28 October 2020

Dr. Shannon Bettridge, Chief
Marine Mammal and Sea Turtle Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225

Dear Dr. Bettridge:

The Marine Mammal Commission (the Commission), in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the National Marine Fisheries Service's (NMFS) 31 August 2020 proposed rule (85 Fed. Reg. 53763) to implement section 101(a)(4)(A) and (B) of the Marine Mammal Protection Act (the MMPA), which authorizes deterrence of marine mammals in certain situations. The Commission also reviewed NMFS's draft environmental assessment (EA), web tool for certain acoustic devices, and factsheet. NMFS analyzed both acoustic and non-acoustic deterrent devices to inform whether a device would be approved or prohibited for deterring marine mammal species or stocks listed under the Endangered Species Act (ESA) and non-listed species or stocks. The Commission appreciates the effort involved in developing the proposed rule, draft EA, web tool, and factsheet and commends NMFS's efforts, particularly those of its acoustic expert for compiling and analyzing the various data used to inform the acoustic deterrent portions of those documents and to develop the web tool.

The Commission also appreciates that NMFS has included a section in the preamble to the proposed rule that strongly encourages fishermen, private property owners, and government officials to practice avoidance before deterrence (85 Fed. Reg. 53765). The Commission concurs with that guidance as well as the related guidance concerning factors to consider before attempting to deter a marine mammal, as described in the "General Guidelines" section of the preamble to the proposed rule (85 Fed. Reg. 53767).

Applicability and other necessary clarifications

NMFS, in its proposed guidelines for safely deterring marine mammals, has gone into considerable detail about the devices and techniques that can be used. However, it has offered little guidance, beyond reiterating the language in section 101(a)(4) of the MMPA itself, to explain who is authorized to engage in deterrence and in what situations.

Section 101(a)(4)(A) of the MMPA lists a range of people authorized to deter marine mammals, including an owner, employee, agent, bailee, and government employee. Some of these terms are fairly straightforward and likely require little or no additional explanation. For purposes of section 101(a)(4)(A)(i) and (ii), it is generally understood who is an owner of fishing gear or other private property. It is less clear when someone becomes the "owner" of fishing catch. It would be

helpful if NMFS clarified this point—e.g., is a fish "owned" once it is on someone's line or in someone's net, or must it be landed? Or, in the case of aquaculture, is a fish still owned by an operator if it has escaped from a pen or other enclosure? Similarly, the term "employee" has a common meaning that is generally understood and that probably requires little additional explanation. In contrast, whether someone qualifies as an "agent" or a "bailee" of an owner is less clear. As such, the Commission recommends that NMFS provide additional guidance on when someone becomes the owner of fishing catch, who qualifies as an agent or bailee, and how that status is conferred. For example, would someone who rents a boat for the day be considered an agent or bailee of the boat owner, and, if so, which?

Section 101(a)(4)(A)(iv) of the MMPA authorizes a "government employee" to deter a marine mammal from damaging public property. Unlike section 109(h)(1) of the MMPA, which confers similar authority to government officials or employees, that provision does not specify that the government employee must be acting "in the course of his or her [official] duties." Although, perhaps implied, the Commission recommends that NMFS clarify whether section 101(a)(4)(A)(iv) applies solely to government employees deterring marine mammals in their official capacity and within the jurisdiction(s) where they are authorized to carry out their official duties.

It also may not be readily apparent in every instance what constitutes private property or damage thereto. Presumably, private property refers solely to tangible property such as vessels, docks, and other structures, and damage refers to physical damage to that property. Guidance posted on the NMFS West Coast Region's website states that "The MMPA does not allow private citizens to deter marine mammals from undeveloped property (e.g., a beach) or public property (e.g., a breakwater)." Similar guidance should be included in the text of the final regulations or the preamble to the final rule. Moreover, that guidance should be expanded to provide a more detailed description of those situations when marine mammals can legally be deterred under the authority of section 101(a)(4)(A)(ii) of the MMPA. Specifically, the Commission recommends that NMFS clarify that such authority—

- applies to the taking of marine mammals by deterrence only in situations in which tangible personal property is being physically damaged or is at risk of physical damage absent use of deterrence measures;
- does not apply to actions to protect or prevent marine mammals from using undeveloped property (e.g., waterways, beaches, or other naturally occurring haul-out sites); and
- is predicated on actual or reasonably expected physical damage to the property and not mere inconvenience or temporary lack of access to the property (i.e., short-term denial of access to one's property because of the presence of a marine mammal should not be considered "damage" to that property).

Section 101(a)(4)(A)(iii) of the MMPA authorizes any person to deter a marine mammal from endangering personal safety. It makes sense that this authority would apply not just to the personal safety of the person engaged in the deterrence, but to the personal safety of others. However, the statute is ambiguous on this point and this rulemaking is a good opportunity for NMFS to clarify this matter. Also, NMFS should recognize that, in certain instances, personal safety is put at risk (thereby prompting the need for deterrence measures) because of the intentional or negligent actions of the individual(s) whose safety is jeopardized. The Commission therefore

recommends that NMFS clarify that, while individuals should still be allowed to deter marine mammals from endangering their own or someone else's personal safety, section 101(a)(4) of the MMPA does not insulate those individuals from responsibility and liability for any taking (e.g., closely approaching or otherwise harassing a marine mammal) that placed them in a risky position to begin with.

Authorities for deterring marine mammals in the context of commercial fishing are somewhat more complicated, because section 118 of the MMPA, as well as section 101(a)(4), may be applicable. This complexity is particularly true with respect to aquaculture, which is defined as a "commercial fishing operation" under applicable regulations (50 C.F.R. § 229.2). In turn, 50 C.F.R. § 229.3 defines "fishing" as including "(1) The catching, taking, or harvesting of fish; (2) The attempted catching, taking, or harvesting of fish; (3) Any other activity that can reasonably be expected to result in the catching, taking, or harvesting of fish; or (4) Any operations at sea in support of, or in preparation for, any activity described in paragraphs (1), (2), or (3) of this definition." Thus, deterring marine mammals from depredating catch or damaging gear, or even scaring marine mammals away from an area while transiting or in preparation for deploying gear, arguably fits within the regulatory definition of "fishing" (under either clause (3) or (4)) and could be construed as subject to the broader taking authorization provided under section 118.[1] On the other hand, section 118 applies only to the taking of marine mammals *incidental*[2] to commercial fishing operations, whereas section 101(a)(4) applies explicitly to directed (or intentional) taking. Given this uncertainty, the Commission recommends that NMFS provide additional guidance (1) as to whether measures intentionally directed at marine mammals to deter them from damaging gear or catch or to frighten them away from fishing grounds falls under section 118 at all or is governed entirely by section 101(a)(4)(A)(i) and (2) clarifying whether deterrence measures beyond those authorized under section 101(a)(4) are authorized under section 118 and, if so, what such measures would be.

NMFS, through proposed amendments to sections 229.4 and 229.5 of its MMPA implementing regulations, has partially finessed the need to address this issue. Those amendments would require commercial fisheries to comply with any prohibitions set forth in section 216.115 of the deterrence regulations. This being the case, fishermen cannot claim that section 118 allows them to use deterrence measures that have the potential to kill or seriously injure marine mammals. The Commission supports these proposed amendments and recommends that they be retained in the final rule. In contrast to how prohibitions are addressed, the proposed amendments to Part 229 only "encourage" persons engaged in commercial fisheries to follow other guidelines and recommendations for acceptable deterrence measures. As such, it remains unclear whether fishermen who do not follow the measures set forth in section 216 would be liable for any resulting serious injury or death of a marine mammal that results from deterrence activities or whether they would have additional authority for such taking under section 118. The Commission recommends that NMFS clarify this point.

