



BOEM Bureau of
Ocean Energy Management

Consideration of Underwater Sound During Offshore Wind Development

DOSITS webinar

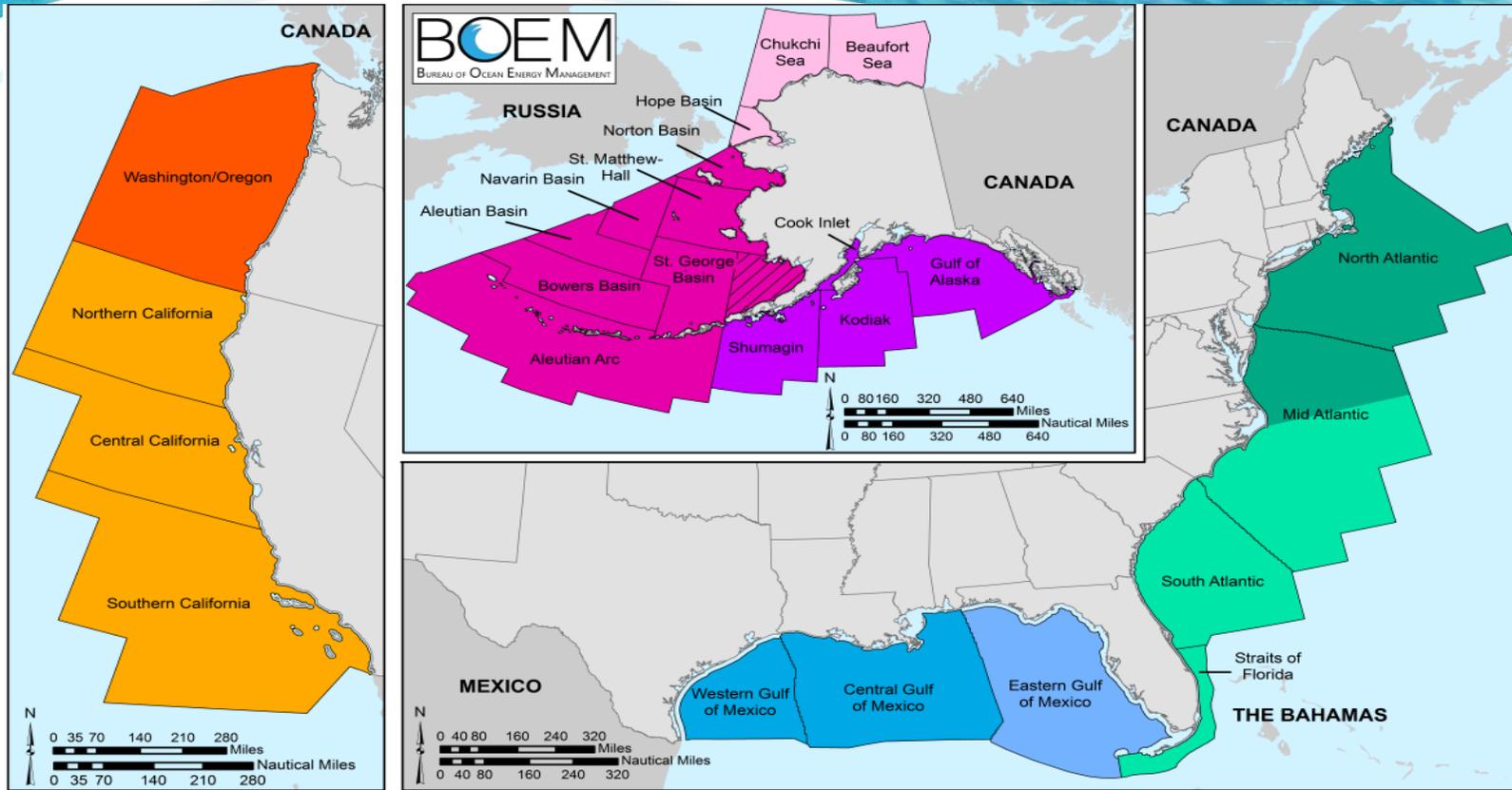
Center for Marine Acoustics

September 14, 2022

BOEM's mission

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

BOEM's geographic scope



BOEM Ecoregions



Outer Continental Shelf:

- All federal waters out to edge of EEZ (~200 nm)
- Federal waters generally start 3 nm from shore
- In Texas and FL, federal waters start at 9 nm
- The Inflation Reduction Act (2022) gives BOEM jurisdiction over territorial waters too
- ~ 3 billion acres!

The maritime boundaries and limits shown hereon, as well as the divisions between planning areas, are for initial planning purposes only and do not necessarily reflect the full extent of U.S. sovereign rights under international and domestic law.

BOEM's programs



Oil and Gas



Marine Minerals



Renewable Energy

BOEM's Center for Marine Acoustics

Be a **trusted voice** on marine acoustic issues.



FUNCTIONS



Modeling. Build models that address current needs and drive improvements in the field.

Knowledge. Track emerging science, fill data gaps, and apply new risk assessment methods.

Policy. Address key policy and management improvements, both internal and external.

Messaging. Improve stakeholder understanding of actual risks.

Strategy. Plan in six-year planning horizons. Adapt based on performance and emerging information.

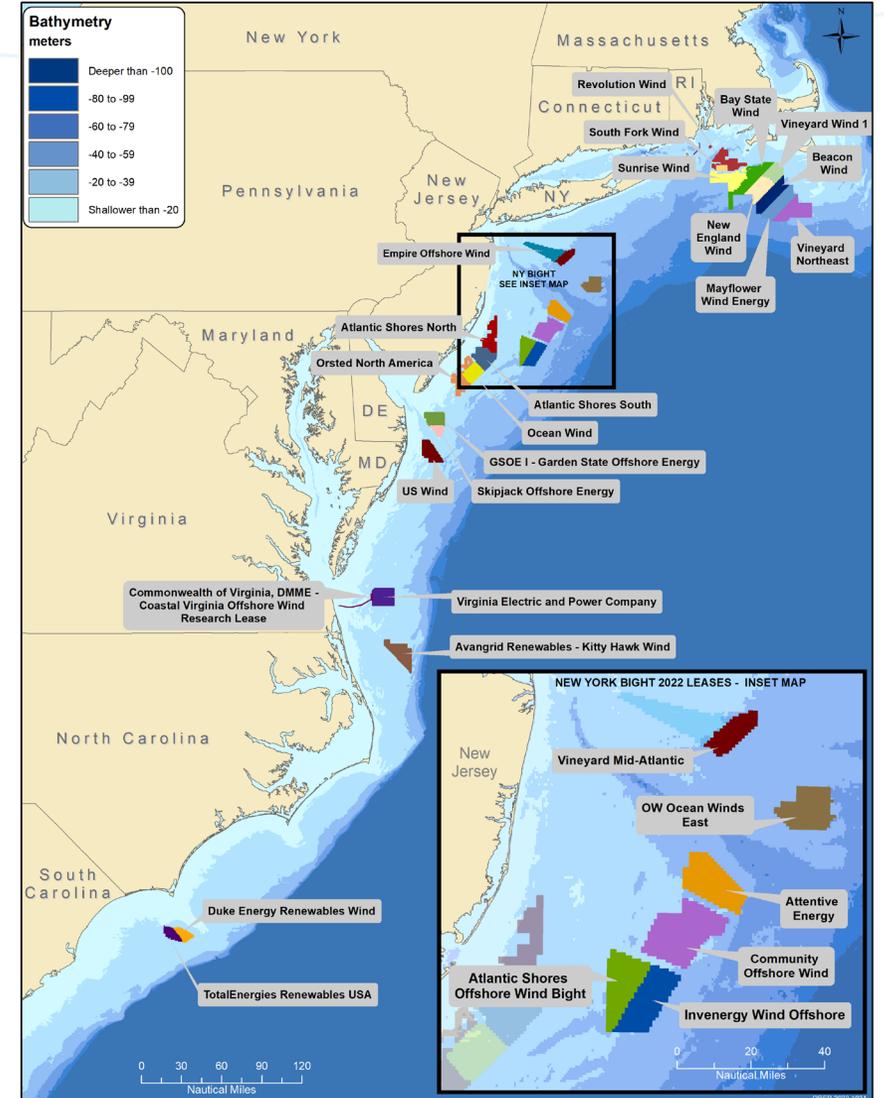
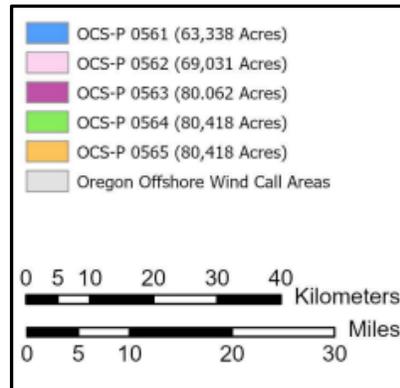
Partnerships. Develop relationships with domestic and international organizations that advance shared goals.

