OSW Site Characterization Activities and Analyzed Impacts from Agency Reviews

Gulf of Maine Task Force meeting

May 10-11, 2023

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Terminology

- Absolute need to conform to legal, scientific and standard operational usage, certain word or terms have specific meaning in the context:
  - human activities in the ocean
  - Especially sound producing activities

- Examples:
  - <u>High Resolution Geophysical (HRG) sources</u>
    - typically sonar sources
    - not Geotechnical sources = physical sampling activities
  - <u>"Takes"</u>
    - From Marine Mammal Protection Act (MMPA) wording
    - = Impacts to animals
    - Injurious to hearing, or changing important behaviors of animals

How BOEM has approached the *study* of HRG sources

- Decades of research on acoustic issues, issue coming up initially over Navy sonars, then seismic airguns
- HRG sources were not generally a concern, have been used for a long time by O&G and MMP, but to be sure we initiated a few studies:
  - Measuring sound sources in the lab (Crocker and Fratantonio 2016 report)
  - Field study to validate lab results (Heaney and Halvorsen reports)
  - Peer-reviewed paper characterizing HRG sources, whether likely to exceed threshold for behavioral harassment (Ruppel et al 2022, *Journal of Marine Science and Engineering*)

Journal of *Marine Science and Engineering*

MDPI

Article

Categorizing Active Marine Acoustic Sources Based on Their Potential to Affect Marine Animals

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Abstract: Marine acoustic sources are widely used for geophysical imaging, oceanographic sensing, and communicating with and tracking objects or robotic vehicles in the water column. Under the U.S. Marine Mammal Protection Act and similar regulations in several other countries, the impact of controlled acoustic sources is assessed based on whether the sound levels received by marine mammals meet the criteria for harassment that causes certain behavioral responses. This study describes quantitative factors beyond received sound levels that could be used to assess how marine species are affected by many commonly deployed marine acoustic sources, including airguns, high-resolution geophysical sources (e.g., multibeam echosounders, sidescan sonars, subbottom profilers, boomers, and sparkers), oceanographic instrumentation (e.g., acoustic doppler current profilers, split-beam fisheries sonars), and communication/tracking sources (e.g., acoustic releases and locators, navigational transponders). Using physical criteria about the sources, such as source level, transmission frequency, directionality, beamwidth, and pulse repetition rate, we divide marine acoustic sources into four tiers that could inform regulatory evaluation. Tier 1 refers to high-energy airgun surveys with a total volume larger than 1500 in^3 (24.5 L) or arrays with more than 12 airguns, while Tier 2 covers the remaining low/intermediate energy airgun surveys. Tier 4 includes most high-resolution geophysical, oceanographic, and communication/tracking sources, which are considered unlikely to result in incidental take of marine mammals and therefore termed *de minimis*. Tier 3 covers most non-airgun seismic sources, which either have characteristics that do not meet the *de minimis* category (e.g., some sparkers) or could not be fully evaluated here (e.g., bubble guns, some boomers). We also consider the simultaneous use of multiple acoustic sources, discuss marine mammal field observations that are consistent with the *de minimis* designation for some acoustic sources, and suggest how to evaluate acoustic sources that are not explicitly considered here.

Keywords: active acoustics; marine noise; sonar; airguns; marine seismic; high-resolution geophysics; pingers; echosounder; multibeam; marine mammals; endangered species; cetaceans; delphinids; sea turtles

check for updates

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1. Introduction

A wide range of controlled sound sources is deployed in the marine environment to map, explore, and characterize the seafloor, the subbottom, and the water column and to communicate with or track remote devices (e.g., remotely operated vehicles, seafloor sensors) that are also used to accomplish these tasks. For controlled sound sources, physical factors such as the power level, transmission frequency, duration of sound pulses, and deployment depth, as well as characteristics of the seafloor and seawater, influence sound propagation in the marine environment. An animal's response to a sound source depends on the biological characteristics (e.g., hearing range and sensitivity, behavioral activity) and the environmental context (e.g., depth in the water column, distance from the source) of the marine species receiving the sound. The combination of the physics of the sound sources

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Which sources are used for site characterization for offshore wind sites?

- Most HRG sources can be described as:
  - Non-impulsive
  - Intermittent
  - Having very low duty cycles (short pulses of sound with relatively long periods of silence)
  - Directional
  - Having source levels (SL) lower than airguns

Which sources have been included in the IHAs thus far:

- Boomers (impulsive)
- Sparkers (impulsive)
- CHIRP sub-bottom profilers
- Parametric sub-bottom profilers

Other systems not operated <180 kHz:

- Underwater communication devices
- Split-beam echosounders
- Multibeam echosounders (occasionally)
- Fathometers
- ADCPs

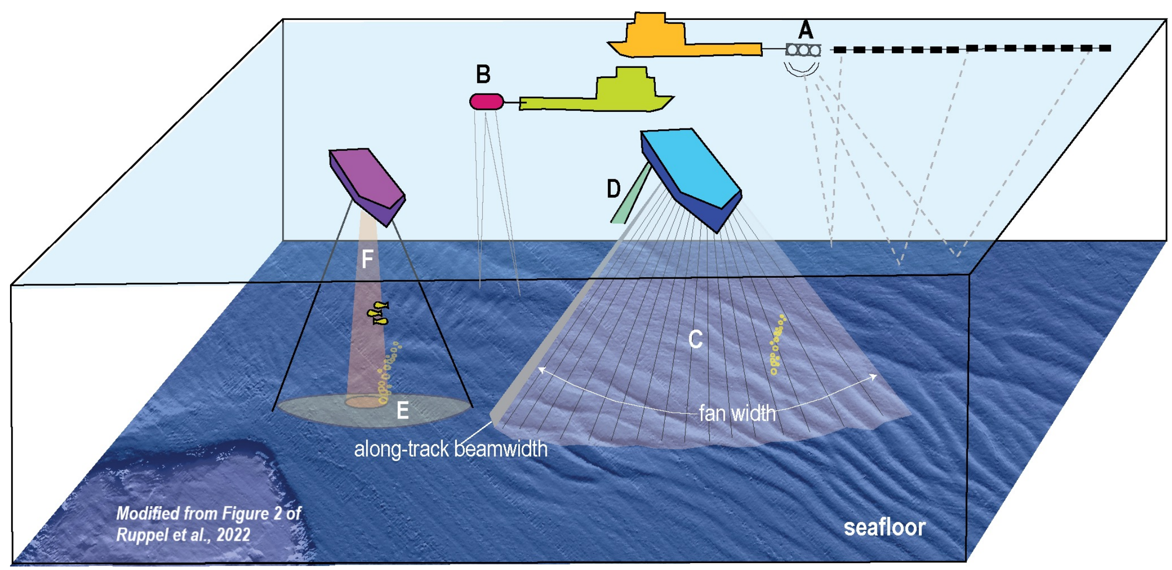
The Watch the BOEM Video

https://www.youtube.com/watch?v=hdlOkQOtgMk&t=37s

How to characterize these sources?

