

Bodega Bay Boat Launch Facilities Improvements Acoustical Analysis



Prepared for:

Sonoma County Regional Parks
2300 County Center Drive, Suite 120A
Santa Rosa, CA 95403

Prepared by:

Prunuske Chatham, Inc.
400 Morris St., Suite G
Sebastopol, CA 95472

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Acronyms

Caltrans	California Department of Transportation
dB	Decibels
dB RMS	Root-mean-squared decibels
dBA	A-weighted sound levels measured in decibels
EFH	Essential Fish Habitat
FHWA	Federal Highway Administration
Hz	Hertz
IL_{bar}	Insertion loss from barriers
L_{dn}	Day-night noise level
L_{eq}	Equivalent noise level
L_{max}	Maximum noise level
L_{min}	Minimum noise level
L_{min}	Minimum noise level
L_x	Noise level exceeded X% of the time
OSHA	Occupational Health and Safety Administration
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
Pa	Pascal
PPV	Peak particle velocity
SCRIP	Sonoma County Regional Parks
SEL	Sound exposure level
SPL	Sound pressure levels
μPa	micro Pascals
VdB	Vibration decibels

ACOUSTICAL ANALYSIS FOR BOAT LAUNCH FACILITIES IMPROVEMENTS AT WESTSIDE AND DORAN REGIONAL PARKS

Noise Assessment Process

Introduction

Sonoma County Regional Parks (SCRCP) is proposing upgrades to the boat launch facilities at Doran and Westside Regional Parks. In compliance with County, state, and federal regulations, SCRCP conducted acoustical analysis to identify potential noise conflicts between the proposed project and existing uses. This assessment exclusively evaluates noise from construction because the facilities upgrades are not expected to change or increase use at the project sites.

Sound and Noise

Sound and noise, although often used interchangeably, are distinct. Sound is used to describe both the actual physical pressure differences in the air caused by sound-generating events, which result in vibrations, and the way the pressure differences are directly perceived. For example, a person clapping compresses the air as they bring their hands together. Those compressions propagate through the air in expanding and contracting pressure (sound) waves. The sound waves spread out in a sphere around the point where the hands collided with the intensity of the wave diminishing as the size of the sphere increases. When the sound pressure waves reach someone who can hear them, called a “receptor,” the pressure waves get interpreted into what we generally think of as sound, and the receptor “hears” a clap. Thus, sound has two components, the physical waves and the hearing capacity of the receptor.

Sound is measured by instrumentation that deals with the physical characteristics of the wave, but the importance of the measurement results is interpreted by the way the receptor perceives the sound. Since there is a finite amount of energy in the vibration or compression that generated the sound, the energy at any part of the sphere is reduced as it expands. Thus, the further the receptor is from the sound source, the quieter it will seem.

Noise is a particular kind of sound that is generally unwanted by, and sometimes damaging to, the receptor. Depending on the sound generated, different people may experience it differently, such as music that soothes one person but is annoying to another. However, some sounds will always be disruptive or annoying, such as very loud sounds or high-pitched whines. Negative effects of noise include simple annoyance, stress, sleep disruption, concentration challenges, cognitive impairment, high blood pressure, gastrointestinal problems, chronic fatigue, and hearing loss (Occupational Health and Safety Administration (OSHA) 2011; Stansfeld & Matheson 2003). The California Department of Transportation (Caltrans) defines noise as “(airborne) sound that is loud, unpleasant, unexpected or undesired” (Caltrans 1998). Although this definition limits noise to air, human activities can also create underwater sounds that can cause disruption and physical damage to aquatic and marine wildlife. In air, in ground, and underwater sounds are all considered noise for environmental analysis herein.

When a sound is made, the energy of motion of an object colliding or vibrating is translated into motion of energy as a pressure (compression) wave through a medium such as air, water, or soil. Sound waves have three characteristics:

- The amount of pressure in the sound wave (amplitude), which we interpret as loudness.
- The wavelength or frequency, which we interpret as pitch.
- Timing, which encompasses how long a particular sound lasts, how often it recurs, and the percent of the time it occurs.

Each of these characteristics can be described in a number of ways depending on the purpose of the sound evaluation.

The loudness of a sound is primarily a result of the amplitude (pressure difference with each compression) of the sound waves, generally measured in Pascals (Pa). The range of human hearing is from 20 micro Pascals (μPa) to 20,000 Pa, the loudest sound humans can hear without pain. Since assessing values with this magnitude difference is a bit unwieldy, sound pressure is converted into a logarithmic scale of sound pressure levels called decibels (dB). Decibels are actually a ratio of the measured sound to a reference sound level chosen so that the threshold of human hearing is at 0 dB. Sounds above 90 dB can damage hearing with prolonged exposure. Sounds above 140 dB can cause deafness with short-term exposure.

The frequency or pitch of a sound is measured in hertz (Hz), which correspond to cycles per second, describing the number of compressions that pass a point within one second. Human hearing for a young person with good hearing spans a range of approximately 20 to 20,000 Hz. Higher pitches indicate air that is vibrating faster and has more energy, which is the other way to assess the energy in a sound. The total mechanical energy in a sound is a combination of the amplitude and frequency and is measured in watts.

For environmental noise measurements, pitch is important because humans hear more of the amplitude of a sound in the middle frequencies than at the ends of the spectrum. From approximately 1,000 to 5,000 Hz, humans hear most or all of a sound, so electronic filtration is used that de-emphasizes the frequencies below 1,000 Hz and above 5,000 Hz to create readings that more strongly emphasize sound levels as they are relevant to humans in most circumstances. This method of frequency weighting is referred to as A-weighting and is expressed in units of A-weighted decibels (dBA). Other weighting systems exist but are not relevant to this project.

