31 August 2015

Nicole LeBoeuf, Chief
Marine Mammal and Sea Turtle Conservation Division
Office of Protected Resources
National Marine Fisheries Service
Attn. Acoustic Guidance
1315 East-West Highway
Silver Spring, MD 20910-3226

Dear Ms. LeBoeuf:

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[1] (NMFS) 31 July 2015 notice (80 Fed. Reg. 45642) and revised draft guidance regarding the acoustic thresholds for activities causing an onset permanent threshold shift (PTS) and temporary threshold shift (TTS) for marine mammal species under NMFS's jurisdiction[2] and application of those thresholds under the regulatory context of the Marine Mammal Protection Act (the MMPA), Endangered Species Act (the ESA), and National Marine Sanctuaries Act. NMFS's proposed thresholds are based on a Navy technical report that was developed in support of the Navy's Phase III compliance documentation for training and testing activities (Finneran 2015). The Commission would like to acknowledge Dr. Finneran for his comprehensive and thoughtful work in compiling the best available science and thus incorporating available data in the development of the acoustic thresholds.

Background

NMFS proposed to issue guidance regarding criteria and thresholds for assessing the effects of anthropogenic sound on marine mammals in 2005 (70 Fed. Reg. 1871). NMFS developed its draft guidance[3] and in 2013 and early 2014 provided it for peer review, interagency review, and public review. In January 2015, the Navy provided NMFS with a technical report (Finneran 2015) describing the Navy's proposed methodology for updating the auditory weighting functions and subsequent numeric thresholds for PTS and TTS for its Phase III acoustic effects analyses. NMFS preliminarily determined that Finneran (2015) reflects the best available science and decided to revise its original draft guidance based on the updated auditory weighting functions and thresholds from that technical report. NMFS provided Finneran (2015) for peer review[4], but it was not provided to the relevant agencies for interagency review. Based on comments from the public review of the original draft guidance, NMFS also conducted a peer review in 2015 of its methods for

[1] The draft guidance was provided on behalf of NMFS and the National Ocean Service, referred to collectively as NMFS herein.
[2] NMFS did not include in-air PTS and TTS thresholds for pinnipeds, only underwater thresholds were included.
[3] Some of which was based on Finneran and Jenkins (2012) that was developed in support of the Navy's Phase II efforts.
[4] The Commission provided NMFS a list of peer reviewers for both the original draft guidance in 2013 and Finneran (2015).

defining the appropriate threshold usage for sources characterized as impulsive and non-impulsive. The current public review consists of NMFS's revised draft guidance, which includes Finneran (2015).

The Commission previously recommended that, due to the complexity of the documents and the significance of the acoustic thresholds, a comment period of at least 60 days be allotted to provide sufficient time for both interagency and public review of the draft guidance. In this instance, no prior interagency review occurred and the public comment period is 45 days. NMFS did follow the Commission's previous recommendation to provide all peer reviewer comments and NMFS's responses to those comments to inform the current public review. Since the current guidance is incomplete with respect to thresholds for PTS and TTS in-air thresholds for pinnipeds and mortality, slight lung and GI tract injury, and behavior for all marine mammals, those thresholds will be revisited in future notices. Accordingly, the Commission recommends that, for all future interagency and public reviews of draft guidance regarding criteria and thresholds for assessing the effects of anthropogenic sound on marine mammals, NMFS provide (1) all peer reviewer and interagency comments and NMFS's responses to those comments and (2) at least a 60-day comment period.

Criteria and thresholds in general

NMFS originally planned to provide guidance regarding thresholds for PTS and TTS[5] for all sound-producing activities and for behavior specifically in response to seismic surveys. However, due to comments received during the interagency review of the original draft guidance, NMFS decided to move forward only with its proposed PTS and TTS thresholds for all sound-producing activities. Since that time, NMFS has decided to revise its draft guidance based on Finneran (2015). Although Finneran (2015) does not include in-air thresholds for PTS and TTS for pinnipeds[6] or criteria and thresholds for mortality, injury, and behavior for marine mammals in general, the Navy presumably has reviewed and/or revised those Phase II criteria and thresholds for use in its Phase III acoustic effects analyses.