[1] Although section 118 does not authorize intentional lethal taking, unlike section 101(a)(4), it does authorize incidental taking that could result in the death or serious injury of a marine mammal. Also, section 118, as interpreted by NMFS's implementing regulations, arguably applies to deterrence to protect future or prospective catch, whereas section 101(a)(4) does not.

[2] The term "incidental" is defined at 50 C.F.R. § 229.3 to mean "with respect to an act, a *non-intentional* or *accidental* act that results from, but is not the purpose of, carrying out an otherwise lawful action (emphasis added).

Unlike most other commercial fishing operations, aquaculture facilities are generally stationary and relatively permanent. As such, aquaculture operations have greater flexibility in selecting designs and materials for their enclosures capable of excluding marine mammals, thereby reducing or potentially eliminating the need to use deterrent devices to protect fish[3] within the enclosures from depredation. As NMFS and other agencies move forward with plans for expanding aquaculture in U.S. waters, the Commission encourages them to establish siting and construction requirements that consider and minimize impacts on marine mammals and that reduce the need for deterrence. More specific to this rulemaking, the Commission recommends that NMFS clarify whether aquaculture facilities are considered "fishing gear" and the products "catch" for purposes of MMPA section 101(a)(4)(A)(i), or instead are considered "private property" and covered by section 101(a)(4)(A)(ii).

Acoustic deterrents

References for source levels and other parameters—NMFS omitted from the draft EA the relevant references associated with the source levels, signal durations, and duty cycles for the more than 120 acoustic deterrent devices[4] it analyzed (see Tables B.1–3). This is inconsistent with NMFS's practice of including such information in other rulemakings and authorizations involving acoustic sources (e.g., see Table 5 at 84 Fed. Reg. 31004, Table 2 at 84 Fed. Reg. 36057). The lack of associated references made it difficult for the Commission, and presumably the public, to crosscheck the various parameters that NMFS used. The Commission was able to find some of the information regarding non-impulsive devices in McGarry et al. (2020) and informally provided NMFS with a list of typographical and other errors associated with Appendix B in the draft EA. That list is included in Addendum I, along with some additional minor issues the Commission noted in the preamble to the proposed rule, the proposed regulations, the draft EA, and NMFS's factsheet. NMFS should have included all associated references to provide transparency and aid the public in its review of the proposed rule. For completeness, NMFS should include them in the final EA. The Commission recommends that NMFS include all relevant references for source levels, signal durations, and duty cycles in Tables B.1–3 of the final EA.

Exposure time and number of devices deployed—NMFS's evaluation criteria for determining whether the various acoustic devices should be approved are based on its Level A harassment thresholds for onset of permanent threshold shift (PTS; NMFS 2018) and whether a deterrent has the potential to result in PTS at a distance greater than 100 m[5] after an hour of exposure (85 Fed. Reg. 53766). NMFS indicated that its analysis used twice the duration used by McGarry et al. (2020) in their simulations (i.e., 30 minutes) to account for the potential that multiple exposures could occur within a day (85 Fed. Reg. 53766). McGarry et al. (2020) modeled potential auditory impacts from non-impulsive, underwater acoustic deterrent devices, similar to and the same as some of the devices included in Table B.3 of the draft EA. Based on NMFS's evaluation criteria and the operational characteristics of the devices, many of the non-impulsive deterrent devices would exceed the PTS thresholds. As such, NMFS indicated that only those devices with source levels up to 170 dB re 1

[3] The term "fish" includes "any marine finfish, mollusk, crustacean, or other form of marine life other than marine mammals, reptiles, and birds" (50 C.F.R. § 216.3).
[4] Except for seal bombs.
[5] Justification for this metric is detailed in the *Federal Register* notice.

$\mu Pa_{root\ mean\ square\ (rms)}$ at 1 m and with a maximum duty cycle of 54 percent[6] met the evaluation criteria[7] (85 Fed. Reg. 53766). To assist the public in determining whether a device would meet its evaluation criteria, NMFS developed a web tool for non-impulsive underwater devices[8]. The Commission commends NMFS for developing the web tool, which is easy and straightforward to use and provides quick and explicit information regarding whether a device meets NMFS's evaluation criteria. However, NMFS did not specify in either the proposed regulations or the preamble to the proposed rule whether a deterrent device could be used for longer than one hour in a given day.

Many non-impulsive (e.g., pingers) and impulsive, non-explosive (e.g., low-frequency (LF) broadband devices and pulsed power devices)[9] underwater devices are used for longer than one hour, as they are turned on and left on until they are not needed any longer or until fishing has concluded for the day. Some devices also are deployed in pairs or multiples in a given area to deter marine mammals, particularly along fishing nets and aquaculture pens. NMFS routinely recommends a 24-hour accumulation time (or less, if the sound source would be operational for less time (e.g., 8 hours)) when estimating the range to its PTS thresholds (e.g., see Table 4 at 85 Fed. Reg. 36553). For those devices that could be active for longer than one hour *or* for devices that are deployed in pairs or multiples in a given area, it is unclear why NMFS did not apply its recommended 24-hour (or less) accumulation time consistently. These issues would apply to in-air non-impulsive and impulsive, non-explosive devices as well, but to a lesser degree, because those devices generally are not turned on and left on, continually activated, or deployed in multiples in a given area. The Commission recommends that NMFS (1) clarify whether non-impulsive and impulsive, non-explosive devices would be approved for use for more than one hour per day *or* in pairs or multiples in a given area, (2) if not, specify explicitly in the final regulations and the final factsheet that their use for more than one hour per day or when deployed as multiples is prohibited, and (3) if so, explain in the preamble to the final rule and final EA why it did not implement its own 24-hour accumulation time (or less, if a device is operational for only a portion of the day) and how it would ensure that PTS is minimized as intended by its evaluation criteria. An additional point to note, NMFS did not address whether repeated instances of temporary threshold shift (TTS) could lead to PTS, as it has in other proposed rules (e.g., 83 Fed. Reg. 10996, 83 Fed. Reg. 29914). It should do so in the preamble to the final rule.

For impulsive, explosive deterrents, NMFS's evaluation criteria would allow the majority of the devices to be deployed every 3 to approximately 5.5 minutes[10] in the assumed 1-hour timeframe (see Table B.1 in the draft EA). More than 20 seal bombs or 11 cracker shells may need to be deployed on a given day to deter persistent pinnipeds. For example, Simonis et al. (2020) indicated that up to 88 seal bombs detonated per hour and 335 detonated per day in Monterey Bay based on

[6] NMFS indicated that the duty cycle would equate to sound being produced for less than 32 minutes during the given 1-hour timeframe. The Commission notes that a 54-percent duty cycle would equate to sound being produced for 32.4 minutes, which would be less than 33 minutes.
[7] The Commission notes that 30 percent of the non-impulsive devices analyzed by NMFS in Table B.3 of the draft EA did not meet those criteria.
[8] https://jmlondon.shinyapps.io/NMFSAcousticDeterrentWebTool/.
[9] NMFS's evaluation criteria would allow for the majority of the impulsive, non-explosive devices to be deployed or activated every 30 seconds to 20 minutes (see Table B.2 in the draft EA).
[10] The Commission notes that Table 4 in the *Federal Register* notice indicated that the silent interval for cracker shells was 6 minutes, which would allow for only 10 rather than 11 cracker shells to be deployed in the 1-hour timeframe. This discrepancy needs to be resolved in the preamble to the final rule and final EA.

