Peer Review of NMFS's Updated Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater and In-Air Thresholds for Onset of Auditory Injury and Temporary Threshold Shifts (Updated Technical Guidance)

Peer Review Report

INTRODUCTION

The U.S. Navy (Navy) recently provided the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) with *Marine Mammal Auditory Weighting Functions and Exposure functions for US Navy Phase 4 Acoustic Effects Analyses* (Navy Technical Report[1]) describing the Navy's proposed methodology[2] for updating marine mammal acoustic criteria and auditory weighting functions in NMFS's *Updated Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater and In-Air Thresholds for Onset of Auditory Injury and Temporary Threshold Shifts* (Draft Updated Acoustic Guidance). The Navy's Technical Report describes the rationale and steps used to define updated auditory weighting functions and numeric thresholds for predicting auditory effects (temporary threshold shifts (TTS)/Auditory Injury (AUD INJ)) on marine animals exposed to active sonars and other active acoustic sources.

NMFS reviewed the Navy's Technical Report and provided input into the development of the final version. NMFS regards the Navy's Technical Report as the best available science on this topic, and we plan to adopt it to update our current Technical Guidance (NMFS 2018). However, before adopting, NMFS is responsible for conducting an independent peer review of our Draft Technical Guidance[3]. A peer review was conducted in October/November 2023, and this Peer Review Report compiles the comments of the peer reviewers and NMFS's responses to those comments.

The intent of this NMFS-initiated independent peer review was to evaluate the methodology proposed in the Navy Technical Report for consideration and incorporation into NMFS's Draft Updated Acoustic Guidance) (i.e., Navy Technical Report is included in Appendix A of our

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[1] Authored by Dr. James J. Finneran, United States Navy Marine Mammal Program, Naval Information Warfare Center (NIWC) Pacific.

[2] Note: The methodology provided in the Navy Technical Report is very similar to the methodology used in their previous technical report, which NMFS adopted for our current 2018 Technical Guidance via a peer review and public comment process. For more information, see: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance

[3] Before finalization of the Draft Updated Technical Guidance, NMFS will also conduct a Federal Agency Review and public comment period (i.e., the Peer Review only is the first step in the process of updating our current Technical Guidance).

Draft Updated Technical Guidance document). This Peer Review Report does not address how the U.S. Navy will incorporate or consider this peer review. NMFS requested the Navy's assistance in addressing certain comments, which are specifically designated as including input from both NMFS and the Navy

For the peer review of the Draft Updated Technical Guidance, potential qualified peer reviewers were nominated by a steering committee put together by the Marine Mammal Commission (MMC). Nominated peer reviewers were those with expertise in marine mammalogy, acoustics/bioacoustics, and/or acoustics in the marine environment. Of the thirteen nominated peer reviewers, three volunteered, had no conflicts of interest, had the appropriate area of expertise,[4] and were available to complete an individual review. The focus of the peer review was on the scientific/technical studies that have been applied and the manner that they have been applied in this document.

PEER REVIEWERS[5]

- David Barclay, Ph.D., Dalhousie University (Canada)
- Douglas Wartzok, Ph.D., Florida International University
- Jillian Sills, Ph.D., University of California, Santa Cruz

GENERAL COMMENTS[6]

REVIEWER 1

Comment 1: This update to the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* follows a five year cycle of providing updated guidance as new data become available. Accepted methodology is used to incorporate all relevant new information into the revised guidelines. My primary concern with the document is the categorization of PTS/AUD INJ [permanent threshold shift/auditory injury].

It has always been recognized that PTS represents auditory injury. However, it is known from studies in terrestrial mammals that auditory injury can also occur in the absence of PTS. In PTS the neuropathy is associated with the hair cells whereas the neuropathy without PTS can have more general metabolic and synapse associations. In the absence of a PTS, the basis for the neuropathy can only be determined by postmortem examination, if then. What is important is

[4] Reviewer credentials are posted at: https://www.noaa.gov/information-technology/update-to-20162018-technical-guidance-for-assessing-effects-of-anthropogenic-sound-on-marine-mammal

[5] Note: Peer Reviewers' comments are presented as provided to NMFS. Generally, NMFS did not make any alterations (i.e., there may be spelling, grammatical, or other minor errors). If alterations were made, they were done for clarity and are indicated by brackets [ ].

[6] Reviewer identification numbers do not necessarily correspond to the order of reviewers above.

that the non-PTS neuropathy has been observed only subsequent to threshold shifts of greater than 40 dB (in the cases where the observed TS [threshold shift] has been less than 40 dB, the measurements have been made after a longer recovery period than established for TS testing in relevant marine mammal studies). Because there has been only one study in a marine mammal that resulted in a PTS, all the other PTS thresholds are based on extrapolations to the level that would cause 40 dB threshold shift. Hence the thresholds presented are those which result in auditory injury, including both PTS and neuropathy without PTS.

I believe the explanation of auditory injury given in the Finneran appendix [Navy Technical Report, Appendix A] is clearer than that provided in the Technical Guidance. Also I think, following the Finneran appendix [Appendix A], the clearest label for these thresholds is simply Auditory Injury. The text can clarify that one form of auditory injury is PTS but the thresholds provided in the tables are more encompassing than just PTS and define thresholds for all currently recognized forms of auditory injury.

> ***Response:*** NMFS agrees with Reviewer 1's suggestion and has changed the term "PTS/AUD INJ" to "AUD INJ" to be consistent with the Navy Technical Report (Appendix A) and provide greater clarity in the Draft Updated Technical Guidance.

Comment 2: The categorization of marine mammal hearing groups follows the revisions suggested by Southall et al. (2019) which is a reasonable approach.

> ***Response:*** NMFS thanks the Reviewer for their comment.

Comment 3: Throughout the document there are numerous examples of taking a precautionary approach to determining thresholds. Given the current status of information, I think a precautionary approach is justified. Examples are: (1) expanding the marine mammal hearing range to 65 dB above threshold in contrast to the human defined range of 60 dB above threshold; (2) not considering the recovery of function that occurs between intermittent exposures even though there is evidence that some recovery occurs; (3) excluding some mean TTS [temporary threshold shift] onset data points for groups of VHF [Very-High Frequency] cetaceans and PW [Phocid Pinnipeds Underwater] pinnipeds from the fitting process where new data indicate higher TTS onset values than those predicted in the 2018 guidelines; (4) using 20 dB as the difference between TTS onset thresholds and AUD/INJ onset thresholds; (5) using only the lowest onset-TTS exposure level when there were multiple TTS onset data for the same animal at a single exposure frequency; and (6) eliminating northern elephant seal data from PCA [Phocid Carnivores In Air] onset TTS curve fitting because of evidence that Monachinae are less susceptibility [susceptible] to noise compared to Phocinae.

> ***Response:*** NMFS thanks the Reviewer for their comment.

Comment 4: At several places the document mentions consideration of kurtosis in defining the impulsive nature of the sound. The document does not mention the consideration of kurtosis in evaluation of TTS and AUD/INJ thresholds. While the importance of kurtosis in these thresholds has been demonstrated in terrestrial mammals, much work needs to be done before it can be incorporated in NMFS guidelines. However, this area of research should be mentioned in the

future research section. [e.g., Brenda-Beckman et al. 2022. Evaluation of kurtosis-corrected sound exposure level as a metric for predicting onset of hearing threshold shifts in harbor porpoises (*Phocoena phocoena*). JASA 152:295-301.].