As stated in the Commission's comments on NMFS's original draft guidance, the value of a guidance document is based, in part, on its level of completeness. At present, NMFS requires action proponents to use criteria and thresholds based on various guidance documents, informal policies, and/or applicable regulations. Although the current guidance from 2005 is outdated and not reflective of best available science, it is unclear if and how NMFS plans to implement the Phase III criteria and thresholds[7] for non-Navy action proponents that would be using similar sources. Historically, NMFS has deferred to the Navy's criteria and thresholds, when they have been updated. In any case, NMFS should not use inconsistent thresholds for similar sources.

Numerous studies have been published in recent years, and will be published in the near-term, regarding behavioral effects of various sound sources on marine mammals, dose response

[5] Underwater only.
[6] Those were included in the version of Finneran (2015) that was peer reviewed but were removed from the current version.
[7] Specifically, in-air thresholds for PTS and TTS for pinnipeds and criteria and thresholds for mortality, injury, and behavior for marine mammals in general.

functions, and suggested thresholds—data that presumably the Navy has incorporated into its Phase III efforts. Rather than NMFS develop its own criteria and thresholds, the Commission believes it is time for NMFS to consider incorporating into its guidance, as reference, technical reports (i.e., Finneran 2015) and peer-reviewed literature (i.e., the upcoming revision to Southall et al. (2007)) that have already compiled and evaluated the best available science. NMFS still would need to provide guidance for implementation of those criteria and thresholds but would not be tasked with their development. This should be a less time-consuming task and should still represent a compilation of more recent, peer-reviewed best available science. Accordingly, the Commission recommends that NMFS formulate a strategy for updating in-air thresholds for PTS and TTS for pinnipeds and criteria and thresholds for mortality, injury, and behavior for all marine mammals—the Commission believes such criteria and thresholds should be peer reviewed, made available to the public for review, and finalized within the next year or two.

Further, it is unclear what NMFS's strategy is for implementing the proposed thresholds once finalized. This is especially important for those action proponents who already have submitted incidental take authorization applications that will not have been issued when the new thresholds are finalized. Because the final thresholds would be considered the best available science, the Commission recommends that NMFS (1) provide specific guidance regarding how action proponents who have already submitted incidental take authorization applications should incorporate the final thresholds and (2) require all other prospective applicants to use the final thresholds for any applications yet to be submitted.

NMFS indicated that it would convene staff from its various offices, regions, and Science Centers and re-evaluate and update the acoustic threshold levels at least every 3 to 5 years as new data become available and, as deemed appropriate, provide opportunities for adaptive management. The Commission is unsure if re-evaluating every 5 years would ensure that the thresholds are kept current, based on the best available science. Therefore, the Commission recommends that NMFS review the final guidance every 3 years and revise as necessary or implement any necessary adaptive management measures to ensure that action proponents are using thresholds based on the best available science. If NMFS incorporates the thresholds as reference as recommended above by the Commission, this task should be less time-consuming than developing thresholds outright.

Impulsive vs. non-impulsive sound and peak pressure metrics

Finneran (2015) defined impulsive sounds as sounds with high peak pressure, short duration, fast rise-time, and broad frequency content. He defined non-impulsive sound as steady-state sound[8] that has sufficient duration to overcome starting transients and reach a steady-state condition. Finneran (2015) specified that underwater detonations, airguns, and impact pile driving are considered impulsive sources; whereas, military sonar, other coherent active sources, and vibratory pile driving are considered non-impulsive sources. NMFS's revised draft acoustic guidance included similar definitions, but NMFS indicated that its definition of impulsive is not meant to reflect how sounds have been characterized, and continue to be characterized, for Level B behavioral harassment. The Commission believes the definitions of impulsive and non-impulsive sounds

[8] For harmonic signals, sounds with duration greater than approximately 5 to 10 cycles are generally considered to be steady-state.

should be the same regardless of the type of effect and that Finneran's (2015) definitions should be used for all sources and in all contexts.