Ruppel et al. (J. Marine Science & Engineering, 2022) evaluated the following factors while considering the current behavioral harassment threshold of 160 dB re 1 µPa:

1. Transmission frequency
2. Incidental take radius
3. Beamwidth
4. Total Radiated power
5. Degree of exposure

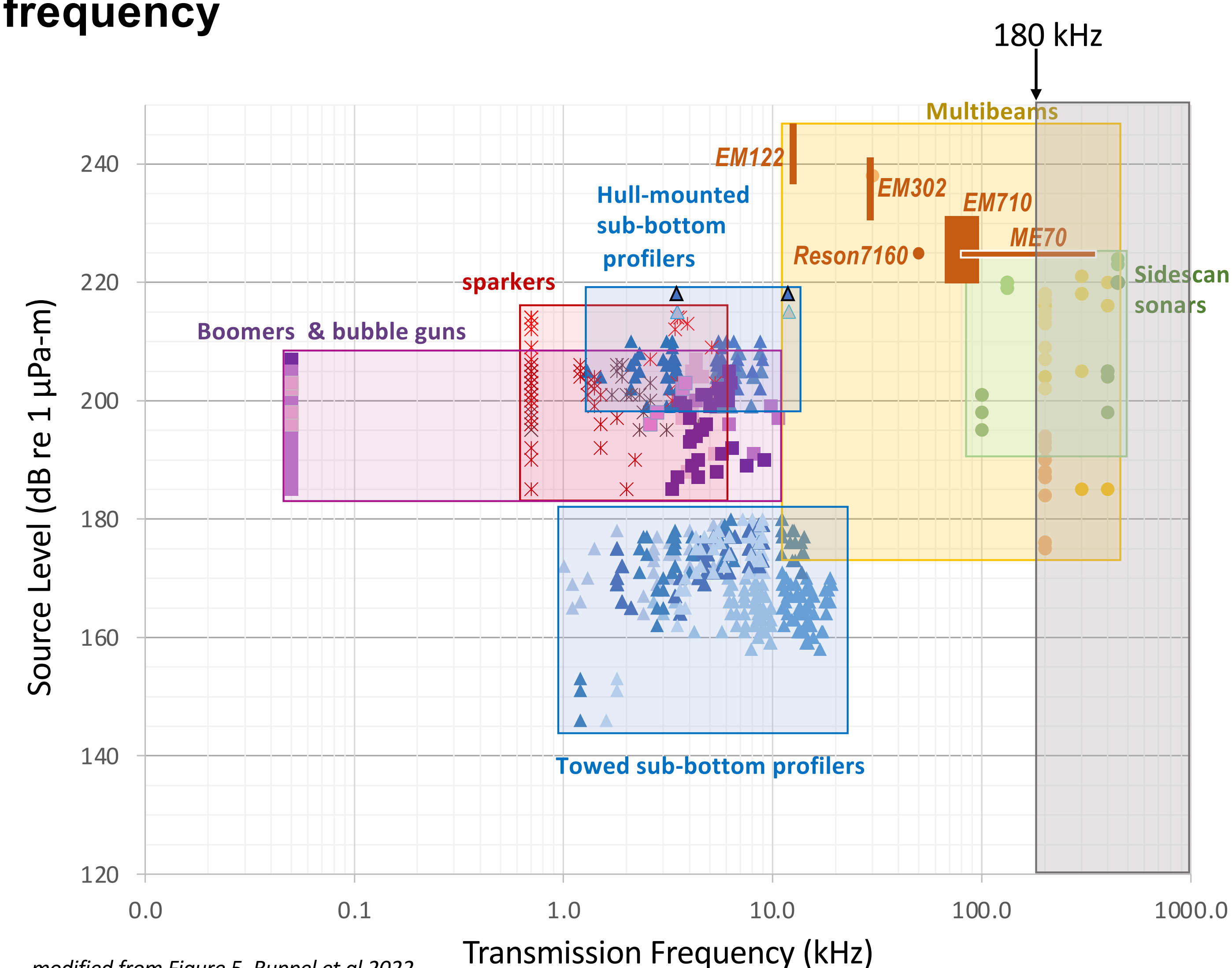


Factor 1: Transmission frequency

Consistent with current practice:

- Sources transmitting > 180 kHz are not audible, thus not likely to affect marine mammals
- Recent MMPA IHA applications have not even analyzed sources > 180 kHz

<u>Factor 1 renders *de minimis*:</u>
Some Multibeams
Some Split Beams
Some side scan sonars



modified from Figure 5, Ruppel et al 2022

Factor 2: Incidental take radius

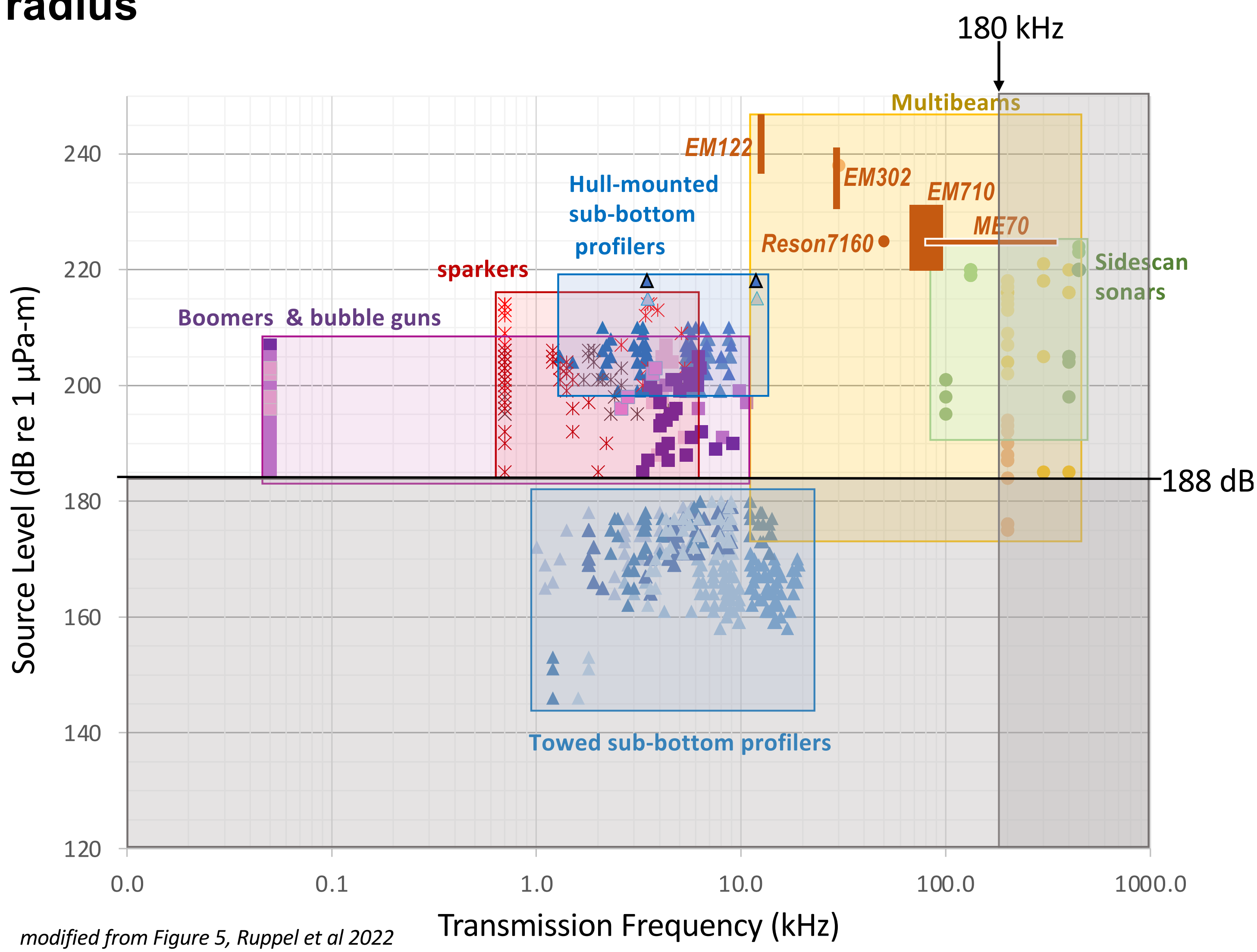
Conventional practice assumes animals will not approach within R=25 m from a source.

