UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115

Memorandum

To: Interested Parties

From: NMFS Northwest Region and Northwest Fisheries Science Center

Subject: Guidance Document: Data Collection Methods to Characterize Underwater Background Sound Relevant to Marine Mammals in Coastal Nearshore Waters and Rivers of Washington and Oregon

Date: January 31, 2012

Objectives: Provide guidance to characterize underwater background sound (overall sound levels absent those from the proposed activity) in areas of proposed activities that have the potential to injure or disturb marine mammals. These measurements should take into account spectral, spatial and temporal considerations, as specified below. Equipment considerations and guidance on data processing are also provided.

Scope: This guidance is applicable to characterizing background sound in the Northwest Region, specifically for use in marine mammal consultations and permit applications, pursuant to the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). These measurements should take into account spectral, spatial, and temporal considerations, as specified below. Equipment considerations and guidance on data processing are also provided.

Guidance:

Spectral considerations

For purposes of characterizing background sound relevant to marine mammals, analysis of collected data should eliminate frequencies below the range of functional hearing of marine mammals (described in Southall et al. 2007). The list below identifies common species that occur in nearshore waters of Washington and Oregon by functional hearing group.

Common marine mammal species that occur in nearshore waters of Washington and Oregon:

- Low-frequency cetaceans: humpback, gray and minke whales
- Mid-frequency cetaceans: killer whales (resident and transient)
- High-frequency cetaceans: harbor and Dall's porpoises
- Pinnipeds: Steller and California sea lions, harbor seals, and northern elephant seals

Previous field measurements in this region demonstrate that there is an insignificant amount of acoustic energy contributed to background sound above 10 kHz in terms of overall sound pressure level (SPL).

For example, a study originating from the Smith Island Marine Sanctuary in Washington, (Dall'Osto 2009) found that the SPL for background sound levels when based on inclusion of frequencies up to 50 kHz (beyond which thermal noise influences the measurement) is less than 0.1 dB greater than the SPL based on inclusion of frequencies only up to 10 kHz. This is also consistent with background sound spectra shown in Figures 4 and 5 of Holt (2008), for which the spectral rate of decay is between 30 and 35 dB between 100 and 10,000 Hz (or two decades). Therefore, doubling this value to 20 kHz provides a robust high-frequency limit (f-high) for all background sound estimates, whereas the low frequency limit (f-low) should be defined by the estimated auditory bandwidth for each functional hearing group (Table 1).

At very low frequencies (i.e., around f-low for the low-frequency cetaceans), self-noise from hydrophone and cable movement may contaminant recordings and in most cases commercially available devices will have a high-pass filter in which signal attenuation or roll-off begins above 7 Hz. A compensation factor may be applied to the data during post-processing that will add an equivalent amount of gain that compensates for roll-off above 7 Hz. The specifications of any compensation factor applied to the data should be documented. In other cases, there should be no attenuation in the band between f-low and f-high for the appropriate functional hearing groups listed in Table 1. The roll-off below f-low and above f-high should be as steep as possible and at a rate of at least -40 dB/decade (a decade is a factor of 10 in frequency) after f-low and f-high.

Table 1. F-low and f-high limits for characterizing underwater background sound relevant to marine mammals.

Functional hearing Group[1]	f-low[2]	f-high[3]
Low-frequency cetaceans	7 Hz	20 kHz
Mid-frequency cetaceans	150 Hz	20kHz
High-frequency cetaceans	200 Hz	20 kHz
Pinnipeds	75 Hz	20 kHz

[1] See the above list of common species that occur in nearshore waters of Washington and Oregon, which identifies species to functional hearing groups. All genera represented in each functional hearing group are specified in Southall et al. 2007.
[2] F-low values of estimated auditory bandwidths in Southall et al. 2007.
[3] As justified in the above Section.

Spatial considerations

The location of background sound measurements needs to be in close proximity to the area of the proposed activity. One hydrophone is sufficient for conducting measurements. The hydrophone should be placed within 500-1,000 m distance of the proposed activity. Hydrophone depth should be between mid-water column to at least 4 m above the bottom. This depth range will best sample the nominal central tendency of the background sound. Remaining at least 4 m above the bottom is preferable to avoid accidental immersion of the hydrophone into the sediment and consequent contamination of the measurement. In shallow waters, nearshore

waters, and rivers there is no critical depth below which background sound decreases, and thermoclines that are sufficiently strong and acoustically relevant are largely absent (e.g., as documented in Puget Sound; Dall'Osto 2009). Hydrophone placement should not be in a ferry or shipping lane. If the site being characterized has a current velocity ≥ 1.5m/sec, flow noise may influence measurements. Best practices to minimize flow noise include deploying the hydrophone at a depth close to the bottom (but at least 4m off the bottom) or use of a flow shield made of latex or spandex that does not trap air, such as the shroud depicted in Figure 1.