NMFS's acoustic thresholds are based on dual metrics, notably a cumulative sound exposure level (SEL_{cum}) and a peak sound pressure level (SPL_{peak}). NMFS stated that dual metrics of SEL_{cum} and SPL_{peak} have been recommended as most appropriate for establishing PTS onset threshold levels for marine mammals (Southall et al. 2007, Finneran 2015). However, Finneran (2015) only used the dual metrics for impulsive sounds, that is, those sources that elicit a high peak pressure. Based on a lack of supporting data for an SPL_{peak} metric for non-impulsive sound, NMFS merely assumed that the SPL_{peak} metric would be the same for non-impulsive as impulsive sources. The Commission is unsure why NMFS would include an SPL_{peak} metric for sounds that do not have a peak pressure component and agrees with Finneran's (2015) approach. Therefore, the Commission recommends that NMFS use dual metrics of SEL_{cum} and SPL_{peak} only for impulsive sources and use SEL_{cum} for non-impulsive sources.

In addition, SPL_{peak} values are available only for mid- and high-frequency cetaceans (MF and HF, respectively). Because of the paucity of data, Finneran (2015) applied the SPL_{peak} threshold of 224 dB SPL_{peak} for MF to all other marine mammal functional hearing groups (i.e., low-frequency cetaceans (LF), phocids in water (PW), and otariids in water (OW)). One of the peer reviewers of Finneran (2015) pointed out that due to the lack of data, the conservative approach would have been to apply the dynamic range[9] for humans of 140 dB SPL_{peak}[10] to the thresholds at f_0 for each functional hearing group rather than applying values ranging from 157 to 177 dB SPL_{peak}[11] for PTS[12] (NMFS 2015a). NMFS responded that the SPL_{peak} threshold for MF was obtained from direct measurements, which supports a larger dynamic range than the range for humans. The Commission agrees that marine mammals may have a larger dynamic range. However, since the HF dynamic range is 20 dB less than that of MF, the conservative and more appropriate approach would have been to apply the measured dynamic range of HF[13] to the thresholds at f_0 for LF, PW, and OW (Table 7 in Finneran (2015)) rather than applying the SPL_{peak} TTS and PTS thresholds of MF to the other functional hearing groups. Furthermore, the assumption that all marine mammal functional hearing groups (except HF) have the same TTS and PTS SPL_{peak} thresholds is counter to the method in Finneran (2015) in which various hearing groups are ascribed different hearing sensitivities. Until SPL_{peak} data are obtained for LF, PW, and OW, the Commission recommends that NMFS apply the measured dynamic range of HF[14] to the thresholds at f_0 for LF, PW, and OW to yield (1) 216 dB SPL_{peak} for the TTS threshold for LF, 213 dB SPL_{peak} for the TTS threshold for PW, and 218 dB SPL_{peak} for the TTS threshold for OW and (2) 222 dB SPL_{peak} for the PTS threshold for LF, 219 dB SPL_{peak} for the PTS threshold for PW, and 224 dB SPL_{peak} for the PTS threshold for OW.

[9] The difference between the threshold at the frequency of best hearing (f_0) and the SPL_{peak} TTS or PTS threshold.
[10] Based on C-weighted SPL_{peak} values from Starck et al. (2003), whereas, A-weighted SPL_{peak} values were 135 dB SPL_{peak}.
[11] The MF SPL_{peak} threshold was assumed for the other functional hearing groups, resulting in a dynamic range of 163–177 dB SPL_{peak} for PTS for MF, LF, PW, and OW; whereas, the HF SPL_{peak} threshold resulted in a dynamic range of 157 dB SPL_{peak} for PTS for HF.
[12] The TTS SPL_{peak} thresholds are 6 dB less than the PTS SPL_{peak} threshold.
[13] 151 and 157 dB for TTS and PTS, respectively.
[14] 151 and 157 dB for TTS and PTS, respectively.