In addition to A-weighting, other adjustments may be made to account for the differences in how noise is experienced depending upon circumstances. Isolated sounds with low background level noise may sound much louder than they otherwise might. The nature of the sound, such as continuous or sudden, may also influence how it is perceived. Since sensitivity to noise increases during the evening and at night – because excessive noise interferes with the ability to sleep – 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. In Sonoma County, the General Plan 2020 provides separate standards for daytime and nighttime noise, with nighttime defined at 10 pm to 7 am.

Sound Attenuation

Sound attenuates over distance, greatly reducing noise impacts. Sound is usually generated as a point source vibration. The sound expands in all unblocked directions, creating a sphere. As the sphere grows, the initial energy of the sound source is spread in all directions so that the amount of energy at each point in the sphere is lower. Thus, the sound pressure level (SPL) is inversely proportional to the distance from the source. This relationship is captured for air as a 6 dB drop for each doubling of the distance from the sound source. Because distance is a critical factor in sound level, decibels always need to be evaluated by where they are measured or received.

Objects that block sound can also attenuate noise. Sound travels in air, water, and solids. However, depending on the circumstances of the transition, much sound can be lost by reflection or refraction at the border between different media. In addition, many solids attenuate sound more sharply than air or water so a solid barrier can very much reduce the sound at a sensitive receptor. Sound barriers may be:

- Natural, such as a hill,
- Fortuitous, such as a warehouse that just happens to have been built between a freeway and a school, or
- Intentional, such as a freeway sound wall.

Sound in Water

Sound in water has notable differences to sound traveling in the air. The sound wave is similar, but traveling through the denser medium (more molecules per volume) generates higher pressures and longer wavelengths. The overall speed of sound in water is about 4 times the speed of sound in air. The SPL is still measured in decibels but uses an unweighted scale and a different reference sound level (1 μ Pa) to encompass the range of potential receptors. As in air, sound in water can spread spherically or cylindrically depending upon whether the sound comes from a point source or a line source.

Vibration - Sound in Ground

Vibration is sound radiated through the ground. Sound waves in the ground differ from those in air; they have the compression wave in the direction of travel but also have shear waves that vibrate perpendicular to the direction of travel. Caltrans usually describes ground motion caused by vibration as vibration velocity amplitude measured as peak particle velocity (PPV) or vibration velocity level measured as vibration decibels (VdB) (Jones & Stokes 2004). As with water, vibration velocity levels are compared to 1 μ Pa. Groundborne vibration can cause disturbance to sensitive humans and cosmetic or structural damage to buildings. It can also interfere with sensitive instrumentation or other human uses that respond to vibration.

The most sensitive use to groundborne vibration is laboratory equipment, which can be negatively impacted by a vibration level as low as 42 VdB (FTA 2006). The background vibration velocity level in residential areas is usually around 50 VdB. The vibration velocity level threshold of perception for humans is approximately 65 VdB. Residential structures should not be exposed to levels above 72 VdB during the night and 78 VdB during the day (FTA 2006). Typical sources of perceptible groundborne vibration generated by construction come from jackhammers, pile driving, crack-and-seat operations, demolition, and blasting (Jones & Stokes 2004).

Noise Impacts

Noise can create a variety of problems. In humans, noise can:

- Cause annoyance;
- Disrupt sleep;
- Induce stress and anxiety;
- Impair decision-making functions;
- Reduce children's development of cognitive and language skills;
- Damage hearing;
- Slow healing;
- Cause long-term health impacts, including high blood pressure, gastrointestinal problems, and chronic fatigue; and
- Increase incidence of fatal heart attacks.

(Novotney 2011; OSHA 2011; World Health Organization and the European Commission's Joint Research Centre 2011)

Noise can also create severe disruptions to wildlife, including avoidance behavior, reduced foraging and breeding, and death.

Assessment Process

Noise assessment has 4 components: characterizing the existing noise environment, identifying sensitive receptors likely to hear project noise, identifying changes in noise level likely to be generated by the project, and evaluating potential conflicts between project noise generated in the context of existing conditions and noise tolerance of sensitive receptors. Mitigation measures are then recommended to resolve potential conflicts.

To evaluate the existing noise environment, sound measurements were taken at 4 locations in the project area on November 19, 2012. Measurements were taken during business hours, during the week. Peak noise in the project area is likely to occur mostly on weekends because of higher tourist and recreational use; however, project construction is planned for the traditional workweek. Therefore, workweek measurements give the best approximation of background noise.

Measurements of equivalent sound level (L_{eq}), maximum sound level (L_{max}), and minimum sound level (L_{min}) were recorded with A-weighting over 30-minute intervals using a Casella CEL-246 integrating sound level meter set to a 30 – 100 dB range. No range exceedances were recorded. The instrument was calibrated before each measurement using a CEL-120/2 single level acoustic calibrator. A foam windshield was used for all measurements.

Nearest sensitive receptors were preliminarily identified by aerial photography and then field verified. The distance from project activities was measured using ArcGIS tools. Priority categories for sensitive receptors were taken from the Sonoma County General Plan 2020 prioritization.

Project noise contributions are anticipated to occur only during construction; post-project conditions will not change compared to pre-project conditions. Noise of construction was calculated at the nearest sensitive receptor using compiled data from Caltrans and individual monitoring data from similar projects to provide base noise output of the kinds of construction activities required for this project. In order to compare the maximum noise level from the construction equipment to County standards, maximum noise levels were converted to the equivalent noise level in continuous noise (L_{eq}) and the 10% exceedance levels (L_{10}) using equations from the *Road Construction Noise Manual* (FHWA 2006).

$$L_{eq}, \text{ dBA} = L_{max} \text{ at 50 feet} - 20\log(D/50) + 10\log(UF/100)$$

$$L_{10}, \text{ dBA} = L_{max} \text{ at 50 feet} - 20\log(D/50) + 10\log(UF/100) + 3 - IL_{bar}$$

Where:

L_{max} at 50 feet = maximum equipment noise level at 50 feet from previous data

D = distance of interest to the nearest sensitive receptor

UF = usage factor or fraction of time period of interest equipment is in use

IL_{bar} = noise reduction from intervening noise barriers

For this analysis, factors such as the sound absorbency or reflectivity of the ground were not considered because the sound path to the nearest sensitive receptor is a mixture of hard and soft ground, but with a preponderance of soft ground, grass, and low bushes that absorb sound. Therefore, the estimates without ground considerations are conservative toward protecting sensitive receptors. Likewise, IL_{bar} was not included in the calculations because there are no substantial noise barriers between the project site and the nearest receptors.