data from Ryan (2019). Deploying more than the approved number of deterrents in response to the same persistent pinniped(s) could inadvertently cause PTS, particularly if the same animals occur near the fishing gear throughout the day. Further, impulsive, explosive devices are more injurious and detrimental to the animals than the other types of devices. As such, NMFS must be explicit regarding whether more than 20 seal bombs or 11 cracker shells can be deployed at the same target animals on a given day, while abiding by the minimum distances specified in Table 4 of the *Federal Register* notice. The Commission recommends that NMFS (1) specify whether more than 20 seal bombs or 11 cracker shells[11] can be deployed in response to the same target animals on a given day, (2) if not, specify explicitly in the final regulations and the final factsheet that deploying more than 20 seal bombs or 11 cracker shells[11] on any given day is prohibited, and (3) if so, increase the minimum distances at which such devices can be deployed to account for the additional deployments in the 24-hour timeframe in the preamble to the final rule, the final regulations, and the final EA. If NMFS intended to round up[12] the silent interval of cracker shells[13], it should implement the same approach for *all* impulsive, explosive and non-explosive devices not just for cracker shells.

Minimum distances for otariids—NMFS used its current Level A harassment thresholds for underwater devices (NMFS 2018) to estimate the minimum distance at which each type of acoustic deterrent would need to be deployed to avoid inadvertently inducing PTS in the target animal (Tables 4–7 of the *Federal Register* notice)[14]. Those distances may be appropriate for LF, mid-frequency (MF), and high-frequency (HF) cetaceans and phocids, but may be underestimated for otariids. NMFS's Level A harassment thresholds were based on TTS measurements of a single California sea lion exposed to octave-band sound centered at 2.5 kHz (Kastak et al. 2005)[15]—those data informed both the non-impulsive *and* impulsive thresholds[16] for otariids (NMFS 2018). Given the very limited TTS data available for otariids, the U.S. Navy's Living Marine Resources (LMR) program has funded Dr. Ron Kastelein to investigate frequency-dependent, underwater TTS in California sea lions[17]. Dr. Kastelein's preliminary, unpublished data would be useful to confirm whether NMFS's current Level A harassment thresholds are consistent with, or underestimated by, his recent data. Differences in the thresholds may not be considered crucial for Navy rulemakings that involve incidental rather than directed taking of pinnipeds, particularly since the Navy updates its criteria and thresholds every five to seven years. However, if the otariid thresholds have been underestimated, their use in the deterrence guidelines would have more profound consequences.

NMFS's deterrence guidelines are intended to be a resource for the public to use for safely deterring marine mammals. If NMFS's Level A harassment thresholds have been underestimated for otariids, the proposed minimum distances would not minimize the potential for PTS and could

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[11] Or 10 cracker shells if NMFS intended the silent interval to be 6 minutes rather than 320 seconds.
[12] Rather than the 6-minute silent interval being an error in Table 4 of the *Federal Register* notice.
[13] Either to the next minute, as NMFS appears to have done for cracker shells, or to the next half minute (e.g., 18 seconds for banging objects underwater would be rounded to 30 seconds).
[14] NMFS also considered the ranges at which slight lung and gastrointestinal (GI) tract injury could occur for explosives (see Appendix B in the draft EA).
[15] NMFS did not include the Navy's in-air thresholds described in U.S. Navy (2017) in NMFS (2018). However, NMFS used the Navy's in-air thresholds (U.S. Navy 2017) for its deterrence guidelines (see Appendix B in the draft EA). Similar to the underwater TTS thresholds, the in-air thresholds for otariids were based on TTS measurements of a single California sea lion exposed to octave-band sound centered at 2.5 kHz (Kastak et al. 2007).
[16] Among other assumptions.
[17] https://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/lmr/LMRNewsSpring2020v2.pdf.

inadvertently induce PTS. In addition, if Dr. Kastelein's data indicate that the thresholds for otariids are more similar to those for phocids, NMFS would have underestimated the minimum distances by an order of magnitude for many of the scenarios it evaluated (see Table 4–7 in the *Federal Register* notice), including for the use of seal bombs in Table 4. Furthermore, this is the first time that NMFS has proposed to issue guidelines under section 101(a)(4)(B) of the MMPA since its enactment in 1994. As such, the guidelines likely will not be updated for quite some time. It therefore is imperative that the guidelines fulfill the MMPA's directive and NMFS's stated purpose, which in this specific case, is to minimize the potential for PTS. Toward that end, the Commission recommends that NMFS (1) consult with Dr. Kastelein and determine whether his recent data indicate that the Level A harassment thresholds from NMFS (2018) have been underestimated for otariids and (2) if so, apply the Level A harassment thresholds for phocids to both phocids and otariids until the Level A harassment thresholds for otariids have been updated and base the minimum distances for all pinnipeds on the Level A harassment thresholds for phocids. The Commission further recommends that, if the in-water Level A harassment thresholds have been underestimated for otariids, NMFS (1) assume that the in-air Level A harassment thresholds have been as well and (2) apply the in-air Level A harassment thresholds for phocids to both phocids and otariids and base the minimum distances for all pinnipeds on the in-air Level A harassment thresholds for phocids.

Seal bombs—NMFS used source level data obtained by Wiggins et al. (2019) and spherical spreading (20logR) to estimate the minimum distances for deploying seal bombs near phocids and otariids—NMFS used practical spreading (15logR) for all other devices[18]. Spherical spreading is supported by the data in Wiggins et al. (2019). However, while their measurements were made in water depths of 635–870 m, NMFS's deterrence guidelines would be applicable in all water depths. Research has shown that spherical spreading is not appropriate and is more complex for shallow-water depths (200 m or less; Kuperman and Lynch 2004) and would result in overestimated transmission loss and underestimated minimum distances. Thus, NMFS's proposed minimum distances would not minimize the potential for PTS when seal bombs are deployed in shallow water.

It is unlikely that NMFS would fund researchers to conduct in-situ measurements in shallow-water depths. Therefore, modeling is necessary to determine the water depth at which transmission loss is no longer accurately explained by spherical spreading. The member of the Commission's Committee of Scientific Advisors with expertise in underwater acoustics and propagation loss modeling conducted multiple simulations showing that 20logR is not appropriate in various water depths (see Figures 1–3 in Addendum II). The figures are based on the normal-mode model, KRAKEN[19], and various assumptions[20]. It is evident that, for water depths ranging from 50 m to nearly 150 m, the propagation loss coefficients would be less than 20logR at the various receiver depths and frequencies[21]. As such, NMFS has underestimated the minimum distances at

[18] Both impulsive and non-impulsive.
[19] The ray-tracing model, BELLHOP, provided similar results.
[20] For Figures 1–3, the assumptions included a maximum detonation depth of 4 m (Myrick et al. 1990 as cited in Wiggins et al. 2019), sand substrate (with a bottom speed of 1650 m/sec, density of 1.9 g/cm^3, and a wavelength attenuation of 0.8 dB/km), a constant sound speed profile of 1500 m/sec, and varying water depths of 50 m, 100 m, and 150 m. Incoherent transmission loss also was assumed. These either typical or worst-case scenario assumptions are consistent with NMFS's analysis approach depicted in Appendix B of the draft EA.
[21] In this situation where the majority of the sound emitted is very LF sound (< 500 Hz) and the range to target and non-target species is less than 150 m, spherical spreading generally is appropriate at lateral ranges that are less than one water depth. That is, it is appropriate to use spherical spreading in water depths of 300 m if the lateral range of interest

which pinnipeds would not incur PTS if 20 seal bombs are detonated within one hour. The Commission recommends that NMFS re-estimate the minimum distances for deploying seal bombs by using a simple propagation loss model that explicitly incorporates the effect of water depth, where propagation loss is (1) 20log(D)+15log(R/D), when the range (R) > the water depth (D) and (2) 20log(R), when R < D. If NMFS is unable to incorporate such an equation into its user spreadsheet to determine the relevant Level A harassment zones, then the Commission recommends that NMFS use practical spreading for water depths of 150 m or less to re-estimate the minimum distances for deploying seal bombs based on the results provided herein. Had NMFS assumed practical spreading, the minimum distance for deployment of seal bombs would have been 53 m rather than 20 m, which, as the Commission has recommended herein, should apply to both phocids and otariids.