Federal Agencies - Cooperating, Participating, and Consulting



Offshore wind energy projects

- **Approved:**
 - 2 turbines installed in Fed. waters off VA
 - 5 installed in State waters of RI
- **Review process: >18**
 - NY Bight: 6



Planning for offshore wind projects



Planning & Analysis

~ 2 YEARS

- Intergovernmental Task Force
- Request for Information or Call for Information and Nominations
- Area Identification
- Environmental Reviews

Leasing

~ 1-2 YEARS

- Publish Leasing Notices
- Conduct Auction or Negotiate Lease Terms
- Issue Lease(s)

Site Assessment

UP TO 5 YEARS

- Site Characterization
 - Site Assessment Plan
- *HRG surveys, vessels

Construction & Operations

~ 2 YEARS (+25)

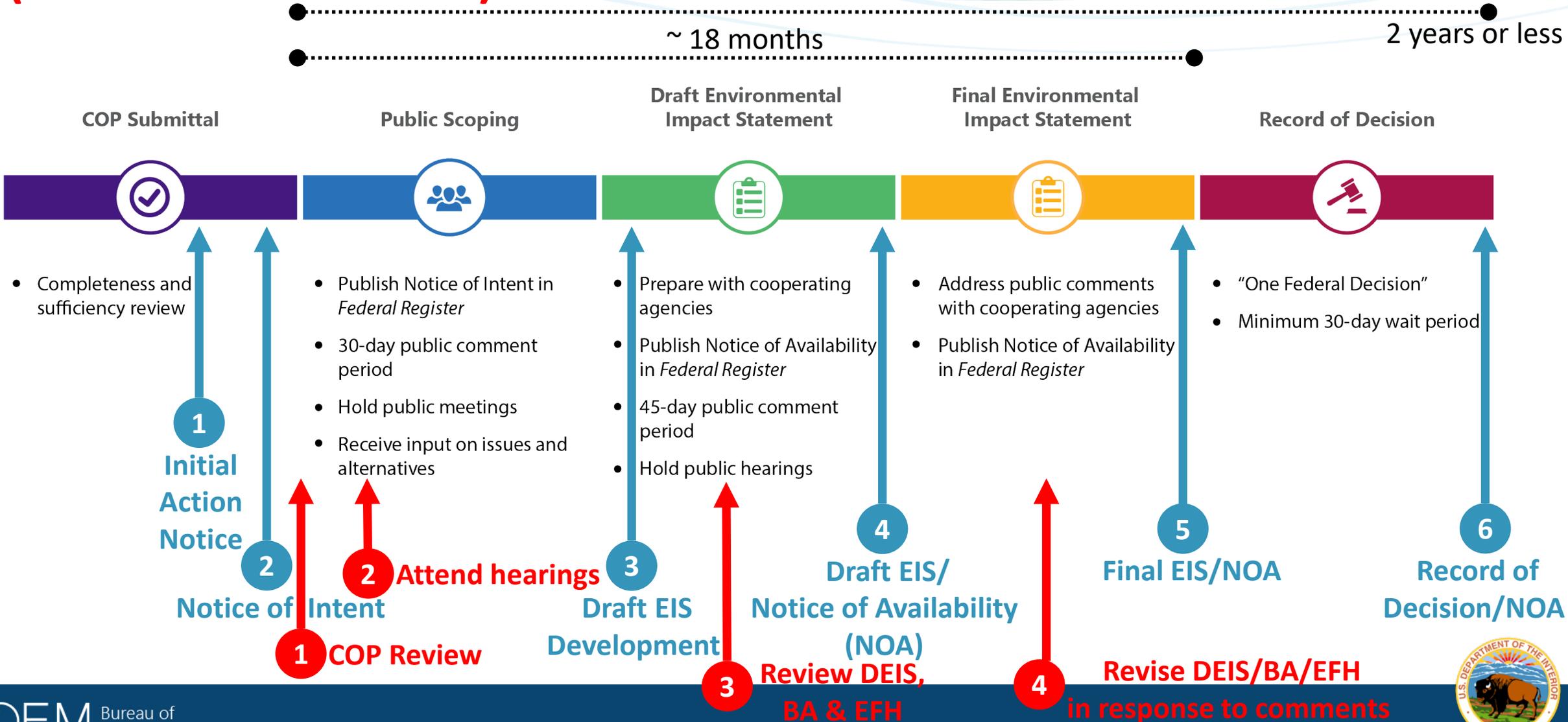
- Construction and Operations Plan
- Facility Design Report and Fabrication and Installation Report
- Decommissioning
- Environmental and Technical Reviews

*Pile-driving, vessels, trenching, possibly explosives

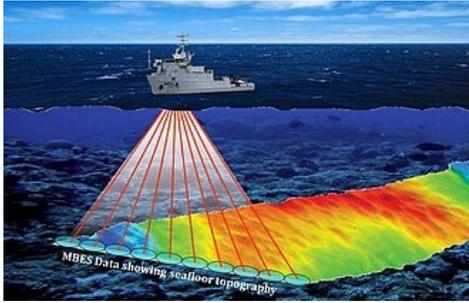


Department of the Interior Briefing and Clearance Points

(CMA Actions in RED)



Sound sources throughout the offshore wind life cycle



High-resolution geophysical surveys



Construction (impact or vibratory pile-driving)