Potential conflicts were identified using standards generated by the government entity with primary responsibility for health and well being of the receptors, Sonoma County for humans and NOAA Fisheries for marine wildlife. Mitigation measures proposed followed the guidance of those agencies.

Both analysis of potential groundborne vibration and acceptable levels followed Caltrans guidance in the *Transportation- and Construction-Induced Vibration Guidance Manual* (Jones & Stokes 2004). The manual states that humans begin to perceive vibration at 0.01 to 0.04 PPV, and annoyance begins between 0.1 and 0.9 PPV. Structural damage on older residential structures begins at 0.3 PPV for intermittent and continuous sources. The manual provides equations to calculate the particle velocity for both impact and vibratory pile drivers:

$$PPV_{\text{Impact Pile Driver}} = PPV_{\text{Ref}} (25/D)^n (E_{\text{equip}}/E_{\text{Ref}})^{0.5}$$

Where:

$PPV_{\text{Ref}} = 0.65$ in/sec for a reference pile driver at 25 feet

D = distance from pile driver to the receiver in feet

n = 1.1 is a value related to the vibration attenuation rate through ground

$E_{\text{Ref}} = 36,000$ ft-lb (rated energy of reference pile driver)

E_{equip} = rated energy of impact pile driver in ft-lb

$$PPV_{\text{Vibratory Pile Driver}} = PPV_{\text{Ref}} (25/D)^n$$

Where:

$PPV_{\text{Ref}} = 0.65$ in/sec for a reference pile driver at 25 feet

D = distance from pile driver to the receiver in feet

n = 1.1 (the value related to the attenuation rate through ground)

Project Description

Proposed Action

SCRP proposes renovating boat launch facilities at the two parks to improve boating safety and access. The project has three components: resurfacing boat launches and upgrading supporting facilities, dredging of the side channel to Westside Regional Park from the main channel maintained by USACE, and dredge material upland placement/dune restoration at the Cypress Day-use Area.

Project Elements that May Create Noise-related Impacts

The project would only create new noise from construction. Site use and noise generation after construction would remain largely unchanged, although there may be minor noise reductions from resurfaced parking at Doran Regional Park where parking conditions are currently gravel and very broken pavement. All project elements will produce some construction noise. Overall, construction would take 16 weeks at Westside and 10 weeks at Doran. Construction at the two sites would occur in different years. Construction activities are proposed to occur during daytime, non-weekend hours. Overall, construction noise is likely to be fairly constant during the workday. Overall estimates for construction noise are included in Tables 3-5 in the Project Noise section below.

Certain project construction elements would create higher sporadic noise, including:

- ***Channel Dredging:*** In order to avoid sediment impacts on sensitive habitats, channel dredging will likely use a clamshell shovel. This shovel closes, creating higher noise levels than other construction equipment.
- ***Pile Driving:*** Floating docks at both Doran and Westside need new pilings. The piles would be 12-18 inches wide and would be driven into loose, wet bay sediments with the lowest portions in firmer material beneath for stability. Pile driving may be done with an impact or vibratory hammer. Impact pile driving, in addition to being loud, creates an impulsive noise that is more disruptive than continuous sound.

Project Setting

Regulatory Setting

Federal, state, and local jurisdictions have the authority to regulate the ambient noise environment to provide for the public good, including human health and environmental integrity. Sonoma County has primary responsibility for public health and welfare in the project area. The recently adopted General Plan 2020 specifies acceptable long-term noise levels, as shown in Table 1 below.

Table 1: Sonoma County Maximum Allowable Exterior Noise Exposures for Non-transportation Noise Sources

Hourly Noise Metric ¹ in dBA	Daytime (7 am to 10 pm)	Nighttime (10 pm to 7 am)
L ₅₀ (30 minutes in any hour)	50	45
L ₂₅ (15 minutes in any hour)	55	50
L ₀₈ (5 minutes in any hour)	60	55
L ₀₂ (1 minute in any hour)	65	60

¹ The sound level exceeded n% of the time in any hour. For example, the L₅₀ is the value exceeded 50% of the time or 30 minutes in any hour; this is the median noise level. The L₀₂ is the sound level exceeded 1.2 minutes in any hour. *This is Table NE-2 from Sonoma County General Plan 2020 Noise Element.*

While General Plan 2020 does not specifically address noise from construction sources, Policy NE-1c does address non-transportation new noise sources including short-term noises.

“Policy NE-1c: Control non-transportation related noise from new projects. The total noise level resulting from new sources shall not exceed the standards in Table NE-2 [Table 1 above] as measured at the exterior property line of any adjacent noise sensitive land use. Limit exceptions to the following:

“(1) If the ambient noise level exceeds the standard in Table NE-2, adjust the standard to equal the ambient level, up to a maximum of 5 dBA above the standard, provided that no measurable increase (i.e. ±1.5 dBA) shall be allowed

“(2) Reduce the applicable standards in Table NE-2 by 5 dBA for simple tone noises, noises consisting primarily of speech or music, or for recurring impulsive noises, such as pile drivers and dog barking at kennels

“(3) Reduce the applicable standards in Table NE-2 by 5 decibels if the proposed use exceeds the ambient level by 10 or more decibels

“(4) For short-term noise sources which are permitted to operate no more than six days per year, such as concerts or race events, the allowable noise exposures shown in Table NE2 may be increased by 5 dB. These events shall be subject to a noise management plan including provisions for maximum noise level limits, noise monitoring, complaint response and allowable hours of operation. The plan shall address potential cumulative noise impacts from all events in the area. . . .”