Translating this to source level (SL) for spherical spreading:

$$\textit{Adjusted SL} = 160 \text{ dB} + 20\log_{10}R$$
$$= 188 \text{ dB}$$

We determined an "incidental take radius" by combining population densities with the probability of a single animal being ensonified at > 160 dB re 1 μPa.

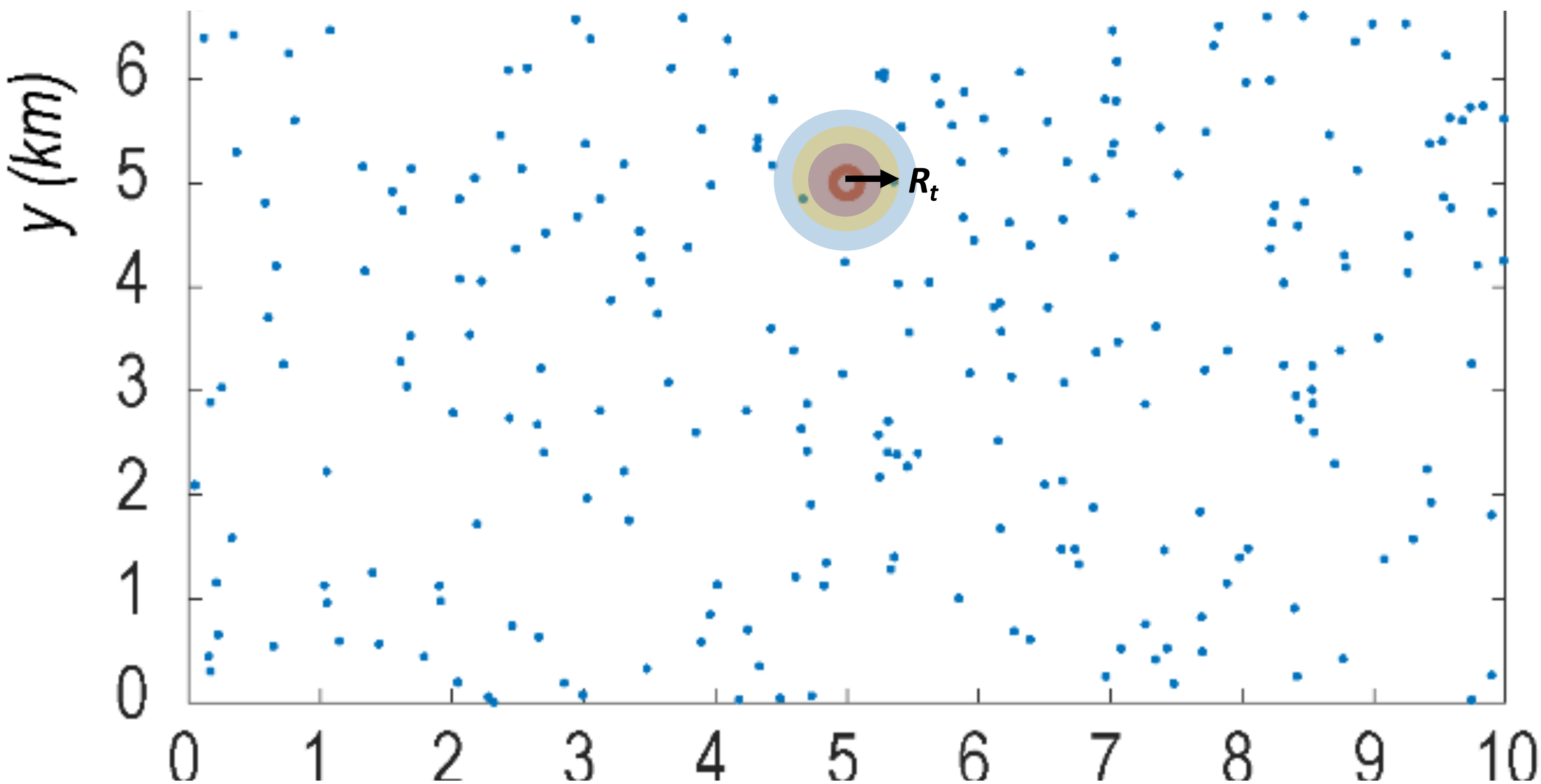
R_t is the radius around the source at which the 160 dB criterion applies.



modified from Figure 5, Ruppel et al 2022

Determining incidental take radius (R_t)

Start with random distribution of animals based on real-world animal densities.
Do this 100k times.
What are the odds that an animal will fall within a given radius of the source?
For what size radius will you have a probability that 1 animal is inside the circle in 1% of the simulations?



The R_t can then be converted to an adjusted SL_{it} as we did before in the 25 m case

Determining incidental take radius (R_t)

Vary the probability

Vary the size of R_t

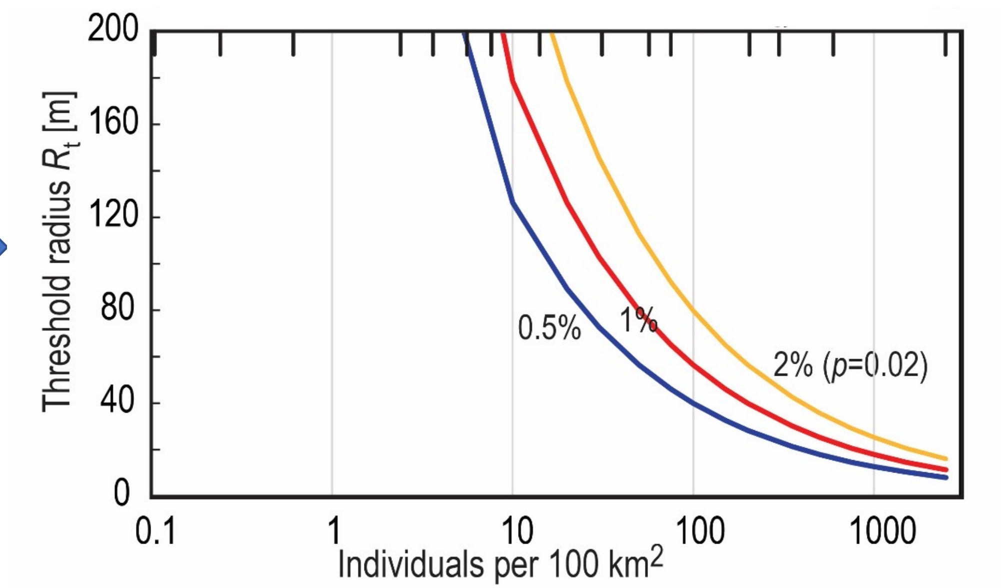
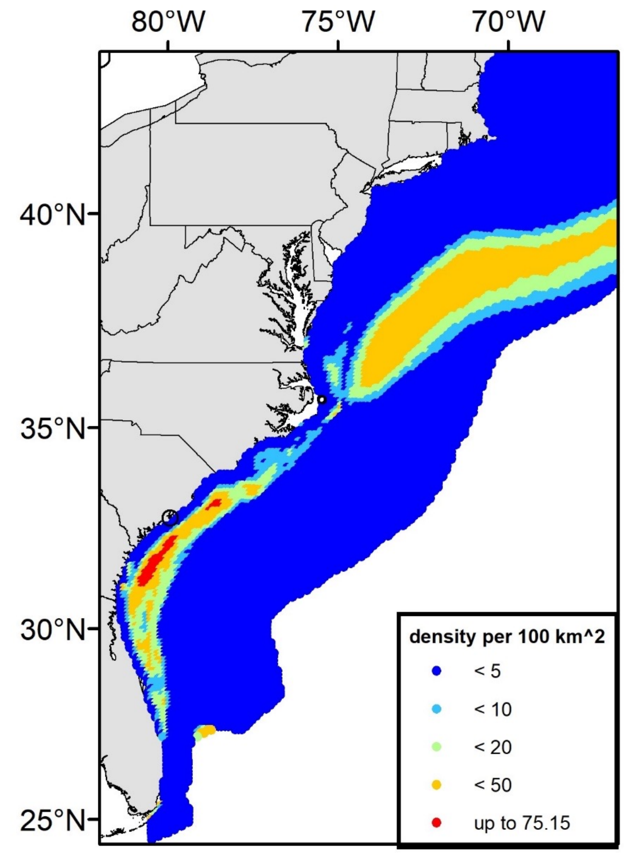