> ***Response:*** NMFS acknowledges that kurtosis has recently been recommended as more appropriate metric for defining the impulsiveness of a sound (Martin et al. 2020; Müller et al. 2020; Guan et al. 2022). However, NMFS agrees that caution is recommended before adopting this metric for consideration of TTS and AUJ INJ thresholds for marine mammals. Furthermore, NMFS does mention the kurtosis metric in Appendix B Research Recommendations for Improved Thresholds, specifically in Section 1.10 Metrics and Terminology, including referencing von Benda-Beckmann et al. 2022.

Comment 5: In conclusion, this revision uses the best methodology and the latest data to determine TTS and AUD/INJ thresholds and should be welcomed by those studying marine mammals and those conducting operations that potentially impact marine mammals.

> ***Response:*** NMFS thanks the Reviewer for their comment.

REVIEWER 2

Comment 6: NMFS's [Draft] Updated Technical Guidance interprets what is currently known about hearing capabilities and noise-induced hearing loss in marine mammals and presents a comprehensive approach for applying these data to predict TTS or PTS resulting from noise exposure. Although in many areas data are limited, this is clearly stated and the assumptions or extrapolations used are explained. Given what is known (and the many unknowns), the methodology used is valid. New data that have become available since the development of the existing Technical Guidance have been appropriately incorporated into this framework.

> ***Response***: NMFS thanks the Reviewer for their comment.

REVIEWER 3

Comment 7: The challenge of the task is really made clear in reviewing the work, but ultimately this is a supremely useful document for researchers, regulators, and practitioners alike. I'm sure it will continue to evolve as our knowledge improves over the decades. The data summaries in Finneran [Appendix A] were fascinating and I hope the co-reviewers were able to scrutinize those aspects of the document closely.

> ***Response***: NMFS thanks the Reviewer for their comment.

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

REVIEWER 3

Comment 8: [Regarding "*C* Weighting function gain (dB)"] Units provided for some symbols, but not for others.

Response: NMFS provided units for those abbreviations that are associated with the auditory weighting functions or auditory exposure functions exclusive to this document because the reader would less likely be familiar with these parameters.

Comment 9: [Regarding "PK Peak sound level]" Preferable symbol would be L_pk (where the _ means subscript, because I can't do that in the comments…), though L_p,pk may be even better, considering exposure is also discussed in this document (e.g. L_E,pk could be a relevant metric).

Response: NMFS has included both symbols ($L_{0\text{-pk}}$) and abbreviations (PK) within the Draft Updated Technical Guidance. Symbols are used in equations and tables, while abbreviations are used in the text of the document. Furthermore, symbols are compliant with the ISO Underwater Terminology Standard (ISO 2017).

Comment 10: [Regarding "HF High-frequency"] If possible - some band definitions for these types of acronyms would be desirable.

Response: NMFS has clarified this term to indicate HF is referring to the high-frequency cetacean hearing group (i.e., "cetacean" is now added to this acronym).

Comment 11: [Regarding "$L_{0\text{-pk}}$ Peak sound pressure level"] I think the 0-pk here is more specific than simply pk which is good, but this table should specify that. I believe it should be deleted and replaced with L_pk (or L_0-pk, or L_p,0-pk) everywhere.

Response: Symbols presented in the Draft Updated Technical Guidance are compliant with the ISO Underwater Terminology Standard (ISO 2017). Furthermore, NMFS finds value in using the abbreviation (vs. symbol) in the text of Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols).

Comment 12: [Regarding "$L_{0\text{-pk,flat}}$ Peak sound pressure level (unweighted)"] It would be easier to follow if these were reversed, e.g. L_pk,weight, instead of L_pk,flat. Particularly since there are several weightings that can be applied

Response: For clarity, NMFS had modified this entry to "Unweighted Peak Sound Pressure Level."

Comment 13: [Regarding "msec Milliseconds"] Not the SI abbreviation – recommends ms

Response: NMFS has made this change.

Comment 14: [Regarding "p_0 Sound Pressure Level"] Should be reference level?

Response: For clarity, NMFS has removed this term from this Section, since this term is no longer used in the Draft Updated Technical Guidance.

Comment 15: [Regarding "PK peak sound pressure level"] Repeat [Same as Comment 11].

Response: Again, NMFS finds value in using the abbreviation (vs. symbol) in the text of Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols).

Comment 16: [Regarding "RMS Root-Mean-Square sound pressure level"] For consistency, L_p,rms would be preferable here.

Response: As with previous comment, NMFS finds value in using the abbreviation (vs. symbol) in the text of Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols).

Comment 17: [Regarding "*s* Distance from source"] r for range would be more intuitive and avoid the conflict with seconds.

Response: For clarity, NMFS has removed this term from this Section, since this term is no longer used in the Draft Updated Technical Guidance.

Comment 18: [Regarding "SEL_{24h} Cumulative sound exposure level over 24-h"] Reduce redundant symbols for clarity - line 42 [$L_{E,24h}$] is preferred.

Response: As mentioned in an earlier response, NMFS finds value in using the abbreviation (vs. symbol) in the text of Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols).

Comment 19: [Regarding "SL Source Level"] L_s may also be used - this is more common in the 'sound exposure' literature, while SL is standard in the SONAR equation context.

Response: For clarity, NMFS has removed this term from this Section, as well as the Glossary, since this term is no longer used in the Draft Updated Technical Guidance.

Comment 20: [Regarding "SL_E Energy Source Level"] Somewhat unclear on how this will be different from SL given the definition. This is a good example of how units would help clarify entries in the table.

Response: For clarity, NMFS has removed this term from this Section, as well as the Glossary, since it is not used in the document.

Comment 21: [Regarding "SPL Sound Pressure Level"] Ambiguity creeps in with a more generalized acronym.. L_p,rms has been defined above (line 76) so it isn't totally clear why SPL is needed. It could be for instantaneous SPL or some other context?

Response: NMFS finds value in using the abbreviation (vs. symbol) in the text of the Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols). The use of SPL is related to either peak sound pressure level, which is abbreviated via PK SPL or root-mean-square sound pressure level that is abbreviated via RMS SPL.

EXECUTIVE SUMMARY

REVIEWER 1

Comment 22: In Table ES1: Marine Mammal Hearing Groups, the term "underwater" should be removed from "Otariid Pinnipeds (OW) (underwater)". This is not needed as all in this section are underwater hearing ranges.

> ***Response:*** NMFS agrees and has removed the term "underwater" from this Table, as well as the corresponding Table in the Main Document.

REVIEWER 2

Comment 23: [Regarding Table ES1 ^footnote] Similarly, as more data become available for Monachinae seals, separate hearing group designations may be appropriate for the two phocid subfamilies. This is mentioned in the Finneran Technical Report [Appendix A], but would be good to highlight here as well.

It also might be worth mentioning somewhere that, because of this emerging difference between subfamilies (and specifically, the relatively high in-air thresholds for the Monachinae seals that have been tested), the Monachinae data were not used to generate the composite audiogram for phocids in air. Despite this, the PCA group thresholds should be conservative (protective) for monachid seals, and thus appropriate to use until more data are available describing hearing and noise effects in Monachinae species.