Cable-laying vessels



Operations

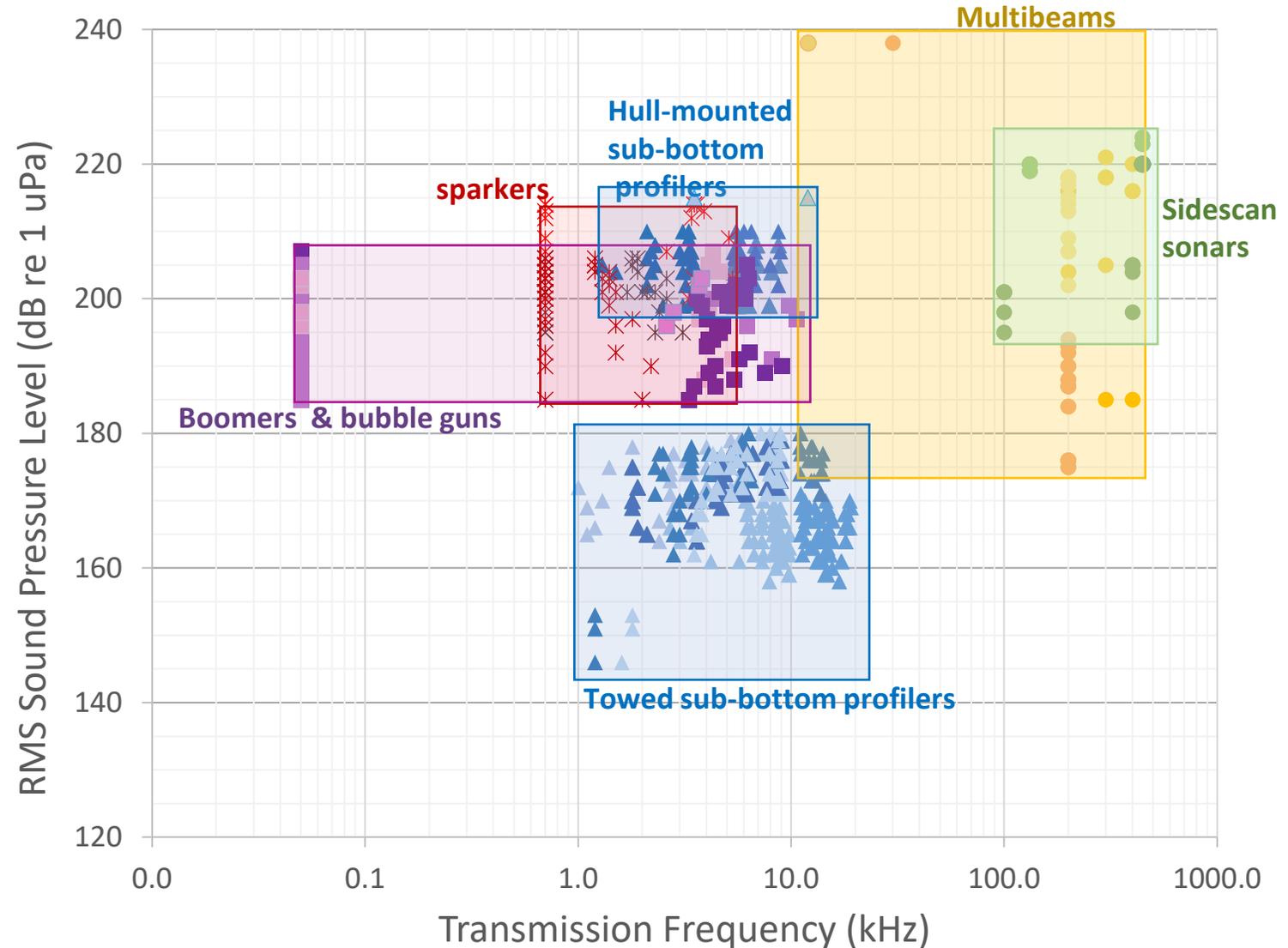


Crew and service vessels

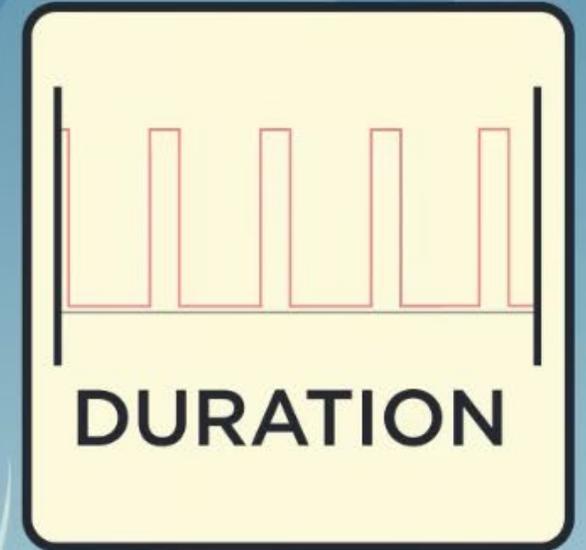
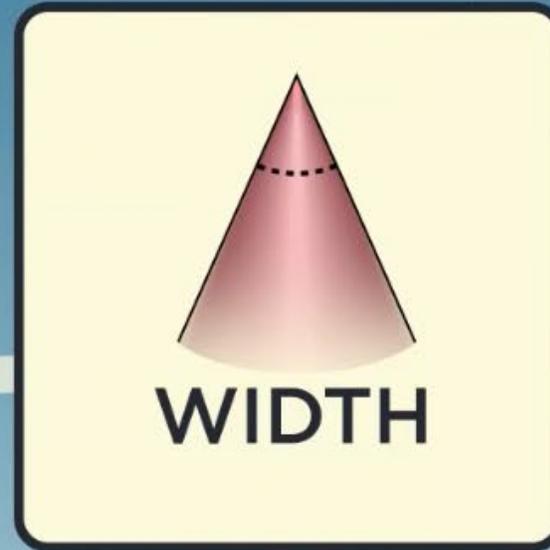
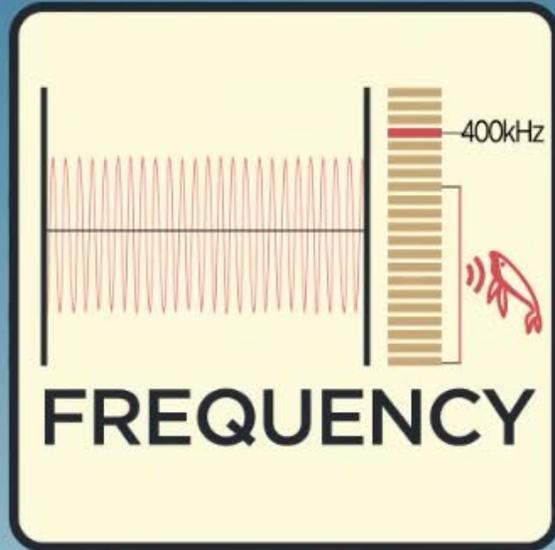
High Resolution Geophysical (HRG) sources

- Regulation of HRG sources is not as simple as with high-intensity sources like airguns
- Sources can be evaluated for *additional* factors
 - Duration
 - Duty cycle
 - Beamwidth
 - Operational parameters
- Recently completed analysis with USGS, NSF, NMFS shows many HRG sources *de minimis* for marine mammals

https://mdpi-res.com/d_attachment/jmse/jmse-10-01278/article_deploy/jmse-10-01278.pdf?version=1662733255



Key Characteristics of HRG Sources



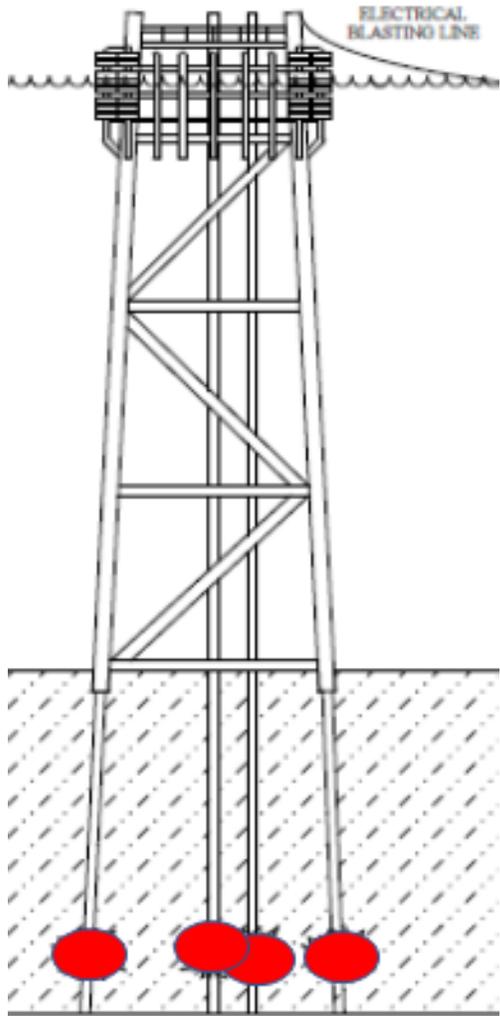
Suggested tiering of active acoustic sources

Tier 1: incidental take likely	Tier 2: incidental take likely	Tier 3: incidental take unlikely with mitigation	Tier 4: incidental take unlikely (<i>de minimis</i>)
<ul style="list-style-type: none"> Airgun surveys with total volume >1500 in³ Airgun surveys with > 12 airguns 	<ul style="list-style-type: none"> Single airguns Arrays with total volume <1500 in³ 	<ul style="list-style-type: none"> Highest-powered sparkers Other impulsive sources not evaluated fully: <ul style="list-style-type: none"> Bubble guns Some 1- and 2-plate boomers 	<ul style="list-style-type: none"> MBES SSS Hull-mounted SBP Towed SBP Parametric SBP SBES Lower-powered sparkers ADCPs Pingers (locators) Acoustic releases Seafloor/tracking devices for ROVs

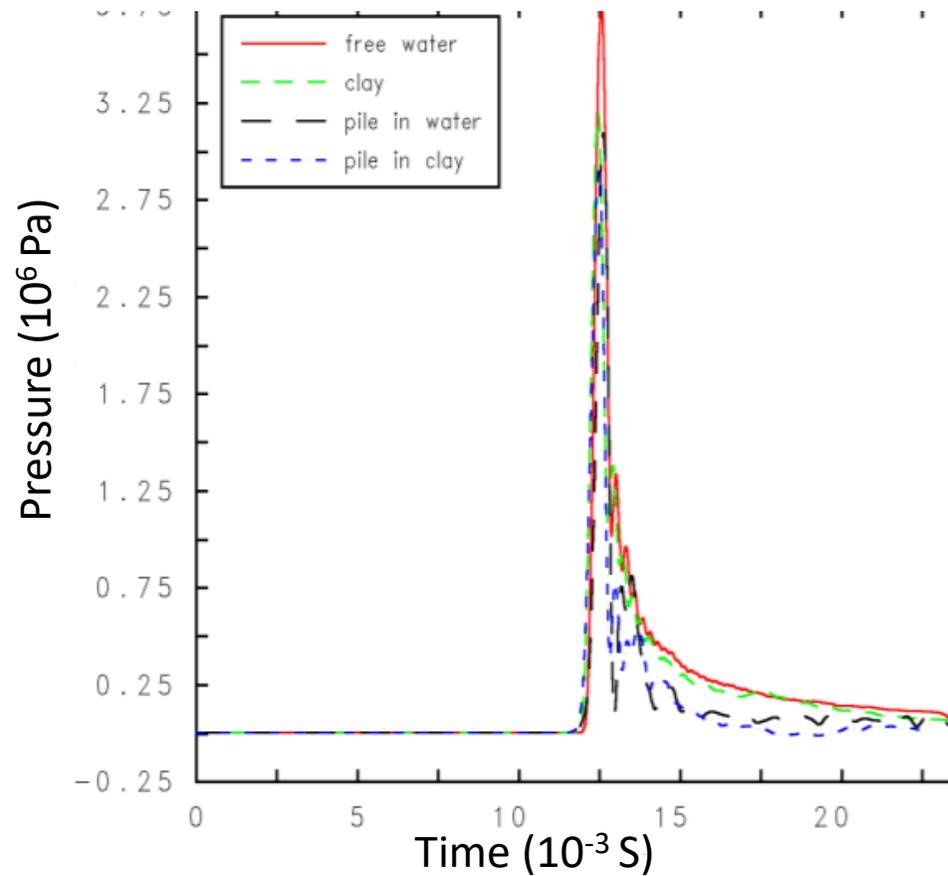
We are still working with other agencies to determine appropriate levels of mitigation for each source

Munitions and Explosives of Concern (MEC)