In addition to Sonoma County, several agencies have authority over project noise, including:

Federal Agencies with Jurisdiction

- U.S. Army Corps of Engineers (USACE) – USACE has jurisdiction over placement of fill below the level of ordinary high water under §404 of the federal Clean Water Act and §10 of the Rivers and Harbor Act. Permits from USACE would be required for project implementation and would include consultation with NOAA’s National Marine Fisheries Service and the California Coastal Commission that would be likely to incorporate noise because of specific project circumstances.
- NOAA’s National Marine Fisheries Service – NOAA Fisheries is a department of the National Oceanic and Atmospheric Administration, which is overseen by the Department of Commerce. In Bodega Bay, NOAA Fisheries has designated Essential Fish Habitat (EFH), which includes eelgrass beds and other aquatic habitat elements, under the federal Endangered Species Act. Noise can constitute a serious impact on resources protected by NOAA Fisheries.

State Agencies with Jurisdiction

- California Coastal Commission – The Coastal Commission is responsible for protecting, conserving, restoring, and enhancing the state’s coastal resources under the California Coastal Act and with designated federal authority under the Coastal Zone Management Act of 1972 (CZMA). Their evaluation of projects includes noise impacts on protected coastal resources.

- California Department of Fish and Game (CDFG) – CDFG is a trustee agency with regard to the fish and wildlife of the state. CDFG designates and protects rare or endangered native plants and animals under the California Endangered Species Act (CESA).

Physical Setting

The project is located on the Sonoma Coast at two developed boat launch facilities adjacent to Bodega Harbor in Westside Regional Park and Doran Regional Park. Bodega Harbor is located at the northern edge of Bodega Bay. It is bounded by Bodega Head to the north and west and by a spit to the south on which Doran Regional Park is located. Bodega Harbor is used by recreational boaters and fishers and by small commercial fishing operations.

The area surrounding both Doran and Westside Regional Parks is protected land. At Doran, the entire spit is part of the County park except for the U.S. Coast Guard station immediately east of the project area, while at Westside, the park is surrounded by Sonoma Coast State Park, with the residential area for the Bodega Marine Laboratory just to the west and a small neighborhood of residential and harbor-related commercial uses a little to the north. See Figure 1. Location Map.

Doran is the more isolated of the two sites. There is one road leading from the entrance of Doran Regional Park to the end of the spit that is used by park traffic and for Coast Guard Station access. The nearest non-park use is more than a mile away along the spit and more than 0.5 miles away on Bodega Head across the water. Although water is a highly reflective surface that can actually increase sound transmission, the path to the nearest sensitive receptors, residences, goes through Westside, so any activity that does not bother those residences from work at Westside also will not bother them from Doran. Sensitive marine species occur adjacent to the project site; however, the same sensitive marine uses occur at Westside Regional Park. Therefore, this analysis focuses on Westside Regional Park as noise impacts and precautions there will more than adequately address any possible noise conflicts arising from project activities at Doran.

Except along Highway 1, Bodega Bay is very quiet. Noise sources in the project area include wind and water, conversation, cars, boats and boat-related equipment, and the foghorn. Because Bodega Bay's primary industry is fishing, both recreational and commercial, a good deal of the noise at the project sites is related to fishing equipment. The loudest sounds in all measurements were from passing cars.

Table 2: Ambient Noise in the Project Area

Ambient Noise ¹ in the Project Area	Spud Point Area (Location A)	Westshore Road by Nearest Residence (Location B)	Westside Park at Boat Launch (Location C)	Westshore Road by Bodega Marine Laboratory (Location D)
L ₅₀	45.6	43.8	52.8	47.1
L ₂₅	50.3	46.5	54.4	49.6
L ₀₈	60.6	52.3	56.5	55.7
L ₀₂	67.4	62.4	58.9	60.9

¹ The sound level, expressed as dBA, exceeded n% of the time at sites located around the project area. Measurements were taken mid-week during normal business hours. Graphs of sound level measurements are in Figures 4-7 below. Measurements at Locations B and D were taken 23 feet from the mid-point of the road, and Location A was taken 36 feet from the mid-point of the road. Measurement numbers for A, B, and D are adjusted to give the 50-foot sound pressure level.

Westside Regional Park does have a line of Monterey cypress around the edge of the parking lot that may provide some limited noise attenuation. However, the line has gaps and does not cover the portion of the parking lot between the construction area and the nearest residences near Spud Point, so no attenuation effects, other than distance, are included in project noise calculations.

Sensitive Receptors

Different sensitive receptors may have different vulnerabilities to noise effects. Considerations in the County General Plan for allowable noise include surrounding land use, ambient noise levels, time of noise generation, and type of noise. Noise standard levels may be adjusted upward for high ambient noise and downward for very simple, repetitive noise. The plan gives priority to protecting the following sensitive human receptors:

- Residences.
- Schools.
- Long-term care facilities.
- Places of public worship.
- Libraries.

The nearest sensitive human receptors to Westside Regional Park are the residences associated with the University of California at Davis Bodega Marine Laboratory just to the west and a small neighborhood of mixed residential and harbor-related commercial uses a little to the north. See Figure 2. Noise Source and Receptor Locations.

Other sensitive receptors likely to occur in the project area include:

- Aquatic species.
- Marine mammals.
- Breeding and migratory birds.

Sound can disrupt sensitive marine receptors in several ways.

Sound is used by many marine animals for basic survival activities, such as foraging, detecting predators, navigation, and communication. Human-generated noises can affect these behaviors and have an impact upon organisms in other ways as well. For example, masking (the drowning out of certain sounds by other sounds) can reduce the effective communication distance among conspecific organisms. Anthropogenic noise can also cause physiological impacts, such as temporary or permanent threshold shifts (temporary or permanent hearing loss and tissue damage).