The Commission also notes that the Level A harassment zone for LF and HF cetaceans would exceed 100 m if practical spreading is used. However, NMFS can reduce the number of seal bombs approved for use to ensure that the Level A harassment zone for LF cetaceans would not exceed 100 m, as the extent of the zone is dependent on the cumulative sound exposure level threshold and the number of bombs detonated. The range to Level A harassment for HF cetaceans is based on the peak sound pressure level (SPL_{peak}) threshold and is not dependent on the number of seal bombs deployed. The range to Level A harassment based on SPL_{peak} for HF cetaceans is 136 m, which would still provide a very high probability of detecting the animal(s) based on Roberts et al. (2016; see Figure 10[22]). Furthermore, harbor porpoises generally do not occur close to or actively approach vessels. As such, NMFS should not favor protecting non-target species that are unlikely to occur in close proximity to the activities in lieu of using a more appropriate propagation loss factor and minimum deployment distances for target pinnipeds.

Impulsive, non-explosive devices—NMFS specified in the footnote associated with Table 6 of the *Federal Register* notice that a blank cell indicates that the particular deterrent is not included in the guidelines or specific measures for the taxon (85 Fed. Reg. 53771). It is unclear whether that means that the various impulsive, non-explosive devices could be used for those functional hearing groups for which the cell was left blank or whether use of the devices would be prohibited. NMFS included a similar footnote[23] in Table 8 that included specific measures for deterring ESA-listed species (85 Fed. Reg. 53771–53772). That second footnote also did not specify whether use of devices for the various ESA-listed species was in fact prohibited. Guidance documentation should provide explicit information regarding whether a device is approved or prohibited for use, similar to the prohibitions NMFS listed in Table 9 of the *Federal Register* notice (85 Fed. Reg. 53773), the proposed regulations, and the factsheet. The Commission recommends that NMFS explicitly state whether blank cells in the relevant tables of the preamble to the final rule denote devices that are prohibited from use and, if so, include those prohibitions accordingly in the final regulations and the final factsheet.

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is 200 m. If the water depth is 50 m and the lateral range of interest is 100 m, then practical spreading is not appropriate. The Commission further notes that the propagation loss coefficients for lateral ranges of interest of 1 km and 10 km are much less than those depicted in Addendum II—many are less than practical spreading and approach cylindrical spreading (10logR).

[22] Figure 10 denotes that the probability of detection with the naked eye at 100 and 150 m is comparable.

[23] Blank cells indicate that those deterrents are not included as specific measures. NMFS specified the same footnotes in its acoustic deterrence guideline tables for ESA-listed cetaceans and pinnipeds in its factsheet.

Exemptions for ESA-listed cetacean species—NMFS proposed to approve banging objects underwater and use of non-impulsive underwater devices to deter Southern Resident killer whales (SRKWs) but not Cook Inlet beluga whales (CIBWs) or Main Hawaiian Islands insular false killer whales (MHI FKWs). Although NMFS did not explain its rationale for proposing to approve the various devices for any of the ESA-listed species, either in the preamble to the proposed rule or draft EA, it is apparent that the agency believes that such devices should not be used for CIBWs and MHI FKWs. Given that all three stocks are MF cetaceans with similar hearing capabilities and are all critically endangered, none of the aforementioned devices should be approved. This is particularly true for SRKWs that number only 75 individuals—the fewest of the three stocks in question. The Commission recommends that NMFS not approve banging objects underwater or the use of non-impulsive underwater devices to deter SRKWs, CIBWs, or MHI FKWs in the preamble to the final rule, the final regulations, the final EA, and the final factsheet.

Airhorns—In Table 1 of the *Federal Register* notice and all subsequent tables, NMFS characterized an airhorn as a non-impulsive device. Airhorns are pneumatic devices that emit sound using compressed air. As such, they are considered impulsive, non-explosive devices similar to the other devices[24] that NMFS indicated emit broadband sound with a rapid rise time and decay (see, for example, Wright et al. 2010). The Pacific Island Fisheries Science Center (PIFSC) accurately characterized an airhorn as an impulsive device in Appendix L of its recent scientific research permit application[25] that involved the use of in-air and underwater devices to deter Hawaiian monk seals. Assuming an airhorn is impulsive rather than non-impulsive and using NMFS's source level of 129 dB re 20 Pa_{rms} at 1 m from Appendix B of the draft EA, the minimum distance would increase from 4 m to 22 m for phocids[26] (see Table 7 in the *Federal Register* notice). The Commission recommends that NMFS (1) characterize an airhorn as an impulsive, non-explosive device and (2) revise the minimum distances for pinnipeds using its impulsive thresholds and update the relevant tables and text of the preamble to the final rule, the final regulations, the final EA, and the final factsheet[27] accordingly.

Banging objects in air—In its analysis, NMFS assumed that the in-air source level for banging objects was 113 dB re 20 μPa_{rms} at 1 m, which the Commission understands was based on a cowbell. However, PIFSC used a source level of 165 dB re 20 $\mu Pa_{peak\text{-}to\text{-}peak}$ at 1 m for banging pipes based on in-situ measurements made by the University of Hawaii (UH; see Appendix L of PIFSC's permit application). It is unclear whether UH used a sound level meter on the impulse setting[28] to conduct the in-air measurements of banging pipes or whether the measurements were in fact peak-to-peak measurements. If the former, then the source level is not a peak-to-peak source level as reported by PIFSC and is in fact indicative of a SPL_{rms} source level. If the latter, then the SPL_{rms} source level would be less than the peak-to-peak source level reported. For a sine wave, the difference between a $SPL_{peak\text{-}to\text{-}peak}$ and SPL_{rms} source level is 9 dB. For impulsive devices, such as banging pipes, the difference would be less than 9 dB. In any case, the source level for banging pipes would be at least 156 to 165 dB re 20 μPa_{rms} at 1 m, which is much greater than either the 133-dB re 20 μPa_{rms} at 1 m source level assumed by NMFS for banging objects or NMFS's 142-dB re 20 μPa_{rms} at 1 m acoustic

[24] i.e., banging objects (e.g., Oikomi pipes), LF broadband devices, and pulsed power devices.
[25] Permit number 22677.
[26] The minimum distance would remain at 2 m for otariids if NMFS continues to use the otariid-specific thresholds.
[27] Including the cartoon depictions of airhorns under the non-impulsive category of the factsheet.
[28] Based on a 35-msec averaging window.

evaluation criterion for impulsive airborne devices (85 Fed. Reg. 53767). Thus, NMFS's proposed minimum distances would not minimize the potential for PTS. This is particularly important when deterring ESA-listed pinnipeds, including Hawaiian monk seals. The Commission recommends that NMFS either (1) clarify the metric measured by UH and use the 165-dB re 20 μPa at 1 m source level to re-estimate the minimum distances for pinnipeds or, (2) if it believes that the source level reported by UH is erroneous, work with UH to conduct additional in-situ, in-air measurements of banging pipes and re-estimate the minimum distances accordingly.

