshore Wind Mooring Configurations

Common floating OSW platforms include:

- Single point anchor reservoir
- Semi-submersible
- Tension leg platform

Platforms are moored to maintain position and/or stability using:

- Catenary mooring lines
- Tensioned mooring lines

Inter-array electrical cables connect platforms to one another.

Illustration by Joshua Bauer, National Renewable Energy Laboratory.

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Primary v. Secondary Entanglement

Primary Entanglement

Marine life becoming directly entangled with a mooring line or inter-array cable.

Secondary Entanglement

Marine life becoming entangled with marine debris that is snagged on a mooring line or inter-array cable.

Primary v. Secondary Entanglement

Current literature suggests that the risk of primary entanglement is low because floating OSW cable systems are:

- Engineered to prevent them from looping and entangling marine life
- Occupy a small cross section of the water column

Fishing gear is the main cause of entanglement in large whale species; therefore, the potential for secondary entanglement is the leading cause of concern.

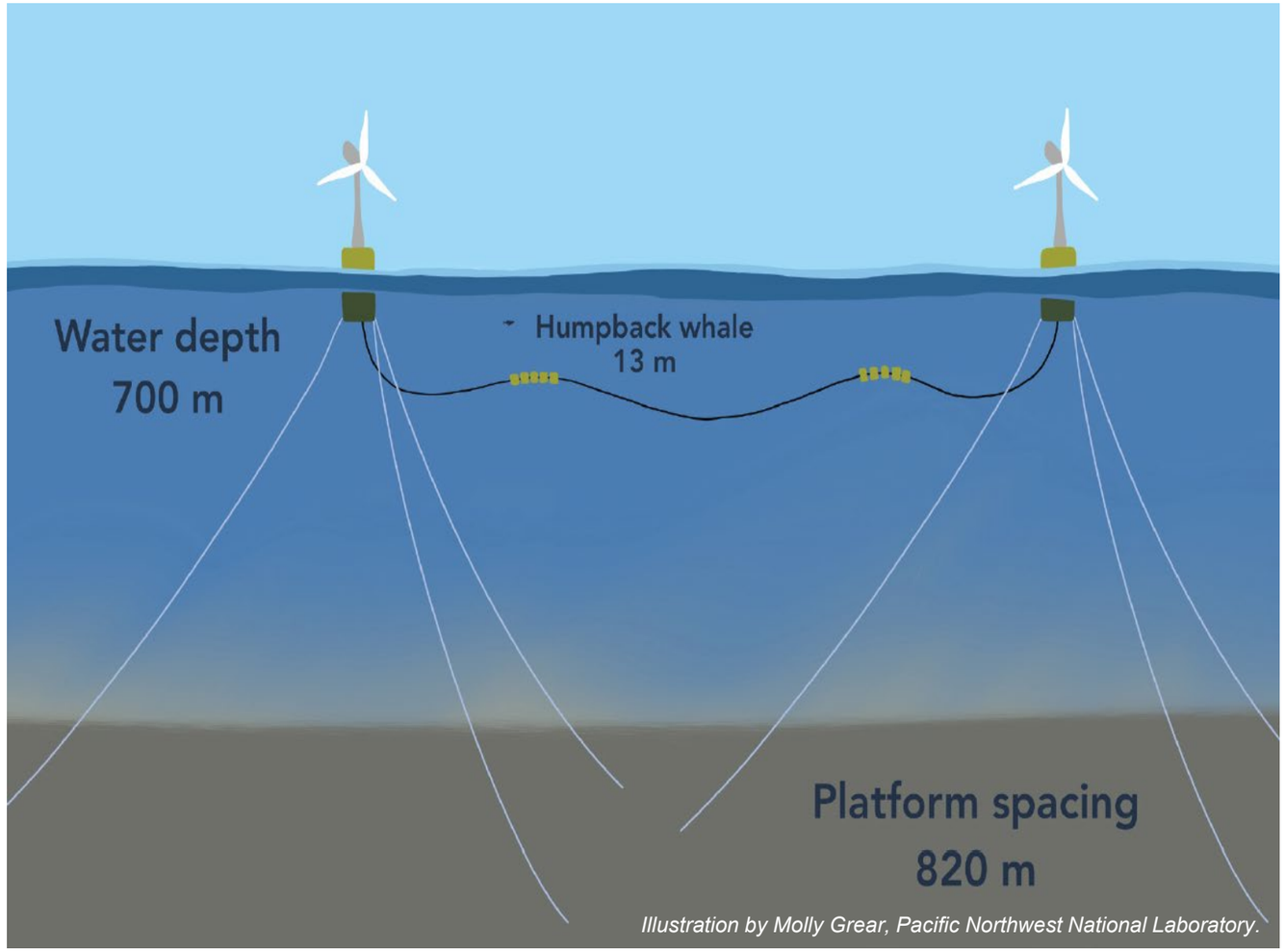

Illustration by Molly Grear, Pacific Northwest National Laboratory.

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Entanglement: Risks & Effects

Knowledge of the likelihood and potential consequences of secondary entanglement of marine life in floating OSW cable systems remains limited because of the:

- Infancy of the industry
- Lack of entanglement and marine debris monitoring for existing floating OSW

Large migratory whale species are anticipated to be most at risk because of their size and feeding behavior.

Some fish species, sea turtles, seals, and diving seabirds may also be at risk.

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Entanglement: Risks & Effects

Impacts of entanglement with active and derelict fishing gear may provide the greatest insight into the potential consequences of secondary entanglement associated with floating OSW cable systems.