Anthropogenic Noise in the Marine Environment,
University of Maryland for NOAA Fisheries, 2011

Listed fish and Essential Fish Habitat are protected by NOAA Fisheries under the Endangered Species Act, marine mammals by the Marine Mammals Protection Act, and birds by the Migratory Bird Treaty Act.

NOAA Fisheries Standards for Sound

NOAA Fisheries recognizes two types of underwater sound: pulsed (impulsive) and non-pulsed (referred to as continuous). NOAA's acoustic exposure criteria for underwater sound are measured differently than on land. Underwater noise is measured in geometrically averaged sound levels as root-mean-squared decibels (dB RMS) compared to a reference measurement of 1 µPa. NOAA Fisheries identifies two underwater impact harassment levels for marine mammals:

- Level A harassment = 180 dB re 1 µPa (RMS)
- Level B harassment =
 - 120 dB re: 1 µPa (RMS) for continuous sources
 - 160 dB re: 1 µPa (RMS) for impulsive sources

Because of the different method for calculating underwater decibels, they are not directly comparable to the dB or dBA of air measurements. For instance, 180 dBA in air would cause instant deafness. For this reason, NOAA Fisheries has set separate in air exposure criteria for pinnipeds, the marine mammals that primarily leave the water, as 90 dB (unweighted) for harbor seals and 100 dB (unweighted) for all other pinnipeds.

NOAA's underwater threshold for harm of fish is 206 dB RMS peak, 187 dB RMS accumulated sound pressure levels (SPL) for fish over 2 grams, and 183 dB RMS for fish less than 2 grams (NOAA Fisheries 75 FR 207:66070 *et seq.*; 76 FR 245:79410 *et seq.*; 77 FR 128:39471 *et seq.*; Boudreau Associates LLC 2012). Exposure criteria for fish are for impulse-type noise.

Project Noise

Project-generated Noise Levels

Table 3 summarizes typical construction noise levels identified in the *Roadway Construction Noise Model User's Guide* (FHWA 2006). Construction noise is evaluated using a combination of the loudest noise a specific piece of equipment might make and the percentage of time it is likely to be operating (usage factor). Impact devices create impulsive noise that is more disruptive than continuous noise.

Table 3. Construction Equipment Noise

Type of Equipment	L _{max} at 50 feet (dB)	L _{max} at Nearest Sensitive Receptor to Westside (dB)	Usage Factor (UF) %	Impact Device?
Auger drill rig	85	60	20	No
Backhoe	80	55	40	No
Bar bender	80	55	20	No
Chain saw	85	55	20	No
Clam shovel	93	66	20	Yes

Type of Equipment	L _{max} at 50 feet (dB)	L _{max} at Nearest Sensitive Receptor to Westside (dB)	Usage Factor (UF) %	Impact Device?
Concrete mixer truck	85	60	40	No
Concrete pump truck	82	58	20	No
Concrete saw	90	65	20	No
Crane	85	60	16	No
Dozer	85	60	40	No
Dump truck	84	60	40	No
Excavator	85	60	40	No
Flat bed truck	84	60	40	No
Front end loader	80	55	40	No
Grader	85	80	40	No
Impact pile driver	95	70	20	Yes
Jackhammer	85	60	20	Yes
Paver	85	60	50	No
Pickup truck	55	30	40	No
Pneumatic tools	85	60	50	No
Pumps	77	53	50	No
Slurry plant	78	54	100	No
Slurry trenching machine	82	58	50	No
Tractor	84	60	40	No
Vibratory concrete mixer	80	55	20	No
Vibratory pile driver	95	70	20	No

Source for L_{max} at 50 feet and % usage: Federal Highway Administration (FHWA) 2006.

Although the Table 3 (FHWA 2006) identifies impact and vibratory pile drivers as producing the same amount of noise, many sources identify impact drivers as making more noise than vibratory drivers. Specifics on pile-driving circumstances are not included in Table 3; however, roadway construction often uses larger piles driven into more solid ground than would be the case for the piles into Bodega Harbor for the boating facilities. Many factors influence the amount of noise generated by a vibratory pile driver. For this assessment, monitoring data from Vashon Island collected for the Washington Department of Transportation was used because pile-driving circumstances would be similar to the planned project with 18-inch piles going into saturated bay soils; see Table 4.

Table 4: Vashon Island Vibratory Pile-driving Airborne Monitoring Results

Pile #	Distance from Pile	L _{eq} /RMS (dBA)	L _{eq} /RMS (dBA) at 50 feet*	L _{max} (dBA)	L _{max} (dBA) at 50 feet*
1	26 feet	80.7	75	87.8	82
2	36 feet	81.2	78	97.2	94
3	26 feet	79.8	74	84.4	79
4	36 feet	81.5	79	88.9	87
mean	31 feet	80.8	76.5	89.6	85.5

*L_{eq} at 26 and 36 feet were measured in the original pile-driving monitoring (Laughlin 2010). The L_{eq} and L_{max} at 50 feet are calculated for comparison with Caltrans construction monitoring data.

The loudest construction activity, as shown in Tables 3 and 4, is pile driving. The amount of noise generated during pile driving varies depending upon the size and type (steel v. concrete) of the pile, size and type (impact v. vibratory) of hammer, water depth, and geotechnical conditions that determine how difficult it is to drive the pile (Illingworth & Rodkin 2007).

Project construction would avoid the combination of an impact hammer and steel piles and instead employ either concrete piles or a vibratory hammer. According to Illingworth & Rodkin (2007), underwater sound levels ranged from 185-188 peak dB RMS for concrete driven with an impact hammer to 165-185 peak dB RMS for steel driven with a vibratory hammer. In a water depth of 5 meters, a representative depth for this project, a 24-inch steel pile driven with a vibratory hammer would produce 160 dB RMS. Since project piles would be only 18 inches wide and would be driven into soft substrate, 160 dB RMS is used as a conservative estimate of underwater noise. As this is below the

exposure limits for fish defined by NOAA Fisheries (206 dB RMS peak, 187 dB RMS for fish over 2 grams, and 183 dB RMS for fish less than 2 grams), underwater impacts on fish are not anticipated.