NMFS evaluated devices with source levels only up to 142 dB re 20 μPa at 1 m. Since UH's measurements indicate in-air source levels exceed that criterion and other devices could exceed it in the future, NMFS should develop a web tool for assessing impulsive in-air devices similar to its web tool for non-impulsive underwater devices. This would assist the public in determining whether a device meets NMFS's evaluation criteria. The Commission recommends that NMFS develop a web tool for impulsive in-air devices similar to the one it developed for non-impulsive underwater devices.

Non-acoustic deterrents

Projectiles and pinnipeds—NMFS specifically requested input on whether it should allow the use of only low-impact (i.e., 0.5 caliber) paintballs or both low- and higher-impact (i.e., 0.68 caliber) paintballs to deter pinnipeds (85 Fed. Reg. 53773). While the proposed rule includes prohibitions on targeting and hitting the heads of pinnipeds with projectiles, there is still a risk that errant projectiles could do so. Although both calibers of paintballs were deemed "safe" for use on pinnipeds, that assessment relied on experience with paintball use by human children who were likely wearing head and eye protection and was likely based on contact with skin away from the vulnerable head and eye region. To minimize the risk of injury should the head or eye be struck, the Commission recommends that NMFS allow only "low-impact" (0.5 caliber) paintballs to be used to deter pinnipeds. Setting the caliber of paintballs appropriate for safely deterring pinnipeds is a clear instance where NMFS should err on the side of caution. It would be wise to allow only low-impact paintballs initially and, if they prove ineffective as a deterrent, consider increasing the allowable caliber, but only if additional research shows that higher-impact paintballs are safe. Further, the Commission recommends that NMFS, in the preamble to the final rule, discourage the use of projectiles, other than foam missiles from a toy gun, to deter pinnipeds in the water. More often than not, only their heads would be above water, thus increasing the risk that a pinniped would be struck in the head.

Projectiles and Hawaiian monk seals—NMFS also requested input on whether the use of paintballs and sponge grenades should be allowed to deter endangered Hawaiian monk seals. For Hawaiian monk seals, the Commission anticipates that situations warranting the use of deterrents to prevent property damage will occur primarily when the seals are hauled out. In that case, the Commission notes that the use of tactile manual deterrents[29] are viable options and likely the safest for both humans and the seals. Cases prompting deterrence of monk seals in the water are most likely to arise around the main Hawaiian Islands and involve recreational fishermen. This being the case, clarifying when fish become "catch" (as recommended above) and non-lethal deterrence is allowed will be particularly important for monk seals. Moreover, given the status of the Hawaiian monk seal, where each individual is vital to the survival and recovery of the species, the use of deterrence techniques

[29] Crowder boards, blunt-tip poles, brooms, mop handles, etc.

that have the potential to injure the eyes[30] of animals, including paintballs and sponge grenades, pose an unacceptable risk. Therefore, the Commission recommends that NMFS not approve the use of paintballs and sponge grenades to deter Hawaiian monk seals in the final rule. Further, the Commission notes the discussion in the draft EA about the need for measures to deter aggressive monk seals safely in situations that put the personal safety of swimmers and divers at risk. The Commission concurs with NMFS's suggestion that the use of the butt of a spear gun or another blunt object should be permissible in those situations.

Mitigation, monitoring, and reporting requirements

Pre-activity monitoring—NMFS proposed to require users of deterrents to conduct visual scans in all directions for cetaceans out to 100 m before using impulsive[31] underwater devices and to conduct additional scans in all directions before each subsequent deployment (85 Fed. Reg. 53370)[32]. However, it did not specify a duration for such scans. NMFS routinely requires action proponents seeking incidental taking authorizations under section 101(a)(5) of the MMPA to implement a 15-minute clearance time for small and medium-sized cetaceans and pinnipeds. That timeframe is based on the dive times of those animals[33]. To help ensure that cetaceans are not within the 100-m clearance zone, the Commission recommends that NMFS specify in the final regulations and final EA that users must scan the water in all directions for *at least* 15 minutes (1) before deploying the first impulsive underwater device, (2) in the event that detonations or acoustic transmissions are paused for longer than 30 minutes, and (3) before deploying the first impulsive underwater device in a new location on a given day. All mitigation requirements also need to be included in the final factsheet.

Reporting requirements—The proposed rule would require anyone other than a commercial fisherman to report certain information when a mortality or serious injury occurs in the course of deterring a marine mammal. Specifically, NMFS would require the user[34] to include in the report a description of the deterrent used (including the number of attempts/deployments), specifications of the devices used, and any other relevant characteristics (85 Fed. Reg. 53772 and section 216.116(a)(4) of the proposed regulations). Those reporting requirements are vague and incomplete, especially for acoustic deterrent devices. NMFS is basing its acoustic deterrent evaluation criteria and minimum distances on the silent intervals, distances between the device and the animal being deterred, and the number of deployments. To evaluate whether NMFS's deterrence guidelines are fulfilling their intended objectives, which in this case is avoiding or minimizing the risk of PTS, all relevant data should be reported. That is, if the users are abiding by NMFS's minimum distances and silent intervals but mortalities or serious injuries are nevertheless occurring, then NMFS should immediately reassess its guidelines and revise them, as necessary, to avoid additional mortalities or serious injuries. The Commission recommends that NMFS include in section 216.116(a) of the final regulations a requirement that users report the number of device deployments, the silent intervals

[30] Eye injuries also may decrease the effectiveness of any of the visual deterrents
[31] Both explosive and non-explosive devices.
[32] Similar requirements were included in the draft EA.
[33] NMFS also routinely uses a clearance time of 30 minutes for mysticetes, sperm whales, beaked whales, Risso's dolphins, pilot whales, false killer whales, and dwarf and pygmy sperm whales (see, for example, 85 Fed. Reg. 19624).
[34] Except for commercial fishing vessel owners and operators, who are subject to other reporting requirements under section 118 of the MMPA and its implementing regulations.

between each deployment, and the minimum distance to the animal during each deployment when a mortality or serious injury occurs during or subsequent to the use of an acoustic deterrent.

NMFS also indicated that it would integrate the reporting of deterrent-related mortalities and injuries caused by commercial fishermen with the existing reporting requirements under section 118(e) of the MMPA and revise the existing form (Office of Management and Budget (OMB) number 0648–0292) to require that additional information be reported when marine mammal deterrents are being used, when the form is next reviewed under the Paperwork Reduction Act (85 Fed. Reg. 53772). NMFS last requested comments on the referenced information collection at the end of 2018 (83 Fed. Reg. 54916) and submitted the then-currently-approved information collection to OMB sometime after April 2019 (84 Fed. Reg. 10796). As such, NMFS would not normally renew or revise its form until the end of 2021, and commercial fishermen would not be subject to any new reporting requirements until mid-2022. Given that commercial fishermen likely will constitute the largest group of users of marine mammal deterrents, they should be subject to the reporting requirements established under the final rule once effective. The Commission recommends that NMFS (1) not wait until the next mandatory review of form OMB 0648-0292 but revise it contemporaneously with issuing the final rule and (2) require commercial fishing vessel owners and operators to report the same information as other deterrent users. That is, commercial fishing vessel owners and operators should be required to report the information currently specified in section 216.116(a) of the proposed regulations, as well as the number of device deployments, the silent intervals between each deployment, and the minimum distance to the animal during each deployment when a mortality or serious injury occurs during or subsequent to use of an acoustic deterrent as recommended herein.