Figure 6, Ruppel et al 2022



Atlantic Spotted Dolphin

Vary the density

Red line: the odds that in 1% of the simulations, 1 animal will be within the given R_t zone

Factor 2: Incidental take radius

Red line: odds that in 1% of the simulations, 1 animal will come within the given R_t zone

E.G., North Atlantic Right Whale: R_t could be > 200 m before you would ensonify a single animal in 1% of the simulations

For some species, densities are so low that the radius could become unreasonably large, so we capped it a 100 m.

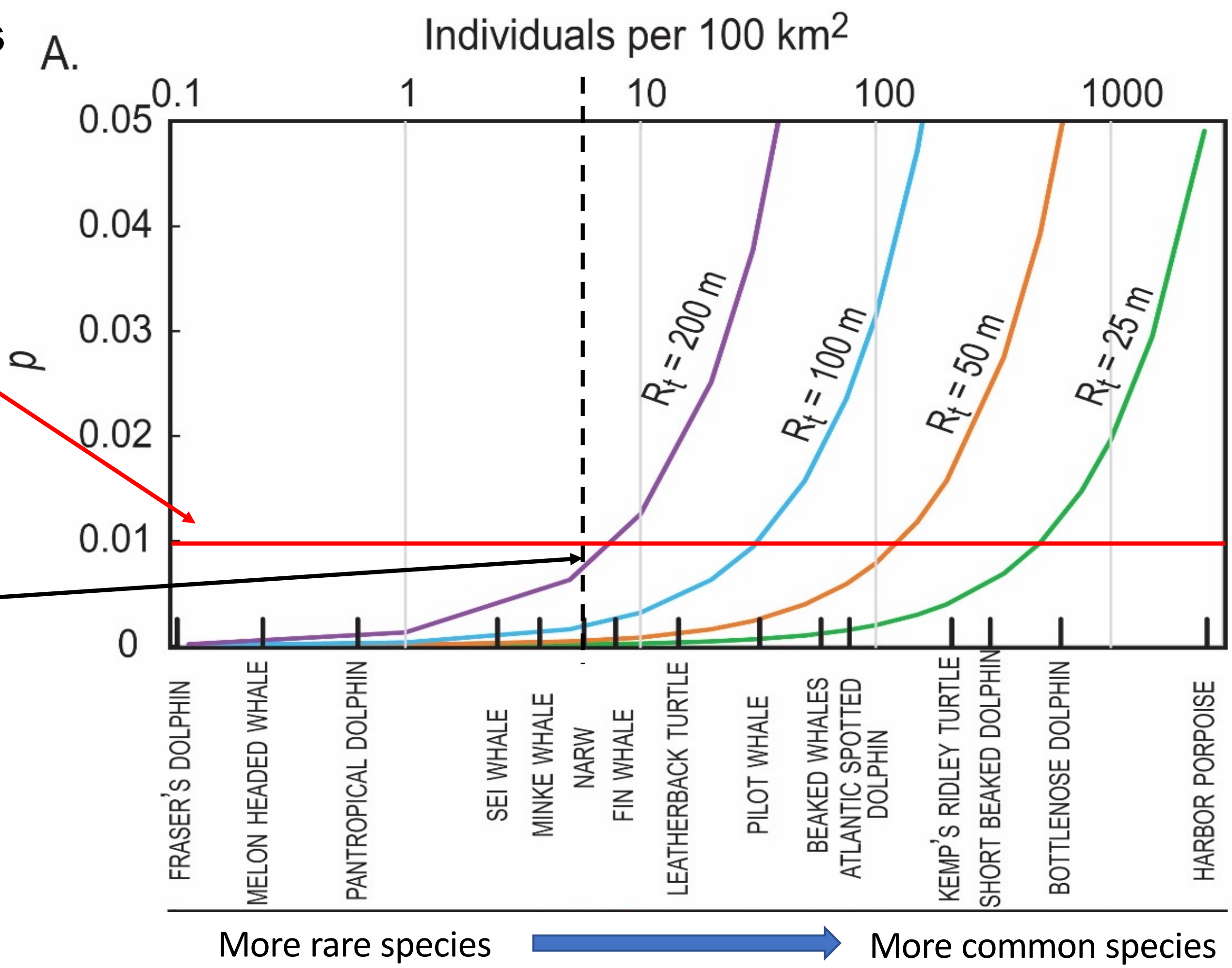


Figure 6, Ruppel et al 2022

Factor 2: Incidental take radius

<u>Key point</u>: It's a combination of source level, propagation loss, and real-world animal densities that matter.

Current practice of using 25m is very conservative based on realistic animal densities.

Capping R_t at 100 m corresponds to adjusted SL_{it} = 200 dB re 1 μPa

<u>Factor 2 renders *de minimis*</u>:

- **low powered sparkers**
- **low powered boomers & bubble guns**
- **towed SBPs**
- **communication/tracking devices**