Weighting functions and SEL_{cum} thresholds

Similar to NMFS's original draft guidance, Finneran (2015) used various weighting functions and various weighted SEL_{cum} thresholds based on the hearing sensitivity of various groups of marine mammals at numerous frequencies (i.e., functional hearing groups). NMFS's original draft guidance used weighting functions based on Southall et al. (2007)[15], Finneran and Jenkins (2012)[16], and NMFS's own method[17]. Since publication of Finneran and Jenkins (2012) and NMFS's original draft guidance, new data have been obtained regarding marine mammal hearing/audiograms, equal latency/loudness contours, and potential effects of sound on marine mammals (primarily TTS). Finneran (2015) used those data and the same basic method to derive his weighting functions[18] and weighted thresholds for all functional hearing groups. In addition, Finneran (2015) developed exposure functions, which incorporate both the shape of the weighting function and the weighted threshold. The Commission notes that the methods described in Finneran (2015) are quite complex compared to previous methods and may be difficult for most to understand (refer to the report for specifics). However, the weighting functions and associated weighted thresholds should not be more difficult to implement than previously proposed or currently utilized functions and thresholds.

Low-frequency cetaceans

For LF, empirical data are lacking regarding general hearing thresholds and audiograms, equal latency/loudness contours, and TTS. Thus, Finneran (2015) based the LF composite audiogram and normalized thresholds (which are used to derive the weighting function) on (1) modeled values from measurements of basilar membrane dimensions obtained from computerized tomography (CT) scans of cetacean ears (Ketten and Mountain 2014) and finite element models of head-related and middle-ear transfer functions derived from CT scans of whole heads (Cranford and Krysl 2015), (2) an estimated lowest threshold of 65 dB re 1 μPa based on Clark and Ellison (2004) and comparison with historical ambient sound curves (National Research Council (NRC) 2003), and (3) thresholds from other species. The weighting and exposure function *a* parameter is essentially based on the slope of the composite audiogram at lower frequencies (s_0), which apparently was set to 30 dB/decade based on the slopes of low-frequency ambient sound curves (i.e., Wenz curves; NRC 2003). Other parameters for the weighting and exposure function were based on assumptions that mean or median values of other species groups would best represent LF.

In the absence of data, relying on assumptions may be the only option. However, those assumptions also should result in derivations of weighting functions and weighted thresholds that make intuitive sense. The s_0 parameter in Finneran (2015), and thus the *a* parameter, appears to be

[15] Southall et al.'s (2007) weighting functions are flat over a wide range of frequencies and then decline at the extremes of the animal's hearing range, which reflect more closely C-weighting in humans that generally is applied to peak pressure thresholds. Those functions were used for pinnipeds, with proposed adjustments of greater (for phocids) and lesser (for otariids) high-frequency hearing limits than the original pinniped weighting function from Southall et al. (2007).
[16] For mid- and high-frequency cetaceans, the weighting functions were derived by combining the precautionary Southall et al. (2007) functions with equal loudness weighting functions based on empirical studies of bottlenose dolphins (Finneran and Schlundt 2011)—the latter which reflect more closely A-weighting in humans.
[17] For low-frequency cetaceans, NMFS chose not to use the weighting functions derived by Finneran and Jenkins (2012; Equation 4) but rather developed its own auditory weighting function using the equation from Finneran and Jenkins (2012) and NMFS's revised weighting function parameters.
[18] Which are more similar to A-weighting in humans.

based on the slope of the upper limit of the prevailing noise on the Wenz curves rather than the slope of the actual Wenz curves at various sea states—the latter appears to yield an approximate 19 dB/decade slope. In addition, Figure 7 of Finneran (2015) depicts the composite LF audiogram increasing in slope at higher thresholds in the low-frequency range, which matches more closely the upper limit of prevailing noise rather than the actual Wenz curves that plateau and represent low-frequency ambient sound.

The Commission believes that NMFS should be taking a precautionary approach in the absence of empirical data, not only for deriving composite audiograms but also for onset TTS or equal latency/loudness contours. One peer reviewer indicated that the estimation of hearing based on the methods of Ketten and Mountain (2014) and Cranford and Krysl (2015) resulted in audiograms that are too biased toward the higher frequencies (NMFS 2015a). Rather than splitting LF into subdivisions based on the paucity of modeled data and lack of empirical data, the Commission believes that the slope from the PW composite audiogram from Figure 7 should have been used. It better depicts what an audiogram for a sound-limited species, similar to LF, may represent when compared to the ambient noise spectral density levels. In addition, the s_0 parameter of 16 dB/decade reflects the better sensitivity in the low-frequency range and is a closer approximation to the actual Wenz curves. Until empirical data are available for LF, the Commission recommends that NMFS use the s_0 and a parameters for the PW weighting and exposure functions to adjust the LF weighting and exposure functions for impulsive and non-impulsive sources.