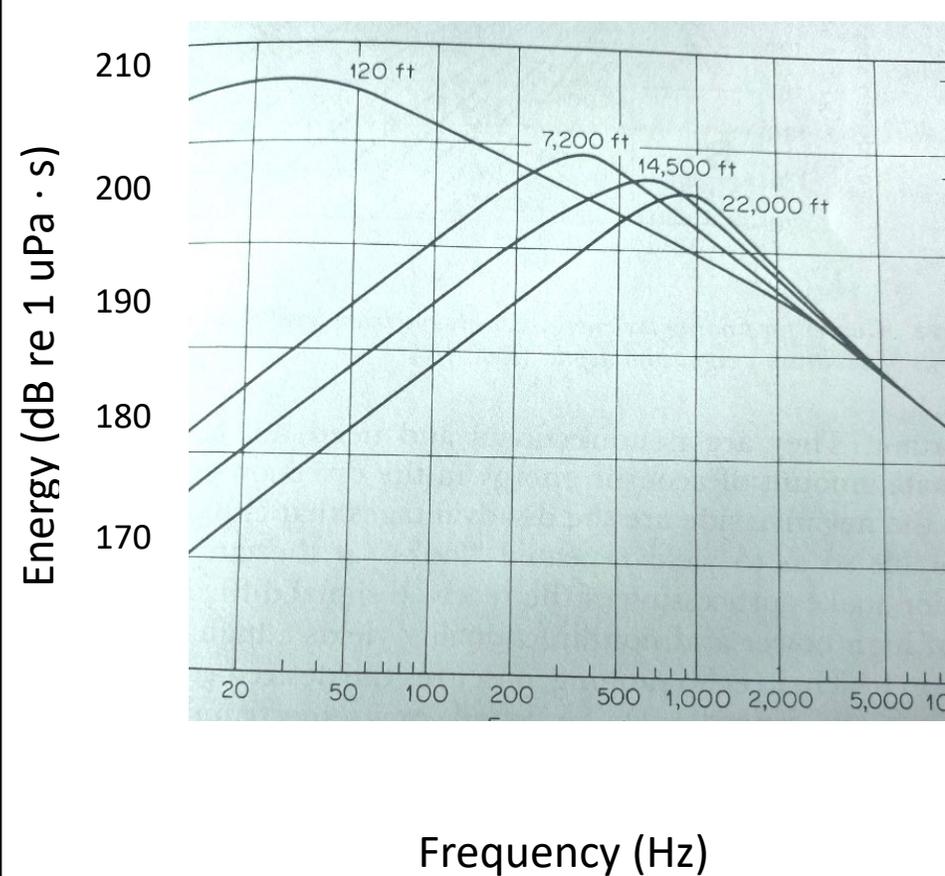
Unexploded Ordnance (UXO)



Time series of sounds produced
50 lb charge, 20m distance, different sediments



Frequency spectra of sounds produced
1-lb explosives at different depths



Foundation types

Fixed foundations:

- North Sea, U.S. East Coast
- Depth < 60 m
- Impact or vibratory pile-driving of foundations is required

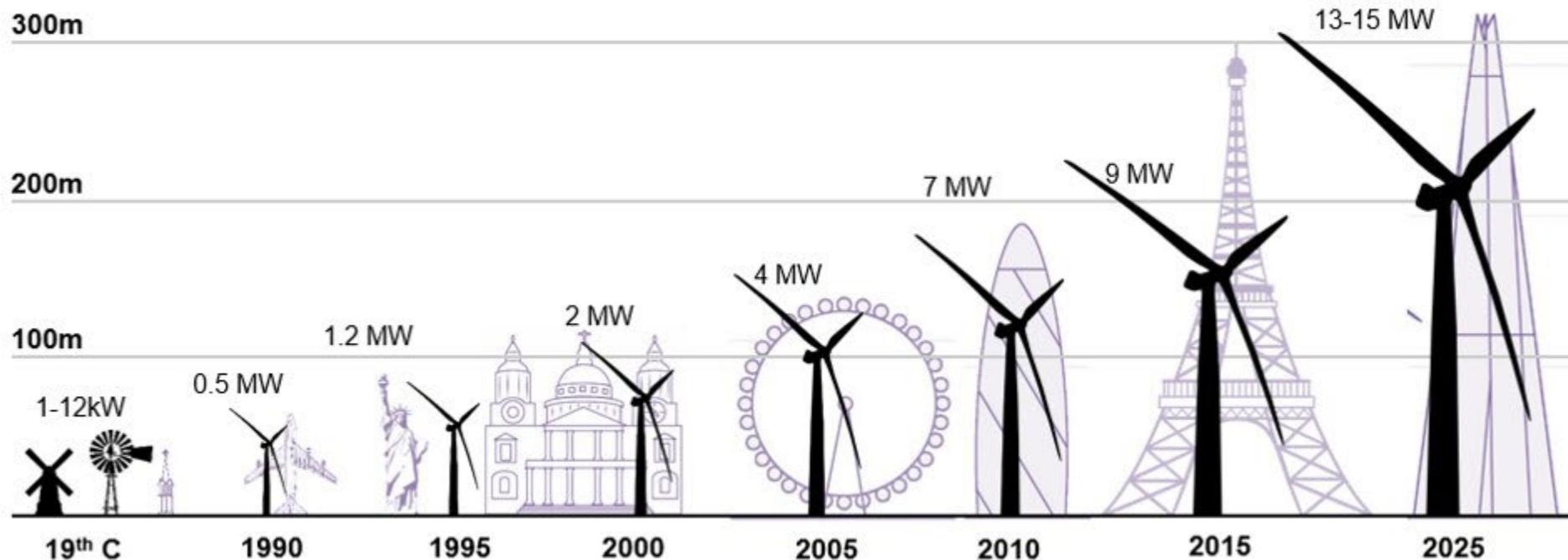


Floating foundations:

- Gulf of Maine, U.S. West Coast, Hawaii, Territories
- Depth > 60 m
- Anchoring systems need to be attached, likely using tugboats and drag anchors

Turbines are growing in size

Evolution of wind turbine heights and output



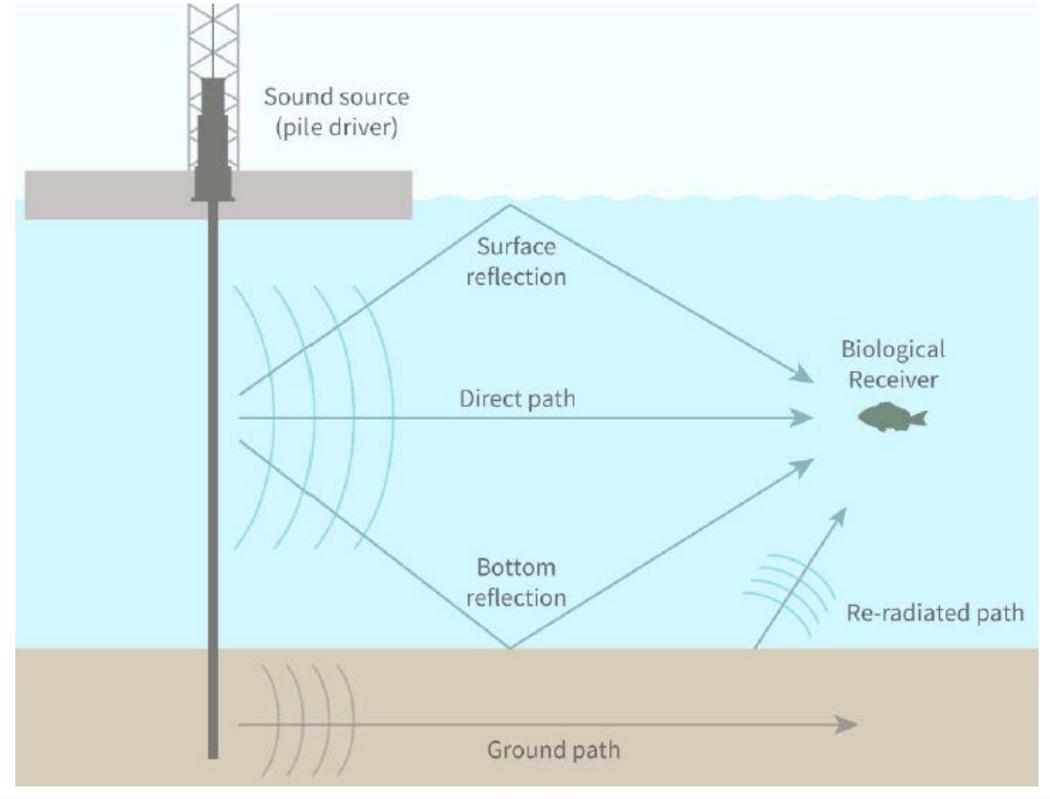
Sources: Various; Bloomberg New Energy Finance

