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1315 East-West Highway,
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Attn: Acoustic Guidance Docket no. NOAA-NMFS-2013-0177

Dear Ms. LeBoeuf,

On behalf of the Marine and North America Sections of the Society for Conservation Biology (SCB), please accept the following comments regarding the National Oceanic and Atmospheric Administration (henceforth NOAA) issued Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts dated the 23rd of December, 2013 (hereafter, the Draft Criteria). We have a number of concerns that we have arranged into sections. Specifically, these relate to: (1) the procedures used to establish the criteria values, as these do not seem to be in line with the stated goals; (2) the coverage of the hearing weighting functions; (3) the inconsistent treatment of data; (4) the criteria values themselves; and (5) the use of the alternative criteria presented in the Draft Criteria.

We are submitting comments because the scientific perspective provided by our organization, and the research conducted by our organization's member scientists, are relevant to the proposed policy. Additionally, key deficiencies in the proposed policy should be remedied in order for NOAA to meet their responsibilities under the Marine Mammal Protection Act ("MMPA"), the Endangered Species Act ("ESA"), the National Marine Sanctuaries Act ("NMSA"), and also the National Environmental Policy Act ("NEPA"). Estimating the numbers of acoustic takes is an important piece in MMPA "negligible impact" and ESA "jeopardy" determinations, and NMSA "likely to injure" or "may affect" determinations. As a result of this, the number of takes will also play a substantial role in any associated NEPA analyses. Accordingly, any acoustic criteria that underestimate the number of takes undermines NOAA's ability to appropriately assess the extent of impact for a given activity and thus make appropriate environmental determinations.

SCB is an international professional organization whose mission is to advance the science and practice of conserving the Earth's biological diversity, support dissemination of conservation science, and increase application of science to management and policy. The Society's membership comprises a wide range of people interested in the conservation and study of biological diversity. Resource managers, educators,

government and private conservation workers, and students make up the thousands of members worldwide.

1 Inherent flaws in the procedure for establishing the criteria

These Draft Criteria represent a substantial step forward in the construction of workable thresholds for assessing a certain subset of the impacts of noise on marine mammals, while specifically acknowledging their various weaknesses based on restricted data availability and the associated limitations on their use. Specifically, NOAA clearly states that:

"The acoustic thresholds for PTS [permanent threshold shift] will be used in conjunction with sound source characteristics, environmental factors that influence sound propagation, anticipated marine mammal occurrence and behavior in the vicinity of the activity, as well as other available activity-specific factors, ***to estimate (acknowledging the gaps in scientific knowledge and the inherent uncertainties in a marine environment) the number of takes of marine mammals*** *(Level A harassment and harm under the MMPA and ESA, respectively) and facilitate compliance with the MMPA, ESA, and NMSA as described above"* (Draft Criteria, page 22, emphasis added).

This passage establishes that the guidance contained within the Draft Criteria is designed to provide an estimate (while acknowledging uncertainties) of the number of animals expected to be taken at the level of "Level A harassment" or "harm", as defined elsewhere.

Given NOAA's expressed intention that the Draft Criteria should provide a reasonable estimate of "take," SCB strongly recommends that the procedures for those Criteria be revised (at the very least) to use the lowest available value or, more preferably, through use of statistical methodology (or some other correction factor) to account for the likely lack of full representation of the distribution of PTS onset in a population in the available samples. We offer the following in support of this.

Consider that human noise exposure criteria typically set two targets. Firstly, such guidelines set a level of impact that is deemed to be necessary to address. Secondly, they also declare the proportion of the population beyond which that level of impact needs to be addressed, above and beyond what would occur in normal life. In the Draft Criteria, NOAA expressly set the level of impact requiring consideration at PTS, which is stated to be equivalent to auditory "injury" even though this may not be consistent with all the statutes (see more below). In any case, NOAA then established its numerical criteria for this level of impact through the use of the procedure laid out in Table B7. The PTS onset level upon which everything is based is itself extrapolated from the onset of temporary threshold shift (TTS) through the addition of a constant. If enough TTS onset data points were available (5+), NOAA selected the median value of all reported estimates of each individual's. This is essentially establishing the second target mentioned above (the proportion of the population at which impact needs to be considered) at a level where approximately 50% of individuals will have already been exposed to anthropogenic sound expected to induce PTS. The problems are confounded further given the exponential nature of increases in exposure counts with the rising distances from a source associated with lower thresholds.