> ***Response:*** NMFS added the following text to this footnote to reflect Reviewer 2's recommendation: "Additionally, recent data indicate that as more data become available for Monachinae seals, separate hearing group designations may be appropriate for the two phocid subfamilies (Ruscher et al. 2021; Sills et al. 2021)." NMFS has also made these changes to the corresponding footnote in Table 1.
>
> Regarding Monachinae data (Kastak and Schusterman 1998, 1999; Reichmuth 2013; Ruscher et al. 2021) not being used to generate composite audiograms for PA pinnipeds: Table A.1-2 indicates these data were not included because "Monachid in-air thresholds very high re: other phocids."

Comment 24: [Regarding Table ES1 *footnote] To make this [hearing ranges are typically not as broad] more accurate, I suggest rewording to "…hearing ranges **may not be** as broad."

> ***Response:*** NMFS made the suggested edit to the footnote in this Table, as well as to the corresponding footnote in Table 1.

Comment 25: [Regarding Table ES1 *footnote] I suggest rewording [animals may be able to detect very loud sounds] to "…animals **are able to** detect very loud sounds…"

> ***Response***: NMFS made the suggested edit to the footnote in this Table, as well as to the corresponding footnote in Table 1.

REWIEWER 3

Comment 26: [Regarding the term "acute" in the following sentence: "Specifically, it identifies the received levels, or thresholds, at which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater or in-air anthropogenic sound sources based on updated information."] I have always found this word to be vague in this context. Is a time scale important here?

> ***Response***: NMFS has added clarification to indicate "acute" refers to exposure equal or less than 24 hours, which corresponds to our recommended accumulation period.

Comment 27: [Regarding *W(f)* Auditory weighting function and *E(f)* Auditory exposure function equations] Equation figure quality.

> Note: NMFS followed up with the Reviewer for more clarification on this comment, with the Reviewer responding: "I was just referring to the fact that the equation was pixelated or distorted."
>
> ***Response***: NMFS has worked to improve the resolution of these equations.

Comment 28 [Regarding Note associated with Table ES3] Clarity is decreased for the user who is only glancing at the table as reference for their work, and ignoring both fine print and the rest of the document. Using full units would provide more guidance. There is also the discomfort of identical unit annotation being used for L_p and L_E.

> Note: NMFS followed up with the Reviewer for more clarification on this comment, with the Reviewer responding: "'full units' would have the reference value, particularly important since exposure has a reference pressure and a reference time, while peak only has a reference pressure. Having these references explicitly in the table will emphasize their very real differences, which I think is important for the casual user, which may see dB used for both and become confused or use the thresholds inappropriately."
>
> ***Response*:** NMFS agrees that having "full units" is necessary in order for the thresholds in this Table to be explicit and used correctly. However, moving this information from the footnote to the Table only makes the Table more crowded and text "heavy." Instead, NMFS has added red text within the Table directing the reader to the footnotes (i.e., "PLEASE SEE TABLE NOTES TO FULLY UNDERSTAND SYMBOL MEANING."
>
> Once again, symbols within the Draft Updated Technical Guidance are compliant with the ISO Underwater Terminology Standard (ISO 2017).

Comment 29: [Regarding Figure ES1] Though these curves can be computed from information in the document, a background grid would be useful for the user that wants to quickly determine a value at a particular frequency.

> ***Response***: NMFS has updated the auditory weighting function figures with a grid to help better determine a value at a particular frequency.

MAIN DOCUMENT SPECIFIC COMMENTS BY SECTION

I Introduction

REWIEWER 1

Comment 30: With the definitions of Permanent Threshold Shift and Auditory Injury, it is important to clarify that both PTS (often associated with hair cell neuropathy) and non-PTS associated neuropathy occur with TS of 40 dB or greater.

> ***Response:*** NMFS agrees and has added the following clarification (via footnote) to the Draft Updated Technical Guidance "In situations where destruction of auditory tissue has occurred in terrestrial mammals, threshold shifts were 30–50 dB measured 24 h after the exposure. There is no evidence that an exposure resulting in < 40 dB TTS measured a few minutes after exposure can produce AUD INJ. Therefore, an exposure producing 40 dB of TTS, measured a few minutes after exposure is used as an upper limit to prevent AUD INJ (i.e., it is assumed that exposures beyond those capable of causing 40 dB of TTS have the potential to result in AUD INJ, which may or may not result in PTS)."

REVIEWER 2

Comment 31: In reference to footnote 5: Please also mention inclusion of in-air hearing data from sea otters and polar bears to derive the composite audiogram for the otariid pinniped (in air) hearing group.

> ***Response***: NMFS has adopted the Reviewer's recommendation and now includes additional citations (Ghoul and Reichmuth 2014 for sea otter data and Nachtigall et al. 2007; Owen and Bowles 2011 for polar bear data).

Comment 32: [Regarding TTS definition] I think that the inclusion of 6 dB here in parentheses is a bit confusing. For clarity, it may help to also define TTS onset (perhaps in a second sentence), specifying that a TTS of 6 dB is considered the minimum reliable change in threshold.

> ***Response***: NMFS has made the updated text reflect the Reviewer's recommendation.

Comment 33: [Regarding PTS definition] The inclusion of this number here seems misleading. I understand that PTS is estimated to occur when TTS reaches 40 dB. However, as currently written, it sounds like PTS only occurs when the irreversible increase in the threshold of audibility is as large as 40 dB (i.e. that PTS is only considered PTS if there is a 40 dB permanent shift). I suggest removing this number or addressing it more explicitly in a second sentence about how PTS onset is estimated.

> ***Response***: NMFS has made the updated text reflect the Reviewer's recommendation.

Comment 34: [Regarding AUD INJ definition] I think the INJ terminology used in the Finneran Technical Report [Appendix A] (including PTS within auditory injury rather than separating them out as two different things) makes more sense, as PTS is one type of auditory injury. Why did NMFS not adopt the terminology suggested in the Finneran Technical Report [Appendix A]?

Response: NMFS notes that Reviewer 1 made a similar comment (see Comment 1). NMFS has changed the term "PTS/AUD INJ" to "AUD INJ" to be consistent with the Navy Appendix (Appendix A) and provide greater clarity in the Draft Updated Technical Guidance.

1.3 Changes Associated with Draft Updated Technical Guidance

REVIEWER 2

Comment 35: [Regarding addition of pinniped in-air thresholds] Why does NMFS feel that these thresholds should be included now, when they weren't included in 2018? Are there more data available, or what is the reasoning behind this change?

Response: Typically, NMFS has not need to rely upon airborne TTS/PTS thresholds for activities we authorize (i.e., typically airborne activities we analyze only exceed our behavioral disturbance thresholds and not TTS or PTS thresholds). However, to be consistent and complete, we have decided to adopt the pinniped airborne thresholds in this Draft Updated Technical Guidance document.

Comment 36: [Regarding the inclusion of AUD INJ to PTS] The acknowledgement of neural degeneration in the absence of measurable hearing loss is important. However, it is unclear why NMFS defines auditory injury separately from PTS. Rather, PTS is one form of auditory injury (which is accurately stated below). I would suggest that NMFS discusses this, but keeps the terminology consistent with the Finneran Technical Report [Appendix A] (TTS and INJ, the latter of which includes PTS)

Response. NMFS agrees and has changed the document to reflect better the terminology in Appendix A (see Response to Comment 1).