For this project, pile-driving noise in air is expected to have an L_{max} of 95 dBA at 50 feet using concrete piles with an impact hammer or 86 dBA with a vibratory hammer. As the County prioritizes protecting private residences as the most important sensitive receptor, and the closest sensitive receptor is a residence, all potential effects on humans are evaluated using the noise levels near the closest residence. Using the equations from the *Assessment Method* above, this would result in noise levels at the property line of the nearest residence as shown in Table 5 for the loudest and most used construction equipment.

Table 5: Anticipated Project Construction Noise Levels in Air at Nearest Receptor to Westside Regional Park

Equipment	L_{max} at 50 feet	Usage Factor	Distance to Closest Receptor to Westside (feet)	L_{max} at Nearest Receptor	L_{eq} at Nearest Receptor	L_{10} at Nearest Receptor
Impact pile driver	95	20	1150	68	61	64
Vibratory pile driver	86	20	1150	59	52	55
Slurry plant	78	100	885	53	53	56
Clam shovel	93	20	1250	65	58	61
Excavator	84	40	800	60	56	59

Project Noise Compliance

Sonoma County’s standards are for L_{50} , L_{25} , L_{08} , and L_{02} . To compare predicted noise levels from Table 5 above to County standards, the predicted L_{10} (exceedence 10% of an hour or 6 minutes) was used, which is very close to the County’s L_{08} (exceedence 8% of an hour or ± 5 minutes). The County’s standard L_{08} during the workday is 60 dBA or less, but General Plan policies specify adjustments to the levels according to project-specific circumstances:

- Impact pile drivers must be 5 dBA quieter.
- Short-term noises that occur less than 6 days per year may be 5 dBA louder.

It is estimated that pile driving at both sites will take only three days (2 at Westside and 1 at Doran) spread out over two years, so it would be a short-term noise. Both adjustments above apply to impact pile driving, leading to no net change in the standard of 60 dBA. If vibratory pile driving is employed, the allowed L_{08} level would be 65 dBA.

Construction generally will meet County standards; see Tables 1 and 5. However, impact pile driving and clam-shovel dredging are above County limits. Mitigation is proposed that will allow these activities to meet County standards.

Air noise standards for pinnipeds (i.e., 90 dB (unweighted) for harbor seals and 100 dB (unweighted) for all other pinnipeds) are higher than the potential project L_{max} levels in Table 5. However, clamshell dredging and impact pile driving, both of which produce noise levels above 90 dBA at 50 feet, could disrupt marine mammals in the project area. Mitigation measures are recommended to keep marine mammals safe during construction.

Because eelgrass beds, an important habitat for fish and other aquatic species, occur close to the project site, mitigation measures have also been included to ensure that unsafe sounds do not travel underwater.

Groundborne noise generated by the project would occur during pile driving. Using the Caltrans equations described in the *Assessment Method* section, the vibration from an impact driver would be 0.009 in/sec as shown below. This uses the reference equipment energy as the value for the project equipment energy, since the actual equipment is not yet known.

$$PPV_{\text{Impact Pile Driver}} = 0.65(25/1150)^{1.1} (36,000/36,000)^{0.5} = 0.009 \text{ in/sec}$$

Where:

$PPV_{\text{Ref}} = 0.65$ in/sec for a reference pile driver at 25 feet

$D = 1150$ is the distance from pile driver to the receiver in feet

$n = 1.1$ is a value related to the vibration attenuation rate through ground

$E_{\text{Ref}} = 36,000$ ft-lb (rated energy of reference pile driver)

$E_{\text{equip}} = 36,000$ ft-lb (since the actual equipment to be used is not yet known, we use the reference value)

$$PPV_{\text{Vibratory Pile Driver}} = 0.65(25/1150)^{1.1} = 0.009$$

Where:

$PPV_{\text{Ref}} = 0.65$ in/sec for a reference pile driver at 25 feet

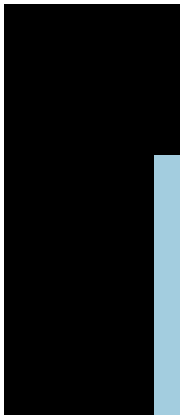
D = distance from pile driver to the receiver in feet

n = 1.1 (the value related to the attenuation rate through ground)

Since a vibration level of 0.009 is well below the level that would result in structural damage and below the level perceptible to humans at the nearest receptor, no vibration impacts are anticipated, and no mitigation is proposed.

Recommended Mitigation Measures

- Noise – 1: Construction should occur during the work week (Monday through Friday), in the daytime, when nearby residents are least likely to be adversely affected.
- Noise – 2: The minimum number and size of piles necessary to support the floating docks and gangways should be used.
- Noise – 3: Concrete piles may be driven by impact hammer; however, if steel piles are utilized, they should be driven by vibratory hammer to reduce noise impacts. If an impact hammer is used, a wooden cushioning block should be placed between the hammer head and pile to reduce both air and underwater noise levels. This will reduce air sound pressure levels by 5 dBA bringing the project into compliance with both County and NOAA Fisheries airborne noise standards.
- Noise – 4: To achieve compliance with NOAA Fisheries' underwater noise standards and protect marine organisms, underwater noise transmission should be reduced by:
- Driving piles only during periods of minimal current (slack tide).
 - Conducting underwater noise monitoring and implementing noise barriers such as bubble curtains or temporary noise attenuation piles if necessary.
 - If NOAA Fisheries recommends work windows, pile driving should be performed only during those windows.
- Noise – 5: In order to comply with County standards, clamshell dredging should require either:
- Total dredging time be less than 6 days per year, or
 - Noise monitoring be performed for the first hour of dredging activity to confirm that the project is meeting County standards. If noise levels exceed the County standards, a temporary noise barrier should be erected in the transmission path between the project and the Spud Point residential neighborhood.
- Noise – 6: For protection of marine mammals and other aquatic species, the contractor should:
- Bring loud mechanical equipment on-line slowly.
 - Maintain sound levels below 90 dBA in air when pinnipeds (seals and sea lions) are present.
 - During pile driving with an impact hammer and during dredging:
 - Maintain a 200-foot safety zone around sound source in the event the sound level is unknown or cannot be adequately predicted.
 - Halt work activities when a marine mammal enters the 200-foot safety zone.
 - Allow marine mammals to completely exit the project area before pile driving or work with other loud mechanical equipment resumes.





