

additional commenter concerns and NMFS determination on mitigation.

The PIDP study involved driving three piles, with two different sizes of hammers and the use of two different methods of underwater sound attenuation. The test piles, Piles 1, 2 and 3, were made of steel and were 2.4 m (8 feet) in diameter. Pile 1 was driven straight down and did not use any sound attenuation. Pile 2 was a battered pile angled 1h:6v to the east and used an air bubble curtain. The single-ring air-bubble curtain provided a curtain of air around the pile to attenuate noise from driving activities. Bubbles emerged from a submerged piping system that surrounded the pile template (used to hold the hammer/pile in place). The piping system was comprised of three 10.2-cm (4-in) diameter perforated polyvinyl chloride (PVC) pipes attached to a steel frame, forming a 30.5-m (100-ft) diameter octagonal ring. Two rows of 0.1-centimeter (0.04-inch) diameter holes were drilled into the PVC pipes. The bubble curtain system was fabricated and assembled off-site, then transported to the pile-driving site using a barge-mounted crane. The piping system ring was then submerged to the Bay floor to encircle the pile template. Air was supplied from a 1,600 ft³/min (cfm; 45.3 m³/min) compressor located on the PIDP barge. Though Pile 2 was driven at an angle, the bubbles streamed straight up to the water surface, potentially providing less attenuation near the surface than at greater depths. A similar system was used by Wursig *et al.* (2000) for attenuating noise received by dolphins during pile driving activities for an airport expansion.

Pile 3 was a battered pile angled 1h:6v to the west and was surrounded by a proprietary method of sound attenuation referred to as a fabric barrier system with an aerating mechanism. The fabric barrier system consisted of an in-water, double-layer fabric curtain with a single 7.6-cm (3-in) diameter pipe between the two fabric sheets and three 7.6-cm (3-in) diameter pipes between the inner fabric layer and the pile. The fabric curtain was made of water-permeable material which enclosed the pile template. The top of the curtain attached to the pile template at a level a few meters above the surface of the water. The bottom was attached with beams to the bottom of the template. The fabric barrier system with aerating mechanism had a 10.7-m by 22.9-m (35-ft by 75-ft) rectangular footprint. This proprietary fabric barrier system with aerating mechanism was assembled and attached to the template off-site. The template/air bubble and

fabric barrier was transported by barge to the Pile 3 location. Air was supplied from the same 1,600-cfm compressor that was used on Pile 2; however, air was supplied to four pipes which were arranged in a smaller footprint than for the air bubble curtain, thereby providing a higher density of air bubbles around the pile.

Each pile was made up of four 33-m (108-ft) long sections which were driven and welded together in succession until the full length of the pile was achieved. Two types of Menke hydraulic hammers were employed to drive the piles; a small hammer rated at 500 kJ, and a large hammer rated at 1,700 kJ.

Sound measurements were taken during pile driving, and marine mammals were monitored at the project site and at harbor seal haul-out site on YBI. Problems were encountered with the collection of data about sound pressure levels. As a result, the information about sound pressure levels that CALTRANS has obtained to date is limited. Based on the available data, the distances to the 190 dB contour for the large hammer without attenuation was estimated for each test pile driven. (The underwater sound level boundary for the pinniped safety zone was specified by the IHA as 190 dB re 1 mPa RMS (impulse) to protect pinniped hearing). Field measurements indicated that this 190 dB re 1 microPa RMS (impulse) contour would be between 100 and 350 m (328 and 1,148 ft) for the unattenuated pile (Pile 1) and the bubble curtain pile (Pile 2) and less than 100 m (328 ft) for the fabric barrier system with aerating mechanism (Pile 3).

The PIDP Report (CALTRANS, 2001) determined that:

the air bubble curtain is effective and adaptable to a seafloor with either a sloping or flat bottom. The air bubble curtain has a disadvantage in that fast currents in deep water may divert the air bubbles at an angle thereby reducing the effectiveness of the curtain. However, even with strong currents during the PIDP, the bubbles always surrounded Pile 2. Assembly of the bubble ring must typically be done off-site where sufficient land area is available for construction. For repeated use during the proposed East Span Project, this system could be redesigned to better withstand the pressures of being repeatedly raised to the surface. When compared to the fabric barrier system with aerating mechanism, there would be a larger economy of scale if it were designed for multiple reuse. The air bubble curtain is advantageous in that it does not need to be attached to the pile template itself, and marine construction equipment can easily maneuver around and over the site without any hindrance from the air bubble curtain. Marine construction equipment does

not appear to affect the operation of the air bubble curtain. For reuse, the air bubble system's lack of bulk reduces the deployment logistics of relocating it to other pile locations. Once deployed, this system requires minimal inspection. With easier deployment maneuverability, and minimal inspection, the chances for time consuming delays would likely be decreased. For the PIDP, the bid cost was \$120,000 for one installation.

The fabric barrier system with aerating mechanism would be most effective in an area where a flat or consistently level bottom exists. Differences in bottom contour would result in a gap between the bottom of the curtain and the seafloor where sound would not be attenuated. For the proposed East Span Project, this system might be redesigned to be smaller for a single pile or much larger for a whole pier system. When compared with the air bubble curtain, there would be a smaller economy of scale if this system were designed for multiple reuse. Designing this system for reuse may include moving the template off-site, fitting different length curtain to it, and returning the refitted template back out to the project site. This could reduce the possibility of a gap between the bottom of the curtain and the sloping seafloor bottom. Costs would increase if the system needed to be redesigned for varying bottom elevations. Strain on the system from currents is less of a problem with this device than with the air bubble curtain alone, as the weight of the (fabric) curtain typically keeps the system nearly vertical. For the PIDP, the fabric barrier system was attached to the pile template by the proprietor of the system. In future applications, this can be expected to be performed off-site. The bulkiness of this arrangement makes movement to the project site and movement between piles to be driven very difficult. The first attempt to deploy this system at the PIDP had to be postponed because in windy weather the (fabric) curtain and template effectively acted as a sail. The height of this system and having it welded to the template does not allow for easy maneuverability for the marine equipment. For example, a derrick barge cannot maneuver over it, and equipment on the barge must reach over the barrier to the pile being driven. Once deployed, this system requires inspection of the condition of the zippers in the fabric and the bottom alignment. Any damage to the fabric barrier system would likely require removing the template and barrier from the water to conduct repairs. This would cause time-consuming delays to the pile driving operations. For the PIDP, the bid plus change order cost was \$580,000 for one installation at Pile 3. This included an additional bubble ring between the curtain and the pile, which was not in the project specifications, but likely aided in sound attenuation.

CALTRANS believes that an air bubble curtain is preferable to the fabric curtain in that the air bubble curtain does not need to be attached to the pile template itself and the marine equipment needed on site can easily maneuver around and over the site without any hindrance. The air bubble