REVIEWER 3

Comment 37: [Regarding AUD INJ thresholds] Which metric?

Response. It is the 24-h cumulative sound exposure level metric (SEL_{24h}). NMFS has added this clarification to the text.

II NMFS's Thresholds for Onset of Permanent Threshold Shifts in Marine Mammals

REVIEWER 3

Comment 38: [Regarding $SEL_{24h,}$] In regards to previous comments, I propose the 'mathematical' symbols L_E, L_pk are used within the body of the text, rather than have an abbreviation for text and another for equations.

Response. As mentioned in an earlier response, NMFS finds value in using the abbreviation (vs. symbol) in the text of the Draft Updated Technical Guidance, since most users of the document are likely more familiar with common acoustic abbreviations (vs. symbols).

Comment 39: [Regarding "Additionally, to account for the fact that different species groups use and hear sound differently, marine mammals are sub-divided into seven broad hearing groups (i.e., LF, HF, and VHF cetaceans; PW, OW, PA, and OA pinnipeds; See Table 1 in next Section) and thresholds in the weighted SEL_{24h} metric incorporate auditory weighting functions."] Just a reference to the bandwidths of hearing sensitivities, or other processes?

Response. NMFS has updated the document to reference Table 1 in this sentence, which directs the reader to the marine mammal hearing groups' generalized hearing ranges.

2.1 Marine Mammal Hearing Groups

REVIEWER 2

Comment 40: The footnote here (14) discusses the definition of hearing range for humans. This is also the definition that Southall et al. 2019 uses, which would be useful to mention in the footnote as well.

Response: NMFS has added text to indicate Southall et al. 2019 used 60 dB to indicate audiometry data by species (not by hearing group).

Comment 41: [Regarding Table 1 aligning with Southall et al. 2019] There is not complete alignment between the methods (or reported ranges). Southall et al. 2019 defines hearing range as the frequency bandwidth at +60 dB from best sensitivity. Additionally, this is done by species (in Southall) rather than for the whole group. The effect of reporting a generalized hearing range based on the composite audiogram is that the generalized hearing range represents an average of the available data across individuals and species. While this may be representative overall, it will not necessarily be sufficiently protective for the more sensitive species. For example, the OW underwater range here extends up to 43 kHz, but the upper limit for California sea lions (based on + 60 dB from best sensitivity) is 55 kHz. This is actually the opposite of what is stated in the Table 1 footnote, which says, "individual species' hearing ranges are typically not as broad" as the generalized hearing range. So is this range supposed to encompass the hearing of all species within the group, or represent a group average that may or may not be as broad or as sensitive as the hearing of particular species?

Response: NMFS thanks the Reviewer for this comment. The generalized hearing range is intended to encompass the hearing of all species within a group (i.e., upper and lower frequency range of the hearing group as a composite). Thus, NMFS went back to consult the individual species' hearing ranges from Southall et al. 2019 to ensure our generalized hearing ranges in the Draft Updated Technical Guidance fully encompass individual species' hearing ranges. In doing so, NMFS found it necessary to make two

modifications: 1) the upper frequency range of OW pinnipeds is now changed from 43 kHz to 55 kHz (based on the California sea lion example provided in the Comment), and 2) the upper frequency range of PA pinnipeds is now changed from 46 kHz to 52[7] kHz (based on spotted seal data).

REVIEWER 3

Comment 42: [Regarding Note for Table 1 that says, "Additionally, animals may be able to detect very loud sounds above and below that "generalized" hearing range."] Instead of this statement (since we know the weighting curves exist), perhaps clarification on what generally determines these ranges? 3 dB down from peak sensitivity (a very electrical engineering definition) or something else?

Response: NMFS disagrees that a precise definition can be provided and intended this statement to be more generic. NMFS also disagrees with replacing this statement, and directs Reviewer #3 to see Comment 24 from Reviewer #2 and NMFS's response, on this same text.

2.1.1. Application of Marine Mammal Hearing Groups

REVIEWER 2

Comment 43: [Regarding the statement: "Outside the generalized hearing range, the risk of auditory impacts from sounds is considered highly unlikely or very low"] While it's true that sounds outside the generalized hearing range would need to be quite loud to be detected, the limits of the hearing range provided here (at the +65 dB from best sensitivity level) do not necessarily correspond to a shift in detection from an auditory to a non-auditory mechanism, as suggested in the footnote (16). The +65 dB level is not correlated with hearing pathways. It should also be made clear that the generalized hearing ranges can be used as a guide for understanding which frequencies may be most relevant/harmful in terms of noise exposure for a particular species. However, they do not provide an absolute cutoff, beyond which noise impacts are irrelevant or even unlikely. This depends on many factors, including the target species and characteristics of the noise (spectrum, amplitude, etc.) in question.

Response: NMFS has supplemented this footnote with the following text to reflect the Reviewer's recommendation: "Thus, generalized hearing ranges do not provide an absolute cutoff, beyond which noise impacts are irrelevant or even unlikely. This depends on many factors, including the target species and characteristics of the noise (spectrum, amplitude, etc.) in question."

[7] Spotted seal behavioral audiogram data in Southall et al. 2019 indicate an upper hearing range of 51.2 kHz. For our Updated Technical Guidance, NMFS rounded this value up to 52 kHz.

2.2 Marine Mammal Auditory Weighting Functions

REVIEWER 3

Comment 44: [Regarding A-weighting] Only applicable to human.

> ***Response*:** NMFS has replaced the footnote indicating that A-weighting was originally developed for human hearing, and added this directly to the text (i.e., removing the need for this footnote).

2.2.2 Marine Mammal Auditory Weighting Functions

REVIEWER 3

Comment 45: [Regarding caption for Figure 1 that indicates VHF is depicted in green] Grey.

> ***Response*:** NMFS has corrected this Figure, so the VHF cetacean line is depicted as green.

Comment 46: [Regarding Equation 1] Referenced to maximum.

> Note: NMFS followed up with the Reviewer for more clarification on this comment, with the Reviewer responding: "Again, just to specify that the dB are referenced to a maximum such that 0 dB is maximum sensitivity. dB ref max would be appropriate."
>
> ***Response*:** NMFS has added text to reflect that 0 dB indicates maximum susceptibility to noise-induced hearing loss.

2.2.3 Derivation of Function Parameters

REVIEWER 2

Comment 47: [Regarding Table 2, where it says: Bearded sealed (2)] Should be bearded seal.

> ***Response***: NMFS will correct this error.

Comment 48: [Regarding Table 2, Terhune et al. 1972] Should this be italicized? Was this data set not used previously? If not, why was it added now?

> ***Response (NMFS and Navy)***: The Terhune et al. 1972 was not previously included. However, in re-examining these data, it was found that the upper cutoff matches the other phocids. In the absence of other harp seal data, it could not be concluded that this audiogram was not normal, so it was included in the Draft Updated Technical Guidance.

Comment 49: [Regarding Table 2 *footnote] How much of a difference does the inclusion of these data [the otariid pinniped (in air) hearing group's composite audiogram contains data from a single sea otter (*Enhydra lutris nereis*) from Ghoul and Reichmuth 2014 and five polar bears from Owen and Bowles 2011] make in the composite audiogram? This may be useful

information to include here, especially if it makes a considerable difference, as these other data are not necessarily representative of otariids.

