The best available science? Are NOAA Fisheries marine mammal exposure noise guidelines up to date?

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Abstract

NOAA Fisheries employs a set of in-water noise exposure guidelines that establish regulatory thresholds for ocean actions that impact marine mammals. These are established based on two impact criteria: Level A – a physiological impact, and Level B – a behavioral impact or disruption. Since the introduction of these exposure definitions, much more work has been published on behavioral impacts of various noise exposures, and consideration of other variables such as frequency, sound quality, and multiple sound-source exposures. But these variables have not yet been incorporated into the NOAA Fisheries exposure guidelines.

A little history

In 1972 the Marine Mammal Protection Act (MMPA) was signed into law. Aimed most particularly at regulating activities that caused damage or mortality to marine mammals in the course of marine industrial activities (including whaling itself). But noise was not given much regulatory consideration until the first high-profile noise-associated stranding in 2000. The profile of this event was elevated because it occurred during the hearings and public comment period for the US Navy-proposed Surveillance Towed Array Sensor System – Low Frequency Active (SURTASS_LFA). But even while these high-profile cases were in play, there was still many questions about whether sound had negative impacts on marine mammals. Prior work on the impacts of marine mammals evaluated injury only in the context of secondary effects of noise disturbance of behaviors, and even as late as 2003 there had been little direct evidence of acoustic trauma in marine mammals.

Acoustical disturbance was first regulated under the MMPA in 1981 – mostly associated with “takes” from oil and gas exploration which at the time often used dynamite as the excitation source – so the regulation was more about impulse damage than “noise” per se.

Perhaps one of the more ambiguous statutory terms used in the regulation is the word “take.” The MMPA defined a “take” as “to harass, hunt, capture, or kill or attempt to harass, hunt, capture or kill any marine mammal” which likely folded out of the original driving incentive of the Act in response to high marine mammal mortality associated with purse seine operations, and of course the intentional takes of commercial whaling. The term is ambiguously defined until 1994, “…but in practice the term was interpreted to mean any documented change in distribution or behavior caused by human activity.”

There was also a lot of equivocation about the relative value of “takes” between commercial takes for zoos and aquariums, takes for scientific research, and takes by subsistence hunters.

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There was also the unintentional - or “incidental” takes for navy exercises and offshore oil and gas operations for which “Incidental Harassment Authorizations” were devised.

Distinguishing the severity of the takes began flavoring the 1981 amendments of the Act, but the actual statutory definitions of “Level A” and “Level B” takes didn’t show up until 1994, when the term “harassment” was statutorily defined under these distinctions. A “Level A” take is pretty clearly defined as “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild.” The acoustical exposure threshold for this can be determined by way of inferring (through auditory threshold testing) how loud a sound exposure would need to be to cause a permanent hearing damage. I say “inferred” because empirically determining the threshold of hearing damage on a marine mammal would be unethical and immoral.

**Determining regulatory thresholds**

In the early stages of the “Level A Take” defined by the National Marine Fisheries Service (NMFS) as a “do not exceed” threshold below which physical injury would not occur. In whales and whales, dolphins, and porpoises this was 180dB (re: 1μPa).

A “Level B Take” is defined as “any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered.” But defining what constitutes “disruption” is itself fraught with threshold vagaries – given that behavior is always contextual, and the weight of the biological significance of the disruption hinges on a human value scale. How biologically significant is it when Bowhead whales change their vocalization rates in response to barely audible airgun exposure, well below the Level B threshold? How biologically significant is it when a sea lion risks exposure to loud, intentionally (above Level A) Acoustic Harassment Devices in a behavioral relationship known as “the dinner bell effect.” (This is when the sound of a device intended to scare the sea lion away actually attracts them by letting them know that “dinner” is available.)

**Regulatory Metrics**

Regulations work best when they are unambiguous. Regulators are not fond of nuance. Dichotomous decisions of Yes/No, Go/No-Go are their stock and trade. It was for this reason that until just recently the marine mammal exposure guidelines were really simple:

- Noise exposure above 180dB = Level A exposure.
- Noise exposure above 160dB = Level B exposure (for impulsive sounds)
- Noise exposure above 120dB = Level B exposure (for continuous sounds)

But it was clear that these regulatory thresholds were actually too simple. When dolphins were riding the bow waves of seismic survey vessels – frolicking in a Level A noise field, it was apparent that the regulatory thresholds did not reflect common field conditions. This was recently addressed in guidelines that more accurately reflected the noise exposure criteria relative
to the hearing ranges of a range of the various marine mammal species – from large “Low Frequency” baleen whales, to small “High Frequency” dolphins and porpoises. While this new standard more accurately reflected the frequency-defined hearing ranges of the exposed animals, it did not accurately address the complexity of the noise exposures in terms of sound qualities, nor in terms of the complexity of the sound environments in which the exposures would typically occur.

**Actual sound exposures**

Increasingly complex signals are being used in the sea for underwater communication and equipment control. These communication signals can be rough or “screechy” sounding and more disturbing and more damaging than the simple signals used for auditory testing.

Additionally, when sounds presented in a typical Environmental Impact Statements, they are presented as single sources of sound. And while there is some consideration for accumulated noise impacts, the accumulation period “resets” after 24 hours, so the metric only reflects accumulated noise exposure and does not address the impacts of a habitat completely transformed by continuous, or ongoing noise. Given that typical seismic airgun surveys run around the clock for weeks to months at a time, and have an acoustical reach of hundreds to thousands of kilometers, the activity is likely to have much greater behavioral impact than is reflected in accumulating and dumping of a noise exposure index every 24 hours.

Furthermore, operations such as seismic survey, or underwater extraction industry operations typically have a lot of different, but simultaneous sound sources. Seismic surveys may include seafloor profiling with multi-beam or side-scan sonars. Underwater extraction industries such as seafloor processing for oil and gas extraction, or seafloor mining operations will necessarily have multiple sound sources - with noisy equipment, along with acoustical communications for status monitoring, and acoustical remote control of the equipment. These concurrently operating compliments of equipment can create a very complex soundscape. And even if the specific pieces of equipment don’t in-and-of-themselves exceed regulatory thresholds, they may nonetheless create acoustically-hostile soundscapes likely to have behavioral and metabolic impacts on marine animals. So far there is no qualitative metrics for compromised soundscapes, but modeling for concurrent sound exposures is possible, and in this context, many concurrent sounds would constitute “continuous sound,” thereby qualifying the soundscape as a whole under the Level B continuous sound criteria of 120dB.

This is particularly the case for a proposed set of seismic surveys in the Mid-Atlantic, wherein three separate geophysical surveys would be occurring simultaneously in close proximity. “Incidental Harassment Authorizations” have been released by NOAA Fisheries for these surveys which have not taken the ‘concurrent noise exposures’ into account.

Additionally, while sound sources in the near-field may be considered “impulsive sounds.” And thus regulated under “Level B” criteria for impulse sounds, due to reverberation, louder sounds which have a long reach should be considered as “continuous sound sources” and thus be regulated under the Level B ‘continuous sound’ criteria of 120dB.
Recommendations:

1. NOAA sound exposure metric should be updated to reflect sound quality (accommodating for signal characteristics) as well as amplitude.
2. “Soundscapes” need qualitative and quantitative definitions, and then incorporated into the regulatory framework.
3. Exposure metrics needs to accommodate for concurrent sound source exposures.
4. The threshold for what constitutes “continuous sound” needs to be more clearly defined, particularly in terms of loud sound sources in the far field subject to reverberation and “multi-path” echoes.