Impact pile-driving sound

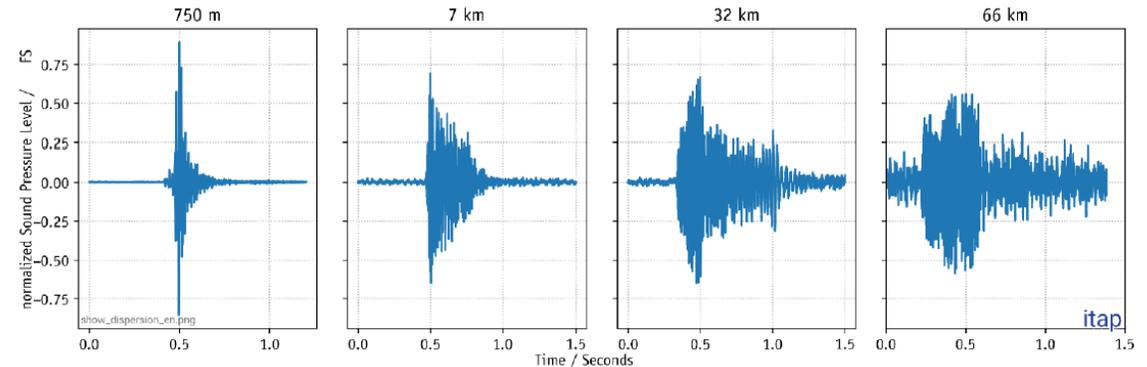


Underwater noise produced during pile-driving

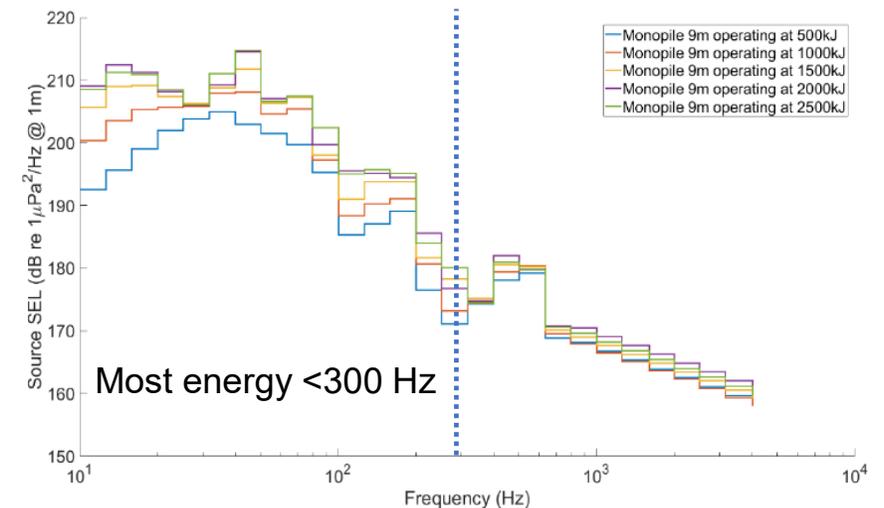
From Vineyard Wind Draft EIS 2018



Time series of pile-driving with distance



Impact-pile Driving Acoustic Spectra

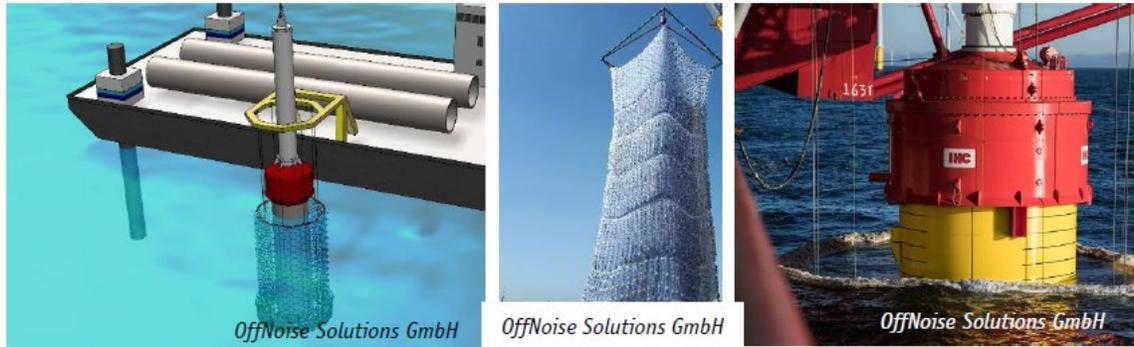


Pile-driving noise depends on:

- Foundation type
- Water depth
- Sediment type
- Abatement system used

Noise abatement methods for pile-driving

Hydro Sound Damper (HSD) — System



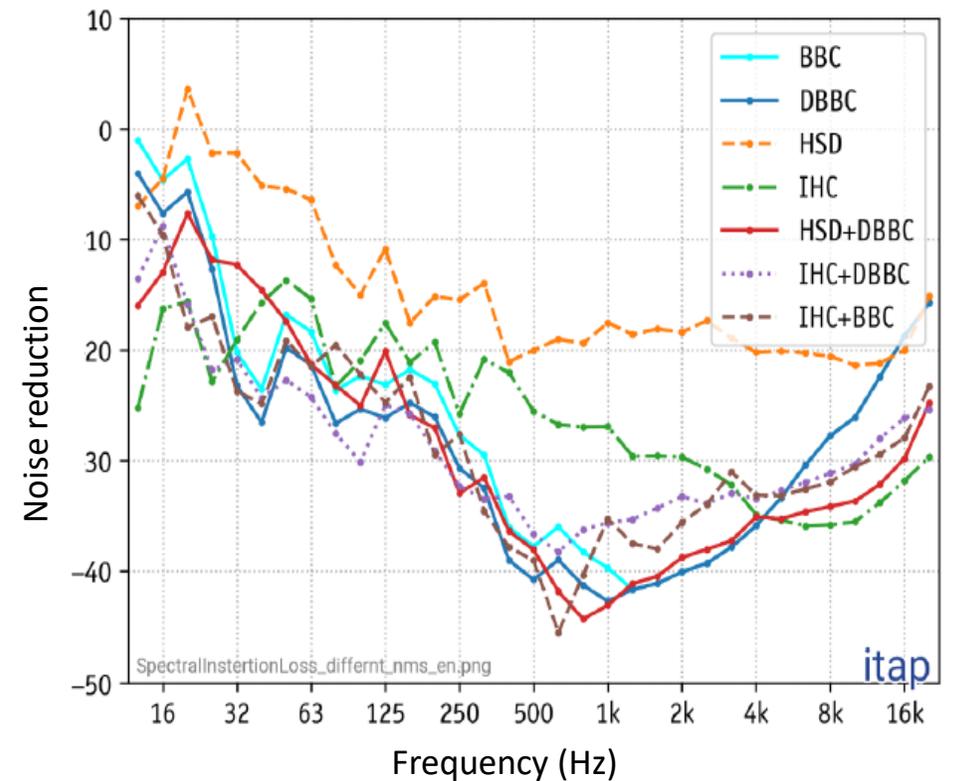
Double Big Bubble Curtain (DBBC)