Response: A separate U.S. Navy Technical Report (DoN 2017) specifically addressed the Reviewer's comment. Below is a figure from this 2017 report, in which the right side of this figure provides a comparison between mustelid, ursid, and otariid hearing thresholds in-air. In this figure, the thick line represents the composite for all species (mustelids and ursids) in the OA pinniped hearing group, while the dashed line represents just otariids. The inclusion of mustelid and ursid audiogram data does not appear to make a considerable difference to the composite audiogram for OA pinnipeds.

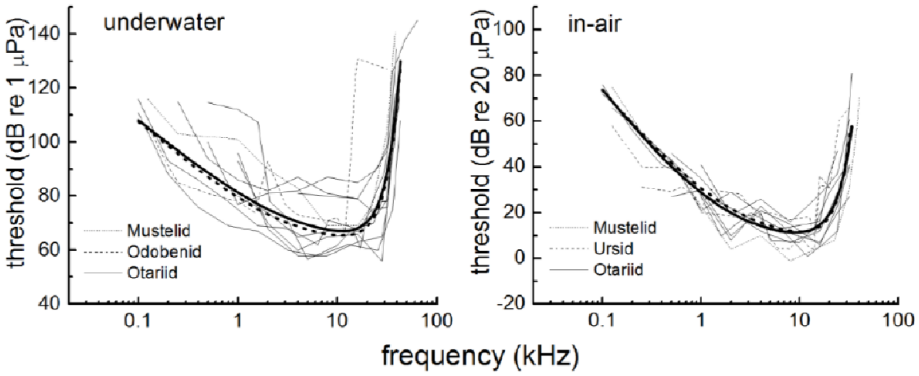

Figure 2-4. Comparison of Otariid, Mustelid, Odobenid, and Ursid psychophysical hearing thresholds measured underwater (left) and in-air (right). The thick, solid line is the composite audiogram based on data for all species. The thick, dashed line is the composite audiogram based on the otariids only.

Comment 50: [Regarding Step 4] Why not just increase this [*b*] value to 5 for the OW group? Is there a reason to set parameter *b* to the same value for all hearing groups? Parameter *a* is set differently for each group, for example.

Response (NMFS and Navy): In the 2018 Technical Guidance (and Southall et al. 2019), the *b* parameter is the same for all hearing groups, while the *a* parameter is different for each hearing group. Thus, the changes made to the Draft Updated Technical Guidance are consistent. Increasing the *b* parameter from two to five was done to fit better the OW pinniped function without substantially affecting the other marine mammal hearing group fits. The decision to keep the same *b* parameter for all groups, as in current and the Draft Updated Technical Guidance, was made to try to reduce complexity where possible.

Comment 51: [Regarding Figure 6] PCA and OCA should also be defined in this caption.

Response: NMFS has corrected the caption for this Figure by including PA and OA pinnipeds.

Comment 52: [Regarding Step 5] Suggest reiterating that the remaining groups are those without TTS onset data, for clarity.

Response: NMFS has added the qualifier "(without TTS)" after the suggested text for additional clarity.

REVIEWER 3

Comment 53: [Regarding Equation 3 and use of median thresholds] This should be computed in linear space. Was it? Missing parentheses.

$$T(f) = T_0 + A \log_{10}\left(1 + \frac{F_1}{f}\right) + \left(\frac{f}{F_2}\right)^B$$

Response (NMFS and Navy): Sound pressure is coded by the ear on a logarithmic basis, not linear basis (e.g., just noticeable difference is ~1 dB, regardless of actual sound pressure), so the statistics should be done on the dB quantities not linear quantities. For median calculation, the answer will be the same if the number of data points is odd. For even number of points, the mean of the two middle data points will be biased towards the higher value if the mean is computed in linear space. Finally, there is no missing parenthesis in this equation.

Comment 54: [Regarding Table 3, Minimum threshold (dB) column] Would be more specific - applies to all tables.

Note: NMFS followed up with the Reviewer for more clarification on this comment, with the Reviewer responding: "Many practitioners/consultants can use as much clarity as possible, so I would include explicitly reference units in all tables, either in headers or with values."

Response: NMFS has tried to do a better job ensuring the Draft Updated Technical Guidance provides clarification on metrics provided in the Tables.

Comment 55: [Regarding Table 5, Weighted TTS onset threshold (SEL_{24h}) column] Re previous comments on units: particularly here as people may consult these tables directly without reading rest of text.

Response: NMFS has tried to do a better job ensuring the Draft Updated Technical Guidance provides clarification on metrics provided in the Tables.

2.2.4 Application of Marine Mammal Auditory Weighting Functions for AUD INJ Onset Thresholds

REWIEWER 1

Comment 56: In footnote 22 note that "...include the PK metric, which are flat..." should read "...include the PK metric, which is flat…"

Response: NMFS has made this correction.

REWIEWER 3

Comment 57: [Regarding the following sentence: "If the frequencies produced by a sound source are outside a hearing group's most susceptible hearing range (where the auditory weighting function amplitude is 0 dB), sounds at those frequencies are required to have a higher sound pressure level to produce a similar threshold shift (i.e., PTS/AUD INJ onset) as sounds with frequencies in the hearing group's most susceptible hearing range."] Or -INF dB, since the weighting functions are not discussed in linear terms/units in this doc. Really, at '0' or -INF dB the hearing is truly non-existent according to the model. The models do allow for 'out of band' hearing, so this point, which is raised many times, is a bit confusing.

> Note: NMFS followed up with the Reviewer for more clarification on this comment, with the Reviewer responding: "My point had two points. First the weighting functions amplitudes are reported in dB (see Fig ES1 for example), so 0 is not the right value to use. The 10*log_10(amplitude^2/max^2) version of the weighting function would have a value of -INFINITY if the 'amplitude' were 0, which is what I think the text is implying. But the second point is that sounds that "are outside a hearing group's most susceptible hearing range" are not where a group has no (in the mathematical sense, either 0 or -INF) ability to hear, so things become murky. A more accurate equivalency might be "outside a hearing group's most susceptible hearing range" = weighting function amplitude << 0 dB, or weighting function amplitude < -6 dB."
>
> ***Response:*** Regarding the Reviewer's first point, NMFS agrees that weighting function amplitudes should be expressed as dBs and has ensured this is clear in the Draft Updated Technical Guidance.[8]
>
> As to the Reviewer's second point, NMFS agrees the sentence as originally written was unclear and has made the suggested edit (i.e., sentence now reads "If the frequencies produced by a sound source are outside a hearing group's most susceptible hearing range (where the auditory weighting function amplitude is << 0 dB), sounds at those frequencies are required to have a higher sound pressure level to produce a similar threshold shift (i.e., AUD INJ onset) as sounds with frequencies in the hearing group's most susceptible hearing range.")

[8] When NMFS followed up with Reviewer #3, we inadvertently did not include "dB" at the end of our question regarding the following sentence "Regarding the following sentence: "If the frequencies produced by a sound source are outside a hearing group's most susceptible hearing range (where the auditory weighting function amplitude is 0)" (should have indicated "weighting function amplitude is 0 **dB**"). This omission likely caused confusion and prompted Reviewer #3 to make the first point.

2.3 AUD INJ Onset Thresholds

REWIEWER 1

Comment 58: In the following sentence "Southall et al. (2007) also recommended this definition of PTS/AUD INJ onset," the cited authors only dealt with PTS not PTS/AUD INJ."