High-frequency cetaceans

Based on the composite audiograms in Figure 5 of Finneran (2015), HF are more sensitive than MF at both 300 Hz and 1 kHz. Although HF have lower weighting and exposure function thresholds than MF, TTS data have not been collected for either HF or MF below 1 kHz. It is known that HF, specifically harbor porpoises, react to broadband, primarily low-frequency sound (both impulsive and non-impulsive) at lower thresholds than other species. Thus, it follows that HF also would have lower thresholds and thus exposure functions at low frequencies. The degree to which they are lower has yet to be determined. Therefore, the Commission recommends that NMFS add to its research priorities (listed in Appendix C) the measurement of TTS at frequencies lower than 1 kHz for the various functional hearing groups during TTS behavior studies. Further, if not already subsumed in one of NMFS's research priorities, the Commission recommends that NMFS include in its research priorities the measurement of TTS from multiple pulses or hammer strikes when evaluating effects from impulsive sources rather than single pulses or strikes.

Since NMFS has not updated its behavior thresholds, it is continuing to use the 160-dB re 1 μPa threshold from its 2005 guidance for impulsive and intermittent sources (except for underwater detonations and military sonar). The Commission is unsure how NMFS plans to implement the proposed TTS SEL_{cum} threshold of 139 dB re 1 μPa^2-sec for HF, which (even though the units are different) may be a lower threshold than the behavior threshold depending on the frequency of the source. NMFS's revised draft acoustic guidance does not address this issue but clearly should have. As stated previously, the Commission believes the behavior thresholds should be revised and finalized within the next two years. Therefore, the Commission recommends that NMFS update its acoustic guidance to specify how action proponents are to implement its outdated 160-dB re 1 μPa threshold in concert with the new TTS thresholds.

TTS thresholds

NMFS indicated, via a footnote in its revised draft guidance, that there may be some situations in which determination of TTS may be necessary, and in those situations, the TTS threshold levels provided in its guidance document (Table 10 in Finneran (2015)) should be used. Historically, TTS thresholds have been used for underwater detonations and military acoustic sources (including sonar). The Commission is unsure why NMFS would not instruct all action proponents to use the TTS thresholds since the thresholds are relevant for all types of sources. Determining the range to TTS and the number of TTS vs. behavior takes for Level B harassment should have practical implications for NMFS when making its small numbers and negligible impact determination findings. Furthermore, effects of TTS (and, in some instances, ranges to and takes resulting from TTS) are and have been included by NMFS within the *Federal Register* notices soliciting comments on incidental take authorizations and by the action proponents in their applications. Accordingly, the Commission recommends that NMFS require all action proponents to use the impulsive and non-impulsive TTS thresholds for all types of sources.

Alternative PTS and TTS thresholds

NMFS indicated that alternative PTS and TTS SEL_{cum} thresholds (some of which are essentially weighted step-function thresholds[19], Table E1 of Appendix E) should be used if it is not possible for action proponents to use the weighting functions and associated weighted thresholds. However, NMFS did not indicate what criteria would need to be met or what circumstances would necessitate the use of those alternative thresholds. NMFS stated that the thresholds for MF and HF[20] in Table E1 are based on (1) sound within the most susceptible hearing range of the functional hearing group and (2) sound outside that range. NMFS apparently assumed that most impulsive sources and broadband, non-impulsive sources produce the majority of their sound pressure level at lower frequencies, below 3 kHz. If an impulsive or non-impulsive, broadband source produces the majority of its energy above 3 kHz, NMFS indicated it may modify the threshold on a case-by-case basis. NMFS also acknowledged that seismic airguns are capable of producing sound at higher frequencies and that further evaluation may be necessary to determine whether those sources produce enough higher-frequency energy for enhanced susceptibility of noise-induced hearing loss to occur. The Commission disagrees with this approach on various levels.