Figure 1. Remote hydrophone device with flow shield providing a fluid filled space between shield and hydrophone (photo: J. Laughlin, WSDOT).

Temporal considerations

A variety of temporal factors affect background sound levels. For example, close approaches by vessels and inclement weather will likely result in the highest background levels. Thus, it is necessary to capture the temporal variation in background sound levels that occur at the location of interest. Measurements should be collected during the period when the proposed action is likely to be conducted (e.g., within the in-water work window). If the proposed action is restricted to daylight hours, one could limit data collection or the data used in analysis to daylight hours, as inclusion of night hours may underestimate background sound levels (e.g., Veirs and Veirs 2006). Collect at least three consecutive 24-hr periods (or, optional, three consecutive daylight periods if work is restricted to daylight hours) (Stockham et al. 2010).

Data should be collected during the season when pile driving will occur. There may be seasonal differences in background sound levels depending on site-specific characteristics, such as increased recreational boat traffic during summer months (e.g., summer background sound is typically 3 dB higher than winter background sound in Haro Strait; Veirs and Veirs 2006). If pile driving is anticipated to occur in more than one season then data should be collected to capture seasonal variability. If it is not possible to collect data in more than one season, winter

season is preferable since sound levels in the winter are likely lower (i.e., less recreational boat traffic).

Data processing

Measurements should be reported in overall SPL across the entire frequency band (referred to as "broad band SPL", and defined as the decibel equivalent of the rms pressure within the frequency band, referenced to 1 μPa). This SPL will be consistent with the way NMFS applies acoustic thresholds for marine mammals that are also in dB rms units. Overall dB rms levels should be based on short enough time windows to capture temporal variation in sound levels. Those based on 10-30 sec averages will likely capture this variation. For example, a single datum represents the decibel-equivalent of the 30-sec rms pressure (for defined frequency range, e.g., 150 Hz to 20 kHz); there would be 2,880 of such data points collected in one 24-hour period, or 8,640 in a 3-day period. From this set of data, a cumulative distribution function (CDF) can be generated. Figure 2 (from Stockham et al. 2010) shows such a CDF along with several percentiles. For example, the 50th percentile in this example is 96 dB (CDF = 0.5), the 5th percentile is 90 dB, and the 95th percentile is 112 dB.

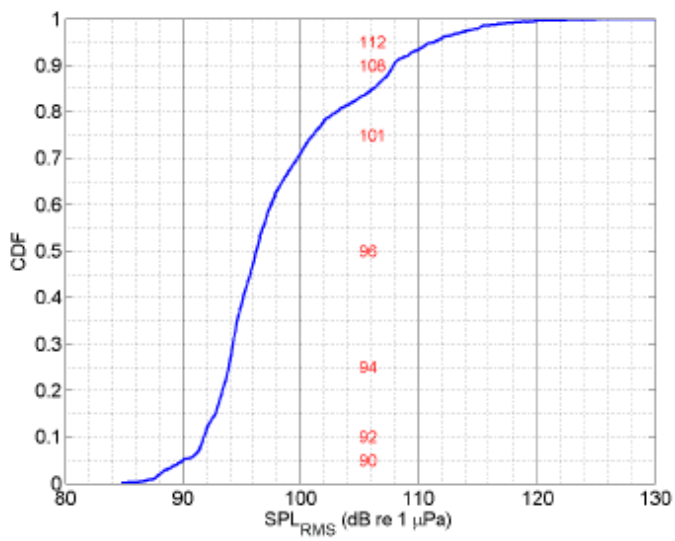

Figure 2. Example of a cumulative distribution function for background noise, with 7 percentile values shown by the red numbers.

In order to characterize average conditions, the dB rms level that occurs at least 50% of the time (50th percentile) should be the value represented in consultations as average background sound.

Equipment considerations

The hydrophone should be appropriate for the frequency range of measurements. It should be calibrated having a known and flat frequency response curve across the bandwidth of measurements. If the same recording system will be used for all functional hearing groups listed above (Table 1), then this range would be from 7 Hz to 20 kHz. Otherwise, the hydrophone used to collect background sound measurements should have a nominally flat frequency response between 20 Hz to 20 kHz. The particular hydrophone sensitivity (with gain stage included) should be noted, for example, -160 dB re 1 V/μPa. The recording system should have the

capability to continuously record sound levels at a minimum of three consecutive 24-hour periods. The self noise floor of the recording system should be compared with the lowest spectral level measured in the field to illustrate that the reported levels are not limited by equipment performance.

References

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