> ***Response:*** NMFS agrees. NMFS has changed this sentence to indicate, "Southall et al. (2007) also recommended this definition of PTS onset" (i.e., the phrase "AUD INJ" has been removed).

REWIEWER 3

Comment 59: [Regarding Table 6 Note] See comments on the reproduction of this table at the beginning.

> ***Response:*** Please see NMFS's response to Comment 28.

2.3.1 Impulsive and Non-Impulsive Source Thresholds

REVIEWER 2

Comment 60: [Regarding physical characteristics of the source] As NMFS acknowledges, at a certain distance this [physical characteristics of impulsive sources] is no longer valid. Accurately characterizing the dynamic environment is definitely challenging, and considering impulsive sources in this way (rather than categorizing them as non-impulsive beyond a given range) should be conservative in terms of TTS and PTS estimations. While this method seems appropriate given the unknowns, is there a plan to address this more explicitly at some point, informed by propagation modeling? E.g. for a particular sound source NMFS could specify that in a given environment (water depth, substrate, etc.), beyond X m there would be an expected shift from impulsive to non-impulsive?

> ***Response***: NMFS agrees that this is a challenging topic, which is why it has been explicitly identified in Appendix B (Research Recommendations), under Section 1.8 Characteristics of Sound Associated with NIHL and Impacts of Propagation. As more data become available, NMFS is open to further exploring this topic.

REVIEWER 3

Comment 61: [Regarding Impulsive definition, specifically "(less than 1 second)"] Won't gripe about the vagueness of the [definition] but I suspect others will grumble, despite the footnote.

> ***Response***: NMFS agrees that this definition lacks certain details that would make it more definitive. However, there currently is no standard definition (i.e., ISO 2017) providing the quantitative details requested.

2.3.2.1 Weighted Cumulative Sound Exposure Level (SEL_{24h}) Metric

REVIEWER 3

Comment 62: [Regarding text that states, "Often this metric is normalized to a single sound exposure of one second"] I actually think some equations to clarify this would be useful.

> ***Response*:** NMFS has provided additional text via a footnote to clarify further that for this metric, it is essential to specify the duration over which it is being calculated.

Comment 63: [Regarding text that states, "The recommended application of the weighted SEL_{24h} metric is for individual activities/sources. It currently is not intended for accumulating sound exposure from multiple activities occurring within the same area or over the same time or to estimate the impacts of those exposures to an animal occurring over various spatial or temporal scales."] In reference to my above comment [Comment 62]. The threshold metric pertains to a persistent SEL_1sec assumed to occur constantly over 24hour, or a SEL_24hr that might be computed from a single ship pass that occurs repeatedly, or once, or…. In the first case, the only difference between SEL_1sec and SEL_24hr is a constant, so maybe it's not the right metric. As far as data analysis goes, [people] will be more interested in applying the metric to the case you say it cannot be applied to, and for risk analysis/modelling, they will want to apply it to the 2nd case described above. To avoid confusion, the addition of some equations to clarify the meaning of the text would be very useful.

> ***Response*:** To this text, NMFS now references, as an example, our optional User Spreadsheet that accompanies the Technical Guidance, which illustrates this point for both stationary and moving sources (i.e., "safe" distance methodology).

Comment 64: [Regarding text that states "Factors like sound level (e.g., overall level, sensation level, or level above background),"] Unnecessarily vague.

> ***Response*:** This sentence simply is meant to illustrate generically the numerous factors that could contribute to the consideration of calculating cumulative sound exposure levels.

Comment 65: [Regarding PK metric] Outside my area, but peak pressure is responsible for instantaneous physical injury (like tissue damage), thus is a key metric despite any debate surrounding the impulsiveness of a sound.

> ***Response*:** NMFS agrees. This is specifically addressed in Section 2.3.2.2 Peak Sound Pressure Level Metric.

2.3.2.3 Comparison Among Metrics

REVIEWER 1

Comment 66: Section 2.3.2.3 appears to be copied from the 2018 revision when these changes in metric took place. Neither the 2018 nor the 2023 revisions use the RMS SPL metric. This section should be eliminated.

> ***Response:*** NMFS agrees. NMFS has removed this section from the Draft Updated Technical Guidance.

REVIEWER 2

Comment 67: Should this state that NMFS's original thresholds were expressed as RMS SPL? The 2018 guidance used PK and weighted cumulative SEL, as recommended here.

> ***Response***: See Response to previous Comment. NMFS has removed this section from the Draft Updated Technical Guidance.

REVIEWER 3

Comment 68: [Regarding text stating "a RMS SPL threshold of 180 dB is not equal to a PK threshold of 180 dB"] Unit clarity needed.

> ***Response:*** NMFS has removed this section from the Draft Updated Technical Guidance.

Comment 69: [Regarding text stating "(re: 1µPa^2-s). Thus, it is not directly comparable to other metrics that describe sound pressure levels (re: 1 µPa)[9]."] A point that should be made throughout the document by using this notation consistently.

> ***Response:*** NMFS has added text to Section 2.3.2.1 to clarify this point.

2.3.3 Development of AUD INJ Thresholds

REVIEWER 2

Comment 70: [Regarding Reichmuth et al. 2019] Although this study cannot be used directly to derive TTS or PTS onset thresholds, it is an important validation for these values. This is discussed in the Finneran Technical Report [Appendix A] and seems like a relevant point to make in the main body of the technical guidance as well. It would be useful to see a discussion of how close the theoretical values get to these empirical measurements.

> ***Response***: Text from the Navy Technical Report (Appendix A) has now also been included in this Section, upon the Reviewer's recommendation. NMFS also indicated that

[9] For more information and illustrations on metrics, see: http://www.dosits.org/science/advancedtopics/signallevels/.

the PTS onset threshold for PW is lower than the level (195 dB $SEL_{24h)}$ that resulted in PTS in Reichmuth et al. 2019 (199 dB SEL).

Comment 71: [Regarding Table 7 *footnote] This symbol appears for one study (correctly), but also appears in the header for column 1 (where it does not seem appropriate).

Response: NMFS has corrected this error, so this symbol no longer appears in the column header.

REVIEWER 3

Comment 72: [Regarding Table 7, 2nd column] Reviewer suggests making text in parenthesis lower case.

Response: NMFS has made the suggested change.

Comment 73: [Regarding Step 3, which references "SEL_{cum} "] What is this? Not in symbol table.

Response: NMFS has corrected this to SEL24h, which is consistent with how this metric is referred to throughout the Draft Updated Technical Guidance.

Comment 74: [Regarding Step 3 text that states, "The mean SEL_{24} for TTS onset was then computed at each frequency for which more than one data point existed."] Should be linearized, mean computed, then put back into log space. Apply this comment to all instances of mean/median or other statistical computations done on sets of metrics in dB.

Response (NMFS and Navy): Sound pressure is coded by the ear on a logarithmic basis, not linear basis (e.g., just noticeable difference is ~1 dB, regardless of actual sound pressure), so the statistics should be done on the dB quantities not linear quantities. Using linear calculation of means would bias the results towards the highest thresholds at each frequency.

III. Updating Acoustic Technical Guidance and Thresholds

REWIEWER 1

Comment 75: This section, originally entitled "Updating of Acoustic Draft Updated Technical Guidance and Thresholds," should remove the word "Updated."