Low Current

High Current

Measured noise reduction from different abatement technologies

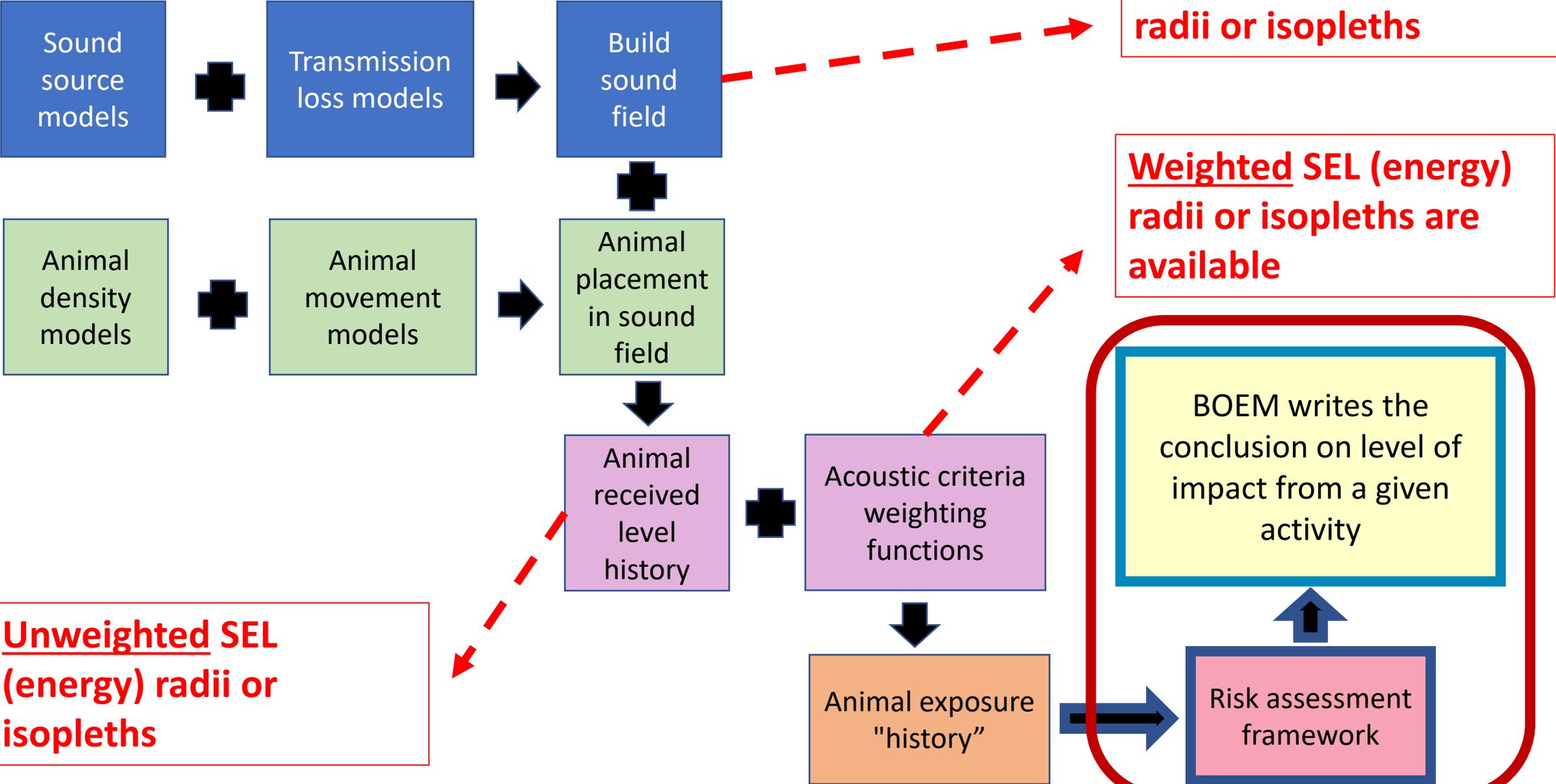


Sounds produced during operations



- **Predicted broadband source levels: 150–180 dB re 1 μ Pa-m**
 - Based installations smaller < 6.5 MW (Tougaard, 2020)
 - Statistical fit based on:
 - Turbine power rating
 - Range
 - Windspeed
- **Block Island and CVOW measurements in US waters fall with this range**
 - Direct-drive systems quieter than gearbox

How we conduct noise impact modeling



Center for Marine Acoustics Workbench Vision

The Center for Marine Acoustic (CMA) Workbench will be a well-understood, respected, and dynamic tool for predicting acoustic and biological effects of anthropogenic sound on the outer continental shelf (OCS) — a “useful” model answering current needs, while driving next-generation regulatory approaches.

- **Related to underwater acoustic issues: To improve the CMA's:**
 - Flexibility and timeliness
 - Self reliance and support BOEM decision-makers
 - Ability to verify external modeling and results
 - Internally examine and explore acoustic technical issues and ideas
- **BOEM's need for this capability is based on decades of experience addressing the issues/needs of OSCLA, NEPA, MMPA, ESA, etc.**
- **Initially, the Workbench will address BOEM's underwater acoustic needs, but other agency needs will potentially eventually be included.**

Development of a Risk Assessment Framework

- How modeling results inform the alternatives and mitigation in NEPA
 - During the Draft EIS to ROD portion of the process
- Risk Assessment Framework Approach
 - Uses expert elicitation and acoustic impact analysis to quantify species exposure & vulnerability
 - One for each scenario identified for examination
 - Geometries, seasons, proposed timing, etc.
 - Currently provides a relative assessment of risk for each species and scenario
- Some results from Proof of Concept work
- Future Efforts
 - Aggregate noise exposure for multiple acoustic sources
 - Cumulative look across all stressors (acoustic and non)
 - Case studies and ways it's been applied so far

A Risk Assessment Framework to Evaluate the Potential Relative Effects of Noise on Marine Mammals
 Southall, B.L.1,2, Amaral, J.J, Clark, C.W.3,5, Ellison, W.J, Joy, R.4, and Tollit, D.4, Ponirakis, D.W.5
 1Southall Environmental Associates, Inc., 2999 Soquel Dr., #8, Aptos, CA 95003, USA, 3 Institute of Marine Sciences, Long Marine Laboratory, University of California, Santa Cruz, 4 Marine Acoustics, Inc., 5 SMRU Consulting, 6 Cornell Biocoustics Research Program

Background
 Following earlier efforts to apply risk assessment methods in evaluating the effects of noise on marine mammals within environmental impact assessment projects (Wood et al., 2010), several of the authors here began to adapt and derive such methods to evaluate discrete acoustic exposure events. The initial objective of an Expert Working Group (EWG) was to develop a transparent and structured process that included logical elements of previous assessment methods for estimating potential effects of noise on hearing and behavior, and also integrated relevant biological, acoustical, ecological, and environmental contextual variables within a population context. The resulting risk assessment framework (Ellison et al., 2015) was influenced by a number of important emergent conclusions from the past several decades of science on these issues (e.g., Clark et al., 2009; Ellison et al., 2012, 2015; Southall et al., 2017). These include the following observations:

- Industrial activities occur within complex acoustic environments involving other human and natural sound sources and consequently, aspects of noise exposure beyond simply received sound level should be considered.
- The geographic scales for noise impact assessments should be broader than previously considered.
- Potential effects are critically dependent on the spatial, temporal, spectral, and contextual nature of the noise in relation to hearing and the spatio-temporal distribution of species in question.
- Potential effects should be evaluated within a biological-ecological significance framework that incorporates key species-specific parameters such as population status, distribution patterns, adaptability, and variability and uncertainty in these and other parameters.

Objectives and Approaches
 The EWG's initial objective was to develop a biologically-based and scientifically-current process with logical elements from previous assessment methods for evaluating effects on hearing and behavior, and to integrate relevant biological, acoustical, ecological, and environmental contextual variables in evaluating significance of noise exposure within a population context. The first approach (*acute exposure risk assessment*) was designed to evaluate acute events (e.g., seismic surveys, discrete pile-driving operations) and was deliberately designed to ensure consistency with current U.S. regulatory assessments by adapting aspects of existing analytical methods (Ellison et al., 2015). The initial risk assessment framework evaluated the relative magnitude and duration of exposure in terms of its potential severity within a population perspective using population consequences of disturbance (PCOD) methods. This evaluated risk was then considered for certain (behavioral) impacts in relation to a host of life history, population, contextual, and environmental parameters considered to mediate the potential species-specific vulnerability to disturbance.

The ongoing EWG described here aims to improve and adapt the original risk assessment framework for two very different levels of evaluation. The *acute exposure risk assessment* approach retains the perspective of a discrete, identifiable acoustic activity within the context of injury and behavioral response. The second approach (*aggregate exposure risk assessment*) moves to broader temporal and spatial scales and considers the potential risk of many overlapping activities within an aggregate framework and without reference to specific effects (but rather a relative disturbance index). Both approaches share some common philosophies in terms of evaluating overall exposure magnitude and comparing this with species-specific biological and environmental variables in estimating vulnerability. However, there are also fundamental differences, including how the magnitude of exposure is quantified and how potential susceptibility to masking is quantified. Both the acute and aggregate risk assessment frameworks are presented as overviews. It should be clearly recognized that this project is in progress and is expected to appear subsequently in further developed and published format.

Acute Exposure Risk Framework – Overall Design
 (Applied in both acute and aggregate approaches)

Species-Specific Vulnerability
 (Applied in both acute and aggregate approaches)

- Species-specific vulnerability rating is determined using a structured evaluation of key species and environmental contextual specific factors.
- The factors used to determine an overall potential vulnerability rating include:
 1. Species Population
 2. Species Habitat Use and Compensatory Abilities
 3. Potential Masking
 4. Other Environmental Stressors

Acute Exposure Risk Assessment (Potential Injury)
 Estimates of total number of individuals predicted to experience physical injury (defined as PTS onset), given specified noise exposure criteria thresholds are determined. The total number is related to the residual potential biological removal (PBR), and a relative risk assessment rating is determined.

Description	Rating	Severity rating threshold definition
Very High	5	>100% of stock population residual PBR affected
High	4	>50% of stock population residual PBR affected
Moderate	3	>15% of stock population residual PBR affected
Low	2	>1% of stock population residual PBR affected
Very Low	1	<1% of stock population residual PBR affected

Acute Exposure Risk Assessment – Behavioral Response Severity
 Risk scores, relating the relative magnitude (M), defined as the proportion of the total zone population estimated to be disturbed) and duration (D) of exposure, based on median paired undisturbed and disturbed population differences as a percentage of potential biological removal (PBR), are calculated and color coded (explanation below left).

This risk score is the Y-axis (severity) of a M-D behavioral risk assessment matrix (example, below right)

Behavioral Risk Assessment Matrix (Acute Exposure)

Exposure Index	Risk Assessment Matrix				
	1	2	3	4	5
5	M	H	H	H+	H+
4	M	M	H	H	H+
3	L	M	M	H	H
2	L-	L	L	M	M
1	L-	L-	L	L	M

Risk Assessment Matrix (Aggregate Exposure)

Exposure Index	Risk Assessment Matrix				
	1	2	3	4	5
5	M	H	H	H+	H+
4	M	M	H	H	H+
3	L	M	M	H	H
2	L-	L	L	M	M
1	L-	L-	L	L	M

Aggregate Exposure Risk Assessment
 Species-Specific Exposure Magnitude ("Exposure Index")

A modular, quantitative process is applied to calculate an "Exposure Index" relating known (or predicted) human activities as distributed sources of disturbance for marine mammals within broadly defined areas (i.e. zones) based on species-specific distribution patterns.