Potential consequences of marine life entangled in fishing gear include:

- Asphyxiation or respiratory distress because of a lack of oxygen (underwater entrapment)
- Tissue damage, potentially resulting in scarring, muscle/nerve injury, infection, and death
- Reduced foraging ability, potentially leading to emaciation
- Impacts on mobility, including the ability to dive, migrate, and reproduce
- Impacts on population growth as a result of mortality or reduced reproductive success

As multiple floating OSW arrays are constructed, the potential cumulative effects of OSW development, combined with other ocean activities, will need to be examined.

Entanglement: Monitoring & Mitigation Methods

Recommended Entanglement Monitoring & Mitigation

- Use of underwater cameras
- Monitoring mooring line loads/motion
- Use of underwater vehicles to detect and remove marine debris

Potential Environmental Monitoring

- Aerial and drone surveys
- Remote sensing technologies
- Passive acoustics
- Underwater cameras
- Animal tagging

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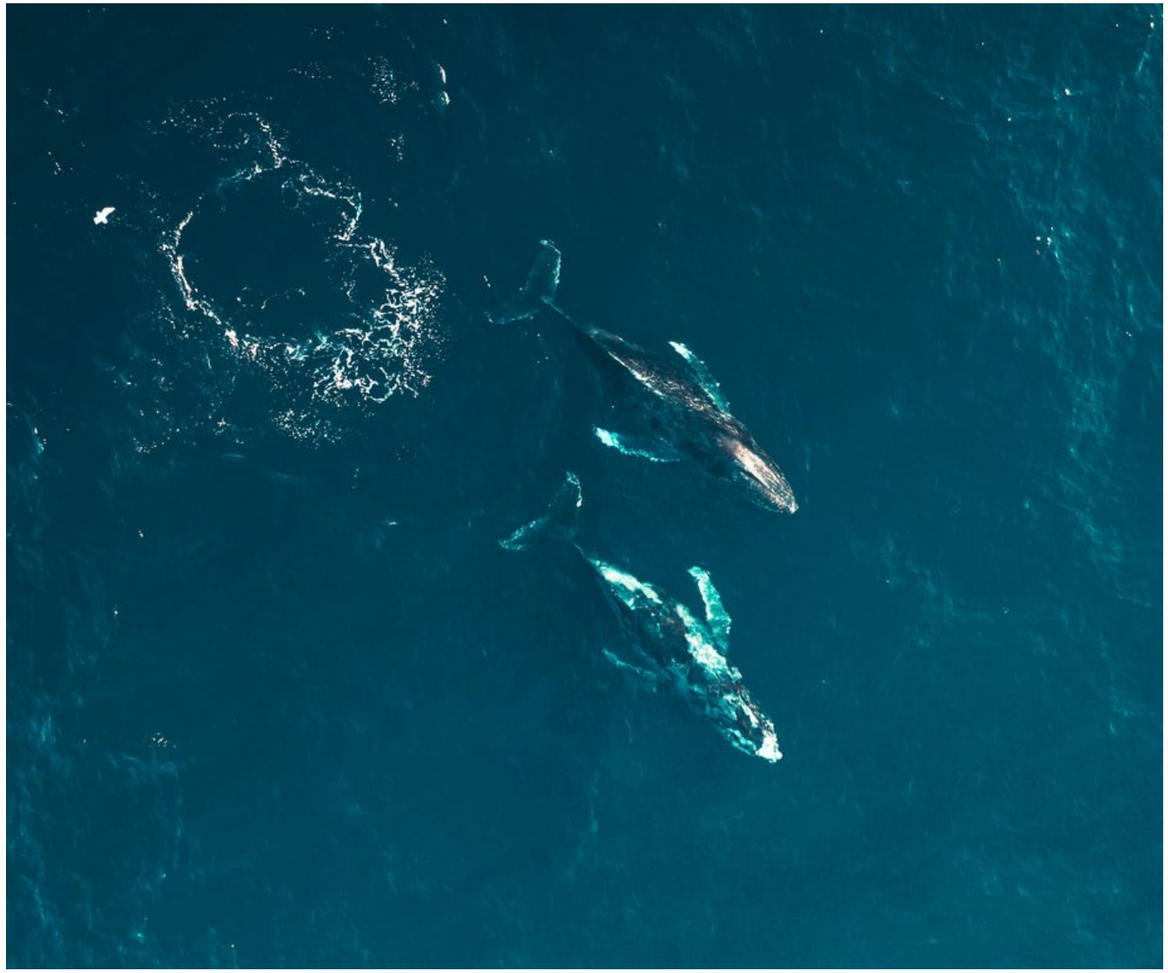
Entanglement: Knowledge Gaps & Research Needs

Knowledge gaps related to marine life ecology are being addressed through ongoing research on habitat preferences, migration patterns, and diving behaviors.

Research is needed to develop more effective technologies for monitoring, detecting, and removing marine debris snagged on floating OSW cable systems.

Open dialog among the international OSW community is needed to share lessons learned, identify knowledge gaps, and develop research agendas.



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Panel Discussion

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Upcoming Webinars

Benthic Disturbance from Foundations, Anchors, and Cables & Introduction of New Offshore Wind Farm Structures: Effects on Fish Ecology

Wednesday, December 15, 2021, 8:00-9:30 AM PST

Vessel Collision: Effects on Marine Life & Electromagnetic Field Effects on Marine Life

TBD

Bat and Bird Interactions with Offshore Wind Energy Development

TBD