The Commission hopes its comments and recommendations are helpful. Please contact me if you have questions regarding the Commission's recommendations.

Sincerely,

Peter O. Thomas, Ph.D.,
Executive Director

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Addendum I

The Commission noted the following minor typos, omissions, or errors in the preamble to the proposed rule, the proposed regulations, the draft EA, and NMFS's factsheet. Those include—

- NMFS indicated that all underwater devices with source levels up to 170 dB re 1 μPa_{rms}[35] and with a maximum 54 percent duty cycle met its evaluation criteria (85 Fed. Reg. 53766). That statement applies only to non-impulsive devices, not all devices, and should be revised in the preamble to the final rule.
- NMFS indicated that waterguns could be used in Tables 1, 2, and 8 of *Federal Register* notice. NMFS should clarify in the preamble to the final rule, the final regulations, the final EA, and the final factsheet that waterguns are intended to be "toy waterguns"[36] and not those considered seismic waterguns (e.g., see Finneran et al. 2002).
- NMFS used various terms to describe the devices used to deploy paintballs (e.g., air rifles, paintball guns) and sponge grenades (e.g., airguns, airsoft guns, hand-held launchers) in the text and tables of the preamble to the proposed rule, the proposed regulations, the draft EA, and the factsheet. NMFS should use the same term throughout all documents to clarify that paintballs deployed using paintball guns and sponge grenades deployed using hand-held launchers would be the devices approved for use in the preamble to the final rule, the final regulations, the final EA, and the final factsheet.
- Table 5 of the *Federal Register* notice—
    - NMFS did not specify the minimum silent intervals between deployments in Table 5, as it did in Tables 4 and 6 of the *Federal Register* notice and in Table B.1 of the draft EA. NMFS should include those specifics in the associated table in the preamble to the final rule.
    - NMFS did not include sponge grenades or paintballs[37] in Table 5, as it did in Table 6 of the draft EA. NMFS should include those devices in the associated table in the preamble to the final rule.
- NMFS indicated that, for airborne impulsive, explosive devices, users must aim the device in the air above the animal and abide by the required minimum distances in Table 5 of the *Federal Register* notice. NMFS should clarify that the minimum distances apply to all areas around the animal (e.g., lateral distance, slant distance, and altitude) in the preamble to the final rule and the final regulations.
- NMFS omitted the prohibitions for use of crossbows, bows, and spear guns for deterring pinnipeds from Table 9 in the preamble to the proposed rule, Table 8 in the draft EA, and the factsheet. NMFS should clearly include those prohibitions for pinnipeds in the preamble to the final rule, the final EA, and the final factsheet, consistent with Table 22 in the draft EA and the proposed regulations (section 216.115(k)).
- NMFS omitted from the proposed regulations (sections 216.113(d)(2), 216.114(d)(1), and 216.114(d)(2)) the specific implementation requirements for the use of certain physical barriers with pinnipeds. NMFS should include those requirements as stated in the draft EA that "…rigid fencing in air, horizontal bars/bull rails, and gates or closely spaced poles used

[35] All source levels specified in the Addendum are referenced to 1 m.
[36] Similar to foam projectiles launched with toy guns.
[37] For which air rifles were used as a proxy.

to deter pinnipeds must be constructed, installed, and maintained in such a manner as to ensure spacing, height, and/or width would not result in the entrapment or entanglement" in sections 216.113(d)(2), 216.114(d)(1), and 216.114(d)(2) of the final regulations for non-ESA-listed pinnipeds, Hawaiian monk seals, and the western Distinct Population Segment of Steller sea lions, respectively.

- NMFS indicated in the draft EA that, if impulsive explosive deterrents are deployed too close to an animal, blast injuries (e.g., ruptured eyeballs, lung and GI injury) could result in mortality or serious injury, which refutes the information earlier in the draft EA that slight lung injury and GI tract injury are considered Level A harassment, not mortality or serious injury. NMFS should specifically amend the first phrase to "(e.g., ruptured eyeballs, severe lung injury)" in the final EA for clarity.
- NMFS used the 50-percent injury criteria to estimate the range to effects for severe and slight lung injury and GI tract injury for impulsive, explosive devices (see Table 6 in the draft EA). That is inconsistent with Department of the Navy (2017) that stipulates the onset injury criteria are used for determining the range to effects for mitigation purposes (Table 4.6) and the 50-percent injury criteria are used to predict quantitatively the numbers of takes (Table 4.5). NMFS should use the onset severe lung injury, onset slight lung injury, and onset GI tract injury thresholds to estimate the ranges to effect for seal bombs, consistent with all other rulemakings involving impulsive, explosive devices.
- In Table B.1 of the draft EA—
  - Based on the signal duration and silent interval, the duty cycle for (1) cracker shells should be 0.00003 not 0.005 and (2) seal bombs should be 0.0017 not 0.001.
  - NMFS should specify what frequency it assumed when a range of frequencies or broadband is denoted for the various devices in Tables B.1-3.
- In Table B.2 of the draft EA—
  - The source level for airguns/air rifles should be 135.5 re 20 μPa_{rms} not 133.5 re 20 μPa_{rms}.
  - Airguns/air rifles should include "(i.e., sponge grenades and paintballs)", as air rifles were used as a proxy for deploying sponge grenades with a hand-held launcher (i.e., an airsoft gun/airgun) and paintballs with a paintball gun.
- In Table B.3 of the draft EA—
  - For the Ace Aquatec US2, McGarry et al. (2020) indicated that 5.5 scrams[38] could be emitted per hour. However, the 3-percent duty cycle used by NMFS would allow for only half that many scrams, or a scram every 22.3 minutes. NMFS should assume the worst-case scenario[39] of 5.5 scrams per hour, consistent with the assumptions it made for the Seamarco Fauna Guard devices, rather than the duty cycle of 3 percent.
  - For the Airmar dB Plus II, McGarry et al. (2020) obtained the relevant information from Lepper et al. (2014) who noted that the Airmar dB Plus II typically is deployed in multiples of four but can be deployed such that one device covers each fish farm cage or pen (e.g., 10 transducers could be deployed to cover 10 different cages or pens, see Figure 7 in Lepper et al. 2014). However, NMFS assumed that only one device was active at a given time. NMFS should consider a scenario in which at least four devices are used, thereby increasing the signal duration from 81.2 msec to 324.8 msec and decreasing the silent interval from 4.16 sec to 3.93 sec.

[38] NMFS assumed a worst-case scenario of a double scram that is emitted for 40 msec.
[39] As it had for other devices.