First, an "Activity Index" is calculated for each zone within a larger region and is based on date, duration and area covered by each activity in the zone. The Activity Index is a function of aggregate spatial and temporal "risk factors" for a zone.

Spatial risk factor
 $A_{spatial} = \sum \frac{\text{Exposure Index} \times \text{Zone Area}}{\text{Total Zone Area}}$

Temporal risk factor:
 $A_{temporal} = A_{spatial} \times \sum \frac{\text{Activity Area in Zone, where}}{\text{Days within Analysis Period}}$

Activity index:
 $A_{total} = A_{spatial} + A_{temporal}$

Next, a Spectral risk factor ("Spectral Index") term is calculated from the spectral content ratio of a generic defined

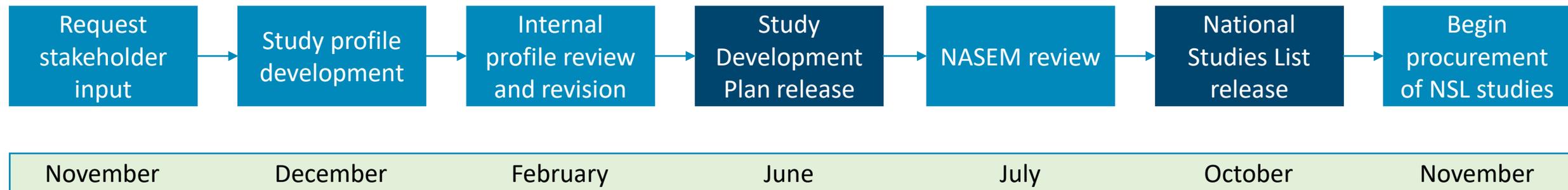
Key

Color	Risk Assessment Rating
Red	Highest (H+)
Orange	Higher (H)
Yellow	Moderate (M)
Green	Lower (L)
Blue	Lowest (L-)

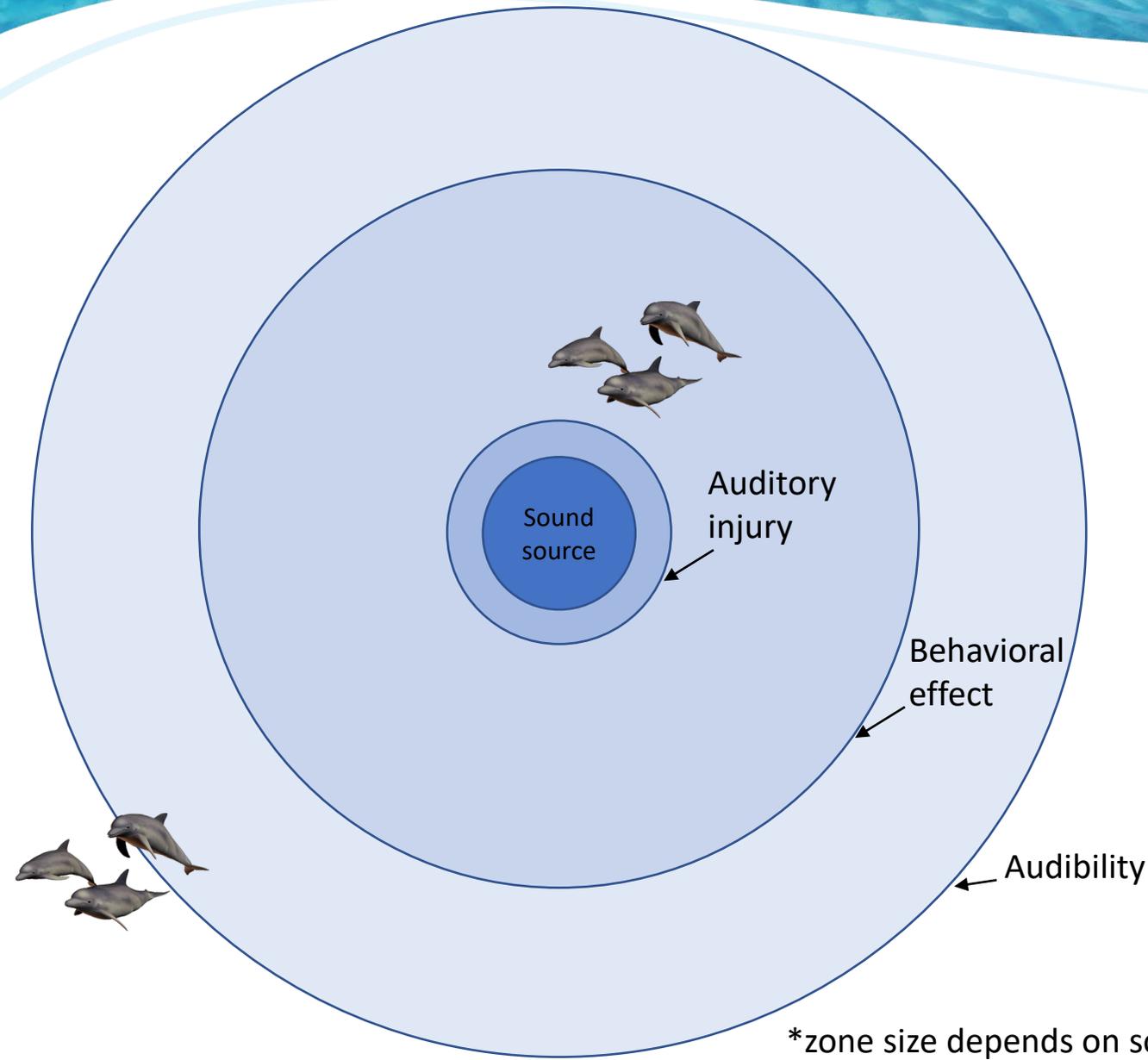
BOEM's Environmental Studies Program (ESP)

- BOEM has been funding underwater acoustics research since the 1980s
- We have an annual cycle of study development, prioritization, and then funding
- More and more topics of concern related to offshore wind

If you have ideas for research, submit to BOEM in Nov-Dec timeframe
Please do not send unsolicited proposals! Only high-level ideas



Range of effects at distance, and ways to mitigate



- Injury
 - Most acute effects occur close to source
 - Exclusion zones help mitigate
- Behavioral effect
 - Usually occur over larger scales
 - Difficult to quantify biological significance of behavioral impacts - area of research
 - Not practical to monitor such large zones
- Audibility
 - Largest
 - Audible but not bothersome?
 - Chronic and aggregate noise exposure may be an issue – area of research
- Quieting the source has benefits for all effects

*zone size depends on sound source, physical environment, and hearing capabilities of species!

Monitoring for mitigation

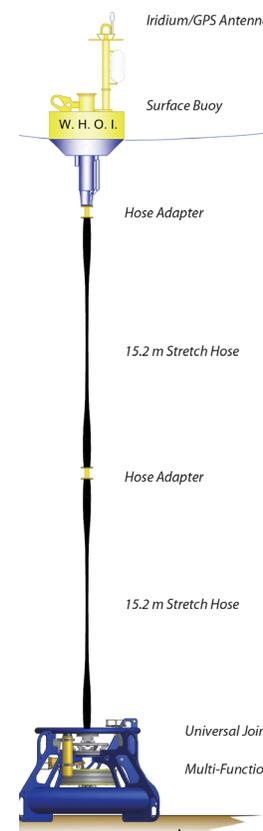


NOAA

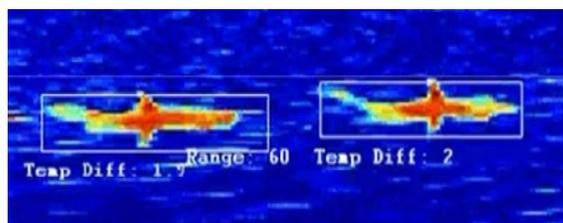
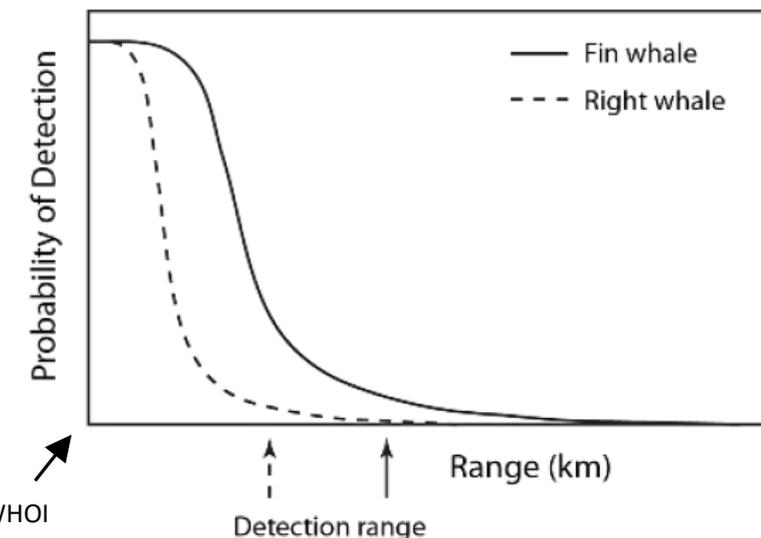
- Mitigation monitoring is only as effective as its detection capabilities
- Each method has pros/cons:
 - Visual observers: daytime, good weather conditions, limited distance
 - Drones: daytime, good weather, limited time
 - PAM: unknown # of individuals and difficult to localize without an array
 - Thermal cameras: short detection range
- Larger zones are not necessarily more effective