First, it should not be up to the action proponent to decide if it should implement the weighting functions and associated weighted thresholds. NMFS should hold all action proponents to the same standard. Second, NMFS should not evaluate or adjust thresholds on a case-by-case basis. Consistent thresholds should be implemented by all action proponents. Further, the evaluation of seismic airguns should have been conducted before NMFS published its revised draft acoustic guidance. As it stands, there would be no public review of either the case-by-case modified thresholds or whether seismic airguns fall within the arbitrary 3-kHz cutoff.

[19] Without having to implement the weighting functions themselves.
[20] NMFS determined that the majority of sound sources had energy within some band of the most susceptible hearing range of LF, PW, and OW. Thus, the thresholds were not divided into two broad steps.

The Commission believes that NMFS should not introduce an arbitrary value, for essentially the best hearing range[21], when such values were derived by Finneran (2015) for each functional hearing group. The Commission also notes that the 3-kHz cutoff originally was based on the inflection point where the M-weighting functions and the equal loudness contours intersected (Finneran and Jenkins 2012), as stated in the original draft guidance. Those weighting functions are no longer being used—as such, neither should the 3-kHz cutoff. If NMFS believes action proponents are unable to use the weighting functions and associated weighted thresholds, nothing precludes them from having multiple species-specific weighted step-function thresholds based on the data from Finneran (2015). In addition, NMFS provided various scenarios in which the alternative thresholds should be used. For narrow-band, non-impulsive sources above 35 kHz (e.g., sonars), NMFS indicated that no adjustment would be made for PW or OW since the sources are considered within the functional hearing groups' most sensitive range. That statement, however, does not hold for OW, whose upper frequency limit for best sensitivity is 27 kHz.

All in all, the Commission does not see the utility of having two sets of thresholds. If an action proponent can calculate or determine the isopleths (ranges) to the relevant thresholds (weighted or unweighted), then that action proponent can apply the weighting functions. NMFS indicated that it had compiled, interpreted, and synthesized the best available science to produce the new thresholds. Accordingly, NMFS should require action proponents to use the best available science, which in this case would mean using weighting functions and relevant weighted thresholds. Therefore, the Commission recommends that NMFS require all action proponents to use weighting functions and the associated weighted TTS and PTS SEL_{cum} thresholds for impulsive and non-impulsive sound rather than give action proponents the choice of using the alternative thresholds as denoted in Table E1. If NMFS insists on including alternative SEL_{cum} thresholds, the Commission recommends that NMFS include multiple weighted step-function thresholds based on the best hearing range of MF and HF rather than an arbitrary 3-kHz cutoff.

Alternative methodology including transition zone for SEL_{cum} thresholds

Both SPL_{peak} and SEL_{cum} thresholds can yield large ranges[22] to PTS. As such, NMFS included specific methods in Appendix B[23] that delineate a transition zone at which impulsive sound[24] has less injurious characteristics based on a ratio[25] of peak pressure[26] to pulse duration[27]. NMFS approximated that zone to be 3 km, at which action proponents may choose to substitute the non-impulsive PTS acoustic threshold for the impulsive PTS acoustic threshold. However, NMFS did not specify which 'acoustic' threshold it intended be substituted by the action proponents. Since NMFS has included the same SPL_{peak} impulsive threshold for impulsive and non-impulsive sources, NMFS presumably did not intend for applicants to replace 230 dB SPL_{peak} with 230 dB SPL_{peak}. The Commission originally assumed that NMFS meant for the SPL_{peak} impulsive threshold to be replaced

[21] Or as NMFS has termed it, the most susceptible hearing range in this instance.
[22] i.e., distances.
[23] That also were peer reviewed.
[24] Except for underwater detonations or what NMFS has termed high explosives.
[25] 5,000 was used an appropriately precautionary approximation of where most impulsive sound sources begin to transition to having physical characteristics less likely to result in auditory injury.
[26] In Pascals.
[27] As a surrogate for rise time.

with the SEL_{cum} non-impulsive threshold, which appeared to be supported by data regarding SPL_{peak} levels and pulse duration as stipulated in Appendix B.

