Underwater acoustic assessment during pier demolition and reconstruction in Bechers Bay, Santa Rosa Island, 2009-2011

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Abstract
Anthropogenic underwater noise emitted during marine construction poses a serious threat to marine mammals by exposing them to potentially loud sounds that can potentially impair hearing and disrupt normal behavior. Underwater noise was monitored during demolition and reconstruction of a pier in Bechers Bay, Santa Rosa Island, CA from April 2009 to April 2011. Sound pressure levels (SPLs) were monitored for noise spikes exceeding 160 dB re 1 µPa, the level that harassment threshold for pinnipeds and cetaceans. Demolition by hydraulic vibratory pile extraction and partial drilling via pneumatic percussion occurred from May to October 2010 for which SPLs were recorded on 27 monitoring days via a hydrophone interfaced with dynamic acquisitioning system/USB audio input (different units were used per season). Sound pressure levels (SPLs) were monitored and recorded in order to determine if noise levels exceeded 160 dB re 1 µPa, the level B harassment threshold for pinnipeds and cetaceans (MMC 1995). Demolition by hydraulic vibratory pile extraction and partial drilling via pneumatic percussion occurred from May to October 2009 (Season 1). Reconstruction via an auger drilling technique, a relatively new method consisting of six in-water construction phases, occurred from November 2010 to April 2011 (Season 2). Acoustic data from both seasons are presented to provide preliminary information on the potential difference in noise level production between these two pile driving methods of construction.

Introduction
Marine construction can generate harmful anthropogenic underwater noise that would expose marine mammals to potentially loud sounds leading to disruption of their behavior, hearing impairment, stress, and, in extreme cases, death (Lepper 2007, Wellard 2007). As part of a mitigation and compliance project during demolition and reconstruction of a pier in Bechers Bay, Santa Rosa Island, CA, sound pressure levels (SPLs) were monitored and recorded in order to determine if noise levels exceeded 160 dB re 1 µPa, the level B harassment threshold for pinnipeds and cetaceans (MMC 1995). Demolition by hydraulic vibratory pile extraction and partial drilling via pneumatic percussion occurred from May to October 2009 (Season 1). Reconstruction via an auger drilling technique, a relatively new method consisting of six in-water construction phases, occurred from November 2010 to April 2011 (Season 2). Acoustic data from both seasons are presented to provide preliminary information on the potential difference in noise level production between these two pile driving methods of construction.

Methods
• A single omni-directional hydrophone was interfaced with a laptop computer equipped with a dynamic real-time high-speed acquisitioning system/USB audio input (different units were used per season).
  - Season 1: Sensor Technology Ltd Hydrophone A (Sensitivity = -197.98 dB; Capacitance 9.8 nanofarad (nF); Dissipation 0.017%) or B (Sensitivity = -197.69 dB; Capacitance 10.9 nF; Dissipation 0.016%) was interfaced with a Dell™ Latitude D630 equipped with Soundscape software (Sound Technology).
  - Season 2: Sensor Technology Ltd Hydrophone C (Sensitivity = -198.3 dB; Capacitance 10.47 nanofarad (nF); Dissipation 0.016%) was interfaced with a Panasonic Toughbook Model 1400 ENV equipped with Soundscape software (Sound Technology).
  - Hydrophone deployed to 1-2 m depth from inflatable skiff (10') located 50-200 m offshore for 17 days in season 1 and 23 days in season 2; or from a platform located under the pier (112-140 m from shore) for 34 days in Season 2.
  - Recordings collected for 1-5 min every 30-60 min during in-water construction. Maximum SPLs per recording documented.
  - In Season 1, SPLs logged continuously in real-time 1/4, during all phases of in-water construction.
  - In Season 2, SPLs over 160 dB threshold were recorded instantaneously when they occurred (by max. spike per min.).
  - Source SPLs calculated with cylindrical spreading equation:
    \[ TL = 20 \cdot \log \left( \frac{D}{r} \right) \] (\( r \) = distance to sound source, measured with range finding binoculars)

Table 1. Descriptive statistics for Seasons 1 and 2 including the calculated source SPL (dB re 1 µPa), arithmetic average, maximum, minimum, and when exceeding the 160 dB threshold, and the number of instantaneous noise spikes.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average SPL (dB re 1 µPa)</th>
<th>Minimum SPL (dB re 1 µPa)</th>
<th>Maximum SPL (dB re 1 µPa)</th>
<th>Number of Instantaneous Noise Spikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season 1</td>
<td>150</td>
<td>148</td>
<td>167</td>
<td>19</td>
</tr>
<tr>
<td>Season 2</td>
<td>139</td>
<td>165</td>
<td>185</td>
<td>283</td>
</tr>
</tbody>
</table>

Conclusions
• The average calculated source SPL for Season 1 (150 db re µPa) was much higher than that of Season 2 (129 db re µPa), suggesting that the lesser-used auger drilling technique produces less underwater noise (Table 1).
• The most instantaneous noise spikes above 160 dB (72-4%) were produced during the auger drilling phase of in-water construction in Season 2, when compared to the other 5 phases, suggesting that the action of driving the auger screw into the sediment contributes most to the total underwater noise produced (Table 2).
• Though the number of instantaneous noise spikes above 160dB produced during Season 2 (283) was dramatically higher than the number documented during Season 1 (29), this is likely a result of the different SPL measurement protocols between seasons, as well as the increase in the number of acoustic monitoring days in Season 2. Therefore, the amount of noise spikes shown for Season 1 (Table 1) is not an accurate report of the actual amount that could have occurred if that method had continued.
• Because of differing methods of SPL collection between seasons (i.e., instantaneous noise spikes were only documented during the 5 minute sound recordings in Season 1), data from both seasons cannot be compared directly. Instead, the recorded calculated source SPL averages per season provide suggestive evidence that the auger drilling technique (Season 2) generates less noise overall, and therefore is less potentially harmful to marine mammals when in proximity to marine construction.

Literature Cited

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Figure 2. Calculated source SPLs for 17 days of acoustic monitoring during demolition and pneumatic percussion drilling (Season 1).
Figure 3. Calculated source SPLs measured for each defined in-water construction phase during Season 2, including percentage of noise spikes and the maximum calculated source SPL when exceeding 160 dB re µPa.
Figure 4. Calculated marine SPLs measured at each defined in-water construction phase during real-time monitoring and sound recordings during Season 2.
Figure 5. Pneumatic hammer being inserted into piling (Photo by: Erica Dazey 2009).
Figure 6. Auger drill positioned above piling (Photo by: Brittany McIntosh 2010).

Table 2. Descriptive statistics per defined in-water construction phase during Season 2, including percentage of noise spikes and the maximum calculated source SPL when exceeding 160 dB re µPa.