JASCO Applied Sciences



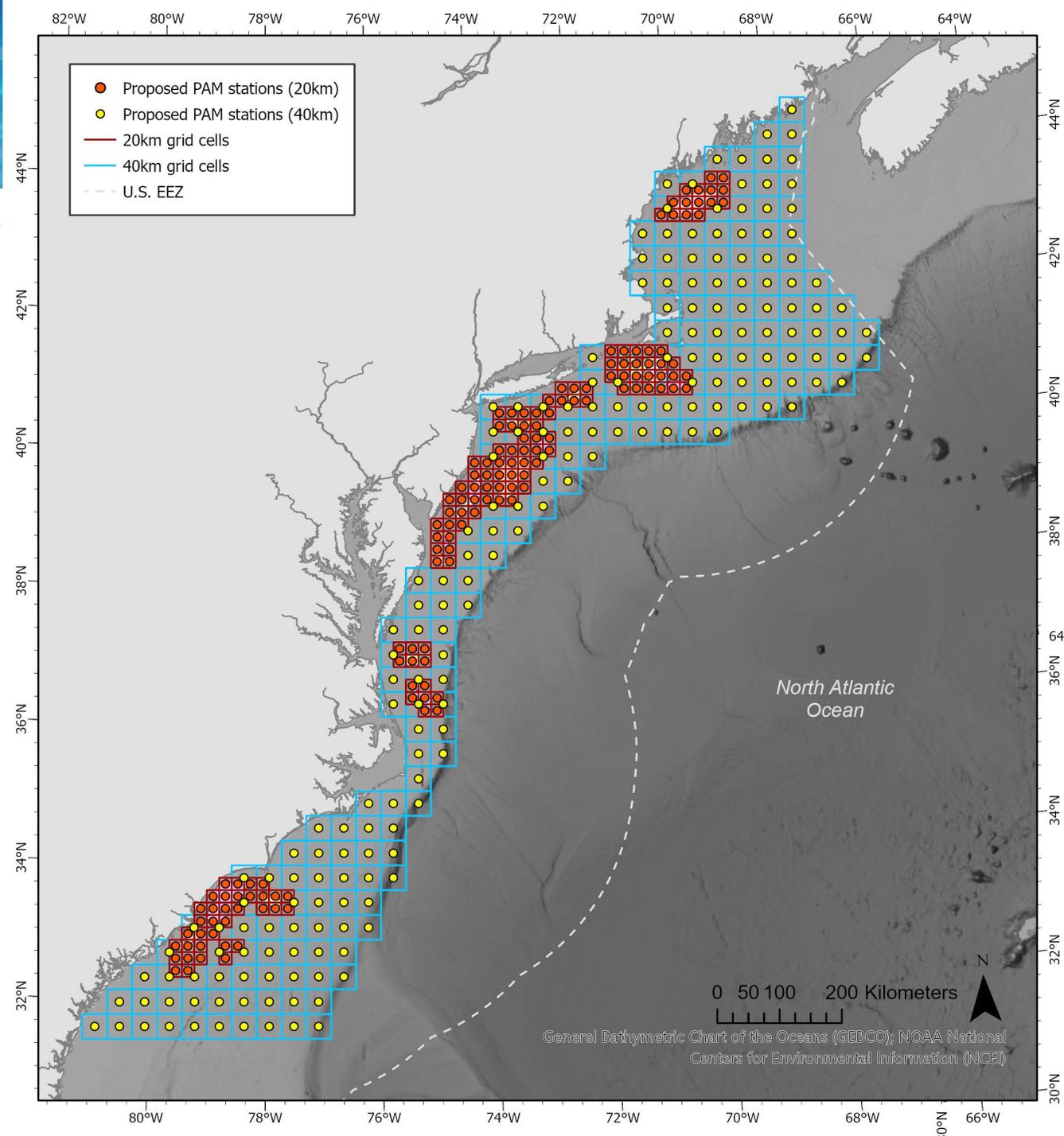
Dr. Mark Baumgartner, WHOI



Graber, 2011

Long-term monitoring

- Atlantic Regional PAM Network
- **Driving question:** Is the distribution, abundance, or behavior of baleen whales changing?
 - If so, how?
 - Why?
- Disentangling the potential effects of offshore wind vs. other ongoing stressors will be a major challenge!
 - Need for multiple data streams, not just PAM



Existing knowledge gaps and ongoing research

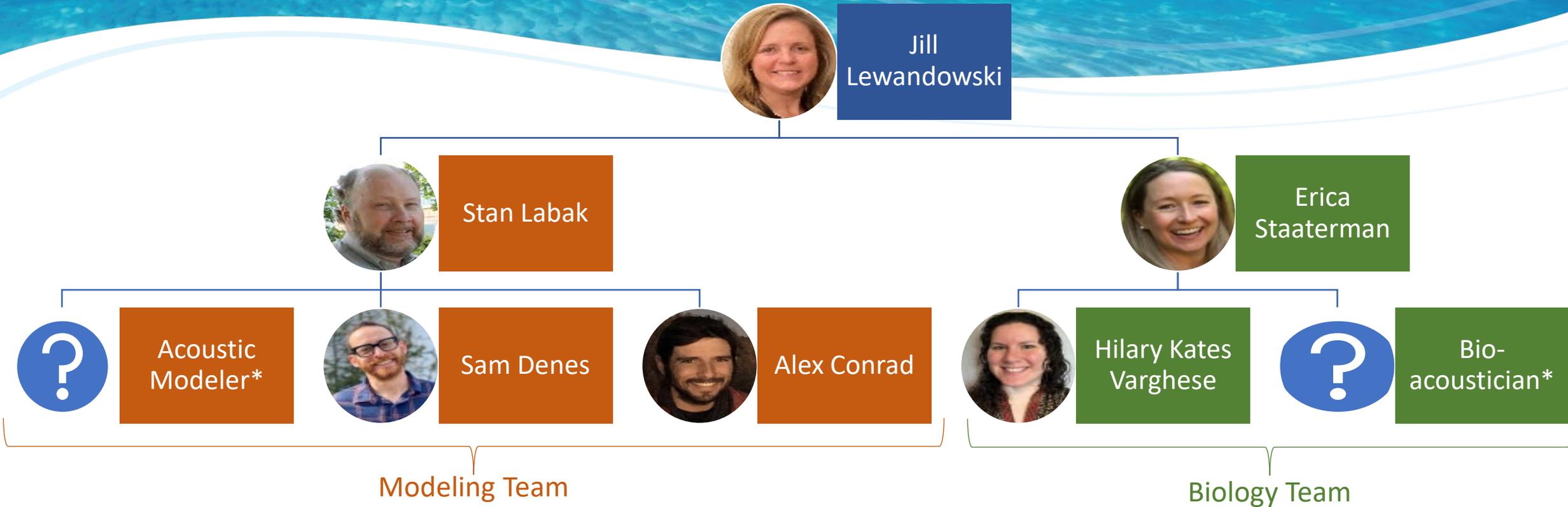
- Developed BOEM's first-ever Acoustics Science Strategy (summer 2022) – currently looking for funding partners for high-priority topics.
- Ongoing and upcoming research highlights:
 - Hearing in LF cetaceans (ongoing, partnered with other agencies)
 - Behavioral effects of offshore construction sources on seabass and squid: field study (ongoing)
 - Understanding cue rates of North Atlantic Right Whales in the mid-Atlantic (in development)
 - Measurements of substrate vibration from pile-driving (in development)
 - Behavioral responses of fish and inverts to substrate vibration (in development)

ESPIS: <https://marinecadastre.gov/epis/#/>

Other projects of note...

- 1) Exploring quieting performance targets for impact pile-driving
 - differences from Europe to U.S. waters – high-frequency vs. low-frequency cetaceans, size of turbines, etc.
 - addition of quieting technology to new construction vessels
- 2) Working with NOAA to develop a ‘living’ strategy “*to protect and promote the recovery of North Atlantic right whales while responsibly developing offshore wind energy*”
- 3) [BOEM recommendations for offshore wind project pile driving sound exposure modeling and sound field measurements](#)

Center for Marine Acoustics



*Could be you! WE ARE HIRING! - deadline Sept 20th 2022

<https://www.usajobs.gov/job/675417700> and <https://www.usajobs.gov/job/675417300>

<https://www.boem.gov/center-marine-acoustics>
<https://www.boem.gov/renewable-energy>

Questions? boemacoustics@boem.gov