Legend

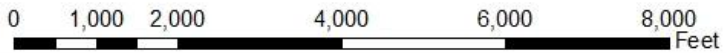
- Project_Locations
- Nearest_Sensitive_Receptors



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Date Created: December 2012
 Created By: Laura Saunders

**Figure 2. Bodega Bay Boat Launch Facilities Improvements
 Noise Source and Receptor Locations**



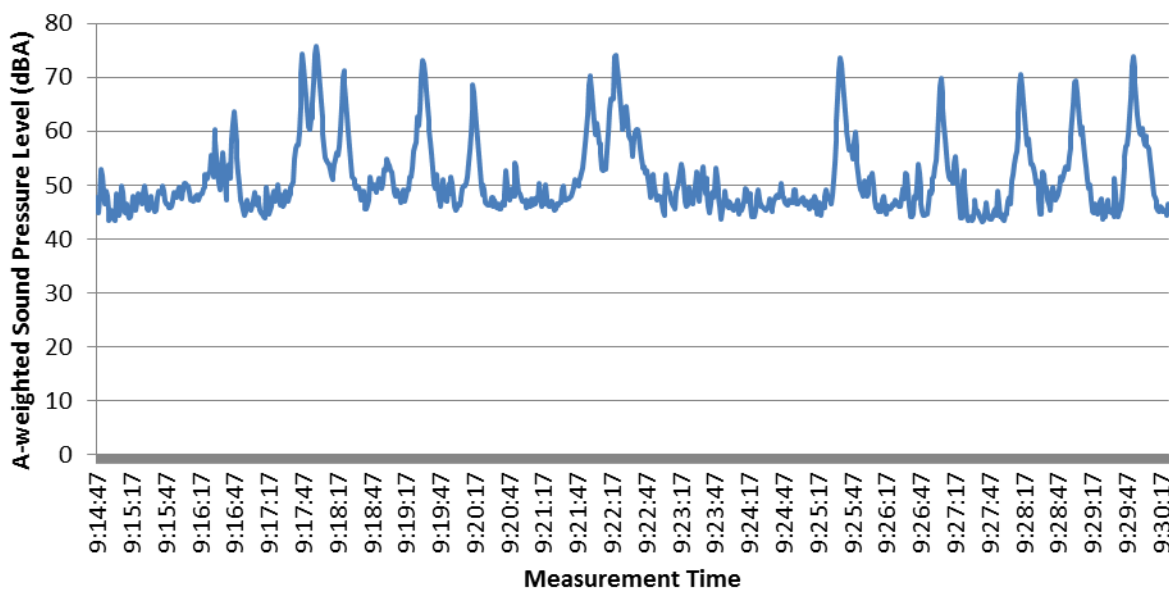


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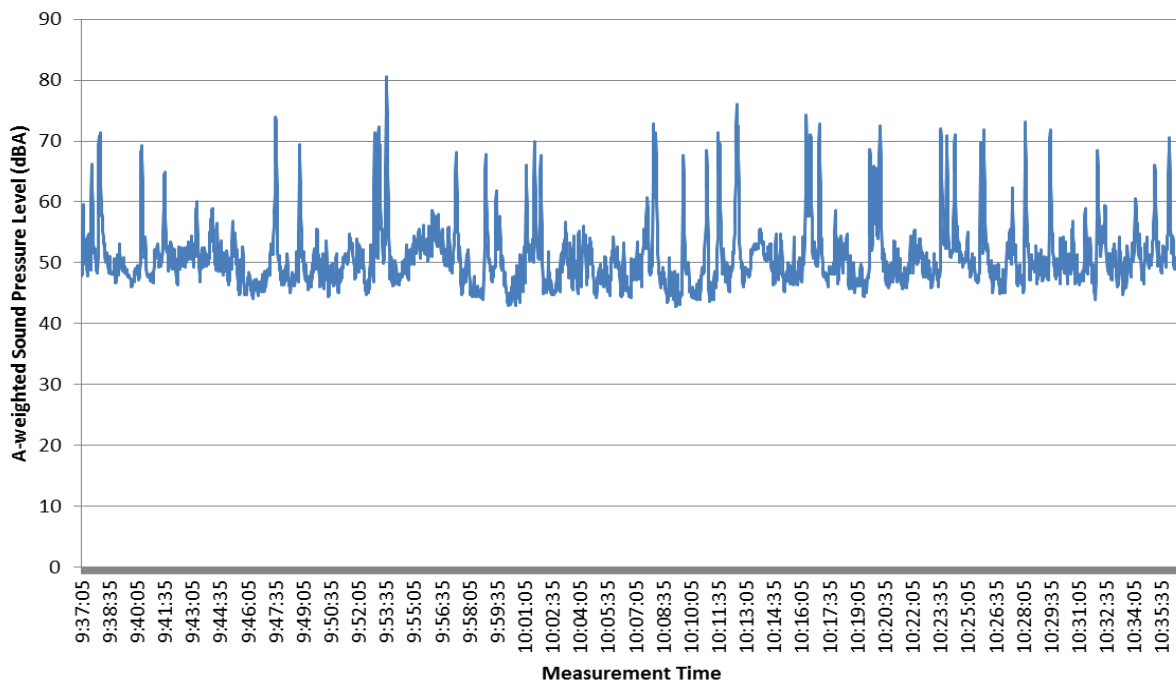
Date Created: September 2012
 Created By: Laura Saunders