If the Draft Criteria are indeed intended to be used in estimating the number of animals that might be 'taken', then the procedures need to attempt to select a value for PTS onset that incorporates a much greater part of the expected population distribution. One way to accomplish this would be to set the criteria low enough to capture 90% of all potential takes, meaning that the Draft Criteria for auditory injury/PTS should be based on the lowest recorded TTS onset level for an animal in the most sensitive 10% of the population. Simple probability dictates that one animal randomly selected from a population has a 10% chance (a probability of 0.10) of being in this most sensitive 10%. With two data points, the probability that one will be from this sensitive 10% rises to 0.19. However, even at 10 data points, the probability that one animal was randomly selected from the most sensitive 10% is still only 0.65. It is only when 28 randomly selected animals have been tested that we can say, at a 0.95 level of probability, that one of those animals lies in the most sensitive 10%.

In addition, by stating that auditory "injury" is equivalent to PTS, the Draft Guidance appears to be inconsistent with the regulatory definition of the term "injure" under the NMSA, which is to "change adversely, **either in the short or long term**, a chemical, biological or physical attribute of, or the viability of" (Draft Criteria, page 22, emphasis added). **To capture short term injury, the Draft Criteria should look to include TTS, at least to some extent.**

2 Weighting functions do not represent the hearing sensitivities of all included species

While we approve, in principle, of the effort to construct more realistic weighting curves (e.g., Draft Criteria, page 7) than previous efforts (e.g., Southall et al., 2007), such curves cannot accurately represent the various hearing sensitivities of the full range of species in each functional hearing group. For example, bottlenose dolphins cannot be used to effectively represent killer whales or sperm whales, which are known to have regions of greatest hearing sensitivities at much lower frequencies (e.g., Szymanski et al., 1999; Ridgway and Carder, 2001; Madsen et al., 2002, 2003). Bottlenose dolphins are thus not representative of other species in their own hearing group. Instead, the mid-frequency weighting function must include the areas of greatest sensitivity (i.e., 0 dB regions of the hearing weighting curve) relevant to any single species in the mid-frequency (MF) cetacean group.

Similarly, the weighting function for the high-frequency (HF) cetacean hearing group must incorporate the greatest sensitivities (i.e., near 0 dB) at the frequencies most important to the hearing of the tested harbor porpoises (best hearing at around 125 kHz, with a range of approximately 30-140 kHz, with variability; Kastelein et al., 2010) and finless porpoises (range approximately 45-128 kHz, with variability; Popov et al., 2011), but also prioritize (i.e., at 0 dB) frequencies expected to be very important to, for instance, Irrawaddy and Ganges river dolphins (65-125 kHz and 45-73 kHz, respectively; Jensen et al., 2013) and Commerson's and Peale's dolphins (120-140 kHz; Kyhn et al., 2010).

For low-frequency (LF) cetaceans, NOAA presented data (e.g., Draft Criteria, page 5) supporting the premise that, as a group, these species can be expected to have high sensitivity at frequencies from 20 Hz to around 7.5 kHz, with reasonable hearing capacities reported extending upwards to 30 kHz. These additional hearing capabilities may well reflect the need to detect predators. However, it cannot be determined from the data exactly how sensitive these species are between 10 and 30 kHz. Despite this,

the weighting function incorporates great sensitivity (i.e., 0 dB) at only a fraction of this range. Additionally, we note that any loss of cochlear neurons associated with neurological damage to hearing from TTS would decrease effectiveness of hearing in low signal-to-noise conditions (Kujawa and Liberman, 2009) and that gray whales have been reported to operate at a 0 signal-to-noise ratio (e.g., Malme et al., 1983). As a result, hearing loss at the lower frequencies where levels of noise from shipping and natural sources can be expected to be relatively high would be expected to seriously compromise the capabilities of these animals at those frequencies. The Draft Criteria present no science-based reason for limiting the extent of the region of greatest sensitivity of the hearing function on the lower end of the frequency spectrum for these species.

Finally, with regard to the pinniped weightings, the Draft Criteria include (pages 10-11) an extended version of the Southall et al. (2007) weighting functions for the Phocid group in line with new data demonstrating higher sensitivity for some species at higher frequencies. However, the resulting function doesn't actually incorporate all of these frequencies (e.g., up to 40kHz; Kastelein et al., 2009), due to the underlying equation for generating that weighting function.

We recommend that flat M-weighting functions, similar to those provided by Southall et al. (2007) be used to represent the aggregate ranges of hearing sensitivity in every species within each functional hearing group. However, it is clear that the underlying equations are not sufficient to achieve this and they should be revised to make sure, for example, that the most sensitive part of the low-frequency weighting curve (i.e., 0 dB) extends up to preferably 10 kHz, but at very least up to 7.5 kHz.