- For the Airmar Technologies Corp. pinger, the signal duration and silent interval were transposed. The signal duration should be 0.099 seconds with a silent interval of 4.3 seconds.
- For the Aquamark Responsive pinger (the 165-dB device), the silent interval should be 4.7 seconds rather than 4.27 seconds.
- For the Future Oceans "Netguard" Whale pinger, McGarry et al. (2020) reported the source levels to be up to 149 dB re 1 μPa_{rms}. NMFS used the highest source level reported (including those with error bars) for all of the Fishtek devices and the Savewave Orca Saver. NMFS should use a source level of 149 dB re 1 μPa_{rms} rather than 145 dB re 1 μPa_{rms}.
- For the GenusWave Turbine/Construction Safe pinniped and porpoise setting devices, the duty cycles were transposed based on McGarry et al. (2020). The duty cycle should be 0.8 percent for the pinniped setting and 0.6 percent for the porpoise setting.
- For the GenusWave SalmonSafe, the silent interval should be 4.8 seconds in order for the duty cycle to be 0.04 percent as noted in McGarry et al. (2020) rather than 20 seconds.
- For the Lofitech seal scarer, McGarry et al. (2020) reported the source level as 204 dB re 1 μPa_{rms}. NMFS should have used a source level of 204 dB re 1 μPa_{rms} rather than 198 dB re 1 μPa_{rms}.
- For the Marexi, McGarry et al. (2020) reported the source levels to be up to 136 dB re 1 μPa_{rms}. NMFS used the highest source level reported (including those with error bars) for all of the Fishtek devices and the Savewave Orca Saver. NMFS should use a source level of 136 dB re 1 μPa_{rms} rather than 132 dB re 1 μPa_{rms}.
- For the Seamarco Fauna Guard Porpoise, McGarry et al. (2020) reported the lower end of the frequency range as 60 kHz. NMFS should amend the lower frequency to be 60 kHz rather than 6 kHz.
- For the Terecos Ltd devices, McGarry et al. (2020) reported the source levels to be up to 180 re 1 μPa_{rms} for the Terecos Ltd, DSMS-4 Program 2 and 179 dB re 1 μPa_{rms} for Program 3 and Program 4. NMFS used the highest source level reported (including those with error bars) for all of the Fishtek devices and the Savewave Orca Saver. NMFS should use a source level of 180 dB re 1 μPa_{rms} rather than 179 dB re 1 μPa_{rms} for the DSMS-4 Program 2 and 179 dB re 1 μPa_{rms} rather than 178 dB re 1 μPa_{rms} for the DSMS-4 Program 3 and Program 4.

- NMFS's factsheet did not specify that marine mammals accidentally injured or killed by a deterrent must be reported within 48 hours. NMFS should specify the 48-hour timeframe in its final factsheet, consistent with the preamble to the proposed rule (85 Fed. Reg. 53772) and the proposed regulations (section 216.116(a)).
- NMFS's factsheet did not include all of the non-acoustic deterrents evaluated as listed in the preamble to the proposed rule (Table 1, 85 Fed. Reg. 53765)[40]. NMFS should specify the full list of deterrents evaluated in its final factsheet, consistent with the preamble to the proposed rule and Table 2 in the draft EA.
- NMFS's factsheet omitted bird bombs and underwater firecrackers under the "explosive pest control device" category for the deterrents it evaluated. NMFS should include bird

[40] Specifically, Table 1 included but the factsheet omitted: vessel chasing, lasers, anti-predator netting, cattle prods, electrical nets, electroshock weapon technology, underwater electric barriers, sharp-ended poles, and butt of a spear gun. The factsheet also included bull rails, which were omitted in Table 1.

bombs and underwater firecrackers under the explosive pest control device category in its final factsheet, consistent with the preamble to the proposed rule and the proposed regulations.

- NMFS's factsheet did not specify what "additional implementation provisions" entail for its acoustic deterrence guideline tables. NMFS should specify "additional implementation provisions (e.g., minimum silent intervals, minimum distances, and clearance times)" in its acoustic deterrence guideline tables for non-ESA-listed cetaceans and pinnipeds and ESA-listed cetaceans and pinnipeds in the final factsheet for clarity.
- NMFS's factsheet omitted that impulsive, explosive and impulsive, non-explosive devices would be approved only for those in-air devices with source levels <142 and <158 dB re 20 μPa_{rms}, respectively, in the acoustic deterrence guideline tables for both non-ESA-listed and ESA-listed pinnipeds. NMFS should include the in-air source levels in both the non-ESA-listed and ESA-listed pinniped tables of the final factsheet, consistent with the proposed regulations and non-impulsive underwater devices[41] in NMFS's draft factsheet. NMFS also should specify that impulsive, explosive in-air devices ≥142 dB re 20 μPa_{rms} and impulsive, non-explosive in-air devices ≥158 dB re 20 μPa_{rms} would be prohibited[42] in the non-ESA-listed pinniped table of the final factsheet, consistent with non-impulsive underwater devices in the proposed regulations and the draft factsheet.
- NMFS did not specify which impulsive, explosive deterrents were underwater and in-air devices in its acoustic deterrence guideline table for ESA-listed pinnipeds. NMFS should specify that the first impulsive, explosive category is in regard to underwater devices and its second category is in regard to in-air devices in the ESA-listed pinniped table of the final factsheet.

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[41] Which NMFS denoted as <170 dB re 1 μPa_{rms}, in the factsheet. However, NMFS included in-air deterrents in the same category, even though the 170-dB source level only applies to underwater devices. NMFS should clarify this in the final factsheet as well.

[42] Unless NMFS provides a web tool for impulsive in-air devices.

Addendum II

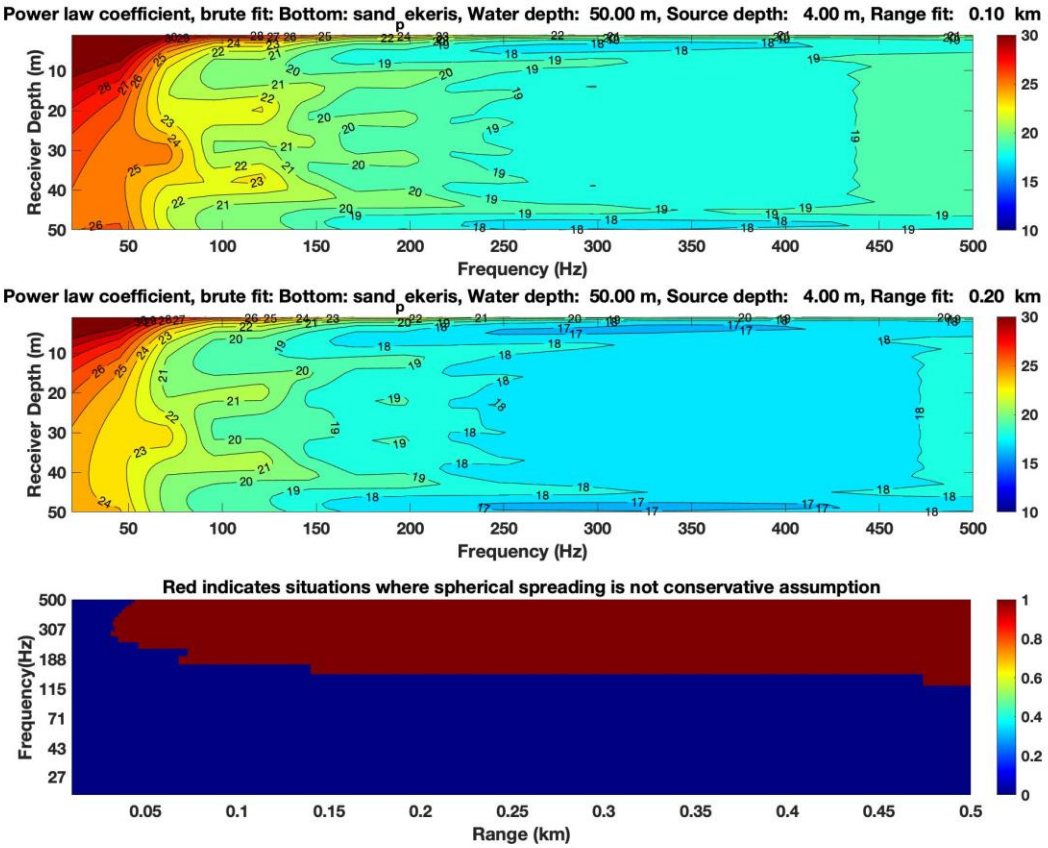

Figure 1. KRAKEN results in 50 m of water with sand substrate and an impulsive source at 4 m depth. The top two subplots depict equivalent propagation loss coefficients relative to acoustic frequency (x-axis) and receiver depth (y-axis), out to ranges of 100 m (top) and 200 m (middle). The bottom subplot denotes in red the frequencies and ranges at which spherical spreading is not an appropriate model for propagation loss.