The Commission has since been informed by NMFS that it intended the SEL_{cum} impulsive threshold to be replaced with the SEL_{cum} non-impulsive threshold at 3 km, which is a very important distinction to make. Based on some of the peer reviewers' comments and questions, it does not appear that they were provided with a summary of the proposed acoustic thresholds nor were they advised that dual metrics were to be used for those thresholds—both of which are important pieces of information necessary for conducting an informed review. In addition, some of the peer reviewers' comments indicated that they may not necessarily support use of such a transition zone in general (NMFS 2015b). As such, the Commission is not convinced that NMFS has substantiated its case for the use of a 3-km transition zone when substituting the SEL_{cum} impulsive threshold with the SEL_{cum} non-impulsive threshold.

Further, NMFS indicated that underwater detonations (i.e., high explosives) did not follow the trend that at 3 km the sound begins to transition to having physical characteristics less likely to result in auditory injury. However, NMFS was not explicit regarding whether the 3-km transition range would apply to underwater detonations. The Commission believes that the data provided in Table B2 of Appendix B do not support use of the 3-km transition range for underwater detonations, irrespective of the metric that NMFS has intended to use. Therefore, the Commission recommends that NMFS (1) provide all relevant information to the peer reviewers and allow for an additional review of the proposed 3-km transition zone when substituting the SEL_{cum} impulsive threshold with the SEL_{cum} non-impulsive threshold for impulsive sources (except underwater detonations) prior to the zone being implemented and (2) refrain from using any transition zone, 3-km or otherwise, for substituting the SEL_{cum} impulsive threshold with the SEL_{cum} non-impulsive threshold for underwater detonations.

Appendix E of NMFS's revised draft acoustic guidance also included alternative modeling approaches for determining the range to the various thresholds and associated exposures of marine mammals based on the TTS and PTS SEL_{cum} thresholds. NMFS indicated that it does not provide specifications necessary to perform exposure modeling but *relies on the action proponent to determine* the model that best represents the activity. The Commission strongly disagrees with that approach. If the action proponent uses an inappropriate model to determine the range to or exposures of marine mammals based on the various thresholds, it is NMFS's responsibility, as the regulatory agency charged with making the required findings, to *direct* applicants to the appropriate types of models, the appropriate types of inputs to such models, and the appropriate factors to be considered by such models.

NMFS included two types of models to determine the range to the various thresholds, one for moving and one for stationary sound sources. The model for moving sound sources was based on Sivle et al. (2014), who developed the equations 2Ea and b referenced in the revised draft guidance and assumed that the source is ensonifying a cylinder as it moves forward. The equations also depend on the depth of the source. NMFS indicated that the approach was not peer reviewed *per se* but was reviewed when the method was published by the journal. It is unclear if the 3-D development of the Sivle et al. (2014) model, which relies on the depth of the sound source, is directly applicable to the 2-D application that NMFS proposes to be used. Further, for stationary sound sources, NMFS suggested that action proponents can consider a transition range, much like

the 3-km transition zone it uses to delineate when impulsive sources become non-impulsive in the far-field and that SEL_{cum} non-impulsive thresholds should be used instead of SEL_{cum} impulsive thresholds. However, NMFS did not specify at what range this would occur. Due to the complexities of those methods/approaches and lack of scientific justification and peer review, the Commission recommends that, if it intends to move forward with the proposed alternative modeling approach, NMFS conduct a peer review of the methods for modeling moving sources based on Sivle et al. (2014) and stationary sources, including the transition zone based on SEL_{cum} impulsive and non-impulsive thresholds.