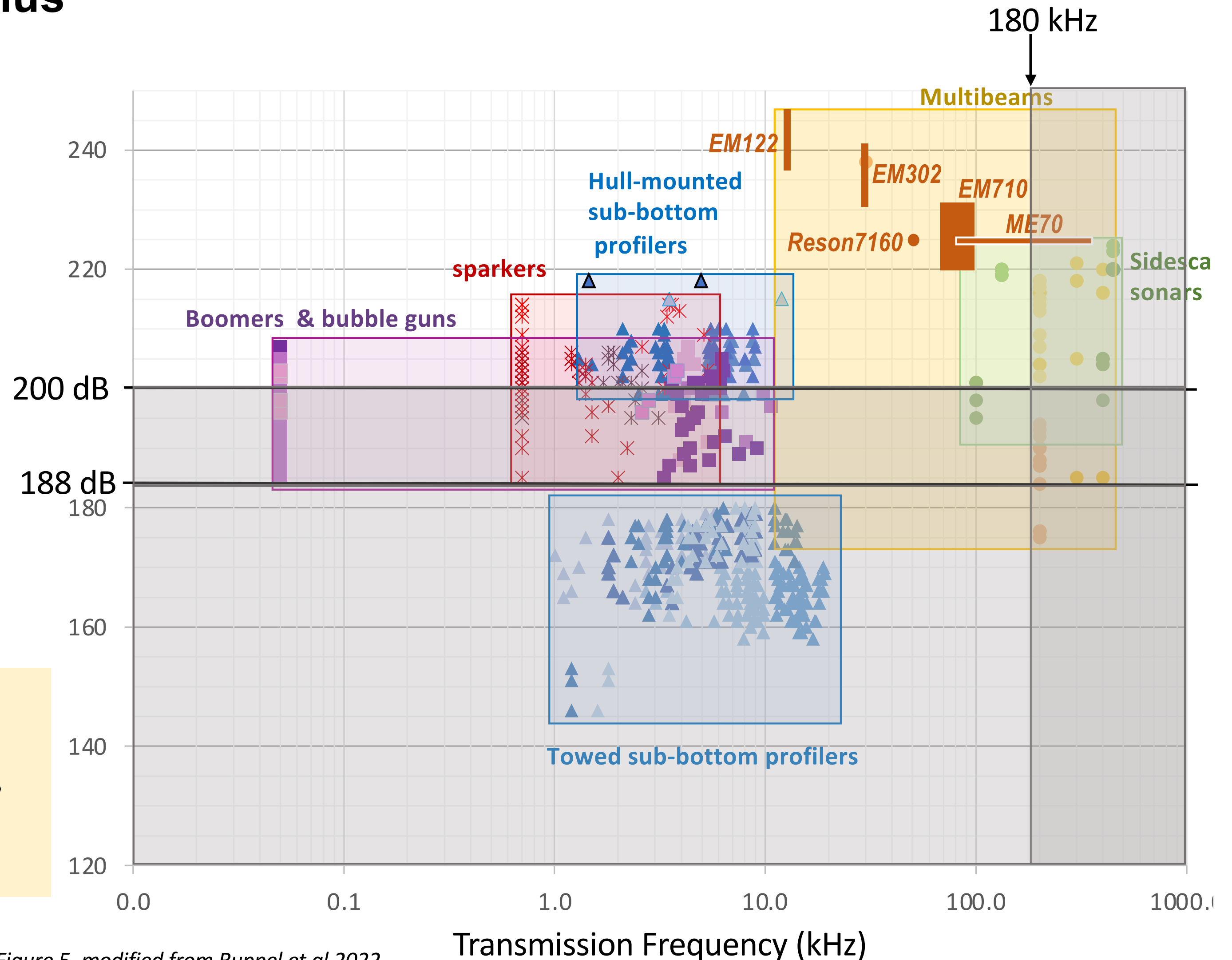
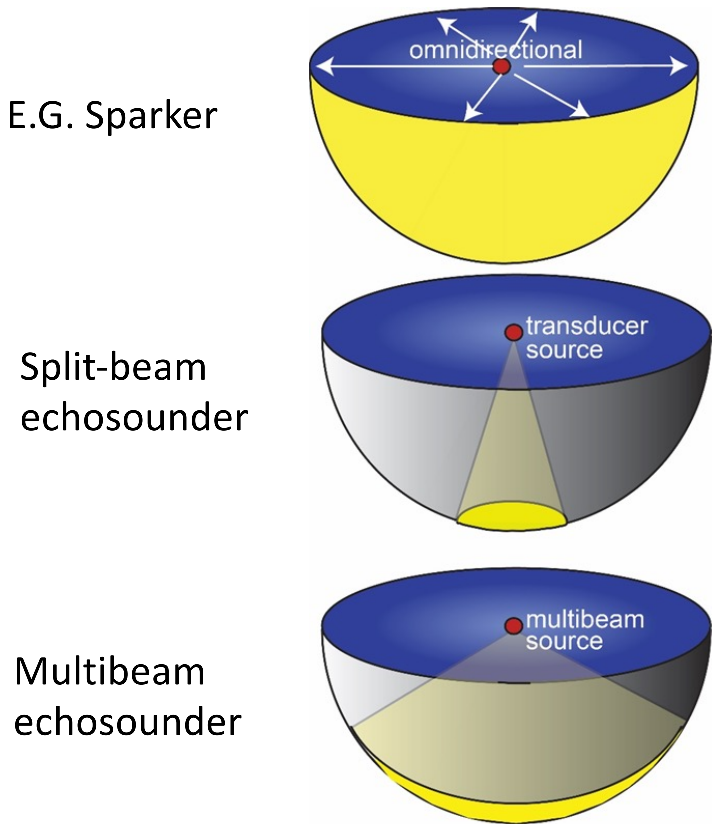


Figure 5, modified from Ruppel et al 2022

Factor 3: Beamwidth

Not all sources radiate sound equally!



And water depth plays an important role!

Same Monte Carlo approach, but now animals are distributed in 3-dimensions. Animals are more densely concentrated near the surface of the ocean.

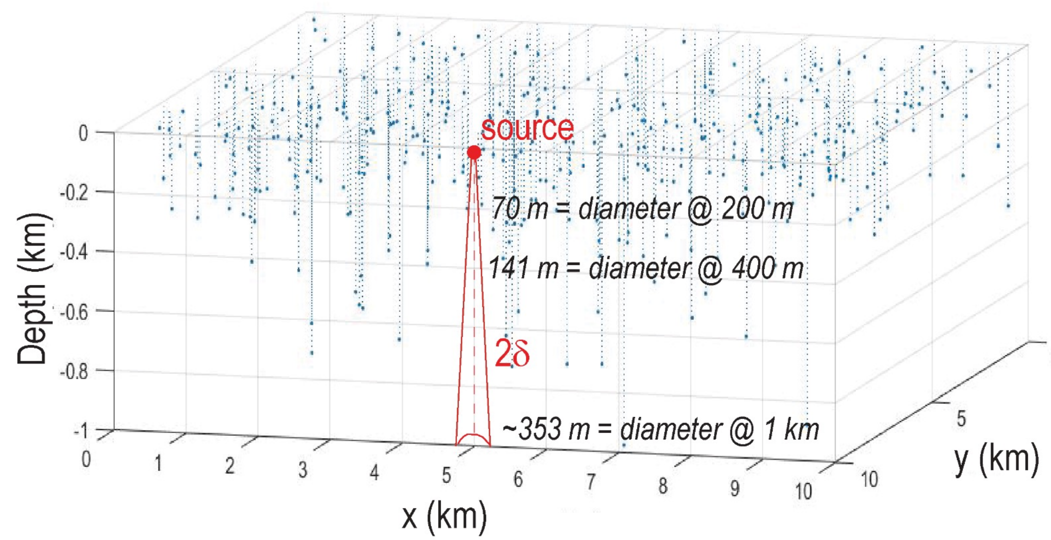


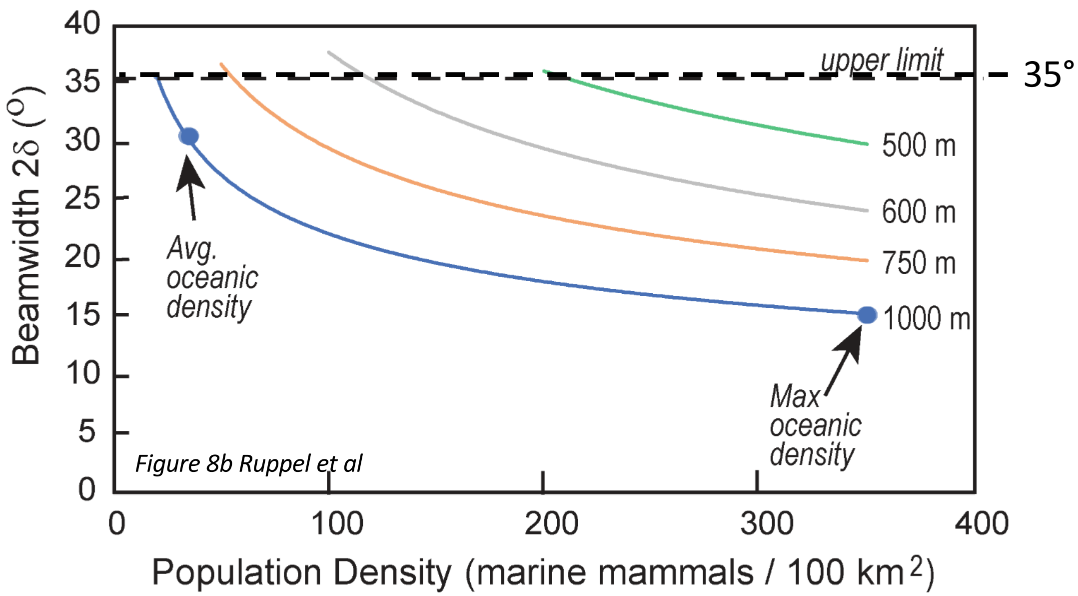
Figure Supplement 6, Ruppel et al. (2022)