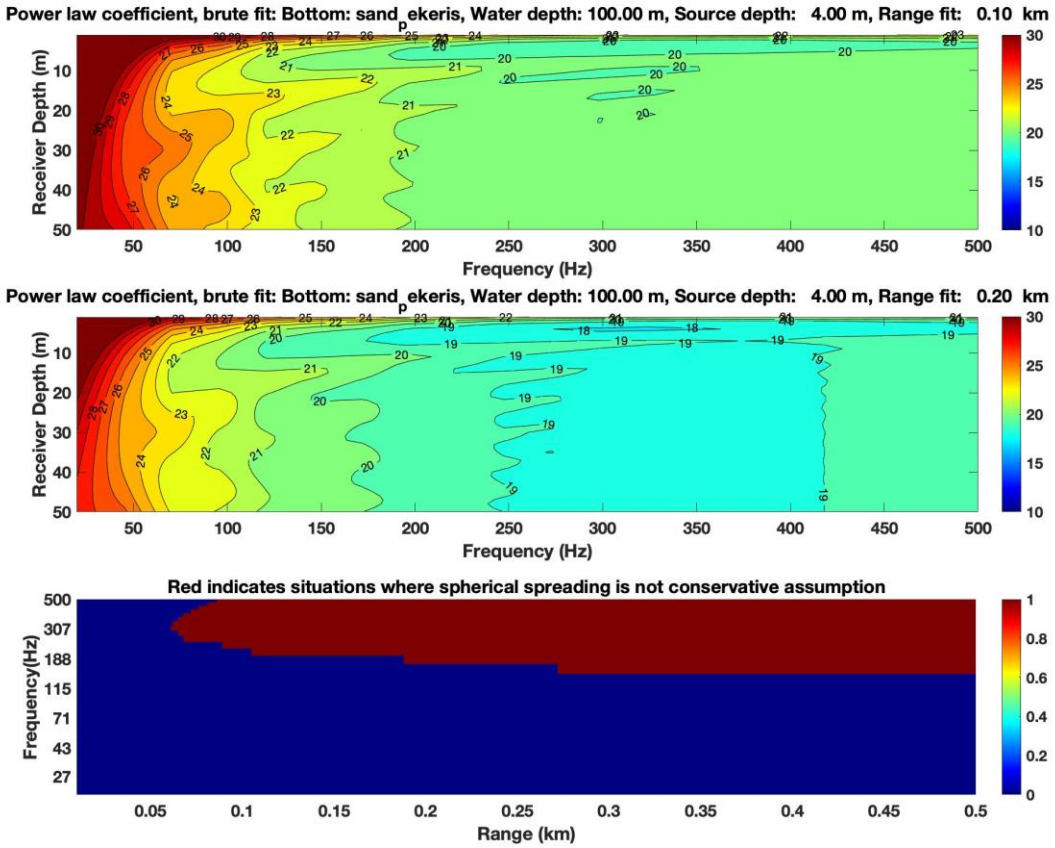

Figure 2. KRAKEN results in 100 m of water with sand substrate and an impulsive source at 4 m depth. The top two subplots depict equivalent propagation loss coefficients relative to acoustic frequency (x-axis) and receiver depth (y-axis), out to ranges of 100 m (top) and 200 m (middle). The bottom subplot denotes in red the frequencies and ranges at which spherical spreading is not an appropriate model for propagation loss.

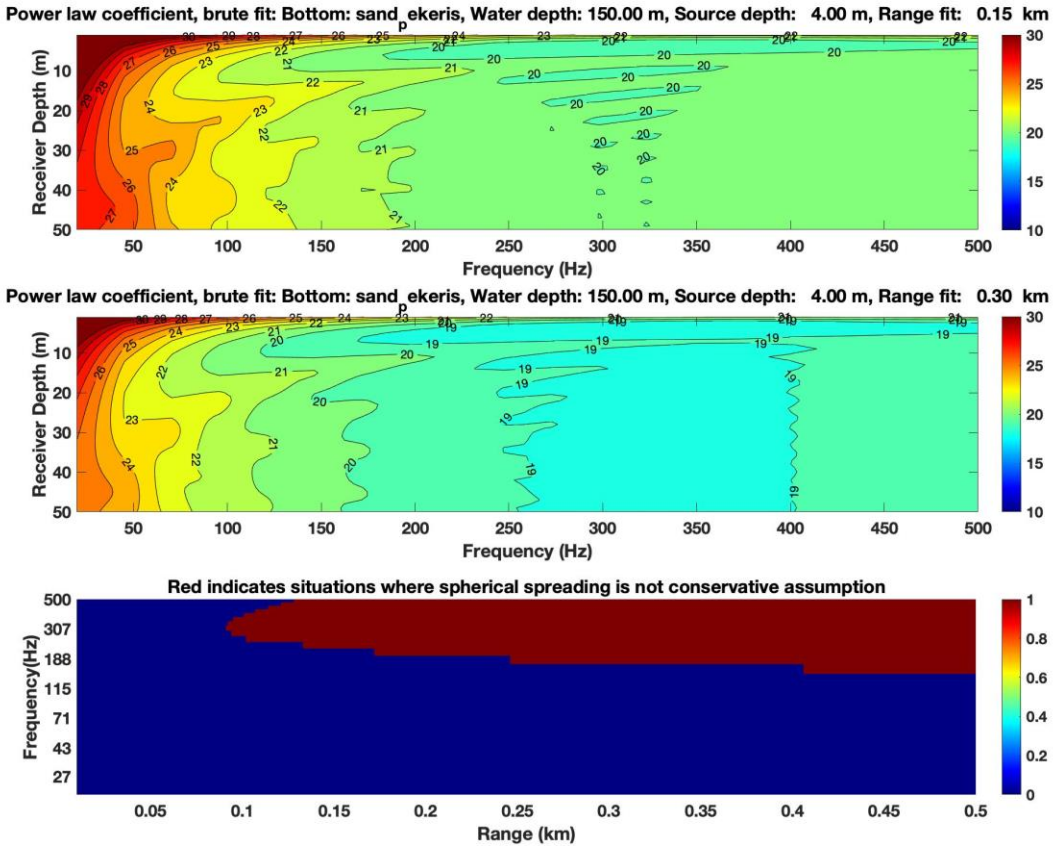

Figure 3. KRAKEN results in 150 m of water with sand substrate and an impulsive source at 4 m depth. The top two subplots depict equivalent propagation loss coefficients relative to acoustic frequency (x-axis) and receiver depth (y-axis), out to ranges of 150 m (top) and 300 m (middle). The bottom subplot denotes in red the frequencies and ranges at which spherical spreading is not an appropriate model for propagation loss.