Response: NMFS agrees. NMFS has retitled this Section as "Updating Acoustic Technical Guidance and Thresholds."

APPENDICES: SPECIFIC COMMENTS BY SECTION

Appendix A: Finneran Technical Report

REVIEWER 2

Comment 76: [Regarding text saying "i.e., it is assumed that exposures beyond those capable of causing 40 dB of TTS have the potential to result in INJ (which may or may not result in PTS"] This is a useful explanation. Suggest stating this explicitly in the discussion in the main text of the NMFS Technical Guidance, where the distinction between auditory injury and PTS is currently a bit unclear.

> ***Response***: NMFS agrees and, as addressed in an earlier Comment, has changed the term "PTS/AUD INJ" to "AUD INJ" to be consistent with the Navy Technical Report (Appendix A) and provide greater clarity in the Draft Updated Technical Guidance.

Comment 77: [Regarding text saying "TTS and INJ (which includes, but is not limited to, PTS"] Suggest using this type of language/terminology in the main text of the NMFS technical guidance to imply that PTS is one type of auditory injury that may occur at high levels of TTS.

> ***Response***: NMFS has changed the document to indicate that AUD INJ includes, but is not limited to, PTS and made the language in the main text more reflective of that from the Finneran Technical Report (Appendix A).

Comment 78: [Regarding Table A.7] How can this R^2 value for PCW be interpreted? Perhaps it would be more informative to report the deviation between the Phase 4 exposure function and the actual TTS onset data?

> ***Response (NMFS and Navy)***: The negative R^2 means the curve-fit does not follow the general trend in the data (i.e., the data would have been fit better with a flat line). This is a result of the assumption that the weighting function should be broader than the audiogram, thus f_1 was decreased after fitting for the PCW group to match the audiogram 10-dB bandwidth. This prevented the weighting function from adjusting to best-fit the data points and causes the very low R^2 value.

Comment 79: [Regarding the caption for Figure A.17] The word cetacean should not appear here.

> ***Response***: NMFS has corrected this error by removing the word "cetacean" from Figure A.17 caption.

Comment 80: [Regarding Table A.1-1] Why are monachid data (*Mirounga angustirostris and Neomonachus schauinslandi)* used to derive the PCW composite audiogram but not the PCA audiogram? In both cases, the data were collected with the same individuals in air and water. Thresholds are high relative to those of other phocid seals in both media.

> ***Response (NMFS and Navy)***: As mentioned in an earlier Comment/Response, Monachinae data (Kastak and Schusterman 1998, 1999; Ruscher et al. 2021) are not

being used to generate composite audiograms for PCA pinnipeds: Table A.1-2 indicates these data were not included because "Monachid in-air thresholds very high re: other phocids." All evidence to date suggests that monachids are not very sensitive to airborne sounds, and the excluded PCA thresholds are distinct from the (included) very-low phocid in-air thresholds. In contrast, underwater thresholds do not fall neatly into separate, distinct groups. Underwater monachid thresholds are closer to phocid thresholds showing similar upper cutoff frequencies.

REVIEWER 3

Comment 81: [Regarding Section 6 TTS Data Review] Methodology seems consistent between this appendix and the primary document. My comments from the primary apply here.

Response: NMFS acknowledges this comment.

Comment 82: [Regarding use of SEL] Is it desirable to keep the appendix in its original author's form, or to make it consistent with the primary document. This is a perfect example (I think this is referred to as SEL_cum above) but differently defined here from the way SEL is used previously.

I would suggest 'synergizing' the documents, or providing this as a stand alone reference, hosted along side the primary document on the NMFS website. It certainly has useful detail.

Response: NMFS believes keeping Appendix A in its original form is essential and that this Navy Technical Report needs to be directly included in the Draft Updated Technical Guidance vs. a stand-alone reference. NMFS has added a "conversion" table to the beginning of Appendix A to "synergize" the acronyms used in the Draft Updated Technical Guidance with those that are different in Appendix A.

Appendix A.2: Estimating a Low-Frequency Cetacean Audiogram

REVIEWER 2

Comment 83: I appreciate this clearly described, thoughtful approach to the estimation of a low-frequency cetacean audiogram given the available data and the many uncertainties (which are acknowledged here).

Response: NMFS thanks the Reviewer for their comment.

REVIEWER 3

Comment 84: [Regarding Equation A.2-2] Always awkward to have a mathematical statement without an =.

$$T_0 + L(f) + H(f)$$

***Response*:** Equation A.2-2 references Equation A.2-1 that *does* include an equal sign:

$$T(f) = T_0 + A \log_{10}\left(1 + \frac{F_1}{f}\right) + \left(\frac{f}{F_2}\right)^B$$

Furthermore, the accompanying text indicates, "To understand the roles of the parameters T0, F1, F2, A, and B, Eq. (A.2-1) may be viewed as the sum of three individual terms." Thus, Equation A.2-2 is illustrating the three individual terms.

Appendix B: Research Recommendations for Improved Thresholds

REWIEWER 1

Comment 85: The recommendation for future research might also include a reference to alternatives to the equal energy hypothesis used to accumulate exposure.

Response: NMFS has added a reference to future research on alternatives to the equal energy hypothesis to Section 1.5.1 Frequency and Duration of Exposure of Appendix B.

REVIEWER 2

Comment 86: [Regarding Table B1, second column] Does this refer to all of the data available, or just the data that were used to generate composite audiograms? If it's the former, these numbers should be revised. For example, there are behavioral audiograms available for 8 species of PW pinnipeds (not 7) and for 7 species of PA pinnipeds (not 3). If this is just the audiograms that were used to derive group audiograms, that should be clearly stated. In any case, more data are certainly needed for additional species, and also to increase the sample size for species for which data are already available.

Response: NMFS has added a footnote to this Table to indicate that this column refers specifically to data to derive the composite audiograms presented in the Draft Updated Technical Guidance.

REVIEWER 3

Comment 87: This whole appendix is such a useful and concise element of the doc.

Response: NMFS thanks the Reviewer for their comment.

1.1 Low-Frequency Cetacean Hearing

REVIEWER 2

Comment 88: [Regarding the text saying, "data collected on either stranded or animals associated with subsistence hunts"] What type of data are being alluded to here? Anatomical data? AEP data?

***Response*:** NMFS was alluding to both anatomical as well as potentially AEP data and has included these qualifiers in the text for additional clarity. Of course, proper permits/authorizations would need to be secured before the collection of these data.

1.8 Characteristics of Sound Associated with NIHL and Impacts of Propagation

REVIEWER 3

Comment 89: [Regarding the text saying "frequency content with lower frequencies typically propagating further than higher frequencies; pulse length due to reverberation or multipath propagation in shallow and deep water)."] +Dispersion in continental shelf or trapped waveguide propagation. Pulse length increase.

Response: NMFS has added the suggested text to the Draft Updated Technical Guidance.

Comment 90: [Regarding text on transition range and kurtosis metric] Particularly useful for predicting the effective range of impulsive sounds.