For a source with a given beamwidth,
greater water depth = larger volume ensonified = greater impact

Factor 3: Beamwidth

Vary the beamwidth

Vary the water depth



Vary the density

Key point:
It's a combination of beamwidth, water depth, and real-world animal densities that matter. You can have a large beamwidth in areas of low density and still not ensonify an animal.

Factor 3 renders *de minimis*:

Hull-mounted SBPs
ADCPs
Split-beam echosounders

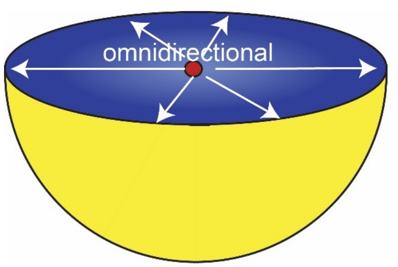
Blue line represents the 1% chance of 1 animal being ensonified at 160 dB for the 100k realizations done for that water depth

Factor 4: Total Radiated Power or Sound Power Level

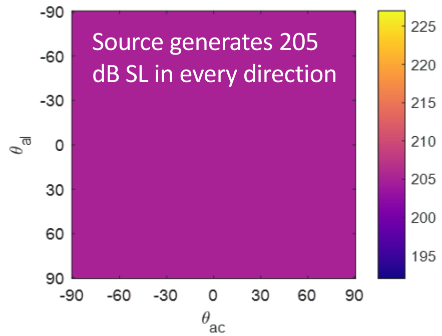
Sound power level incorporates *both* the source level and the directionality of the source. It is an integrative measure of the radiated sound intensity <u>over all directions</u>.

Why use it? It helps quantitatively address this question with a single metric: What is the difference between a 'loud' source with a very narrow beam, and a 'quiet' source with a very broad beam?

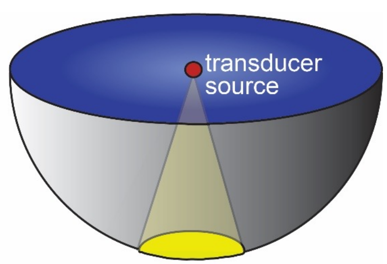
Omnidirectional

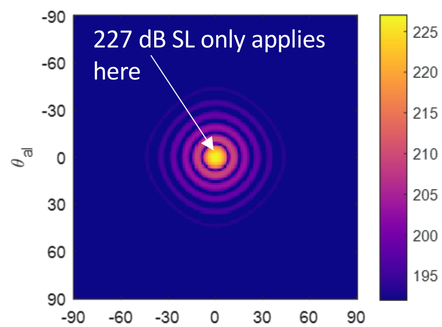


Radiation Pattern
(top-down view)



7° cone





Source Level		Sound Power Level
205 dB re 1 µPa@1m	-57 dB	148 dB re 10^{-12} Watts
227 dB re 1 µPa@1m	-79 dB	148 dB re 10^{-12} Watts

Factor 4: Total Radiated Power or Sound Power Level

- Key point:
  - Incorporating the source directivity with the source level gives a more complete sense of the *total* radiated sound field. You can think of it like the average over the whole sound field.

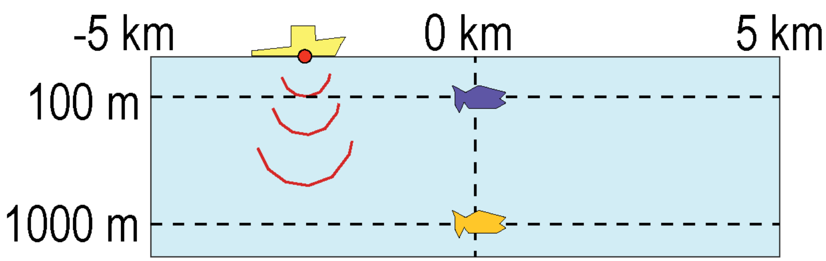
Factor 4 renders *de minimis*:

Nothing! – factor 4 alone was not enough to render a source *de minimis*, but since it is such an informative metric for these sound sources, we incorporated it into factor 5

Factor 5: Degree of Exposure

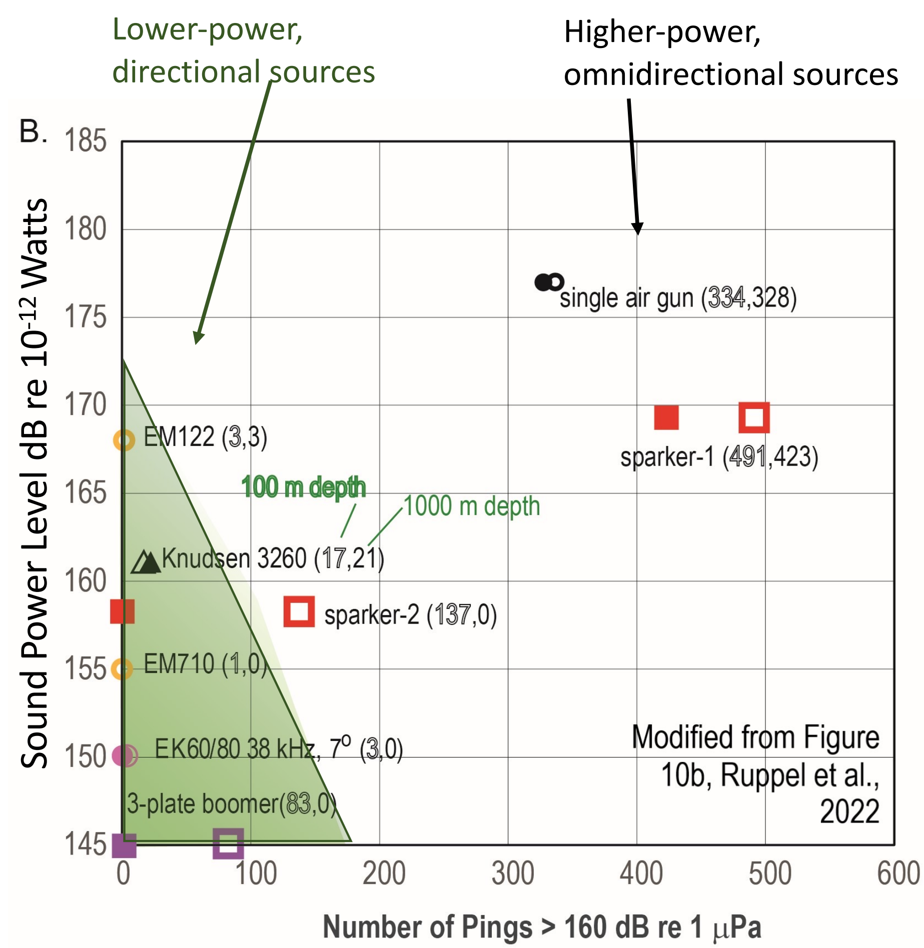
Degree of exposure = how long or for how many pings an animal is exposed to > 160 dB re 1 μPa