3 Inconsistent use of data and references

The Draft Criteria are heavily based upon work by Finneran and Jenkins (2012), which despite NOAA's data standards (e.g., Draft Criteria, page 3) is not peer-reviewed. The work by Tougaard et al. (2013) and by Kastak et al. (2008; which is also noted in a memorandum to the Navy: Reichmuth, 2009) should be equally considered in revising the Draft Criteria.

For example, Tougaard et al. (2013) note that weighing functions cannot themselves be 'conservative' if evenly applied in establishing and then applying acoustic criteria. However, they also note that application of a more tailored function at the criteria determination stage in combination with a wider and more energy-inclusive function at the implementation stage would lead to a 'conservative' approach. Such an approach is necessary to "[acknowledge] the gaps in scientific knowledge and the inherent uncertainties in a marine environment" (Draft Criteria, Page 22). **We are strongly in support of this approach and suggest that NOAA use a function normalized to a lower level (e.g., -3 dB) for establishing the criteria, while using functions normalized to a higher level (e.g., 0 dB) for estimating the number of takes when implementing these criteria.**

Similarly, the PTS reported by Kastak et al. (2008) and Reichmuth (2009) was accidentally generated at levels expected to cause only TTS. **Given the ethical issues with attempting to replicate this, we recommend that NOAA consider this as the best available information about PTS.**

In one other major inconsistency, NOAA extrapolates PTS onset from TTS onset using TTS growth rates deemed to be applicable (Draft Criteria, from page 54), but then discards data from Popov et al. (2011) and Popov et al. (2013) as they only report TTS levels, and not onset (Tables B12 and B17). TTS onset can easily (and should) be calculated from these data. **We recommend that NOAA use the growth rates they have deemed to be appropriate for establishing PTS onset to also determine likely TTS onset from these two data sets and incorporate these figures into the Criteria.**

Finally, NOAA has, on at least one occasion, misapplied their own weighting functions, based on the values provided in Appendix A. As a result, NOAA set the non-impulsive TTS onset threshold for high-frequency cetaceans at 160 dB SEL_{cum} instead of 157 dB SEL_{cum} as calculated using the weighting scheme in the Draft Criteria (which should, in any case, be revised as discussed elsewhere).

4 Inappropriate values used to establish acoustic criteria

The proposed auditory criteria are largely based on hearing tests in aging bottlenose dolphins in potentially noisy environments. Given that the these animals are likely to have compromised hearing in comparison to younger animals, the possibly masked resulting thresholds may be 10 dB overestimations of the levels required to trigger TTS onset in more sensitive animals (see discussion by Tougaard et al., 2013, noting Finneran et al., 2002 in comparison to Johnson et al., 1968). Likely TTS onset calculated using NOAA-set TTS growth-rates from Tables B12 and B17 also supports substantially lower criteria than proposed in the Draft Criteria. Basing criteria across all hearing groups (with the exception of the high-frequency cetaceans who have notably lower thresholds) through one extrapolation or another on the older Navy bottlenose dolphins is thus inappropriate. **Instead, we recommend use of the onset data available from Tables B12 and B17 to establish MF and HF SEL_{cum} criteria. We also recommend using the lowest criteria from either the MF or HF hearing groups to establish the low-frequency hearing group criteria, to best address the uncertainties in this group. Finally, we also recommend that any criteria based upon older animals be adjusted downwards by an appropriate amount, potentially 10 dB, to account for any noise and the sensitivities of other, younger animals.**

We acknowledge that the pinniped hearing groups are likely to be less sensitive than the cetacean hearing groups, but find the extrapolations suggested by Southall et al. (2007) and used by NOAA in the Draft Criteria to be flawed. This is even admitted in the Draft Criteria (page 54), where it produces unrealistic results for some Otariid criteria, leaving us unconvinced of the suitability of this extrapolation to any criteria. **Given the current lack of information, we thus recommend that the highest criteria values from any of the cetacean groups (and not any higher) be used to establish the underwater criteria for the pinniped hearing groups.**

5 Preference for the use of the Alternative criteria

The alternative unweighted values presented in Table 7 represent completely flat weighting curves at the areas of greatest sensitivity in the delimited parts of the frequency spectrum. These criteria thus

conservatively over-estimate the number of takes from sources with frequencies along parts of weighting curve other than these areas of greatest sensitivity, where the estimated number of takes would be accurately reflected (provided the criteria are correct). **These thus represent a simple and conservative way to present the criteria and we recommend that they be applied to all applicants in an effort to address the concerns raised by Tougaard et al. (2013), at least to some extent. Such a change would also simplify implementation for all authorization applicants, as well as those processing and reviewing the applications, including the associated public comments. This would increase process transparency and reduce application handling times.**

Respectfully submitted,

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Literature Cited

Finneran, J.J., and Jenkins, A.K. (2012). Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis. San Diego, California: SPAWAR Systems Center Pacific.