***Response*:** NMFS addresses the kurtosis metric in 1.10 of Appendix B.

1.10 Metrics and Terminology

REVIEWER 3

Comment 91: [Regarding ANSI and ISO standards] A great document of note is the ADEON standards from a group led by Dr. Miksis-Olds at UNH. It is detailed but strives for clarity while paying respect to the level of depth that researchers in this field require (unlike ANSI and ISO which tend to be more industry, thus defence oriented? Just an opinion). I think the turn around time on updating ANSI/ISO standards is slow, so I suspect the ADEON crew will have considerable influence on the next updates. https://adeon.unh.edu/standards

***Response*:** For the Draft Updated Technical Guidance, NMFS believes relying upon a published standard on underwater sound is the most appropriate (ISO 2017).

Appendix D Glossary

REVIEWER 2

Comment 92: [Regarding "Auditory Injury" definition] Again, it seems that auditory injury should be defined to include PTS, rather than being considered as damage to the ear that can cause PTS. This would be consistent with the Finneran Technical Report [Appendix A].

***Response*:** NMFS has modified this definition by adding the following text "Auditory injury includes, but is not limited to PTS," in order to address the Reviewer's recommendation.

Comment 93: [Regarding "Generalized Hearing Range" definition] Suggest updating to also state that Southall et al., 2019 defined hearing range as the +60 dB frequency bandwidth from best measured sensitivity.

> ***Response***: NMFS has added the reference to Southall et al. 2019 to the definition of "Generalized Hearing Range."

Comment 94: [Regarding "Propagation Loss" definition] I believe this should state "propagation loss is associated with the source level, while transmission loss is associated with a measurement at a specified distance."

> ***Response***: The Reviewer is correct. NMFS has fixed this error.

Comment 95: [Regarding "Temporary Threshold Shift" definition] This definition is clearer than the one provided in the main body of the NMFS Technical Guidance. As noted previously, I suggest updating that definition to be more similar to this one.

> ***Response***: NMFS has made the Reviewer's recommendation by providing this definition in the main body of the document.

REVIEWER 3

Comment 96: [Regarding "Ambient noise" definition ANSI 1994 reference] Was this updated in 2013? Jives [Jibes] with the background noise [definition] below.

> ***Response***: NMFS has corrected this definition to reference the more recent ANSI 2013 document, which does include this definition.

Comment 97: [Regarding "Audiogram" definition, Figure D1] re: y-axis. I noticed the audiograms in the text used y axis labels like amplitude (dB) or threshold (dB) - obviously I prefer something more specific like shown here, but again clarity of units would eliminate all confusion, regardless of the text in the axis label. I'm totally unaware of the conventional labeling.

> ***Response*:** NMFS has relabeled the y-axis of this figure to "threshold (dB)" to be consistent with the rest of the document.

Comment 98: [Regarding "Energy Source Level" definition] Answers a question/comment I had way back at the beginning. Essential difference from SL is that it is energy, not in units of dB.

> ***Response***: NMFS has removed this definition, since this term is no longer used in the Draft Updated Technical Guidance.

Comment 99: [Regarding "Far-field" definition that states **"**The acoustic field sufficiently distant from a distributed source that the sound pressure decreases linearly with increasing distance (neglecting reflections, refraction, and absorption)"] Who am I to argue with a standard, but linearly seems like at least a misleading term here. Probably not important…

Response: NMFS has removed this definition, since this term is no longer used in the Draft Updated Technical Guidance.

LITERATURE CITED

REVIEWER 1

Comment 100: For the following reference: Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, F. Kuiphof, L.A.E. Huijser, and J.M. Terhune. 2022c. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to one-sixth-octave noise bands centered at 32 and 40 kHz. Aquatic Mammal. (in prep), do you normally cite articles "in prep"? (I expect Ron will publish before too long).

Response: The Navy's analysis presented in Appendix A of the Draft Updated Technical Guidance includes data from this study, even though it is yet to be published. The Navy has worked very closely with Dr. Ronald Kastelein to obtain his recent California sea lion data ahead of publication because of its importance and implications for updating TTS and AUD INJ thresholds for the Otariid pinniped hearing group. NMFS predicts that these data will be published before the Draft Updated Technical Guidance is finalized. NMFS has revised the document to indicate this will likely have a 2023 publication date (i.e., not 2022 as originally indicated).

Comment 101: For the following reference: Reichmuth, C., J. Sills, J. Mulsow, M. Holt, M., and B.L. Southall. 2022. Temporary threshold shifts from mid-frequency airborne noise exposures in seals. Journal of the Acoustical Society of America (in prep), same comment as Kastelein. Colleen [Reichmuth] also likely to publish.

Response: An earlier version of the Navy's Appendix A, provided to NMFS, included the following citation supporting the one TTS onset data point available for Phocids Pinnipeds In-Air (PA): Kastak, D., Holt, M.M., Kastak, C.J.R., Southall, B.L., Mulsow, J., and Schusterman, R.J. (2005). "A voluntary mechanism of protection from airborne noise in a harbor seal," presented at 16th Biennial Conference on the Biology of Marine Mammals (San Diego, CA, December 12-16, 2005). It also appears that Southall et al. 2019 used this same data point to derive their TTS onset threshold for Phocid Carnivores in air (PCA) (although, Southall et al. 2019 does not include the Kastak et al. 2005 reference). However, this reference is referring to an abstract, which makes it difficult to glean many of the important details without a more complete write-up. Thus, NMFS requested that the Navy contact the authors to see if these data could be published. NMFS predicts that these data will be published before the Draft Updated Technical Guidance is finalized, making the use of this data point more transparent. NMFS has revised the document to indicate this will likely have a 2023 publication date (i.e., not 2022 as originally indicated).

Comment 102: For the following reference: Sills, J.M., C. Reichmuth, B.L. Southall, A Whiting, and J. Goodwin. 2020a. Auditory biology of bearded seals (*Erignathus barbatus*). Polar Biology 43:681-1691, the page number should be changed from 681-1691 to ***1***681-1691.

Response: NMFS has corrected this error.

REVIEWER 2

Comment 103: Several references are cited in the main text with 2022 as the publication year, but then "in prep" is noted in the References section. Should this be made more explicit in the main body of the document for clarity?

Response: NMFS anticipates that these data will be published before the Draft Updated Technical Guidance is finalized. If the status of these references has not changed by then, then NMFS will make this clear in the main body of the document. NMFS has revised the document to indicate this will likely have a 2023 publication date (i.e., not 2022 as originally indicated).

Comment 104: This literature cited section includes three manuscripts that are noted as "in prep" and one that is "in review." Is it expected that the status of these papers will change before the guidance is finalized? If not, perhaps these papers should be cited as "in prep" in the main text as well, so that their status is clear to the reader.

Response: NMFS anticipates that these data will be published before the Draft Updated Technical Guidance is finalized. If the status of these references has not changed by then, then NMFS will make this clear in the main body of the document. NMFS has revised the document to indicate this will likely have a 2023 publication date (i.e., not 2022 as originally indicated).

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Kastak, D., M.M. Holt, C.J.R. Kastak, B.L. Southall, J. Mulsow, and R.J. Schusterman. 2005. A voluntary mechanism of protection from airborne noise in a harbor seal, presented at 16th Biennial Conference on the Biology of Marine Mammals. San Diego, CA, December 12-16, 2005.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, F. Kuiphof, L.A.E. Huijser, and J.M. Terhune. 2022c. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to one-sixth-octave noise bands centered at 32 and 40 kHz. Aquatic Mammal. (in prep).

Martin, S.B., K. Lucke, and D.R. Barclay. 2020. Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals Journal of the Acoustical Society of America 147:2159–2176.

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