Assessed number of pings received above 160 dB re 1 μPa based on:
-- Source characteristics (SL, directivity)
-- Vessel speed
-- Position of (stationary) animal relative to source



Modified from Fig 10a (inset) Ruppel et al., 2022

There is a natural "grouping" of sources

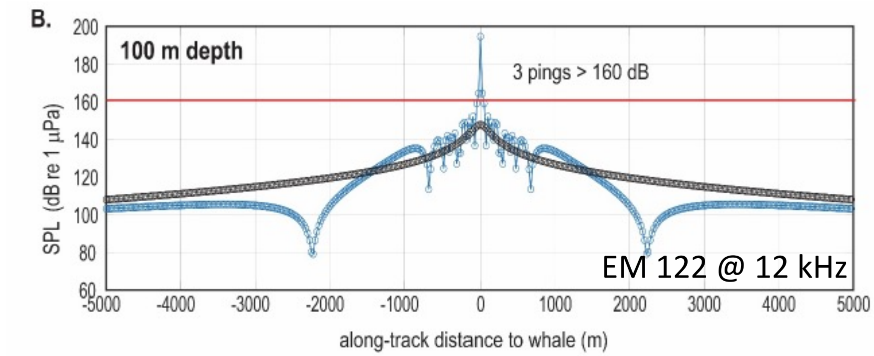


Modified from Figure 10b, Ruppel et al., 2022

Factor 5: Degree of Exposure

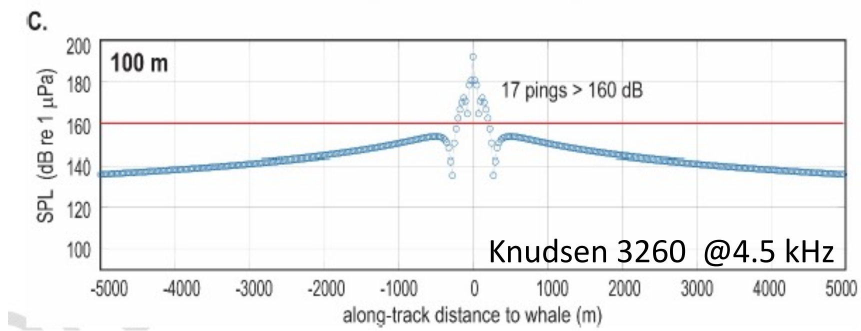
<u>Factor 5 renders *de minimis*</u>:

- MBES
- SBES
- 3-plate boomers
- Side-scan sonars
- Hull-mounted SBPs
- ADCPs
- Communication/tracking devices
- Pingers



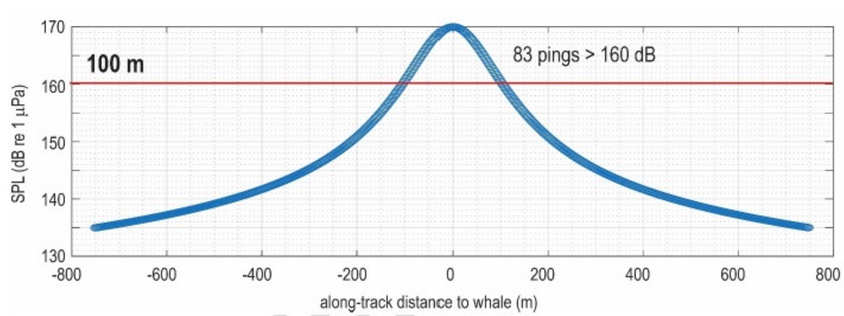
<u>Multibeam echosounder</u>

- 245 dB max source level
- 10 km trackline, 9.7 kts
- 0.5 degree beamwidth
- 15 ms pulse length
- < 1% duty cycle
- Sound is ON for .045 s



<u>Hull-mounted SBP</u>

- 232 dB max source level
- 10 km trackline, 9.7 kts
- 64 ms pulse length
- 6% duty cycle
- Sound is ON for 1.1 s



<u>3-plate boomer</u>

- 210 dB max source level
- 1600m trackline, 4.9 kts
- 60 degree beamwidth
- 0.6 ms pulse length
- <1% duty cycle
- Sound is ON for .05 s

Figures 11, 12, 13 Ruppel et al 2022

Bringing it all together

1. Frequency
   Some MBES, some SBES, some side-scan sonars
2. Incidental take radius
   towed SBPs, low-powered sparkers, low-powered boomers, communication/tracking devices
3. Beamwidth
   ADCPs, SBES, hull-mounted SBPs
4. Total Radiated Power
   None
5. Degree of Exposure
   MBES, SBES, side scan sonar, hull-mounted SBPs, 3-plate boomers, pingers, underwater communication devices