Finneran, J.J., Schlundt, C.E., Dear, R., Carder, D.A., and Ridgway, S.H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America* 111: 2929-2940.

Jensen, F.H., Rocco, A., Mansur, R.M., Smith, B.D., Janik, V.M., Madsen, P.T. (2013). Clicking in shallow rivers: Short-range echolocation of Irrawaddy and Ganges River dolphins in a shallow, acoustically complex habitat. *PLoS ONE* doi: 10.1371/journal.pone.0059284.

Johnson, C.S. (1968). Relation between absolute threshold and duration-of-tone pulses in the bottlenosed porpoise. *Journal of the Acoustical Society of America* 43: 757-763.

Kastak, D., Mulsow, J., Ghoul, A., and Reichmuth, C. (2008). Noise-induced permanent threshold shift in a harbor seal. *Journal of the Acoustical Society of America* 123: 2986.

Kastelein, R.A., Hoek, L., de Jong, C.A.F., and Wensveen, P.J. (2010). The effect of signal duration on the underwater detection thresholds of a harbor porpoise (*Phocoena phocoena*) for single frequency-modulated tonal signals between 0.25 and 160 kHz. *Journal of the Acoustical Society of America* 128: 3211-3222.

Kastelein, R.A., Verboom, W.C., and Terhune, J.M. (2009). Underwater detection of tonal signals between 0.125 and 100 kHz by harbor seals (*Phoca vitulina*). *Journal of the Acoustical Society of America* 125: 1222-1229.

Kujawa, S.G., and Liberman, M.C. (2009). Adding insult to injury: Cochlear nerve degeneration after “temporary” noise-induced hearing loss. *Journal of Neuroscience* 29:14077-14085.

Kyhn, L.A., Jensen, F.H., Beedholm, K., Tougaard, J., Hansen, M., and Madsen, P.T. (2010). Echolocation in sympatric Peale’s dolphins (*Lagenorhynchus australis*) and Commerson’s dolphins (*Cephalorhynchus commersonii*) producing narrow-band high-frequency clicks. *Journal of Experimental Biology* 213: 1940-1949.

Madsen, P.T., Carder, D.A., Au, W.W.L., Nachtigall, P.E., Mohl, B., and Ridgway, S.H. (2003). Sound production in neonate sperm whales. *Journal of the Acoustical Society of America* 113: 2988-2991.

Madsen, P.T., Møhl, B., Nielsen, B.K., and Wahlberg, M. (2002). Male sperm whale behaviour during exposures to distant seismic survey pulses. *Aquatic Mammals* 28(3): 231-240.

Malme, C.I., Miles, P.R., Clark, C.W., Tyack, P., and Bird, J.E.. (1983). *Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray*

whale behavior. BBN Report 5366, Report from Bolt Beranek & Newman Inc., Cambridge, MA for US Minerals Management Service, Anchorage, AK.

Popov, V.V., Supin, A.Ya., Rozhnov, V.V., Nechaev, D.I., Sysuyeva, E.V., Klishin, V.O., Pletenko, M.G., and Tarakanov, M.B. (2013). Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. *Journal of Experimental Biology* 216: 1587-1596.

Popov, V.V., Supin, A.Ya., Wang, D., Wang, K., Dong, L., and Wang, S. (2011). Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaorientalis*. *Journal of the Acoustical Society of America* 130: 574-584.

Reichmuth, C. (2009). *Effects of noise and tonal stimuli on hearing in pinnipeds*. Report to the Office of Naval Research on Grant Number N000140610295.

Ridgway, S. and Carder, H.M. (2001). Assessing hearing and sound production in cetacean species not available for behavioral audiograms: experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals* 27: 267-276.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R., Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33: 411-521.

Szymanski, M.D., Bain, D.E., Kiehl, K., Pennington, S., Wong, S., and Henry, K.R. (1999). Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. *Journal of the Acoustical Society of America* 106: 1134-1141.

Tougaard, J., Wright, A.J., and Madsen, P.T. (2013). *Marine mammal acoustic criteria revisited*. Pp. 173-193 in Wright, A.J., How harbor porpoises utilise their natural environment and respond to noise. Ph.D. thesis, Aarhus University, Denmark.