Multiple sound sources

NMFS stated that the SEL_{cum} metric is proposed to be applied to individual activities/sources and is not intended to accumulate sound exposure for multiple activities occurring within the same area or during the same time or to estimate the impacts of those exposures to an animal occurring over various spatial or temporal scales. The Commission is unsure specifically what is meant by that statement. However, because the SEL_{cum} metric is the only metric that incorporates the element of time, the Commission believes that SEL_{cum} is the best way to account for the use of multiple simultaneous sources by the relevant action proponent(s) in the same general area during the same timeframe (e.g., multibeam echosounders and sub-bottom profilers being used simultaneously with airguns during a seismic survey, various types of sonar and/or impulsive sources being used simultaneously during a military exercise).

NMFS further stated that the data available for deriving acoustic threshold levels using the SEL_{cum} metric are based on exposure to only a single source and may not be appropriate for situations where exposure to multiple sources is occurring. The Commission is unclear if NMFS is implying that all sources are to be analyzed separately and then the exposures added together, which generally would be considered a fairly precautionary approach. However, the Commission notes that the ranges to the various TTS and PTS thresholds would be underestimated if action proponents determined them in such a mutually exclusive manner. This topic is one of the research priorities identified in Appendix C. However, until such data become available, NMFS should modify its requirement regarding determining ranges to the relevant thresholds. Accordingly, the Commission recommends that NMFS require action proponents to use SEL_{cum} (and SPL_{peak}) thresholds for determining the ranges to the relevant TTS and PTS thresholds for activities that use multiple sound sources in the same area and during the same timeframe rather than requiring action proponents to apply the thresholds to discrete sources used during a specific activity.

Exclusion zones

Implementation guidance regarding how to calculate the exclusion zones based on PTS (Level A harassment) was not provided by NMFS either in its revised draft acoustic guidance or original draft guidance. Some of the currently used criteria are based on SPL_{peak}, SPL_{rms}[28], or impulse thresholds, which are fairly easy to implement when determining the appropriate exclusion zone based on Level A harassment. However, it is much more difficult to determine the timeframe that should be used for determining exclusion zones based on SEL_{cum} thresholds, since NMFS has not required action proponents to accumulate the energy emitted for an entire 24-hour period. For

[28] Sound pressure level based on root mean square.

example, the Navy appears to base its ranges to PTS (which then serve as the basis for its exclusion or mitigation zones) on a single ping of its sonar sources and it assumes that marine mammals would not maintain a nominal speed of 10 knots parallel to a ship and thereby would not receive sound from more than a single ping. The Navy also assumes that marine mammals would leave the area near the sound source after the first 3–4 pings. The Commission has questioned those assumptions in the past, remains unconvinced of their validity, and is concerned about their potential to lead to an underestimation of the relevant exclusion zone.

There are a number of other instances in which calculating appropriate exclusion zones based on a single ping, pulse, or hammer strike is problematic. For example, seismic and geological/geophysical surveys emit sound at a higher duty cycle and vessels transit at slower speeds than Navy operations that use hull-mounted sonar. The Commission has raised similar concerns for stationary sources that emit sound at multiple pings per minute in small geographical areas. Further, pile driving activities also emit sound at very high duty cycles and often occur in coastal regions inhabited by resident populations of marine mammals. In these cases, it would not be appropriate to base an exclusion zone on a few shots, pings, or hammer strikes. If NMFS does not plan to require action proponents to determine the size of exclusion zones based on accumulating the energy during the 24-hour period, the Commission recommends that NMFS consult with scientists and acousticians to determine the relevant accumulation time(s)—which should incorporate more than a few shots, pings, or hammer strikes but likely be less than 24 hours—that action proponents should use to determine the exclusion zones based on the associated PTS SEL_{cum} thresholds and include that accumulation time in the final guidance. Without such information, the guidelines fail to provide criteria for determining when injury could occur or for mitigating the effects caused by various sound sources.

Additional comments

The Commission appreciates the enormity of NMFS's effort to revise its draft acoustic guidance. In its review the Commission has identified some minor errors and miscalculations, misrepresentation of information, and inconsistencies in the document. The Commission has provided NMFS with a list of these additional comments and recommends that NMFS incorporate them into the acoustic guidance before it is finalized.

The Commission hopes you find its comments useful. Please contact me if you have questions concerning the Commission's recommendations or rationale.

Sincerely,

Rebecca J. Lent, Ph.D.
Executive Director

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