**Figure 3. Westside Park
 Boat Launch Facilities
 Noise Measurement Locations**

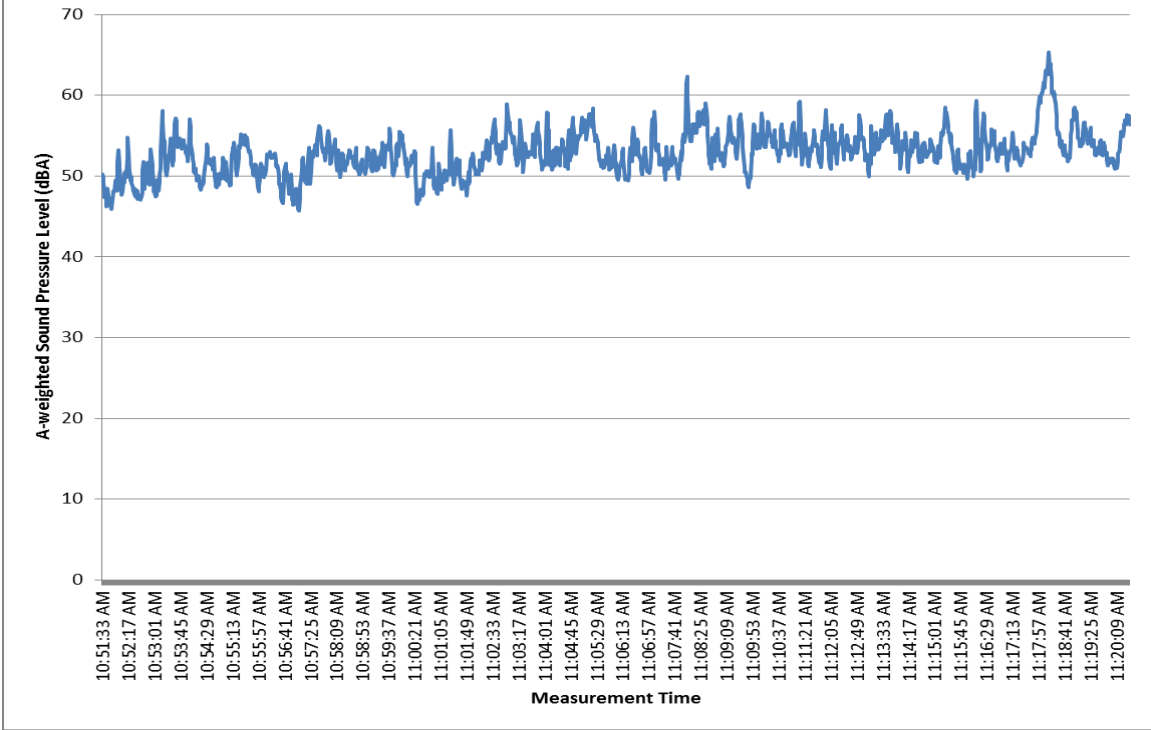
**Figure 4. Ambient Noise Measurements
Location A - Near Spud Point Marina**



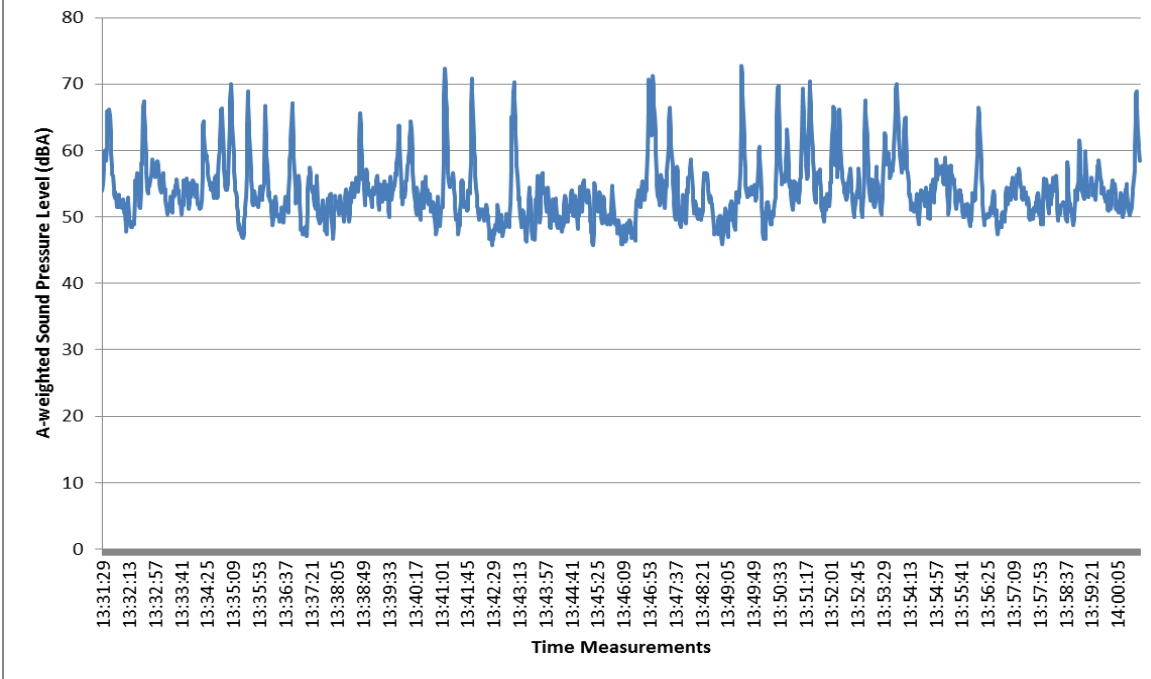
**Figure 5. Ambient Noise Measurements
Location B - Nearest Residence**



**Figure 6. Ambient Noise Measurements
Location C - Westside Park at Boat Ramp**



**Figure 7. Ambient Noise Measurements
Location D - Westside Road near Bodega Marine Laboratory Housing**



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