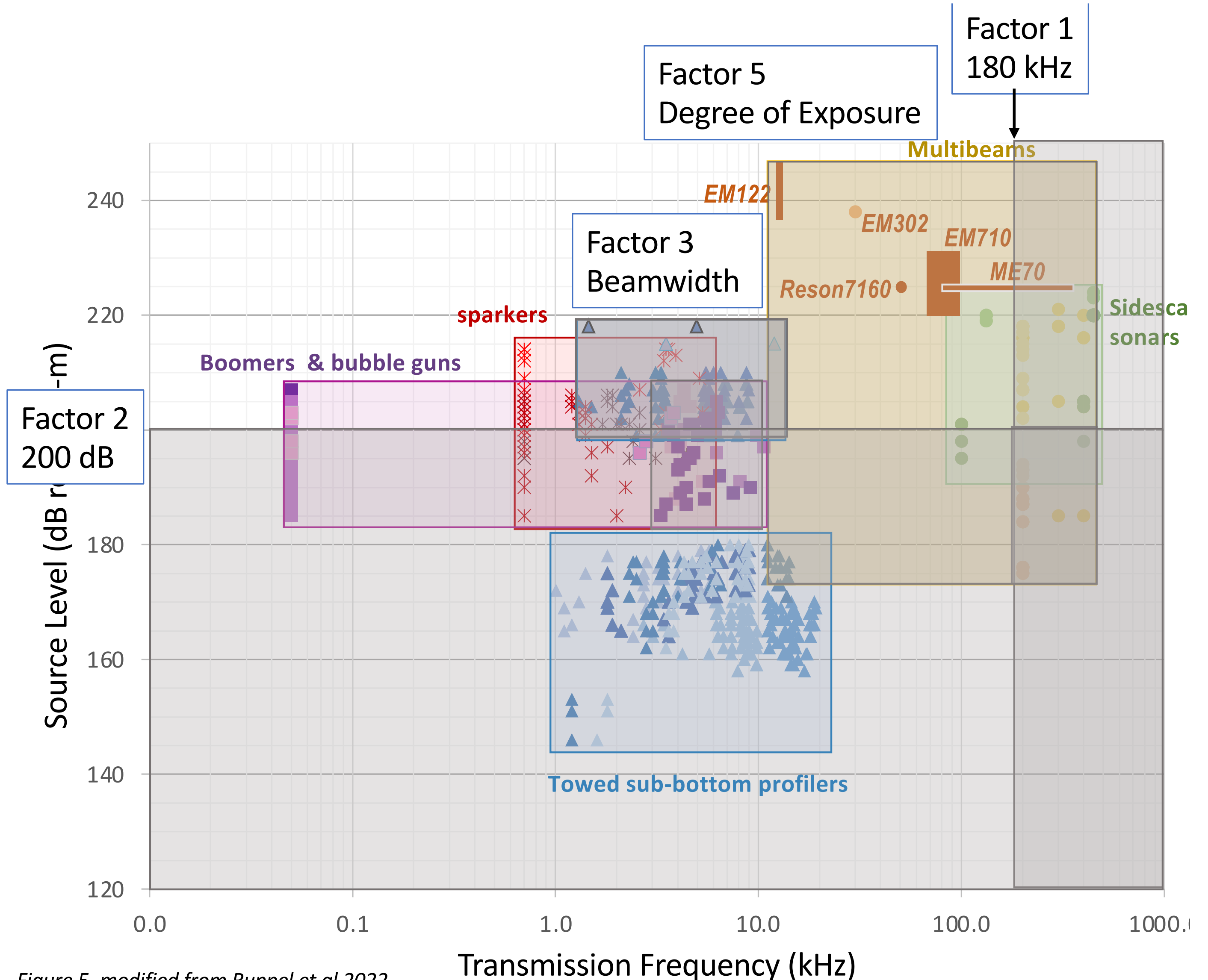


Figure 5, modified from Ruppel et al 2022

What is left, i.e. not *de minimis?*

- Higher-powered sparkers
- 1 and 2-plate boomers
- Bubble guns
- New sources not considered

<u>Other key points:</u>

- The higher-powered sources are typically used in *deeper* waters (not those typical for offshore wind)
- This analysis did not consider biological factors like auditory recovery time, aversion/avoidance, auditory integration time
- Also does not include mitigation

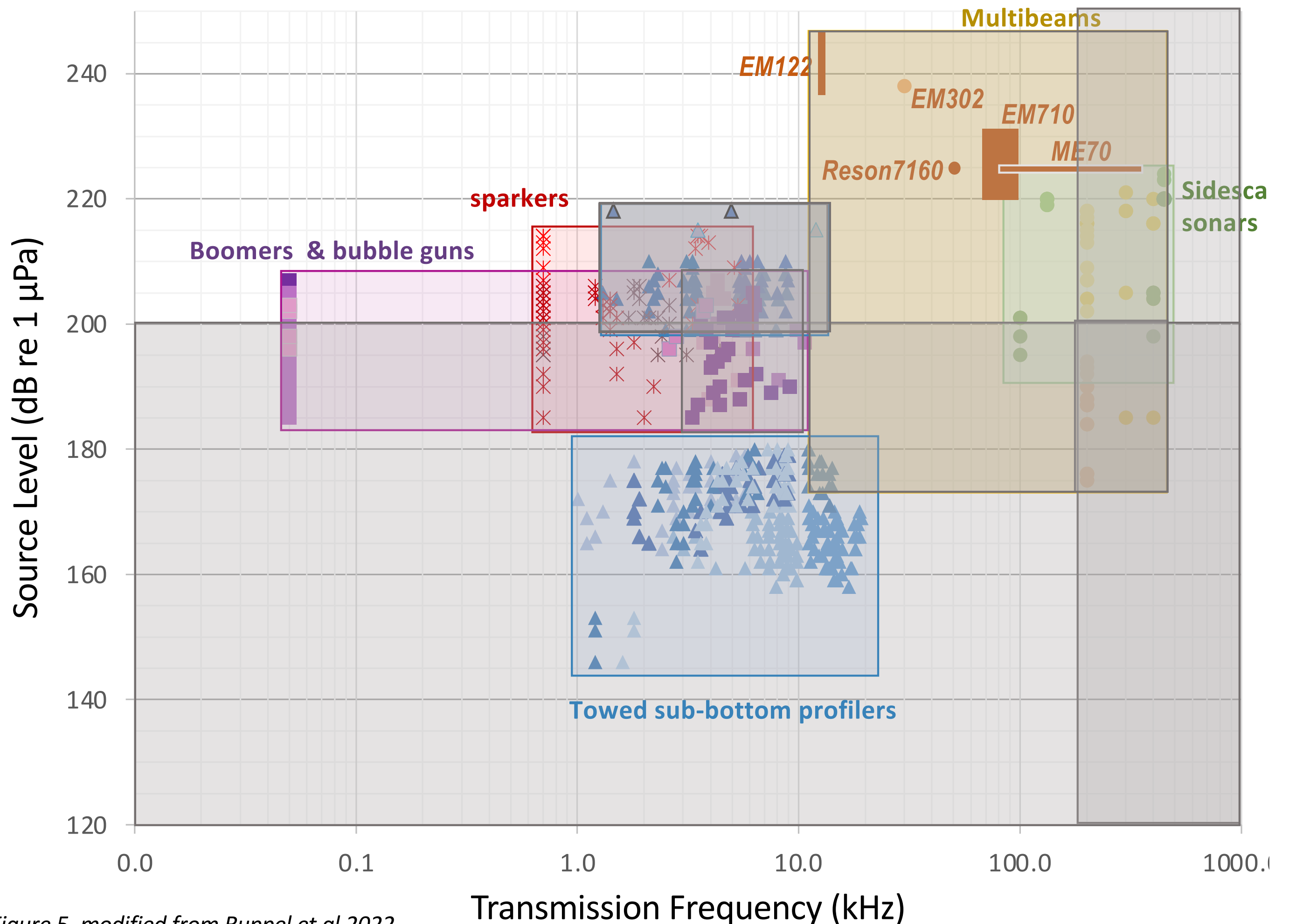


Figure 5, modified from Ruppel et al 2022

Tiering Framework *proposed* by Ruppel et al 2022

Tier 1: IHA required
- Airguns >1500 in^3

Tier 2: IHA required
- Airguns < 1500 in^3

Tier 3: No take with mitigation
- High-powered sparkers
- 1 and 2-plate boomers
- Some new sources may remain here until vetted
- ✓ 100m EZ except for NARW
- ✓ Shutdowns required
- ✓ PAM not required
- ✓ Nighttime ops allowed

Tier 4: *de minimis*
No IHA; no mitigation required
- Low-powered sparkers
- 3-plate boomers
- Bubble guns (most likely)
- Hull-mounted and towed SBP
- Split beam echosounders
- Multibeam echosounders
- Acoustic releases
- Fathometers
- Pingers
- ADCP
- USBL
- Instruments on AOVs, ROVs, etc.
- Any source operating above 180 kHz

This framework was proposed in the paper, but *current* mitigation requires mitigation for Tiers 3 and 4.

BOEM's overall assessment of HRG sources

- The information needed to assess the degree of impacts from these sources is sufficient.
- The current mitigations that are used for site assessment should be more than adequate.

- Current areas of focus for BOEM:
  - Multi-year regional monitoring of baleen whales using PAM and other methods
    - If change in distributions does occur, is it caused by offshore wind development *or other existing stressors*?
  - Impacts of substrate vibration/particle motion on fishes and invertebrates
  - Auditory recovery time for impulsive sounds
  - Noise abatement methods for impact pile-driving
  - Acoustic exposure tradeoffs of impact vs. vibratory pile-driving

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Ruppel et al. (2022): Characterizing active acoustic sources based on their potential to affect marine mammals. *Journal of Marine Science and Engineering* (10: 1278). **Open Access**

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